Introduction to ICT Infrastructure

The information and communication technologies (ICT) infrastructure is a key element in many organizations. This infrastructure is composed by a set of hardware, software, services, procedures, processes and persons. Our vision considers ICT Infrastructure as an organization, with a great number of elements, with persons that interact with these elements and with other persons, with complex processes, with a great number of procedures, etc. This infrastructure should interact with its environment, should adapt to it and should evolve. With this vision we have consider the ICT infrastructure as a complex system. In our work we have developed a methodological framework to model and to design this ICT infrastructure concept.

Concept of ICT infrastructure

Our concept of the ICT infrastructure is not only a set of equipment or elements. The ICT infrastructure enables to share the ICT capabilities which provide services for other systems of the organization (Broadbenta et al, 1999). For Broadbenta et al these capabilities require the complex combination of the technical infrastructure (cabling infrastructure, hardware platform, base software platform), ICT shared services (as communications services), ICT applications (as WEB services), the human operators and the managerial expertise to guarantee reliable services (see figure 1). All these resources are designed, developed and managed over time. In our system ICT infrastructure does not include the specific computer applications, but the teachers or other users should experience and innovate using specific computer applications on the ICT infrastructure.
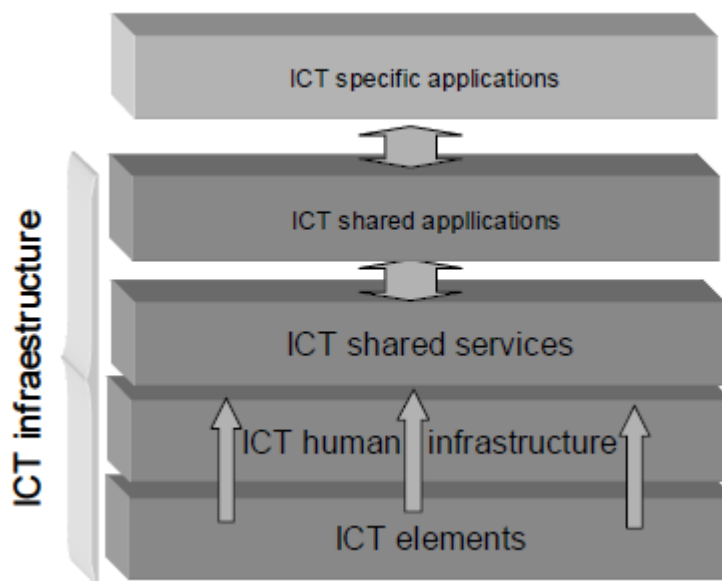

Figure 1 – Concept of ICT Infrastructure

The ICT infrastructure must be flexible to support the operation among different applications and to facilitate the communication of the information inside and outside of the enterprise. Thus, it must be flexible and integrated:
• Building a flexibility infrastructure implies cost and complexity because that supposes to add a characteristic that may be exercised in the future, and must consider the variety of user necessities that an organization can handle without modifying the infrastructure significantly. An organization can take different approaches to invest in the ICT infrastructure investments. ICT infrastructure needs to respond more rapidly to changes in the environment and between the different functional units.

• The integration increases the importance of relations among services and information. This integration implies the capability of exploiting resources shared across services, locations and departments. In this way, an ICT infrastructure must be unique and shared rather than separate ICT platforms.

Other aspects that permit to have a flexible and integrated infrastructure include the knowledge, the skills and the experience embodied in the human infrastructure.

This conception of ICT infrastructure in a large organization can be considered a complex dynamic system (variable environment, organizational system, a great number of elements, etc) in which deterministic and mathematical rules representing all the details of the models can not be easily formulated.

Methodologically, the first step in our analysis of this complex system has been to use the method of decomposing the whole system in subsystems with a smaller complexity degree. In our framework each subsystem can be treated independently, although in each subsystem the whole integration and the synergy with the other subsystems have been considered and one subsystem is the responsible of the integration of all the parts. The decomposition of this system has been based on the Viable System Model (VSM) (Beer, 1984). The Viable System Model considers an organization interacting with its environment. Beer pointed out that a system is only viable if it has a specific management structure. According to the proposed VSM a set of management tasks is distributed to five systems ensure the viability of any social system. The five systems are Operation, Coordination, Integration, Intelligence and Policy. These five systems can be

summarized as follows: Operation realizes the primary activities; Coordination regulates and coordinates the different subsystems of Operation; Integration is the controlling unit of the operational level (Operation, Coordination and Integration). It has to ensure the operation of all the system and to optimize the allocation of resources; Intelligence is the link between the primary activities and its environment. On this level the future developments according the systems capabilities and changing of the environment (customer demands) are planned; and Policy is the main decision level of the whole system. The main roles of Policy are to provide clarity about the overall direction, values and purpose of the organizational unit.

