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## ICT Network assessment framework for Healthcare Service

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**ABSTRACT:** A prototype method to assist the evaluation process of an Information and Communication Technology (ICT) network system in health care service to improve QoS is presented. Integrating the planning process, Information Technology (IT) provision and simulation with network modeling, through Optimization Network Engineering Tool (OPNET) platform, data analyses techniques and interactive multi-criteria approaches permitted the design and development of a methodology to evaluate the QoS of ICT and communications resources. Through a case study for Chilean hospitals, the user interface perception and resources for ICT network support are investigated. New guidelines for identifying the high-priority issues of QoS management in a healthcare IT system are provided. The model will assist in obtaining client perception of QoS related to the communications system in a Health Care institution, identifying critical areas for QoS, providing a decision making tool as guidance for analyzing and evaluating a networked system for health related activities, compare different requirements and to enable tradeoffs in accordance with the institution's requirements.

**KEYWORDS:** ICT Healthcare, network, Multicriteria, QoS

### I. INTRODUCTION

There is growing scientific evidence that health-related activities stand to benefit enormously from the Internet and an increasing use of modern Information and Communication Technology (ICT) can report many advantages to improve the quality of a service. Although, it is complex to estimate quality in healthcare services since the agents (patient, clinical doctors, hospital staff, government, etc) involved should attend contradictory petitions: on one hand, to respond the increasing demand and, by another, to attend to budgetary restrictions. There are many factors involved such as humans, economic, communications technology, governmental and others. The only answer to this dilemma is to improve ICT QoS and the efficiency. Reorienting the Healthcare system towards the needs of the client, medicine based on the evidence, clinical management and the continuous improvement of the processes (QoS, Total quality, contemplating the human factor as the main assets of the business) are key elements in future.

Considering the strong relationship between quality and the resources provided, and that the primary goals in health care are to maximize patient welfare, to reduce undesired outcomes and to be consistent with the current state of knowledge, the QoS in healthcare is approached from three main perspectives; the technical aspects perspective, the user perception to test if the service meets their expectations and the organizational viewpoint.

The need for QoS stems from a design characteristic of networks whereby resources (e.g., especially backbone links) are generally shared among many users who are running applications simultaneously. Thus, even if the bandwidth of the system is measured in megabits or gigabits per second, any single user might gain access to only a small fraction of that bandwidth. How much bandwidth a single user obtains depends on the level of activity of the other users. When using the Internet, for example, a user often obtains high bandwidth and low latency over certain paths and at certain times of the day, but it is not currently possible to ensure that such conditions will be available on a given path at a given time. Quality of service requires mechanisms that enable applications with specific requirements to negotiate to receive appropriate

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treatment in the network. Those mechanisms must be able to deal with requests from huge numbers of applications running simultaneously. [1]

The communications network infrastructure, the devices attached to it, the communications links, and its performance are crucial for helping to deliver a service in a hospital. A number of potential health applications demand guarantees on the quality of service (QoS) they can get across the network and Internet. Several technical factors need to be considered in evaluating the performance. Alternatively, all the participants in the sector (patients, doctors, nurses, paramedics, health staff, managers and researchers) now have access to communications technology and information systems which offer an obvious potential to improve many of the activities related to the healthcare provided daily by these participants. The population already carries out diverse activities through the Internet (banking, tourism, e-commerce etc.) and begins to require basic information on its health, at a distance without the need of appearing, and with the sufficient security and quality of service. However, still some public health offices remain unconnected to the Internet and are therefore unable to accept electronic reports from testing laboratories or communicate health information over the Internet to neighbouring jurisdictions. The ICT QoS users perspective is one that expects fast, reliable and easy access to online resources, applications and Internet (databases, e-mails, voice, file transfer, browser, and so on.). Nowadays, Chile's Information Technology and Internet are incorporated to the clinical activity, the health professionals should increase their ability to make use of information management (search, access, filtered). The hospitals have been undoubtedly benefited by the automation of the routine.

The quality of service expectations will depend upon the type of use. Then the commitment is to improve quality from the perspective of the main participants. The main objective of the research is to outline a methodology that will contribute to the evaluation of QoS of the communications network services for Chile and National Health Service. This will include getting an appreciation about users (patient, medical paramedics, staff, etc.) perception regarding the communication network quality when facing healthcare requirement. This information we call quality of experience (QE). The main related activities they perform within the hospital are confronted with the ICT support required. Section II provides a Multicriteria decision model developed to determine the necessary attributes for the ICT system in unanimity their activities. Section III present the prototype procedure based on data collected from the main users of the health network system that will help to design a user profile.

