Hongxiu Li | Jonna Järveläinen (Editors)

Effective, Agile and Trusted eServices Co-Creation

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Effective, Agile and Trusted eServices Co-Creation

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PREFACE

It is with great pleasure that we bring out this Proceedings volume of the fifteenth International Conference on Electronic Commerce (ICEC 2013). The conference was held at University of Turku, School of Economics, in Turku Finland, August 13-15, 2013 and was jointly hosted by University of Turku and Åbo Akademi University, and was supported by the regional innovation and business community.

The International Conference on Electronic Commerce (ICEC) has as an objective to "annually bring together the leaders of the scientific research community in e-commerce and e-business from all over the world". Having travelled across the globe from Hawaii to Liverpool and from New Brunswick to Singapore, the conference returned to Europe, for the first time to Fenno-Scandia, the medieval Capital of Finland and Hanseatic city of Turku, Finland. Turku is situated at the shore of a beautiful maritime archipelago. It is a medieval city of harbors and sea fare, having a long history in trade and logistics. It is a prosperous, growingly international, and culturally rich part of Finland, with one of the eldest academic institutions of Europe.

The theme of ICEC 2013 was Effective, Agile and Trusted eServices Co-creation. The theme reflects alignment between computerized, formalized business procedures with the need for innovating business genuinely on the spot, or ad-hoc, to the needs of a customer.

The authors were asked to find a balance between designing effective and profitable ways of delivering eServices and maintaining customer relationship with the help of designing and running eCommerce systems. These are to be effective enough to handle not only millions of transactions, but also adaptive enough to manage hundreds of exceptions and tens of customer segments in real-time - all this with sufficient analysis, feed-back and security mechanisms for trusted sales between remote sellers and buyers, or between authorities and citizens.

All the submitted papers to the conference have undergone anonymous peer-review process and were selected based on academic quality criteria. All papers have been reviewed double blind by at least two reviewers and for a number of papers by four reviewers. From the submitted papers only 50% was accepted for presentation during the conference.

This Proceedings volume published by Turku Center for Computer Science (http://tucs.fi) consists of a selection of the accepted papers. The papers were selected by a joint board of the conference program committee and the conference chairs, based on the reviews as well as coherence in content. The papers have not previously been published. The papers are grouped according to themes; first we will introduce the **mobile and social media** papers. Then we pay attention to **strategic and IT services related** papers. Finally there are papers that deal with **recommender systems**.

Mannonen et al., *An Approach to Understanding Personal Mobile Ecosystem in Everyday Context* is focused on understanding usage context. The usage context is conceptualized as a micro-ecosystem and is researched by making use of smartphones to capture experiences. Relevance of experience sampling for designing applications is explored. In contrast, Laya et al. in their paper *Business Challenges for Service Based on New Technology*, focus on the business side because in their view value creation, value networks (provider eco-system) and leadership are key factors that

play a role in the commercialization of services. One of the cases Laya et al. discuss is related to mobile payment. Liu et al. focus on empirical research in trying to explain why NFC mobile payment is adopted. In their paper *Risks of Using NFC Mobile Payment: Investigating the Moderating Effect of Demographic Attributes* Liu et al. discuss different dimensions of risk, for instance the risk of privacy invasion. In the same grain Xu et al. look into the different dimensions of value in their paper *Users' Continuance Intention of a Mobile Check-in Service in China*.

The papers on social media are looking into alternatives to TAM to explain behavior. For instance Hou et al. in their paper *An Optimal Experience for People Social Online: The Perspective of Cognitive Absorption* look into cognitive absorption in relation to acceptance. Also the paper by Li et al. discusses empirical research in relation to Person-2-Person lending markets. The title of the paper makes the focus clear: *How Friendship Network Works in Online P2P Lending Markets*. Where research is most of the time focused on prosper.com, this paper focus on PPDai in China. In the last paper on social media, Understanding Web Portal Navigation with Markov Chains and Spreading Activation Networks Calin et al. use log data to understand user navigation patterns. In their analyses they use Markov chains in combination with activity theory.

Four papers focus on ICT support services for eCommerce activities. The topics are rather divers. In their paper *Inter-organizational Business Processes: On Redundancies in Document Exchanges* Engel et al. discuss how redundancy in document exchanges can be reduced in inter-organizational processes. In contrast Cai et al. in their paper *Dynamic Vehicle Routing Services with Anticipatory Optimization – A Decentralized Scheme Based on MapReduce* discuss the complexity of dynamic route guidance systems as well as the fast growing data-sets and how to reduce them, in an attempt to provide drivers more accurate, real-time information on routing and even push notifications by making use of cloud computing capabilities. The third paper discusses the role of ICT in health care services. The focus of Chen et al. *Establishing a Bi-directional Personal Healthcare Record Service with NFC Technology* is on NFC as a technique to make it possible for users to have their own portable health records. The last paper discussing the ICT support function is related to education. This paper by Miyata et al., *A Model of the Value Exchange System in the University with the Big Boss Game* discusses value exchange in a university context, making use of experiments in which relations between participants can be characterized as student-teacher.

The paper by Peng et al. *A Survey Research on Customer Value of Service-class Online Group-buying* is empirical in nature and analyses the antecedents of customer value in online group buying websites, with a focus on service quality. They conclude that website design and assessment of real business service quality is important, but also advice not to spend too much time on website interactivity and voucher elasticity.

The paper by Grad-Gyenge *Network Science @ Recommender Systems* discusses the possibilities of network concepts in the context of recommender systems. Based on the analogy with neural networks, cognitive processing of information sources and types and their relationships with a labeled, directed, weighted non-acyclic graph/network are used for improving recommender systems.

We would like to thank the reviewers for the 15th International Conference on Electronic Commerce who helped to select the papers and to suggest improvements

papers. We hope that you enjoy reading the selection of highly topical and relevant papers that reflect the current state of the art in eCommerce research.

June 2013

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Dynamic Vehicle Routing Services with Anticipatory Optimization – A Decentralized Scheme Based on MapReduce

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Abstract. Building an intelligent route guidance system is increasing important to ease traffic congestion pressure in fast growing cities, as a result of the urbanization trend. In another aspect, the network infrastructures promoted by the ideology of digital city reinforce the Intelligent Transportation Systems (ITS), which provides innovative resolutions to the challenge. As traditional centralized dynamic route guidance systems are becoming incapable of coping with these challenges, because of computational complexity and fast growing traffic big data, this paper proposes how to apply the MapReduce approach, the kernel approach in cloud computing, to construct a novel decentralized dynamic route guidance system (DDRGS). By distributed computing architecture, DDRGS is able to effectively reduce the overall data processing time, require less information from drivers, achieve more effective communication, and provide more accurate real-time route recommendations and push notification service.

Keywords: digital city, vehicle route guidance, decentralized optimization, MapReduce, cloud computing

1 Introduction

With the rapid urbanization in the emerging countries, building an efficient, safe, and sustainable transportation system has been a challenge to an increasing number of cities, as the severity of congestion is barely questionable. According to the Texas Transportation Institute's 2011 Urban Mobility Report, in 2010, congestion caused urban Americans to waste 4.8 billion hours and 1.9 billion gallons of fuel [1]. Therefore, building a vehicle route guidance system that enables to push updated best-route recommendations based on real-time traffic information to system users is valuable to keep growing cities healthy, smart, and green.

In another aspect, the concept of digital city leads urban development in an interactive and intelligent way. In a digital city, people can get customized transportation information services through digital sharing, collaboration, interaction and communication [2]. Since the mid-2000s, digital city has flourished with wide use of smart devices and rapid construction of wireless network based on mobile

communication technologies [3]. Benefited from the ideology of digital city, the accessibility of broadband network in many cities has been promoted. Some cities, such as Louisville, Salt Lake City, and Ann Arbor in the USA[1], Helsinki, and Vienna in Europe, and Hong Kong, Taipei, and Kyoto in Asia[2], have been operating city-wide wireless broadband network for years. In particular, WiMax, the technology of metropolitan area network, has been deployed in many American cities (http://www.clear.com/coverage). These network infrastructures reinforce the Intelligent Transportation Systems (ITS), which was born in 1990s and originally used for highway systems [4]. ITS integrates the information from vehicles, drivers, and infrastructure (roads, traffic lights, tolls, etc.) with advanced networking and communication technologies to provide intelligent transportation information services, such as route optimization, traffic information notification and safety warning, to system users [5].

So far, most previous studies focus on centralized dynamic route guidance systems, in which the traffic information collected from different traffic infrastructures is processed by a centralized super-computer. TravTek is an early-stage example of centralized dynamic route guidance systems. Traffic information, which is collected by a network of agencies and companies, vehicles, historical data, and operator-entered information, is sent to the Traffic Management Center (TMC); the TMC processes the information and provides the status of accident or congestion to the users [6]. Von Tomkewitsch introduced the ALI-SCOUT where infrared beacons at partial traffic lights are traffic information collectors, and are able to update central database in the TMC [7]. After computing the best route based on the information collected from the above origins, TMC then sends routing recommendations to system users via infrared beacons. STRG collects traffic information with the loop detector and the image processing detector, and the routing recommendations send through roadside variable message signs (VMSs), variable information boards (VIBs), and traffic information broadcasting system [8].

Although these early centralized route guidance systems pay attention to how to collect traffic information to improve the quality of the route guidance recommendations, they are not able to process the real-time traffic information. RETINA improves the centralized route guidance systems to enable to provide route guidance services with soft-real-time traffic information over a cellular network [9]. Chen et al. suggest collecting real-time traffic information with wireless sensor network (WSN) and vehicles reports, which can provide more accurate data at lower construction and maintenance cost than traditional wired ITS [10]. In addition, Yamashita et al. proposes that the traffic network efficiency can be significantly improved by integrating the driving plans reported by drivers to estimate the real-time traffic [11].

However, as IT is stimulating the explosive growth of available traffic data, the centralized route guidance systems have encountered major problems that restrict them to be applied in the real world. First, an extremely powerful central computer is needed to process a huge amount of traffic data. Since the time consumed on single computation request is too long, the computing results cannot respond to real-time

[1] http://www.digitalcommunities.com/survey/cities/
[2] http://cs.gmu.edu/~jpsousa/classes/895/readings/0933.pdf

traffic situation and the services of active push notifications on traffic changes is not available. Therefore, more efforts with wireless communication technologies turn to decentralized dynamic route guidance systems.

Encouraged by the emerging distributed computing technology, particularly the idea of MapReduce in cloud computing, we introduce a novel decentralized dynamic route guidance system (abbreviated as DDRGS). In DDRGS, TMC only works as a routing information request management center. The route guidance schemes are produced by a computer cloud consisting of multiple computing units that constantly capture and analyze dynamic traffic information following the assignments of TMC. Even with little involvement of drivers in the road, this decentralized system can produce satisfactory routing guidance and even can push the notification messages in real-time to the users. In this way, DDRGS is able to effectively reduce the overall data processing time, require less information from drivers, achieve more effective communication, and provide more accurate real-time route recommendations and push notification service. At the same time, DDRGS is easily adopted in a business model using software as a service (SaaS), where users subscribe the DDRGS at a certain price, the route guidance services with latest (or real-time) traffic information can be provided on demand [12].

The rest of paper is organized as follows. Section 2 explains the principles of the system. Section 3 defines the functions and the structure of DDRGS, and then covers the details how DDRGS operates. We summarize the paper in Section 4 with the research issue in the next step.

2 Principles of Decentralized Vehicle Route Services

With wide adoption of wireless networking technology (such as cellular radio, WIMAX, etc.), the decentralized algorithm is delivering more feasible solutions to route guidance systems. In a decentralized system, each travelling vehicle or each road intersection in the infrastructure may host a computing unit to collect and analyze traffic information, and communicate with their neighbors. Vehicles or traffic infrastructures make decisions on optimal route selection by joint efforts. Wunderlich et al. and Deflorio both demonstrated that with increasing users of a decentralized route guidance system, the decentralized system can make more accurate simulation of traffic conditions and provide better route guidance services [13][14].

A number of decentralized route guidance systems are infrastructure-less or infrastructure-free. In this type of systems, the vehicles (or onboard mobile devices) rather than detectors built at the roadside or intersections collect traffic information, exchange their information with others through Inter-Vehicle Communication (IVC) (e.g. [15][16][17]) or peer-to-peer (P2P) (e.g. [18][19]), and finally compute the best routes for themselves [5]. However, the vehicles (or onboard mobile devices) in these systems are required to have powerful computing units to process the data and communicate with others.

The mainstream decentralized dynamic route guidance systems are infrastructure-based, which means they need traffic detection systems (such as sensors, report of vehicles, street nodes, traffic surveillance systems, etc.) to collect traffic information. The infrastructure-based decentralized route guidance systems have passed from dependent systems to autonomous systems during the past twenty years. “While in an

autonomous system, the operations of system will be done without any control/cooperation of external party (human or machine), dependent systems are needed to cooperate" [5].

In a dependent system, the communication network plays key role in facilitating the system operation. SOCRATES and TravelGuide are two typical instances. The agents in the former system communicate via the cellular network such as GSM; while the latter system allows hand-held or portable computers built in vehicles to collect broadcasting data stream and compute the optimal routes [20][21]. In provisioning real-time traffic routing information services, some systems, such as MINS, allow drivers to monitor real-time traffic information through cellphones in wireless application protocol (WAP) format, and some, such as SNMS, provide dynamic traffic information based on wireless sensor network (WSN) and peer-to-peer (P2P) network [22][23].

Although these decentralized dependent systems involve travelling vehicles in the route guidance computations, the total calculation load of the system is still huge. To reduce the computation time and get rid of the control or cooperation of external party, recent studies provide valuable suggestions. Claes et al. suggest employing a multi-agent system to achieve decentralized route guidance [24]. Vehicle agent is responsible for routing computation based on delay time estimation provided by infrastructure agent and virtual map, and the traffic prediction is achieved by communication between vehicle agents and infrastructure agents [24]. UTOSPF is based on WSNs and Open Shortest Path First (OSPF) protocol [25]. In this system, street units detect the local average speed of passing vehicles and send it to intersection units (IUs); IUs then compute estimated street travel time of these streets; after exchanging these estimations between IUs, every IU will have estimated street travel time of every street and compute the best routes [25].

It is obvious that current research effort in decentralized vehicle route guidance is still far from enough. In particular, the application of cloud computing in processing big traffic data has become popular but a lot room remained unexplored for the application of vehicle route guidance when facing fast growing big data. MapReduce, as a great mechanism in cloud computing, is a programming model to deal with big datasets and heavy computing tasks, first introduced by Google in 2004. By parallelizing and distributing big data, MapReduce is capable of achieving high computing performance [26]. Kondekar et al. proposed a MapReduce based hybrid genetic algorithm to solve time dependent vehicle routing problem (VRP), a differentiated problem from the vehicle route guidance services as tackled in this paper [27]. This is what we have found the application of MapReduce in ITS. According to the VRP practice, the MapReduce approach is feasible to solve vehicle route guidance with large-scale dynamic traffic data and to our best knowledge, and there is no such vehicle route guidance system based on MapReduce approach.

MapReduce benefits from the design ideas of a functional programming language, which is a framework for processing parallelizable problems across huge datasets using a large number of computers [28]. In the MapReduce framework, the task can be accomplished in a distributed manner through the following steps: "Map" step – the MapReduce partitions the task to several independent subtasks, and assigns them to work units. Each work unit will process the allocated subtask in parallel; "Reduce" step – the master unit then collects the output results from all the work units, and

combines them in some way to generate the final solution to the original input problem.

The critical point in our context is how to split a large task into smaller subtasks to be assigned to individual IUs, in which the IUs will have balanced computation load. Simply decomposing an integer programming task for a supercomputer into smaller ones for IUs is definitely not a good resolution. However, assigning an individual routing service request as a task to an IU has effectively reduced one dimension in a regular integer programming problem – the vehicle, which could be more than tens of thousands in operation simultaneously in a city.

3 System Framework

3.1 Settings of Dynamic Vehicle Routing Services

DDRGS is an urban traffic routing advice system based on distributed computing facilities. It is intended to provide the following services to vehicles: (1) Provides the optimized route for each vehicle given the start and end points of the trip; (2) Collects traffic conditions in real time and predict road conditions; (3) Actively sends the updates of the routes to vehicles when necessary in accordance with the changes of road conditions.

The provisions of above vehicle routing services are based on the following assumptions: (1) The vehicles in the urban traffic system do not need to constantly send their positions to DDRGS. They send out the routing service requests to DDRGS and will receive the route guidance information plus pushing information from DDRGS whenever there is an event which will change the optimized route. This assumption of one-inquiry-for-all information service will provide vehicles great convenience with minimal effort in looking for good routing services throughout their journeys. (2) DDRGS employs multiple computers for the route calculation, each of which is in charge of information processing for a given set of intersections and roads. The computing tasks are assigned to these computers by TMC, which collects the computing results and delivers the results to vehicles. This implies that these computers form a kind of cloud and can operate in a collaborative way to improve the routing calculation efficiency. (3) We assume that the available information includes: (a) the expected time for a vehicle to pass a specific intersection, and (b) the expected time for a vehicle to go through a section of road. This kind of information is changing over time due to fluctuating traffic conditions, and therefore forms time series. The availability of the information is based on the situation in which digital cities are prevailing and various sensors and detectors can be deployed in a city to collect the needed traffic information in real time. We can limit the available information to a minimal level but good enough for DDRGS to deliver good services, neglecting the details how the collection and preprocessing of the information are done. (4) Traffic conditions at different bottleneck sections of roads are stored in a shared database, either centralized or distributed, which are accessible to all computers in DDRGS but updated only by designated computers in charge of the set

of roads. This assumption is realistic because the traffic information in any given section of a route can always be retrieved and delivered to the computer whenever it requests. (5) The routing information of vehicles, including the predicted future arrival and departure at certain position of the road, can be aggregated to predict the future traffic conditions in all possible bottlenecks.

3.2 System Architecture and Components

Based on the above assumptions, we conceive a decentralized routing service scheme to underpin the MapReduce approach. In Fig. 1., there are three kinds of components: (1) Traffic Management Center (TMC); (2) Vehicle Unit (VU); and (3) Intersection Unit (IU).

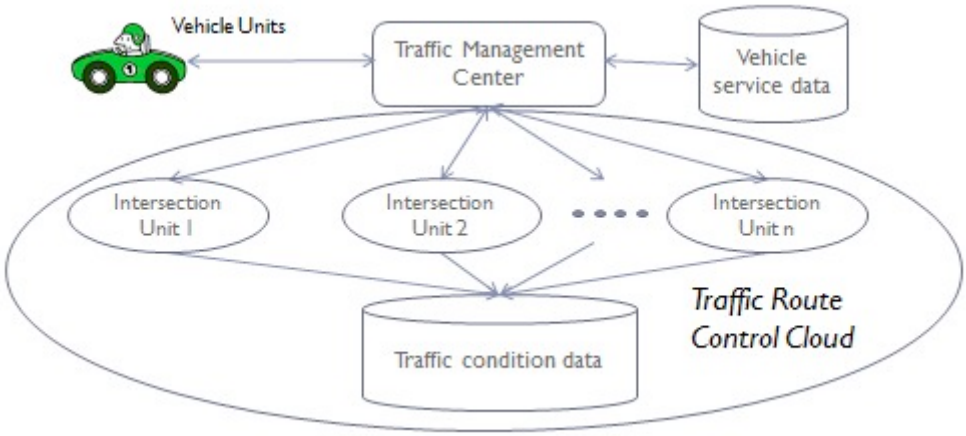

Fig. 1. System Architecture

TMC is the customer service center in DDRGS. It does not compute any route, but acts as an interface between VUs and IUs. TMC provides three functions: (1) receives and maps VUs' routing guidance requests to specific IUs; (2) collects the routing guidance information from the IUs and forward it to the requesting VU; and (3) maintains a dynamically updated vehicle service database, by which VUs and IUs can share different parts of information for better routing services. The information may include the registered VUs' information, their service request status, and the status of road emergencies.

A VU represents the intelligent device within every vehicle, which can send routing guidance request to TMC, and receive the route suggestions and the pushing notifications from TMC. VUs are active traffic participants and customers of the system.

IUs are the elementary computing devices, each of which is logically in charge of computing tasks for a designated intersection as well as relevant roads in a specific geographical location. They well represent the core elements of the road infrastructure (i.e. intersections). IU devices include standalone computers, computing units in a blade server system, or even virtual machines sharing slices of CPU time in a

supercomputer. They could be physically centralized or decentralized hosted regardless logically distributed tasks. IUs may perform three fundamental roles: (1) Start IU, representing the initial IU in a route to collaborate with the End IU; (2) End IU, representing the IU associated to the destination of a route; (3) Intermediate IU, maintaining and providing the local traffic conditions to each pairs of Start IU and End IU. An IU only play one role in any of the three types for a vehicle routing service request, but could be playing any combinations of the three types when handling multiple routing services simultaneously. Therefore, an IU possesses four basic functions: (1) monitoring and predicting local traffic conditions, (2) maintaining a localized routing table, (3) responding to information requests from other IUs, (4) communicating with TMC in a routing service and coordinating a route planning task once designated by TMC as the leader of the task.

There are two types of data in DDRGS. The vehicle service data are stored in the TMC database and dynamically maintained when VUs propose route guidance requests; and the traffic condition data are stored in the database maintained by each IU, which are fully shared with all the IUs in the whole traffic network. In actual calculation, the Start IU and End IU are jointly responsible for finding the optimal route in a travel trip, by means of calling the data stored in the databases of all the involved Intermediate IUs.

3.3 System Operation Mechanism

In general, TMC can assign the IU closest to the location where the VU sending guidance request message as Start IU. Once the Start IU and End IU are determined, End IU can call all the Intermediate IUs forming all paths between Start IU and itself to calculate the optimal path. In our system, each IU builds its own database in which the traffic condition data are stored, and each database maintains two kinds of tables. One is Routing Table, which contains the End IU information (i.e. the destination), the preceding IU information leading to the present IU, the subsequent IU information which can be reached by the present IU, and the Intermediate IU information passed by from the current IU to the End IU; the other is Intersection Table, which contains the local waiting time (that is the passing time of the current intersection), and it is worth noting that there are several time values for different directions according to the intersection type (such as three-way intersection, four-way intersection, three-way intersection, etc.). Another element included in the Intersection Table is the road patency (and the basic information of road conditions – road length, road capacity, speed limit, etc.), which maintains if the road is smooth for every direction, in other words, if there is some traffic congestion, accident, disaster, road work, traffic control, etc.

The process of a route guidance service is shown in Fig. 2. In the basic routing process, a VU sends its route guidance request to TMC, attaching its current location and destination. After receiving the request, TMC subsequently allocates this routing task to the correspondent Start IU and End IU. When the two IUs receive the task, they are jointly responsible for finding optimal route for the vehicle, by means of the information retrieval of all the Intermediate IUs between the Start IU and End IU. Once the task is completed, the results are fed back to TMC, and TMC sends the optimal route to the requesting VU.

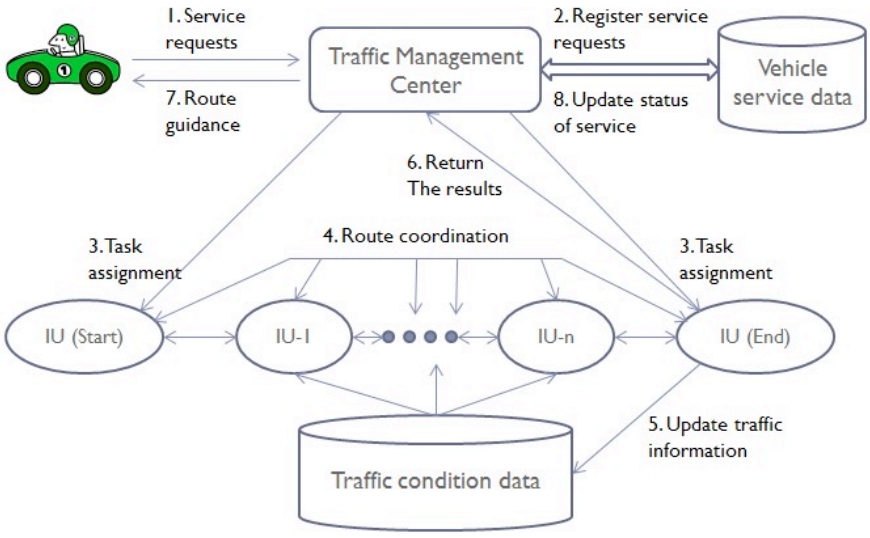

Fig. 2. The process of route optimization

In the remaining portion of this section, we will discuss main details in the above mechanism: The first is how the pair of Stat IU and End IU identifies the optimal route for the requesting VU; the second is how to implement anticipatory optimization; and the third is how to implement the pushing services for any changed conditions in the route a VU is taking.

How a pair of Stat IU and End IU identifies the optimal route for the requesting VU. In calculating the best route the End IU is assigned by TMC to perform the task with the help of the Start IU. The collaborating Start IU and End IU retrieve the data stored in the intersection routing tables of all the Intermediate IUs between them, in addition to their local data, and construct a traffic sub-network diagram as shown in Fig. 3. The information embedded in the network includes the expected passing time at each intersection and each section of road, which must take into account the future traffic conditions of at each point. In this process, the End IU actively communicates with all the Intermediate IUs, as well as the Start IU, and feed back its optimization results to relevant IUs in the route for them to update their future traffic information according the expected arrival time of the service requesting vehicle.

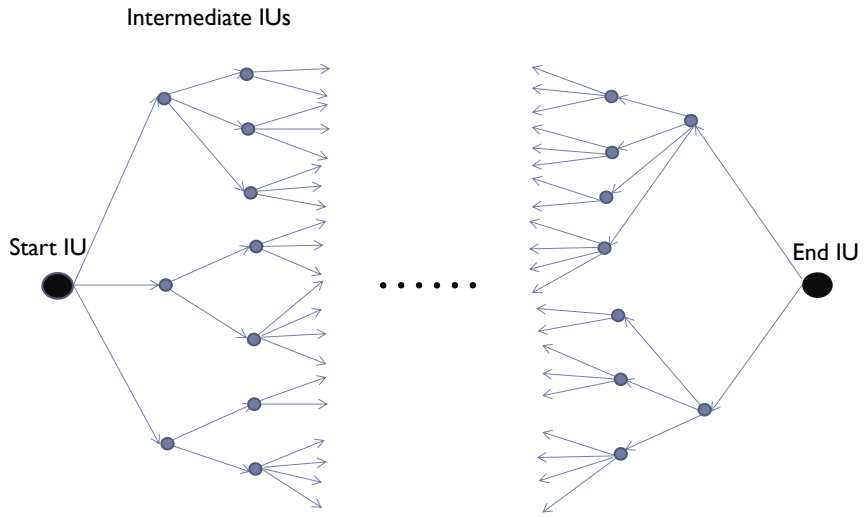

Fig. 3. An illustrative traffic sub-network diagram

Specifically, the shortest trip duration should be the sum of the shortest passing time of the roads and the shortest passing time of the intersections. Given a traffic sub-network diagram as shown in Fig. 3., there are several candidate approaches in the graph theory to solving the shortest path, typically, Dijkstra's algorithm, Bellman–Ford algorithm, and Shortest Path Faster Algorithm (SPFA).

Dijkstra's algorithm is a famous graph search algorithm that solves the single-source shortest path problem for a graph with non-negative edge path costs in the Feibonaqidui complexity $O(E + V * logV)$, where E is the number of edges and V is the number of vertices [29][30]. The Bellman–Ford algorithm computes shortest paths from a single source vertex to all of the other vertices in a weighted digraph. It is slower than Dijkstra's algorithm for the shortest path problem, but capable of handling graphs containing some edges having negative weights. It has a complexity of $O(VE)$, which is high than that of Dijkstra's algorithm [31]. SPFA is a queue implementation of the Bellman-Ford algorithm to reduce unnecessary redundant computation. It can obtain the shortest path from the source vertex to all the other vertices within the time complexity of $O(KE)$, where K is a constant that is not more than 2, and is able to handle the negatively weighted edges [32]. The key point in which it improves the efficiency of the algorithm is that only those vertices affecting the distance estimation in the last calculation step are included in current calculation step. Therefore, it maintains a FIFO queue to store vertexes successfully relaxed. Therefore, SPFA is superior over the other two competitive algorithms, especially, when there are more vertices and fewer edges in a graph. Therefore, we adopt SPFA for DDRGS implementation. However, in addition to the standard SPFA algorithm, we need to take into account the local passing time of each Intermediate IU. As such, the departure time of the local IU is the sum of the passing time of the previous road and the passing time of the local IU in the computational process from the End IU to the Start IU.

In implementing the updated version of SPFA algorithm, we adopt a cost function $T_{opt}(r)$ to calculate the estimate travel time of a vehicle to pass the road r and the intersection i in the direction j. $l(r)$ represents the length of road r, $v(r)$ stands for the average speed of the vehicle passing road r, and t_{ij} is the local passing time of the intersection i in the direction j.

$$T_{opt}(r) = \frac{l(r)}{v(r)} + t_{ij} \tag{1}$$

Then we replace the single path cost of SPFA with the joint time cost $T_{opt}(r)$ for executing the iteration in the procedure SPFA. In the flowchart of SPFA (Fig. 4.), Q is the queue, e is the first vertex (End IU in DDRGS), v is any vertex except u, and the exit condition is that v is successfully refreshed and not in the queue.

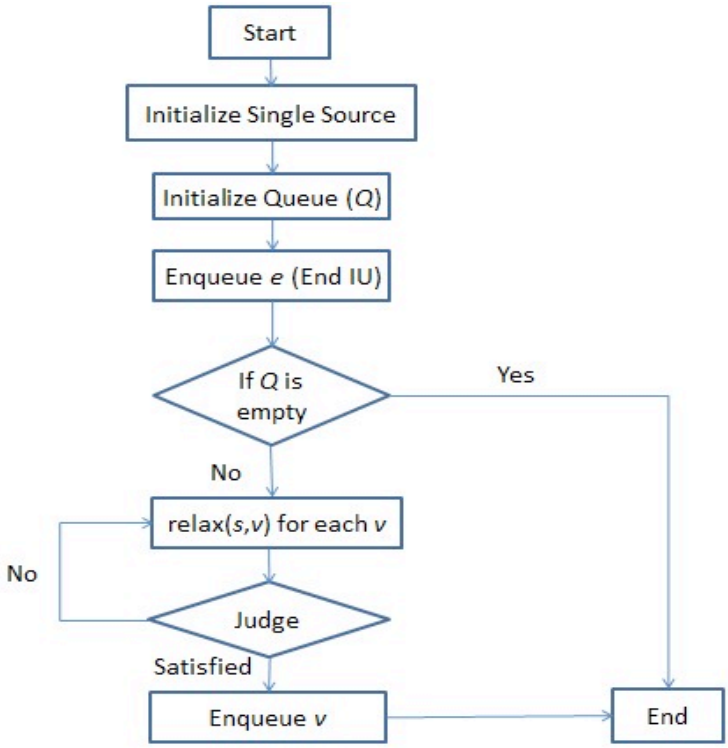

Fig. 4. The flowchart of SPFA

How to implement anticipatory optimization. To deliver dynamic traffic route guidance services, DDRGS must be able to predict the traffic conditions in the near

future, as these predictions can help reducing congestions. Such a guidance system is called "anticipatory", as interpreted by Rosen [33].

DDRGS implements anticipatory optimization in the following way. First, according to the route guidance requests for the vehicles in the overall traffic environment, it will provide a basic route guidance recommendation. By means of the information fed back from the End IU and all the previous IUs in the optimal route, all involved intermediate IUs will receive the expected departure time of the vehicles that submit the requests. Then according to the through time at the series of intersections and sections of roads, retrievable from intersection routing tables, the expected arrival time of vehicles at each intersection can be inferred for the relevant IUs. Then, by aggregating the number of the arriving vehicles at each intersection in different future time period, the expected waiting time for vehicles in different directions of each intersection can be inferred. To improve the accuracy of future through time at each intersection, we can use the errors between presently forecasted situation and the actual situation to correct the predicted through time for future arriving vehicles.

Because of the uncertainty of the travel time for a vehicle in a route, the above estimate of the expected through time at each intersection may not be accurate enough. In the simplified context, we can assume the arrival of vehicles in an intersection is a Poisson process. Then the time series of the previously predicted and current actual though time at each interaction can be applied to improve the prediction accuracy of the future through time at the intersection.

To make the above feature more feasible, we introduce the Kalman filter algorithm to improve traffic flow prediction. The Kalman filter, also known as linear quadratic estimation (LQE), is an algorithm that uses a series of measurements observed over time, containing noise (random variations) and other inaccuracies to produce estimates of unknown variables that could be more precise than those based on a single measurement alone [34].

Specific steps are as follows: the first step – prediction, the Kalman filter produces estimates of the current state variables, using estimates of the previous state; the second step – update, the Kalman filter uses the observed value of the current state variables to optimize the estimates obtained in the prediction step, in order to obtain a more accurate estimated value. From a theoretical standpoint, the essence of the Kalman filter is the recursive nature, so the algorithm can run in real time using only the present input measurements and the previously calculated state, without additional past information.

Considering a general linear dynamic system:

$$\begin{cases} x_{k+1} = Fx_k + Bu_k + w_k \\ z_{k+1} = Hx_{k+1} + v_{k+1} \end{cases} \quad (2)$$

Where x_k denotes the system state vector, representing the theoretical travel time of the VU from the Start IU to the k^{th} IU; z_k is the measurement vector, denoting the actual travel time of the VUs from the Start IU to the k^{th} IU; and u_k is the travel time of the VU from arriving at the k^{th} IU to the $(k+1)^{th}$ IU. In this paper, we

consider F, B, and H as the identity matrices of E. The state transition process noise w_k and measurement noise v_{k+1} are assumed to be independent of each other. The covariance of the process noise is Q, and the covariance of measurement noise is R.

Prediction:

$$\begin{cases} \hat{x}_k^- = F_k \hat{x}_{k-1} + B_k u_{k-1} \\ P_k^- = F_k P_k {F_k}^T + Q \end{cases} \tag{3}$$

Update:

$$\begin{cases} \hat{x}_k = \hat{x}_k^- + K_k(z_k - H\hat{x}_k^-) \\ P_k = (I - K_k H_k) P_k^- \end{cases} \tag{4}$$

Where $\hat{x}_k^-$ is an a priori state estimate of the travel time x_k from Start IU to the k^{th} IU; $\hat{x}_k$ is an a posteriori state estimate of x_k given the measurement z_k; K_k is the gain matrix, and

$$K_k = \frac{P_k^- H_k^T}{H_k P_k^- H_k^T + R} \tag{5}$$

In conclusion, we can use the modified recursive formulas to predict the vehicle arrival time of each intersection, and further aggregate all the time information on basis of all the vehicles requesting routing service in DDRGS, in order to calculate the traffic flow of each intersection at different times. Hence, by estimating the vehicle waiting time of each intersection, DDRGS can achieve the traffic flow anticipatory optimization.

How to implement the pushing services for vehicles according to any changed conditions in the route. DDRGS must be able to actively send the updated route guidance notices to vehicles in accordance with traffic condition changes, such as a congestion-causing incident, or more or less passing time in an intersection, both of which may affect the optimality of the route calculated by End IUs. When a vehicle is traveling following an optimal route recommendation from DDRGS, if a change (such as the congestion, accident, disaster, etc.) takes place in some point (such as some intersection or road) of the recommended route, the End IU servicing the VU will recalculate the route, produce a notification message including the prediction of the current passing time or "not available to pass", and push the up-to-the-minute traffic conditions with the new route guidance to the VU. The VU will decide whether to adopt the new route recommendation or not. If the VU does not want a new recommendation, the VU can choose to ignore this pushing notification and continue

to travel according to the original recommendation. In the process, the VU can also send a new routing request at any time, according to its specific travel practice.

3.4 Notes on the Computational Complexity

It is of no doubt that the computational complexity of DDRGS is superior to a normal centralized vehicle route guidance system. As there is little information about the improvement, it is worth estimating how much the performance has been improved. The major improvement of DDRGS compared to a centralized system is in the reduction of computational dimensions.

Assuming that there are N travelling vehicles in the traffic environment, in a centralized system, the routes for all vehicles must be considered simultaneously in a mathematic model. Assuming that routing service requests arrives at an IU in a Poisson process, the IU only needs to handle one routing service at each moment. The reduction of vehicle dimension can lower the system overhead significantly. Therefore, a single IU should be capable of handling its local computational tasks without major problem.

A centralized system tends to work out a seemingly optimized global solution, which takes into account all intersections and sections of roads, while DDRGS only considers a subset of intersections and sections of roads in a routing service request. In a classical integer programming model the complexity of the model is NP-complete. In another aspect, according to Duan, the time complexity of SPFA algorithm is $O(E)$, where E is the number of edges in the graph [32]. Therefore, the time complexity of DDRGS's algorithm is linear.

The interactions among different routes, which affect the throughput time at each intersection or each road, can be very complicated in centralized system for the optimization solution. Whereas, DDRGS updates the affected traffic conditions in intersections and roads sequentially in accordance with the computing results from each route guidance request, provided that the request arrival is a Poisson process. Since the vehicle route optimization problem in DDRGS is solved in such a sequential manner with regard to the arrivals of routing guidance requests, the future traffic conditions at each intersection or road are then predicted according to the traffic route schedules for VUs' requests. In this way, the complexity of the problem can be reduced because of scattering the problem into smaller pieces along a certain time interval.

4 Summary

In this paper, we adopt a distributed computing method based on MapReduce to fulfill the task of calculating the optimal vehicle routes for vehicles and predicting traffic flow in the short-term future. In terms of decentralization, our system can effectively reduce overall processing time and computing amount, and computing requirement on the processors. According to accumulated routing recommendations in IUs, the number of the arriving vehicles in each intersection can perform as prediction to coordinate the routing results in the next period. In addition, push notification service when emergencies take place can help vehicles quickly detect and respond the traffic

changes during travelling. Therefore, DDRGS is able to achieve providing dynamic vehicle routing services with anticipatory optimization and push notification services on traffic emergencies.

There are a few limitations in DDRGS, which can be improved in the future research. The most critical one is the assumption of sharing information among IUs. This makes the optimization much easier. Actually, we can assume the information of local traffic conditions is not publicly accessible because of the costs to send and update the information in a centralized database. Letting each IU maintain a local database matched the philosophy of MapReduce better. Further implementation is to be explored in the next research stage.

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Understanding Web Portal Navigation with Markov Chains and Spreading Activation Networks

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Abstract. The study takes a new approach at analyzing web portal navigation patterns by combining two theories from distinct research areas towards achieving a higher practical relevance. Markov chain models are used to provide the statistical foundation for the analysis, which is augmented by the spreading activation theory of psychology for a better understanding of the cognitive processes of the users. Bringing in qualitative information about the Markovian states helps understanding the mechanics behind the navigation.

Keywords: Markov chains, spreading-activation theory, semantic processing, web navigation, price comparison portal

1 Introduction

Web navigation pattern analysis is a hot topic in the industry. Prominent examples like Amazon's "Users who bought x, also bought y" or Netflix' Movie Recommender System, show how understanding the user and aiding his/her quest for information can bring a significant increase in quality, popularity and ultimately revenue, for an online platform.

In this study, we embark on an analysis of the navigation logs of a price comparison platform. The platform compares prices of services such as Health Insurance, Mortgage, Car Leasing, Tax, Rent etc. Examining the logs of tenths of thousand of users, we take a cross-disciplinary approach at explaining the reasoning behind the user navigation pattern. Specifically we combine two approaches coming from two distinct research areas: Markov chain from quantitative research area and spreading activation theory from cognitive psychology research area. We argue that the synergy of the two methods helps us to better understand the user navigation patterns.

The navigation log data contains transition events generated by users who change the type of services they wish to compare the prices for. We first utilize the 1st order Markov chain model and compute the transition probability matrix for the transition between any two states (in this case, any two price-comparison webpages). The result

[1] A special thanks to Mona Weiss (monaweiss@ethz.ch) for her input on the spreading-activation theory of semantic processing.

highlights the service types (called categories in the rest of the paper) that are often visited together by the same user. The result also reveals the ordinal relationship between the states. When applying the 2nd order Markov chain model, we find more evidences that users did not necessarily show preference for a certain order when visiting categories, but rather showed preferences for groups of categories. This behavior can be explained by the spreading-activation theory of semantic processing, which states that upon activating a certain concept in the brain, other concepts related to the activated one will also get activated to a certain extent. This would explain why when people compare the price of a car, they will also compare the price of the insurance for that car.

This paper is structured as follows: Section 2 discusses previous works on Markov chain and spreading activation theory and proposes the connecting link between them, Section 3 presents the dataset, the research methodology and briefly introduces the results, which will be discussed in Section 4, together with suggested future research on this novel yet important topic.

2 Related Work

The analysis of web navigation patterns, especially towards link prediction, has recently received much attention from researchers due to its high practical importance. Using the concept of link prediction, Ramesh [1] highlighted several alternatives for browsing the web: agent-assisted navigation, website-tour generation and web hub/authority identification. He further claimed that all these alternatives share a common approach of creating a probabilistic user navigation model using a discrete Markov chain model.

A discrete Markov chain is a stochastic process through which a discrete system can transition randomly from one state to the other [2]. By empirically observing the system, a transition probability matrix is created which estimates the probability of transition between each two states. Depending on the order of a Markov chain, the transition probability of the current state depends on one or more previous states, i.e. Markov chain of the first order depends on one previous state, Markov chain of a second order depends on two previous states etc. [2]. Ramesh [1] provides a good introduction to the mathematical fundamentals of the Markov chain models.

Because of the conceptual similarity between Markov chain transitions and web navigation steps, Markov chains is a natural choice for modeling web navigation patterns [3]. Li and Tian [4] validated the memory-less property of Markov chains on two data sets of web navigation; thereby confirming the rationality of using Markov chain models as usage model in statistical testing and quality assurance of web navigation modeling. Other researchers used variations of the classic Markov chain model in order to model user web data. For example, Deshpande and Karypis [5] built k^{th}-order Markov models and included the highest possible order model to cover each state; whereas Eirinaki et al. [6] provided web path recommendations by integrating a page ranking scale into a Markov model.

Modeling the transition probability between states using a Markov model enables a better understanding, and most importantly an accurate prediction, of user web

navigation patterns. Applying this analysis to a web portal opens the way for displaying personalized cross-site advertisements and links. However, being a purely statistical representation of the observed web navigation paths, it cannot explain *the reason* why a user chooses a certain path. Nor can it argue *whether* and *why* the order of the transitions is of any importance. To achieve this, we combine *Markov model* and *spreading-activation theory of semantic processing* to understand how a statistical relationship between two states is modelled in the user perception of those two states.

