IT infrastructure: standards and flexibility

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Abstract: - Information system development is often in connection to functional requirements and business processes in organization. The development and relevance of the basic information technology infrastructure (IT infrastructure) is therefore easily forgotten. However, a reliable infrastructure is the key to successful operations. Furthermore, as business needs change information system flexibility and compatibility become important. In development of the IT infrastructure are standards in a key role as they are the basis for flexibility.

Key-Words: - IT infrastructure, information technology, standards, flexibility

1 Introduction

Information technology infrastructure, or shorter IT infrastructure is the basic, shared platform for all business applications [1]. Its impact is organization-wide and infrastructure decisions have future consequences for a number of years [2]. The management of IT infrastructure is decisive because management practices have been developed over time and they are unique in each organization [3].

IT infrastructure should seamlessly support transactions that are based on information system use because all levels and functions in the organization share infrastructure in some way [5], [1]. Therefore the role of IT infrastructure is strategic [4]. Business flexibility requires a common IT infrastructure as a basis for operations rather than separate systems and services [5].

Existing infrastructure is a solid foundation but it evolves over time. There is a need for best practices that guide what choices to do in order to develop infrastructure. They ensure that parts fit together and enable the integration of business processes [10]. This is a fact that makes standards and standards compliance of previous, existing and future infrastructure development choices crucial part of infrastructure. The standards are in a key role, and so infrastructure management can be argued to be a question of implementation of standards [13].

2 IT infrastructure

IT infrastructure is not just a combination of different devices and components. Additional dimensions to information system are applications, information and its processing, and working practices [8]. IT skills and managerial practices are also important in IT infrastructure management [1], [6], [10].

The human element binds IT components into a reliable set of IT infrastructure services that are shared in business processes. The management aspect is considered important, and IT infrastructure needs to be actively developed and managed to support organizational goals and operations. This is typically done by organizations IT department together with line and top management.

Infrastructure is a resource [7], which is difficult to imitate as it is created through interaction between technology and people in the organization [1]. Infrastructure contains elements shared by different levels of users and functions [8]. The span in infrastructure management is both short – it must deliver right here and right now - and long. Infrastructure investments are long-term, however the most important thing in infrastructure is that it enables people to share knowledge [9].

2.1 Challenges of IT infrastructure management

In general, information technology infrastructure is relatively stable over time [10]. Despite this it must be possible to change the IT infrastructure - and it must be economically feasible [11]. In a changing world this is a significant management challenge: how should infrastructure be managed so that it would provide opportunities instead of being a hindrance to development. Here we look at these management challenges in more detail [12], [5].

First, the challenge of infrastructure management is to use and develop it in a way that it supports operational and strategic goals of the company (or organizational goals in general). The management can be divided into maintenance of existing systems and development of new infrastructure. Typically, information system development is based on current hardware, software and resources [13]. Infrastructure must adjust to short-term business needs, but at the same time it is important to seek new opportunities [9]. Vision is needed in both business and information technology in order to assess what technology can do and how to make best possible use of it [12].

Second, information system needs to be run at low cost and with high quality [12]. In organization outsourcing and partnerships may provide solutions to this challenge. However, outsourcing has both advantages and disadvantages, and it is not a straightforward decision [14], [15], [16], [17], [12].

Third, the IT architecture should be both reliable in daily operations and open for future changes. Infrastructure development can be seen as building the technology asset of the company [18]. All choices that are made in developing the infrastructure are important, because the infrastructure is meant to be used for a long time. Consequently, IT architecture should be open to changes in business needs [13], [12], [9]. What is problematic here is how to make right choices; in what technology to invest.

Lastly, infrastructure is the enabling foundation upon which business applications are built. Therefore it must be managed so that it does not fail under any circumstances. The robustness of infrastructure is a critical issue in information system [5], [9], [19]. The result is that management needs to understand the weaknesses and strengths that the organizations information system has, follow industry trends and understand business needs [20].

3 Standards

Standards are in a very important role in information technology. Manufacturers and vendors have historically driven telecommunications industry, each developing their own, proprietary networking solutions [21]. When these networks should be interconnected, a common language – standard - is needed for communication [22]. A standard is a specification describing the performance and interface parameters for a device, software or network. Typically proliferation of incompatible networks is a result of a lack of widely accepted standards for protocols and interfaces in telecommunications. Most manufacturers products are incompatible with other manufacturers systems in the early development stages for a number of reasons [21]: they wish to protect their installed base, there are difficulties in making new technology to work and lack of standards in areas that are developing fast.

There are three kinds of standards [23]: reference, minimum quality and compatibility standards. Compatibility standards are particularly important in telecommunications and networking as they ensure that component adheres to set of standards that ensure that it can be installed into a larger system. Standards can also be classified into de facto, de jure and formal standards [24]. Typically standardization process is affected by formal, international standardization organizations [25]. Among the most important standardization bodies are ISO, the International Standardization Organization, CCITT, IEEE and ANSI. Also Internet can be considered as an important standardization body [26], [22].

