Information Systems Management – Understanding Modular Approach

Seppo J. Sirkemaa
University of Turku, Pori Unit, Finland
Email: seppo.sirkemaa@utu.fi

***Abstract*—Information systems management in an ongoing process. There is a need to map and evaluate technological innovations and evaluate whether they should be adapted to the organization. Technologies are continuously changing, but development should be a managed process so that changes follow architectural guidelines, and eventually add value to business operations and activities. In this article we approach information systems management with a modular approach. Here it refers to a situation where the system is combination of models that are integrated together. These modules have different functions but should work together as smoothly as possible. Clearly, this is a challenge for developers of information systems.**

***Index Terms*—information systems, development, management, modularity**

I. Introduction

In this paper we look at information systems management. It is seen as an ongoing development activity and process. The successfulness of information systems management is often measured in the reliability and trustworthiness of the information system [1]. Furthermore, technologies and systems should be flexible, bring added value to business functions and operations.

It is here suggested that modular approach in information systems management and development can help in creating an infrastructure and system that provides functionality and allows changes in systems and processes.

II. Modularity

Modularity is a term with many definitions [2], [3]. It refers to a system that is built of components, where the architecture, functions of components and relationships can be described, and the whole system is manageable [3]. Modularity can further be seen as a continuum describing the degree to which a system's components can be separated and recombined, and it refers both to the tightness of coupling between components and the degree to which the 'rules' of the system architecture enable (or prohibit) the mixing and matching of components [4]. The degree of modularity depends on the extent to which products are specific, how independent or separate modules are, and how transferable or reusable they are [5], [6], [4].

Manuscript received February 28, 2019; revised August 26, 2019.

Modular design approach includes architecture, interfaces, and standards [7]. Architecture defines which modules are incorporated in the system and what they will be doing. Standards are needed to make the modules compatible, and also for setting performance goals for individual modules. Interfaces are the connection points that have to be defined to make combination of modules possible. The flexibility and possibility to connect, mix and use modules in different configurations and environments is possible only if there are standards and interfaces that are acknowledged and shared [8]. Compatible modules allow interoperability and make it possible to change individual modules (Fig. 1).

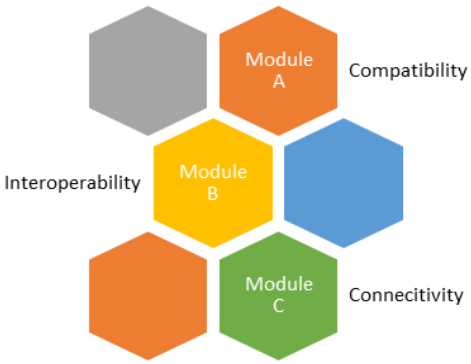

Figure 1. Modularity is about interoperability

Modularity can be understood as a strategy for organizing complex processes related to manufacturing and services efficiently [7]. Modularity allows "numerous services modules that are flexibly and uniquely compatible, and which are typically produced by multiple providers" [9]. In outsourcing this is a widely accepted approach in providing services that meet the needs of the users and organizations in question.

Modularity and modular design approach is based on independency of components [10], [4], [11]. Accordingly, modularity enables components to be flexibly combined in order to create unique bundles and solutions into different environments [3], [12], [13].

In general, modular design is based on decomposable architecture [10], [11], [2]. This supports outsourcing and makes it possible to take advantage of capabilities beyond organization's own boundaries [7], [11].

III. Role of Standards

Modularity is based on compatibility between different modules, and this again is directly result of how they are

© 2019 J. Adv. Inf. Technol.
doi: 10.12720/jait.10.4.148-151

standardized [14], [15]. As a result, it is critical that connections and interfaces are standardized, to enable flexibility, changes in the system and interoperability [16].

Standards are important in development of products, processes and services. Therefore, concepts of modularity and standardization are interconnected. Also, connections and interfaces between these need to be standardized in order to make systems functional and to allow changes in different parts or modules.

It is clear, that standardization and coordination are tightly connected. Each module needs to have a standardized interface, which has been chosen so that it interconnects with the overall system. As an example, service development is not possible without mutually agreed standards, and requires coordination. Standards agreed at the organizational level are further implemented to products, services, and processes. As a result, development of interfaces should be based on collaboration with external stakeholders [17], [18].

