

Infrastructure Development – Stages in Development

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Abstract—Information systems infrastructure is the basis of business systems and processes in the company. It should be a reliable platform for business processes and activities, but also have flexibility to changes in business needs. The development of an infrastructure that is robust, reliable, and flexible is a challenge. Understanding technological capabilities and business needs is a key element in development of successful information systems infrastructure.

Keywords—development, information technology, networks.

I. INTRODUCTION

INFORMATION systems management is a challenge. Information systems should run as a reliable backbone of operations. They need to enable manufacturing, customer service, or whatever the operative and strategic processes are. At the same time information systems should allow flexibility, growth and adapt to changing needs. Planning and managing a system that provides variety of services with different goals is a challenge, especially in smaller organizations where resources are limited. [1]

In this paper we look at development of organizations information systems infrastructure [2]. It is the basis for business applications and processes. Ideally, when an entrepreneur hires employees and the company grows there is a need to connect computers together so that it becomes possible to work with common data and processes. This is the time and place for infrastructure management and network development.

II. UNDERSTANDING INFRASTRUCTURE MANAGEMENT

Information systems development is a continuous process, there are often several development projects and activities going on simultaneously. When a project is completed, the developers start working with some other development challenge. In general, development is a process which involves planning a solution and implementing it [3], [4]. In the context of information systems, it is about technology and how to use it to bring added value. The role of developers is considerable, even though the results depend on technology, and it's fit to organization [5], [6]. The development process can better be managed with [7]

- Assigning clear responsibilities at different stages of the development work.
- Understanding basic requirements and keeping them in mind during the process.
- Managing changes to keep within plans.

- Having different experts in the development team, using also external expertise when needed.
- Integrating and controlling external partners during the process.

Management of information systems infrastructure and networks is a combination of several tasks ranging from planning and preliminary analysis to feasibility study, implementation and to managing the use and growth of the infrastructure [8], [9]. When projects are completed, they move into maintenance stage, where the focus is on smooth operation of the technologies and systems. Information systems development and management can therefore be seen as a continuum of development activities, which at some point become more maintenance oriented.

Consequently, in information systems infrastructure management are some tasks dealing with maintenance, installations, and technical configurations, while other activities relate to finding problems and bottlenecks, which become future development areas.

Infrastructure management involves various activities and tasks. These are generally organized into stages [10] which involve recognizing the needs, feasibility study, selecting and appointing of a task force / project group, which will work planning. Once the project proceeds there will be implementation, followed by maintenance, evaluating, and later expanding. This approach has many similarities with general systems development stages, but also some differences. Amongst the most important is the focus, which in general development tends to be on the planning and implementation stages. Here we also highlight the importance of evaluation, modifications and expansion of systems and infrastructures.

The successfulness of infrastructure management depends on the commitment of the developers [11], [12]. Another key success element is involvement of organization's management [13]. Management support is needed so that there are sufficient resources, and management also encourages developers in their work. Furthermore, management support is an example, and a positive sign for organization. Management involvement and support help in lowering user resistance, and speeds organizational change and implementation of new systems and practices.

It is important to have key persons and stakeholders involved in the development process. In fact, the involvement of managers, IT department and users is a critical factor for information systems infrastructure development [14], [15], [16]. The development process calls for a mutual understanding of development priorities, schedules, responsibilities, and resources. It is also important that all who are affected by the

changes are being informed, otherwise there can be significant resistance, or otherwise the goals of the development will not be fully reached.

Infrastructure development requires various types of skills and expertise. Technologies are complex and evolve rapidly, there is a need to follow technological development. The developers should have expertise and information to make effective plans and choose technologies and systems that bring added value. It is not uncommon to rely on external advice and expertise, especially when developing new technologies or systems which are not widely used in the organization. They may be specialists or experts, consultant that have detailed knowledge of a technology or system. It is important to have knowledge and expertise to choose technologies to build a system that runs reliably, remains flexible and as open for changes in the future [16].

Development work relies on interaction between developers, internal and external experts, together with users of technologies and systems. Interaction is considered as one of the key requirements for successful implementations and change process [17], [18]. Understanding the development task and goals, requirements, issues, and challenges is based on interaction among all involved in the development work. On the other hand, promoting interaction, discussion and innovation are all important, but they will not automatically ensure optimal results [17]. Information systems development is not only about understanding technology, but it is also important to have persons with the process who understand and are able to explain organizational processes and information needs, both on operational and strategic level [19].