The spreading-activation theory of semantic processing, developed by Collins and Loftus [7] is an extension of the theory of semantic memory [8], which discusses how the relationship between two concepts is matched in the brain. The theory of semantic memory is similar to an algorithm running on a computer and makes the following assumptions about how the human static memory is structured and processing information. The memory is structured in concepts and connections between the concepts. A concept is usually a word or a series of words or a phrase; examples of concepts are "a car", "a car I own", "driving a car" and even "what to do if you see a red light" [7]. A concept can be visualized as a node in a network of concepts, while the edges of the network represents (usually bi-) directional pointers between concepts. The search in the memory happens by activating two initial search terms (nodes). Starting from these two nodes, the other nodes are activated in parallel, and the activation signal is transmitted along the edges of the graph from one node to all its neighbors. This mechanism repeats until the same node is reached by both activation signals coming from the two distinct search terms (initially activated nodes) [7]. If the found path is evaluated as valid (according to rules described in Quillian [9]), it represents the relationship between the two initial concepts.

Since the theory of semantic memory was designed to be simulated on a computer, it comes with some limitations, mainly regarding the non-variable strength of an edge (of a connection between two concepts) [7]. The spreading-activation theory of semantic processing extend the initial theory by introducing four local processing assumptions and eight global assumptions about memory structure and processing, which bring a finer grain in how broadcast activation happens while prioritizing stronger existing paths [7]. The concept of spreading activation has been used in models for letter processing [10], speech production [11], and memory and problem solving [12]. It is also central to the adaptive control of thought model [12].

Roelofs [13] introduced the spreading-activation theory of lemma retrieval in speech and presented a process of lexical items retrieval governed by the same concept of spreading-activation, like in the original memory setup. Crestani [14] reviewed the use of spreading activation models to explain associative information retrieval; proving it to be a relevant tool in associative information retrieval research. Vinogradov et al. [15] presented a very interesting explanation for the formation of paranoid processes involving spreading-activation models. They claimed that temporary neighboring concepts create cognitive associations, which need to be explained and given a meaning. The erroneous explanation (cognitive association) is then learned and becomes permanent; thus becoming a delusion. All these studies show that spreading-activation accounts not only for the creation and strengthening of concept associations at cognitive level, but also for information retrieval and interpretation. A study on false memories [16] showed how the activation of a non-

present concept can be achieved due to the activation of a high number of related concepts. Using Deese-Roediger-McDermott paradigm, the experiment showed that the activation of the following concepts: bed, rest, awake, tired, dream, wake, snooze, blanket, doze, slumber, snore, nap, peace, yawn and drowsy – increase the false recognition of the word 'sleep' among the list of words [16].

To summarize, spreading-activation theory of semantic processing can provide a cognitive explanation of what the Markov chains are pointing out in a probabilistic manner. If for example, there is a statistically significant path from a state A to a state B, it means the user perceives the two states to be closely related concepts and so, they are activated simultaneously in the brain. As a deduction there should also be a statistically significant path from B to A. Further, we can group the two *states* (A and B) into a group of *concepts* that are related to each other in terms of user perception.

3 Conceptual Framework and Analysis

In order to explore the relationship between the Markov chain's modeled transitions and the cognitive relationship between the concepts, we will use logged user transitions in a web portal. After building the Markov transition probability matrix for all combinations of two states, we plot the transition graph. The transition graph is made of *nodes* that represent the different states of navigation (e.g. A and B) and *edges* that state the probability of transition between the respective nodes (e.g. from A to B). After plotting the graph, the edges with small probability are dropped such that we can identify highly interconnected nodes more easy. We adjust the probability threshold such that we can identify several relatively small sized groups of interconnected nodes. Next, considering only nodes and transitions with the highest transition probability, we compute the 1st and 2nd order Markov chain transition probability for these nodes and show that most of the transitions are bi-directional, which aligns to the previously introduced spreading-activation theory of semantic processing. The obtained information is used to better explain the users' navigation behavior and to personalize the navigation experience similar to a collaborative-item-based recommender system, e.g. Amazon's "User's who bought x, also bought y" [17]. However, the construction of a recommender system is out of the scope of this paper.

The dataset is based on a popular price comparison portal. The portal is split into 22 categories (see Table 3), each comparing one type of service, for example: Health Insurance, Mortgage, Car Leasing, Tax, Rent etc. The dataset contains transition logs of all users visiting the portal over a period of three months, from the 1st of January 2012 until the 1st of April 2012. Each log entry represents a transition between two of the categories of the portal (e.g. after comparing Mortgage, a user proceed to comparing Car Leasing), and the session in which this transition was made. A session represents one particular visit of a certain user to the platform - all actions performed in that visit are considered to belong to one and the same session. Table 1 lists statistics about the dataset. Table 2 provides aggregated demographic data, however a note should be made that not all users have answered all demographic questions. The column "Response Rate" shows what percentage of the population size has provided

data for the respective statistic. The demographic data was provided by users as part of their input, when this data was needed for price comparisons (e.g. a car insurance calculator requests the age of the driver).

Table 1. Dataset Statistics

Property	Value
Number of transition log entries	208,963
Number of users	79,049
With only one session	63,375
With only one transition	38,975
Number of sessions	111,009
Average session length in minutes	15.43

Table 2. User Demographic Data

Property	Value	Response Rate
Average (Median) Age	39 (36)	73%
% Male (vs Female)	64%	8.2%
% Married (vs Single, Divorced, or Widowed)	42%	8.7%
% Rural Population (vs Urban)	42%	72%

Using Markov chain model, we computed an estimation of the transition probability matrix for all combinations of 22 possible states. Appendix 1 lists the probability matrix. The probability matrix was translated into a graph where nodes represent the different categories and the bi-directional edges represent the transition probability among the nodes. In order to find the appropriate truncation for the transition probability, we represented and analyzed the graph for the following probability truncation values: 0.1, 0.15, 0.2, 0.25 and 0.3. Based on the sparseness of sub-graphs and the average size of the sub-graphs, we chose 0.25 as the ideal truncation value for the transition probability. Figure 1 depicts the graph for truncation value 0.25.

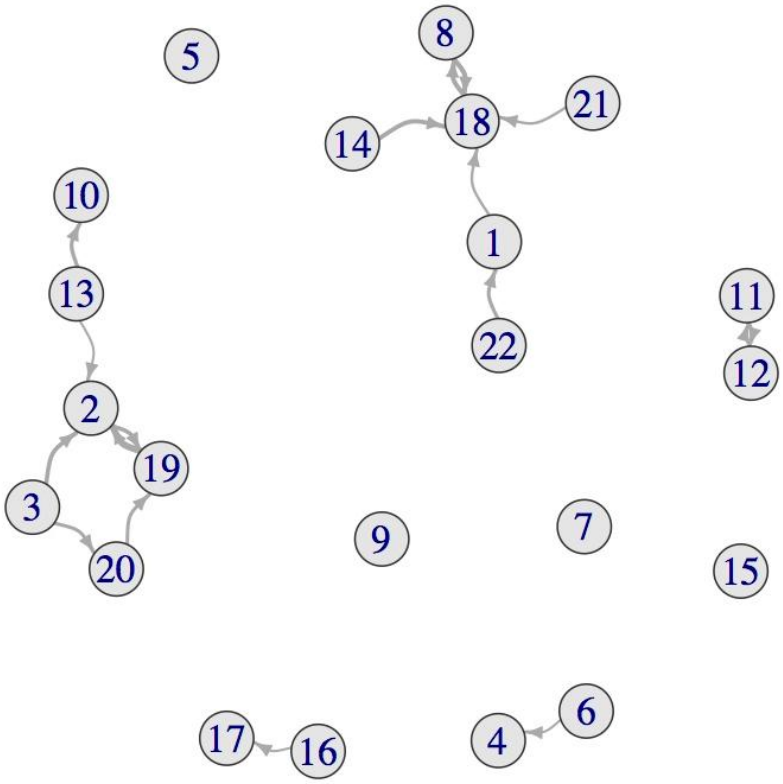

Fig 1. 1st order Markov chain transition probability graph between the states of the web portal. The edges of the graph were truncated at transition probability 0.25

Using the generated transition matrix, the limiting transition probability matrix for the 1st order Markov chain was computed. The limiting transition probability shows the probability of a user being in a certain node, and is computed for each node by applying the transition matrix repetitively, allowing users to 'move' within the graph according to the probabilities of the transition matrix. The limiting transition matrix is complete when the percentage of users in a node remains constant despite re-applying the transition matrix. Table 3 lists the probability of users ending up in any of the 22 categories given by the 1st order of Markov chain model. The probability presented in Table 3 was normalized to sum up to 1. Appendix 2 shows a graph representation of the limiting transition probabilities (and essentially shows how, after applying the transition matrix sufficiently enough times, users will end up being in the central nodes and not in the periphery nodes).

Table 3. Limiting Transition Probability Matrix for 1st Order Markov Chain Model

Number	Category	Limiting Transition Probability
1	Health Insurance	0.06
2	Car Insurance	0.15
3	Motorbike Insurance	0.00
4	Household Insurance	0.04
5	Life Insurance	0.00
6	Legal Protection Insurance	0.01
7	Travel Insurance	0.01
8	Mortgages	0.10
9	Credit Cards	0.03
10	Consumer Credits	0.04
11	Pillar 3a	0.05
12	Interests and Investments	0.05
13	Car Leasing	0.03
14	Tax Comparison	0.02
15	Tax Comparison Foreigners	0.01
16	Mobile	0.02
17	ADSL	0.03
18	Property	0.16
19	Car Finder	0.14
20	Motorbike Finder	0.02
21	Retail	0.02
22	Immigration	0.01

Observing the most prominent categories and transitions depicted in Figure 1, we chose the pair-categories (2,19), (8,18) and (11,12) for closer inspection. We can already observe how for categories 2 and 19, both the direct path and the reciprocal have high probability (see Figure 1 and the table in Appendix 1). We can thus assume that categories 2 and 19 (Car Insurance and Car Finder) both represent nearby concepts in the brain, as explained by the spreading-activation theory of semantic processing, i.e. when a user enquires the price of a car, (s)he desires to know the price of the insurance for the respective car as well. This becomes even more evident for all groups when we plot the 2nd order transition probability in Figure 3, meaning we analyze two consecutive transitions of the same user. The graph in Figure 3 is read like this: 37% of users that are in category 8 go to category 18 in their first step, and 70% of them go back to 8 in their second step. Note that the dataset used to generate Figure 3 is a subset of the one used to generate Figure 2. The reason is that for Figure 2 all jumps of all users are taken into consideration, while for Figure 3 only those users are taken into consideration that do at least 2 consecutive jumps.

Just like categories 2 and 9 (Car Insurance and Car Finder) are related, we see how categories 11 and 12 (Pillar 3a and Interests and Investments) are also related on a psychological concept level. Both concepts are related to investments of surplus earnings, one into a pension fund and the other one into a saving account, and represent similar concepts in the brain. Categories 18 and 8 (Mortgages and Property) are also related concepts; when thinking about a property acquisition (also a type of

investment) people tend to compare ways of financing the investment. The other way around, when having an attractive financing offer, people tend to compare property investment alternatives.

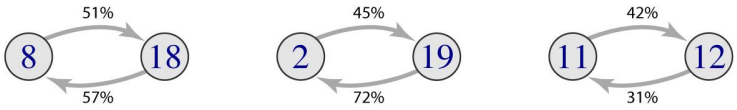

Fig 2. 1st order transition probability for prominent categories

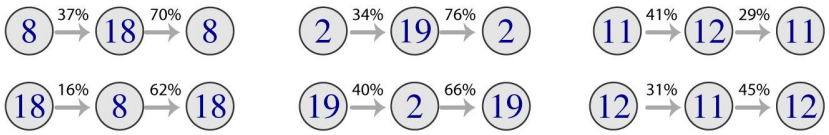

Fig 3. 2nd order transition probability for prominent categories

To sum up, the statistical analysis with Markov chain models has identified groups of statistically highly interconnected states. Recalling the notion of connections between related concepts in the brain, as highlighted by the spreading-activation theory of semantic processing, one explanation for the interconnection is that the activation of the corresponding concepts in the brain happened simultaneously. The implications of this finding are discussed below.

4 Discussion and Research Opportunities

The current study uses 1st and 2nd order Markov chain models, which implicitly contain ordinal information about the transitions. Despite Markov chains being a popular choice for web navigation data analysis, some studies have successfully applied other methods for modeling web navigation behavior, especially at predicting a buy on e-commerce sites. Moe and Fader [18] propose a model of conversion behavior that predicts each visitor's probability of purchase, by computing a purchase threshold based on weighted visit and purchase history events. Park and Fader [19] use a stochastic timing model to analyze a users' navigation on more than one website, being able to combine the information from all observed websites into better activity forecasts for each site. In their analysis they combine two sources of data: arrival times at the website and visit propensities across competing websites. Bucklin

and Sismeiro [20] propose a different portal navigation model based on the clickstream of users and on the information they are presented with. The modeling is done by splitting the user activity into distinct 'tasks', the prediction being based on binary (yes/no) completion of the tasks in a certain sequence. These studies show how different probabilistic models can also provide good estimates for web navigation models.

In our approach we take a cross-disciplinary view at understanding what motivates the people to traverse between different categories by using cognitive psychology theories. Using 1st and 2nd order Markov chain models, isolated groups of categories are identified, which are accessed by users in the same session. The spreading-activation theory of semantic processing provides an explanation for this behavior by stating that concepts that are perceived to be similar by the brain are activated at the same time in the brain. For researchers, these findings provide a theoretical reasoning for cases where the Markov chain model does not provide clear start-to-finish transitions through all states but build transition cycles and groups of highly interconnected states.

From a practitioner's point of view, this study shades a new light on findings obtained by purely quantitative methods like the Markov chain models. Similar studies exploring web navigation data sets rely on the help of Markov chain models or derivatives thereof (e.g. [4], [5] or [6]) to model a transition sequence between different categories of a web portal or of different websites. In our approach we argue that the transition through states can also be explained by cognitive processes triggered in the brain and not only by statistical approaches. After having used Markov chain models to identify statistical relationships between certain pairs of states at *population* level, we can use this information to make transition predictions at *individual* level. As an example, if states A and B represent highly connected concepts, a user will want to visit B after visiting A. If (s)he fails to do so, this could signal for example a design error, which doesn't allow her/him to find the path from A to B.

Furthermore, similar portals can profit from the identified relationship between car insurance and car acquisition, interest investments and pension funds, and mortgage calculation and property acquisition.

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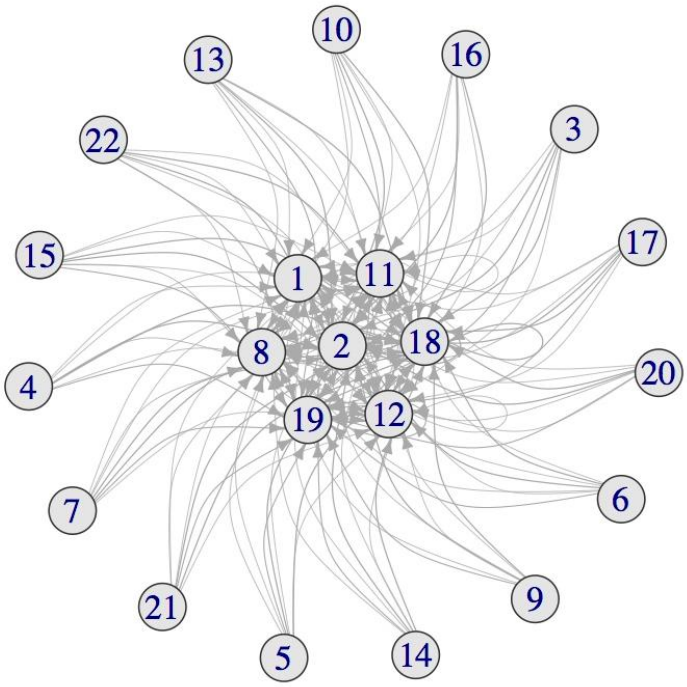
Appendix 1: Transition Probability Matrix

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Health Insurance	1	0.00	0.09	0.00	0.09	0.01	0.02	0.01	0.03	0.02	0.01	0.06	0.02	0.01	0.04	0.02	0.05	0.05	0.30	0.11	0.01	0.02	0.06
Car Insurance	2	0.06	0.00	0.00	0.05	0.00	0.01	0.00	0.01	0.01	0.08	0.02	0.01	0.07	0.01	0.00	0.02	0.02	0.11	0.45	0.04	0.01	0.01
Motorbike Insurance	3	0.04	0.46	0.00	0.02	0.00	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.03	0.03	0.38	0.00	0.01
Household Insurance	4	0.13	0.11	0.00	0.00	0.02	0.10	0.03	0.02	0.02	0.01	0.04	0.03	0.01	0.02	0.01	0.04	0.08	0.20	0.07	0.01	0.03	0.02
Life Insurance	5	0.10	0.04	0.00	0.08	0.00	0.05	0.02	0.02	0.02	0.00	0.17	0.05	0.01	0.02	0.02	0.01	0.01	0.25	0.03	0.00	0.03	0.08
Legal Protection Insurance	6	0.09	0.18	0.00	0.27	0.03	0.00	0.05	0.01	0.02	0.03	0.03	0.02	0.01	0.02	0.01	0.03	0.02	0.08	0.06	0.01	0.02	0.02
Travel Insurance	7	0.14	0.08	0.00	0.11	0.02	0.12	0.00	0.03	0.18	0.01	0.10	0.03	0.01	0.01	0.02	0.02	0.01	0.05	0.03	0.01	0.02	0.01
Mortgages	8	0.05	0.03	0.00	0.02	0.00	0.01	0.01	0.00	0.01	0.04	0.06	0.07	0.01	0.02	0.00	0.01	0.02	0.51	0.10	0.01	0.02	0.00
Credit Cards	9	0.05	0.02	0.00	0.01	0.00	0.01	0.01	0.04	0.00	0.19	0.14	0.20	0.03	0.03	0.01	0.04	0.05	0.08	0.04	0.00	0.02	0.01
Consumer Credits	10	0.04	0.12	0.00	0.01	0.00	0.01	0.00	0.05	0.14	0.00	0.05	0.15	0.14	0.03	0.01	0.02	0.02	0.09	0.11	0.01	0.01	0.00
Pillar 3a	11	0.05	0.02	0.00	0.02	0.01	0.01	0.00	0.04	0.10	0.02	0.00	0.42	0.02	0.04	0.02	0.02	0.04	0.09	0.04	0.01	0.02	0.01
Interests And Investments	12	0.04	0.02	0.00	0.02	0.01	0.01	0.01	0.07	0.11	0.04	0.31	0.00	0.01	0.04	0.02	0.04	0.04	0.14	0.05	0.01	0.02	0.01
Car Leasing	13	0.01	0.26	0.00	0.01	0.00	0.00	0.00	0.01	0.01	0.43	0.01	0.02	0.00	0.02	0.01	0.01	0.01	0.03	0.16	0.01	0.01	0.00
Tax Comparison	14	0.10	0.02	0.00	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.14	0.02	0.01	0.00	0.11	0.01	0.02	0.49	0.03	0.00	0.01	0.01
Withholding Tax Comparison	15	0.14	0.02	0.00	0.02	0.00	0.00	0.00	0.01	0.01	0.01	0.09	0.02	0.01	0.18	0.00	0.02	0.02	0.21	0.04	0.01	0.01	0.18
Mobile	16	0.07	0.03	0.00	0.09	0.00	0.01	0.00	0.01	0.03	0.01	0.10	0.02	0.01	0.02	0.01	0.00	0.26	0.18	0.09	0.01	0.04	0.02
ADSL	17	0.24	0.15	0.00	0.03	0.00	0.01	0.00	0.01	0.02	0.01	0.02	0.02	0.02	0.02	0.01	0.18	0.00	0.15	0.06	0.00	0.04	0.02
Property	18	0.06	0.02	0.00	0.08	0.00	0.00	0.00	0.51	0.01	0.01	0.01	0.01	0.00	0.03	0.01	0.01	0.02	0.00	0.17	0.01	0.03	0.01
Car Finder	19	0.01	0.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.02	0.00	0.00	0.01	0.01	0.14	0.00	0.04	0.01	0.00
Motorbike Finder	20	0.02	0.25	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.14	0.01	0.00	0.01	0.00	0.00	0.00	0.01	0.14	0.37	0.00	0.02	0.00
Retail	21	0.07	0.03	0.00	0.02	0.00	0.01	0.01	0.02	0.02	0.02	0.04	0.04	0.01	0.02	0.01	0.05	0.07	0.29	0.19	0.03	0.00	0.04
Immigration	22	0.41	0.19	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.07	0.02	0.01	0.12	0.02	0.00	0.01	0.00

Appendix 2: Limiting Probability Transition Graph



Establishing A Bi-directional Personal Healthcare Record Service with NFC Technology

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Abstract. Personal Health Record (PHR) includes information provided by the patients, physicians, and other medical health care providers. It is used to manage individual medical record and other related medical health care information. By using an electronic PHR management program, the patient can self-monitor any changes in their physical condition and healthcare institution can save paper comsumption, and improve efficiency of outpatient clinic process. Thus, in order to construct a refined PHR, interface integration, alternation, promotion of medical health information management and applications, and emphasis a secure channel to attain private information are required.

The purpose of this study is to provide a secure channel by using Near Field Communication (NFC) to achieve a portable individual health record that can be transmitted via a platform service mode. It can provide users to gather their health information for further disease prevention.

Keywords: Personal Health Care Record, Telecare, Near Field Communication.

1 Introduction

With the advances in medical technology, the rate of the elderly populations around the world has significantly increased due to the extension of life expectancy. The data of UN Population Division showed that Taiwan will reach the standard of Super Aged Society in the year 2026, and elderly people ages over 65 years will account for more than 20% of the population, as well as decrease in population growth rate.

With the advent of super aged society, the aging populations will progressively and widely impact our society. The changes of the population structure willbring problems in public healthcare, mental health, long-term care, economic safety, constitutional policies, etc.. Healthcare programs usually focus mainly on emergency treatment, then progress to chronic diseases, and then as the frequency of chronic diseases gradually increases, medical expenses continues to rise. Therefore, how to achieve the effect of early detection, preventionand reduce the medical expenditure becomes an important issue globally.

Common elderly disease includes hypertension, diabetes, heart failure and other chronic diseases. However, proper care for patients with chronic diseases is significantly inadequate due to inappropriate medical transfer plan and lack of long-term health monitoring program.Meanwhile, modern medical facilities and health care plans can only supply treatment for acute diseases.

In 1987, Kaplan and Seeman [1] pointed out the main cause leading to chronic diseases is from personal behavior. If an individual can promote health care activities,he/she can reduce the incidence of diseases and death, therefore, it is important to have patients with chronic diseases partake in measuring their own physiological parameters at home in order to improve their health concepts. Base on this purpose, many countries around the world uses information technology to develop an application for telecare systems.

According to the practice of telecare from Japan, long-term self-monitoring health data can remind elderly patients to focus on their own physiological health [2]. Related functions include self-monitoring physiological status, abnormal diet warnings, everyday medication reminder, health e-learning education, remote video and medical consultations, and so on. The purpose of these functions is to enable users to be aware of their health records and increase their concepts of health support through self-measuring physiological data, in order to prevent the occurrence of diseases and further reduce medical costs. Therefore, it is important for elderly people to monitor their own health information, which not only can reduce the medical costs, but also can enhance their life quality. If the telecare system can be applied in the long-term care institution, it can also reduce the load of institutional care labor, ease the anxiety of elderly people who lives alone, and promote a safe environment for the elderly [3].

There has been numerous of experimental projects or products that provide hospitals to implement the management of chronic diseases via remotely monitoring the patients' physiological signs and diet changes. The data are then uploaded to the back-end platform of the hospital for follow-up processing that is conducted by a healthcare crew. Since these services are mostly provided by the hospitals, patients are still unable to grasp their own health conditions, thus would need to rely on the hospital for health care. Such care models are unable to meet the public demands for further diseases prevention, and failed the initial purpose of self-care.

According to a research done by the MARKLE Foundation, patients with chronic diseases, frequent doctor visits, or care providers for the elderly are extremely interested in understanding the electronic Personal Healthcare Records (PHR). With the volume of annual clinic visit, the public interests of PHR have risen to 71% from 57%. Moreover, patients with chronic diseases and non-chronic diseases of wanting to immediately own or use the PHRs are 65% and 58% respectively [4]. Conventionally, patient uses paper or any document software to record their own living habits, physiological values, medication, medical records, etc., and manage their own health. There are many inconveniences in this conventional data management and maintenance. Proper care for patients with chronic diseases needs to accommodate with the patients' self-health management, by improving patient’s living habits in order to reach the purpose of improving the patients' health sta.

Therefore, it is essential and important to have patients with chronic diseases to fully understand their self-health statuses through PHRs [5].

PHRs store the public lifelong health information electronically, complete medical treatment information, and automatically maintain their personal health record, and interact with the healthcare providers [6]. PHR is a very important basic information for the personal health management, however, most of its applications adopt from the Institution-Centered-to-Patient-Centered service framework model, and the service conventions proposed by various health consultation companies still adopt their own ways to retrieve and store the health information provided by individuals, and these information are stored in the health consultation companies or the hospitals' repository center. Therefore, will encounter problems such as personal data leakage, and if an individual wants to change to a different health consultation company or provide their information to other companies, they often fail to obtain past personal health records due to the restrictions from former companies. In addition, current personal health consultations data, telecare, and previous diagnosis in the healthcare information system (HIS) may not exist in the same healthcare institutions, making the former PHRs not portable, and significantly limit its original broader and more advanced applications.

This study hope to establish a framework based on the existing tele-data monitoring model, and provide a closed service framework based on the Near Field Communication (NFC) safety mechanism, thus in order to achieve a portable platform to transfer personal health records. Participants can store their personal health records and data from the simulated HIS platform under this framework, and create a self-tracking health management profile project through the framework provided by the client shell service interface. Feedbacks from the consultants division using the shell application system, integrate seamlessly with the end division analytic tools or medical information system, thus provide more accurate medical advices to the participants, and further become a part of personal health records, so as to early preventions and effectively apply the works related to the preventive medicine.

2 Related work

2.1 Definition of Telecare

The definition of Telecare varies with the developmental goals from different countries. Generally, it refers to a healthcare crew who uses telecommunication and computer technology to come across a certain distance in order to provide healthcare or social service for the patient living in remote area, in communities and institutions [7,8].

2.2 Telecare Development Experience in Taiwan

Telecare in Taiwan are at incubation stage and is developed from the hospitals to perform remote health care service. Remote health care service in Taiwan is divided

to three types, the community-based primary care, the home-based primary care, and the institution-based primary care. Community-based primary care generally uses a various types of community resources and collaborates with professional health care and local services. Such health care method mainly discover health problems through health survey questionnaire, targeting those that needed health care service, providing active care from health care personnel, and evaluate which types of health care they needed, in order to object an appropriate service or assist referral to another health care system.

The concept of institution-based primary care is integrated from cross-medical specialty, and the cross-professional medical care service team. Connecting the medical institution via the internet system, by collecting and analyzing residents' physiology signs (such as blood pressure, pulse rate, body temperature, and SpO2), can help medical physicians diagnose patients disease during clinical examination. At the same time, it can target and alert individual health irregularities, prevent and decrease diagnostic misconception, reduce readmission rate, achieve an institution-based primary long-term care, and personalize the purpose of health management information service.

In order to achieve a better quality for the remote health care service, Taiwan has developed innumerable related informative technology program, such as the "Senior Citizen U-Care Flagship Plan." This plan works with the security company and medical institutions, managing health-care service center via a service website, with instantaneous monitoring senior citizen living condition, and providing a variety of health-care service. The University Chung-Ho Memorial Hospital uses remote health care technology to monitor patients with chronic illnesses, such as high-blood pressure, diabetics, and stroke. Changhua Christian Hospital collaborated with Taidoc Technology Corporation using remote system to coordinate with the hospital to control and collect blood sugar level and condition in patients with diabetes. The Chang Gun Health and Culture Village provide a holistic care service innovation system. All of their intention is to increase life expectancy, and also provide a quality of life-care. However, these applications are limited, patients do not have access to their own health information, thus it is difficult to change lifestyle and improve their health situation.

2.3 NFC

This study proposes a safer NFC technique to transmit and download the personal health information based on the PHR's need. NFC is also called the short-range wireless communication, and it is a technique which adheres to the standard short-range wireless connections of ISO/IEC 18092 and ISO/IEC 21481 [11]. It allows the electronic equipment to perform the non-contact data communication and transaction, and access the digital content and connect with other NFC devices within the 10-centimeters distance.

The devices that support NFC, can exchange the data under the active or passive model. Under the active model, while a device sends data to another device, it must produce its RF-field as shown in the Fig. 1. Both initiator device and target device

must have their own RF-field to conduct communications. This is the standard model of reciprocal internet communications, and can connect to the devices quickly.

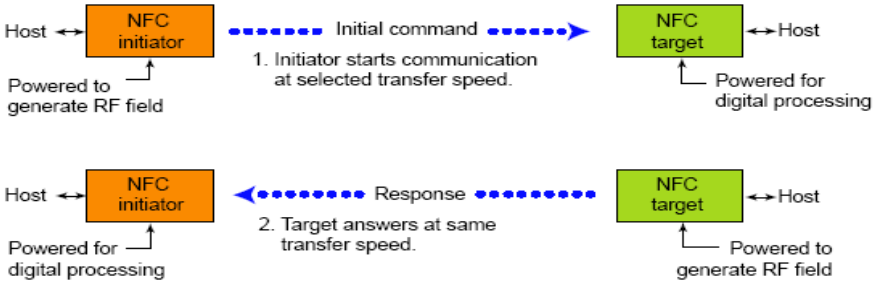

Fig. 1. Active model operation in NFC.

3 Method

A small paper pamphlet was primarily used to record personal health record by the patient him/herself. The health care provider then can utilize this information to carry out a long-term follow-up and arrange for a treatment, and also promote communication between the patient and health care provider. Wang et al. [9], proposed and develop an internet based on Personal Health Information System (PHIMS) by using the referral medical service, thus whenever patients visit a new medical institution to help doctor diagnosis. Then patient can provide this information system and record or gather PHRs at any time that is provided by the medical institution, and receive a more precise health-care information, significantly enhance owing a PHRs. However, a specific network application system might come across problem like personal data safety and in maintenance performance.

3.1 System Infrastructure

This research is mainly constructed via personal medical record system, and primarily integrates electronic medical records from various medical institutions into a mobile device. Within this system, using Personal Health Ontology method to unite medical record information and form into a personal mobile health record system; system procedure shown in Fig. 2. Inclusive information are obtained through data technology, in addition, it gives users access to their own personal medical history, and also it has a build-in logical regulation that can determine abnormal values and analyze abnormal condition, in order to achieve a self-advisory function. Owing to the fact that patient might visit different medical institution for different specialty, thus this system also must integrate HIS data and exchange procedure functionality. We follow the exchange standard from the CCR and HL7 CAD R2, as the Shell layer supply information from the consultation section, which is automatically selected to the user section in PHRs and transforms into CCR format, thus it is temporary stored in the Shell layer platform at the consultation section. The consultation section can

then transform these user's PHRs, which is in CCR format into HL7 CAD R2 format, in order to collect and process additional value for subsequent analysis. Research system infrastructure as shown in Fig. 3. This system can implement an NFC safety mechanism by a closed service Framework transmission medium; NFC transmission format will be packed and send to a smartphone device via wireless transmission mode (receiving end), once the receiver has retrieve the information, it is then transfer to the smartphone's analytic processing module.

Patient can access to their personal health record information by simulating through the HIS platform, and can go through the user's section and set-up a self-tracking system from the health management profile index, which is provided by the Framework via Shell layer service interface. By using the Shell system service interface's standard exchange protocol, it provided a safety channel to maneuver, integrating an easy access to insert health data record and at the terminal section, the analysis instrument or medical data system, therefore, making PHRs more compact to have. At the same time, user can also use their home computer and upload their information to our common cloud platform upon receiving health record information. At the consultation section, the Shell system would apply its feedback, and integrate with the terminal section's analysis instrument or medical data system, thus providing user a more precise health advice. Lastly, for those that is experimenting Personal Health Record (PHR) exchanging medical information in the Taiwan medical community is currently outsourced to the third-party cloud service providers to store in an patient oriented module [13]. This soon will be one typical e-commerce method, considering problems with excess amount of information or the storage unit for access data-backups, there must be a secure and more effective way to access to. Nowadays, there are a variety of cloud platform, such as the Google App Engine, the Azure from Microsoft, etc. all have launch a cloud platform model; other companies invested in developing open source platform, such as Eucalyptus, Hadoop, VMware ESXi, Citrix XenServer, etc. This system will also process its signal to send to a cloud server through wifi/3G wireless network, the cloud server will then store and backup the signal it received. If necessary, it can provide the person in charge of monitoring (medical physician/family member) observe the users' evaluation data, in order to achieve a secure and portable personal health record transmission platform service module.

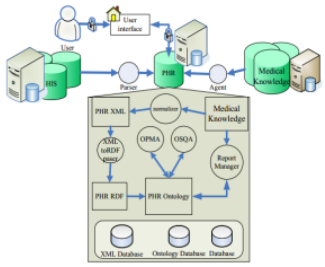

Fig. 2. System procedure diagram.

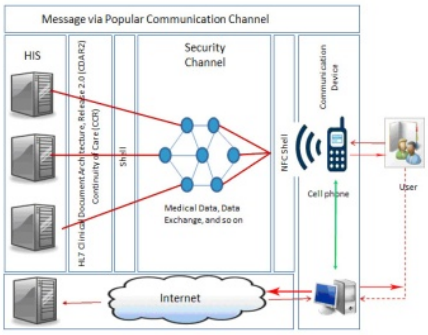

Fig. 3. System infrastructure.

3.2 Instrumental Platform and Function Development Infrastructure

This system mainly will provide user via smartphone's build in NFC induction and enter the smartphone's App system, thus by using the Android 4.0 system platform with the database from MySQL 5.0, maneuvering JAVA as App language. Health management App function can be divided into inspection from the clinical record, self-build data/record, synchronization upload platform, input physiological values or other report/data and managing functions, feedback reading function from the monitoring side. After the user login with their username (by using the SSL <Secure Socket Layer> encrypted login page), user's personal data and health record are saved; at the same time it utilizes a virtual server to increase security and system mobility. Although medical data transfers require encryption of all sensitive information related to personal health,specific security features for rapid key generation and distribution, ensuring privacy and integrity.Nevertheless, it have to also inform the user the possibility of loosing their personal data, thus consent from the user is also required [15].

3.3 Expert Interview

Currently, the health management system that is available on the market only provides a one-way login system for the user. However, this development is focusing on a two-way feedback mechanism health concept, thus an expert panel with consisted of six experts. They are provided suggestion and recommendation to allow the functions of this system to be more ideal. We convene several meetings with expert panel to discuss the system design and system analysis with two doctors in Family Medicine and Neurosurgery, two university professors in department of information system and medical informatics, and engineers who familiar with HIS and EMR totally, We hold a three group meetings to improve the system.

4 Result

Base on the discussion above, an initial prototype for an experimental environment is developed for this research. As for the user's section, an NFC support and handheld communications device with Internet access are utilized in this experimental environment portion, giving access to the medical institutions section to download clinical treatment, physiology data, and non-standard health information as an input mechanism. At the consultation section, its experimental environment portion will give an simulating consultation environment, set up a website with functions similar to "Google Health," that can upload to mobile devices, and uses another account to enter health consultation advise. This section mainly simulate under a virtual environment that will provide an level in API and retrieve PHRs to convert accurately into CCR and HL7 CDA R2 format, as well as the operation to give consultation advisory feedback from the consultation section, and convert the standard CCR format through shell application to reply to user's PHRs environment. With this experimental plan, we have developed a Web-based system to retrieve health information, and have successfully integrated information input system from the handheld communication devices as a main part of PHRs.

After discussing with medical informatics experts, experts agree that this research implementing on a personal health record framework is viable for the future and will its standard business model will be based on the basis of the electronic medical record. However, experts also advise medical institutions should also have a standard HL7 engine framework for an easier connection, because individual medical information system might come in different format, and an standardized format can cause a single Shell layer unable to generalize information, thus it cannot transfer integrated information to conversational interactive model and convert into the same mode, in order to facilitate the data entry, read, and retrieve, and produce an consultation advisory from the medical logical section.

Experts recommendations for data conversion and patients' privacy, if the original system of the medical institutions do not have the HL7 engine data format will not be standardized to integrating the information. So the system assumes that medical institutions has standardized format. Hospital A and hospital B has different formats, they sent medical information to the same interaction model ,in order to read and write data. It's very important that promote PHR need to note System security and patient's privacy. NFC has a convenient short-range communication technology, but the lack of a mandatory safety requirements of security and communications. So we provide Authentication, Data Integrity, Confidentiality and Non repudiation to incorporate into the planning system. At the same time, experts also suggest expending the function for more strengthening is viable. For example, if this research can cooperate with medical institution and obtain the institution's floor plan, it can serve as guidance. After sensing patient via NFC, it can receive both registration and appointment record. When the patient's appointment time is near, the system can use this information to guide the patient by through the medical institution floor plan to the specific outpatient examination room. After each examination, user can instantly

use their smartphone equipped with NFC safety transfer device to sense the medical institution's device, and obtain treatment records and assessment result [17].

Currently, medical imaging is being used as an urgent clinical diagnostic tool, however it consumes a large storage space in any hospital data system. Medical imaging such as CT, and MRI both are costly, thus if repetition examination can be avoided or reduced, this can reduce a considerable amount from medical resources. Thus, experts also suggest include medical imaging into PHRs; let this system to be diversify. As to how to safely conceal the information technically applying to medical imaging is very important, if the medical imaging is transferred to a cloud-computing environment, in aspect of an confidential and protected workaround, an symmetric encryption method can be used (IDEA) to encrypt and decrypt the transmission data to reach confidentiality purpose. Because medical imaging is a part of biological imaging, it requires professional interpretation, clinical diagnosis, and reading; any common user who obtained this information could not give an interpretation, thus upon downloading medical imaging, using medical physician's card as a key, is required to key-in, the certificate authority will then verify user's identification, and manage user's public key.

In this research, we propose to build PHR NFC technology to resolve the problem of Taiwan's health care system is the lack of interoperability and interoperability.

In the future, Personalized medicine is the development trend of the prediction and prevention of medical research, Patient involvement will be a critical factor in making the necessary connections. Web-based bi-directional PHR that is interoperable with hospital and physician systems could provide the "gateway" for the patient [18]. Patient can improve the quality of life ,and understand their own physical condition.In th hospital,PHR can help doctor more understanding of the information on the patient's conditio,and improve the medical quality.At the same time people can make personal health management and preventive care early.

5 Conclusion

Aging Society is coming, as well made health management and preventive medicine become more important. For future study, the content of cloud computing and network technology can be implanted into medical care service, via remote health care network, services such as nutritional diagnosis, monitoring physiology data, etc. Using this information technology to monitor users' various physiology data can anticipate and respond to user's needs, providing 24-hours 7-days a week professional residential-health service.

In Taiwan, to establish a bidirectional PHR is still in the infancy. Therefore, more consideration is needed in system security to provide necessary protection and careful assessment risk and accident mechanism with daily information security are also needed of stage. Nevertheless, the limitation of this system is only based on local expert suggestion to area other than Taiwan.

This research mainly focuses on developing a personal health record application via NFC from a smartphone device, and can also communicate with medical

institutions via a cloud platform, and to explore the cloud-computing platform in respect of increase amount in people and physiology parameter on transmitting and storage function. Other than checking their personal health situation, patient can also communicate and interact with the medical institution, and medical physicians in regards to their own medical examinations and reports. In the future studies, we will combine a practical approach, search for a medical institution or health consultation institution for further cooperation, to further implant a platform, by integrating experimental electronic science-technology, data science-technology, and medical technology, in order to achieve the development and application for a remote mobile health care and living service in the future.

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Inter-organizational Business Processes: On Redundancies in Document Exchanges

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Abstract. Current business document standards, such as EDIFACT, are defined in an all-embracing manner and, thus, usually include several thousands of elements. This is due to the fact that a standardized document type represents a superset of all data elements required in any industry, in any geopolitical region, etc. Furthermore, standardized document types are defined as stand-alone documents, similar to paper-based documents, comprising all information from previous process steps. In other words, standardization neglects the notion of processes by repeating information in different documents of the same process. In this paper, we propose a methodology for assessing redundancies in business document exchanges and evaluate different real-world industry *message implementation guidelines* (MIGs) with respect to their efficiency in reducing complexity and redundancies. Insights on redundancies can help companies and standardization committees to improve designs of MIGs and entire EDI standards. Furthermore, one can use the concepts presented in this paper to compare different MIGs with regard to their (dis)similarities, which might be useful when two organizations are to be merged and their IT systems consolidated.

Keywords: EDI, Electronic Data Interchange, Redundancy, B2B, MIG

1 Introduction

Companies and organizations exchange data electronically to perform business transactions (e.g., requests for quotes, purchase orders, invoices, etc.). If the interchange of data is carried out in an automated and standardized manner, such processes may be referred to as Electronic Data Interchange (EDI) [5, 17]. One prerequisite for successful implementation of EDI systems are commonly accepted standards for business documents, such as EDIFACT [2] or ANSI X12. These traditional EDI standards have been around for more than two decades, and the majority of inter-organizational systems operate on their basis. According to a survey [22] conducted in 2007, an estimated 85%-90% of the total volume of electronic Business-to-Business (B2B) transactions were carried out using traditional EDI standards at this time. Presumably they will continue to play an important role in B2B interactions for years to come [22, 12].

Due to the absence of an explicit notion of process in traditional EDI approaches, every business document is rather considered standalone and not in the context of a set of document exchanges. This has led to the fact that EDI documents convey a lot of information repeatedly in the course of inter-organizational business processes, whereas a minimal subset of the conveyed information is actually sufficient for a certain step of a transaction. In other words, information is exchanged redundantly as an inter-organizational business process does not require the exchange of complete business documents as in a paper-based world, but only the appropriate delta of information required to handle the next step in the process. Such redundancies are - with some exceptions, such as for referencing purposes (i.e., document correlation) or legal requirements - generally undesirable, as implementation costs of an EDI system for a potential receiver of messages rise with the amount of data elements conveyed in a particular message type. Moreover, redundancies increase the risk of interoperability issues.