Section IV provides some results from the pilot study handling data from three types of health institutions in Chile.

In section 5 the conclusions are provided.

## I. II. HEALTHCARE ICT NETWORK EVALUATION

The hospital management *challenge* is based on the achievement of the articulation and the convergence of values among the agents, the staff members and the patients; the Information Technology and Communications Systems needed are not just mere data agents, instead, they are of information, knowledge and intellectual capital.

The study refers to the development of a decision model related to the support of an ICT system in health activities and quality de service as a function of the discrepancy between consumer service expectations and their perceptions about the service actually provided by the system. The authors suggest that to reduce that difference depends on the efficient management provided by the network service. Considering that modern ICT can support the operations and quality of health service, the participants may wish to endow the system with different attributes. Furthermore, the ICT system of the health institution could count on attributes that not often match with user's requirements (quality level, performance, cost and others). At this point, interrogations arise. What attributes are the appropriate for each activity? Does ICT QoS have an effect on each activity? In what activity does the ICT support has more impact.

From the ICT QoS user perspective, they expect fast, reliable and easy access to online resources, applications and Internet (databases, e-mails, voice, file transfer, browser, etc.). The quality of service expectations will depend upon the type of use. The study involved 3 main phases. Starting by evaluating the ICT infrastructure support for Hospital followed by the identification of main Healthcare ICT system user, its applications and requirement attributes. QoS offered by a particular network could be established by technical parameters that could be measured objectively. However the user perception depends upon their needs, their right direct application and their expectations. It is a difficult task to find a set of universal

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parameters for every type of service since there are dissimilar parameters involved in the performance evaluation. Then, it is useful to analyze which of the parameters would be relevant when considering the user perception for a determined service. An initial model is developed involving user main applications and its attributes.

Some general questions to be answered are:

- What are user expectations about the ICT needs?
- What type of users can be distinguished?
- What are the main applications?
- Is the current ICT infrastructure appropriate?
- What are the main QoS parameters?
- How may ICT network for Healthcare service be able to be evaluated?
- What technical capabilities do health applications demand from Internet?

The main related activities they perform within the hospital are confronted with the ICT support required. The ICT system needs are recognized according to their activities. A multicriteria approach is utilized to develop a model through applying the analytic hierarchy process (AHP)[ 2].

What are in question are the *implied* needs from type of users, which must be worked out through user profiling and requirements analysis techniques. So far it has not been possible to do much work on defining appropriate techniques for characterizing health ICT users and their needs, but their importance has become increasingly obvious

This model based on data collected from the main users of the health network system will help to determine the necessary attributes for the ICT system in unanimity their activities. Regarding to the institution necessity enables to make tradeoffs. Figure 1 depicts a hierarchy model for attributes network assessment.[3].