Information systems and infrastructures have impact on organizational processes, and therefore they need to adapt and fit the organization [14], [12], [20]. Information systems have lot of potential applications, but successful use and implementation of technology depends on “the human factor” [6], [21], [16]. Therefore, interaction is a vital part of the development work.

III. PLANNING INFRASTRUCTURE DEVELOPMENT

There are many reasons for information systems development. If we look at infrastructure, it is typically considered as the basic, enabling backbone system in the organization. It connects different applications, databases and processes together making it possible to deliver products and services to the marketplace, or whatever the organizational processes and goals require. If there are shortcomings, interruptions in operations or simply new needs it is time to develop existing systems and infrastructures.

The development process starts by assigning a development group. This group will have a key role in preliminary planning and thereafter in all stages throughout the development process. Development group should include key persons from the IT department, line managers, users, experts, and other key individuals. Here also providers of technology, systems and services for the ICT processes are mapped. altogether, the development group can and usually will change as there is need to have different kinds of expertise, advice, and input in

different stages of the development process.

Analyzing existing systems and infrastructures is one of the first tasks for the development group. Mapping the infrastructure, devices and systems is a start for the development process. This development stage looks at issues with existing systems, especially problems: description, impact and how often they occur, bottlenecks: mapping legacy technologies and components, unreliable and slow systems that should be replaced and planned changes to existing systems [22], [23]. The developers should make the technical analysis in such detail that findings can be used as the basis for the development work.

Information systems analysis is important also therefore that any changes, new technologies and systems need to integrate with other, already existing systems and technologies. Therefore, mapping describes hardware, software, and infrastructure in detail. It is also important to describe communication links, all connections and interfaces between the new, to-be-developed system and other systems so that interoperability and connectivity can be ensured. Thorough information system infrastructure description gives developers a comprehensive picture of the system and is the basis for further development activities.

Information systems planning involves also other than technical planning and expertise. Feasibility analysis is an important part of the development process, it is about evaluating costs and benefits. There is need to analyze short-term and long-term perspectives. It includes financial aspects, but it also involves studying the impact of technology, what are the desired changes, and how development supports organizational goals and structures. In addition, project timing needs to be done, so that resources can be allocated, and project started at the best possible time. Clearly, understanding user needs and requirements is needed in successful information systems development projects. There is a need to meet individual’s needs, together with organizational, departmental, and functional goals.

Information systems infrastructure related changes have a wide and long-lasting impact on the whole organization. Noteworthy, changes to existing infrastructures may also impact the way people work and interact when tasks, responsibilities, and processes change. Therefore, changes in information systems and technologies is more than compatibility with existing infrastructures. In many cases the organizational impact can be even more important aspect in information systems development [6].

The development group should do a feasibility study, together with identification of expected goals and benefits [10]. Information systems tend to be expensive and have a significant impact on the whole organization, and therefore management support is important [14]. Management plays also an important role in management of the change process. Motivation and encouragement are needed throughout the organization to manage user resistance, adoption of changes in systems and processes [24].

The key aspects of infrastructure development could be outlined in terms of connectivity, portability, user information

needs, system controls, future expansion, and costs [10], [16]. Connectivity refers to the extent to which users are connected, impacting resource sharing and applications that need to be available from each user's terminal device. On the other hand, connectivity means that whatever the new technology and systems are, they should integrate with existing systems, technologies, and infrastructures. The technological compatibility with the existing infrastructure also needs to be analyzed. It is inevitable that the result will be a mixture of old and new technologies and systems. In this context standards and standards compliance are important elements as they enable connectivity between technologies and devices from different manufacturers and providers [25], [26]. The second aspect, portability, refers to the idea that data and systems should be accessible from different devices and locations. As an example, the sales representative might access systems from different company offices, from his car or from a meeting with the customer. The goal is to enable and empower the user to work more effectively, and so the needs of different users should be understood. System controls relates to managing access control and paying attention to security development and crisis management practices.