In addition to the redundancy problem, bulky and overloaded EDI standard specifications make it difficult - or even impossible - for potential receivers of messages to implement the ability to correctly interpret arbitrary EDI business document types completely. For example, our research shows that in order to implement the ability to correctly interpret any arbitrary invoice document adhering to EDIFACT release D.07A, more than 29,700 different data element variants would need to be understood (cf. Section 4.4). In practice, bi- and multilateral agreements are negotiated between collaborating business partners (*message implementation guidelines*, MIGs) to define subsets of EDI standards for specific industries or companies to mitigate this problem. MIGs concretize *whic*h and *how* data elements are to be used and *when* they are to be exchanged *at what state* of a business transaction. This is done in recognition of the fact that reducing the number of data elements in turn reduces implementation costs on the receiver side of an EDI message. MIGs are often specified in semi-formal specifications (often in PDF format) that are shared among collaborating partners. However, the implementation of such additional off-line agreements makes traditional EDI difficult and costly to set-up and to maintain [11].

In this paper, we present a generic methodology for eliciting redundancies in EDI-based inter-organizational business processes and evaluate different real-world MIGs with regard to their complexities and amount of redundancies. Such an effort enables one to (i) get an indication of the scale of the redundancy problem in systems based on traditional EDI approaches, (ii) assess the quality of different MIGs and (iii) provide companies and standardization committees with insights that can help them improve designs of MIGs and EDI standards, respectively. Furthermore, one can use the concepts presented in this paper to compare different MIGs with regard to their (dis)similarities, which might be useful when two organizations are to be merged and their IT systems consolidated.

The remainder of this paper is organized as follows. Section 2 describes the current state-of-the-art and related literature on redundancies in business documents. In Section 3, different manifestations of redundancies in EDI-based business processes are discussed. In Section 4, a methodology for eliciting redundancies in EDI-based inter-organizational business processes and the empirical results of evaluating different MIGs are presented. In Section 5, a conclusion and summary is given.

2 Related Work

So far, the notion of data redundancies has been primarily addressed in the context of databases and XML documents. Redundancies in relational schemas are well studied as they may induce anomalies during relational operations such as insertions, updates, and deletions. Dependencies (e.g., functional dependency and multi-valued dependency) and normal forms are used to describe redundancies in relational schemas [15]. In the context of distributed databases, Wadsack et al. [23] proposed a classification of inter-schema data dependencies including redundancy, inclusion and constraint dependency. Redundancies in XML documents have also been well studied [24, 25, 26]. Wang and Topor [24] define functional and equality-generating dependencies and use them for detecting redundancies in XML, and propose normal forms of Document Type Definitions (DTDs) to address these constraints. Yu and Jagadish [25, 26] propose approaches for efficient discovery of XML functional dependencies and proposed a normal form based on generalized tree tuples, called GTT-XNF, for XML documents. Techniques for transforming any original XML schema to a normal form have also been proposed.

Redundancies in business documents that are exchanged in the course of inter-organizational business processes have been addressed in literature as early as in the 1990s [10], but have only partly been recognized in standardization efforts so far. With regard to traditional EDI standards, there have been proposals for amendments to standards that explicitly or implicitly tackled the topic of redundancies. For example, Interactive EDI (I-EDI) [1, 8] was an attempt under the umbrella of UN/CEFACT originating from the tourism domain with the goal of advancing EDI to handle near real-time "conversations" that are closely aligned with real-world business processes. This included the objective of reducing the amount of redundant data to be transmitted in transactions. The I-EDI initiative has led to the development of a number of EDIFACT message types[1], but has not been broadly adopted so far, except for parts of tourism and healthcare sectors. As another example, Simpl-EDI [4] was an initiative within UN/CEFACT with the objective of simplifying EDI. This was attempted, among other measures, through the reduction of the amount of redundantly transferred information in EDI messages by utilizing so-called master files to be exchanged in the beginning of multi-message EDI transactions. These master files were intended to contain the information that is "stable" in a series of messages belonging to the same transaction, and is hence to be transferred only once instead of repeatedly and redundantly. However, best to our knowledge, the Simpl-EDI initiative has never reached the state of an official standard.

When XML emerged in the late 1990s, it was hyped as a general solution to the various problems of traditional EDI standards. Consequently, the focus of standardization organizations has considerably shifted from tackling conceptual problems of EDI standards, such as that of redundancies, to migrating from traditional syntaxes to XML-based formats. It seems that in the context of this change, the goals of initiatives like I-EDI and Simpl-EDI have been "forgotten" to some extent, basically leaving XML-based syntaxes afflicted with the same conceptual shortcomings as the original syntaxes (cf. [16, 9]). As a consequence, people have

[1] http://www.unece.org/trade/untdid/d10b/timd/timdi1.htm

learned that for addressing the issue of redundancies in business documents a more comprehensive view on inter-organizational business processes is required. Initiatives such as ebXML [13], RosettaNet [3], and UN/CEFACT's Modeling Methodology (UMM) [19] emerged, which address the topic of redundancies by adopting a state-centric perspective as opposed to a document-centric one. Thereby, those approaches suggest transferring only state changes between information systems of business partners instead of complete business documents. However, as of today none of these approaches gathered significant relevance compared to EDIFACT or X12.

The topic of redundantly transferred data elements in inter-organizational data transfer has recently been addressed in the field of service-oriented computing in [14], where the authors propose metrics for enabling the discovery of data redundancy from semantically annotated Web service descriptions (SA-WSDL). These metrics are especially useful for distinguishing "unintentional" redundancies from data elements that are used for referencing purposes (i.e., correlation keys).

In this paper, we intend to identify the types of redundancies manifested in EDI document exchanges and propose a method for detecting such redundancies. The topic of resolving redundancies (such as normal forms proposed in databases or XML schemas) is beyond the scope of this paper.

3 Manifestations of Redundancies

We define a redundancy in an EDI-based inter-organizational business process as a piece of identical information that is transferred more than once in the course of this process. Note that this definition of redundancies does not imply that they may be entirely eliminated without preventing the sound execution of the underlying business process. If all redundant information was indeed eliminated, it may not be possible to correlate individual business documents to corresponding business cases anymore, or other requirements (e.g., legal issues) may be violated. For instance, some legislations require that invoices explicitly display the products (i.e., line items) that are invoiced, even if they may be clearly inferable from a corresponding previously exchanged order document.

Redundancies may be classified based upon whether only the structure (i.e., the data schema) or also the semantics of business documents are taken into consideration. Hence, we propose a distinction between *structural redundancies* and *semantic redundancies*[2].

Structural Redundancies. In its simplest form, redundancies in EDI may manifest as specific data elements of an EDI data schema that are repeatedly sent and/or received between collaborating business partners in the course of an inter-organizational business process while at the same time conveying identical data. For example, in a purchase order transaction, all involved business documents (e.g., quote, order, invoice ...) may contain an identical customer's address, line item

[2] This terminology is inspired by the taxonomy of interoperability levels by A. Sheth [18].

description or order number[3]. We refer to such redundancies that manifest as repeated values in repeated data elements as structural redundancies.

Semantic Redundancies. EDI messages may be afflicted with more subtle forms of redundancies that are not as simple to define and detect as structural redundancies. Due to bulky and overloaded standards specifications in traditional EDI standards, different data elements may convey semantically similar information. In other words, when an organization implements a particular EDI standard it can choose from different data elements for encoding a particular piece of information. As a result, in practice the same information may be transferred in different message exchanges, but in different data elements with similar semantics or in another variation of encoding. We refer to such redundancies as semantic redundancies.

Due to space limitations, a thorough discussion of semantic redundancies is not included in this paper. However, we claim that the identification and/or detection of semantic redundancies can only be conducted based upon a rich semantic understanding of the contents of messages and underlying EDI standards. Furthermore, we state that this includes a highly subjective component, as is inherent to any exegesis of textual standards. Accordingly, in the remainder of this paper we will concentrate on structural redundancies only.

4 Eliciting Structural Redundancies in EDI-based Business Processes

In the following, we describe a method for eliciting structural redundancies in inter-organizational business processes based on traditional EDI standards and present empirical results of two experiments in which we apply this method on data from real-world industry MIGs. We look specifically at EDIFACT because it is currently the most prevalent EDI standard in practice.

4.1 Extended EDI Data Model

In traditional EDI standards, including EDIFACT and X12, specific data elements may have varying semantics depending on concrete values of so-called qualifiers at other positions in the business document. We believe that when attempting to elicit redundancies in EDI structures, the accurateness and usefulness of results can be significantly improved if these qualifiers are taken into account. Hence, we extend our notion of the structure of EDI messages (i.e., the data model) to include qualification characteristics of data elements [6]. In the following, we present a heuristic approach to conceptualize qualified data elements by means of *data element variants* (DEVs) to arrive at a more fine-grained extended data model of EDI structures.

Qualified Data Elements. In traditional EDI standards, one can distinguish between qualified and non-qualified data elements. Consider the following instance of

[3] See [10] for an illustrative example of redundancies in a typical procurement process.

an NAD (Name and address) segment instance, assuming that it was created based on release D.10B of the official EDIFACT directories:

```
NAD+ST+TU Vienna'
```

This segment instance consists of two data elements[4]: (i) data element 3035 (*Party function code qualifier;* here: "ST") and (ii) data element 3039 (*Party identification details;* here: "TU Vienna". The party qualifier is coded and resolves to "ship to"[5]. In this case, the *Party function code qualifier* qualifies the *Party identification details* in the sense that "TU Vienna" is a ship-to address, i.e., this segment instance conveys the information that something should be shipped to "TU Vienna". Hence, in this example, data element 3039 is a qualified data element and the concrete semantics of an instance depend on a code specified in an instance of data element 3035.

In a naive approach for redundancy elicitation, one would not distinguish between qualified and non-qualified data elements. For example, repetitions of data element 3039 would be considered generally redundant. However, this approach would fall short of the different semantics that this data element may have in concrete instantiations. It is very likely that in a single EDI message type, multiple instances of data element 3039 with differing semantics are found (such as for buyer, seller, shipper, etc.). We claim that the same is true for a wide range of other qualified data elements in EDIFACT and X12; however, a rigorous quantification of qualified data elements is difficult because qualification relationships are generally not formally described in textual EDI standards [6].

Extended EDI Data Model. In order to abstract from qualified and non-qualified data elements, we introduce an extended EDI data model based on the notion of DEVs (*data element variants*). We define a DEV as either (i) a qualified data element that is associated with a specific code in a corresponding qualifying data element, or (ii) a non-qualified data element. For example, an instance of data element 3039 qualified by the code "BY" in an instance of data element 3035 represents one DEV of data element 3039 - this DEV could then be labeled, for instance, *"Buyer PartyIdentificationDetails"*. Analogously, there are as many DEVs of data element 3039 as there are allowed codes for data element 3035, as illustrated exemplarily in Fig. 1. Note that the exemplary three-element enumeration of allowed codes in Fig. 1 is just a small subset of codes allowed by typical EDI standards in reality. For instance, EDIFACT release D.10B defines 589 different codes for data element 3035, which would lead to 589 different DEVs originating from data element 3039.

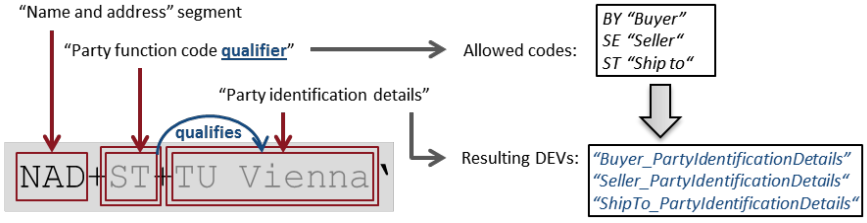

Fig.1. Example for DEVs resulting from allowed codes in a qualifier

[4] http://www.unece.org/trade/untdid/d10b/trsd/trsdnad.htm
[5] http://www.unece.org/trade/untdid/d10b/tred/tred3035.htm

If qualification relationships between data elements are known, the set of contained DEVs ("DEV sets") can be computed for messages, MIGs or entire EDI standards. Thereby, non-qualified data elements are included into DEV sets as exactly one DEV (i.e., these DEVs act as surrogates for non-qualified data elements). Hence, DEV sets contain all non-qualified data elements as well as all qualified data elements in every conceivable semantic variant according to the actually occurring qualifier codes in a message, or according to the allowed codes in a MIG or in a standard. In the experiments presented in this paper, our notion of structural redundancies is based upon this extended EDI data model; i.e., we consider EDI message types to be structurally defined by their DEV sets.

Qualification Heuristics. However, as mentioned before, the traditional EDI standards do not formally specify qualification relationships between data elements. While to humans such qualification relationships can usually be concluded from the context, they are not obvious to a machine[6]. Best to our knowledge, a comprehensive and/or official codification of qualification relationships is not yet available. Hence, in order to compute DEV sets, information about qualification relationships between data elements needs to be provided. While manual modeling of qualification relationships is conceivable [6], in this paper we apply automated heuristics to approximate qualification relationships in EDIFACT standards in order to ensure confirmability of our results. These heuristics distinguish between qualified and non-qualified data elements according to the following rule: *If a data element stands at the beginning of a composite data element (CDE)[7] or at the beginning of a segment and its name ends with the string "qualifier" (ignoring character case), then it is considered to qualify the remaining data elements of that CDE or of that segment (including data elements embedded in nested CDEs), respectively.*

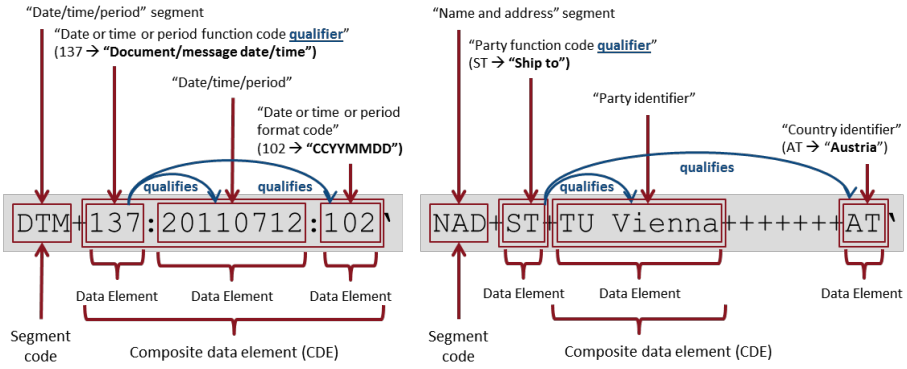

Fig.2. Examples illustrating the employed qualification heuristics

[6] The problem of the inexplicitness of the EDIFACT standards on qualification relationships, as well as a technical solution for modeling these relationships is extensively discussed in [6].

[7] In the EDIFACT standards, CDEs are specific groups of related data elements.

Fig. 2 illustrates by means of examples of DTM *(Date/time/period)* and NAD *(Name and address)* segment instances how the qualification heuristics work for the cases of qualified CDEs and qualified segments, respectively. As stated before, the exegesis of textual EDI standards with regard to qualification relationships is subjective; hence, the quality of these heuristics is difficult to assess. However, we believe that they represent a good approximation of reality for the following reasons:

Firstly, of the 156 (batch) segment definitions[8] in EDIFACT release D.07A, 60 define a single (i.e., non-composite) data element at the beginning (i.e., at the first position) whose name ends with the string "qualifier". Opposed to that, only one segment definition, namely the TEM *(Test method)* segment, defines a single data element ending with the string "qualifier" at another position than the first position. Since the aforementioned qualifier data elements are non-composite, they necessarily qualify other data elements in the corresponding segments as otherwise the information they provide would be useless. The EDIFACT standards do not define any formal rules for the scope of such qualifiers. However, some segment definitions such as LOC *(Place/location identification)*, NAD *(Name and address)* or TAX *(Duty/tax/fee details)* are particularly illustrative in that their qualifiers are mandatory and relate to the whole segment rather than to only a subset of the contained data elements. Hence, we conclude that qualifiers at the first position of segment definitions generally qualify all other data elements (including those contained in nested CDEs) of that segment, thereby justifying the above described heuristic rule for the case of qualified segments.

Secondly, of the 197 (batch) CDE definitions[9] in EDIFACT release D.07A, 17 have a qualifier as their first data element and 13 have qualifiers at other positions. These sets overlap, i.e., there are CDEs containing multiple qualifiers both at the first and at other positions. There are again some illustrative cases suggesting that qualifiers at the first position may qualify entire CDEs, such as C186 *(Quantity Details)*, C506 *(Reference)* and C507 *(Date/time/period)*. Hence, analogously as for segment definitions, we conclude that qualifier data elements at the first position of CDE definitions generally qualify all other data elements of that CDE, thereby justifying the above described heuristic rule for the case of qualified CDEs. For the 13 CDE definitions having qualifiers at other positions than the first, the subordinated positioning of the qualifier reflects relatively lower importance. Moreover, since they are generally optional (as opposed to first-position data elements which are typically mandatory in the standards), they are evidently not required to qualify the rest of the data elements. Hence, we neglect them in the proposed qualification heuristics.

4.2 Data Set for the Experiments

Because of the difficulty of acquiring real-world EDI message sets from a representative number of organizations that are sufficiently large for research purposes, in the experiments depicted in this paper we refrain from eliciting redundancies in actual messages. Instead, we analyze industry MIGs, since we

[8] http://www.unece.org/trade/untdid/d07a/trsd/trsdi1.htm
[9] http://www.unece.org/trade/untdid/d07a/trcd/trcdi1.htm

consider them to represent an abstraction and generalization of arbitrary EDI messages exchanged in the real world. Doing so is justified by three underlying assumptions. (i) Since EDI systems are usually implemented on the basis of MIGs, implementation costs do not only rise with the occurrence of redundancies in messages that are actually being exchanged, but also due to MIGs. Hence, redundancies in industry MIGs are drivers for implementation costs of EDI systems. (ii) Since MIGs constitute implementation directives, data elements defined in MIGs can be assumed to appear also in actual real-world messages. (iii) Analyzing MIGs instead of messages does not allow us to elicit structural redundancies by means of detecting repeated data element *values*[10], but only by means of detecting repeated data element *types*. This implies that repeated data element types detected in an analysis of MIGs cannot formally fulfill the requirements for structural redundancies according to our previous definition in Section 3. However, data element types often have business semantics that are related to an entire business case instead of a particular message (e.g., customer's address, order number, seller's bank account, etc.). Hence, we assume that repeated data element types generally coincide with repeated data element values, even if they occur in different messages. Under this assumption, a survey on MIGs as presented in this paper may indeed yield indications of structural redundancies in EDI-based inter-organizational business processes.

As mentioned before, MIGs used in industry are usually only available as semi-formal specifications, often in PDF format, which are difficult to process automatically. However, the commercial software suite GEFEG.FX[11], which is currently the market leader in the field of design tools for EDI standards, provides a formal model of MIGs. In this model, MIGs are defined as subsets of full EDI standards, i.e., elements and codes that are marked as optional in the standards may be selectively removed in MIGs. This formalization allows for automated processing of contained segments, data elements and code lists, such as for purposes of set analyses and counting. The GEFEG.FX software suite also contains a number of concrete instantiations of real-world MIGs that are encoded according to this formal model. These MIGs are organized into industry- and/or organization-specific sets. For the experiments in this paper, we relied on a data set that we extracted from MIG sets and MIGs contained in GEFEG.FX, Version 6.1 SP1, as described in the following.

4.2 Methodology for Redundancy Elicitation

For each of the two experiments presented in this paper, we selected an exemplary business process that can be implemented using EDIFACT and/or MIGs based on EDIFACT. For the selection of these processes we considered literature on common business processes [20] and the available MIGs in GEFEG.FX 6.1 SP1, such that the selected business processes could be simulated by means of the available data. Table 1 shows the specific MIG sets and message types that are used for the experiments presented in this paper. These MIG sets, as well as one full EDIFACT standard

[10] MIGs usually do not contain values in data elements unless for demonstrative purposes.
[11] http://www.gefeg.com

(release D.07A) for comparison purposes, were analyzed in the experiments according to the following algorithm.

Algorithm for Redundancy Elicitation. For each activity (i.e., message type) that is contained in the examined business process, the corresponding MIGs/message type specifications of the analyzed MIG sets/EDIFACT standards are selected and the respective DEV sets computed according to the method described in Section 4.1. For example, if the examined business process contains the activities DELFOR-DELJIT-RECADV and the JAI Global Messages and EDIFICE MIG sets are to be analyzed, six DEV sets are computed in total. Then, the DEV sets are compared within (and only within) each MIG set. For each individual DEV, the number of DEV sets within the corresponding MIG set that contain this DEV is computed. DEVs that are contained in multiple DEV sets of MIGs in a MIG set or in an EDIFACT standard (i.e., more than 1 occurrence) are considered to be redundant. Fig. 3 shows an example of how the algorithm works on the basis of a fictional example.

Table 1. Data set used for the experiments

Experiment	Examined msg. types	Used MIG sets and corresponding industry, version and underlying EDIFACT standards
1. Purchase Order Process	ORDERS, ORDRSP, INVOIC, DESADV	- EANCOM (Consumer goods), version 2002 S4, Edition 2010; based on EDIFACT D.01B - EDIFICE (Electronics), version 2011-1; based on EDIFACT D.10A - Siemens SES (Technology), version 07/2012; based on EDIFACT D.10A - VDA (Automotive), version 1.0 except for INVOIC (VDA 4938 GLOBAL INVOIC version JAI 3.1, 2010); based on EDIFACT D.05A (ORDERS, ORDRSP) and D.07A (DESADV, INVOIC)
2. SCM Process	DELFOR, DELJIT, RECADV	- JAI Global Messages (Automotive), version 2008; based on EDIFACT D.04A (DELFOR), D.04B (DELJIT) and D.03A (RECADV) - EDIFICE (Electronics), version 2011-1; based on EDIFACT D.10A

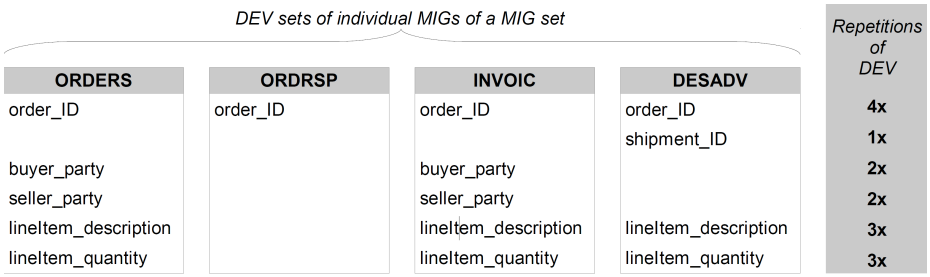

Fig.3. Example for the employed algorithm for redundancy elicitation (fictional data)

4.4 Experiment 1: Purchase Order Process

Purchase order processes are frequently used examples for business processes in literature and can be considered typical applications of EDI (cf. [20, 10]). Due to the broad coverage of corresponding EDIFACT message types in the MIG sets of our data set, we choose this type of business process as an archetype for our first experiment and assume the following sequential structure of such a process: *Order (ORDERS) - Order Response (ORDRSP) - Invoice (INVOIC) - Dispatch Advice (DESADV)*. The results of the experiment are shown in Fig. 4. The figure displays the aggregated number of repetitions of DEVs in each of the examined MIG sets (i.e., one to four times in the examined business process). These figures allow for several insights:

(i) The EDIFACT standards contain large amounts of DEVs (~29.700 in the four examined message types) that make complete implementations of these standards generally infeasible in practice. Most of the DEVs (~99%) are used in several message types of the examined business process. In other words, if these standards were to be implemented, this would result in a high degree of redundancies.

(ii) The analyzed industry MIGs manage to significantly reduce the complexity of the underlying EDIFACT standards as measured by the total number of DEVs. The aggregated DEV sets in the EDIFICE, Siemens SES and VDA MIG sets account for less than 3%, 2% and 6% of the examined EDIFACT standard, respectively. Furthermore, in these MIG sets the amount of redundant DEVs is significantly lower than in the EDIFACT standard (~29% and ~5%, resp.).

(iii) The EANCOM MIG set contains relatively large MIGs in terms of number of contained DEVs; this is accompanied by a high degree of redundancies across message types (~92%). Both the complexity as well as the affliction with redundancies suggests that implementations of the EANCOM MIGs are relatively costly when compared to other MIGs examined in this experiment.

Purchase order process: Order - Order Response - Invoice - Despatch Advice

MIG set		times repeated 4x	3x	2x	1x	Sum
UN/EDIFACT D.07A	# DEVs	22256	6961	223	280	29720
	%	74,89	23,42	0,75	0,94	100
EANCOM	# DEVs	4271	2346	169	524	7310
	%	58,43	32,09	2,31	7,17	100
EDIFICE	# DEVs	42	61	101	521	725
	%	5,79	8,41	13,93	71,86	100
Siemens SES	# DEVs	19	55	56	319	449
	%	4,23	12,25	12,47	71,05	100
VDA	# DEVs	6	9	63	1598	1676
	%	0,36	0,54	3,76	95,35	100

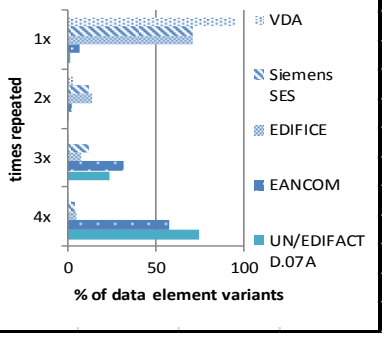

Fig.4. Results for purchase order process experiment

By applying the proposed methodology for redundancy elicitation one may look at specific DEVs to gain further insights on how individual MIGs can be improved. For example, all VDA MIGs of the purchase order process contain the DEV buyer's *order number* (data element 1154 qualified by code ON in data element 1153), whereas three of the four MIGs (ORDERS, INVOIC, ORDRSP) contain the DEV *delivery date/time requested* (data element 2380 qualified by code 2 in data element 2005). While order numbers are probably needed as reference numbers in each of the messages, requested delivery dates could likely be safely omitted in subsequent messages after having been transferred once.

4.5 Experiment 2: Supply Chain Management (SCM) Process

Supply chain management processes backed by EDI systems are used in various industries. Based on literature on SCM processes in the automotive industry [21, 7] we assume the following sequential structure of such a process for this experiment: *Delivery Forecast (DELFOR) - Delivery Just-in-Time Request (DELJIT) - Receiving Advice (RECADV)*. The results of the experiment are depicted in Fig. 5. These results allow for several insights:

(i) The EDIFACT standard again exhibits high complexity (~22,900 DEVs) paired with a high degree of structural redundancies. However, the amount of redundancies in the SCM process experiment is significantly lower than in the purchase order process experiment (~78% and ~99%, respectively).

(ii) The analyzed MIGs again significantly reduce the complexity of underlying EDIFACT standards as indicated by the total number of DEVs. The MIGs of the JAI Global Messages and EDIFICE MIG sets contain less than 17% and 1% of DEVs defined in the examined EDIFACT standard, respectively.

(iii) The JAI Global Messages and EDIFICE MIG sets differ significantly in terms of complexity as measured by their total numbers of DEVs (3813 and 200 DEVs, respectively). However, the figures for redundant DEVs behave inversely. While the JAI Global Messages MIGs exhibit ~10% structural redundancies, the EDIFICE MIGs comprise 33% redundant DEVs. This suggests that the former have a better ratio of expressive power to implementation cost than the latter.

SCM process: Delivery Forecast - Delivery JIT Request - Receiving Advice					
MIG set		times repeated			Sum
		3x	2x	1x	
UN/EDIFACT D.07A	# DEVs	17899	103	4964	22966
	%	77,94	0,45	21,61	100
JAI Global Messages	# DEVs	87	289	3437	3813
	%	2,28	7,58	90,14	100
EDIFICE	# DEVs	11	55	134	200
	%	5,50	27,50	67,00	100

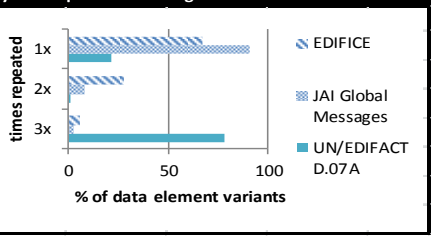

Fig.5. Results for SCM process experiment

5 Summary and Conclusion

In this paper, we presented a generic methodology for eliciting structural redundancies in EDI-based inter-organizational business processes that takes into account the specifics of traditional EDI standards with regard to semantic variations of data elements. The methodology employs a set of heuristics to automatically infer data element variants (DEVs) from the standards specifications and thereby allows for analyzing structural redundancies on a more fine-grained level of DEVs instead of plain data elements. In order to empirically assess the prevalence of redundancies in common inter-organizational business processes we performed two experiments based on real-world data from industry MIGs. Our results give an indication of the scale of the redundancy problem and suggest that MIGs currently used in practice are generally successful in reducing both complexity and redundancies in inter-organizational business processes. However, they differ with regard to efficiency in doing so. Our insights may guide EDI-implementing organizations in creating more redundancy-aware, and hence cost-efficient, MIGs in the future. Moreover, by applying our approach, individual redundancies may be highlighted. The ability to compare different MIGs with regard to their (dis)similarities might be useful when two organizations are to be merged and their IT systems consolidated. Furthermore, our empirical results justify current efforts of standardization committees of moving towards process-oriented and/or state-centric approaches for reducing the complexity and cost of implementing EDI systems.

Our future work plans include addressing the question of how one can distinguish more precisely between desired and undesired redundancies. This includes a thorough investigation of the trade-off between costs (i.e., required implementation efforts) and potential benefits of redundancies. This needs to be researched on all three of empirical, theoretical and conceptual levels. Furthermore, the herein presented approach for eliciting redundancies is in principle independent of underlying transfer syntaxes in EDI systems. Hence, we plan on including XML-based document types into a comparative survey of redundancies in different EDI standards. We expect that this will result in further empirical evidence that merely changing the transfer syntax does not solve certain shortcomings of EDI standards, such as that of redundancies.

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Network Science @ Recommender Systems

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Abstract. We present a conceptual approach in the field of recommender systems, which is intended to model human consumption by maintaining a network of heterogeneous nodes and relationships. We think of this model as the reflection of the corresponding cognitive functionality of human thinking, as we maintain a structure which is similar to the structures established by neural networks. To explain our motivation and the proposed structure we are combining the results of recommender systems and network science. We propose a generalized approach that intends to involve concepts from social networks, semantic distance, association rule mining, ontological modeling and expert systems. Our approach will access and integrate different information sources, modeling also additional information types. We expect that our approach will find the importance factors of the aforementioned information sources for the generation of high quality recommendations.

Keywords: Network Science, Recommender Systems, Spreading Activation, Error Back-propagation, Recommendation Spreading.

1 Introduction

What are the mechanisms and what is the structure of the motivations behind consumption? This question could be reconstructed into a form that brings us closer to a methodology that helps us to measure the mechanisms of human consumerism through the lens of recommender systems. Recommender systems basically build a model or provide a methodology that provides a personalized and prioritized list of consumer goods and services that could be relevant for a particular customer. In other words recommender systems model human behavior from the aspect of consumption.

The origin of recommender systems can be dated back to 1966 [15] and were popularized in 1993 [1]. Since then, in the last 20 years the strong pressure from electronic commerce and the content industry have catalyzed the evolution of recommender systems and have led to a considerable progress in this area. This development can be measured either in the increasing amount of information sources involved and also in the ascending number of the methods and models that are processing the data. Researchers developed several models and found many sources of information to produce personalized recommendations. By utilizing these models and methods recommender systems are implicitly modeling the incentives of

consumption by maintaining a personalized, reflective model of human consumer motivation, with rather good results.

Our goal is to build an appropriate framework that is suitable for modeling human consumption by working with a methodology that generalizes the concept of information source type and the relation between the aforementioned types. We present a conceptual contribution of our novel framework in the area of recommender systems that will act as the basis of the analysis of heterogeneous information sources personalized recommendations can be supported by. The framework helps us to find the importance factor of each information source type. The approach is strongly based on the achievements of network science and maintains a knowledge base with a structure of a labeled, directed, weighted non-acyclic graph, namely a network.

The related work in the area of recommender systems will be discussed in more details in Section 2. Section 3 contains a detailed description of our motivation. In Section 4 we present our conceptual framework, we also propose novel sources of information we expect to benefit from. To summarize our contribution, the paper is to be concluded with Section 5.

2 Related Work

The first algorithm providing personalized recommendations to end-users that was developed in the area of recommender systems was mining association rules between products based on purchased-together events. The goal of Association Rule Mining (ARM) [21] is to find the articles that customers tend to purchase together. The first association rule method appeared in 1966 [15] and was popularized in 1993 [1].

The need for better recommendations involved additional sources of information to make personalized recommendations more precise. A possible categorization of recommender systems: collaborative recommendations, content-based recommendations and knowledge-based recommendations [17]. The aforementioned approaches are often combined to improve recommendation quality by various hybridization techniques [7].

Collaborative recommendation – often referred to as Collaborative Filtering (CF) – is basically a prediction of user rating supported by a historical rating database which is in most cases represented as a huge and sparse matrix. Probabilistic methods treat the rating matrix as a sample of a distribution and try to model it by applying various probabilistic methods. Examples are naïve Bayes classifier [30], matrix factorization (SVD) [20] and tensor factorization (HOSVD) [26].

Advanced CF methods for instance involve sampling [23], Bayesian belief networks [31] or apply clustering [32]. In the clustering case, CF can be treated as the refinement of the ARM technique. The most conspicuous problem of group or cluster based CF is the cold start effect, which means that the recommender system cannot provide reliable recommendations until the necessary information is collected on the user. There are various techniques developed to avoid the cold start effect, for example by defaulting ratings [5], or by involving social network [12]. The basic idea behind group based CF is that people with similar friends or interests tend to buy items similar to those a particular person would purchase [13].

Involving social networks into recommender systems is a novel and promising trend to improve the quality of recommendations. Guy et al. [12] improve CF by replacing the implicit weights with explicit weights derived from social ties to generate recommendations. He et al. [13] define a naive Bayes approach, which generates recommendations based on item attribute values, user attribute values and social ties. Defining their model they distinguish between immediate and distant friends. Yang et al. [33] define a distributable querying approach based on social networks and Bayesian inference. Konstas et al. [19] compute the recommendations utilizing random walks with the help of an adjacency matrix on a network containing users, tags and recommendable items. They introduce different weights for user-user, user-tag and user-item relationships. Kazienko et al. [18] define a layered representation of social networks where each layer represents a different aspect of the social relationships between users. These approaches show that involving social networks into recommendations is a promising source of information and also describe various methods for the technical implementation of gathering this information.

Content-based approaches – often referred to as Content-Based Filtering (CBF) – are based on a similarity measure between the recommendable items. The similarity measure is usually defined over a vector based representation of text documents. The representation can be prepared for example with a variant of the bag of words method [24] or with term frequency/inverse document frequency (TF-IDF) [27]. A common practice in text representation is to use manually defined features, like title keyword frequency related to the content [4] or genre [35]. After the document is transformed into the vector space, similarity measures (binary cosine, Jaccard [16] or cosine similarity [23]), clustering [2], linear algebra methods, linear classifiers [34], similarity trees [4] can be applied to item recommendations. The recommendations of CBF methods are the items that in the meaning of the applied distance method are similar to the items the particular customer implicitly or explicitly already expressed interest.

Knowledge-based approaches are useful in scenarios where the items have a well-structured attribute set. The philosophy of these methods is to help the user to explore the item space by following different strategies. The two most important classes of knowledge-based approaches are constraint based [10] and case based [29] recommendation techniques. Constraint based techniques are narrowing the set of possible items by asking the user for limiting constraints. Constraint based methods are also describing various strategies to resolve conflicting condition sets. Case based methods define strategies to aid the user explore the items in the high dimensional space of attributes.

The basic idea behind **hybridization** is to combine the strengths of different techniques. Parallelized hybridization design combines the results of self-contained methods by various techniques, for example the mixed, weighted or switching method [7]. Pipelined hybridization design follows a cascading rule, where recommender systems in the pipeline act as filters on the list of the recommendable items [7].

3 Motivation

The basic motivation behind hybridization techniques is to combine different recommender systems as subsystems while usually treating them as autonomous units. This technique is excellent from the point of view of system architecture and modularity, but unfortunately has the potential to lose important information that can be found in small information chunks which might be present at the level of the model, but is inherently filtered out by the hybridization technique.

Next to the information sources presented in Section 2, additional information sources can also be involved to produce recommendations. These sources are for example user tagging, rating, commenting (user-item relation with textual data); visiting patterns as transitions (item similarity with direction); sophisticated social network features (user blocks another user, user influence on another user, SNA group membership); person or item clustering on attributes or on dimension reduced attributes (PCA); calculating with antonyms in textual description or the exclusion of a manufacturer by personal taste.

We think that it is important to build a system that has the potential to involve even the smallest information chunks that can be found between the different actors because after a possible accumulation these chunks can have the influence on the final relevance order. In Section 4 we present a hybridization technique that has the capability to combine multiple information sources with the possible highest integration and lowest possibility of information loss.

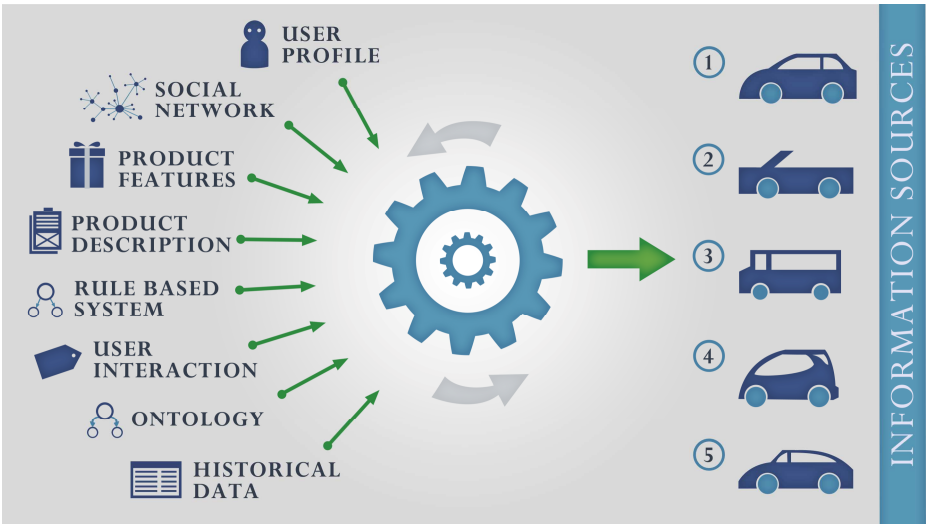

Fig. 1. The different kinds of information sources recommendations can be calculated from.

Figure 1 presents a summary of the possible information sources recommender systems can derive the recommendations from. As Figure 1 shows the scenario is very heterogeneous. Our intention is to create a generalized representation of information

that is able to unite all the already existing information sources and has the potential to provide space also for additional types as newcomers. Once the system sits on top of a huge and heterogeneous collection, then it should have the ability to learn the importance factor of each information source.

By estimating probability utilizing naive Bayes, Bayesian inference methods, applying clustering, grouping the persons and items or creating weighted sums of data, most CF and CBF methods aggregate the information. The motivation behind applying these methods is to avoid overfitting and overlearning the represented model as well as to avoid computational burdens. Our goal is to produce personalized and high quality recommendations. Our proposed method keeps the data in a higher fidelity by applying an appropriate representation method.

The social ties between human entities and the structure of the social network play an important role in the life of human individuals. People strongly rely on their social relationships even when looking for a job [11] or gathering information on the Internet [8]. The principle that individuals tend to be similar to their friends [9] is reflected also in their consumption behavior. Human entities often receive recommendations from their friends either implicitly (by experiencing new consumer behavior among acquaintance) or explicitly (by asking individuals in their social network). Modeling the cascading behavior [9] in social networks is another aspect showing that the information – which in our case is a recommendation – spread in social networks is a general property of human communication. Our intention is to utilize this mechanism of homophily in its living context, in the network, to produce more human-like recommendations.

CBF methods often involve shallow text processing methods to measure item similarity. Shallow text processing methods operate with statistical text representation and miss the semantical interpretation of the descriptions of the recommendable items or – in the case of a news recommender system – of the item itself. Although the accuracy of statistical text processing is often inadequate, it is more widely used than semantical text processing. The reason why semantic analysis is not popularized in this area could be traced back to historical reasons and its high resource requirements. Our concept gives a method for the implicit calculation of semantic distance utilizing the background information that exists in the relationships between ontology items, which calculates semantic distance with similar resource requirements than processing the other information sources.

Explanations play an important role in the life of recommender systems. Presenting reasonable explanations to the users next to the recommendations significantly increases the effectiveness of the recommendation process [17]. In order to provide explanations, nodes or paths with the highest activation values will be presented to the user. We expect that our proposed method produces effective explanations, because the method of their generation is similar to human thinking.

3.1 A Sample Scenario

Before we introduce the system, we illustrate our motivation with an imaginary scenario, which can help us to explain the proposed mechanism behind the generation of recommendations.

Eve wants to buy a new perfume to replace her current one, Orienta. There are two possible candidates, Pinky and Fracca. She asks her boyfriend, Peter, and he suggests Pinky. Eve also asks her friend, Irene, who is not interested in perfumes but asks her friends, Petra and Sarah. Petra votes for Pinky and Sarah votes for Fracca. Reading the product descriptions Eve finds out that Fracca is produced in Paris and Orienta is produced in Angers. Both cities are located in France. Besides other components, Orienta contains Musk and Amber. Eve likes Musk, but dislikes Amber. Musk is also the component of Pinky and Amber is also the component of Fracca.