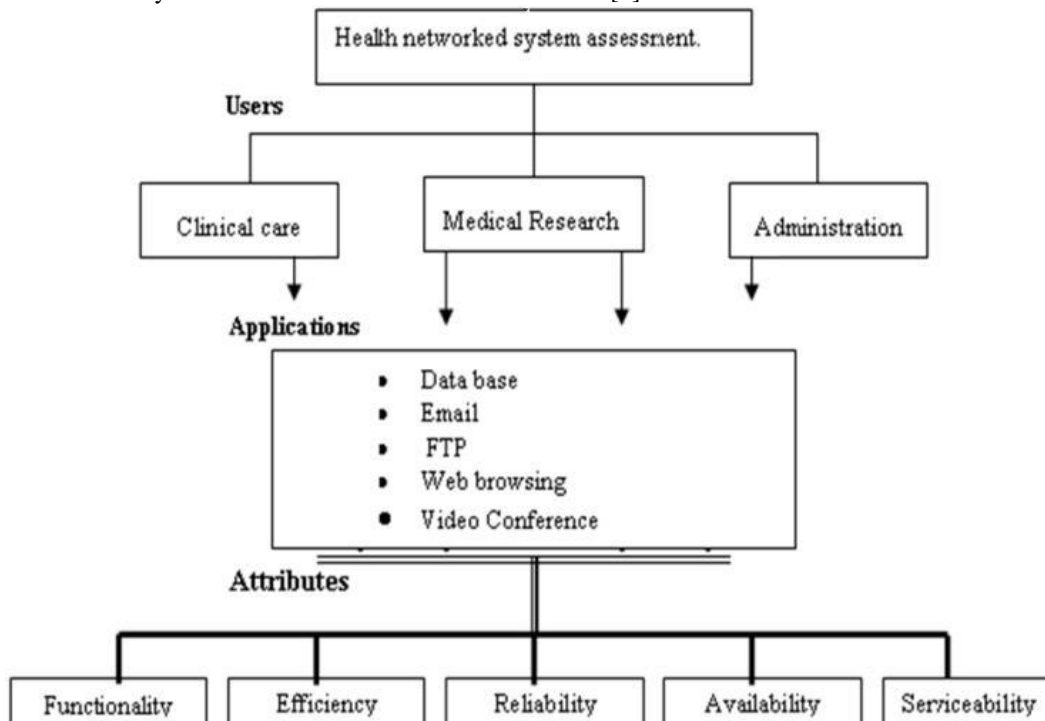


Fig 1. Hierarchy model for network assessment

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The organization must then define a service level agreement (SLA) for their main applications.

## II. PRO TO TYPE METHOD FOR HEALTH ICT NETWORK

The prototype method scheme as seen in fig.2 displays the stages involved in the evaluation of health ICT system regarding a particular service starting from the end user [4].

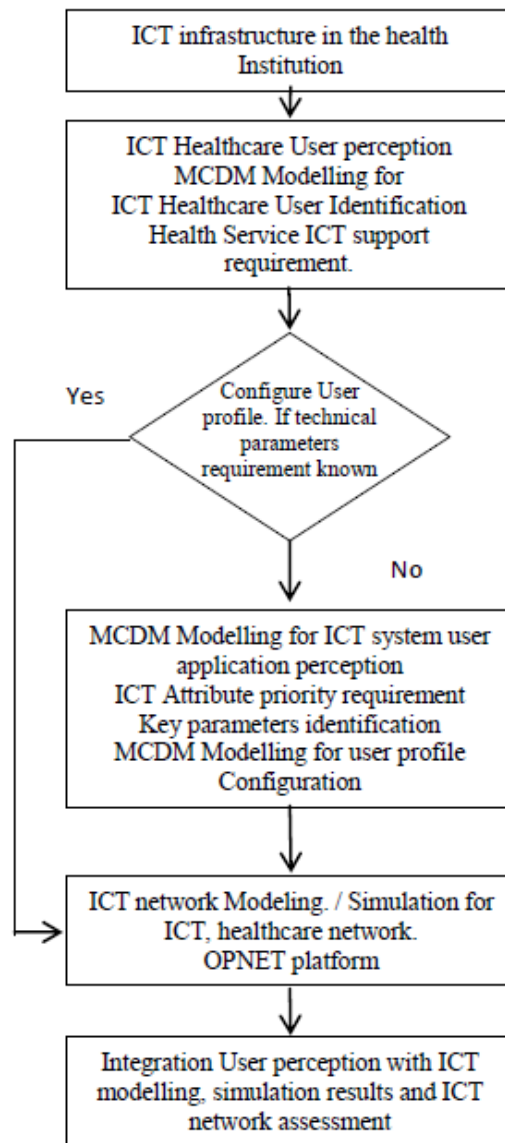


Fig. 2. Proposed new procedure scheme

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## III THE HEALTHCARE ICT SYSTEM CASE STUDY

The first phase of the study consists of identifying the critical end users' activities, main health related ICT applications and technical aspects within a health institution. As a result, a great number of factors come up. Based on AHP method, the next phase consists of constructing a hierarchy structure incorporating decisive categories at each level and their relationships. Once the basic structure is stated, the efforts are oriented to create a Team of Experts for all types of hospitals in consideration. Then, it follows a pair-wise comparison process, in such a way that all the elements at the same level are compared and weighed with each other. This procedure is repeated for all the elements of the whole structure, obtaining a ranking, reflecting the relative importance of the applications and attribute requirement. In addition, it is possible to detect inconsistencies when experts emitted judgments. Under such situations, it is necessary to review them until obtaining an acceptable index.

The case study considered data from three types of health institutions in Chile (private, public & other) to examine ICT infrastructure, ICT network provision, stakeholders' perception related to hospital ICT network system.