Figure 2 shows the VSM model where an organization is composed by two elements: Operation which does all the basic work and Meta-system which provide services to Operation by ensuring the whole organization works in an integrated and viable way. Operation contains the productive units (in our case, schools). Meta-system procures cohesion, optimization, synergy, cohesion, stability and future planning to ensure adaptation to a changing environment. Both Operation and Meta-system must be in contact with, and interacting with, their environment. In our case the set of students (and their parents) is the environment.

ICT elements

ICT human infrastructure

ICT shared services

ICT specific applications

ICT shared appllications
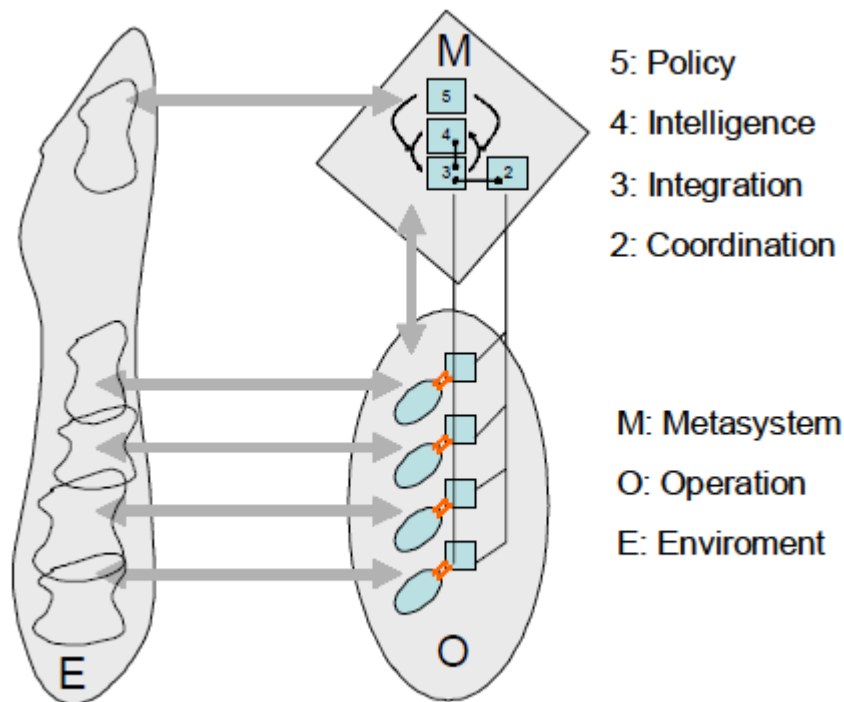
ICT infrastructure

5: Policy
4: Intelligence
3: Integration
2: Coordination

M: Metasystem
O: Operation
E: Enviroment

Figure 2 – Viable System Model

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We have considered our ICT infrastructure as an organization. Thus, VSM model has been applied to the ICT Infrastructure and, moreover, Operation, Coordination, Integration, Intelligence and Policy have been identified. ICT infrastructure as a viable system is shown in figure 3. In our model each subsystem has a specific framework.

We have decomposed Operation in other VSM systems: the corporate applications and all the schools (ICT infrastructure of schools are considered as a VSM system). The number and the situation of all ICT elements can be seen in figure 3.

To reduce the complexity of Operation a uniform solution has been designed for all the schools. Thus, important scale economies will take place with the centralized acquisition of ICT equipment. The uniformity of equipment has important economical profits, also, facilities and simplifies the operation, administration and centralized maintenance. Also, the selection of a uniform technological solution is the only viable way of executing a project that embraces all the great quantity of centers from a unique technical project office. In Operation teacher play two roles: one role as human infrastructure and the other one as environment. The complexity due to the great number of teachers has been managed identifying three types of teachers in function of their ICT skills. Each school ICT Infrastructure has synergies with the whole system, Intelligence subsystem is supported by Intelligence of the whole system (for example, backup copies are realized centrally). Thus, technical staff and technical knowledge are not necessary in schools. There exists an ICT coordinator in each school that is a teacher (without high technical knowledge) dedicated to promote ICT use.

On the other hand, the complexity of Meta-system is completely different to Operation. While in Operation ICT elements are the basic elements, in Meta-system the human infrastructure plays an important role. The number of persons in each subsystem is shown in figure 3. This system should fulfill the functions of the Meta-system: integration, monitoring, control, optimize and resolve conflicts inside the whole organization and realizes future planning to

ensure adaptation to a changing environment. Thus, we have decomposed the Meta-system in four systems (based on VSM): Coordination (including the communication network), Integration (software developing, infrastructure deployment, educational support and the ICT center) and Intelligent and Policy (as management system)