Once a standard has been widely accepted, manufacturers compliance is guaranteed as it offers access to wider markets [21]. The amount of other compatible products and installed base, also called network externalities becomes a driver for both standards compliance and adoption [27]. Compatibility to hardware and software from other manufacturers is important criteria, as users organizations information technology platform is typically made of products from several manufacturers. Therefore compatibility ensures full use of technology including economies of scale, combining information from separate applications, cross-functional information flows, avoiding redundant resources and linking organizations system to suppliers, customers and other partners. Therefore shared use of technology and infrastructure, high level of compatibility in hardware, software and networks is essential [6].

From the customers perspective the interoperability of telecommunications products has become important: instead of picking the best possible individual system for a specific need companies increasingly choose the best system within a standard [21]. Interoperability, integration and standards compliance are the drivers of telecommunications, not individual features in some specific technology. A widely accepted, properly defined standard becomes invisible to the user, but it enables products that have been developed by different manufacturers to function together.

The dynamics of customer's standards adoption is affected by relative attractiveness of a technology [27]. In effect, a given solution is more attractive the larger the amount of installed base or other consumers using that solution is. Secondly, in the presence of network externalities the perceived future success of competing solutions impacts the adoption process. Technology adoption is also affected by whether technologies are sponsored. A sponsor is defined as an entity having rights to the technology and hence is willing to make investments to promote it [27]. When one of rival technologies is sponsored, the sponsored technology has advantage and may be adopted even though it is inferior. A sponsored technology may dominate the market even when all consumers consider that a rival, nonsponsored technology is better. In case two competing solutions are sponsored the one that will be superior in the future has a strategic advantage. However, if there are no sponsored technologies users tend to favor technology that is superior today [27].

Every organization needs to ensure that its information system addresses standards. If we look at communications from users view in a case where organization wants to connect to another organization there are several ways to establish interoperability [22]. In a case of only few actors bilateral agreements between communications partners can provide interoperability. However, managing a large amount of bilateral agreements is not possible if more partners are sharing the telecommunications infrastructure. Proprietary protocols are one solution between bilateral agreements and common standards. A vendor specific system or an application specific solution may in some cases be effective, but in a general-purpose, open infrastructure are widely accepted industry standards and practices necessary [22].

Standardization has also its costs [28]. Firstly, it may retard innovation like QWERTY keyboard arrangement [29]. Secondly, standardization process itself can become costly. Costs include resources spent on standards committees and the delay cost caused by slow decision-making process. In informal standardization may reverse-engineering be needed to comply to existing de facto –standards [28]. Typically in case of de facto standards users may suffer incompatibility until one technology triumphs, leaving users of other technologies customers stranded. If no technology emerges as a standard users suffer persistent incompatibility like in the case of Apple-computers and IBM-compatible technologies [27]. Since standardization typically constrains product design it may limit product variety. Because compatibility benefits from network externalities [27] by creating economies of scale on the demand side, the problem respects the trade-off between variety and production economies of scale [28].

The concept of standard is central to development of compatible and open networks. Standards can still range from narrow to broad, specific to vague, complex to simple, or formal to informal [21]. The challenge for the organizations IS-department is to install and integrate new product into existing multivendor, multitechnology base without discarding pieces and starting from the beginning. A fuzzy standard or multiple interpretations of a standard can lead to incompatibility or lack of interoperability between products that are designed to meet these standards. In some cases vendor specific standards can be more open than formally open standards, as they can be both fully defined, stable and clearly published so that they can be incorporated to products made by others. For example many IBM's proprietary standards fall into category of de facto –standards. The IBM PC-compatible industry evolved largely on the basis of different manufacturers hardware and software that were designed to meet the DOS operating system standard [21].

Best possible interoperability is a result of an evolutionary process [22], [21]. The first step toward compatibility and integration is to adopt a set of standards that are currently widely adopted and fully implemented. Some of these standards may be partly proprietary. Compatibility is a matter of degree and it can be achieved also using converters [28]. There are two possible approaches to avoid networking technology from becoming autonomous and develop without control [22]: broad participation in network development process and evolutionary standardization. Evolution towards open system standards occur as such

standards become de facto –standards and generally supported.

4 Infrastructure develops through standards

IT infrastructure development depends on previous, existing infrastructure [13]. Its limitations and possibilities are the starting point for any infrastructure development process. The existing infrastructure acts in two ways. Firstly, it is involved in every infrastructure development activity. Secondly, it is in a mediating role between development activities and non-technological actors. Therefore organizational development and new business opportunities typically affect existing information system or depend on it.

4.1 Mechanisms of standards diffusion

Standards work as a self-reinforcing mechanism [30], [31]. The self-reinforcing mechanism appears if value of a product or technology increases when the number of adopters increase. There are four sources of self-reinforcing processes [32]: large set-up or fixed costs involved in the implementation and maintenance; learning effects, which mean improved ability to use the system with more experience; advantages when doing similar choices with others, coordination effects and adaptive expectations. The self-reinforcing process of IT infrastructure is called as the irreversibility of the installed base [13].