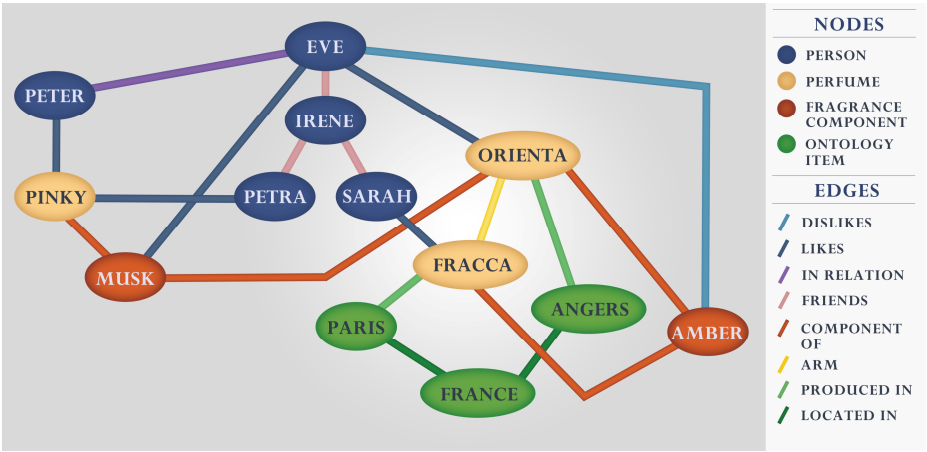

Fig. 2. A sample scenario for a recommendation case. The nodes of the network show the entities and the edges show the relationships between the entities.

Figure 2 visualizes the described scenario, illustrating the different node and relationship types with their respective colors. For this imaginary recommendation case various information sources present for the estimation of the most adequate perfume for Eve. Eve, Peter, Irene, Petra, Sarah and the relationships "in relation" and "friends" between them illustrate a social network. The edge "likes" between persons and perfumes show their relationship to the perfumes. Musk, Amber, their relationships "component of" to the perfumes and the edges "likes" and "dislikes" from Eve to Amber and Musk can be processed involving an expert system. The relation "located in" between Angers and Paris can be perceived with the help of an ontology, while the edges "produced in" between perfumes and ontology items illustrate the result of text processing. The edge "ARM" between Orienta and Fracca illustrates that association rule mining can also aid recommendations.

This example illustrates that this scenario combines (i) social networks – as a special case of CF; (ii) expert systems – as an illustration of knowledge-based recommendation; (iii) ARM – a similarity measure for CF and (iv) ontology as a semantic distance, which can be treated as a CBF approach.

Analyzing Figure 2 we may ask the following questions: Which perfumes are suggested to Eve? Are the social relationships or perfume components (expert system) more important than the geographical locations (ontology relations) for producing

recommendations? How do recommendations depend on the distance in the graph of the social network? Is it enough to define a weight for each relationship type or is it necessary to involve the weights inherently presenting in a social network, thus it can lead to higher quality recommendations?

4 Description of the Method

In Section 3 we expressed in detail that we would like to define a sophisticated recommender system which involves social networks; integrates the information sources instead of working with autonomous units; aggregates multiple kinds of information sources; works with semantic distance instead of shallow text processing; generates human-like recommendations; provides explanations which fit to human thinking and is as sophisticated as possible by the availability of avoiding the creation of user groups or clusters.

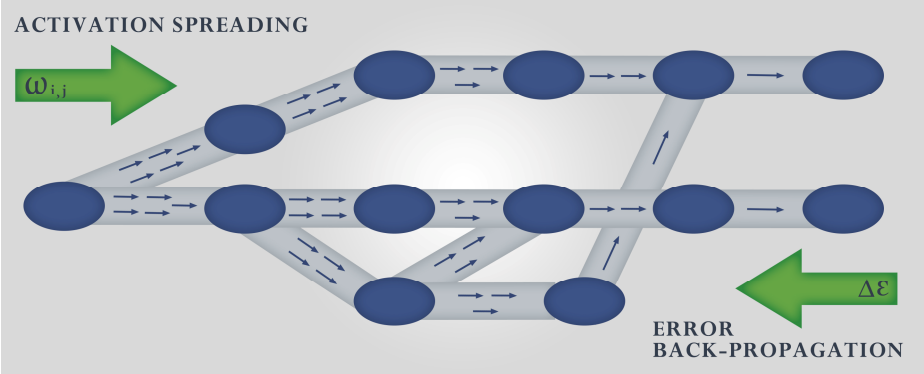

Fig. 3. Recommendations are generated by applying spreading activation, the relationship type weights are maintained by error back-propagation.

For the knowledge base of our approach we choose a directed weighted labeled graph. The nodes represent the entities. An entity is for example a user, a recommendable item, an ontology item, a tag, a group of items or a customer group. The weighted edges represent the relationships between the entities. A relationship is for example a friendship, a like, an is-a relation between ontology items or a tag presence on an item or group membership. Each edge has a type and a weight is assigned to each edge type. The recommendations are produced applying a spreading activation algorithm [3]. The type weights are tuned applying error back-propagation [6], as illustrated on Figure 3.

The model distinguishes between the weights belonging to the relationships and the weights belonging to the relationship types. A relationship type weight may represent the strength of a social tie between two persons or the confidence of an ARM rule between two items. The relationship type weights are introduced to distinguish the importance of different kinds of relationships which exist among the

nodes. It is important to let the model adapt for example to the difference between the importance of social ties and the is-a relationship in the ontology. These weights are then fine-tuned by the error back-propagation algorithm based on the feedbacks provided by the users and after a long time application on a specific domain we expect these weights to converge and let us reveal the structure behind the importance of these factors.

The model enables assigning attributes to the nodes of the network, which we treat as the content of the nodes. Deriving relationships from the content of the nodes is important because these relationships can help us provide better recommendations. A possibility that is inherently supported by our model is to create grouping nodes based on the attributes of the persons or items. Figure 2 illustrates how these relations can be represented in the case of perfumes and perfume fragrance compounds. These attributes can be processed by various clustering algorithms or expert systems and can bind the person or item nodes to clustering or grouping nodes. By involving clustering methods and examining how their relationship type weight is related to the weights of explicit relationship types the usefulness of aggregated information versus high fidelity information can be revealed.

In Section 3 we mentioned that one of our goals is to introduce a distance measure that is a possible alternative to shallow text parsing. IJntema et al. [16] define a measure over textual content involving an ontology by examining how the direct contexts (one step away in the ontology) of the two words overlap. In our approach we will extend this one-step context of words inherently by spreading activation. The ontology will be stored in our knowledge base as a subnetwork with the distinguishing node type: “ontology”. To preserve the ontology relationships we introduce the following relationship types: “hypernym”, “hyponym”, “synonym”, “acronym” and “meronym” and will assign these types to the corresponding relationships. We will bind the item nodes to ontology nodes based on the result of text processing (for instance: TF-IDF). We expect that our spreading method will reveal hidden relationships between nodes, provides a more appropriate measure of textual items, and will act as a proper semantic similarity.

A frequently used relationship between recommendable items is provided by ARM. As our model is flexible, it can represent an association rule between two items as a relationship between the nodes representing the particular items. The attributes of this derived relationship represent the confidence and support of the association rule, and similarly to Lin et al. [22] its weight can be derived from these measures.

4.1 Spreading Activation

Web science has a strong influence on our approach. An often mentioned and illustrative method for the calculation of the importance of nodes in networks is PageRank algorithm [25]. PageRank is an iterative algorithm that can be explained by circulating a "fluid" in the network, which fluid represents importance (in its specific meaning) and will be accumulated at the influential nodes. The PageRank algorithm can be treated as a spreading activation algorithm.

Spreading activation is applied on networked data. Its goal is to define a similarity or distance measure among the nodes in a network. The interpretation of the distance

depends on the information stored in the knowledge base, to which it is applied. Spreading activation was introduced in 1983 [3] and has several applications, for example Sieg et al. [28] involve this technique to generate personalized web search results, Hochmeister [14] spreads expertise scores among topics in learners' models.

Our spreading activation algorithm starts with initial spreading values in the nodes. In the recommendation case for a particular person we will set its activation value to an initial constant value. The activation value of other nodes will be set to zero. Each iteration step a percentage of the activation value spreads out from each node to its neighboring nodes weaken by the weight values of relationships and relationship types. The activation of each node will be decreased by a factor, with the intention to reduce the static activation towards zero in time. Thresholding is applied to the activation scores and to the length of the activation path. The spreading continues until a termination condition occurs.

4 Conclusion

We presented a conceptual recommendation technique in the field of recommender systems with the involvement of network science. We introduced an approach that (i) aggregates multiple information sources, (ii) shows a refined hybridization technique, (iii) works at a higher level of fidelity, (iv) suggests an enhancement to shallow text analysis by integrating an ontology, (v) involves social networks and (vi) provides explanations that are close to human thinking.

We propose a novel hybridization technique and a possible alternative to collaborative filtering (in case of involving a social network), content based filtering (utilizing the network to measure item similarity) and knowledge based recommendations (a reasoning technique based on spreading). Deduced from its architecture our approach is not intended to be used as a constraint based recommender system. As mentioned in Section 4, in case a social network is not available, clustering methods can be applied to create clustering nodes of persons. By spreading through these clustering nodes our method can be treated as a CF approach. Similar to clustering nodes on persons, grouping nodes of items based on item properties can also be created. Starting the spreading from these grouping nodes leads to a case based recommendation technique.

In case of a huge network, activation spreading can be resource consuming. To avoid the resource burden we apply constraints to the spreading, which may lead to a decrease in the recommendation quality. Another possibility is to involve distributed computing, in which case the computations can be evaluated over the network in parallel.

To evaluate our approach we are primarily interested in its accuracy (precision, recall, root mean squared error) as also described by Jannach et al. [17] as a pure measurement of recommendation quality. Based on measures of precision and recall ROC curves of different relationship type weight configurations will also be examined as high level indicators.

Future work focuses on implementation. In the meantime we will be continuously looking for possible applications. As our method is strongly based on a social

network, we intend to introduce our method as a background service in an online environment. This is also a weakness of our approach, that in order to be able to test or utilize its capabilities a very heterogeneous database is necessary, which is probably not present at the moment.

Recommendation spreading in a heterogeneous network described in this paper and then back-propagating the error will help us finding the optimal weights for different relationship types. We expect that with the help of this technique we will reveal the importance factors of each information source types recommendations can be generated from.

Our approach maintains its knowledge base at a finer level of fidelity, while making it possible to aggregate the information. We expect that the forthcoming research with this technique will provide us with information about the optimal level of fidelity to maintain information at, for the generation of high quality, personalized recommendations.

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An Optimal Experience for People Social Online: The Perspective of Cognitive Absorption

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Abstract. "Have you tended to your Happy farm today?" This greeting has gain widespread popularity in Taiwan though mass media, indicating that visiting social networking sites (SNS) have become one of the most popular activities among people while surfing on Internet. Nevertheless, existing information speculating the reasons behind this popularity remains limited. Unlike traditional models that utilized the Technology Acceptance Model (TAM), this study adopts the notion of cognitive absorption (CA) and combines it with the perceived social interaction and perceived enjoyment to develop a research model to explore reasons for using SNS service. Empirical results showed that CA, though the perceived enjoyment, has a positive effect on intention to use SNS, and perceived social interaction has same effect too. The results of this study can improve understanding toward SNS service as well as provide suggestions to related entities regarding the trends of SNS service use.

Keywords: Social networking sites, cognitive absorption, perceived social interaction, Intention to use

1 Introduction

Social networking site (SNS) is a breakthrough Internet application in recent years that promotes interpersonal communication. SNSs first became popular among young adults and later spread to other social groups. The Pew Research Center conducted a survey of American young adults regarding their Internet use and found more than half of the respondents using SNSs [15]. Empirical evidence also shows that the number of bloggers rapidly declined; instead of blogging, people turned to SNS services [16].

Many operators have also set their sights on the commercial interests of SNSs for their ability in aggregating popularity. It is crucial for SNS operators to attract and retain users on the platform to generate revenue. While the majority of literature probes individual's SNS use by the Technology Acceptance Model (TAM) [14; 24], studies on why users stick on SNS service are still limited. Besides, the fundamental presumption of TAM was that individuals accept new technology from a goal-oriented, organizational perspective [5; 6]. Many online activities today do not necessarily come with specific goals or purposes; they could simply be "killing time" without specific objectives [12; 10]. Therefore, the behaviours of SNS users may differ from the

original presumption of TAM. Meanwhile, theoretical background is needed to explore why or how users stick to one particular SNS.

The study emphasizes on the individual's intrinsic motivation and proposes a research model to discuss users' participating in SNS. The model is developed by integrating cognitive absorption in psychology and perceived social interaction in sociology. Cognitive absorption, an expanded concept of flow, is chosen for its ability to conduct further exploration. This hybrid research model contributes to an inter-disciplinary integration of theories. Based on such perspectives, current understanding on why people use SNS could be enhanced, and the results can serve as a reference to operators in practical operations.

2 Theoretical background

2.1 Cognitive absorption characteristics

Csikszentmihalyi [4] first proposed the term "flow". It refers to the presentation of optimal experience perceived from the user fully concentrating in one activity. He defined the flow as "the holistic sensation that people feel when they act with total involvement." Any other perception unrelated to this activity is screened out and the individual will appear in detachment of time and space. When in the state of flow, an individual may have more voluntary interaction with his or her environment. The flow experience can bring optimal experience to individual who involves in specific activity. Scholars suggested that is why people are willing to repeatedly engage in certain activities, which is identical to people undergoing flow experience [4; 27; 10].

In a study on how the flow affects users' evaluation in computer-mediated environment, Webster et al. [27] proposed that the following antecedents would trigger state of flow: control, focus, curiosity, and intrinsic interests. They posit that the state of flow is influenced by the technology type, ease of use, and computer skill. In a follow-up study, Hoffman and Novak [9] proposed a structural model based on flow to study the using of WWW technology in marketing discipline. They posited that an interesting websites generally contain three characteristics: control, content, and process. These three features form the entire flow process of browsing websites. Therefore, if a website lacks one of the three features, users will feel bored or anxious, and then quit the site. On the contrary, when all three features are presented to a certain extent, consumers will experience flow, and then further stick on the site [9]. Relating work also support that flow has an incremental mechanism that would encourage users to replicate the behaviour [10].

Agarwal and Karahanna [1] investigated flow further and proposed the notion of cognitive absorption (CA). They posit that CA is "a state of deep involvement with software." The original notion of CA has five dimensions: temporary dissociation, focus immersion, heightened enjoyment, curiosity, and control. All these sub-constructs represent different forms of intrinsic motivations thus reflect CA as a second-order, abstract construct [22]. The empirical evidence indicates that these

sub-constructs, except control, form the CA experience of students surfing on WWW and e-learning [1; 22].

2.2 Perceived Social Interaction

The development of Internet offers various applications for people can using to communicate with each other, including e-mail, instant message, and the most recent, SNSs. Among these, the use of SNSs can allow users to meet people sharing common interests, with the purpose of developing romantic relations or maintain their social network. Such objectives achieved through SNSs have shown significant influence on the social interaction among people in the modern society [3].

In terms of other entertainment-oriented information technology (IT), the perceived social interaction brought by massive multiplayer online role-playing games (MMORPG) is critical to attract user playing online [12]. Hsu and Lu [11] also found that MMORPG-playing generates social cohesion- a kind of social interaction result, which can make assemble individual players into a group and fight together online. The more players interact with others in the same online game, the more loyal they are [10].

3 Research hypothesis

Figure 1 shows the research model, which CA is conceptualized as a more abstract, second-order level construct, which integrates with perceived enjoyment (PE) and perceived social interaction (PSI) later in the process. This session explain our selection of these factors and their positions at the model.

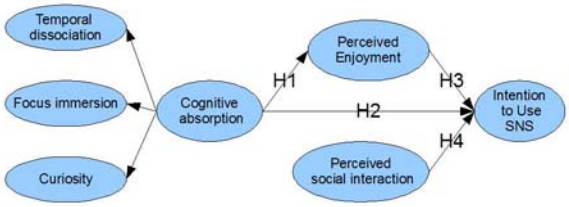

Fig 1. The research model

Users participate voluntarily in online entertainment-oriented IT to enjoy themselves, and obtain an optimal experience [12]. The optimal experience generate through using a specific IT has a close relationship with flow [7; 17]. When users achieve flow state, they are absorbed in the activity and totally control the whole environment. According to Csikszentmihalyi [4], there is an incremental mechanism in flow. People will repeat consumption behaviour if the environment facilitates the flow state [9]. At extreme levels, users become incapable of leaving a specific IT [10]. CA is an expanded concept of flow, which also inherits such an incremental mechanism and generates enjoyment for the use of IT and services [23]. The higher the user perceives

CA, the stronger the enjoyment will become. Hence, we hypothesized H1 and H2 as below:

Hypothesis 1: The state of cognitive absorption has positive effect on perceived enjoyment.
Hypothesis 2: The state of cognitive absorption has positive effect on intention to use SNS.

Davis et al. [5] posited that people are willing to commit efforts in certain IT, which could be induced by intrinsic and extrinsic motivation. Intrinsic motivation refers to committing an action because of interest in the action itself, rather than external reinforcement, while extrinsic motivation refers to committing an action because of its perceived helpfulness in achieving value [25]. They posit that perceived usefulness (PU) and perceived ease of use (PEOU) are extrinsic motivations, while perceived enjoyment (PE) is an intrinsic motivation in IT usage. In the study of intrinsic and extrinsic motivation for computer usage at workplace, the researchers discovered that PU has positive effect on individual using word processing package [13]. Similarly results are found by Lin el al. [17], who posited that perceived playfulness affects the use of WWW. Follow-up research also suggested that if an IT brings users with enjoyment, users would become profoundly involved in it [23]. SNS is an entertainment-oriented IT. It should have same characteristic as traditional IT. According to this, the study proposed the following hypotheses:

Hypothesis 3: The higher the enjoyment users perceive when using SNSs, the more willing they intend to use the platform.

Hoffman and Novak [9] adopted the two constructs, media interaction and reality to depict the characteristics of WWW. Users may apply media interaction to manipulate online media in real-time and obtain the extent of content provided; whereas reality is a characteristic of Internet media wherein the media information will render a rich level of stimulation on the senses. The social interaction created by the Internet media affects individual's using of IT. When individuals engage in online entertainment-oriented activity, they will perceive the company of people sharing the common interests rather than feeling alone in online environment [12]. The more intensive the online interaction is, the more willing users are to participate in the online activities [10].

Most of the friends we have on SNS are acquaintances from the real world. Users merely add these friends into their friend list and interact with them in the virtual world [21]. SNSs allow people to quickly learn of their friends' current status by sharing details of their lives via the platform. In addition, people can "like" or leave comments as responses, thus recreates interactivity. Therefore, the use of SNS can make users to perceive social interaction in the virtual environment instead of acting alone online. For this reason, the study infers that perceived social interaction is one possible antecedent of why people use SNSs. As people perceive more social interaction in SNS, they are more likely to blend into the scenarios with ease. This result is similar to the goal of online game design, which allows players to interact more with each other in order to attract players playing online [20]. Only when SNSs allow more personal interactivity will users be attracted to this service. This logic leads us to predict the following:

Hypothesis 4: Perceived social interaction of SNS has positive effects on users' intention to use.

4 Research method

4.1 Instrument development

The study conducted data collection through a questionnaire survey. With regards to development of the survey instrument, the items of constructs were based on prior literature and were modified to comply with the context of this study without affecting the premise of the original questions designed for different research contexts. As shown in Appendix A, there are 4 concepts with a total of 24 items. Among which, Cognitive absorption (CA) was an abstract construct adopted from Agarwal and Karahanna's [1] scale, including the concepts of temporal dissociation, focus immersion, curiosity, and enjoyment, but excluding the "control" aspect. Their study showed that the influence of control in the WWW service was limited. Perceived social interaction (PSI) was modified from the socializing items by Hou et al. [10]. Intention to use (IU) was measured using the scale described by Shang et al. [23]. The instrument was presented in a 7-point Likert scale or a 7-point semantic differential scale except for two sections used to collected data about user experience and demographic background. The questionnaire was first reviewed by two professors of marketing to validate the context. Before starting the regular survey, a pilot test was conducted with a total of 48 respondents to verify the instrument script is clear to respondents and well-formulated.

4.2 Data collection

We collected data via an empirical field survey with self-selected subjects on Facebook, which is one of the most popular SNSs in the world [21]. Researchers placed a message on some popular fans clubs of Facebook recruiting volunteers to join this survey. A "snowball" sampling method was applied in this survey. After users agreed to join, the research team mailed the questionnaire via post and sent a $3 gift certificate as rewards to the respondents after they have replied in order to enhance the data quality. It is crucial to highlight that only users with at least one Facebook account were considered valid respondents for this study. If individuals had more than one SNS account, they were asked to answer the questions based on their experience of using Facebook.

5. Results

5.1. Descriptive statistics

A total of 198 respondents were yielded. After removing those with unanswered items, the total numbers of responses were 171. Approximately 56% of the respondents were male. The majority respondents were between 21 and 30 years or older (50%), and 33% were 20 years or less. Approximately 53% of the respondents were students. Overall, the sample was consistent with "Taiwan online entertainment behaviour analysis" which indicates the study has a certain degree of representativeness [18].

Table 1. Construct reality analysis

Construct	Items	Path coefficient	Cronbach's alpha
IU**	3	0.93; 0.94; 0.91	0.94
TD	5	0.83;0.88;0.88;0.89;0.82	0.92
FI	6	0.84; 0.83; 0.79; 0.81; 0.75; 0.84	0.81
CU	3	0.96; 0.84;0.88	0.89
PE	4	0.85;0.86;0.85;0.83	0.91
PSI	3	0.89;0.88;0.92	0.90

** IU: Intention to Use, TD: Temporal Distortion, FI: Focus Immersion, CU: CUriosity, PE: Perceived Enjoyment, PSI: Perceived Social Interaction

5.2 Measurement model

The study utilized SPSS 17 to test the reliability of the survey instrument, and the result is shown in Table 1. The Cronbach's alpha of all concepts reached more than 0.8, meaning that they all reached a high reliability standard [2].

To verify the construct validity of the questionnaire, the study conducted convergent and discriminant validity. In the convergent validity, we adopted the criteria proposed by Fornell and Larcker [7]: convergent validity is reached only if 1) the factor loading exceeds 0.7, and 2) the average variance extracted (AVE) exceeds 0.5. The factor loading of all items is shown in Table 1. The AVE of all concepts is higher than 0.6, exceeds the 0.5 threshold, confirming that the questionnaire claims construct validity. Moreover, in the discriminant validity, we first calculated the AVE value with the factor loading of the standardized path coefficient generated by CFA. If the square root of the AVE of the concept in question is higher than the correlation coefficient between the concept and other concepts, it means that variances are better explained with that concept and that it has discriminant validity. The correlation matrix of all concepts is shown in Table 2.

Table 2. Construct related matrix

Concepts	IU	TD	FI	CU	PE	PSI
IU**	(0.926)*					
TD	0.101	(0.851)				
FI	0.020	0.249	(0.890)			
CU	0.033	0.195	0.109	(0.919)		
PE	0.322	0.104	0.364	0.191	(0.903)	
PSI	0.060	0.266	0.225	0.142	0.315	(0.851)

* Diagonal values in parenthesis is the square root of AVE

** IU: Intention to Use, TD: Temporal Distortion, FI: Focus Immersion, CU: CUriosity, PE: Perceived Enjoyment, PSI: Perceived Social Interaction

5.3 Structural model

Partial least square (PLS) is used to verify the research model. The analysis of PLS was conducted using the SmartPLS 2.0 program [19]. The model consists of a second-order construct, CA and two one-order concepts, PE and PSI. Based on the hypotheses, the three concepts will affect user's intention to use SNS. The analysis strategy involved a two-step process because CA is a second-order constructs. First, all of the subconstructs were subject to CFA. Second, the factor scores derived from the CFA of the subconstructs—including TD, FI, CU—were used to assess the structural model using the PLS technique. The first applied the CFA results to derive the standard path factors for these first-order variations, then path factors were used to calculate the factor score of each first-order factor. In the second stage, the factor score of each first-order factor was used as the observing score for second-order factors. The model for second-order was simplified into first-order model and reapplied with PLS to undergo analysis in order to obtain the path coefficients of all factor paths, thereby verifying the hypothesis.

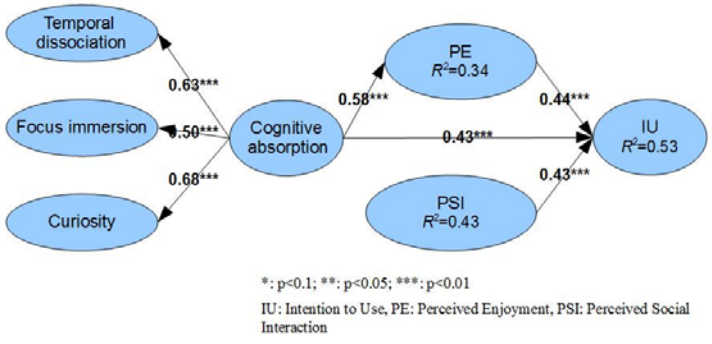

Fig 2. Results of PLS analysis

Fig. 2 shows the results of the PLS analysis and the path coefficient of the constructs. The predictive validity was evaluated by examining the *R* square and the path coefficient. The results indicate that our model explains 53% variance, which is

satisfactory. CA has positive effects on PE and IU, thus H1 and H2 were supported. PE also shows significant effect on IU, which supports H3. PSI has also positive effect on IU thus H4 was supported.

6. Discussions

This study applied a psychological state CA to combine with PSI and PE then develop a research model in understanding people using SNS. The empirical results showed that CA, though the PE, has a positive effect on intention to use SNS usage. Our findings contribute the following to theory development and practice.

The mainly exploration of IT usage had been conducted based on the TAM [23]. This study, on the other hand, attempted to apply CA, an intrinsic motivation developed in psychology discipline to explain entertainment-oriented IT usage. Such perspective provides another academic dimension of thinking in terms of IT usage. The empirical results showed that CA reflects of PE, which in turn provides satisfactory explanatory capacity for intention to use SNS. Our findings expand the knowledge of SNS usage and are consistent with prior studies which explored WWW and e-learning from the perspective of CA [1; 22]. Such results show that if SNSs can effectively generate CA, users will generate highly enjoyment, which can eventually stick on this service. Therefore, the SNS operators are recommended to enhance their users' CA experience by developing social games or applications to produce absorption and adhesion effects in the using process. By this way, people will be more willing to commit in SNSs and such state of CA will push people to further stick on SNS services.

High frequent social interaction in the real world is one element that enhances intimacy among people. The more frequent the social interaction is, the closer the relationship between each other will become. The empirical results showing perceived social interaction has positive effect on SNS usage. This result shows that social interactivity generated from SNSs is valued by users.

Nonetheless, the virtual social interaction brought by the SNS upon users still falls behind in great extent in comparison with interaction in the real world. This gap results from the more direct and genuine social interactions in the real world are further discussions.

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Appendix A. Survey Instrument

IU Intention to use
IU1 I plan to use SNSs in the near future *(SD…SA)*
IU2 I am inclined to continue using SNSs in near future *(SD…SA)*
IU3 I expect myself to continue using SNSs in the near future *(SD…SA)*

PE Perceived Enjoyment
The current SNS I use makes me feel:
EN1 Bored…Interested
EN2 Sad…Entertained
EN3 Bored…Stimulated
EN4 Painful…Entertained

PSI Perceived Social Interaction
According to my experience in using SNSs,
PSI1 When using an SNS, I can feel the interactions among friends *(SD…SA)*
PSI2 I reveal recent happenings around me to others on SNSs *(SD…SA)*
PSI3 Using an SNS enables me to keep in touch with friends I already knew in the real world *(SD…SA)*

CA Cognitive Absorption

Please assess the perception brought by current SNS according to your using experience.

CA1 When I use SNS, several hours would have passed before I realize the time *(SD…SA)*

CA2 When I use SNS, sometimes I will lose track of time *(SD…SA)*

CA3 In the process of using SNS, I feel time flies *(SD…SA)*

CA4 It takes me more time to spend on SNS activities than expected *(SD…SA)*

CA5 Usually, I spend time on SNSs exceeds my planning *(SD…SA)*

CA6 I can fully concentrate on SNSs *(SD…SA)*

CA7 I fully concentrate on the website when using SNSs *(SD…SA)*

CA8 When using SNSs, I focus on the tasks in execution *(SD…SA)*

CA9 When using SNSs, I am easily distracted by other things *(SD…SA)*

CA10 When using SNSs, I can usually focus *(SD…SA)*

CA11 When using SNSs, I often forget what I am supposed to do *(SD…SA)*

CA12 Using SNSs could inspire my curiosity *(SD…SA)*

CA13 Using SNSs can satisfy my curiosity *(SD…SA)*

CA14 Using SNSs can inspire my imagination *(SD…SA)*

SD: Strongly Disagree; SA: Strongly Agree

Business Challenges for Services Based on New Technology - Analysis of IoT Service and Mobile Payment Cases

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Abstract. New services based on the Internet of Things (IoT) are currently being proposed in several industries. Other services such as mobile payments and ticketing have been implemented many years ago. But even with advances in new technology, most of these services do not get to be deployed on a large scale. For this reason, we consider that the main obstacles are to be found in the business domain. These services need to be integrated in the overall user and service context. Therefore, business models must be adapted to integrate mobile payments and IoT solutions in different services. This study presents data from key cases in order to analyse how successful services have been accomplished and to identify barriers. Key aspects here are the value of the services, how the value network is organized and what actor that takes leading positions.

Keywords: Business model, Cost savings, End-user value, Internet of Things, Mobile payments; Parking services, Smart cities, Smart energy, Value network

1 Introduction

The improvement in technology, together with the growing need in society to have access to real-time information, has extended the use of communications beyond the exchange of information between human users. The Internet of Things (IoT) refers to networks of sensors and devices used for many applications in order to optimize resources and services. Determining effective business models for IoT services in different sectors in order to create value from this technological shift is an arduous task [1]. But there are key challenges that still need to be addressed [2]. For instance, current deployments are typically dedicated to a single application where each solution exists in a vertical market [3]. Moreover, services are often part of a complex value constellation where the traditional provider-customer model does not apply [4].

Telecom and broadband operators face their own obstacles, since their traditional revenue stream is based on high amount of traffic per users. But IoT devices usually generate very low traffic and operators can hardly base the charging on the traffic volumes, hence alternative revenue models needs to be considered [5]. In addition, consumers can also be part of the aftermarket and deliver usage data and feedback to manufacturers and service providers in the co-creation of values [6], [7].

There are multiple motivations that drive mobile payment and IoT services. For mobile operators, there is an increased interest in the IoT market since there is a current decline of voice revenues [8]. Besides, adopters can appreciate declining costs in hardware and network connectivity. For example, in the e-Health sector, there is an emphasis to change from episodic-care to continuous-care services by remotely taking care of patients at home instead of the traditional care at hospital facilities [9]. In addition, large scale applications related to smart metering, automotive and e-Health count with strong incentives from public funding [10].

New services based on IoT and Machine-to-Machine (M2M) communication solutions are proposed for smart homes, smart cities and smart energy systems. But one type of services based on communications with machines (more H2M than M2M) has been around for many years - mobile payments and ticketing. In this area many solutions have been proposed and there have been many pilot projects, especially when combined with Near Field Communication (NFC) technology. However, although the technology is available mobile payment services do not take off at large scale in developed countries. Mobile payment and ticketing solutions exist in some specific areas like public transport and parking but no common solution similar to the bank card payment system can be identified.

Although the technology for mobile payments and IoT services are here, we cannot see any large scale take-off of commercial services based on these technologies. We believe that the reasons behind it are to be found in the business domain. Technical solutions for these services represent only part of the overall service and business context. Mobile payments and IoT type of services can hardly be offered as a standalone service, they need to be integrated in the overall and service context. This requires knowledge about the core business, e.g., public transport, power distribution or facility management; knowledge that telecom companies usually do not have.

In order to analyse these challenges for the adoption of mobile payment and IoT services based on new technology, the main research questions with sub-questions are the following:

- What type of values and benefits can be identified for different services?
    - Can the value be estimated?
    - Are these values large or small?
- How is the value network organized?
    - What actor or actors take leading position(s)?

This study summarizes data gathered from cases, including mobile SMS payment, mobile parking ticketing, smart grids, smart cities and e-home care.

The outline of the paper is the following: next, related work on mobile payment and IoT techno-economic analysis is summarized. The data collection process and our analysis approach are explained in Section 3. In Section 4, five study cases related to mobile payment and IoT solutions are introduced and finally, discussion and further considerations for future work are presented in Section 5.

2 Related Work

Business models and scenario proposals are focused on generic or future markets and the role of new actors in IoT services [11], but not on how IoT solutions can be seamlessly included in existing working services. Most proposals do not consider the complexity in established businesses, the actors needed and the actual benefits that can be achieved. IoT solutions that exist today are those where the value is clear and convey enough benefits by themselves to allow deploying a complete vertical solution, from connectivity to service delivery; this deployment strategy may lead to duplicated infrastructure and high implementation costs. Recently, there has been a strong focus on the benefits of a shared communication infrastructure [3]; based on the proposition that if a common infrastructure can be used for different IoT applications, the initial investment costs will be reduced and the range of future business opportunities will be expanded.

Moreover, the IoT vendor market is extremely fragmented and solutions must be designed for each specific customer. Many small developers attempt to fill the gap with their own solution, leading to high design and deployment costs and poor economy of scale. Major Standards Developing Organizations (SDOs) are focusing on the need for globally agreed specifications that allow a seamless integration of IoT solutions. Additionally, network operators are actively entering the market with the creation of IoT business units and working directly with partners such as system integrators and other operators to expand their footprint [12].

A number of papers on mobile payment market and provider factors listed in [14] describe how to analyse mobile payments and include descriptions of scenarios, business model and analysis frameworks. A framework for business model analysis of mobile payment services are presented in [15]. Analysis of different types of "market failures" for mobile payments can be found in [16], [17]. Discussion on new payment solutions and technologies in a social, institutional, and business model context is provided in [18]; the business performance of Google, Apple and Square as "new comers" in the mobile payment business is analyzed.

There is a common view of the benefit of infrastructure sharing and global partnerships, but all the major efforts are still oriented in connectivity instead of being service-driven [13]. Most of the large scale projects are pilots that prove the benefits but fail to become widespread implementations [9]; deployed solutions count with their own tailored approach but there are few ready-made solutions that are simple to integrate and are dedicated to particular industry segments.

There is a research gap in the quantification of values and benefits that can be achieved with large scale applications such as smart cities or smart grids. Another gap is the understanding in what service settings are IoT services provided. In the case of mobile and broadband services, "operators" used to be the main provider of the service but, for IoT and payment services, a service provider (e.g., a parking operator or energy company) or a merchant have the main customer relation. There is also a need to study whether if successful cases can be replicated in different markets this is fundamental in order to achieve scalability and economy of scale. Lastly, the lack of inter-application coordination remains as the most difficult bottleneck to overcome.

3 Methodology

The starting point for our analysis approach is the business model framework proposed by Chesbrough and Rosenbloom [19], with the following elements: value proposition, market segment, cost structure and profit potential, firm organization and value chain, competitive strategy, and position of the firm in the value network. In the analysis, specific aspects of these business model elements will be highlighted:

- For the value proposition, the key aspect is the end-user value;
- For cost-structure and profit potential, the focus is on cost savings;
- For the value network and position of the firm, three aspects are highlighted, indicating what actor has the dominating position in the value network:
    - Control of the customer interface and billing relation;
    - Business agreements with merchants and service providers;
    - Control of the service platform.

For the market segments, it has been identified that services are provided in a business to business to consumer context (B2B2C), indicating that both consumers and businesses are customers of the payment or IoT services. A similar structure is proposed in [20], where the analysis focuses on what actor controls the customer interface and the service platform. The analysis of actors, roles and relations in the value networks is closely linked to the "markets as networks" approach [21], [22]. The analysis of "values" is also supported by the contributions in [23], [24]; where actors create value in networks rather that in a "value chain".

Input from workshops and interviews have been used to verify the initial findings from the cases. A workshop was organized November 2011 with 25 participants from Swedish electric power companies, mobile operators, ABB, Ericsson and NEC. Interviews were held with representatives from Vattenfall, ABB, Ericsson and the mobile operators Telia, Telenor, Vodafone and Wireless Maingate.

Within the EIT ICT Labs action line Smart energy systems a workshop was organized October 2012 on "Smart grid value modelling and business models". The 20 participants were from Ericsson, Alcatel-Lucent, SICS, DAI Labor, Fortiss, Siemens, TU Berlin, TU Delft and KTH. In November 2012 a workshop on business models for Stockholm Royal Seaport was organized with participants from Acreo, e-Centret, Ericsson, the city of Stockholm, Swedish ICT, SICS, Stockholm School of Economics and KTH. At this workshop, useful results from projects on e-buildings and e-home care were presented [25]. Two workshops on business models for IoT were organized March and April 2013 with participants from ABB, AssaAbloy, Dual Tech, Electrolux, Ericsson, Maingate, Sandvik and G4S. In addition, interviews have been done with AssaAbloy, Ericsson, IBM, Volvo and Vodafone.

In the area of mobile payments, interviews have been made in 2012 and 2013 with: parking operators in Stockholm, Västerås, Linköping, Gothenburg and the regional public transportation companies in Stockholm (SL), Gothenburg (Västtrafik), Malmö (Skånetrafiken), Uppsala (UL) and Linköping (Östgötatrafiken). Between 2011 and 2013 several meetings and interviews have been organized with providers of mobile payment, ticket or security solutions and services; Accumulate, Mobill, Nets, Payair, PayEx, Samtrafiken, Swedbank, Telia, Tele2, Unwire, WyWallet.

4 Cases

In this section, selected cases of different IoT and mobile payment applications are described based on participation in related projects or in-depth studies of the cases.

4.1. Parking using mobile payment services and subscriptions

For payment of parking services, two types of mobile solutions exist in Sweden; SMS payments and mobile parking subscriptions. The parking subscriptions are provided by Mobile Parking Payment Providers (MPPP) like EasyPark and Tele-P which have agreements with parking operators. In order to use the parking subscription, the user needs to register to the MPPP. Upon registration, the user provides registration number of the cars, a mobile phone number, a credit card account and billing address.

In order to use the service, customers call or send a SMS to the MPPP when a parking session starts and ends. The parking session is registered and the "ticket" exists as a data record in a MPPP database. The parking company can check parked cars with their registration number and see if the there is an ongoing parking session.

The end-user values are related to the benefit from the "cashless-ness", no risk to get a parking fine and to only pay for the true parking time. For companies, these solutions imply less administration work due to the aggregated monthly bills. Parking operators report costs savings with a reduction in the number of ticket machines and lowered operational costs due to less maintenance and less cash handling [26].

This type of solution is interesting since it is a mobile payment solution that in which banks and mobile operators are not involved in the service provisioning, as shown in Fig. 1. The service is provided by an intermediary actor that has knowledge about parking services and establishes business relations with the service providers, e.g., the parking operators, garages and municipalities. The payments by end-users are done using a separate payment solution that does not include billing through mobile operators. The MPPP companies control the customer interface and the service platform, i.e., the user accounts, the mobile application and the agreements with the parking companies.

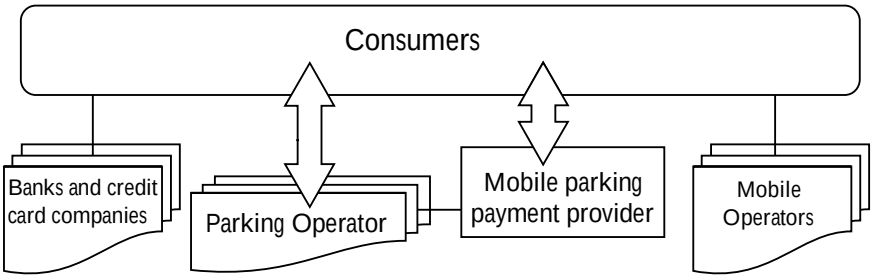

Fig. 1. Actors and business relations for mobile parking subscriptions

4.2 Transition of SMS payment service in Sweden

Mobile operators and mobile service providers, like SMS aggregators and ticket providers, have until now been the main actors providing SMS ticket services in Sweden [26]. SMS ticket providers and aggregators together with mobile operators formed a "provider team" for SMS payment services. An agreed way to do the business was established in which merchants and service providers wanting to offer SMS payments contacted some mobile service providers. Of course, many business agreements were needed for the "provider team" but it was easy to use for consumers. From the consumers perspective the complexity was low, consumers used the SMS premium services and were charged using the mobile phone bill. Mobile operators held the customer relation with end-users through their subscription, see Fig. 2.

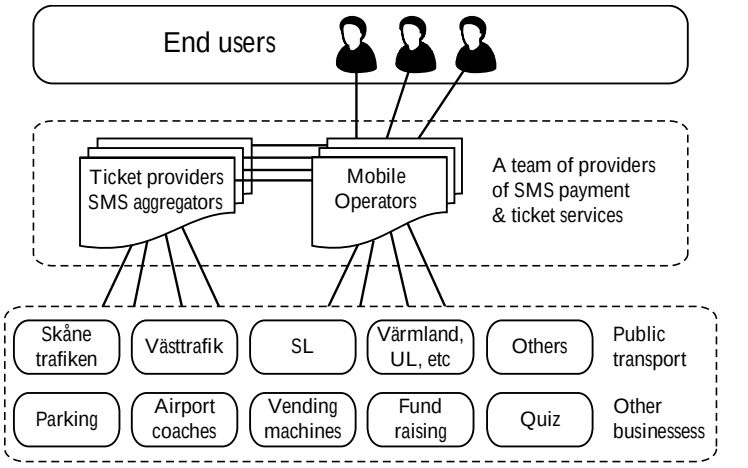

Fig. 2. Traditional model for SMS tickets, with direct relation between mobile operators and end-consumers for the billing process.

Due to financial regulation, mobile operators are no longer allowed to handle transactions for non-telecom services without being a payment provider [27]. The Payment Services Directive (PSD) states that payment providers need to know the identity of the person doing the transaction, which implies the registration of pre-paid customers. In order to avoid being payment providers and to avoid non-telecom items at the phone bill, the Swedish mobile operators formed a joint venture (4T Sweden) to offer mobile payments services. This service is called WyWallet[1] and consumers need to register and then get a separate bill or are being charging using a credit card.

For services like airport coaches, fundraising and parking, the traditional SMS payment services have been migrated to WyWallet. However, this joint venture has not been involved in most of the public procurement of new ticket and payment solutions initiated in 2012 by Swedish local transportation companies. One exception is Skånetrafiken, where WyWallet provides the payment solution and Plusdial the SMS ticket solution.