A preliminary questionnaire was designed and carried out with the purpose of collecting information from each group representatives about the main applications they perform during their contractual obligation. Many uncertainties about attaining desired attributes for the network were found. Are the required functions available? How efficient, reliable, serviceable and available is the network?

As seen in fig.1., for this study we considered a group conformed by the clinic care staff (Physician, nurses, paramedics, etc) who would make use of ICT to deliver a health care service, a group represented by those users who develop medical research, collecting disease statistic and/or investigate new drugs and new devices and a group integrated by users who perform the administrative activities, billing, products distribution, and inventory control or other connected.

Initial data was collected from 440 participants; following an expert team of 36 is grouped comprising representatives from each category from all of the three types of hospitals considered. The application of the AHP procedure bring about information with respect to user perception related to the most important attributes to develop the necessary applications related to the service they perform. The results shown in fig.3 indicated that ICT support has a greater impact on supplying clinical care service.

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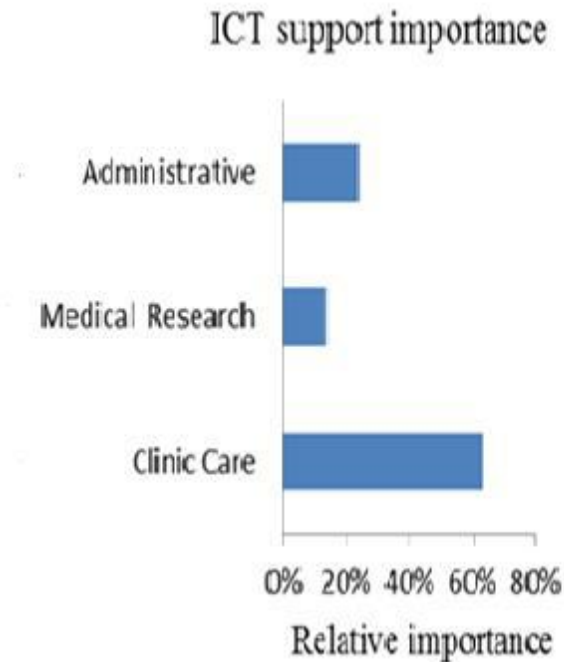


Fig.3.Relative ICT support importance for user type

Regarding the applications, Data base access was revealed to be the most important for the agents as seen in Table I. However, currently the application mostly used is Email by the hospitals..

TABLE I.

### HEALTHCARE RELATIVE PRIORITY FOR ICT APPLICATIONS

Application	Priority
Data base Access	51.1%
web browsing	16,5%,
FTP	15,0%
Email	14,5%
Video & voice	2,9%

Regarding the relative importance for each type of user group; researchers gave more importance to count on Web browsing, the administrative staff and clinic care group demanded the importance to have data base access. The results obtained through the multicriteria model lead to determine the properties or characteristics of the system This data will allow generating user profiles and applications profiles to support the design of models for appraising Health care network QoS.

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Even though all the ICT network attributes considered as shown in the model, fig 1, are important. Fig 4 depicts the overall result indicating that “availability” attribute is the most desired attribute with a 33 % of relative importance. Then, the “reliability” attribute with 22%. Next, the expert panel considered “efficiency” and “functionality” attributes to have a very similar degree of importance. This outcome reflects the relative level of importance the three groups estimate.

