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Healthcare and Distributed Systems Technology

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The Hospital Information System

The healthcare organisational structure in all European countries is naturally distributed, being a geographical spread of centres at different levels of complexity: from the general hospitals down to individual GPs. The ultimate objective of such a structure is to build a network of complementary centres (hospitals, laboratories, ambulatories, co-ordination centres, etc.) spread over the territory, to meet effectively the social needs in the area. Despite the fact that each individual centre is autonomous and devoted to the delivery of a particular set of services, they are mutually inter-dependent and inter-working to ensure the effectiveness of the activities, in terms of prevention, caring and costs.

Furthermore, the on-going modifications in the social context, due to the ageing of the European population, anticipate an increase in such decentralisation approach for the health care services in the coming years. The importance of home-care, ambulatory care and long term nursing care will also increase with respect to the role of the hospitals, which tend to be high-qualified centres, for short specialised treatment.

Also the structure of the hospital itself is evolving from a vertical, aggregated organisation, towards the integration of a set of specialised departments, each of them with its own logistic, organisational and administrative requirements.
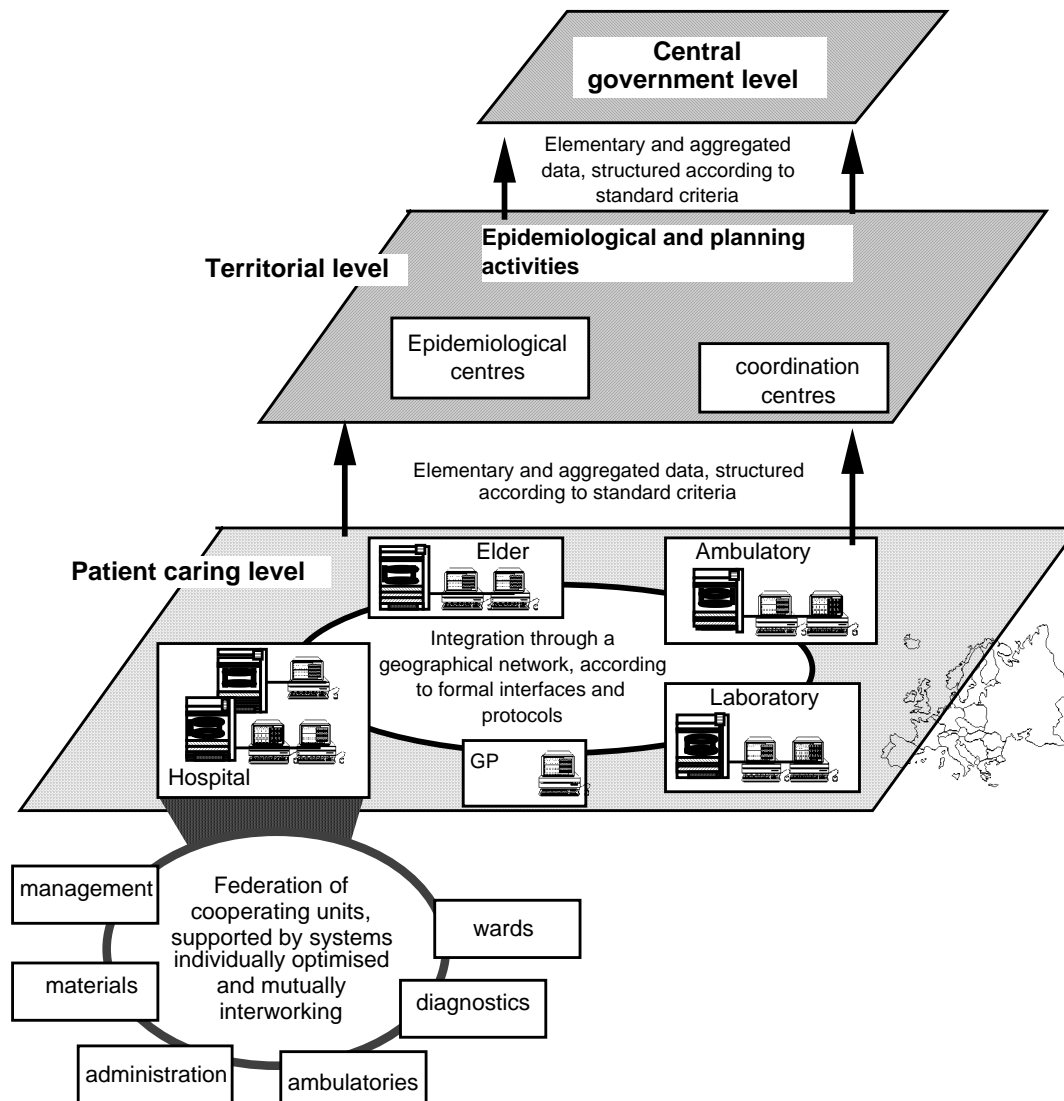
According to such ultimate organisational goal of the whole structure, also the information systems supporting the individual centres must be structured **as a federation of autonomous systems**,