IV. Advantages of Modular Approach

In general, the principle of modularity is to develop systems and technologies dividing the whole system into modules which are logically and functionally autonomous. Another principle of modularity is that the interfaces and connections need to be standardized so that modules connect and work together. Each module and component should be seen as an autonomous entity which can be connected together and fit the overall system in the infrastructure (Fig. 2).

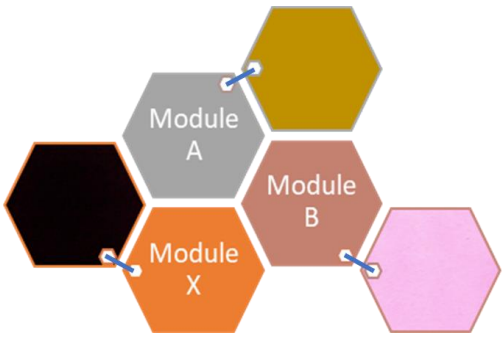

Figure 2. Standards allow interconnectivity

The main benefit of modular approach is that modularization - creating systems from modules by connecting them together – can be fast and flexible strategy when dealing with systems and infrastructures that are large. It has been found that modularity can increase flexibility, both in processes and functions, as well as on the organizational level [2], [4], [6], [3], [19], [20]. Modular approach has also significant potential for cost savings, often because the provider of services can obtain economies of scale in production of modules [3], [12], [20]. Furthermore, modularity is a very good strategy in cases where flexibility and innovations are considered critical [21].

It is argued that modularity fits some organizations and contexts better than others [4], [11], [22]. Modular approach becomes attractive especially in cases where systems have grown large and complex, where there are interdependencies between systems and their components, so that the overall management becomes overwhelming [23]. Furthermore, modularity appeals organizations when they face pressure to rationalize processes, cuts costs and develop production [2].

However, modularity does not automatically provide added value or solve organizational problems. As Greenwood & Miller [24] argue different organizations confront different challenges which can be responded to with structures and designs that are designed to meet the needs of these requirements.

V. Towards Flexibility

The challenge of information systems management is to develop information systems and infrastructures to support operative and strategic goals of the organization. There is a need for understanding of business needs and requirements, together with technical knowledge. Developers of information systems are challenged to develop solutions that meet operative, short-term business needs today, and at the same time provide systems and platforms that enable development of long-term capabilities, flexible and adaptable infrastructures. The term flexibility is in this context understood as possibility to modify, make changes in response to changes in environment or other elements [25].

Flexibility is not result of choosing the “right” single technology or system application from a range of choices and believing that this would directly deliver competitive advantage or other desired results. Instead, success is more result of creating flexibility and capabilities that make it possible to use information technology in the best possible way in the organization [26].

Flexibility is important because it makes it possible to make changes if environment, targets or strategies are changed. It is critical that interfaces and connections between modules standardized so that they work together and can be changed when needed (Fig. 3), allowing changes in the system and making modularity possible [16], [27].

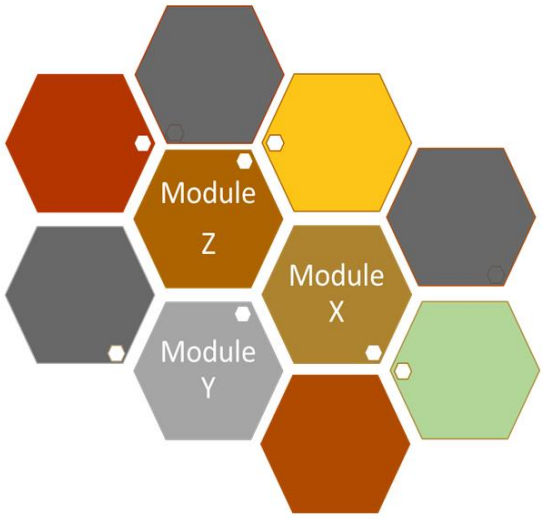

Figure 3. modular approach allows flexibility

© 2019 J. Adv. Inf. Technol.

The idea of developing systems from modules that can be connected together is also referred to as leanness [28]. Leanness is based on the notion that it is usually easier to change something relatively small and simple rather than trying to implement changes in large and complex systems. Modularity makes changes possible, so that they can happen rapidly, and at the same time with minimal costs. This is because changes can be made in one or few modules, without the need to make changes to all modules throughout the information systems infrastructure.