[1] More on the webpage (In Swedish) http://wywallet.se/

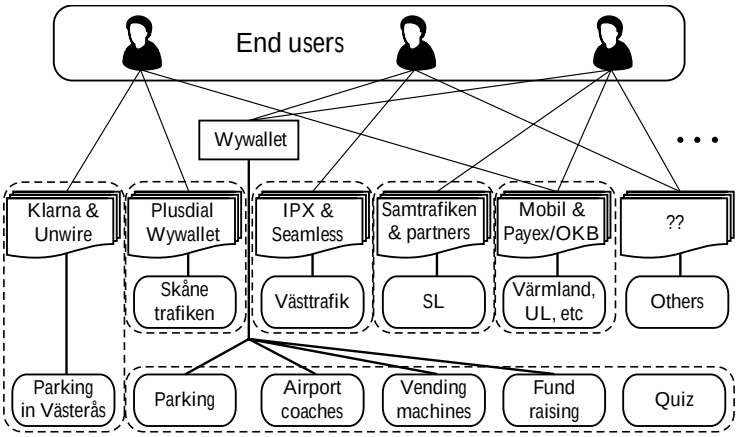

Fig. 3. New model for SMS tickets, with the different payment accounts for the consumer.

The local transportation companies are public organizations that need to make official procurements including tender evaluation of competing offers. WyWallet decided not to bid for several of the procurements of SMS ticket and payment solutions. The outcome of this process is interesting since other actors (Mobill, Seamless, Samtrafiken, PayEx, and IPX) got the contracts for SMS payment solutions. The situation after February 2013 when these new actors have entered the SMS payment business is illustrated in Fig. 3. We can see a fragmentation of the mobile payment service market with many local solutions and new constellations.

There is no positive value for end users because the service complexity has increased. In order to use the new SMS tickets users need to register new accounts. This has resulted in a decrease of SMS payments with 50 - 90%. The customer interface control and the payment service solution are very clear and have moved from mobile operators to the new providers of the new separate charging solutions.

4.3 e-Home Care – the case Västerås

The Swedish town Västerås is developing an e-home care service for elderly people. The home care customer needs assistance several times per day but, with ICT technology and video communication, some of the daily physical visits can be replaced by a video conversation with the home care staff. It turns out that the video conversations work fine for some tasks, e.g., checking medication intake, reminders and as a first contact in case of alarms. However, this solution requires that the customer knows the person on the other side of the call. The town of Västerås estimates that 300 e-home care customers will result in an annual cost saving of 2 M€ while providing the same quality of service [25].

However, the traditional business model for Internet access did not provide a feasible solution, i.e., less than 30% of people of age above 70 years have Internet connection at the homes; they are not used to it and are not willing to pay for it. For the ISPs, the service represents a small and price sensitive market segment; in addition, these customers require a lot of help and customer care.

Hence, a new business model and offer was developed for the e-home care service. The customers do not need to pay for the broadband subscription; instead, they are offered e-home care as part of the overall home care package. The IT department of the town of Västerås buys broadband connectivity capacity and acts as service provider for the home care authorities and is fully responsible for the technical solution [25]. A transition can be seen from a situation with "home care service supported by ICT" to "an ICT service integrated into the home care service". Both the control of customer interface and the service platform moved from the ISP to the home care provider.

4.4 Infrastructure for smart cities – the case Stockholm Royal Seaport

The new Stockholm Royal Seaport urban district is under development in eastern Stockholm. Key aspects are sustainable living, business and recreation. Public utilities and services are to be provided by actors form different sectors, e.g., energy, telecom, media, healthcare and transport. One challenge that has been identified is the fact that traditional actors tend to think in terms that "our services" should be provided by "our infrastructure", although the services are similar and the users are the same. This leads to multiple service infrastructures, as shown to the left in Fig. 4.

This challenge has been identified and discussed by ICT and telecom companies. There are concerns on fragmentation that a "stovepipe" approach could generate; leading to unclear definition of benefits and values to end users. Therefore, these actors propose one common shared infrastructure (see right hand side in Fig. 4) that could be more cost-efficient and open to opportunities to markets that are currently restricted by the entry investment costs in infrastructure.

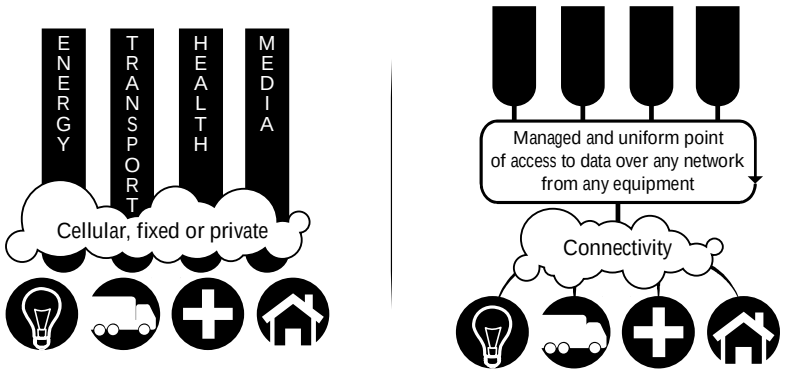

Fig. 4. Separate infrastructures for each sector (left), shared and open infrastructure (right).

This approach entails major technical and business challenges but the consortium of the project is actively working on the determination of requirements, architecture, roles and specifications necessary to adapt and develop the shared communications infrastructure according to the needs of all the actors involved. Nevertheless, even if the service platform and infrastructure is shared, service providers want to control the customer interface. Hence, a fragmentation of ICT and IoT services for smart homes and cities is expected, even if these services are technically very similar.

4.5 Smart Energy Systems – Value Modelling of Smart Grids

Business and value modelling of smart grids were done in 2012 within the EIT ICT Labs Smart Energy Systems Action Line. A cost-benefit and a value and business modelling analysis of smart energy concepts were done in an overall business context. Up to this date, no public reports have been released for the project, but the work it is based on research similar to [28]. For households, the findings indicate that savings from "smart consumption algorithms" are quite small; only 10% reduction in consumption. Such small savings are not able to drive the adoption of these services by themselves. Lower energy consumption corresponds to less income for energy companies and it is hardly a driver for energy providers.

For smart charging of Electric Vehicles (EVs), the "hard" value is small, around 10€ per month in savings for consumer, depending on the driver profile. However, the "soft" value is much higher, an incentive to buy an EV and combine it with private system for renewable energy generation. The study also reveals a number of system failures in the energy production strategy. For example, the price strategy in Sweden does not support consumers to move load to where the energy is "greener"; on the contrary, the lowest price is when energy with high CO_2 emission is imported.

As for the smart meters for electricity and gas, most countries lack of clear regulation to incentive rollouts. Perhaps the only clear regulation comes with the UK mandate for smart meters, expecting to reach most of the population by 2019. The connectivity provision for the meters is regulated and the energy market is based on retailers that allow firms to provide the service on a shared IT infrastructure, easing the adaptation the smart metering initiative. Many options for provisioning of these services can be identified; energy companies, telecom companies or third party actor can manage the service platform. But, it is unclear if energy companies are willing to let other actor take care of the customer interface.

5 Summary, comparison of cases and discussion

After analysing the cases we can identify some similarities and patterns, especially when it comes to values and benefits. The recurrent appearance of the same obstacles and patterns in different scenarios also implies that some conclusions can be drawn about the business model and the position of actors.

For the mobile parking and e-home care cases, the beneficial values to end-users and providers are large and clearly identified; hence they represent drivers for adoption of these services. For the smart city and smart energy cases, the benefits are unclear, or estimated to be very small. The new SMS payment services requiring new registration represents a negative end-user experience, the usage has decreased between 50% and 90%. Hence, no clear drivers can be identified for these latter cases, as seen in Table 1. The facts that systems are deployed and work technically as expected have low significance when it comes to adoption of these services.

For the mobile parking and payment cases we can, besides the service providers and mobile operators, identify a number of intermediary actors; such as the mobile parking payment provider, payment providers and SMS ticket providers.

Table 1. Comparison of cases based on business model elements.

Business model aspect	Mobile parking	"New" SMS payments	e-home care service	Smart city infrastructure	Smart energy
End user value	Positive	Negative	Same	Unclear	Small
Cost savings	Yes	No	Large	Unclear	Small
Control of customer interface	Payment provider	Payment provider	Home care authority	ISPs, Utility companies	Unclear
Relations with services providers	Payment provider	Payment and ticket provider	-	-	Unclear
Control of the service platform	Payment provider	Payment and ticket provider	Home care authority	Unclear	Unclear
Segments	Consumers Businesses	Consumers Businesses	Consumers Businesses	Consumers Businesses	Consumers Businesses

For the rest of the cases, the main actors are different types of service providers. From Table 1 we can see that the intermediary actors have a strong position since they clearly control both the service platform and the relations with end-users and service providers. The home care authority has a clear role and a strong position as service provider. For the smart city and smart energy cases the roles are more unclear; ISPs and mobile operators do not take any clear roles and in these cases they do not contribute at all, the same pattern is evident from other examples [26].

For traditional mobile and broadband connectivity services, an "operator" (mobile operator or ISP) is the key service provider; as seen in the left part of Fig 5. This is different for payment and IoT services. Payment services support the core business of merchants and service providers like parking operators, local transport companies and utility companies. From the operator perspective the end-user is the customer of some other actor. We believe that this should be applied to IoT services as well. However, many of the proposed IoT service concepts give the impression that it is an "operator" (or a technology provider) that provides the IoT service directly to the end-user; left part of Fig 5. We argue that IoT services are provided as part of another service. Hence, IoT solution and technology providers, ISPs and mobile operators need to be positioned as supporting actors to the provider of the core service; right part of Fig 5.

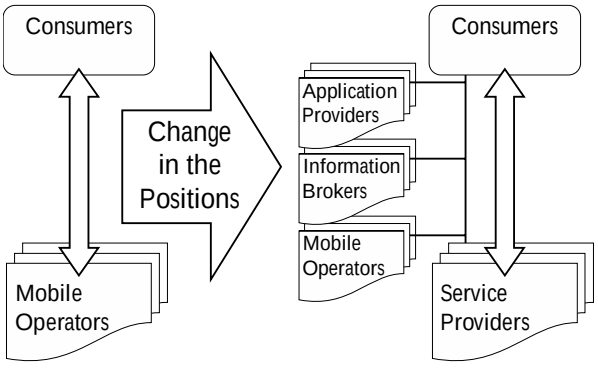

Fig. 5. Change in the position of firms and the relation with end-consumers.

6 Conclusions

Mobile payment and IoT services hitherto have been strongly focused on the use of new technology and not so much in the service delivery. There are also many initiatives on smart cities, smart houses, smart homes and smart energy systems, but no large scale adoption of the service or concepts can be identified. In this study, we analysed potential obstacles and barriers for mobile payment or IoT services based on new technology. The study is based on five cases from different sectors; parking, public transport, home care services, smart city infrastructure and smart energy.

The main findings are that successful services are characterized by clear and large added values for both end-users and service providers; for less successful services, the added value is low or unclear. For successful services we can also see clear distribution of roles among actors where typically one actor takes the lead. Unclear roles or a multitude of providers leads to fragmentation and/or increased complexity for end-users. In the studied cases, intermediary actors have a strong position since they control both the service platform and have relations with both end-users and service providers. In the investigated cases, ISPs and mobile operators have a weak position or are not involved at all in the service provisioning.

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How friendship network works in online P2P lending market: evidence from PPDai

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Abstract. The objective of this paper is to study how friendship network affects economic outcomes in online People-to-People (P2P) lending market. We define different friendship types by using a comprehensive dataset on transactions and friendship networks from PPDai.com, the most prominent P2P lending market in China. We further examine what types of friendship can result in better transactional outcomes, including increase the probability of successful funding and lower interest rate. Our study finds that there are significant relationships between friendships and probability of successful funding, friendship and interest rates on the funded loans. Furthermore, the quality of the friendships is critical to determine the transaction outcomes, which are more important than the quantity variables in PPDai.com market. We discuss the implication of our finding for the design of more effective online P2P lending market.

Keywords: People-to-People (P2P) lending; friendship networks; information asymmetry; PPDai.com;

1 Introduction

As a new form of E-commerce, online P2P lending market allows individuals to lend and borrow money directly among each other without an intermediating bank or credit institution [1]. It provides versatile online services for reallocating small funds among people, particularly for those who have difficulties in accessing traditional financial markets due to their poor credit, which could help to utilize the large number private idle capital efficiently. Now, there are more than 30 P2P lending marketplaces in more than 10 countries worldwide, these markets have enjoyed significant growth since their launch in 2005 [2]. P2P lending market differs from traditional lending markets in two ways: Anonymous online interaction and imprecise credit information (hard information) which make information asymmetry problem more acute in there; Then, P2P lending marketplace encourages lenders and borrowers to use social network (soft information) to alleviate the shortage of hard information in credit, and to mitigate information asymmetry.

The effectiveness of social network in online P2P lending market, including friendship, endorsement, and group affiliation has been intensively studied [e.g., 2-7]. However, social network lack of legal responsibility (do not impose joint liability) in P2P lending market. Also, for its virtual nature, online social network is easy to build

and not strong as offline social network. According these negative aspects, the effect of social network on transaction outcomes is not straightforward. Some social connections may be good signal of the borrower's payment ability, while some ones may be worthless or even gaming instead of real network [3]. Therefore, the effectiveness of the social network in online P2P lending market remains an empirical question.

In the literatures that focus on analyzing the role of social network in P2P lending market, most of them are using public Prosper dataset in last five years to build the linkage between social network and funding outcomes [e.g., 2-7]. According to specific form of social networks in Prosper.com, they discuss group variables and friendship network variables together. And most of empirical results show that group variables are more critical in Prosper.com to decide the transaction results. While, only a few publications focus on the friendship network and discuss different effects of different friendship types on the economic outcomes in P2P lending market. For our best known, [4] is the only example. Lin (2013) studies the relation between the online friendship and transactional outcomes by using the Prosper dataset. He argues that lender may use friendship serve as an informational cue of a borrower's credit quality, and find that borrowers with friends are more likely to have their loan requests funded and that these loans have lower interest rates. Their angle or dataset is different from ours though.

In this study, we focus on how friendship networks affect economic outcomes in the online P2P lending market by using the comprehensive dataset on transaction and social network from PPDai, which is the largest online P2P lending market in China since its official launch in 2007. Compare to the rarity of friendship variables from public Prosper.com dataset, the unique PPDai.com data with comprehensive friendship information used in this paper can help to deepen our understanding of the relationship between friendship network and economic outcomes in P2P lending market. The design of PPDai's lending platform is very similar to other online P2P lending marketplaces, While, the social networks variables are observed different: In Prosper, members create and maintain social networks based on two aspects: friendship networks and group affiliation networks; In PPDai, only friendship network works as "soft information" to mitigate information asymmetry. Therefore, this pure friendship network set up characteristics of social network allows us to find out more accurate results by eliminating noises from group affiliation network variables which have been proved more important in prior studies [e.g., 2-9]. Furthermore, to gain more insights into the role played by friendships, we define different types of friendship and argue that not only the quantity but also the quality of the friendship is essential for determining efficiency of transactions in online P2P lending market, which include increasing the probability of successful funding and lower interest rates on funded loans.

All these above inspire us specify our research questions as follows:

1. Dose friendship network matter in online P2P lending market?
2. What the relation between the friendship network and economic outcomes on the P2P lending markets according to PPDai dataset?
3. What types of friendships are more important than others affecting transaction results?

We claim that this study makes several contributions to both academia and practice. First, based on our literature research, the majority of research regarding P2P lending market is focused on the social network variables, which are including group variables, friendship network variables and endorsement, affecting transaction outcomes. Almost all of them find out that social network, especially group variables, can alleviate the information asymmetry problem and result in better economic outcomes in P2P lending markets. While relatively little research focus on the effect of friendship network except one [4]. Their angle and dataset are different from ours, though. Therefore, for our best knowledge, the analysis of friendship network in PPDai discussed in this study becomes a unique work from previous researches. Second, according to the previous empirical literatures, most of them discuss on the public data provided by Prosper.com. While, there are very limit publications regarding the analysis of Chinese online P2P lending markets. [10, 11, and 12] are examples. The culture constitutes the broadest effect on many dimensions of human behaviors [13], including that in the online market. China has its exclusive culture from other countries, not only in the language and history but also in religion, physical contacts, and social behavior (Liu 2002), which essentially change the ways people make friend online or offline. These different inspire us to diversify research outcomes about the efficiency of social network in online P2P lending markets, and to investigate how different friend types affect differently on economic outcomes.

The rest of this paper is organized as follows. Section 2 reviews the literatures motivating our work. Section 3 describes our research context and then the data set used in this study is introduced in Section 4. Section 5 discusses the methodology and empirical results are discussed in Section 6. Section 5 concludes this paper.

2 Literature review

The relationship between social networks and economic outcomes has been the subject of much attention for researchers in information science. A social network is a social structure made up of a set of actors (such as individuals or organizations) and the dyadic ties between these actors. Social capital theory suggests that economic behavior should not be analyzed without considering constrains of ongoing social relations between individuals [14]. Nahapiet and Ghoshal (1998) identify three dimensions of social capital, namely structure, relational, and cognitive [15]. The structural dimension describes whether and how people or entities are connected. The relation dimension of social capital describes the set of personal relationships that people have developed through interactions. The relational dimension focuses on the quality of relations. The cognitive dimension relates to resources providing share representation, interpretations, and systems of meanings. We argue that structure dimension plays a leading role to determine social capital at first. And relation dimension, especially when the structure is stable, has an increasing influence over time to represent social capital.

Following the literature of P2P lending, we find that it has received only limited attention on discussing the quality of social network. Much of existing literatures focus on the impact of borrower's social capital/social networks (group variables,

friend relationship variables and endorsement) on loan performance [e.g., 2-9, 16-17], while a little relates to how social network works in its different ways. What's more, most previous research uses the public data provided by Prosper.com, headquartered at the US, to verify how social capital helps borrowers obtain loan with an acceptable interest rate, and how they are motivated to make repayment. Comparatively, Qiu et al. (2010; 2011) find that a borrower's social capital could significant enhance her funding probability in Chinese online P2P market based on the transaction data from PPDai.com, and borrower's social capital in the Chinese market (PPDai) is much more influencing than in the US market (Prosper) by comparing the empirical results.

In this paper, we focus on the quality of friendship in P2P lending markets. High quality friendship, represented by high credit scores and high successfully history records, can help to mitigate the information asymmetry in P2P lending market. High quality user in P2P lending market involved in high social cost and is more likely to keep good credit score and not to default. So, those kinds of users' behavior are more trusted for both borrowers and lenders in the market. And a higher level quality friendship is a stronger and more creditable signal to reduce information asymmetry between borrowers and lenders involved in one list.

Lin et al. (2013) is the first study which particularly looks at the relationship between friendship network and transaction outcomes by using Prosper data [4]. They argue that, in P2P lending market, lenders may use friends as a signal because friendships serve as an important cue of a borrower's credit quality, and they find that borrowers with friends are more likely to have their loan requests funded and that these loans have lower interest rates. And, friendships lower default probability and the transaction outcomes show a striking gradation along friend type, with greater effects when friends have roles and identities that signal better credit quality.

For friendship network analysis in online P2P lending markets, we think PPDai is a good sample for its unique friendship network set up in the marketplace. The dataset contains the detail of friendship type and some other variables are not included in the public Prosper data. In summary, the work done by this study could be a contribution to the practical implementation for P2P marketplace to understand friendship network which could help both members and market to improve the efficiency of transaction results, as well as a contribution to the theoretical implementation for exploring the relation dimension of social capital. Furthermore, previous P2P literature has largely been limited to the western context by utilizing Prosper's public transaction data [18], except for some works done by Qui et al.[19]. While the culture constitutes the broadest effect on many dimensions of human behaviors [20], by doing empirical analysis of Chinese P2P market, this paper also presents diversified research outcomes about the same type of market but in a different country with an enriched and unique culture.

3 Research Methodologies

3.1 Market setup

As a new form of e-commerce in latest few years, the platforms of P2P have quit similar business model with each other. Being the leading P2P marketplace, PPDai has over 500,000 registered members and 100 million RMB in funded loans since its official launch in, which could represent the P2P market in China. A transaction in PPDai starts with a loan request listing (named as listing) initiated by a borrower. A listing can be funded by more than one lender. Once a lender starts to bid, the amount she bidding is withheld during the bidding process. If the listing ends with enough bid amount to meet the requested loan amount, the loan is successfully funded and the borrower will receive the loan in the requested amount; if the listing expires without enough bidding amount or is withdrawn by the borrower, the listing will be canceled and the withheld amount of funds by the bidding lenders will be released.

The transaction in this market is conceptualized as a sequential process. First, a borrower who wants to borrow money in the market initiates a listing with systematic decisions. A borrower's decisions in the P2P market are complex because she needs to make trade-off among several loan conditions, e.g., the interest rate (cost of the loan) she is willing to pay for lenders, and loan amount. Presumptively, if the borrower delineates a higher interest rate or smaller loan amount, she could have a higher funding probability with a higher cost. On the contrary, if the borrower delineates a lower interest rate or larger loan amount, she could obtain the loan with a lower cost but in the risk of lower funding probability.

The transaction process is shown in the following Fig. 1.

3.2 Dataset

For a listing, four kinds of information are available on the website for potential lenders: self-reported information which refer to the personal information (age, occupation, income, location, gender, education status, marriage certificate, national ID card, cell phone number, online video footage, diploma and degrees, professional certificates, and others); listing characteristics (borrow amount, bid number, bid type, repayment type, borrow maximum interest rate, loan duration, loan category and others); hard information included in credit score, credit grade and income; and the soft information conveyed by PPDai-specific friendship network variables (number of friends, friend type, friend credit, friend reputation, number of friends' friends, friends' friend type, friends' friends type, friends' friend credit, friends' friends reputation, friend bid amount, friend's friend bid amount). All four categories of variable pools can determine the transaction results.

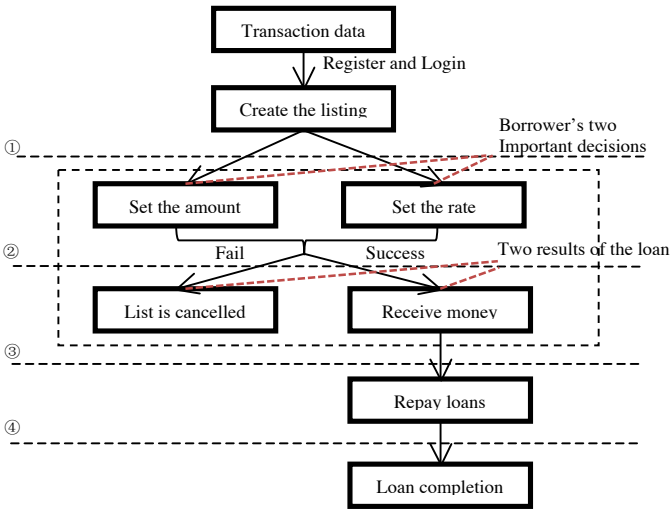

Fig. 1. The loan bidding transaction process on PPDai

In this research, our dataset contains all the four kinds of information mentioned above. The raw dataset contains 17,211 loan request listings with 55,727 bidding transaction records, and 17,188 subscribers' credit profiles. We remove invalid listing records by comparing the bid count in the listing page to the number of bid which is calculated from bid records, and also remove those records with missing values in key variables. Finally, we obtain 51421 cleansed listing records with 10715 successful ones and 40705 unsuccessful ones. The final data set includes: user personal information table, users' verification information table, friendship network information table, listing information table, biding information table and group information table.

We exclude the group information table from this study, because only four groups in PPDai market with same owner ID and similar rating. The group in PPDai is just a chatting room and forum for members to share feeling and anything they interested in PPDai, which is totally different from the group network in Prosper, and makes no sense to the lending transactions results. PPDai builds its own credit scoring system due to the lack of national credit scoring system in China. And credit score is developed mainly depends on users' personal information. And in this paper, we use this PPDai own credit score to evaluate users' hard credit information which stand for the financial situation of the users at that time.

Borrowers in PPDai must be verified by the national ID then can post a list to get funded. Members can enhance their credit by providing other verified information, including cellphone verification, education verification, video verification and so on. From the verification information table, we find that around 68.83% registers in PPDai get ID verification, and only 11.56%, 14.24% and 9.29% for cellphone verification, education verification and video verification respectively.

Listing information table contains information on each loan request initiated by the borrower. In particular, it records whether a loan is successfully funded and the payment term. And we define that a list is successfully funded when the amount

request is less than amount funded, and is fail otherwise. Besides, listing information table includes list borrowers' credit score, maximum interest rate the borrower is willing to pay and the current interest rate of the micro-loan in PPDai market and so on. Our clean data set has 52906 valid listing records. For each list, the average loan amount is 13892.4 RMB, and the average maximum interest rate specified by borrowers is acceptable is 6.71%. There is 66.76% potential lenders review the list in average and 17.17% of them decided to bid in average during the auction.

Biding information table contains information on each bid initiated by the lender, which includes list ID, lender ID, bid amount, bid interest rate, bid time and Auto bid.

Friendships are self-reported by users but require confirmations from the counter-parties. PPDai distinguishes six types of offline friendships (colleagues, friends, close friends, classmates, acquaintances, and relatives) and two types of online friendships (PPDai friends and others). Colleagues refer to both existing and former colleagues of users. Friends and close friends refer to individuals who a user shares a bond of mutual affection, while acquaintances refer to individuals that a user knows in person but does not necessarily shares a common. PPDai friends refer to individuals that a user befriends through the PPDai website while other online friends refer to individuals that a use be friends through other online venues. Not only the one-step friendship network will impact on the economic results, but users' friends' friends network can also significantly involved in the users' economic behavior. PPDai friendship network table contains 107563 friend records described by five variables: report time, confirm time, friendship type and two IDs of both sides of the friendship. There are 15010 users making friends in PPDai, and for more details, 17.27% are offline friends and 82.76% are online friends, "friend" is the most part of offline friend type.

In this paper, we highlight on how soft credit information works in online P2P lending market, especially focus on the friendship network. To gain more insights into the role of friendships, not only friend information but also friends' friends information is included in this study, and we distinguish both friends and friends' friends into ones who are pure borrowers to the listing borrowers and one who bid the list and are real lenders to the list. In addition, friends and friends' friends who bid can be result in successful and unsuccessful. What's more, we argue that the quality variables of friendship is more critical than quantity ones. The higher for friends and friends' friends with credit grade and reputation in the market, which is presented by establishing histories of borrowing and especially successful borrowing that require outlay capital, the closer of relationship between the borrower and her friendship, and the higher quality and stronger of the friendship network is, which can also reduce to better economic results. To define the quality of borrowers' friendship network, we collect three dimensions of variables, including type, credit and reputation which is represented by the lending history of the user in PPDai lending market. And all of these quality variables are specified with four types of friendship to examine the friendship network in PPDai lending market.

Figure 1 illustrates the empirical implementation of the tests based on friend types. At the top level in Figure 1 are friends and friends' friends who have registered on PPDai.com. Level 2 differentiates friends and friends' friends between those who are pure borrowers to the borrower's listing and those who actually bid the borrower's listing. Friendship with lenders who actually bid is a more creditable signal of quality.

And then, the last level, friends and friends' friends who bid are distinguished into ones who win and the other who lose the bid.

Following the prior literature, although much of it does not use PPDai data, such as Greiner et al. [1], Lin et al. [2, 4], Freedman et al. [3, 6], Everett [17], and Puro et al. [21, 22]which could provide some guidance for this study. Considering the available information we could get, we choose the variables mainly based on the prior literature combine with the unit friendship network variables we process from PPDai raw data set into our regression models. In summary, short descriptions of all the variables used in this study is shown in table 1.

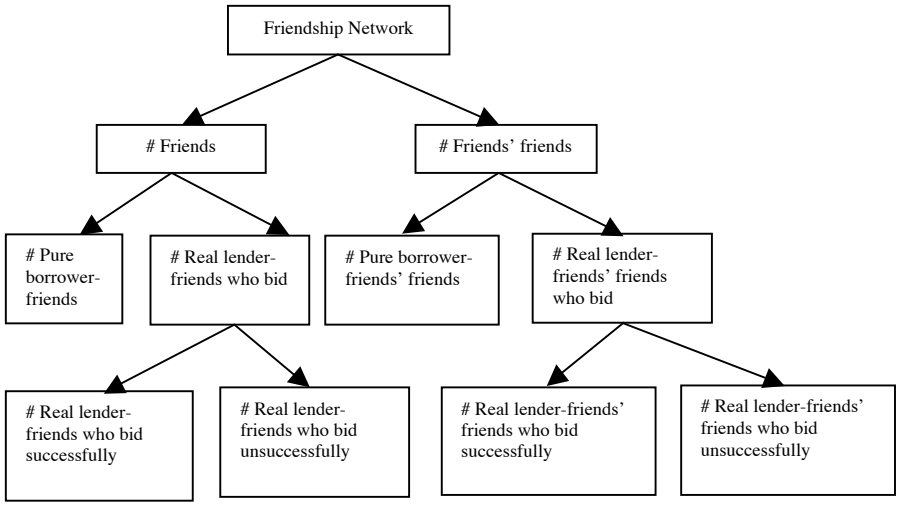

Fig. 2. Hierarchy of Friends

Table 1 Variables descriptions

Variables	Description	Reference
Dependent variables		
FundingPrb	Funding probability, which is 1 for being funded, and 0 for the others.	[16, 21]
IR	Interest rate	[1, 2, 21]
Independent variables		
Listing information		
Ln_AmtReq	The loan amount requested by a borrower.	[2, 21]
BMaxIR	The acceptable maximum interest rate set by borrowers.	[1, 16, 21]
LDuration	The length of the loan in months.	[17]
RepaymentO	Two repayment ways: monthly repayment (1) and pay on due date (0).	

BidType	Three bid modes: Bidding (1), Friendship (2) and offline (3).	[19]
LCategory	A series of dummy variables indicating the loan category that the borrower specified (listing=X), where X=0 (no category specified), 1 (debt consolidations), 2 (home improvements), 3 (personal loans), 4 (business loans), 5 (student loans), 6 (automobile loans), and 7 (other loans).	[4]
IsExp	Whether borrow is just for an experience1? (1-yes, 0-no).	
IsDrwBck	Whether borrower withdraws cash from her PPDai account? (1-yes, 0-no).	
IsAdvPln	Whether the borrower join in the 1-draw, 0-don't draw1-yes, 0-no "advanced plan"2(1-yes, 0-no).	
OthBrw	Whether the borrower has borrowed money from other places? (1-yes, 0- no).	
Vouch	Whether the list is vouched by others? (1-no, 2-by individual and 3-by PPDai).	
Hard information		
Ln_BCreditS	Borrower's credit score as a borrower.	[19]
Ln_LCreditS	Borrower's credit score as a lender.	[19]
Ln_ListN	Number of listing	
SucListPct	Percent of successful listing	
Soft information		
Ln_FrdN	Number of borrower's friends.	[2]
FrdTypN	Number of friend types a user has in PPDai. (7 types of friend are reported by user self, including Friend, Close friend, Colleagues, Classmate, Relative, Acquaintance, PPDai friend and Others.	
FrdOnlinePct	Percent of borrower's online friends, which include: PPDai friend and other.	
Ln_FrdBCreditS	Borrower's friends' average credit score as a borrower.	

1 New register can join this service to experience the whole process of funding in PPDai. And PPDai do not charge service fee for experience lists.

2 PPDai provide "advanced plan" service to help borrower to get funded more efficiency, this service including shorten all sorts of verification time, admit quicker credit limit increase and put the list to eye-catching area of the website without any ads. Borrowers can join this service by depositing 399 RMB into their PPDai account, and only 119 for the first time participation. The deposit will be returned after three successful funding, and borrowers should pay for the service for each transaction. For example, a borrower deposits 199 yuan to join the advance plan. Then she pay 60 yuan service fee when she get funded at the first time, 3000 yuan for example. If she arranges the first monthly repayment on time, PPDai will return 60 yuan deposit into her PPDai account; if she is successfully funded (5000 yuan) for the second time, then she pay 100 yuan service fee. And after first monthly repayment, she will be refunded 100 deposits; and for the third funding transaction, the borrower pay 160 service fee, and get funded 39 yuan deposit.

Ln_FrdLCreditS	Borrower's friends' average credit score as a lender.	
Ln_FrdListN	Number of friends' listing.	
FrdSucListPct	Percent of friends' successful listing.	
FrdBidNPct	The percentage of number of friend bid over all bid number.	
FrdBidAmtPct	Percent of friend bid amount.	[1,2]
FrdSucBidAmtPct	Percent of friend successful bid amount.	
Ln_FrdBidLCreditS	Average credit score of friends who bid as a borrower.	
ln_FrdBidBCreditS	Average credit score of friends who bid as a lender.	
Ln_FrdBidListN	Number of list of friends who bid.	
FrdBidSucListPct	Percent of successful list of friends who bid.	
Ln_FOFN	Number of friends' friend.	
FOFTypN	Number of friends' friend types a user has in PPDai.	
OnlineFOFPct	Percent of borrower's online friends' friend.	
Ln_FOFBCreditS	Borrower's friends' friends' average credit score as a borrower.	
Ln_FOFLCreditS	Borrower's friends' friends' average credit score as a lender.	
Ln_FOFListN	Number of listing of borrower's friends' friends'.	
FOFSucListPct	Percent of successful listing of borrower's friends' friends'.	
FOFBidNPct	Percent of the number of friends' friends bid over all bid number.	
FOFBidAmtPct	Percent of friends' friends bid amount.	
FOFBidSucAmtPct	Percent of friends' friends successful bid amount.	
Ln_FOFBidLCreditS	Average credit score of friends' friends who bid as a borrower.	
Ln_BidFOFBCreditS	Average credit score of friends' friends who bid as a lender.	
Ln_BidFOFListN	Number of listing of friends' friends who bid.	
BidFOFSucListPct	Percent of listing of friends' friends who bid.	
Additional control variables		
Gender	F-female, M-male.	
Ln_Age	Age of borrower at that time.	
Education	Borrowers' education.	
Marriage	1-marriged, 0-unmarriged.	
ChildN	Number of child.	
IDV	Is ID verified?	
CellphoneV	Is cellphone verified?	
EducationV	Is education verified?	
VideoV	Is video verified?	
Ln_ClickN	Number of click of a list during auction.	[3]
Ln_BidN	Number of bid of a list during the auction.	

Different from previous studies, which utilize the Prosper transaction data, and lots of variables used in this study, including Repayment and friend type variables are not appeared in prior literatures for the different operating mechanisms and social networks provided by Prosper.com and PPDai.com. Similar to the credit grade on Prosper.com used in Lin et al. [2], Puro et al. [17] etc., in PPDai, borrower's credit profile concludes two kinds of scores, BCreditS and LCreditS. Besides, we also add quality and quantity friendship network variables into our empirical model to examine the role of different type of friendships in PPDai lending market. Also, additional control variables, including borrowers' personality variables (Gender, Age, Education, Marriage and ChildrenN), PPDai specified variables (Certificated variables and PPDaiIR) and listing characteristics (ClickN, BidN, IsEXP, IsDrwBck IsDrwBck, IsAdvPln, OthBrw and Vouch) are used to specify the borrower, the listing and PPDai market respectively.

Based on data exploration outcomes, we log-transform all the credit score variables and all the number type variables, according to their distribution and relevancy to the output variables. The transformed variables are named with a prefix "Ln" with their original variable names.

4 Empirical models

Firstly, we do t-tests to see whether friendship network matter in P2P lending market, and find that borrowers who have friends could more likely to get funded and along with lower interest rate. For borrowers who have a friend or not, the results are significant, although the difference is only 0.33% for FundingPrb. Also we add personality variables into this test to find out what kind of users in PPDai market prefer to make friends, including gender, age, education, marriage, child number and four verification variables. All the t-test results are shown in the following table 2 and table 3. The result shows us that borrowers who have higher credit score are more likely to build friendship network in PPDai lending market. Considering the personal information, borrowers who have friend have older average age, higher education level and more children compare to borrowers who do not have any friends in the market. What's more, they are also shown to more likely to verify their ID, CellphoneID, EducationID and VedioID in PPDai. These results are reasonable because of borrowers who are willing to build their social network are those ones who are more activity in the marketplace, which can be proved by higher ListN and higher ListSucPct. So, for the further successful lending transactions, they prefer to trust people who are around by providing information which is believed to be reliable.

For borrowers who have friends' friends or not, all the variables are shown significant difference between these two categories. Borrowers who have friends' friend are more likely to get funded. However, the listing characteristics of the loan and credit score do not have big differences between these two categories.

Table 2 T-test results (1)

	Frd			FOF			FrdBid		
	0	1	P	0	1	F	0	1	F
FundinPrb	0.02	0.35	0.00	0.03	0.37	0.00	0.08	0.79	0.00
IR	17.8	17.5	0.01	17.7	17.5	0.19	17.7	17.4	0.56
AmtReq	9.15	8.64	0.00	9.14	8.62	0.00	8.92	8.64	0.00
LDuration	9.51	6.58	0.00	9.50	6.47	0.00	8.30	6.05	0.00
LCreditS	1.56	3.54	0.00	1.58	3.61	0.00	2.23	4.55	0.00
BCreditS	3.16	3.85	0.00	3.17	3.87	0.00	3.40	4.16	0.00
ListN	0.53	1.71	0.00	0.55	1.75	0.00	0.96	2.18	0.00
ListSucPct	0.02	0.36	0.00	0.03	0.37	0.00	0.11	0.65	0.00
Gender	0.80	0.83	0.00	0.80	0.83	0.00	0.82	0.82	0.00
Age	25.7	26.1	0.00	25.6	26.1	0.00	25.7	26.7	0.00
Education	1.80	1.82	0.67	1.80	1.82	0.04	1.80	1.88	0.00
Marriage	0.35	0.45	0.00	0.35	0.46	0.00	0.38	0.53	0.00
ChildN	0.75	1.25	0.00	0.75	1.28	0.00	0.94	1.42	0.00
IDV	0.62	0.95	0.00	0.62	0.96	0.00	0.76	1.00	0.00
CellphoneV	0.05	0.49	0.00	0.05	0.51	0.00	0.18	0.80	0.00
EducationV	0.03	0.22	0.00	0.04	0.23	0.00	0.09	0.35	0.00
VedioV	0.03	0.48	0.00	0.04	0.50	0.00	0.17	0.77	0.00

Table 3 T-test results (2)

	FOFBid			FrdBidSuc			FOFBidSuc		
	0	1	F	0	1	P	0	1	P
FundinPrb	0.04	0.74	0.00	0.11	1.00	0.00	0.10	1.00	0.00
IR	17.9	17.3	0.42	17.8	16.7	0.07	18.0	16.5	0.00
AmtReq	8.95	8.58	0.00	8.88	8.73	0.00	8.89	8.67	0.00
LDuration	8.48	5.94	0.00	8.07	6.31	0.00	8.12	6.10	0.00
LCreditS	2.11	4.44	0.00	0.38	5.03	0.00	2.35	4.94	0.06
BCreditS	3.36	4.14	0.00	3.46	4.27	0.00	3.45	4.62	0.00
ListN	0.90	2.13	0.00	1.05	2.40	0.00	1.03	2.35	0.00
ListSucPct	0.08	0.62	0.00	0.14	0.75	0.00	0.14	0.74	0.00
Gender	0.81	0.84	0.00	0.82	0.83	0.04	0.81	0.83	0.00
Age	25.6	26.7	0.00	25.7	27.1	0.00	25.7	27.2	0.00
Education	1.79	1.86	0.04	1.80	1.89	0.23	1.80	1.88	0.24
Marriage	0.37	0.53	0.00	0.38	0.58	0.15	0.38	0.58	0.07
ChildN	0.91	1.43	0.00	0.98	1.47	0.00	0.97	1.48	0.00
IDV	0.74	1.00	0.00	0.78	1.00	0.00	0.77	1.00	0.00
CellphoneV	0.14	0.80	0.00	0.22	0.90	0.00	0.21	0.91	0.00
EducationV	0.07	0.35	0.00	0.11	0.41	0.00	0.10	0.42	0.00
VedioV	0.13	0.76	0.00	0.22	0.85	0.00	0.20	0.86	0.00

Note: some variables are ln-transformed in the above table, including AmtReq, LCreditS, BCreditS and ListN.

For borrowers who get bids from friends and friends' friends is more likely to be funded finally. And the average differences of FundingPrb between borrowers who have friends or friends' friends bid and who have not is 0.7, which is bigger than that between borrowers who just have friends or friends' friends or not. So, friend or friends' friend bid is a positive qualified signal for lenders. More activity borrowers who listed more times before and got more loans before can also be more likely to get bid from friendship networks. In addition, friends are more probably to choose ones who have more verified information to bid. And if the friends' bids are successful at the end of the listing duration, the loans get corresponded lower interest, and then make borrowers get higher credit score and reputation and stronger friendship network in the market. So, friendship network can enhance the opportunity for borrowers to get funded also with lower interest rate. Even friends involved in the lending process can send more positive signal for other non-friends lenders to get the right information. It is a virtuous circle, in which not only borrowers can get funded with lower cost, but also lender can find out good investment opportunity by friendship signals with lower investment risk.

One more interesting finding is, no except for all the different groups, the differences of borrowers' credit score as lenders between ones who are involved into friendship network and who are not are bigger than those shown in borrowers' credit score as borrowers. This result may be caused by the microstructure of PPDai market, in which there are more pure borrowers act in this marketplace. And users initiate to borrow than lend to register this online lending market, which leads to more volatility of the distribution of credit score as lender variable.

Then, we run two descriptive regression models that correlation observable listing attributes, hard information soft information and additional control variables to the funding probability and interest rate if funded. Based on the friendship hierarchy in Figure 1, we add friendship network variables step by step to test different roles of different friend types. And the modeling process is shown in the following table 4, which describes the different models that we report in this study and the set of variables used in each specification. Then the results are shown in the table 5 and table 6.

The funding probability is estimated by Probit regression and interest rate regression is estimated by OLS.

$$\mathrm{I}_{funded,i} = f_1(ListingVariables, HardInformation, SoftInformation, AdditionalControls) + e_{1i}$$

$$InterestRate_i = f_2(ListingVariables, HardInformation, SoftInformation, AdditionalControls) + e_{2i}$$

Table 4 Estimated Models

	Variable set				
Model	1	2	3	4	5
FundingPrb	Friend Quantity Variables (FrdN, FrdTypeN, FOFN, FOFTypeN)	Friend Quality Variables (FrdOnlinePct, FrdLCreditS, FrdBCreditS. FrdListN. FrdSucListPct, FOFOnlinePct, FOFLCreditS, FOFBCreditS, FOFListN, FOFSucListPct)	Friend and friends' friends who bid quantity variables (FrdBidNPct, FrdBidAmtPct, FOFBidNPct, FOFBidAmtPct)	Friend and friends' friends who bid quality variables (FrdBidLCreditS, FrdBidBCreditS, FrdBidListN, FrdBidSucListPct, FOFBidLCreditS, FOFBidBCreditS, FOFBidListN, FOFBidSucListPct)	Friend and friends' friends who bid and win variables (FrdBidSucAmtPct, FOFBidSucAmtPct)
IR					

Note: The sets of variables used in each model are described in table 5 and table 6.