individually optimised according to the specific characteristics of the involved units. In parallel, the individual systems must be consistent with information and procedural standards, in order to permit the mutual interoperability to provide an effective and efficient support to the co-operation individually provided by each single unit.

On a smaller scale, the same organisational model must be applied in the computerisation of the individual healthcare centres (e.g. the hospital). Each hospital is composed of a set of units, individually specialised for the execution of special activities and the delivery of particular services; all units of the hospital, however, must mutually interact consistently for the effective working of the global structure.

To support effectively such organisational aspects, the healthcare information systems must be structured as a **federation of different applications**, each of them being autonomous and individually optimised to support the specific characteristics of the involved units and users.

In fact, the diversity of the individual hospital organisations, the complexity of the clinical protocols and the variety of the preferences of the various users make it extremely difficult to envisage a unique, "monolithic" system, effectively usable in the whole structure.

On the opposite, a number of applications are already available on the market, individually specialised to specific aspects and needs of the hospital structure. Users must be allowed to select the applications most suitable for their needs and requirements, and the information system must primarily provide the infrastructure to permit the effective integration of distributed and heterogeneous components, ensuring the overall integrity in terms of functional and information interworking.

Through this approach it will be ensured the transfer and integration of consistent information across the overall hospital structure, without causing constraints and/or limitations in the individual units and permitting therefore to achieve the following three primary objectives of an advanced healthcare information system:

- From the **organisational** viewpoint. To provide the necessary support to the individual units, both within the local environment of the healthcare centre and with respect to the interaction with the other centres operating over the territory. The various units must be computerised taking into account their individual characteristics and specific requirements [i.e. also through applications supplied by different vendors], even by ensuring the overall integration and consistency.

- From the **operating** viewpoint. To facilitate the users in the execution of their activities, by reducing the clerical work and emphasising the professional aspects of the various roles. In such a way it is also simplified the introduction of the system in the organisational context and reduced the needs of training.

- From the **technological** viewpoint. To permit the construction of an overall distributed, modular and evolutionary framework, based on openness criteria and on the adoption of the most adequate architectural, information and technological solutions emerging on the international scenario. This approach permits to optimise the costs, by adopting the hardware and software solutions most adequate to the specific needs, even if developed by different manufacturers.

From the technical viewpoint, the adoption of a standard and open architecture, independent from individual supplier (both hardware and software) represent the only solution capable of ensuring the achievement of such objectives, allowing the integration of the diverse components of the system through an incremental approach, according to the evolving requirements and securing the investments already done.

The definition and adoption of standards, not only as concerns the technical aspects but mainly with respect to the information and functional interfaces between the various components of the system, represents a fundamental need to permit different applications, developed by different suppliers, to be utilised synergically in the hospital structure.