Future expansion is a very important aspect in infrastructure development. In general, development activities should be address long term benefits and costs, making choices that are optimal on short-term are not necessarily best in the long run. This also highlights the cost-effectiveness, investments and management costs should be in balance with the benefits and added value that the technologies and systems bring to operations.

IV. IMPLEMENTATION AND EVALUATION

It is time to move from planning and analysis to implementation. This refers ex. to selecting vendors and partners. It also relates to moving forwards with development activities, making the plans become reality. Implementation also involves user training and support arrangements. Furthermore, there is a need for organizing maintenance for the new systems and activities as part of the overall infrastructure.

If the system has a critical role, or otherwise makes significant changes into the organization it might be advisable to test technology and systems in smaller scale before widespread changes. Testing or piloting may reveal problems that have not been addressed, or they become visible when the system is in actual use. Testing should be seen as an opportunity to check that plans and solutions are realistic. Testing allows choosing and comparing alternative technologies and solutions. It is also possible that vendors offer their products for testing with marginal cost, or even free. With testing can problems be found before full-scale implementation, where it is often expensive and difficult to make changes to technologies and systems while they are being in use.

Clearly, implementation involves installation of technologies and setup of systems. One part of implementation is documentation. From the infrastructure management point of view, documentation is an important task [10], [16]. Documentation should include inventory of main components

(like servers and switches) and layout of infrastructure (wiring and connection). Overall, the level of detail should be such that it is possible to troubleshoot if there are problems. Technical specifications, device models, configurations, network identification and numbering, wiring and connections etc. are needed for information systems management purposes.

In connection with documentation, it is advisable to pay attention to authentication and system access. These refer to managing who can access systems, where each user may or may not make changes to data. As privacy and security are increasingly important especially in Europe (GDPR) these concerns require thorough planning. Managing authentication, accessibility and user rights is key to successful information systems infrastructure management.

Overall, it is understood that documentation of infrastructure is important. However, experiences indicate that in real life documentation may be incomplete, old or there are systems that have not been documented at all [16]. This can lead to situations where there are systems in the organization, and IT staff has little or no knowledge about them. For example, those who were designing and installing system X have left the organization, and there is no documentation to be found describing this system. If this should be the case, it is challenging to manage a system is like a black box to the IT department. The function or process that this system has cannot be managed in a way that reliable, continuous operation can be provided. All changes to systems and infrastructures need to be documented, so that it is possible later to verify what has been changed or modified, and where. Therefore, all should understand that systems should be thoroughly documented so that it is possible to maintain and develop infrastructures further. As a result, in many organizations there is a need to develop documenting procedures [16].

It is time for deployment once installation and setup are completed. Before moving over to the new system all necessary data needs to be transferred from older systems to new system. At this point it is also vital to check that systems operate correctly, reliably and run normally. After deployment is time to use the system for its purpose

V. DISCUSSION

Information systems are the basis of processes and operations in organizations. The reliability and robustness of technology and systems is therefore an increasingly important aspect [27]. Especially the reliability of infrastructure can be a critical element [16].

Developing information systems and infrastructures calls for different kinds of expertise and skills. It involves more than technical expertise. Interpersonal skills are needed, and there are also management skills needed in successful development projects. Understanding the potential technology provides for improving processes and bringing added value to the company is needed. Eventually, it is the data and how to use it that matters.