Table 5 Funding Probability results

Variables	Funding Probability			
Soft information				
FrdN	0.06	0.22		0.19
	(0.11)	(0.00)		(0.03)
FrdTypeN	-0.05			
	(0.02)			
FOFN		-0.26		
		(0.06)		
FOFTypeN				
FrdOnlinePct		0.35	0.21	
		(0.00)	(0.08)	
FrdBCreditS		-0.14	-0.19	-0.11
		(0.01)	(0.00)	(0.10)
FrdLCreditS		0.05		
		(0.07)		
FrdListN				-0.12

					(0.10)
FrdSucListPct		0.37	0.54	-0.66	0.64
		(0.03)	(0.00)	(0.00)	(0.00)
FOFOnlinePct		0.87	0.58	0.53	0.48
		(0.00)	(0.02)	(0.05)	(0.11)
FOFBCreditS		-0.16			
		(0.11)			
FOFLCreditS		-0.17	-0.19	-0.16	-0.16
		(0.00)	(0.00)	(0.01)	(0.02)
FOFListN		0.24			
		(0.07)			
FOFSucListPct		0.72	1.01		
		(0.06)	(0.02)		
FrdBidAmtPct			-1.64	-1.58	-0.99
			(0.00)	(0.00)	(0.00)
FOFBidNPct					-0.67
					(0.03)
FOFBidAmtPct			-1.24	-1.12	
			(0.00)	(0.00)	
FrdBidLCreditS				-0.05	0.11
				(0.05)	(0.00)
FrdBidBCreditS					-0.15
					(0.01)
FrdBidListN				0.16	0.18
				(0.00)	(0.00)
FrdBidSucListPct				-0.38	-0.57
				(0.00)	(0.00)
FOFBidLCreditS				-0.11	-0.08
				(0.00)	(0.04)
FOFBidBCreditS				0.25	0.15
				(0.00)	(0.04)
FOFBidListN				0.22	0.31
				(0.00)	(0.00)
FOFBidSucListPct				-0.61	-0.83
				(0.00)	(0.00)
FrdBidSucAmtPct					-60.1
					(0.00)
FOFBidSucAmtPct					-1.56
					(0.00)
AmtReq	1.00	1.05	1.15	1.10	1.28
	(0.00)	(0.00)	(0.08)	(0.00)	(0.00)
BMaxIR	-0.02	-0.02	-0.02	-0.02	-0.03
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
LDuration	0.01	0.01	0.01	0.01	0.01
	(0.08)	(0.10)	(0.05)	(0.03)	(0.28)
PaymentO	0.39	0.25	0.24	0.34	0.37
	(0.00)	(0.07)	(0.13)	(0.04)	(0.12)
BidType	-0.77	-0.78	-0.70	-0.68	-0.52
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
LCategory	0.05	0.06	0.05	0.05	0.04
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)
IsExp	-0.53	-0.55	-0.57	-0.55	-0.34

	(0.00)	(0.00)	(0.00)	(0.00)	(0.10)
IsDrwBck	-0.07	-0.09	-0.15	-0.12	-0.17
	(0.50)	(0.39)	(0.11)	(0.30)	(0.23)
IsAdvPln	-0.31	-0.33	-0.38	-0.35	-0.45
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
OthBrw	0.15	0.11	0.11	0.11	0.10
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)
Vouch	-0.77	-0.76	-0.74	-0.72	-0.60
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
LCreditS	-0.06	-0.08	-0.07	-0.03	0.01
	(0.00)	(0.06)	(0.00)	(0.13)	(0.73)
BCreditS	0.19	0.14	0.13	0.11	0.18
	(0.01)	(0.06)	(0.12)	(0.17)	(0.12)
ListN	-0.03	-0.05	-0.09	-0.40	-0.41
	(0.42)	(0.17)	(0.02)	(0.00)	(0.00)
ListSucPct	-3.53	-3.59	-3.46	-3.89	-3.84
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Gender	-0.02	-0.05	-0.08	-0.08	-0.14
	(0.68)	(0.38)	(0.16)	(0.16)	(0.07)
Age	-0.00	-0.00	-0.00	-0.00	0.00
	(0.53)	(0.55)	(0.53)	(0.42)	(0.95)
Education	-0.00	0.02	0.06	0.06	0.05
	(0.95)	(0.76)	(0.31)	(0.29)	(0.44)
Marriage	-0.03	0.00	0.01	0.01	0.15
	(0.56)	(0.96)	(0.84)	(0.86)	(0.05)
ChildN	0.09	0.04	0.02	0.02	-0.06
	(0.04)	(0.36)	(0.61)	(0.71)	(0.37)
IDV	0.07	0.14	-0.26	-0.01	-0.04
	(0.80)	(0.63)	(0.45)	(0.85)	(0.93)
CellphoneV	0.25	0.17	0.10	0.05	0.06
	(0.00)	(0.01)	(0.18)	(0.47)	(0.53)
EducationV	0.16	0.15	0.11	0.08	0.17
	(0.00)	(0.00)	(0.04)	(0.13)	(0.02)
VedioV	0.14	0.10	0.06	0.04	0.04
	(0.01)	(0.07)	(0.32)	(0.46)	(0.54)
ClickN	-0.04	-0.04	-0.06	-0.04	0.04
	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)
BidN	-1.34	-1.36	-1.43	-1.49	-1.57
	(0.00)	(0.00)	(0.36)	(0.00)	(0.00)

Table 6 Interest rate results

Variables	Interest Rate				
Soft information					
FrdN					
FrdTypeN	-0.08	-0.08	-0.08	-0.08	-0.08
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
FOFN	0.04	-0.34	-0.24		
	(0.07)	(0.04)	(0.14)		

FOFTypeN	-0.07	-0.07	-0.07	-0.06	-0.06
	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)
FrdOnlinePct					
FrdBCreditS					
FrdLCreditS		-0.04			
		(0.15)			
FrdListN		0.10	0.10	0.09	0.08
		(0.05)	(0.05)	(0.10)	(0.11)
FrdSucListPct			0.27	0.31	0.31
			(0.09)	(0.07)	(0.07)
FOFOnlinePct					
FOFBCreditS					
FOFLCreditS		-0.21	-0.21	-0.19	-0.20
		(0.00)	(0.00)	(0.00)	(0.00)
FOFListN		0.32	0.22	0.21	
		(0.04)	(0.15)	(0.17)	
FOFSucListPct		0.76	0.96	1.06	1.04
		(0.06)	(0.02)	(0.01)	(0.01)
FrdBidAmtPct			-0.79	-0.91	-0.84
			(0.00)	(0.00)	(0.00)
FOFBidNPct					
FOFBidAmtPct			-0.51	-0.52	-0.38
			(0.00)	(0.00)	(0.04)
FrdBidLCreditS					
FrdBidBCreditS				0.06	0.06
				(0.10)	(0.14)
FrdBidListN					
FrdBidSucListPct				-0.19	-0.21
				(0.07)	(0.05)
FOFBidLCreditS				0.05	0.05
				(0.11)	(0.08)
FOFBidBCreditS					
FOFBidListN				-0.10	-0.10
				(0.00)	(0.00)
FOFBidSucListPct					
FrdBidSucAmtPct					
FOFBidSucAmtPct					-0.20
					(0.06)
AmtReq	0.36	0.38	0.44	0.47	0.48
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
BMaxIR	0.89	0.89	0.89	0.89	0.89
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
LDuration	-0.01	-0.01	-0.00	-0.00	0.01
	(0.15)	(0.15)	(0.17)	(0.16)	(0.15)
PaymentO	0.49	0.41	0.38	0.45	0.45
	(0.01)	(0.02)	(0.03)	(0.01)	(0.01)
BidType	0.04	0.04	0.10	0.17	0.18
	(0.29)	(0.38)	(0.05)	(0.00)	(0.00)
LCategory	-0.01	-0.01	-0.01	-0.01	-0.01
	(0.24)	(0.35)	(0.29)	(0.23)	(0.24)
IsExp	-5.57	-5.59	-5.54	-5.48	-5.46

	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
IsDrwBck	-0.41	-0.42	-0.44	-0.42	-0.42
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
IsAdvPln	0.03	0.02	0.01	0.02	0.01
	(0.56)	(0.69)	(0.79)	(0.74)	(0.78)
OthBrw	0.32	0.31	0.31	0.31	0.31
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Vouch	-0.37	-0.37	-0.38	-0.38	-0.38
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
LCreditS	-0.05	-0.06	-0.06	-0.06	-0.05
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
BCreditS	-0.14	-0.14	-0.16	-0.15	-0.14
	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)
ListN	0.11	0.10	0.08	0.19	0.19
	(0.00)	(0.00)	(0.02)	(0.00)	(0.00)
ListSucPct	-0.15	-0.21	-0.19	-0.04	-0.03
	(0.09)	(0.03)	(0.05)	(0.73)	(0.80)
Gender	-0.05	-0.06	-0.07	-0.06	-0.06
	(0.29)	(0.20)	(0.13)	(0.21)	(0.17)
Age	-0.00	-0.00	-0.00	-0.00	-0.00
	(0.04)	(0.04)	(0.04)	(0.03)	(0.02)
Education	-0.01	0.01	0.01	0.02	0.02
	(0.85)	(0.87)	(0.76)	(0.60)	(0.61)
Marriage	-0.06	-0.06	-0.05	-0.05	-0.05
	(0.23)	(0.21)	(0.30)	(0.25)	(0.27)
ChildN	0.03	0.02	0.01	0.02	0.02
	(0.46)	(0.58)	(0.74)	(0.56)	(0.56)
IDV	-0.54	-0.51	-0.59	-0.62	-0.62
	(0.18)	(0.21)	(0.15)	(0.13)	(0.13)
CellphoneV	0.29	0.25	0.24	0.27	0.27
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
EducationV	0.09	0.08	0.07	0.07	0.07
	(0.03)	(0.04)	(0.01)	(0.06)	(0.07)
VedioV	0.28	0.26	0.26	0.26	0.26
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
ClickN	0.18	0.17	0.16	0.16	0.17
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
BidN	-0.58	-0.58	-0.66	-0.72	-0.73
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)

Note: This table reports estimates of two models: a Probit specification in which the dependent variable is 1 if a listing on PPDai.com is funded (amount request ≤ amount funded) and 0 otherwise3; and an OLS regression model in which the dependent variable is the interest rate on PPDai.com listing that are successfully funded. The explanatory variables are same and include a borrower's hard credit variables, friendship network variables and listing characteristics of the loan. Because the page limits, we only report results on the main variables. Standard errors are in parentheses.
*p<0.1; **p<0.05;***p<0.01.

[3] This condition is necessary but not sufficient for being successfully funded.

5 Results

We use two-stage model in this study, which the funding probability is model by all the selected variables at first stage and then interest rate is analyzed by only successful funding records. We control all the listing variables, hard information variables and personal information variables, and then add the friendship network variables to see how friend quantity and friend quality variables work in online P2P lending markets. We only show the significant friendship variables in the above result tables.

In summary, all the listing variables significantly affect the funding probability, except IsDrwBck. More specifically, the higher the set interest rate of the listing, the higher probability to get funded at the end. Whether the borrowing list is an experience one or whether the list joined the advanced plan can help borrowers to make loan, that also support that the service provided by PPDai works to benefit users to be funded more easily. However, PPDai services, like advance plan, have no effect on reducing the interest rate borrower should pay back to lenders. Then, all the hard information variables are statistically significant for both models. Higher credit score and more activity lead to be more probably to get funded. And successful lending history can help to decrease lending cost for lenders. And all the hard information variables are less significant when adding friendship variables for both models. Personal information variables show no effect on lending transaction results since the non-significance represented in the above tables. This phenomenon may be caused by self-reported information that is just believed as cheap talk. While, all four verification variables are significantly determine the economic results. And also for the ClickN and BidN variables which reflect the popularity of the listing in the market at its time. More interesting, more click number and bid number, lead to a higher probability for borrowers to get loans. Popularity may turn to competition, however, and then increase lending cost responded by lenders. And, the above tables show that higher click number finally results in higher interest rate.

For those friendship variables, which are emphasized in this paper, we find that almost all the variables significantly impact on economic results. What's more, friendship variables are more important when deciding the funding probability result rather than interest rate result if the list gets funded. For funding probability logistic model, among all the friendship variables, friendship quality variables (FrdSucListPct, FOFOnlinePct), friend bid quantity variable (FrdBidAmtPct and FOFBidNPct), friend bid quality variable (FrdBidSucListPct and FOFBidListN) and friendship bid and win variable (FrdBidSucAmtPct and FOFBidSucAmtPct) are most significant ones, which indicates that quality variables are more important than quantity variables to determine if borrowers can get funded finally. For interest rate regression model, FOFLCreditS, FOFBidAmtPct, FrdBidSucListPct, FOFBidListN and FOFBidSucAmtPct are the most significant ones to reduce the interest rate for lenders. A friend bid is the most positive signal for borrowers to trust lenders.

6 Discussion and conclusion

In this study, by using the comprehensive and unique transaction and friendship network data from PPDai.com, we investigate how quality of borrowers' friendship network variables affecting transaction outcomes. We discuss various friendship network variables, including friends and friends' friends quantity variables, friends and friends' friends quality variables, friends and friends' friends who bid quality variables and friends and friends who bid and win variables. By controlling listing variables, hard credit information variables and additional control variables, we add five levels of friend variables into our two regression models to find out how different types of friendship works in PPDai market. And the regression result shows that quality is more important than quantity in determining funding results. In our study, we find that borrowers who have friends, especially high quality friendship network, are more likely to get funded and associated with lower interest rate on funded loan. What's more, the deeper level the relationship is in our friendship hierarchy, the more significant effect the friendship dose on final economic results, which also means that the higher quality the friendship is involved in bidding process, the more creditable of borrowers will be trusted by lenders. For short, high quality friendship send more efficient signal to the market to mitigate information asymmetry in P2P lending market. And then, we can conclude that friendship network does matter in online P2P lending market, especially high quality friendship types.

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Risks of Using NFC Mobile Payment: Investigating the Moderating Effect of Demographic Attributes

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Abstract. Prior studies indicate that perceived risk is an important determinant of the adoption of commerce-related IT innovations. However, little work has investigated how risk perceptions are formulated in consideration of different demographic attributes. Based on a sample of 377 useful responses, this study quantifies how different risk dimensions (privacy risk, performance risk, psychological risk and financial risk) contribute to the perceived overall risk of NFC (near field communication) mobile payment, and elucidates how demographic attributes (gender, age and income) moderates the relationships between the risk dimensions and the perceived overall risk. The results indicate that privacy and psychological risks are the most important risk dimensions of NFC mobile payment and that people of different demographic attributes tend to be concerned with different categories of risks.

Keywords: NFC, RFID, mobile payment, perceived risk, gender, privacy, age

1 Introduction

A number of technologies and platforms have been proposed for mobile payment including SMS (Short Message Service), WAP (Wireless Application Protocol) and NFC (near field communication)-based payment platforms. In particular, Juniper Research predicts NFC mobile payments market will exceed $180 billion globally by 2017, more than a seven-fold increase over 2012 [11]. The leading regions of North America, Western Europe and Far East & China will contribute 90% of this market value as NFC-enabled smartphones become standard [11]. It is expected that more than 1 in 4 mobile users in the US and Western Europe will use their NFC-enabled mobile phone to pay for goods in-store by 2017 [10]. A similar estimation is made by ABI Research, which predicts the total value of NFC mobile payment transactions will increase from $4 billion in 2012 to over $100 billion in 2016 and $191 billion in 2017 [1]. China Telecom has officially launched an NFC service in China using SIMpass [19]. More than 2 million consumers have already used SIMpass in China, of which 97% actively use it daily [19]. Our study is based on an investigation of Chinese consumers' perceptions of NFC mobile payment service.

Most previous studies refer to mobile payment as an umbrella term independent of different underlying technology platforms. While studies on either SMS or WAP-based mobile payment are many, empirical investigations on NFC mobile payment are scarce. This study is among the first to empirically investigate NFC mobile payment based on a random sample of 377 responses. Specifically, we investigate how perception of overall risk of NFC mobile payment is formulated in consideration of different risk dimensions, namely privacy risk, performance risk, psychological risk and financial risk. Further, the study quantifies how demographic attributes (age, gender and income) moderates the effects of risk categories on perceived overall risk.

We structure the paper as follows: the next section presents the literature review and theoretical background, followed by the research methodology section. Research results are discussed in section 4. Section 5 discusses the results while section 6 concludes the paper.

2 Literature review and theoretical background

2.1 NFC mobile payment

NFC is a set of close-range wireless communication standards, which is built upon short range radio-frequency identification (RFID) technology by allowing two-way communication between endpoints. NFC technology enables consumers to exchange payment information, such as between a consumer's mobile device and a merchant's POS (Point of sale) terminal through simply waving the mobile devices close to the terminal (typically under 20 cm) [3, 4]. A user may need to enter a secure PIN or password to approve the transaction. It is estimated that NFC mobile payments can be 15 - 30 seconds faster than swiping a traditional card and signing the receipt or entering a PIN [9]. NFC mobile payment has a number of unique advantages in particular compared to conventional mobile payment solutions [18]. For consumers, benefits of using NFC mobile payment include reliability, security, ease of use and convenience, wallet functionality, acceptance, device deployment and value-add applications [18].

2.2 Effects of demographic attributes on IT diffusion

Empirical evidences have been found that demographic attributes, such as age, gender and race, has significant influences on user perceptions and diffusion speed of innovations [16, 20]. The unified theory of acceptance and use of technology (UTAUT), as an important IS adoption theory, notes that demographic similarities, like age, gender and experience, exert significant moderating effects on how different IT perceptions motivate the adoption of a particular IT innovation [20]. Prior literature has frequently reported the moderating effects of demographic attributes on the relationship between IT perceptions and IT adoption [2, 6, 16].

2.3 Perceived risk theory

Individuals face risk when a particular decision or action brings about social and economic consequences associated with uncertainty [23]. Thus, research on risk disciplines include economics, psychology, decision sciences, management, risk and insurance, public policy, and finance [for a review see 6]. In recent years, perceived risk theory has been widely applied to commerce-related IT innovations, in which consumers' behavior of IT adoption can be viewed as an instance of risk-taking [14]. Consumers' perceived risk has been widely regarded as a kind of a multi-dimensional construct [i.e. 8, 12]. For instance, Lee [12] employs five sub-dimensions of perceived risk in studying Internet banking adoption, including performance, social, time, financial and security risk. Featherman and Pavlou [8] adopts performance, financial, time, psychological, social, privacy and overall risk as the key facets of perceived risk to predict the e-services adoption. However, little prior work has investigated how perceived risk of NFC mobile payment is formulated in terms of different risk dimensions. Further, little prior research has quantified the moderating effects of demographic attributes on risk formation. Hence, this exploratory study seeks to investigate the risk formation process of NFC mobile payment in terms of different demographic features. Based on the above discussion, we propose that:

H1: Risk dimensions, including perceived privacy risk, performance risk, psychological risk, financial risk, positively relate to perceived overall risk of NFC mobile payment.

H2: Demographic attributes, including age, gender and income, moderates the relationships between risk dimensions and perceived overall risk of NFC mobile payment.

The research model is graphically presented, as shown in Figure 1. Based on prior studies [13, 21], we investigate four risk dimensions of NFC mobile payment:

1. Financial risk: The possible unreasonable financial loss caused by using NFC mobile payment.
2. Privacy risk: The possible loss caused by private information of consumer individuals exposed in NFC mobile payment.
3. Psychological risk: The possibility that consumers bear mental stress of using NFC mobile payment.
4. Performance risk: The possibility that NFC mobile payment does not work properly or can be used for only a short period of time.
5. Perceived (overall) risk: The nature and amount of risk perceived by a consumer in contemplating a NFC mobile payment behavior.

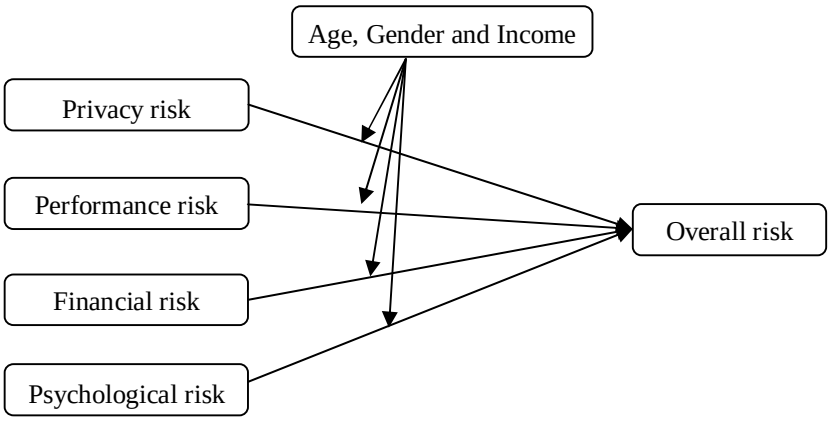

Fig.1. Research Model.

3 Research methodology

3.1 Sample and measurement development

A questionnaire survey was conducted to collect empirical data and evaluate the research model. The measurements of perceived overall risk and risk dimensions are adapted from the works of Lee [12] and Featherman et al. [8]. 5-point likert scale ranging from 1 (disagree) to 5 (agree) is utilized to evaluate each item. The empirical data was collected in China in the summer of 2012. 20 student volunteers from the department helped the researchers to collect responses during their summer vacation. Before the survey, researchers gave training to the volunteers and elucidated the research purpose. Thereafter, the volunteers visited public spaces (i.e. street, railway stations and shopping malls) of their resident cities (16 different cities) across China and invited strangers to participate in our study. The volunteers were requested to explain NFC mobile payment carefully to respondents if the respondents did not have prior knowledge on the technology. Each volunteer recruited about 15-20 respondents. Finally, 377 validated samples were collected, which are used as the sample base of the study. The sample consists of 190 males and 187 females, and their demographic information is presented in Table 1.

3.2 Measurement model

SmartPLS 2.0 was used to evaluate the research model. First, we evaluate the validity and reliability of measurements of basic model. As the demographic factors (age, gender and income) are one-item factor, they are not included in the basic model.

As shown in Table 2, factor loading (FL) and cronbach's alpha (α) values are all above the threshold of 0.7. The values of composite reliability (CR) and average variance extracted (AVE) of all the constructs satisfy the recommended level of 0.8 and 0.5 respectively, indicating good internal consistency. As shown in Table 3, the square roots of AVE of all constructs are greater than the correlations estimate with the other constructs. This reveals that each construct is more closely related to its own measures than to those of other constructs, and discriminant validity is therefore supported. A principle component analysis was performed via the use of SPSS 21 and no substantial cross-loadings were reported, as shown in Table 4. This further confirms the validity of the questionnaire measurement.

Table 1. Demographic information

Demographic profile	**Items**	**Frequency**	**Percent (%)**
Gender	Male	190	50.4
	Female	187	49.6
	Total	377	100
Age	18-24	164	43.5
	25-30	69	18.3
	31-35	35	9.3
	36-40	37	9.8
	41-50	60	15.9
	Over 50	12	3.2
	Total	377	100
Monthly cost of phone usage (RMB)	Less than 50	92	24.4
	50-99	153	40.6
	100-199	103	27.3
	200-399	21	5.6
	Over 400	8	2.1
	Total	377	100
Monthly Income (RMB)	Less than 2000	166	44
	2000-3000	75	19.9
	3001-5000	49	13
	5001-8000	31	8.2
	8001-15000	26	6.9
	Over 15000	30	8
	Total	377	100

Table 2. Reliability and convergent validity statistics

Construct (no of items)	**α**	**CR**	**Minimal. FL**	**AVE**
Privacy risk (3)	0.923	0.951	0.918	0.867
Performance risk (3)	0.898	0.936	0.907	0.830
Financial risk (3)	0.809	0.887	0.824	0.725
Psychological risk (3)	0.888	0.930	0.882	0.818
Overall risk (3)	0.897	0.936	0.899	0.829

Table 3. Discriminant validity (The bold diagonal are the square roots of the AVEs of the individual constructs; off diagonal values are the correlations between constructs)

	PRR	PER	FR	PSR	OR
Privacy risk (PRR)	**0.931**				
Performance risk (PER)	0.629	**0.911**			
Financial risk (FR)	0.535	0.525	**0.851**		
Psychological risk (PSR)	0.517	0.415	0.459	**0.904**	
Overall risk (OR)	0.650	0.571	0.509	0.582	**0.910**

Table 4. Results of principle component analysis

	Component				
	1	2	3	4	5
Financial risk 1	.230	.145	.253	.177	**.802**
Financial risk 2	.118	.132	.006	.222	**.834**
Financial risk 3	.232	.226	.304	.056	**.682**
Performance risk 1	**.831**	.156	.248	.164	.202
Performance risk 2	**.834**	.168	.190	.204	.204
Performance risk 3	**.803**	.099	.249	.254	.174
Privacy risk 1	.319	.138	**.744**	.382	.155
Privacy risk 2	.251	.195	**.850**	.234	.195
Privacy risk 3	.255	.297	**.783**	.209	.221
Psychological risk 1	.187	**.808**	.236	.167	.116
Psychological risk 2	.133	**.844**	.133	.246	.190
Psychological risk 3	.084	**.853**	.141	.229	.174
Overall risk 1	.271	.287	.240	**.741**	.151
Overall risk 2	.199	.256	.253	**.826**	.162
Overall risk 3	.213	.227	.225	**.786**	.230

4 Model testing and results

Bootstrapping analysis was performed to assess the research model by setting subsample and resample sizes to equal the original sample size. The interaction effects are calculated by using standardized indicator values before multiplication. As shown in Table 5, the four dimensions of risks significantly contribute to the perception of overall risk even if in different demographic settings, and the research model interprets over 54% of the variance of perceived risk. Therefore, hypothesis 1 is supported.

Hypothesis 2 is partly supported. The influence of demographic factors of age, gender and income are tested. Age is found to have significant direct influence on perceived overall risk (β=-0.082, $p<0.05$), but gender and income do not have. In addition, age has a significant moderator effect on the influence of psychological risk on perceived overall risk (β=0.148, $p<0.01$).

The results did not show any significant direct influence of both gender and income on perceived overall risk. However, gender significantly moderates the effect of perceived privacy risk on perceived overall risk (β=-0.206, p<0.001), while income significantly moderates the impact of perceived financial risk on perceived overall risk (β=0.146, p<0.01). Note that, for moderating effect analysis, a small effect size does not necessary imply an unimportant effect, if the resulting beta changes are meaningful [5].

Table 5. Results (Dependent variable: perceived overall risk)

Predictors	Basic model	Age as moderator	Gender as moderator	Income as moderator
PRR	0.325***	0.318***	0.329***	0.340***
PER	0.195***	0.187***	0.199***	0.193***
FR	0.101*	0.089*	0.102*	0.091*
PSR	0.287***	0.306***	0.283***	0.270***
Moderator	N.A.	**-0.082***	N.S.	N.S.
PRR×M	N.A.	N.S.	**-0.206*****	N.S.
PER×M	N.A.	N.S.	N.S.	N.S.
FR×M	N.A.	N.S.	N.S.	**0.146****
PSR×M	N.A.	**0.148****	N.S.	N.S.
R^2	54.1%	56.5%	56.8%	56.2%

(M: Moderator; *: p < 0.05; **: p < 0.01; ***: p < 0.001; N.A.: Not available; N.S.: Not significant)

5 Discussion

Consistent with prior risk research, the results show that the four risk dimensions significantly contribute to the perceived overall risk of NFC mobile payment. The four risk dimensions help explain more than half of the perception of the overall risk. Interestingly, of the four risk dimensions, privacy risk has the strongest influence on perceived overall risk, followed by psychological risk. This indicates that consumers have serious concerns to protect their personal information when evaluating the risks of using NFC mobile payment. Also people are concerned whether they can properly use the technology without bearing too much psychological stress. Furthermore, people have relatively weak concerns about financial risks compared to other risk dimensions. This result is partly explained by the work of Lu et al. [15]. They report a trust transformation phenomenon whereby people who trust the use of Internet payment are more likely to trust and adopt mobile payment. In this regard, consumers who are confident of the financial security of Internet payments may easily transform their trust toward the financial security of mobile payment. As a result, instead of financial risk, consumers are concerned more about the features of NFC mobile payment they are unfamiliar with, such as whether the use of NFC technology makes it easier to leak personal information, whether they can easily learn to perform the new payment behavior and whether the system will work properly or not.

Consumers with different demographic features are found to emphasize different dimensions of risk. The results indicate that senior people worry less about the overall

risk of using NFC mobile payment, but have stronger concerns on the psychological stress of using the technology. Prior work indicates that old adults are less confident in their ability to acquire new technological skills [i.e. 17]. It seems that similar concern arises in the use of NFC mobile payment: senior consumers are worried about their ability to learn to use NFC mobile payment, resulting in stronger influence of psychological risk.

An unexpected finding is the moderating effect of gender on the influence of privacy risk on overall risk. Prior studies reported that females have a stronger concern on privacy risk than males [22]. Similarly, females reported a higher perceived privacy risk (Mean = 4.1; S.td = 0.95; N = 187) than males did (Mean = 3.9; S.td = 1.09; N = 190) in our study. Analysis of variance (ANOVA) shows that the difference is statistically significant ($p<0.001$). However, the moderating effect analysis indicates that females' perceived privacy risk only makes a weak contribution to the formulation of their perception of overall risk of using NFC mobile payment, despite the degree of perceived privacy risk being stronger for females than males. The moderating effect of gender on the relationship between perceived privacy risk and perceived overall risk is statistically strong and highly significant (β=-0.206, $p<0.001$). Therefore, the moderating effect analysis of this study contributes to new insights on the risk formation process, which complements ANOVA analysis reported in prior studies. More studies on this phenomenon are needed in order to deepen our understanding on the risk formulation process of different gender groups.

Furthermore, income is found to be a significant moderator on the effect of financial risk on overall risk. This suggests that people with higher income are concerned more about their financial security of using NFC mobile payment than low-income respondents. As high-income users may put more money in their payment platforms for both daily and business use, this may cause them to be more sensitive to the financial security of the new NFC mobile payment solution.

6 Conclusion, contribution and future research

With regard to the body of empirical studies on NFC mobile payment, the study contributes to the literature by elucidating the risk formation process. We distinguish and quantify how four risk dimensions help establish the perceived overall risk of NFC mobile payment. For practitioners, this study identified the risk categories that consumers care about in the context of NFC mobile payment. In this light, business communities need to consider the different concerns of different user groups in both service design and service personalization process. The study enriches risk theories by empirically integrating the theory in the context of NFC mobile payment. The research findings suggest that people of different demographic attributes tend to weigh different categories of risk. Therefore, future risk studies should pay attention to the deviations of risk perceptions between different user groups, because effective strategies to alleviate consumers' feelings of risk depend on an accurate understanding on what sorts of risk are really concerned by the targeted user groups.

While the research model helps interpret approximate 55% of the variance of perceived overall risk, there is about 45% of the variance left unexplained. This

indicates the future research is needed. Also, future research may focus on evaluating the effect of overall risk on the adoption of NFC mobile payment. The study is based on studying NFC mobile payment in Chinese market and China is one of the emerging countries to use the NFC mobile payment. Hence, audience should be cautious with the result generalizations on different market environments.

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An Approach for Understanding Personal Mobile Ecosystem in Everyday Context

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Abstract. Creating effective and useful mobile eServices that are adapted to the customer needs requires one to understand deeply both physical and digital environments of the users as well as their goals, tasks and personal opinions and viewpoints. This article presents a pilot study of Chinese university students' smartphone usage that utilized students' own smartphones to capture these three areas of their lives. Firstly, we harnessed the smartphones as sensors of students' physical worlds, secondly as windows towards their digital lives, and thirdly as capturing devices to allow them to create memory anchors and write down thoughts in situ. This multi-method approach enabled us to illustrate a richer understanding of what we call personal mobile ecosystems of the students. As a conclusion, a research framework to collect and harness rich data about personal mobile ecosystems in service design is presented.

Keywords: context adaptability, personal mobile ecosystem, mobile sensing

1 Introduction

Mobile phones are very popular all over the world and electronic commerce and services are increasingly moving to, or are accessed with, mobile devices. To create and design effective and useful mobile services that also adapt to varied customer needs in real-time one needs a deep understanding of both the physical and digital environment of the users as well as their goals, tasks, and personal opinions.

The personal phone often is the central communication and computer device in people's everyday life and the most important way to access their ubiquitous and always-changing network of services and information resources, i.e. their personal mobile ecosystem. A natural ecosystem is commonly defined and understood as a community of organisms (plants, animals) living in an environment (consisting of components such as air, water and soil) and interacting as a system. Following this, in this paper, we view personal mobile ecosystem as a selection of mobile services and apps running on personal device (or cloud) and being used concurrently and in collaboration (and also together with other users). In broader context, we could use the term personal digital ecosystem, but since the focus of this paper is mobile environment, we use the term personal mobile ecosystem.

The smartphones of today are usually embedded with a set of varied sensors, such as GPS, accelerometer, and digital compass. In combination with the rich embedded

sensor set, the programmability of smartphones allows for very rich data collection about people's behavior, messaging with other people, services they use and their immediate surroundings and environment – wherever they happen to be [1]. This *mobile phone sensing* opens a lot of interesting research and service development opportunities across a wide spectrum of different fields (see e.g. [1,2,3]), but is not without challenges - of which privacy is a key one [1,2,3,4].

Mobile phone sensing can contribute to development of adaptive, customized services in two ways. First, the improving sensing technology is a key enabler for context-aware services – services that adapt in real-time to the context and activities of the user and his/her current environment and location [1,5]. And second –which is of more interest in our paper– mobile phone sensing can serve as a key source of data for understanding people's daily life and their personal mobile ecosystems. Such understanding is essential for development of services that adapt to the user's context in a way that is actually beneficial for the user [6]. One could even argue that we cannot gain data that truly reflects the personal mobile ecosystem of the user unless we utilize mobile sensing on the user's own personal phone. After all, the personal phone is often 'personalized' by the user in many ways. It contains personal data like messages, photos and contact information and also has a set of application the user has deemed useful for him/her. Further, people's daily life needs to be studied in real-time, real-life settings [7,8] –and the personal phone follows people wherever they go.

In usability and user experience research, service usage and usability has been studied with multiple methods varying from simple questionnaires (e.g. [9]) to observing and shadowing (e.g. [10]) to diary and cultural probe studies (e.g. [11]). Diary and cultural probes methods have been successful in capturing everyday events and activities in unobtrusive and cost efficient ways. However, diary studies rely only on users' subjective self-reports of their days. Subjective reports can reveal users' opinions and values but also be biased towards what users' think the researchers or designers want to hear or how the users wish to be seen.

In our view, combining the subjective and meaningful diary data with objective and incorruptible mobile sensing data can provide a richer picture of the studied phenomenon than using either in isolation. In this paper, we propose a mixed-method research framework that augments diary studies with mobile phone sensing data. We demonstrate the framework's potential to gather rich data by describing a pilot study about Chinese university students' daily lives. We argue that such a framework could enable the development of new, better adaptive electronic services that potentially adapt to user context and are inline with users' personal views and self-image.

2 Related Research

Studying mobile service usage in the actual everyday life and contexts of users has been done earlier with several approaches. Here we briefly recap some examples of research that are related to our approach.

In [12,13] usage of varied mobile communication services (such as SMS, voice, MMS) was studied using mobile sensing and context inference algorithms. Both papers find that mobile service usage varies according to the context. However, these

studies rely only on automatic mobile sensing data, albeit on impressive amounts of it. Korhonen et al. [6] studied contextual use and user experiences of mobile products and services based on analysis of user written experience reports using a pre-determined framework designed to identify the relevant contexts and critical experiences. Although self-reports are prone to biases, their study shows the potential of using qualitative data collected from users for contextual service design. Bouwman et al. [4] describe a study that used smartphone sensing and surveys to research mobile media and services usage in a large user base. Oulasvirta [10] in turn, presents quasi-experiments as one way for doing usability evaluations for mobile services 'in the wild' and out of the controlled lab environments. However, these methods rely on a relatively heavy observation effort.

The research opportunities that mobile sensing and automatic context-detection provide for studying people's daily life have been noted in psychology and social science too [3,14,15]. Although these papers do not address mobile service usage per se, they discuss how mobile sensing and context detection can be used jointly with (e.g. smartphone administered) questionnaires and interviews to understand people's daily life in ways that was not previously possible.

There is budding research on using mobile sensing and context detection in evaluating usability and quality of experience (QoE) of mobile services, see e.g. [7,8,16,17]. De Moor et al.[7], Wac et al.[17], and Ickin et al.[8] all complement mobile sensing context data with Experience Sampling Method (ESM) (see [18]) questionnaires. In [8,17] this was also supported with weekly interviews that were based on users' completed detailed diaries of the previous 24 hours following the Day Reconstruction Method (DRM) (see [19]).

3 Material And Methods

The research was conducted in a university campus in China. Total number of 6 Chinese university students participated in the research, which consisted of three days of combined automatic and user conducted logging and 1-2h group interviews with 1-3 students in each. Convenience sampling was used to select the participants. All participants were asked to accept a research consent, in which they confirmed their voluntarily participation, they were informed about the data that was collected, and also were ensured that collected data is treated confidentially and anonymously. Table 1 summarizes the background information of the participants and descriptions of the devices they used in the study. The devices were the students' own. All participants in the study were anonymized and given a unique ID (left-most column in Table 1). These same IDs will be used when referring to study participants later in the text.

The data was gathered by installing a logger software into the phones and by asking the students to use it during the following two days. The participants were instructed to use the software and they also got a small user manual.

The logger software, Contextlogger3[1], has been developed at Department of Computer Science and Engineering of Aalto University. Contextlogger3 can be run

[1] https://github.com/apps8os/contextlogger3
[2] https://code.google.com/p/funf-open-sensing-framework/wiki/BuiltinProbes

Table 1. Study participants and their device types.

ID	Gender	Age	Study status	Device type	Android version
A	Female	25	Doctoral student	phone/pad	4.1.1
B	Male	23	Master student	phone	4.0.4
C	Male	23	Bachelor student	tablet	n/a
D	Female	22	Master student	phone	2.2.2
E	Male	24	Master student	phone	2.3.6
F	Male	22	Master student	phone	n/a

on any Android 2.1+ device and provides two main functionalities. First, it serves as an automatic logging tool to collect data about the mobile device usage and from the various sensors available in them. Second, it provides a user interface to log start and stop times for daily activities and also to write down notes. Sensing part of our tool is built on top of the Funf framework developed at MIT MediaLab (see [20]) and using the ideas originally developed at contextlogger2 project at Helsinki Institute for Information Technology [21].

In the study, the Contextlogger3 was configured to capture data both from hardware sensors, such as accelerometer and GPS, as well as application usage. Table 2 lists the used sensors and data collection interval for each sensor. The software and underlying framework supports all together over 30 different sensors or probes[2].

In practice, the selection of sensors for a particular study is always a balance between the research needs, amount of data generated, battery consumption, and protecting the privacy of the participants (for example, call and SMS data).

Table 2. List of used sensors and data that was collected in the study.

		Amount (KB) of data collected						
Data collected	**Interval (durat-ion)**	**A**	**B**	**C**	**D**	**E**	**F**	**%**
Android system info	24h	1	2	n/a	1	1	n/a	0.00 %
Battery level	30min	138	564	354	146	31	1	0.06 %
Mobile network cell ID	10min	23	42	15	32	27	n/a	0.01 %
Hardware information	24h	1	2	n/a	1	1	n/a	0.00 %
Device acceleration	2min (30s)	135 MB	589 MB	193 MB	n/a	140 MB	n/a	52.23 %
Location (incl.GPS)	30min	33	207	19	n/a	39	n/a	0.01 %
Device orientation	2min (30s)	124 MB	537 MB	211 MB	n/a	66 MB	n/a	46.38 %
Running applications	1min	2 997	12 098	950	1 736	2 131	2	0.96 %
Wifi networks	10min	795	4 765	1 297	335	n/a	n/a	0.35 %
		263 MB	**1144 MB**	**407 MB**	**2 MB**	**209 MB**	**0 MB**	**1.98 GB**
User entered diary	real time	prime	good	good	good	poor	n/a	

[2] https://code.google.com/p/funf-open-sensing-framework/wiki/BuiltinProbes

Table 3. Contextlogger3's pre-defined contexts and new contexts users defined during the research. Predefined contexts that were never used are marked with overstrike.

Pre-defined contexts		**User defined contexts**	
Location related	**Transportation**	**Location related**	**Activity related**
Home	Walking	Dormitory	Sleeping
Campus	Cycling	Library	Studying
~~Lecture~~	~~Motorcycle~~	Lab	Relaxing
Cafe, restaurant	Bus		Having dinner
Workplace	~~Train~~		Reading books
	Metro		Washing clothes
	Car		Visiting a friend
	~~Taxi~~		Discussing
			Playing computer
			Shopping
			Having breakfast

For the above reasons, the selection of sensors for this study included basic system information sensors, sensors that support the analysis of everyday contexts (location and movement related), and sensor to analyze digital context (running applications).

In addition to automatic logging, the students were also asked to log in the different contexts they visited and activities they took part during the days. To help the synthesis and analysis of user-logged data, the Contextlogger3 was configured to include 13 predefined contexts and activities. The predefined selection covered main modes of transport as well as some common places in universities. The students had also an option to add new contexts and notes. Table 3 shows the list of predefined contexts as well as contexts that the users defined during the research. In the table, the user-defined contexts have been slightly altered from original ones to avoid redundancy and improve readability.

After the logging period, semi-structured interviews were arranged. The themes for the interviews were: mobile phone usage, events during the logged time period, experience of participating the research, and opinions about the Contextlogger3.User logged contexts and activities as a Gantt chart and list of detected applications were prepared for each of the student for to support the interviews. In the interviews the student's context and activity chart was used as a framework for discussing the activities the student had conducted during the data-gathering period. Also the applications in the application list were identified with the students and opinions and usage habits of the applications were asked about. All the interviews were held in English and transcribed afterwards.