VI. Challenges

There are various challenges in using modular approach. Schilling [4] and Schilling & Steensma [11] discuss issues that may support or prevent modularity, depending on the situation. Accordingly, there are three factors that make modularity a good approach

1. Input heterogeneity
2. Demand heterogeneity, and
3. Competitive environment that calls for technological change.

From the customer organizations perspective, the more there are technologies and systems available, even competing solutions, the better it is. Having many technologies, systems and modules to choose from means that no single manufacturer or provider has monopoly in pricing. Furthermore, the speed of changes in technological development increases input diversity and heterogeneity. The intensity of these factors is catalyst for modularity [4]. It has also been noticed that availability of standards increases competitive intensity and create a boost in markets. Altogether, these elements are likely to maintain prices or press them downwards, at the same time as better, more advanced technology is entering the marketplace – all these are desirable to the customer organization.

To summarize, the existence of input and demand heterogeneity, intense competition in the marketplace together with availability of standards – at least partly – can act as catalysts towards modularity on organizational level [11]. However, the organization is challenged to choose standard modules with interfaces that allow connecting technologies and systems with existing infrastructures.

VII. Conclusion

Information systems management and development are challenging tasks. It is important that information systems run reliably and provides services to the user so that it is possible to accomplish the actions that they are expected to do. In most cases information systems developers are challenged to develop and implement solutions that are at the same time reliable, cost-effective and operate as a backbone of operative and strategic processes. Changes in business needs and competitive environment demand changes to be made rapidly, which further challenges information systems development.

In this paper we have studied modularity and modular approach, and the potential it provides for information systems management and development. We suggest here that developers use a modular approach in information systems. It refers to identifying technically, logically or functionally integrated domains and functions, and developing and managing them as modules. The modules should be autonomous and have interfaces which allow using them in different systems and infrastructures.

Compatibility and standards of technologies are in a key role as they allow flexibility and connectivity of modules also in the future. Modular approach is based on the idea of reusable technologies and systems, meaning that modules can be connected together in numerous ways. Therefore, modular systems can be changed when needed, inexpensively and rapidly. Modules can be used in different systems and infrastructures, serving a variety of purposes. The difference is significant when compared to technologies and systems that are dedicated and specific [4]. In dedicated technologies and systems changes can become impossible or require significant changes in other systems and infrastructures. The inflexibilities can also lead to a situation where otherwise perfectly functional technology needs to be replaced, as otherwise systems are incompatible and cannot be connected.

Modular approach can be a particularly good strategy in turbulent environments where rapid changes require flexibility from information systems. Modules can also be provided by external partners. The role of external companies, experts and providers of these modules can be significant in development of modules, or in providing and maintaining them as part of organization's system and infrastructure.

Clearly defined modules and standardized interfaces between them makes it possible to outsource development and management of individual modules. Especially in smaller organizations with limited resources may this be a good strategy, but also in larger organizations cooperation with external partners can be very beneficial [21]. Therefore, modular approach allows also outsourcing technologies and systems, using external partners, their services and expertise.

References

[1] S. Sirkemaa, "Infrastructure management: Experiences from two case organizations," in *Proc. the 24th Information Systems Research Seminar in Scandinavia*, Ulvik, Norway, 2001.

[2] J. K. Gershenson, G. J. Prasad, and Y. Zhang, "Product modularity: Definitions and benefits," *Journal of Engineering Design*, vol. 14, no. 3, pp. 295-313, 2003.

[3] A. H. Bask, M. Lipponen, M. Rajahonka, and M. Tinnilä, "The concept of modularity: Diffusion from manufacturing to service production," *Journal of Manufacturing Technology Management*, vol. 21, no. 3, pp. 355-375, 2010.

[4] M. A. Schilling, "Toward a general modular systems theory and its application to interfirm product modularity," *Academy of Management Review*, vol. 25, no. 2, pp. 312-334, 2000.

[5] A. K. W. Lau, R. C. M. Yam, and E. P. Y. Tang, "Supply chain product co-development, product modularity and product performance. Empirical evidence from Hong Kong manufacturers," *Industrial Management & Data Systems*, vol. 107, no. 7, pp. 1036-1065, 2007.

© 2019 J. Adv. Inf. Technol.