The EDITH Initiative

A group of clinical, technical and research bodies working together towards a common goal

The integration and convergence of clinical, organisational, technical and research expertises is the fundamental pre-requisite for the successful identification and delivery of advanced informatic solutions, capable of providing an effective support to the actual needs of the healthcare scenario.

The EDITH Initiative has been launched in 1992 on the basis of several European projects partially funded by the Commission of the European Communities to represent a focal point for the collaboration of independent organisations and project, collaborating in the definition, development, experimentation, and promotion of advanced healthcare systems based on a standard, open and vendor-independent architecture, capable of allowing the functional and information interworking of already existing and new applications, operating both within the individual centre and across the territorial organisation.

The EDITH Initiative closely co-operates with the national and international organisations for standards in healthcare informatics, promotes and co-ordinates research projects aiming at refining specific issues of the complete framework and facilitates cooperations between individual industrial and healthcare organisations for the joint development of specific advanced applications, supporting specific requirements of the healthcare organisations and complying with the common architectural principles.

Among the others, the following main results achieved by the Initiative can be highlighted:
*   An organisational model of the hospital structure, representing the fundamental background for identifying strategies and planning the introduction of information systems in the organisation.
*   The kernel of the architectural specification of the hospital information system, whose fundamental principles and criteria have also been approved and accepted by the Italian UNI-CNR Commission for standards in healthcare informatics.
*   The principal software components of the architecture, providing any generic application with a common technological platform and a set of services specific for the hospital domain to facilitate the consistency and interworking of heterogeneous, distributed applications.
*   The development of a set of applications, capable of providing an advanced support to the main requirements of any hospital, both from the clinical (e.g. admission, wards, laboratories, patient dossier, radiology) and from the managerial viewpoints (in terms of indicators on the cost and the quality of the services delivered to patients).

The organisation of the Initiative is based on two main Committees:
* the EDITH Users Committee - it represents the hearth of the whole initiative, responsible for identifying the evolution guide-lines, in terms of organisational and clinical requirements to be addressed. Furthermore, it is also responsible for the methodological aspects related to the introduction of the informatic solutions in the live environments;
* the EDITH Technical/Scientific Committee - it is responsible for ensuring the harmonisation and the consistency of the technical activities, with a major role with respect to the maintenance and evolution of the architectural and methodological framework and the certification of the compliance of new components with the requirements of the EDITH architecture.

The participation to the EDITH Initiative is open and free to all healthcare, industrial, research and governmental organisations, interested in contributing towards the achievement of such objective and the architectural results are on the public domain, Their contribution may evolve through various levels of participation:
* from a basic collaboration in the identification of the requirements and discussion of the possible solutions;
* to the direct experimentation and validation of working prototypes in live environments;
* up to the definition, promotion and execution of complete projects.

The EDITH Architecture

The architecture proposed for Hospital Information Systems and the DHE, the Distributed Hospital Environment

The fundamental requirement of the current organisational and technological scenario of healthcare organisation is the possibility of integrating different applications, by ensuring their mutual consistency both from the functional and the information viewpoints, even if the individual components are already existing and/or developed by diverse suppliers,

The healthcare information system, therefore, must first of all provide an infrastructure capable of allowing the easy federation of heterogeneous applications, in order to ensure the interworking between the individual modules and the homogeneous and consistent management of the information and procedures relevant for the whole healthcare organisation.

Such objective may be achieved through the definition and implementation of an open architecture where the individual modules:
• are individually responsible for autonomous and self-consistent functional areas;
• interwork through public and stable interfaces;
• are able to operate in a distributed environment, configurable and evolvable according to the specific requirements and characteristics of the individual organisation.

The EDITH Architecture provides an open and modular environment for achieving such objective. Referring to the detail of the architectural documents for a complete discussion and specification, the key-element of the architecture is its layered structure, based on three fundamental layers.

• The NICE[1] **technological distribution platform,** responsible for ensuring the transparency of the actual technological (i.e. hardware and software) configuration, by permitting the interaction of the individual modules of the system over a distributed and heterogeneous environment through mechanisms independent from the adopted network products and the physical location of the individual modules.

