

# Towards Information Technology Infrastructure Management

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## ABSTRACT

Information technology has a vital role in organizations today. Both technical and human components are needed in IT infrastructure management and development. Information technology infrastructure needs to be compatible and flexible as it affects the business value of information technology in the organization. This paper reviews the underlying concepts of Information technology infrastructure management and associated challenges in deriving the benefits expected from transforming business processes and activities.

**Keywords:** *Infrastructure, technology, flexibility, development*

## 1. INTRODUCTION

Today information systems are important in all organizations. In this paper we study information technology infrastructure. In information systems the term infrastructure refers to the basic supporting systems that are shared amongst users. In this context information technology infrastructure is the basic shared platform for all business applications [1,2,3,4,5,6,7].

The management of technology is here seen as a critical success factor for operations. In other words, should there be problems with information systems the impacts can be immediate and very expensive from financial perspective. For example, sales cannot be done if the sales systems are down.

## 2. UNDERSTANDING INFRASTRUCTURE

Information technology infrastructure may be seen as the basic technological platform for other systems that are used in various business activities and processes.

In most organizations technological infrastructure is the enabling foundation upon which business depends. Consequently, advancements in information technology affect the development of organization's IT infrastructure and services that are based on it [8].

Let us look at information technology infrastructure in more detail. There are several dimensions to information technology infrastructure [4,6]:

- Embeddedness: infrastructure is part of other technologies, organizational and social structures.
- Learned as a part of membership: Infrastructure is specific to each organization. New staff members learn about the infrastructure and gradually get familiar with it.
- Transparency: information technology infrastructure is expected to be transparent in the sense that it does not have to be separately reinvented or modified for each application.

- Becomes visible upon breakdown: transparency of the infrastructure disappears immediately if the infrastructure fails to deliver as expected.
- Reach and scope: infrastructure extends beyond a single place, process or event; it is intended to serve over a long period of time, in many locations and for variety of purposes.
- Role of standards: standards are a vital part of infrastructure. Standards make it possible to expand the system and connect it to other infrastructures, like those of other organizations.
- Built on an installed base: development of infrastructure is gradual, it is built and based on existing infrastructure, and is therefore dependent on its strengths and limitations.
- Based on conventions of practice: information technology infrastructure is shaped by organizational practices and vice versa.

Information technology infrastructure is a concept that can further be divided into two related components: technical IT infrastructure and human IT infrastructure [9]. Often information technology is seen only as a combination of different technical devices.

Technical component includes different devices that connect computers and systems, mainly networking devices. Also servers, systems and devices that are commonly shared among users are considered to be part of technical information technology infrastructure.

The human component is a vital part of information technology infrastructure [10, 3]. It consists of individual and organizational skills, expertise, competencies and commitment [3, 11, 9]. According to Lee et al. [10] human information technology infrastructure is a combination of expertise in four areas:

- Technology management.
- Business understanding.
- Technical issues.
- Interpersonal skills and management.

Technology management refers to organization's ability to deploy information technology in a way it enables and supports business targets [12,10,13,14]. Business understanding is very close to technology

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management as understanding business processes is vital for selecting right technologies, systems and applications that make it possible to meet business needs [10].

Business knowledge is needed in order to develop technical capabilities so that business targets, operative and strategic goals can be met [15].

Development of technical infrastructure is seldom possible without technical knowledge, basic understanding in areas such as software development, data communications, together with hardware and software technologies [10]. It is clear that IT staff should have both broad and deep technical knowledge [16]. Especially in smaller organizations IT departments are small, and therefore IT staff is challenged to have knowledge in wide range of different technologies and systems. At the same time it should be remembered that also interpersonal skills are increasingly important in information technology management. Development activities require understanding of business needs and user requirements, and without sufficient communicative skills development may not be as successful as it could be.

Information technology infrastructure can also be seen as a combination of technology, procedures and knowledge, which ultimately materialize in services that support business processes [8]. New innovative technologies and more advanced IT components are being developed. Here the organization's understanding about how to best utilize these technologies, together with advancements in IT components, allows existing and new services that can be developed within an organization for business purposes. As a result, understanding the technological opportunities and benefits of information technology in the organization is vital [17].

Information technology infrastructure is developed over long time period through interaction between people and technology. It is therefore organization specific, and cannot directly be copied or imitated [3]. The components of infrastructure are shared widely, among different levels of users and processes [18].

Often investments in infrastructure may take long time, partly because they require thorough planning, evaluation and official acceptance before implementation. It is not uncommon that during this process there are changes in requirements, environment or technologies.

Information technology should therefore be flexible and open for changes, despite the fact that infrastructure should be relatively stable, robust and basis for operations and applications [11].