REFERENCES

- [1] K.C. Laudon, and J.P. Laudon, "Management Information Systems: Managing the Digital Firm", Plus Mymislab with Pearson Etext -- Access Card Package (14th ed.). Prentice Hall Press, Upper Saddle River, NJ, USA, 2015.
- [2] J. Xu, and M. Quaddus, "Managing Infrastructure for Information Systems". In: *Managing Information Systems*. Atlantis Press, Paris, 2013.
- [3] P. Checkland, and J. Scholes, "Soft Systems Methodology in Action". John Wiley & Sons Ltd, 1999.
- [4] W.A. Cram, and M.K. Brohman, "Controlling information systems development: a new typology for an evolving field", in *Information Systems Journal*, Vol 23, Issue 2, pp. 137-154, 2013.
- [5] W.J. Orlikowski, and D. Robey, "Information Technology and the Structuring of Organizations", in *Information Systems Research*, Vol 2, No 2, pp. 143-169, 1991.
- [6] W.J. Orlikowski, "The Duality of Technology: Rethinking the Concept of Technology in Organizations", in *Organization Science*, Vol 3, No 3, pp.398-427, 1992.
- [7] L. Railing, and T. Housel, "A network infrastructure to contain costs and enable fast response: The TRW process", in *MIS Quarterly*, Vol 14, No 4, pp. 405-420, 1990.
- [8] M. Broadbent, P. Weill, T. O'Brien, and B.S. Neo, "Firm Context and Patterns of IT Infrastructure Capability", in *Proceedings of the Seventeenth International Conference on Information Systems*. New York, 1996.
- [9] P. Weill, M. Subramani, and M. Broadbent, "It Infrastructure for Strategic Agility", *MIT Sloan Working Paper No. 4235-02*. 2002. Available from <http://dx.doi.org/10.2139/ssrn.317307>
- [10] D.V. Nadig, and N.J. Hard, "A Proposed Model for Managing Local Area Networks and Measuring Their Effectiveness", in *Proceedings of the 26. Annual Hawaii International Conference on System Sciences*, pp.538-547, 1993.
- [11] J.F. Rockart, "The Line Takes the Leadership - IS Management in a Wired Society", in *Sloan Management Review*, Vol 29, No 4, pp.57-64, 1988.
- [12] M.L. Markus, *Systems in Organizations*. Cambridge, 1991.
- [13] C.F. Gibson, F. Cyrus, C.J. Singer, A.A. Schnidman, and T.H. Davenport, "Strategies for Making an Information System Fit Your Organization", in *Management Review*, January, pp.8-14, 1984.
- [14] E.H. Schein, *Organizational Culture and Leadership*. Jossey-Bass Publishers, 1986.
- [15] J.C. Henderson, "Plugging Into Strategic Partnerships: The Critical IS Connection". *Sloan Management Review*, Vol 31, No 3, pp.7-18, 1990.
- [16] S. Sirkemaa, "Key Perspectives in Information Technology Infrastructure Management". in *Journal of Advances in Information Technology* Vol. 10, No. 3, August, pp. 100-103, 2019.
- [17] W.R. King, "Strategic planning for management information systems". *MIS Quarterly*, Vol 2, No 1, pp.27-37, 1978.
- [18] W.A. Cram, M.K. Brohman, and R.B. Gallupe, "Hitting a moving target: a process model of information systems control change". *Information Systems Journal*, Vol 26, Issue 3, pp.195-226, 2016.
- [19] B. Dos Santos, and L. Sussman, "Improving the return on IT investment: the productivity paradox", in *International Journal of Information Management* 20, pp.429-440, 2000.
- [20] K.E. Pearlson, C.S. Saunders, and D.F. Galletta, *Managing and Using Information Systems: A Strategic Approach*, Sixth Edition. John Wiley & Sons, USA, 2016.
- [21] K.C. Laudon, "Ethical Concepts and Information Technology". *Communications of the ACM*, Vol 38, pp.33-39, 1995.
- [22] P.G.W. Keen, and J.M. Cummins, *Networks in Action: Business Choices and Telecommunications Decisions*. Wadsworth Publishing Company. Belmont, California, 1994.
- [23] J.Y. Hsu, *Computer Networks: Architecture, Protocols, and Software*. Artech House, Inc. Norwood, MA, 1996.
- [24] D. Leonard-Barton, and I Deschamps, "Managerial Influence in the Implementation of New Technology" in *Management Science*, Vol 34, No 10, pp.1252-1265, 1988.
- [25] O. Hanseth, "Approaches to information infrastructure development and standardization". in *Studies in the Use of Information Technologies*, No 17, Departments of Informatics, Goteborg University, 1996.
- [26] O. Hanseth, E. Monteiro, and M. Hatling, "Developing information infrastructure: the tension between standardization and flexibility", in *Science, Technology & Human Values*, Vol 21, No 4, pp.407-426, 1996.
- [27] T.H. Davenport, and J. Linder, "Information Management Infrastructure: The New Competitive Weapon", in *Proceedings of the 27th Annual Hawaii International Conference on Systems Sciences*, pp.885-899, 1994.

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