• The DHE[2] **application infrastructure**, which represents the central element of the whole architecture and is responsible for permitting the functional and information integrity of the system, according to the organisational, logistic and clinical requirements of the healthcare centre.
To accomplish this goal, the DHE consists of a set of services, specifically oriented to the healthcare business domain, capable of supporting the interaction of the applications in the individual units, the management of those data relevant for the whole healthcare centre and the execution of those activities relevant for the whole healthcare centre. The services provided by the individual components of the DHE may be invoked through client-server mechanisms, based on public and stable interfaces[3]

• The level of the **user-oriented applications**, which are individually autonomous and independent, in order to provide an optimised support to the specific activities of the various units of the healthcare organisation.

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[1] Network Independent Communication Environment

[2] Distributed Hospital Environment

[3] The DHE application platform, therefore, has scope and characteristics completely different from the technological platforms already appearing on the industrial and research scenario (such as OSF-DCE, ANSA, Tuxedo, etc.). In fact, such platforms (which may be included in the technological basic layer of the EDITH Architecture) are devoted to provide generic services for the interaction of applications over a distributed environment, without any specific support to the particular functionalities and information of the healthcare domain.
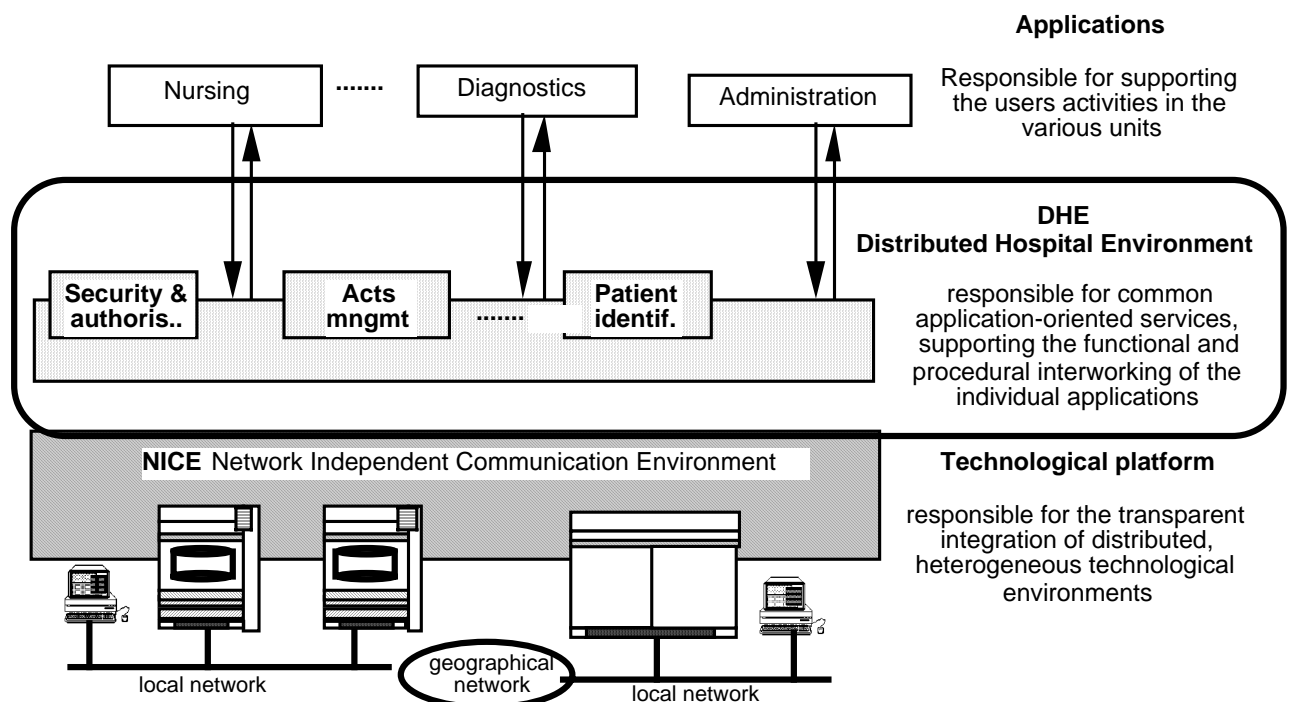
Within the EDITH archtecture, the "Distributed Hospital Environment" (DHE) represents a set of application oriented services specifically oriented to the hospital domain, capable of supporting the various applications in their mutual interaction and in the execution of activities of overall relevance in the hospital information system.