[6] C. Y. Baldwin and K. B. Clark, *Design Rules: The Power of Modularity*, Cambridge, MA, USA: MIT Press, 2000.
[7] C. Y. Baldwin and K. B. Clark, "Managing in an age of modularity," *Harvard Business Journal*, vol. 75, no. 5, pp. 84-93, 1997.
[8] C. Voss and J. Hsuan, "Service science: The opportunity to re-think what we know about service design," in *The Science of Service Systems*, H. Demirkan, J. C. Spohrer, and V. Krishna, Eds., New York: Springe, 2011, pp. 231-244.
[9] M. Vähätalo and T. J. Kallio, "Organizing health services through modularity," *International Journal of Operations and Production Management*, vol. 35, no. 6, pp. 925-945, 2015.
[10] R. Sanchez and J. T. Mahoney, "Modularity, flexibility, and knowledge management in product and organization design," *Strategic Management Journal*, vol. 17, no. S2, pp. 63-76, 1996.
[11] M. A. Schilling and H. K. Steensma, "The use of modular organizational forms: An industry-level analysis," *Academy of Management Journal*, vol. 44, no. 6, pp. 1149-1168, 2001.
[12] M. Jacobs, S. K. Vickery, and C. Droge, "The effects of product modularity on competitive performance. Do integrations strategies mediate the relationship?" *International Journal of Operations and Production Management*, vol. 27, no. 10, pp. 1046-1068, 2007.
[13] R. Sanchez, "Strategic flexibility in product competition," *Strategic Management Journal*, vol. 16, pp. 135-159, 1995.
[14] K. Ulrich, "The role of product architecture in the manufacturing firm," *Research Policy*, vol. 24, no. 3, pp. 419-440, 1995.
[15] K. Ulrich, "Fundamentals of product modularity," in *Management of Design*, S. Dasu and C. Eastman, Eds., Massachusetts: Kluwer Academic Publishers, 1994, pp. 219-231.
[16] J. Hsuan, "Impacts of supplier-buyer relationship on modularization in new product development," *European Journal of Purchasing and Supply Management*, vol. 5, no. 3-4, pp. 197-209, 1999.
[17] A. K. W. Lau, R. C. M. Yam, and E. P. Y. Tang, "Supply chain product co-development, product modularity and product performance: Empirical evidence from Hong Kong manufacturers," *Industrial Management & Data Systems*, vol. 107, no. 7, pp. 1036-1065, 2007.
[18] A. Lau, R. Yam, E. Tang, and H. Y. Sun, "Factors influencing the relationship between product modularity and supply chain integration," *International Journal of Operation and Production Management*, vol. 30, no. 9, pp. 951-977, 2010.
[19] J. Mikkola and O. Grassmann, "Managing modularity of product architectures: Toward an integrated theory," *IEEE Transactions on Engineering Management*, vol. 50, no. 2, pp. 204-218, 2003.
[20] J. Mikkola, "Modularity, component outsourcing, and inter-firm learning," *R & D Management*, vol. 33, no. 3, pp. 439-454, 2003.
[21] C. Y. Baldwin and K. B. Clark, *Design Rules: The Power of Modularity*, Cambridge, MA, USA: MIT Press, 2000.
[22] D. Campagnolo and A. Camuffo, "The concept of modularity in management studies: A literature review," *International Journal of Management Reviews*, vol. 12, no. 3, pp. 259-283, 2010.
[23] S. K. Ethiraj and D. Levinthal, "Modularity and innovation in complex systems," *Management Sciences*, vol. 50, no. 2, pp. 159-173, 2004.
[24] R. Greenwood and D. Miller, "Tackling design anew: Getting back to the heart of organizational theory," *Academy of Management Perspectives*, vol. 24, no. 4, pp. 78-88, 2010.
[25] A. C. J. D. Leeuw and H. W. Volberda, "On the concept of flexibility: A dual control perspective," *Omega, International Journal of Management Science*, vol. 24, no. 2, pp. 121-139, 1996.
[26] J. C. Henderson and N. Venkatraman, "Strategic alignment: Leveraging information technology for transforming organizations," *IBM Systems Journal*, vol. 32, no. 1, pp. 4-16, 1993.
[27] J. Hsuan, "Modularization assessment of product architecture," presented at DRUID Winter Conference, Denmark, January 7-8, 2000.
[28] O. Hanseth, "Information infrastructure development: Cultivating the installed base," *Studies in the Use of Information Technologies*, no. 16, 1996.

Seppo J. Sirkemaa has a Ph.D. in information systems management from Turku School of Economics at University of Turku, in Finland. Dr. Sirkemaa has held several academic positions ranging from researcher to research professor and worked as vice director of Pori Unit in Turku School of Economics at University of Turku, Finland.
Dr. Sirkemaa is also an IT consultant and has published over 100 academic publications.

© 2019 J. Adv. Inf. Technol.