### 3. CHALLENGES

The challenge of information technology management is to develop the information technology infrastructure to support operative and strategic goals. This requires understanding of business needs and requirements, together with technical knowledge. The

organization must set and follow strategy in all its operations, also in information technology management.

The information systems should meet short-term business needs today, and at the same time it should be a platform that enables development of long term capabilities. Here compatibility of technology is a key issue; it allows flexibility in the future. Also reliability is essential in all infrastructures and information systems [19,20,21,22]. In general, users expect the systems function as correctly and reliably as possible. This is also referred to as trustworthiness [23].

Strategic vision is needed in both business and in information technology development so that right technical choices can be made and how they can be applied in the best possible way to support business needs [24]. Development of a common technological base requires strong information systems management, especially in large organizations where there are operations in many different locations [25]. It is not the question of choosing the "right" single application from a range of choices, and believing that this would deliver sustainable competitive advantage. Instead, the organizational success is more result of creating capabilities in order to utilize information technology in the best possible way [15]. Whereas information systems are concerned this often relates to development of a robust and flexible information system infrastructure.

Second challenge of information technology management is to deliver information systems which operate at low cost, reliably and with high quality. Especially if resources are limited outsourcing can be seen as a solution to organize information systems. Here it refers to a situation where some external organization, provider of service provides a service based on agreement between the service provider and the outsourcing organization. Outsourcing arrangements are in some cases ideal solutions to service delivery, but at the same time outsourcing causes other type of challenges. If some or any parts of the information systems are outsourced, this creates a need to manage the resulting partnerships. There is a need of developing information technology outsourcing strategy and policy. Outsourcing also calls for management of existing service agreements and re-arranging them when needed. The result is a need for continuous strategic management and development of information technology sourcing in the organization. Whatever the degree of outsourcing, IT management is challenged to develop new systems and solutions faster and to maintain existing systems better [26]. Clearly, outsourcing is not a straightforward issue [27,28,29,26,24].

The third challenge for IT managers is development of the information technology architecture [24]. Architecture is here understood as technical platform infrastructure and systems that serve business operations. Infrastructure development may be seen as building the technological assets of the company [30]. Information

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system development is incremental in a way that it is based on existing hardware, software and resources [31,32]. All choices that are made in developing the infrastructure need to take account the existing infrastructure. In other words, all choices have long-term consequences. The challenge is that IT architecture should remain open to changing business needs even though it is typically being used for several years, and choices that are being made today may affect decisions in years to come [33,31,24].

In general, developing an IT infrastructure that supports operations is a challenging task, taken into account the fact that business processes can put great demands on the robustness and flexibility of the underlying infrastructure. It is also possible that the external environment changes, and prompts rapid changes in business operations. Development of information systems that allow flexibility and robustness involves considering key 'network variables' in infrastructure [20]:

- Capability - what business activities does the infrastructure support?
- Flexibility - how easy is it to modify the infrastructure to respond to changing needs?
- Quality of service – what is the reliability of the infrastructure?
- Cost - what are the costs of infrastructure, and are the benefits worth the investments?

Information systems are expected to meet business needs. These requirements should be the guidelines in designing the level of capabilities, services and their quality, and flexibility of the information technology infrastructure. All this should be made possible at reasonable costs. Additional aspects that need to be taken into consideration in information technology development are reliability, performance and accessibility [20,22].

Accessibility refers to the extent and reach of infrastructure, in the sense that where can one access the system and what terminal devices can be used here. When access is possible with wide range of devices ranging from desktop computers to portable devices, tablet computers and smartphones independently of their operating systems infrastructure is seamless and does not limit operations. In other words, if only certain geographical locations, terminal devices or operating systems can be used in accessing the information systems this can severely affect the way people do their work. It also impacts the flexibility to organize things differently, and to adapt to changes in business needs.

Accessibility is more than providing range of portable devices to the users. Design of services that are easily accessible can be challenging, and in many cases systems are difficult to use [20]. For example, depending on the system being accessed there may be different login procedures, authentication methods and other steps which

make using the system cumbersome to the user, especially with mobile devices [34].

In some environments is quality of services particularly important. In systems that provide online services can transactions depend on interaction of several subsystems and modules? Here slow connections and responsiveness can cause the interaction to terminate unsuccessfully, or the user may feel that the service in question is not very good. Infrastructures tend to expand as more computers and users are connected to common resources. It would be wise to consider system growth and expansion in information systems planning phase, otherwise, an organization might outgrow it's infrastructure prematurely [35,20]. Depending on the infrastructure there can be limits on numbers of devices or users who access the system simultaneously. These limitations are not only barriers to expansion, they may also turn out to be expensive if adding capacity requires serious investments and cannot be done incrementally. As a result, choices that have been made in the planning stage will influence reliability and quality related issues, and have also an impact on costs [36].