4 Results

Each of the participants collected data for two days. For some of the participants, these days did not represent what they would call normal study days. However all of the students considered the mobile phone usage during these days as normal. The success of both automatic and user conducted logging varied quite much between the

participants. Table 2 lists the amount of data that was collected from each participant and each sensor and the quality and coverage of the user-logged data. All together almost 2GB (in heavily redundant CSV format) were collected amounts varying between the participants from almost none to 1.1GB. Due to the high sampling rate at ~30-50Hz (depending on device) and quite aggressive data collection, 30s every 2 min, acceleration and orientation data alone make up more than 98% of the data.

In the following the results are described by dividing them into the three main focus areas of the pilot study, i.e. physical context, digital context, and personal viewpoints of smartphones and their usage. After this an example of a view towards a student's personal mobile ecosystem is given.

4.1 Physical Context

Students' study activities took place mainly on the campus of their universities. Campus area included University premises such as lecture halls and professors' offices and laboratories, library, some restaurants and cafes, and dormitories where the students lived. As can be seen from **Table 3** the locations and activities students' added to the Contextlogger3 during the research are mostly related to campus area and either studying or home activities. In addition some of the predefined transportation contexts were not used. Interestingly, none of the students attended any lectures during the two days probably because of the ongoing exam period.

In the interviews students confirmed the centrality of campus and some even stated that they visit outside campus only once in a week or two. Although, the physical area where the activities took place was quite restricted, there were a lot of personal differences. For example A and B had completely opposed library usage habits.

A: "There are 2 places I often do my studying. One is my dormitory and other is library. If I wake up late in the morning, I study in dormitory because the library is very crowded. If you are late, you cannot find a seat."

B: "*I just borrow books [from the library] and come back to my dormitory or go to our laboratory."*

4.2 Digital context

During the data collection period, students used all together 64 different downloadable applications (such as reader app) or comparable built-in functionalities (such as call and SMS) of the phone. As a first step, the applications were categorized into 14 categories: utility, productivity, photo, call & messaging, instant messaging, music players, e-readers, video players, application stores, browsers, maps, social networking applications, finance, and games. The distribution of detected apps into these categories is illustrated in Fig. 1.

All the students' had a quite similar application selection in use. **Table 4** shows how many of the students used each application. In addition to the applications listed in the table, all students naturally used Contextlogger3 app and almost all of the students had a security application installed to prevent viruses and other malicious attacks towards their phones and personal data.

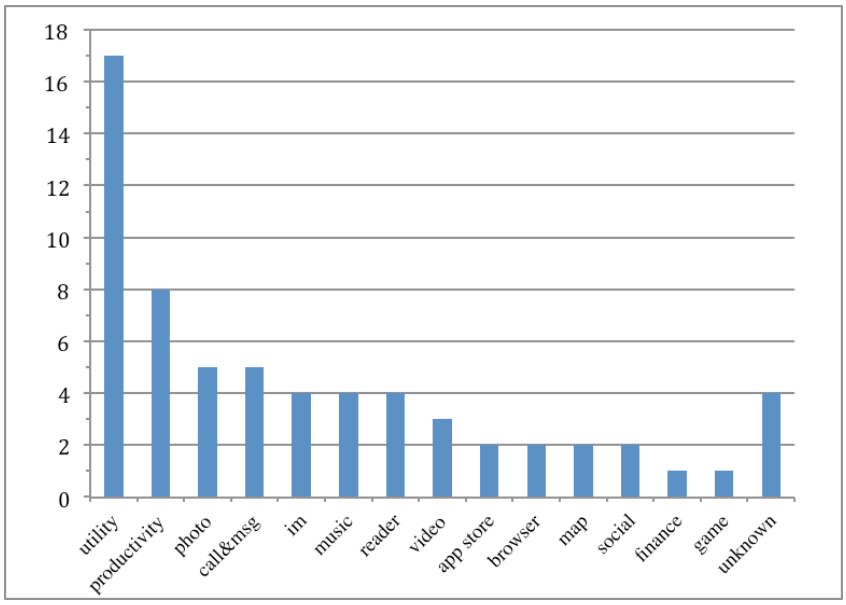

Fig. 1. Amounts of detected applications in each category

The students' perceptions of the most important and used applications differed from the actual usage data. For example music player was considered as one of the most important and used applications by four of the students but only three of them used it during the data-gathering period (**Table 4**).

Table 4. Logged application usage (L) and top applications named in interviews (I). utility and unknown apps have been omitted from the table.

Application	**Category**	**L**	**I**
Android browser	browser	5	
Message	call&msg	5	1
Mobile QQ chat	im	4	3
Android contacts	productivity	4	
Dictionary	productivity	4	1
Clock	productivity	4	
QQ chat	im	3	3
Android calendar	productivity	3	2
Renren	social network	3	1
iReader	e-book reader	3	3
Android player	music	3	4
Gallery	photo	3	
Video player	video	3	2

Application	**Category**	**L**	**I**
Wandoujia	app store	2	
UC Browser	browser	2	
Fetion IM app	im	2	
Baidu map	map	2	1
Camera	photo	2	
Xiaomi app store	app store	1	
Stock price app	finance	1	
Can knock down	game	1	1
Android email	message	1	
Kuwo player	music	1	4
FM Radio	music	1	1
Adobe reader	reader	1	
Microblog Weibo	soc.network	1	2

4.3 Personal Viewpoints of Smartphones And Their Usage

All the students kept their smartphones with them almost always. The phones were also used throughout the days. In some cases smart phone doubled also as an alarm clock. Smartphones were mainly used to keep in touch with friends and relatives and access different kinds of information (e.g. browsing the web and reading documents).

The students were aware of the possible costs that the smart phones could cause via for example data transferring. However, none of the students was following their monthly data usage. Instead all seemed to prefer WiFi hotspots to cellular data.
Although, most of the students had only their first smart phone and the phones were quite new (4 of the students had phones that were less than 1 years old), they already had grasped the "free" culture of Android ecosystem and thought that all Android applications should be free although it was normal for iPhone applications to be subject to charge. In the interview for example E stated that *"Yeah, Android is free. This [iPhone] we should spend a lot of money. Android free. All software is free in android usually."* The same student also commented on his two-phone strategy with *"This [iPhone] is for browsing the net and this [Android phone] for to make phone call and listen to the music"*

4.4 Personal Mobile Ecosystem

In personal level, the gathered data depicts the mobile phone usage of the students in very rich ways. Fig. 2 shows an example of combined data from one of the students for the two days. The image shows user provided context information (Logged context), log of application usage (Application usage), location information (Cell ID), movement information (Acceleration), and battery level of the device (Battery (%)). Both predefined contexts and user created ones are visible in the context information. Two contexts relating to sleeping are a hint of usability problem with the software. The student had forgotten that he had created sleeping context previously and created a new one. In the interview, the student explained that workplace to him means the office of his professor, although there were no good place for working for him. Thus, the workplace context just meant visiting the professor to discuss studies.

Application usage grouping is same as in **Table 4**. Contextlogger3 and phones' operating systems have been removed from the list in order to make the intentional application usage more visible. The data shows for example e-book reader usage of the student. In the interview the student explained that he reads both the study related and popular literature with his phone. Another student said that she reads academic articles since her e-reader software can reformat double column documents to single column ones.

Location information in the visualization is based on Cell ID. For example having lunch is nicely visible from the location information. As mentioned before, the students did not visit outside campus very often. Also this habit of staying in quite small area is visible in the Cell ID data as only few separated Cell IDs were captured.

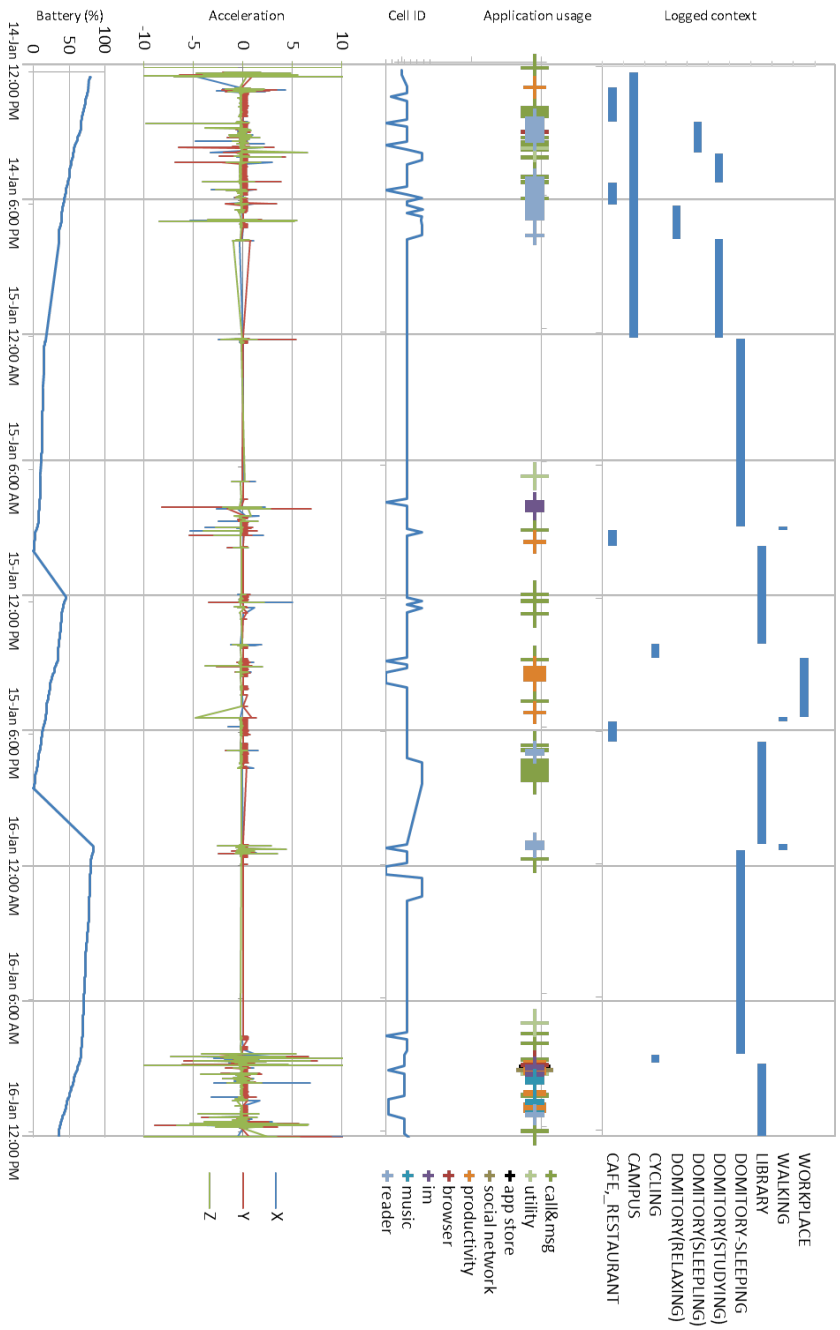

Fig. 2. Example of two days' combined data for one student.

Movement data shows the acceleration of the device in x, y, and z coordinates. For example walking, cycling and interestingly also visiting library, stand out from the data. The new library in the University's campus was very large and the student used library premises for studying. The library serves students in first come, first served principle and thus the student needed to walk around and find a free spot when visiting the library.

The battery level data shows the energy consumption of the context logger software and also the weaknesses of using smart phones as information gathering tools. The battery ran out on January 15th at 10am and 10pm and also the data gathering stopped until the student recharged and restarted the phone and started also the Contextlogger3 application. There is no gap in user-logged activities since they were recorded as starting and ending times while the sensors provided continuous stream of sensor data.

5 Discussion

The pilot study shows that mobile phones are a viable tool for data gathering when studying mobile phone usage and that mobile sensing approach and self-reporting with interviews support each other. The success of the study can be emphasized with the fact that it was conducted in unfamiliar context and culture for the researchers. None of the researchers is Chinese or is familiar with mobile business in China.

Although the results are promising, they also show that there still is need for further development. For example the sensor data collection failed with one of the students. In addition there currently is only Android version of the Contextlogger3. Since it is critical to gather the data with users' own phones and devices, there is strong need to port the software to other mobile phone operating systems.

There is also great potential in developing the analysis tools. For example identifying transportation modes (walking, running, bicycle, car, bus, train, etc.) automatically from the movement data would free user from this task and allow focusing the self-reporting on thoughts and experiences instead of external factors.

All in all the mobile phone focused multi-method approach can provide a very rich picture of mobile phone usage. The results showed an example of a personal mobile ecosystem based on the data collected about one of the students during a couple of days. The aim of user research in service design is to understand the typical patterns of the target user groups and customers. Thus the results from the pilot study are limited in that sense. In our future study, we plan to address this shortcoming by extending our sample and using statistical multivariate methods to advance from an example to an analysis of typical personal mobile ecosystem.

In our pilot research, we used a visualization of the user reported contexts and selected sensor data as a basis for the interview in a bit similar manner, and for the same purpose, as the user-written diaries following DRM were used in [8,17]. While our approach could be used in evaluating usability, see [16], and also partly for QoE, evaluation which was the aim in [7,8,17], our aim was to demonstrate the potential of

this mixed-method approach to gather rich data about mobile service usage even from a relatively small user group over a short period of time.

Based on the lessons learned from the pilot study we suggest the following setup for gathering understanding of personal mobile ecosystems when designing new mobile services (Table 5). The framework builds on the strengths of multi-method approach and also combines big data (phone based sensing of large populations) with focused small-scale material about users' viewpoints and opinions. The framework has three parts: 1) phone based sensing provides the overview of what is happening around the user in both physical and digital worlds, 2) Self-reporting tells how the users see their activities and habits, and 3) Interviews explain the differences between first two and can also help to interpret individual data sets.

Table 5. Research framework for understanding personal mobile ecosystems.

<table>
<tr>
<td>Phone based sensing
Selecting the sensors
• The selection of sensors for a particular study is always a balance between the research needs, amount of data generated, battery consumption and protecting the privacy of the participants
Sample
• In order to get from example mobile ecosystems to typical ones, the user sample needs to be large enough. We would recommend 30-50 users as a good rule of thumb.
• Data collection should last at least few weeks, preferably a month to capture recurring patterns</td>
<td>Self-reporting
Selecting the methods
• Self-reporting can utilize many different media, e.g. text, audio and video
• The reporting task should be selected so that it focuses on most important and potential themes related to the service design project and is inline with the phone based sensing
Sample
• Self-reporting does not demand as big user sample as phone based sensing, e.g. 10 of the 30-50 who are doing the phone based sensing
• Self-reporting could also be narrowed to a shorter time period, like one week.</td>
</tr>
<tr>
<td colspan="2">Interviews
Developing the interview themes
• Interview themes should reflect the general focus of the study as well as the results of and selections made in phone based sensing and self-reporting.
Sample
• Interviews do not require as large samples as phone based sensing or even self-reporting. We recommend approximately 50% of the amount of people participating in the self-reporting.
• The users should be selected in the interviews based on their representativeness of the all collected data and success of their data gathering.</td>
</tr>
</table>

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A model of the value exchange system in the university with the big boss game

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Abstract. We studied a value exchange system among entities who have different senses of value. This system enables smoother exchanges of information resources and services. We defined a value vector that describes the variety of values in our system. A coalition of community members is used to circulate the endowments, services and currencies in a community, because the imputation of the exchange depends on the coalition. Furthermore, an analysis of the coalitions is required in order to evaluate the value of endowments and local currencies that depend on players in the value exchange system. We study a community in which one member has higher ability compared with the other members. This coalition relationship is modeled as a big boss game in game theory. The modeled community is a university laboratory in which worthwhile activities of the lab members (a teacher and a number of students) are exchanged. The aim of the students and the teacher is to achieve an overall research goal and increase their individual levels of satisfaction in their abilities, meet expectations, and achieve aspirations. In applying the big boss game to our scheme, the teacher becomes the big boss and the conditions under which the whole laboratory achieves its research goals is derived wherein the coalition includes all members of the laboratory. This model yields an index of the effort going into the research. Specifically, it shows how long the members of the laboratory have to spend researching in order to achieve their goals in a year.

1 Introduction

In contemporary society, information resources, e.g. knowledge, writing, and personal information, circulate through networks with the various tools of information technology. Moreover, the information resources of different societies need to be circulated among communities that have different values and public entities that do not belong to any particular community. Figure 1 shows the various relationships in communities. Members are bound by agreements based on confidence and exchanges of resources and money such as local currency. Appropriate values for information resources and services should be evaluated before these values and information resources are exchanged so that the information resources can be circulated more smoothly. Furthermore, information resources should be prevented from being leaked. The goal of our approach is illustrated in Figure 2.

The lawful currency is used for most transactions. However, it is difficult for the lawful currency to reflect the sense of values in various communities, and as result, endowments and currency do not always circulate smoothly. Recently, local currencies reflecting the sense of values in communities have been used in shopping centers to circulate endowments and services smoothly. A local currency is suitable for financial settlements between members of a community. Several theoretical approaches [1] [2] [3] have been used to analyze the circulation of local currencies. These previous studies treated the values as criteria, but merely circulating resources in the communities is insufficient to meet our aims. Furthermore, the circulation may be hindered by differences in the sense of values even if the entities belong to the same community.

We have been studying a value exchange system between two entities who have different senses of value [4][5]. This system enables smoother exchanges of information resources and services. The balance between convenience, safety, and circulation is considered in the transactions. We define a value vector that describes the variety of values in our system, what constitutes a settlement between two entities, and the circulation of the values with securities. The credit of the securities is evaluated by using a human relationship diagram [6]. We evaluated the settlement based on an information capsule with agents. Furthermore, multiple values should be combined in order to pay them out as rewards for services. It is generally difficult to decide the optimum combinations that maximize the properties of entities. We applied particle swarm optimization (PSO) and devised a scheme to decide the optimum combinations of values as a reward for services. Our value exchange system works among users who have different senses of value. The exchanges of values are realized in the form of services and behaviors for others and rewards for services. Furthermore, systems in which there are exchanges between communities that have different senses of value have been studied [7].

When we focus on the circulation of endowments, services and currencies in a community, we should consider the coalition of community members because the imputation of the exchange depends on the coalition. There are many relationships among community members. As a first step, we decided to study a community in which one member has higher ability compared with other members, and we modeled the coalition relationship as a big boss game in game theory. Here, the members' "worth" is treated as a local currency and exchanged in the community. In our paper and title, we use "university" as an example of an easy-to-understand. If there are one leader and some people in community, we can apply our model to many real situations. The community is a laboratory composed of students and a teacher in a university and their members' worths are exchanged. The aim of the students and the teacher is to achieve the research goal and increase the level of satisfaction in their abilities, satisfy expectations, and achieve aspirations. In the big boss game, the teacher is the big boss, and the conditions required to achieve the research goal are derived for a coalition including all members of the laboratory. For the sake of simplicity, the time spent on research and each individual's research ability are regarded as the values of effort. This model shows the index of the effort in the research. Specifically, it shows that how long the members of the laboratory have to spend to achieve some level of the research goal in a year. The proposed model

enables us to evaluate the worth of endowments and local currencies that depend on players.

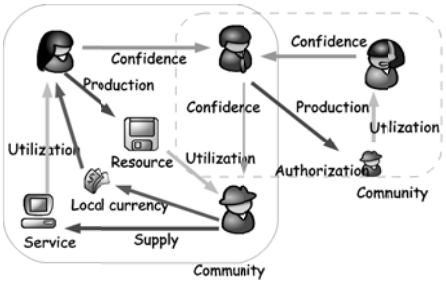

Fig. 1. Relationships in communities

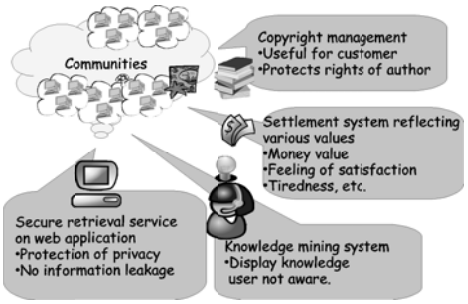

Fig. 2. Goal of our system.

2 Preliminary works

2.1. Relationship between the eServices co-creation and our study

In this subsection, we show the relationship between the co-creation and our study. There are 4 types of co-creation [8]. Our system can be applied to (1) Crowd of people, (2) Coalition of parties and (3) Community of kindred spirits.

Figure 1 in our paper shows the overall concept of the proposed system. Figure 1 shows the various relationships in communities. We assume that members revitalize the communities by exchange of the information and services. To realize the exchanges, some incentives are needed. Currently, these information and services are exchanged by using money or local currency. However, in general, each user has different sense of values. For example, volunteer users exchange "information or services" without money or local currency. This means that each user has a different motivation. Thus, in real situation, we assume that each user has different sense of values implicitly. However, modeling and analysis considering different sense of values has not been studied yet.

Thus our proposed system can realize 3 types of co-creation as following. (1) We can create new types of values by participation of many people because it is possible to take into account the sense of values of a lot of people. (2) We can cause more breakthrough by cooperation of communities because we can make the flow of information and services considering the variety sense of values. (3) We can achieve a big goal among people who has similar sense of values because information and services can be easily exchanged. If our proposed system considering co-creation is realized, the nature of eServices may change significantly. Thus, our proposed system is an essential to eServices co-creation.

However, in order to realize the proposed system such as shown in Figure 1, it is necessary to clear various issues. In this paper, we limit the situation, and we investigated our system theoretically. To realize co-creation, we need to consider the coalition of users. We apply the coalition in co-creation to the big boss game of a coalitional game in game theory. The big boss game can be applied to common situations. The common situations mean that there are one leader and some people in

a community such as companies and universities. The big boss game is able to analyze the best way to exchange "information and services" considering different sense of values theoretically.

2.2 Coalition game

Game theory is the study of how people (players) interact and make decisions. Each player selects its own behavior to achieve its own objective in a game. Game theory is classified broadly into two categories: noncooperative games and cooperative games. In a noncooperative game, each player makes decisions independently. In a cooperative game, players make groups of players (coalitions), and they enforce cooperative behavior.

A cooperative game is a competition between coalitions of players, rather than between individual players. The most basic cooperative game is between groups of cooperating players. One category of coalitional games includes games with transferable utility (TU), as described by von Neuman and Morgenstern [4]. The coalition game of n players (N, v) is defined by a finite set of players N $(|N| = n)$ and a characteristic function $v: 2^N \to \mathbb{R}$. This characteristic function v satisfies $v(\emptyset) = 0$. In the coalition game, a subset of N is defined as a coalition S, and $v(S)$ is defined as the $coalition$ value, which means the maximum value of a member of the coalition. Moreover, N is a coalition called the $grand\ coalition$ (i.e, the coalition of all players).

2.2.1 Superadditivity

We need to justify the assumption of cooperation of all players in a grand coalition. A game (N, v) is called an $essential\ game$ when v satisfies the following condition:

$$v(N) > \sum_{i \in N} v(\{i\}). \quad (1)$$

Equation (1) is only one of the conditions to justify the assumption of a grand coalition; we need to add stronger conditions, as follows ($Superadditivity$):

$$v(S \cup T) \geq v(S) + v(T) \quad \text{for any } S, T \subseteq N \text{ s.t. } S \cap T = \emptyset. \quad (2)$$

Equation (2) means that the value of the union of disjoint coalitions is no less than the sum of the coalitions' separate values. A game (N, v) or v satisfying this equation is said to satisfy superadditivity. Since coalition games are superadditive by definition, the joint payoff of the players is always from the grand coalition.

2.2.2 Solution concepts of coalition games

In coalition games with a grand coalition and superadditivity, the challenge is to allocate the payoff among the players in a fair way. This allocation is called a solution of the game, and a solution concept is a payoff vector $x = (x_1, x_2, \cdots, x_n) \in \mathbb{R}^n$ that represents the allocations to each player. When x satisfies the two following conditions, this vector is called an $utation\ I$.

$$I = \{x \in \mathbb{R}^n | \sum_{i \in S} x_i = v(N), x_i \geq v(\{i\}), i = 1,2, \cdots, n\}. \quad (3)$$

The former condition is called group rationality, and the latter condition is called individual rationality. The solution concepts, and hence imputations, differ depending on the notions of fairness, i.e, core, Shapley value, and nucleolus. The following passages describe these notions.

Core

The core is the set of imputations that are not dominated. Core C is defined by

$$C = \{x \in I \mid \forall y \in I \backslash \{x\},\ y \text{ dom } x \text{ is not hold}\}. \quad (4)$$

where y dom x means that imputation $x = (x_1, \cdots, x_n) \in \mathbb{R}^n$ dominates imputation $y = (y_1, \cdots, y_n) \in \mathbb{R}^n$ through S. This dominance relationship is the basic role of the core in the game, and y dom$x$ satisfies the following conditions.

$$v(S) \geq \sum_{i \in S} x_i, \quad x_i > y_i, \quad \forall i \in S \quad (5)$$

The inequality on the left means that the coalition has a value greater than the sum of its players' payoffs. The inequality on the right means that all players in S prefer x to y. In this situation, these players are not satisfied with y.

Nucleolus $\boldsymbol{\nu(S)}$

The nucleolus is an efficient allocation that successively maximizes the smallest excess. The excess is defined by,

$$e(S, x) = v(S) - \sum_{i \in S} x_i. \quad (6)$$

The existence and uniqueness of a nucleolus are guaranteed for games with a characteristic function and $I \neq \emptyset$.

Shapley value $\boldsymbol{\phi(S)}$

The Shapley value $\phi(S)$ means that each player should be paid according to how valuable his/her cooperation is for the other players.

$$\phi(v)_i = \frac{1}{n!} \sum_{S \subseteq N \setminus \{i\}} |S|!\,(n - |S| - 1)!\,(v(S \cup \{i\}) - v(S)) \quad \forall i \in N, \qquad (7)$$

where $v(S \cup \{i\}) - v(S))$ means an enlargement of the coalition by adding a player i and is called a $marginal\ contribution$. Moreover, the weight put in front of $v(S \cup \{i\}) - v(S))$ is the probability that player i faces S when entering the coalition in a random order. In general, the Shapley value satisfies the group rationality requirement. Moreover, the Shapley value also satisfies the individual rationality requirement when the game is superadditive. In this situation, the Shapley value is an imputation.

2.3 Big boss game

2.3.1 Definition

A big boss game has a special player (the big boss) who has a strong influence on the other players [10]. In the big boss game, if there is no big boss in a coalition, players cannot have a payoff. Let $N = \{1,2,\ldots,n\}$ be a set of players and k be a big boss player. Moreover, let $S, T \subseteq N$ be a coalition, and let us use the characteristic function $v: 2^N \to \mathbb{R}$. Let $v(S)$ be a coalitional value. The big boss game needs to satisfy the following three conditions [10]:

- $Big\ boss$: If there is no big boss in a coalition, players cannot have a payoff.
$$v(S) = 0 \quad k \notin S \qquad (8)$$

- $Concave$: The marginal contribution of a player is large when the size of the coalition is small.
$$v(S \cup \{i\}) - v(S) \geq v(T \cup \{i\}) - v(T) \qquad (9)$$
for any $S, T \subseteq N$ and $i \in N$ s.t. $k \in S \subset T \subseteq N \setminus \{i\}$.
- $Monotonicity$: The payoff of each player is large when the size of coalition is large.
$$v(S) \leq v(T) \qquad \text{for any } S, T \subseteq N \text{ s.t. } k \in S \subseteq T \subseteq N. \qquad (10)$$

The big boss game is superadditive. Thus, the core is not an empty set.

2.3.2 Deriving of the core, the nucleous and Shapley value

The core of the big boss game is defined as,

$$C(N, v) = \{x \in I(N, v) | 0 \leq x_i \leq v(N) - v(N) \setminus \{i\}\ \forall i \neq k\}. \qquad (11)$$

The maximized payoff of big boss k is $x_k = v(N)$, and the minimized payoff of big boss k is $x_k = v(N) - \sum_{j \neq k} v\,((N) - v(N\{j\}))$ [10]. The nucleolus and the Shapley value are equal to those derived from the leader game with a duality

relation [11]. The following equation concerning the coalitional value is valid in the leader game (N, v_L):

$$v_L(S) = \begin{cases} v_L(N) & (1 \in S) \\ \sum_{i \in S} v_L(\{i\}) & (1 \notin S) \end{cases}$$

3 Analysis of the exchange system with the big boss game

3.1 Coalition of all players

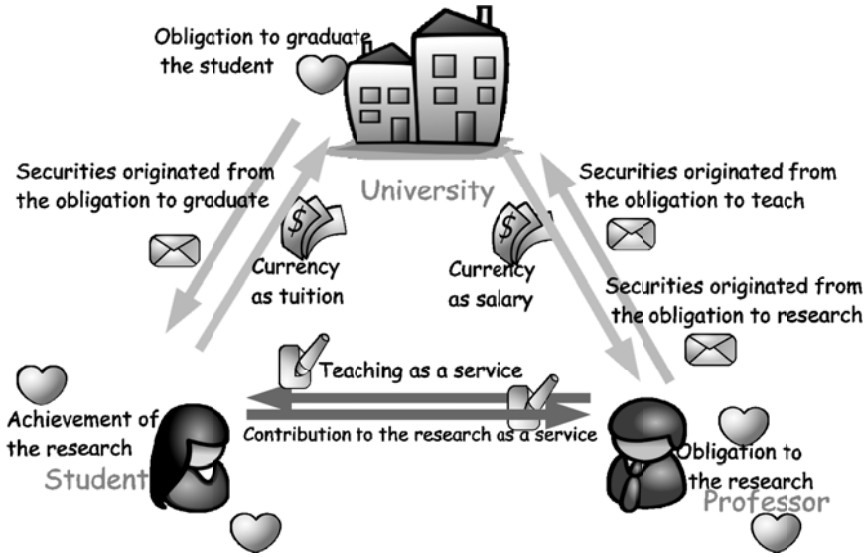

Fig. 3. Circulation of endowments, services and currencies in a university.

Lawful currency, endowments, services and implicit currencies and endowments circulate among professors and students in the community of the university shown in Figure 3. The Titans of students and salaries of professors are paid in lawful currency. The time used to teach students is regarded as a service. The level of achievement in research is regarded as an endowment that represents the sense of obligation. The obligation of the professor in consideration of his/her salary paid to teach students and the obligation of students to get a return on their investment of tuition fees are regarded as negative endowments.

Some endowments such as obligations relate to personal or concerned parties and are generally hard to circulate. Securitization enables such endowments to be circulated [5]. This concept explains why entities trust transactions. The target of the circulation analysis should include currency, services, and endowments. Here, we will focus on the assignment of achievements in teaching. This assignment of the individual achievements can be regarded as an imputation in game theory. Furthermore, the big boss game is a good way to model differences in research ability.

The core, nucleolus, and Shapley value, i.e., the imputations, are derived from the coalitional value of the whole coalition.

3.2 Model

3.2.1 Laboratory

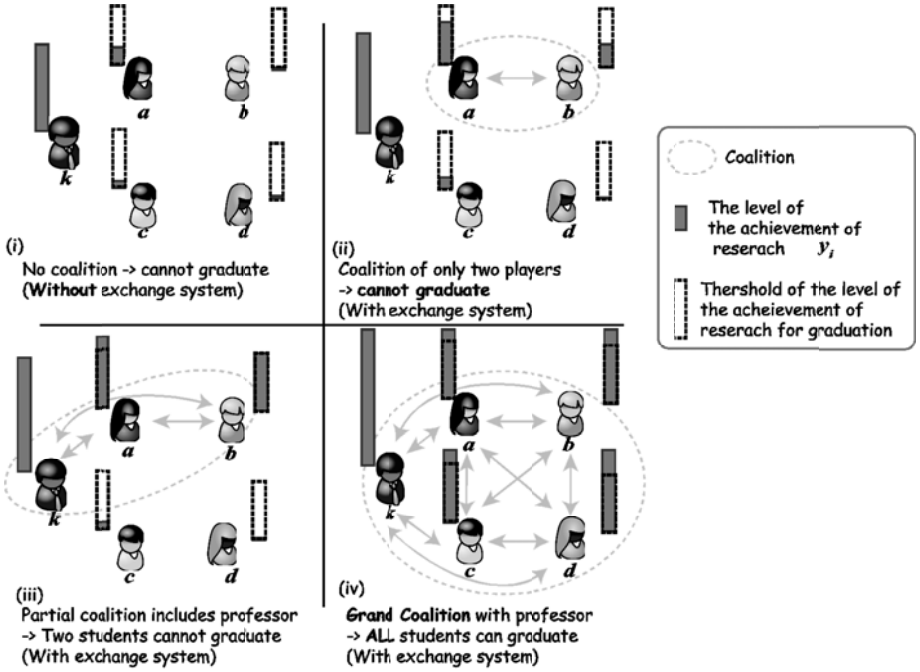

Fig. 4. Imputations in a laboratory

In the model of Figure 4, the university laboratory consisting of a professor and students is regarded as a community. We assume that the professor teaches his/her students, and all students conduct research in order to graduate from their university. The blue bars in the figure mean the level of achievement in research after they have conducted research for a year. In general, the research ability of the professor is high. On the other hand, the research abilities of the students are low because this is their first research project.

We assume that each student needs to exceed a threshold in the level of research achievement in order to graduate from university. Thus, the professor is an essential person in the laboratory, and he/she acts like a big boss. Let us consider the value exchange system. As shown in figure 4(i), there is no coalition in a laboratory. In this situation, all students conduct their research by themselves without advice from the professor and other students. In this situation, the level of the research achievement of

only the professor is high, because only he/she can advance his/her own research, and the level of research achievement of all students is low.

Next, let us consider a coalition with students but without a professor. In this situation, students cooperate with each other and exchange their values. Through these behaviors, students will develop motivation and ambition. As a result, the level of research achievement of the students will increase.

However, the assumption that the coalition consists only of students is not effective. This is because teaching by the professor is a required condition to reach the threshold level of research achievement in order to graduate. In general, therefore, students themselves cannot reach the required level to complete their theses. As a result, we need a coalition with a professor, as shown in Figure 4(iii). In this case, the coalition which includes students a and b goes over the threshold for graduation, because students get advice from the professor. However, students who do not form a coalition with the professor can not get over the threshold. In the figure, c and d can not graduate. Thus, all students will attempt to form acoalition with the professor, as shown in figure 4(iv). The coalition increases the ability of each member of the coalition and raises the levels of satisfaction, expectations, and aspirations.

In addition, we assume that the essential ability of individual students varies but that students of very poor ability who can not do anything don't exist. The time and ability of the professor and the students are set as the levels of effort, and the level of achievement in a year and imputations of the time of effort are calculated from these levels. This scheme is simple because research ability does not change in a short period, but the time of effort is variable and the level of achievement depends on only the time of effort. The solution of the scheme becomes the imputations and the assignment of time becomes clear from the imputations.

3.2.2 Coalitions

The variables in the big boss game are defined as follows.

- k: The professor as a big boss
- $B(S)$: The level of achievement in the coalition S
- B_i: Individual level of achievement
- D: The level of achievement of the whole laboratory as far as achieving the aim goes
- c_i: The maximum achievement of player i in a year
- x_i: The surplus of the effort of player i
- y_i: The level of achievement of player i

Accordingly, the coalitional value $v(S)$ is denoted as

$$v(S) = \begin{cases} B(S) - D > 0 & (S \ni k) \\ 0 & (S \not\ni k) \end{cases}$$

Note that the imputation x_i means the surplus effort of player i. Thus, our goal imputation y_i of the level of achievement of player i is $y_i = c_i - x_i$.

Thus, the imputations y_i mean assignments of time to achieve the level without any disapproval of the members in the laboratory. However, this imputation is very low

when a student does not graduate, as shown in Figure 4(i)(ii)(iii). To graduate from university, the professor and students need to cooperate with each other. For simplicity, the coalitional value under the coalition without a professor are defined as zero.

We assume that all players (the professor and all students) aim to achieve a value D that is the sum of their achievement levels:

$$D = \sum_{i \in N} y_i.$$

This characteristic function satisfies the superadditivity, monotonicity, and big boss conditions. Thus, the core is not an empty set, and there are nucleolus and Shapley values [12].

- The core of this model is equation (11).
- The nucleolus $v(S)$, Shapley value $\phi(S)$ is

$$v(S) = \phi(S) = \begin{cases} \frac{1}{2}B_i + \frac{1}{2}B(N) - D, & \text{if } i = k; \\ \frac{1}{2}B_i, & \text{if } i \neq k. \end{cases} \quad (12)$$

3.2.3 Example

In this example, the players belonging to the laboratory are the professor k and students a, b, c, and d. The maximum abilities of each player are $c_k = 100$, $c_a = 10$, $c_b = 12$, $c_c = 20$, and $c_d = 16$. The level of achievement of the whole laboratory regarding the aim D is 70. The coalitional value, imputations, and Shapley value are found under the whole laboratory coalition, as follows:

$$v(S) = B(S) - D = (100 + 10 + 12 + 20 + 16) - 70 = 88$$

Imputations

- Core

The core of this model is equation (11). Let us consider the two extreme situations using the core definition of equation (11). Here, we define two core sets, x^p and $x^s \in C(N, v)$.

$$x^p = (30,10,12,20,16), \quad x^s = (88,0,0,0,0).$$

In this situation, the set of achievement levels is

$$y^p = (70,0,0,0,0), \quad y^s = (12,10,12,20,16).$$

When a set of achievement levels is y^p, the professor makes a full effort to teach all students, but all students ignore their studies. Thus, the level of achievement of the professor is high (70), but the level of achievement of the students is low (0). On the other hand, when the set of achievement levels is y^s, all students make a full effort to learn, but the professor blows off his/her teaching responsibilities. Thus, the level of

achievement of the professor is low (12), but the levels of achievement of the students are high (10,12,20,16). Here, let us consider the excess $e(S,v)$. From equation (6), the set of cores C satisfies $e(S,v) \leq 0$. We define the maximum excess of all patterns of coalitions as,

$$e_{max}(S,v) := \max_{S \in N} e\,(S,v). \tag{13}$$

When the levels of achievement of the professor and students is y^p, $e_{max}(S,v) = 0$ and $k \in S$. On the other hand, when y^s, $e_{max}(S,v) = 0$ and $s \in S$. The maximum excess of the imputation $e_{max}(S,v)$ is less than or equal to zero even if the assumed situation is an extreme case. Thus, all players have no excesses. However, the level of excesses varies with the set of imputations of the core. Thus, we need the nucleolus and Shapley values.

- Nucleolus $\nu(S)$ and Shapley value $\phi(S)$

From equation (12), we can derive the set of nucleolus and Shapley values $x^n \in C(N,v)$ and the set of achievement levels y^n as follows.

$$x^n = (59,5,6,10,8), \quad y^n = (41,5,6,10,8)$$

In this situation, $e_{max}(S,v)$ is -5. From the definition of the nucleolus, the excess of the nucleolus can be defined as,

$$e^*(S,v) := \min_{x \in I} \max_{S \in N} e\,(S,v). \tag{2}$$

When the level of achievement of the professor and students is y^n, $e^*(S,v)$ is -5. Thus, the excess of y^n is smaller than those of y^p and y^s. The individual levels of achievement of the professor and students y^n are relatively equalized compared with those of y^p and y^s. Moreover, the Shapley value is defined as the imputation according to the marginal contribution by equation (7). In this model, when c_i is large, the marginal contribution is also large. Thus, the magnitude relationship of c_i is the same as that of y_i. As a result, y^n means that the maximum excess in all coalitions can be minimized and that the model accounts for the marginal contribution of each user. Thus, through the imputation of this model which reflects the variety sense of values, it is possible to provide values that satisfy all players.

4 Conclusions

We proposed a value exchange system in a community. A university laboratory is a familiar community and we modeled it. The coalitional value was deduced, and the core, nucleolus and Shapley value were evaluated in all coalitions. Here, we used the big boss game, but there are several other models in the game theory that would be appropriate for modeling similar situations. The proposed value exchange system treats a situation in which one player stands out in their ability in the community. We should use other models to realize other transactions in the community. This sort of situation occurs in many communities, and the proposed model can be used to make a function that evaluates the worth of endowments and local currencies that depend on

the players. In the future, we will consider the circulation of endowments and services among communities.

Acknowledgements

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A Survey Research on Customer Value of Service-class Online Group-buying

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Abstract. This study regards service-class online group-buying as the unit of analyses. Drawing upon the literature in customer value and considering the process of service-class online group-buying, this study proposes an influencing factor model. This study tests each hypothesis based on this conceptual model through empirical analysis. The result shows that: influencing factors of online purchase link include website usability (0.480) and website brand (0.324); influencing factors of offline consumption link include real business brand (0.513) and price (0.378); in the whole process, real business service quality (0.689) and website experience value (0.400) are the main influencing factors of customer value. The findings will provide valuable reference for group-buying website and real business's making-decision.

Keywords: online group-buying, customer value, influencing factor

1 Introduction

Online group-buying is originated from United States' Groupon website, established in 2008. Group-buying can organize customers, who have the same consumption intention, and purchase in bulk from the merchant [1]. In 2010, it raised rapidly in China's major cities, becoming the highlight of e-commerce applications. Group-buying model involves group-buying website, real business and customer. As the third-party platform, group-buying website needs to contact real business and negotiate group-buying. Moreover, it needs to popularize the website and information of group-buying commodities, attracting the customer to buy.

Since 2010, the development trend of online group-buying in China likes inverted "U": in the end of 2010, the number of group-buying website was about 1880, the annual transaction amount was more than CNY 8.86 billion [2]; in the end of June 2011, the number increased to 5104; in the end of 2011, it dropped to 3909 [3], the annual transaction amount was about CNY 21.6 billion [4]; only 3210 group-buying websites were still operating in the end of June 2012, and 2695 in the end of 2012, the annual transaction amount was about CNY 34.89 billion [5]. The statistics show: during 2011, there were 1960 group-buying websites collapsed; during 2012, the number of cumulative collapsed group-buying websites was about 3482 [5]. Online group-buying websites are confronted with tremendous pressure.

Influencing factors exist significant difference when purchasing different online group-buying [4]. For example, convenience will affect customer value of catering-class, but won't affect customer value of clothing-class. Therefore we need to refine object of the study. According to I-Research's Classification, online group-buying is divided into service-class one and physical-class one [6]. Service-class online group-buying requires customer to purchase e-voucher on group-buying website firstly, then consume in real business by e-voucher. Its transaction process includes online purchase link and offline consumption link.