In information technology the self-reinforcing process means that in case new technology fits into existing base the value of the whole system increases. Therefore a standard that builds on installed base becomes more attractive than others not fitting to the existing system, and the choice of standards become heavily affected by those choices that have been made in the early stages of the system development [33]. The mechanism works in both ways: large installed base attracts complementing technological choices, which make the standard cumulatively even more attractive. An increasing technological base makes also the standard more credible, and together they make the standard attractive and will further increase the installed base [33], [13]. Consequently, the cause of standards compliance and its effect are in the installed, existing base of technology [13].

Self-reinforcing mechanisms tend to lead to choices that build on existing system. The effects can be divided into [32]: lock-in; when certain technology has been adopted or chosen, it becomes impossible to switch to competing technologies; path-dependence as previous choices have impact in future and even modest or otherwise irrelevant events can turn out to have great significance; process will lead to possible inefficiency because best solution and technology will not always be chosen

Network externalities [34], [27] are another mechanism that supports adoption of technology that fits into existing, installed base. There are three sources of network externalities [34]: direct physical effect as the number of adopters increase the quality or value of the product (like in telephone network); indirect effects, the more there are buyers of certain operating system the more there will become available software that run on it; post-purchase service depends on the size and expand of the service network which in turn becomes larger as the number of users of the given product increase. The establishment of common standards and standards compliance becomes important when network externalities are significant. In this case the benefits of having compatible products and services that fit together are the most important factor that leads to standard-supporting behavior.

The number of adopters of a certain standard is important, as there will become more products available supporting that standard. Manufacturers and vendors develop technology and services that implement accepted standard, and new innovations are made upon the underlying technology. The number of adopters of a technology also decreases the prices so that the technology will become even more attractive.

Network externalities and self-reinforcing mechanisms have important role in development of the IT infrastructure. The set-up costs and initial investments in infrastructure are large and therefore it is expected that the infrastructure will be usable for a number of years. It is understandable that the effects of previous choices create lock-in and path-dependence in the IT management. Change of technology, even to a better one, becomes unwise if it is not compatible with the existing base [13]. When the number of users grows and they get familiar with existing system transition will become increasingly unfavorable.

4.2 Standards and IT infrastructure flexibility

The need for standards is widely accepted as compatibility brings many benefits. Self-reinforcing mechanisms and network externalities are processes that further impose standards. However, there are also effects that may be considered unwanted as they cause lock-in to a technology that may not be the best possible technology available. Also decisions that have been made years ago may still have great significance and make chances impossible. Furthermore, standards and irreversibility of existing base can cause inflexibility.

IT Infrastructure flexibility is important for a number of reasons [13]: Firstly, there is a growing need to link organizations information system to other organizations or integrate previously separate systems into one network. Secondly, information system and the underlying IT infrastructure should be modified to reflect the changes in organization and its environment. IT infrastructure is relatively stable over time, but requirements for processes change and infrastructure should change accordingly [35], [1]. Thirdly, the growth of the information system and expansion of infrastructure generate need for change. Lastly, there is a learning effect involved in use of technology. In any system it is impossible to foresee all problems and relevant issues, instead they will be discovered as the system is being implemented and used, and the technology needs to be changed accordingly. Users are unable to define what technology best fits their needs, they learn it as they use the system. They also learn how to utilize the system so that it fits the working needs in a best possible way.

It is argued that the success of IT infrastructure depends on its flexibility [13]. If the system is inflexible the first working version of the technology will reach state of irreversibility and no improvements that are based on learning and experience cannot happen. Inflexible systems cannot adapt to changes in environment and organization, and they may not be easily modified to remove problems and meet expansion needs. There are two possible strategies in developing flexible infrastructure [13]: Firstly, standards need to be flexible and adaptable to new requirements. Secondly, existing infrastructure must be developed in a way that installed base can be linked together with new technology. In many cases both strategies work simultaneously and enable development of the infrastructure without insuperable problems.

The level of flexibility can further be increased my modularization and encapsulation [36]. Developing smaller entities like departmental networks and defining interfaces between them can be a more effective strategy than trying to deal with one large organization-wide standard in infrastructure development. Another general strategy that increases flexibility is leanness. This means that each part or module in the system should be as simple as possible. The idea is that it is easier to change something small and simple than large and complex.

Conclusions

Information technology infrastructure is a critical element in organizations information system. Management and development of the IT infrastructure is important because of its operative and strategic importance. Environmental and internal changes in organization require changes in information systems, and therefore the ability to change the infrastructure becomes an important issue.

Here we argue that standards and standards compliance makes the IT infrastructure more flexible. Standards work through network externalities and self-reinforcing mechanisms. Furthermore, the existing base of IT infrastructure is a powerful resource. Standards are important for compatibility, and they make it possible to accommodate changes to existing infrastructure and develop new IT infrastructure that meets business needs.

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