Ideally, performance and quality related problems should be avoided with proper planning "a priori" [36,37]. Planning excessive capacity, duplication of infrastructure or providing other kind of backup resources tends to be very expensive. It would still be important to pay attention to quality of the services, whether it is overall performance or availability of hardware and software resources. Sometimes systems also go down without warning. For example, servers may fail or applications crash without warning. Mapping, understanding and managing key systems and bottlenecks is vital for successful information systems infrastructure management

### 3.1 Development is based on Standards

Organizational development and the potential for new business opportunities are impacted by information systems, or depend on them. In this way also business people need to be involved in development of infrastructures. As a result, existing information systems, technologies and infrastructures are the starting point for any infrastructure development process.

It is relatively rare case where the system is being from scratch, without any existing technologies.

This takes place only when a new company is starting operations. However, in other cases development of information technology infrastructures is influenced by the existing technologies and platforms [4,31]. This affects development activities in two ways [31]. Firstly, whether the choices are about hardware or software it is important to look at the compatibility of new solutions with existing technologies. Technology also has a 'mediating role' between development-related activities and the actors who are involved in the development work.

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It brings different kinds of people and stakeholders together, and is topic for various discussions. Noteworthy, technology does not affect technical staff alone. Understanding the business impact of technologies is not necessarily the one of the areas where IT people excel. From business perspective it is very important to have business people involved in development.

Generally, information technology infrastructure acts as a foundation for business processes and activities.

Infrastructures are being developed over a long period of time when new technologies and systems are being installed to existing base of technology. This type of incremental and additive development makes compatibility, standards and standards compliance of the existing and future infrastructure cornerstones of infrastructure development.

Standards have a central role in technical development. In information technology, standards create a self-reinforcing mechanism [38]. It becomes apparent when the system is being developed; new technology needs to fit together with existing technologies. There are four sources for self-reinforcing mechanisms [38]: there may be significant costs in implementation and maintenance; learning effects, skills and knowledge required in using the systems effectively; copying, referring to advantages if technologies and applications can be applied to multiple or matching cases; together with coordination and adaptive expectations. Here technologies and choices that follow standards are often better than technologies that are incompatible or differ significantly from previous technologies and systems.

Consequently, the information technology development is affected by the choices made in the early stages of the system development [40].

Compatibility affects development in several ways [38,41]. Firstly, it develops lock-in in technologies.

This refers to a situation where adoption of a given technology makes it impossible, very expensive or otherwise unwise to switch to other competing technologies. A “standard” that is compatible with fits installed technical base becomes more attractive than other possible solutions that are not compatible with the existing system. There is path-dependence which means that previous choices have an impact in the future, and even minor changes may have great significance. The self-reinforcing process can also lead to possible inefficiencies because the best solutions and technologies will not always be chosen because of compatibility issues.

There are also other reasons to rely on technology that fits the existing infrastructure. Katz and Shapiro [42,43] use the term network externalities. Accordingly, there are three sources of network externalities [42]:

- The direct physical effect refers to a situation where the number of users increase the value of the product or service (for example, as people have started using mobile phones it has become easier to contact people anywhere and anytime).
- The indirect effects are also adding value: as the number of adopters of a given technology or system increase it will spawn also additional services which support that technology (for example, as the number of users of a certain operating system increases the more software there will become available that run on it).
- The post-purchase services depend on the size and extent of the service network, which becomes larger as the number of users of the technology or system increase.

Having compatible infrastructures, technologies and systems fit together are among the most important factors that lead to standard-supporting behaviour. Standards have a key role because manufacturers develop technologies and services that adhere to standards, with new innovations building over underlying, existing technology. Compatible products are easier to sell, and supporting services together with know-how that support the technology become available. The increasing number of users of a technology also lead to economies of scale reduces prices, and this makes the technology even more attractive.

Self-reinforcing mechanisms and network externalities have an important role in the development of information technology infrastructure. In infrastructure investments and fixed costs are often significant and therefore it is expected that the infrastructure will serve for years ahead. In this situation it is clear that earlier decisions have an impact that will affect the development for years, creating both lock-in and path-dependence in the information technology infrastructure management.

Changing to a technology that does not follow standards can be unwise if it is not compatible with the existing infrastructure [31]. As the number of users grows, people become familiar with an existing system and the relative importance of the system increase switching to an alternative that risks compatibility will become increasingly unlikely.

### 3.2 Role of Flexibility

Flexibility can be defined as the degree to which an organization possesses procedures that it can implement in response to changes happening in the environment [44]. Flexibility is characterized by issues like connectivity, compatibility and modularity [33].