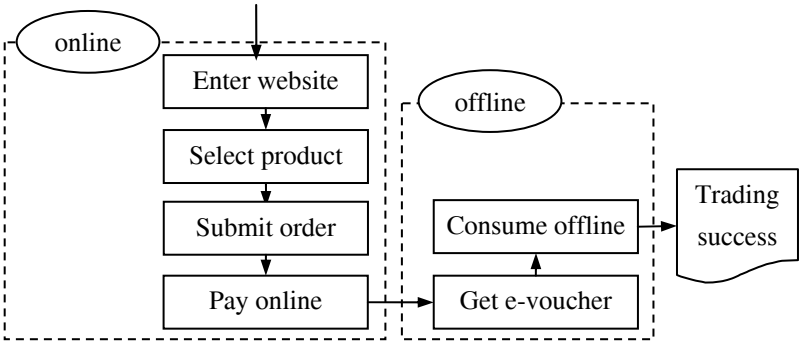

Fig. 1. The transaction process of service-class online group-buying

The object of this paper is service-class online group-buying. Selecting service-class one is because: (1) Service-class one is the mainstream in online group-buying market; (2) Customer value of service-class one is impacted by both group-buying website and real business. Comparing to general e-commerce, there is a big difference in influencing factors of customer value. Research on customer value of service-class online group-buying is more valuable.

2 Theory and hypotheses

2.1 Customer value

Customer value is customer's subjective perception between what he/she receives and what he/she gives up to acquire the benefits. Although its importance has been unanimously approved, there are different viewpoints: theory of customer perceived value, the process theory of customer value, customer value cognitive theory and customer delivered value theory.

Although the definition don't reach a consensus, but these points they all agreed: (1) Customer Value is customer perceived value of product/service. It is customer's subjective evaluation; (2) Customer Value is a relative value. It is a tradeoff between loss and benefit; (3) Customer value, although couldn't be determined by enterprise, but it is created by enterprise. This paper argues that the customer value is an overall evaluation by customer between benefit and loss, according to attributes, performance

and utility of product/service, in specific purchasing /consumption context [7, 8, 9].

2.2 Hypotheses

This paper is to identify influencing factors of customer value of service-class online group-buying and make clear their degrees of importance. According to the transaction process of service-class online group-buying (Fig. 1), it includes online purchase link and offline consumption link. Drawing upon B2C online customer value (Cai Shun & Xu Yunjie) [10], the paper regards website experience value and real business service quality as two directly influencing factors.

Website experience value refers to customer perceived gains during the online purchase link [10], having a positive effect on customer value. Drawing upon the B2C online customer value theoretical framework (Zhan & Dubinsky), the paper regards that website experience value is influenced by website usability, website information quality and website customer service, but the last one's effect is not significant [11]. As website interaction is one part of the comprehensive customer experience in e-commerce [12], the paper regards website interactivity as a positive influencing factor of website experience value.

Real business service quality refers to customer perceived revenue during the offline consumption link, having a positive effect on customer value. The research on customer value of traditional service shows that real business service quality includes core benefit (dominant service effectiveness), form benefit (consumption environment, attitude of waiter) and additional benefit (emotional gain) [13].

Convenience is a characteristic of service, having time, place, acquisition, use and execution dimension [14]. It is e-voucher purchased on group-buying website that stipulates available time and place of offline consumption. Therefore the paper takes availability of e-voucher into account as antecedents of customer value [15]. It refers to the flexibility of consumption time and place. The greater is availability of e-voucher, the more convenient for customer. Thence availability of e-voucher has a positive effect for customer value.

Since Price is the main loss of customer during the process, it should be a factor in the model [16]. Price is the cost of money when customer purchasing, measured in two dimensions: currency price and discount [8]. Price influences customer value through perceived loss and service quality [17]. Therefore, Price has effects on both real business service quality and customer value.

Related studies shows: brand is a significant impact on perceived product/service quality [8, 17, 18]. Therefore, the paper takes brand into account as influencing factor during two links. That is website brand is positively related to website experience value; real business brand is positively related to real business service quality.

In summary, the influencing factor model is shown as Fig. 2 and hypotheses of the paper are shown as Table 1.

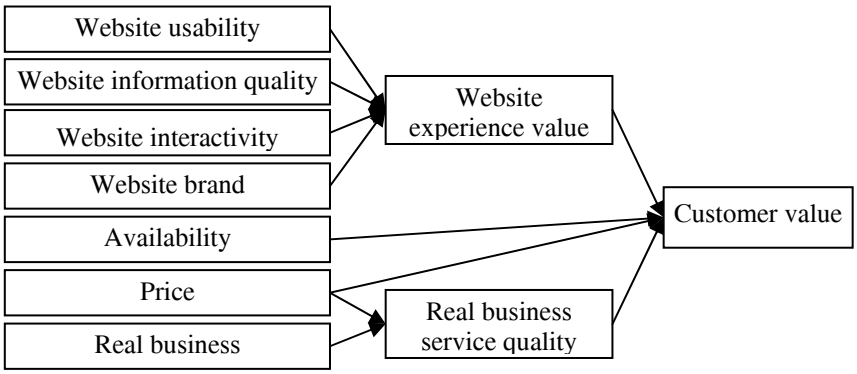

Fig. 2. The influencing factor model of customer value of service-class online group-buying

Table 1. List of hypotheses

No.	Hypotheses
H-1a	Website usability is positively related to website experience value.
H-1b	Website information quality is positively related to website experience value.
H-1c	Website interactivity is positively related to website experience value.
H-1d	Website brand is positively related to website experience value.
H-2a	Price is positively related to real business service quality.
H-2b	Real business brand is positively related to real business service quality.
H-3a	Website experience value is positively related to customer value.
H-3b	Availability of e-voucher is positively related to customer value.
H-3c	Price is negatively related to customer value.
H-3d	Real business service quality is positively related to customer value.

3 Research methodology

The model contains 10 variables: 7 independent variables, 2 mediating variables and 1 dependent variable. They are all latent variables, measured by a number of items. We exploit a survey method to test the proposed model. Every measure item adopts five-score Likert scale. Questionnaire reviews set is {1,2,3,4,5}, respectively corresponding to set {very incompatible, incompatible, does not matter, consistent, very consistent}. Respondents answer items based on prior online group-buying experience. Drawing literature and the whole process, the paper gives items for each variable. The questionnaire has 32 items totally, shown as Table 2.

To ensure recovery rate of the questionnaire and quality of answers, the paper uses face-to-face survey. The respondents are online shoppers who have service-class online group-buying experiences. They are asked to evaluate one of their prior experiences by answering 32 items. The paper distributes questionnaires in 2 tourist attractions, Xiamen University and 2 office buildings by convenient sampling.

Table 2. Measure items for variables

Variable	Item code	Items
website usability	wUSA1	load website quickly
	wUSA2	website classification is reasonable, you can quickly find goods
	wUSA3	process is simple, easy to complete or cancel the transaction
	wUSA4	website provides a number of payment method
	wUSA5	website provides a fast, accurate query function
website information quality	wINF1	comprehensive information
	wINF2	easy to understand information
	wINF3	reliable information
website interactivity	wINT1	convenient to communicate among customers
	wINT2	customer service is able to provide help urgently
	wINT3	personalized recommendation and remind
	wINT4	evaluation to meet feedback is available
website brand	wBRA1	popularity of website
	wBRA2	reputation of website
website experience value	wEXP1	smooth process
	wEXP2	high efficiency
	wEXP3	enjoyable
availability of e-voucher	AVAI1	valid period is long
	AVAI 2	consumption period is not limited(eg busy/weekend is available)
	AVAI 3	there is large number of available real business
price	PRI1	amount is low
	PRI2	discount is high
real business brand	rBRA1	popularity of real business
	rBRA2	reputation of real business
real business service quality	rSER1	customer service is ok
	rSER2	consumption environment is ok
	rSER3	attitude of waiter is ok
	rSER4	the core service is ok
	rSER5	the offline consumption link is enjoyable
customer value	CV1	evaluation of online purchase link is high
	CV2	evaluation of offline consumption link is high
	CV3	evaluation of the whole process is high

4 Data analysis and results

4.1 General statistics

The paper gathers 269 valid questionnaires, reaching the sample size required to factor analysis [19]. Sample general statistics is reported in Table 3, matching the characteristic of online group-buying customer [20].

Table 3. General statistics

Variable	Classification	Number	Percent
sex	male	103	38.3%
	female	166	61.7%
age	≤18	10	3.7%
	19-24	199	74.0%
	25-30	54	20.1%
	≥31	6	2.2%

4.2 Instrument reliability and validity

Before testing hypotheses, we need to verify the reliability and validity of the questionnaire. Table 4 shows the result of reliability using SPSS. All Cronbach's α are between 0.747 and 0.884 except for availability of e-voucher. Cronbach's α of availability of e-voucher is 0.69, almost reaching to 0.7. Thus the paper agrees the instrument is reliable [21].

Construct validity is often explained by convergent validity, exploring comprehensiveness [22]. Confirmatory factor analysis (CFA) is conducted to test the construct validity. Table 5 shows validity result after adjusting the model using Amos.

The criteria of good convergent validity are: factor loading > 0.7, the average variance extracted (AVE) > 0.5 and the combination validity (CR) > 0.6 [22]. Table 5 shows that there are still 6 factor loadings <0.7, 3 AVEs <0.5. Except for availability of e-voucher, 5 indicators that don't meet condition are very close to standard value, so the paper approximately considers the instrument has acceptable validity.

4.3 Model fitting

The paper tries to use structural equation model (Fig. 3) to test hypotheses. Firstly, we need to examine overall fitness of the model. 7 indices used to estimate the model fitting are higher than the standards recommended by the literature (p=0.000, CMIN/DF=1.737, RMR=0.050, RMSEA=0.052, IFI=0.943, TLI=0.929, CFI=0.942), another 3 indices (GFI=0.882, AGFI=0.845, NFI=0.876) are also close to the recommended standards, though a bit low [22]. Considering the sample size, our model is reasonably acceptable to assess the results.

4.4 Hypotheses testing

Hypotheses are tested by the structural equation model (Fig. 3). The examination result is as shown Table 6. There are 6 significant hypotheses and 4 insignificant hypotheses. Website usability and brand are positively related to website experience value. However, website information quality and interactivity have no significant affect for website experience value. Price and real business brand are positively related to real business service quality. Influencing factors of customer value, which pass the test, are website experience value and real business service quality.

Table 4. Reliability analyses of instrument

Variable	Cronbach's α	Item code	Corrected item-total correlation	Cronbach's α if Item Deleted
website usability	0.801	wUSA1	0.500	0.788
		wUSA2	0.595	0.759
		wUSA3	0.668	0.735
		wUSA4	0.568	0.768
		wUSA5	0.589	0.761
website information quality	0.747	wINF1	0.577	0.659
		wINF2	0.629	0.600
		wINF3	0.518	0.727
website interactivity	0.774	wINT1	0.553	0.732
		wINT2	0.636	0.688
		wINT3	0.583	0.717
		wINT4	0.537	0.741
website brand	0.797	wBRA1	0.663	-
		wBRA2	0.663	-
website experience value	0.780	wEXP1	0.567	0.780
		wEXP2	0.607	0.714
		wEXP3	0.707	0.625
availability of e-voucher	0.690	AVAI1	0.462	0.651
		AVAI2	0.544	0.546
		AVAI3	0.513	0.588
price	0.827	PRI1	0.708	-
		PRI2	0.708	-
real business brand	0.815	rBRA1	0.688	-
		rBRA2	0.688	-
real business service quality	0.837	rSER1	0.556	0.829
		rSER2	0.641	0.804
		rSER3	0.674	0.794
		rSER4	0.684	0.792
		rSER5	0.649	0.801
customer value	0.884	CV1	0.789	0.822
		CV2	0.753	0.854
		CV3	0.781	0.830
total	0.942	-	-	-

note: - shows that index value is null.

Table 5. Validity analysis of adjusted instrument

Variable	Item code	Factor loading	AVE	CR
website usability	wUSA2	0.657	0.4821	0.7878
	wUSA3	0.734		
	wUSA4	0.653		
	wUSA5	0.729		
website information quality	wINF1	0.783	0.5737	0.7289
	wINF2	0.731		
website interactivity	wINT1	0.713	0.4903	0.7424
	wINT2	0.726		
	wINT3	0.660		
website brand	wBRA1	0.792	0.6639	0.7979
	wBRA2	0.837		
website experience value	wEXP2	0.736	0.6502	0.7868
	wEXP3	0.871		
availability of e-voucher	AVAI1	0.681	0.4227	0.6868
	AVAI2	0.647		
	AVAI3	0.621		
price	PRI1	0.812	0.7099	0.8301
	PRI2	0.872		
real business brand	rBRA1	0.805	0.6887	0.8155
	rBRA2	0.854		
real business service quality	rSER2	0.706	0.5487	0.8292
	rSER3	0.725		
	rSER4	0.757		
	rSER5	0.773		
customer value	CV1	0.862	0.7189	0.8846
	CV2	0.822		
	CV3	0.859		

Table 6. Hypotheses testing results

No.	Hypotheses	Coefficient	C.R.	P-value	Result
H-1a	wUSA→wEXP	0.480	3.741	***	supported
H-1b	wINF→wEXP	0.154	1.368	0.171	rejected
H-1c	wINT→wEXP	-0.073	-0.945	0.345	rejected
H-1d	wBRA→wEXP	0.324	3.828	***	supported
H-2a	PRI→rSER	0.378	5.166	***	supported
H-2b	rBRA→rSER	0.513	6.553	***	supported
H-3a	wEXP→CV	0.400	6.972	***	supported
H-3b	AVAI→CV	0.015	0.279	0.780	rejected
H-3c	PRI→CV	0.020	0.342	0.732	rejected
H-3d	rSER→CV	0.689	9.171	***	supported

note: *** shows that P-value<0.01.

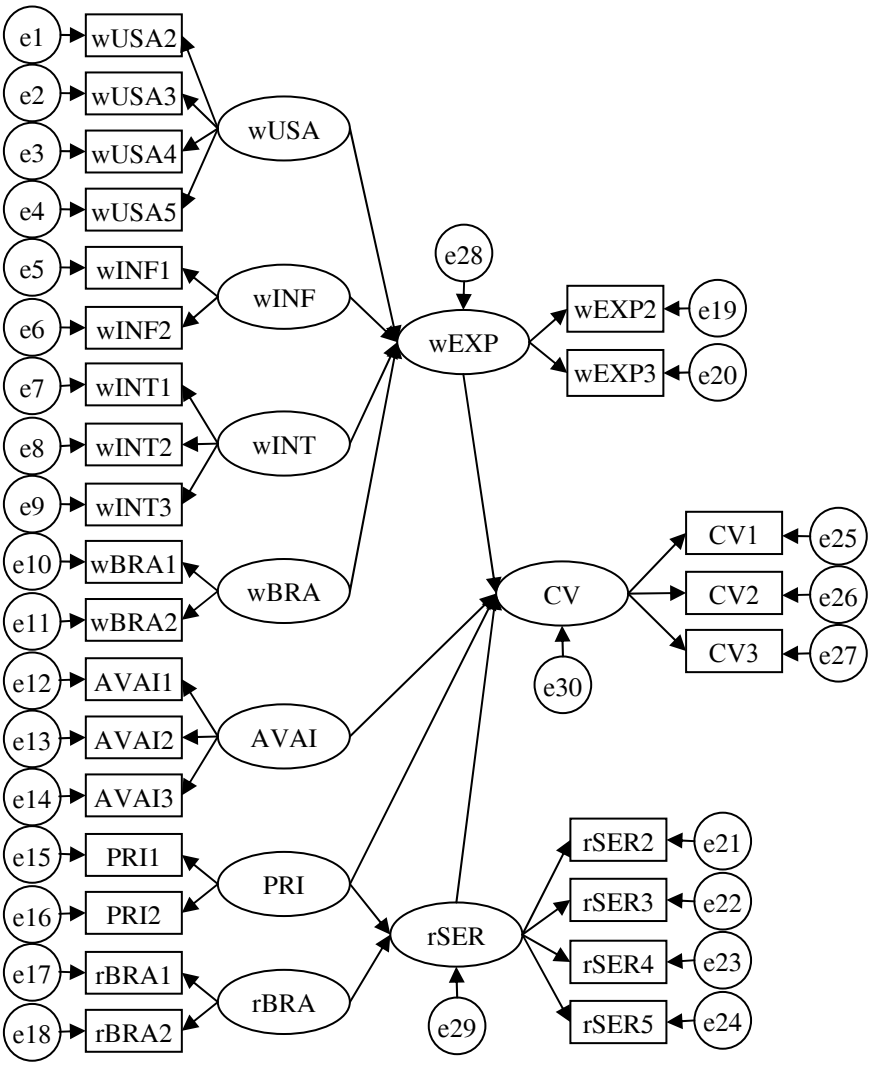

Fig. 3. The structural equation model for testing hypotheses

5 Conclusion and discussion

5.1 Conclusion

This paper regards service-class online group-buying as the unit of analyses. Drawing upon the literature in customer value and the transaction process of service-class online group-buying, this paper proposes an influencing factor model (Fig. 2). Conclusion as follows:

(1) Online purchase link: website usability (0.480) and website brand (0.378) are significant to website experience value.

(2) Offline consumption link: real business brand (0.513) and price (0.378) are significant to real business service quality.

(3) The whole process: real business service quality (0.689) and website experience value (0.400) are directly influencing factors of customer value. The gap of these two data shows that customer value of service-class online group-buying is determined by real business in greater extent.

But it is not significant for availability of e-voucher or price. Analyzing the reasons: (1) as online group-buying is planned consumption mostly, perception to availability of e-voucher is weaker; (2) comparing general e-commerce, online group-buying has obvious price advantage. Moreover, since online purchase link is separate from offline consumption link, the perception of the previous cost weakens as time goes by. Thus, price effect is not significant.

5.2 Discussion

At present, number of group-buying website almost reaches the peak. Online group-buying customer's consumption behavior is becoming more rational. These websites are facing huge challenge. How to grasp consumer behavior and create excellent customer value is the key to websites. This paper makes clear the strength of influencing factors and gives some valuable references: (1) Optimizing website design and daily operation to ensure website usability and brand, finally to improve website experience value; (2) It is necessary to adopt some standardized assessment systems to filter real business to improve real business service quality, which is the most critical factors of customer value; (3) There is no need to spend too much attention on website interactivity or availability of e-voucher, because they don't affect customer value significantly.

However, due to some limitations, this study needs improvement, mainly the following two points: (1) Improving the instrument. Its reliability and validity is acceptable, but don't reach the best level, so we can adjust several items to improve the survey quality. (2) Expanding the research model. Customer satisfaction and loyalty should be added to the model, thus ensuring the integrity of the model.

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Users' Continuance Intention of a Mobile Check-In Service in China

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Abstract. Mobile check-in service as one application of Location-Based Services is becoming a widely used service in China. Thus how users' acceptance of this application develops and whether users' continuance intention is strong are vital to its future with the rapid development of mobile commerce in China. This study examined the factors which affect the users' continuance intention toward mobile check-in service based on the consumption values theory, while incorporating the Technology Acceptance Model to construct the research model. The results indicate that functional value, emotional value, epistemic value, perceived ease of use and service experiences have significant effects on the users' continuance intention toward mobile check-in service. Functional value and social value of mobile check-in have a significant positive effect on the emotional value, and then they all affect the users' continuance intention indirectly.

Keywords: Location-based Services; Mobile check-in; Continuance intention; Consumption values theory; Technology Acceptance Model

1 Introduction

With the development of Mobile Communications Technology (MCT) and the acceptable price of mobile terminals such as smart phones and tablet PCs available to consumers, increasingly more mobile users have gradually formed a dependency on the mobile Internet. The fusion trend of Location-Based Service (LBS) and Mobile Internet (MI) is also exhibiting characteristics typical to social media. LBS application by definition adds a new dimension-- 'location' to the users' application. The applications typically can combine the location of online users into suppliers offline, importing some compete incentives like game elements to enhance users' activity and stickiness [1]. Among them, mobile check-in is an emerging in LBS which exhibits a new trend in mobile business.

Various types of applications and websites applying the user interaction method are trying to encourage users to take the initiative to share their location information to check-in. The mobile check-in refers to the users release and record their own location with the positioning function applications through smart phones, tablet PCs and other mobile equipment to share their consumption experience, get discount information (shopping, restaurant, etc.).

As an emerging mobile service, mobile check-in not only pays more importance on the registered user number but also on the number of active users. IResearch data shows that the growth of China's mobile service users using check-in is slow, contrasting hard with the hot enthusiastic of Chinese electricity commerce suppliers towards this service. By the third quarter of 2012 the active LBS users totaled 75.95 million, mobile check-in service user was only 11.6 million [2]. Therefore, how to retain users and make them long-lasting as possible users of mobile check-in is an important problem for suppliers, especially in the new era with rapid development of MI technology and diverse users' preferences. If there is no sustained and effective use of the mobile check-in providing for users, even initially registered users will run away in case of the service provider cannot bring the expected value [3].

Thus what kind of values can users acquire when adopting mobile check-in service? How does user perceived value affect them to continue use mobile check-in rather than other MI service? All of these questions are very worthy area of studying. From a practical standpoint, we believe that our results can be referenced by mobile check-in service providers to improve their service quality and to enhance their competitive advantage. Understanding the factors which contribute to users' continuance intention toward mobile check-in has both theoretical and practical implications.

2 Literature Review and Hypotheses

2.1 Possible theories to be used

MS continuance intention describes the user's decision to continue to use a specific mobile service. This is different from the user's first-time usage of the MS. MS continuance is crucial because the long-term viability of a MS and its eventual success depend on its continued use rather than first-time use [4] .

There are many theories, such as Technology Acceptance Model (TAM) [5], Diffusion of Innovation (DOI) [6] or Unified Theory of Acceptance and Use of Technology (UTAUT) [7] in the research field of MS continuance intention. Further, the theory of planned behavior (TPB) [8] and the expectation–confirmation model (ECM) [9] are widely used to elucidate user behaviors in MS.

The theory of consumption values states that consumption value, including functional value, social values, emotional value, epistemic value and situational value are the reasons for consumers' purchasing and using of certain product or service.

The mobile Internet can not only meet functional needs and entertainment needs, but also other potential needs. The traditional TAM has a lot of limitations and several

factors of ultimate value have not been included. Consumption value is an advantage beyond quality and a key to the influence of consumers' intention [10], but it gets less attention than other concerns. Although the theory of consumption value has been ripe in the study of consumers' behaviors, there is less study on the consumers' behaviors of mobile check-in based on this theory. When choosing a particular product or service, consumers will not only consider the utility provided, but also that its individuality and social status performance is enough and that the needs of emotion and curiosity are met [11, 12].

This study concerns the phenomenon of the mobile Internet and chooses users of mobile check-in as study objects, trying to explore the relationship between the consumption value and consumers' continuance intention to mobile check-in.

2.2 Functional Value

A product possesses functional value when it has some functional features that meets the purpose of consumers' use. Chang and Wildt [13] proposed that consumers can feel functional interests, social interests, personal interests and experience interests when purchasing and using products or services. By conducting a study on the factors of continual use behaviors to mobile reading business, Petrick [14] found that customer's perceived functional value has a positive influence on the continuance intention. So we put forward the hypothesis:

H1: Functional value of mobile check-in has a positive influence on users' continuance intention.

2.3 Social Value

Sweeney and Soutar [15] defines the social value as social identity or social self-concept which is produced in the usage of service. Steinfield et al [16] considers that the online network location service tended to help students reduce the difficulties encountered in the process of building interpersonal networks and meet their social needs, which is very important to attract students to continue to use the network business. When using mobile check-in services, users may be affected by the people around. In addition, it can also help to strengthen the exchanges with other people so as to enhance users' social image. So we put forward the hypothesis:

H2: Social value of mobile check-in has a positive influence on users' continuance intention.

2.4 Emotional Value

Emotional value means that purchase choice of users may depend on the consumer's emotional desire and expression. Moon and Kim [17] define perceived fulfillment as the strength that how the belief in the interaction between individuals and the network meets his internal motivation, indicating that perceived playfulness include curiosity and pleasure.

Taking college students as survey objects, Pedersen [18] studied the acceptance behavior of the 3G services, finding that perceived playfulness has a significant positive impact to the intention to use 3G services. Zhao and Lu [19] launched a study on the continuance intention of the mobile micro-blogging, finding that users' perceived emotional value has a positive influence on their continuance intention.So we put forward the hypothesis:

H3: Emotional value of mobile check-in has a positive influence on users' continuance intention.

2.5 Epistemic value

Epistemic value refers that consumer's choice depends on whether the product has meet the goals of the customer concerning curiosity, freshness, and the pursuit of new knowledge, and whether the product can stimulate the feeling. T So we put forward the hypothesis:

H4: Epistemic value of mobile check-in has a positive influence on users' continuance intention.

2.6 Situational value

The situational value means that when consumers have to make a choice in particular situation, situational value products usually linked the consumers' preorder status. Minna [20] studied perceived value and customer loyalty on the influence of LBS to users' intention and perceived value is divided into five dimensions as monetary value, containing convenience value, social value, emotional value, situational value and value of knowledge. She found that at the same time, all of the five dimensions have positive influence on continuance intention to LBS. In addition, the social value and emotional value affect the continuance intention indirectly through customer loyalty [21]. So we put forward these hypotheses:

H5: Situational value of mobile check-in has a positive influence on users' continuance intention.

H6: Functional value that users perceived has a positive influence on their emotional value.

H7: Social value that users perceived has a positive influence on their emotional value.

2.7 Perceived ease of use

Junglas et al [22] found that the users' personality characteristics, task characteristics, technical characteristics and perceived ease of use all have an influence on users' intention of LBS. Zhou [23] studied continual use willingness of LBS users with Equity Theory and explored three dimensions of fair and privacy risks and the interaction relationships between perceived ease of use and continuance intention. The results showed that procedural fairness is the most important factor of the privacy

risks, while distributive fairness is the main factor of perceived ease of use, and verified the effects of privacy risks and perceived ease of use to the continuance intention of LBS. Pihlstrom and Brush[24] divided the inherent perception factors into two parts of profits gain and loss, combining the thought of gain and loss in the perceived value theory and the risk-benefit thought in the privacy calculate theory**.** So we put forward the hypothesis:

H8: Users' perceived ease of use of mobile check-in has a positive influence on users' continuance intention.

2.8 Service experience

Torsten and Sabrina [25] conducted a questionnaire survey of Germany LBS users' intention, finding that most users do not know much about LBS applications. Lehrer et al [26] found that LBS service value and users' positive feeling will promote their continual use behavior through the qualitative research of interviews with the LBS users. Li [27] showed that the main factors affecting consumers' acceptance of LBS are: social impact, performance expectation, and consumer experience, contributing factors, effort expectancy, trust environment and perceived cost. .Zhang et al [28] found that contributing factors, consumer experience and consumer trust are key factors affecting users' adoption and use of mobile LBS services. So we put forward the hypothesis:

H9: Users' experience of mobile check-in service has a positive influence on users' continuance intention.

2.9 Continuance Intention-our model

Engel et al [29] shares the opinion that behavioral intention is consumers' behavior tendency which will often predict a person's behavior. Consumer's intention will affect his future actual purchase or consumption behavior. Jillian and Geoffrey [30] define that emotional value, social value, functional value and epistemic value have different contributions to consumer willingness in different contexts. Based on the hypotheses above, it can be concluded the research model of continuance intention about mobile check-in service, shown in Figure.1.

3 Data Collection and Reliability and Validity Analysis

Questionnaires were distributed and filled combining random interception and online survey. 516 valid questionnaires were received in the survey, of the answers 197 were males and 319 were females. As for education level, the ones who received high school education or above are the majority, of which 483 people received undergraduate education or above and occupied 93.6.It is not difficult to make the conclusion that the respondents in the sample are mostly young people with high education, who are the main target customers of the mobile Internet, as well as the

main force of the LBS application users. The study has made the reliability and validity analysis of the scale items from eight aspects shown in Table 1.

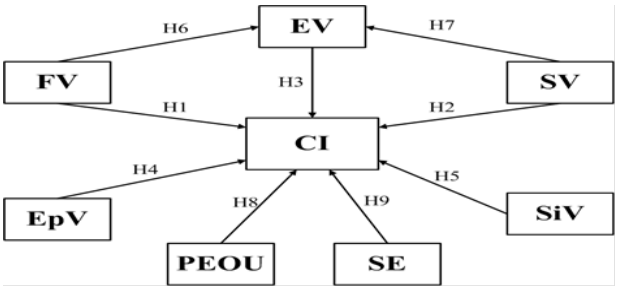

Fig.1. Research model of users' continuance intention toward mobile check-in

Table 1. scale of Cronbach's α coefficient and standardized factor loading coefficient

Constructs	Items	Cronbach's α coefficient	Standardized loading	AVE
Functional value (*FV*)	*FV1*	0.702	0.724	0.517
	FV2		0.691	
	FV3		0.734	
	FV4		0.680	
	FV5		0.763	
Social value(*SV*)	*SV1*	0.789	0.870	0.569
	SV2		0.692	
	SV3		0.701	
	SH4		0.740	
Emotional value(*EV*)	*EV1*	0.778	0.694	0.545
	EV2		0.730	
	EV3		0.880	
	EV4		0.677	
	EV5		0.691	
Epistemic value (*EpV)*	*EpV1*	0.759	0.714	0.539
	EpV2		0.800	
	EpV3		0.730	
	EpV4		0.742	
	EpV5		0.678	
Situational value (*SiV)*	*SiV1*	0.617	0.795	0.613
	SiV2		0.669	
	SiV3		0.871	
Perceived ease of use(*PEOU)*	*PEOU1*	0.772	0.763	0.596
	PEOU2		0.811	
	PEOU3		0.834	
	PEOU4		0.671	
Service experience （*SE*）	*SE1*	0.673	0.795	0.556
	SE2		0.68	
	SE3		0.758	
Continuance Intention (*CI*)	*CI1*	0.804	0.761	0.528
	CI2		0.733	
	CI3		0.683	

Reliability test use the Cronbach's α reliability index, which can be seen from Table 2 is that the Cronbach's α reliability coefficient of each variable is greater than 0.6 and that of the vast majority variables is greater than 0.7, indicating a good level of the above variables and a good reliability of the questionnaire. This study takes the model of confirmatory factor analysis to measure the convergent validity of the model, as shown in Table 1, the value of the standardization factor loading of each variable is greater than 0.5. Moreover, the Average Variance Extracted (AVE) value of each variable is more than 0.5. The eight variables measured: function value, social value, emotional value, epistemic value, situational value, perceived ease of use, service experience, continuance intention have relatively good effect, showing that each latent variable has convergent validity.

This article uses the AMOS 17.0 software to calculate AVE values of each latent variable and correlation coefficient matrixes between latent variables. As shown in Table 2, the square root of AVE of each latent variable is greater than the correlation.

Table 2. Average Variance Extracted and Correlation coefficient matrix

	FV	SV	EV	EpV	SiV	PEOU	SE	CI
FV	**0.719**							
SV	0.47	**0.754**						
EV	0.491	0.652	**0.738**					
EpV	0.544	0.469	0.668	**0.734**				
SiV	0.371	0.475	0.585	0.545	**0.783**			
PEOU	0.532	0.327	0.411	0.493	0.348	**0.772**		
SE	0.42	0.333	0.405	0.439	0.318	0.569	**0.746**	
CI	0.602	0.488	0.488	0.535	0.382	0.574	0.513	**0.727**

Note: The bold figures on the diagonal are the square root of the AVE value, and the lower triangular matrix is the correlation coefficient matrix.

4 The Results and Analysis of Empirical Study

4.1 Analysis of mobile check-in usage among Chinese consumers

At present, mobile check-in still belongs to a relatively new LBS application area in China. Besides, users are not familiar with its usage and features. Therefore, conducting research in this field is quite necessary. It can not only describe the domestic development of mobile check-in, but also provide the basis for further research.

4.1.1 Basic status of mobile check-in usage

Among the 516 valid samples, 438 respondents were familiar with about mobile check-in which accounts for 84.8% of the total. The data show that the vast number of consumers has some recognition to the mobile check-in. The number of people using mobile check-in was 243, accounting for 47.1%. About 84.1% users used mobile check-in at least three times a week. There was a certain number if users who used it

at the frequency of 4-9 times per week. However, respondents rarely used it for more than 13 times which proves that mobile check-in is still in its initial stage of development in China again.

4.1.2 The main purpose of using mobile check-in

Mobile check-in can meet the diverse demand of users because of its various business forms. As shown in Table 3, the results of this research show that Chinese consumers use mobile check-in mainly for discounts, chatting with friends and keeping a visit as a souvenir .

Table 3. The main purpose of using mobile check-in

Purpose	Number	Percentage
discounts	295	57.20%
chatting with friends	154	29.80%
keeping the visit as a souvenir	195	37.80%
service information	132	25.60%
honor and score	103	20.00%
entertainment	137	26.60%
evaluation of purchase experience	107	20.70%
group discussion	71	13.80%
others	46	9.10%

4.1.3 Operation system of mobile terminal

Mobile check-in needs the support of mobile terminal and users mainly choose smart mobile phones and tablet PCs. The amount of mobile check-in application depends on the compatibility between the software of mobile check-in and operating system. Among 516 respondents, 96 used iOS system, 320 used Android systems, 43 used Symbian systems, 31 used Windows system, 26 choose other systems. So it is not difficult to find that Android system is the most popular one whose consumers account for 62.1% .It's open source and moderate prices may contribute to the wide usage.

4.2 Confirmatory factory analysis on continuance intention

4.2.1 The analysis of the model fit index

In this study, we get the fit index containing χ^2/df, NFI, NNFI, RMSEA, GFI and CFI by comparing the differences between the regeneration covariance matrix and sample covariance matrix, with which can reflect the degree of fit between the model and the data. Table 4 can prove the goodness of the fit index of the model, showing that the data can be used to confirm the hypothesis.

Table 4 Model fit index

Fit index	χ^2/df	NFI	NNFI	RMSEA	GFI	CFI
Reasonable range	$1<\chi^2/df<5$	NFI>0.9	NNFI>0.9	RMSEA<0.08	GFI>0.9	CFI>0.9
Measured value	2.232	0.892	0.902	0.068	0.902	0.911

4.2.2 Path analysis

Using SEM, we dispose and analyze the continuance intention model of customers toward the mobile check-in and calculate the standard path coefficient between latent variables using AMOS17.0 software. The relationship between the variables is shown below in Figure 2.

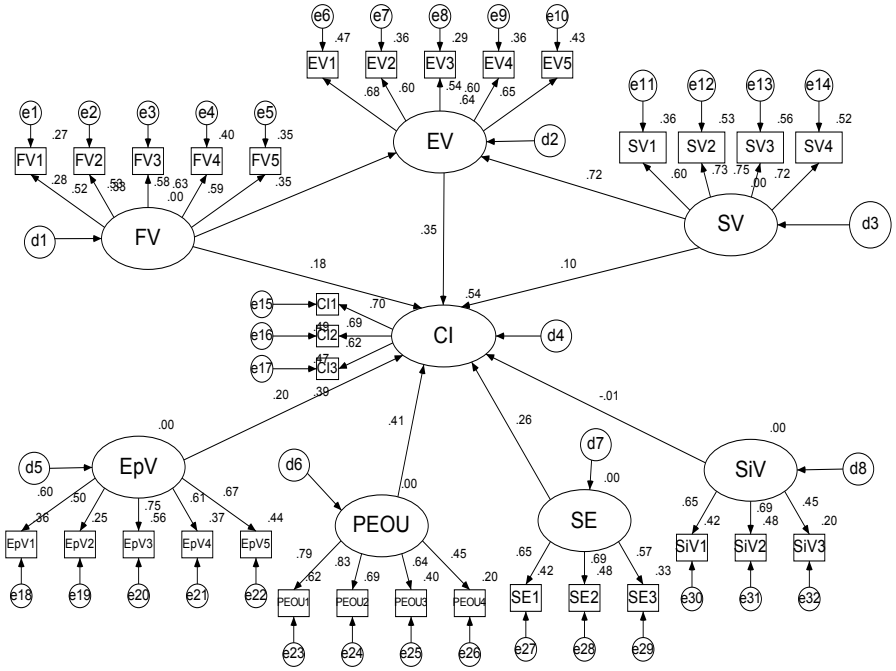

Fig. 2. Result of the model confirmation

4.2.3 Hypothesis testing

According to the result above, we can see that most of the hypotheses are supported while social value and situational value have little effect on the users' continuance intention to mobile check-in. The test result is shown in Table 5.

Functional value, emotional value, epistemic value, perceived ease of use and service experience are proved to have significant and positive influence on the users' continuance intention to mobile check-in service which illustrates that H1, H3, H4,

H8, and H9 are supported. Functional value and social value of mobile check-in has a significant positive effect on the emotional value, and then they affect the users' continuance intention to mobile check-in service indirectly. Hypothesis H6 and H7 can be proved.

Table 5. The path estimation and the support of hypotheses

Hypothesis	Path	Standard path coefficient	T value	Result
H1	FV → CI	0.157	2.202	Supported
H2	SV → CI	0.081	0.995	Unsupported
H3	EV → CI	0.274	2.769	Supported
H4	EpV → CI	0.157	2.697	Supported
H5	SiV → CI	-0.007	-0.092	Unsupported
H6	FV → EV	0.441	5.566	Supported
H7	SV → EV	0.705	9.363	Supported
H8	PEOU → CI	0.539	5.477	Supported
H9	SE → CI	0.292	3.655	Supported

The social value and situational value of mobile check-in don't have a significant effect on the willing of people's continuous use, so the H2, and H5 cannot been verified. This phenomenon may be caused by the short operation time, low recognition of mobile check-in, little involvement in the social networking, and other relevant factors.

The standard path coefficient shows that emotional value and epistemic value's influence on users' continuance intention is not great, which may be caused by the respondents' habits of using MI. One of the main reasons for the low path coefficients is the respondents' worries about security and privacy in using new service such as mobile check-in.

5 Conclusions and Suggestions

5.1 Conclusions

As a new application of LBS, mobile check-in is still in its infancy in China and unpopular. Currently, the main users are young people with high education and the frequency of use is not very high. For most users, their main purposes of using mobile check-in are enjoying discounts, chatting with friends and keeping the visit as a souvenir Moreover, mobile users are also concerned about some other business forms of mobile check-in such as service information, honor and score, entertainment, evaluation of consumption experience and group discussions and so on. In a number of operation systems, Android system is the most popular among users of mobile check-in, just followed by iOS system and Symbian system.

Functional value, emotional value, epistemic value, perceived ease of use and service experience have a positive influence on user's continuance intention to mobile check-in. It means that the higher function value and emotional value of mobile

check-in that users can perceive, the stronger their continuance intention will be, the convenience of operation of mobile check-in service and good customer service can also enhancing this continuance intention. The emotional value is also affected by functional value and social value, and this effect is positive, the functional value and social value of mobile check-in is affecting for emotional value and affecting the user's continuance intention indirectly.

5.2 Suggestions

E-business enterprises should strengthen the promotion of mobile check-in service and raise user' awareness of mobile check-in so that they can enable more people to understand and will to use it continuously. They ought to highlight mobile check-in's novel, original features to attract more young fans. Based on the above, E-business enterprises can introduce some more innovative business forms of mobile check-in in order to cater to the growing diverse demand of the vast number of users. In addition, they should strengthen the protection of customer's privacy to reduce user's concerns in this regard; they may provide the customer with good service, with the aim of improving user's service experience so as to form a good reputation among the users. At the same time, E-business enterprises have to consider strengthening the cooperation with social network, assigning new social and emotional elements to mobile check-in, opening up different market segments for different people, enhancing the cooperation with off-line business and excavating the deeper business benefits of mobile check-in.

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Appendix

Variables	Items
Functional value (*FV*)	*FV1* I think that useful information can achieved through the use of mobile check-in
	FV2 I think that I can accurately express my aspirations through the mobile check-in
	FV3 I think that I can quickly share my consumption experience through the mobile check-in
	FV4 I think that the mobile check-in can help me to find friends and expand the social relationship
	FV5 I think that the mobile check-in can maintain the existing social relationships and emotions
Social value (*SV*)	*SV1* My colleagues, friends and I are all using mobile check-in
	*SV2*I think that I can win recognition of my colleagues and friends through the mobile check-in
	SV3 I think that the mobile check-in can display and enhance the image of myself
	SH4 I think that the use of mobile check-in is very fashion and stylish
Emotional value (*EV*)	*EV1* I think that I can find a sense of belonging through the use of mobile check-in
	EV2 I think that the use of mobile check-in makes me my very proud and it is very cool
	EV3 I think that the use of mobile check-in is in line with my psychology of pursuing substantial benefits
	EV4 I think that the use of mobile check-in makes my mobile network life more interesting
	EV5 I think that the use of mobile check-in is in line with my psychology of advocating freedom
Epistemic value (*EpV)*	*EpV1* I think that the use of mobile check-in can satisfy my curiosity
	EpV2 I think that the use of mobile check-in has changed my way of life and learning
	EpV3 I think that using mobile check-in brings me a novel feeling
	EpV4 I think that the use of mobile check-in will make me more concerned about the mobile Internet
	EpV5 I think that the use of mobile check-in lets me experience the individuation of network service
Situational value (*SiV)*	*SiV1* I think that the mobile check-in can bring me the occupational help
	SiV2 I think that the mobile check-in is a necessity in the social environment which I live in
	SiV3 I think that the mobile check-in can fully reflect the performance of my mobile phone or tablet
Perceived ease of use (*PEOU)*	*PEOU1* I think that the mobile check-in service is easy to use and simple to operate
	PEOU2 I think that it is simple and fast to install the mobile check-in application software in my phone or tablet PCs and other mobile terminals
	PEOU3 I think that the mobile check-in application can meet the requirements of compatibility of different systems
	PEOU4 I think that the mobile check-in can provide perfect customer service
Service experience （*SE*）	*SE1* I think that the existing technical conditions can well support the mobile check-in service
	SE2 I think that the form of mobile check-in business is comprehensive and multi-field
	SE3 I think that the service quality of mobile check-in meets the expectation of using
Continuance Intentiaon (*CI*)	*CI1* I am willing to continue to use the mobile check-in
	CI2 I am willing to continually pay attention to the information about mobile check-in
	CI3 I would recommend others to use the mobile check-in

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