Such application platform, therefore, represents the "nervous system" of the hospital information system, ensuring the interworking and integration (both information and procedural) of the individual applications supporting the various units, even if they have been developed in different moments by diverse suppliers and operate on top of heterogeneous technical environments.

From the architectural viewpoint, the DHE consists of a set of software modules (servers), which interact with the individual applications (client) through interfaces public and stable.

It must be emphasised that the services provided by the DHE are specifically oriented to the application domain of the hospital, and do not have any relation with the underlying technological aspects used for implementing the system[4].

In the EDITH architecture, the technological platform is the layer responsible for providing a unified interface to allow the individual components (i.e. applications and DHE servers) to interact in a uniform modality, transparent from the network protocols and distribution criteria over the network.


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4   In the EDITH architecture, the transparency of all components from the technological and distribution aspects is ensured through the NICE API, a library providing a unique interface allowing the individual modules to interact in a client-server modality, regardless of their mutual location over the network and the specific protocols adopted

EDITH today

The components of the EDITH Architecture available today

A number of components of the complete HIS has been already developed through the collaboration of the various organisations partcipating to EDITH.

All modules conform to the same common architectural approach, based on distribution, openness and modularity.
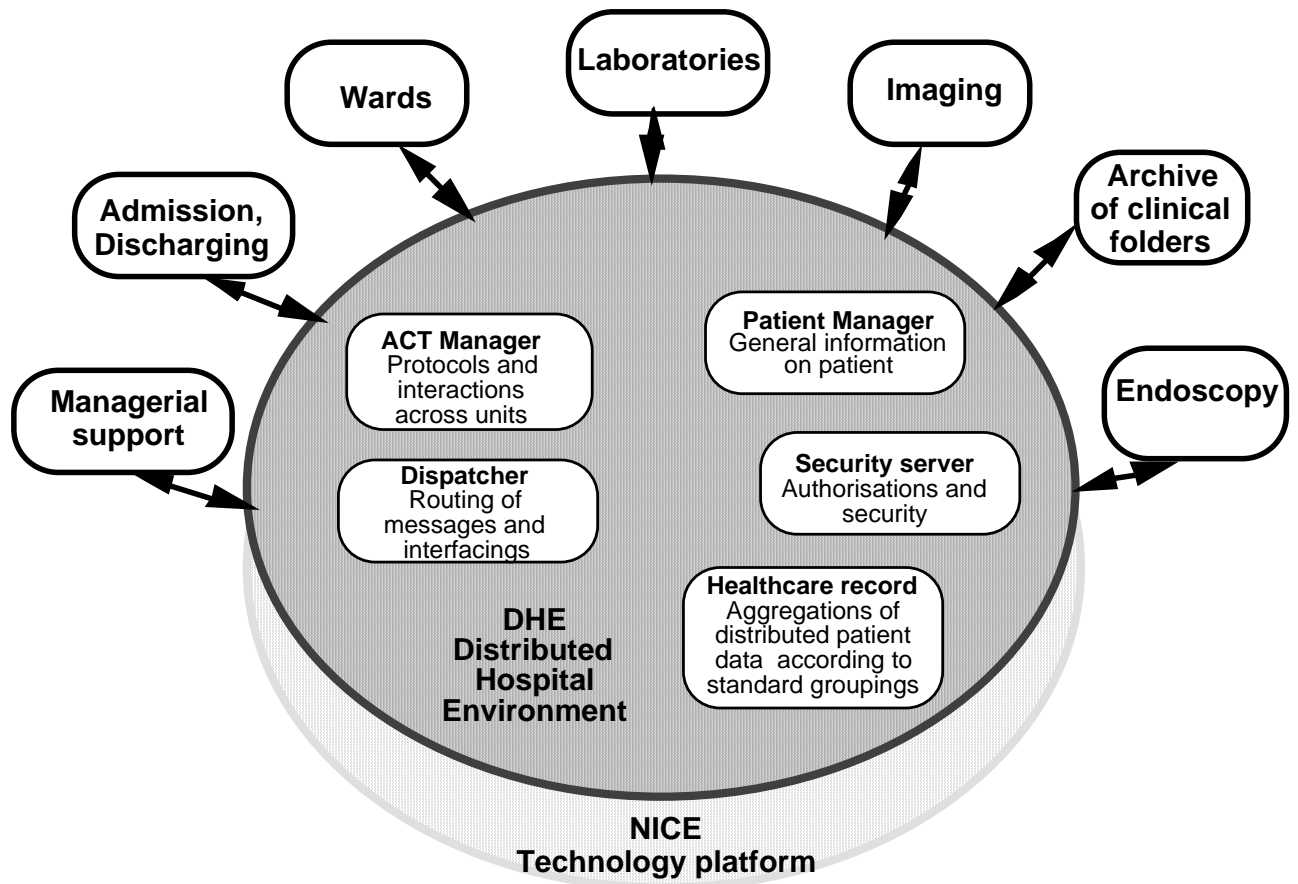
The EDITH environment is already capable of providing a complete and consistent support to the basic activities of any European hospital.