Connectivity relates to the ability to attach technologies with other technologies, devices and systems whereas compatibility refers to the ability of sharing information across the information system. In an ideal situation systems should be integrated transparently so

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that data can be accessed, processed and shared regardless of the systems and technologies used in the process.

There are continuous changes in technology. As a result, systems should be modular so that it is possible to add, remove or modify different components in the system. Modifications should be possible with little or minimal impact on other systems. The ability to modify, add or remove system modules is also called application functionality [45]. When changes are possible without significant technical or operational problems the costs involved in changes can be kept at reasonable level. From this perspective flexibility is also connected with costs and profitability.

Information technology infrastructure flexibility is important for several reasons [31]: Firstly, infrastructure should connect different technologies and systems together. In order to do this successfully there is a need for flexibility that allows integration of different systems into one network. Combined with the fact that there is also increasing pressures to develop interfaces to information systems of other organizations, for example connecting with suppliers or significant customer organizations information systems to streamline processing of orders.

Secondly, as information technology should support operations there needs to be a tight connection between vision, strategies and business targets with the developers of information technology. Typically an information technology infrastructure is intended to serve for several years and be relatively stable over time. At the same time requirements for business operations and processes may change, and this calls for changes in information technology infrastructure [46,3]. Because of the long time span of infrastructure there is a need to modify systems, add new applications and technologies into existing infrastructure in order to meet the changes within organization and its environment.

Thirdly, development of technology and applications generates a need for change. For example, upgrading an application may lead to problems with other systems. Here flexibility, changes and adjustments are needed to keep the system functioning as smoothly as possible. It is also normal that systems expand as business grows. Adding new users, workstations, systems and services is required for information technology infrastructure.

It is important to develop infrastructure so that there it enables rather than limits activities. Flexibility can be further increased by established development approaches which are based on modularization and encapsulation [47]. Here the principle is to develop systems that are logically and functionally autonomous, and defining interfaces between them. It can be significantly faster and more effective strategy than trying to deal with one extensive organization-wide standard in infrastructure development. This strategy is also referred

to as “leanness” [31]. It emphasizes simplicity of each individual system, module or element in the infrastructure. The idea of leanness is that it is easier to change something small and simple rather than trying to make changes in large and complex systems.

#### 4. CONCLUSION

Technology is one of the key resources in organizations. In smaller and larger companies and in practically all fields is information technology the basis for business operations [2]. It is therefore important that technology, systems and networks are reliable [22].

Technology is expected to work transparently, as a reliable basis for business operations. It is still noteworthy that despite ever increasing sophistication of technology it is not enough for successful business operations as technology also needs to be converted into productive outputs [45]. Knowledge and experience are needed to use, maintain and develop technology to meet business needs. Human component is therefore vital part of successful information technology infrastructure [10,45,48].

In this article we have studied management on information technology infrastructure. Infrastructure is here seen as a resource that is combination of technical and human components. The technical component of the information technology infrastructure includes hardware devices, networking technologies and operating systems, as well as core applications that are shared throughout the organization [33,22].

There is a need for expertise in infrastructure management [3], mastering a wide range of technologies, hardware and applications is required. General, widespread knowledge is needed, but also detailed technical expertise should be available. This can be overwhelming as even information technology companies admit that their expertise is often in a narrow area, with other technologies and systems being unfamiliar. It is therefore not surprising that many organizations feel that they lack expertise, and need to seek advice in problems that require specific knowledge. For example, if there are problems with database access outside experts can solve the problem significantly faster than staff in organization’s own IT department as they may not have special knowledge or experience in that type of technology.

External partners can provide solution to various technical problems. Especially in smaller organizations where the IT department is small, or with no IT expert it seems natural to seek advice and cooperation from outside sources. Also in larger organizations external services and partnerships in information system maintenance and development can provide real added value. Outsourcing, partnerships and taking advantage of external services in information technology provides numerous possibilities.

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It is evident that both technical and human components are needed in IT infrastructure management and development [2,45]. Among the most important infrastructure management and development activities are those concerned with IT platforms, networking and telecommunication, together with data and applications [33]. Information technology infrastructure needs to be compatible and flexible as it affects the business value of information technology in the organization.

Understanding the role of knowledge and skills in information technology management is vital. Lee et al. [10] remark that expertise in technology, knowledge of business operations, and interpersonal skills are central issues in information technology infrastructure management. These skills are increasingly important when technological infrastructure is critical from business point of view. Where technical expertise can be bought from outside service providers understanding business goals, infrastructures role in meeting operative and strategic objectives is an area that should be within organizations own domain of expertise.

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