From the technological point of view, the EDITH Architecture in based on a distributed approach and on the utilisation of standard software products complying with the industrial and market standards must be utilised (such as: UNIX and MS-DOS operating systems, MS-Windows and OSF/Motif windowing environment, local area network based on Ethernet and TCP/IP protocols, relational database management systems based on SQL language, C programming language).

The "EDITH Compliant" components already available

Several components are already operational according to such architectural approach and are installed and used in the live environment of several hospitals. They represent the working nucleus for an advanced, open distributed information system, capable of supporting the fundamental needs of any generic hospital. All modules work in a distributed environment, based on local area networks, with UNIX servers connected to workstations consisting of MS-Windows PCs. Several types of network protocols are already supported and completely transparent to the applications.

Technological platform

NICE
Network Independent Communication Environment, a library providing a standard API allowing different modules to interwork according to a client-server approach, regardless of their mutual location over the network.

DHE Services

ACT MANAGER
provides a unified support for the definition of protocols and for the functional interworking of different units, in terms of request and delivery of services.

COMMUNICATION
provides a gateway for the interaction of the various components with external applications, through different types of protocols.

AUTHORISATIONS
provides a unified support to the definition authorisations and rights of the individual users, according to legal and organisational requirements.

PATIENT MANAGER
provides a unified repository for storing summary personal and epidemiological information on the patient.

Applications

WARD
Supporting the clinical and organisational activities of nurses and physicians in the wards, from the beds management, to the caring of patients, to the interaction with external units..

LABORATORIES
Support to the organisational and diagnostic activities of the laboratory, from the initial planning, to the control of the analysers up to the final reporting.

ADT
Supporting the patient identification, admission, discharging and transfer, up to the final production of statistic and administrative reports for external bodies.

MANAGERIAL
Supporting the managerial activities, at different levels of responsibility (ward, unit, hospital) by providing indicators and statistics on the quality and the costs of the services provided, grouped according to different, customisable criteria (e.g. DRG).

RADIOLOGY
Supporting the activities of the imaging department, in terms of booking and planning of activities for in- and out-patients, identification of the most suitable tests for the individual cases, reporting and (partial) management of images, to be transmitted back to the requesting ward