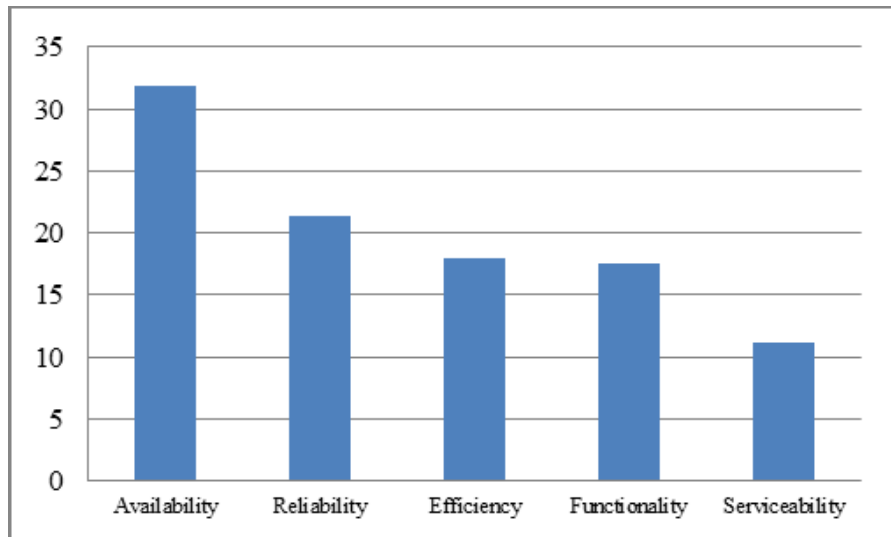


Fig.4. Relative importance for ICT network attributes

A profile based on the results obtained from each user group is designed for clinic care user as shown in table II.

TABLE II  
HEALTHCARE APPLICATIONS PROFILE FOR CLINIC CARE

Applications Profile	Start Time Offset (seconds)
Database Access(Heavy)	Uniform (5,10)
Web Browsing (Heavy)	Uniform (5,10)
Email (Light)	Uniform (5,10)
File Transfer (Light)	Uniform (5,10)
File Print (Light)	Uniform (5,10)
Executive Video	Exponential (600)

In a similar way, application is set for Secretary Administrative in Table III

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TABLE III  
HEALTHCARE APPLICATIONS PROFILE FOR ADMINISTRATIVE STAFF

Name	Start Time Offset (seconds)
Email (Heavy)	Uniform (5,10)
Database Access (Heavy)	Uniform (5,10)
File Transfer (Heavy)	Uniform (5,10)
Web Browsing (Light)	Uniform (5,10)
File Print (Light)	Uniform (5,10)

In a similar way, every application is set for all the groups considered  
A model is structured based on Optimization Network Engineering Tool (OPNET)[6],[7] methodology for a private hospital.to test network behavior and performance.

A partial network topology is represented as illustrated in Fig.5.

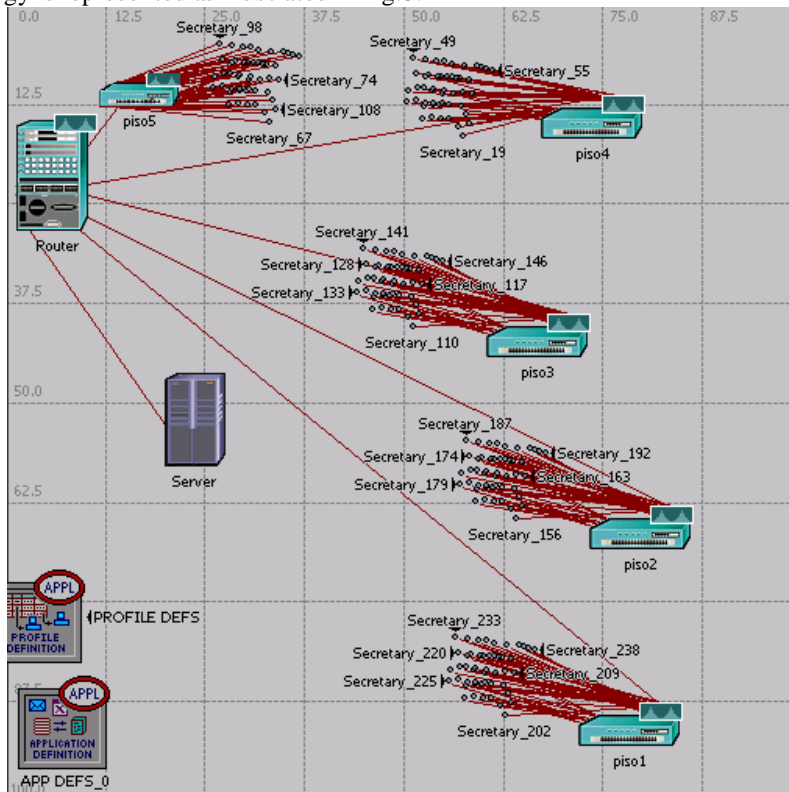


Fig.5. Partial network topology illustration for Hospital

Simulation runs were done for different number of users and also varying devices and links to test utilization percentage usage. The simulation results for this case showed a high throughput and low delay indicating that the infrastructure is



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already prepared to support new applications and traffic load increases. Even though, Users complain about network access and new applications.

## IV. CONCLUSIONS

Through the proposed methodology the main users are recognize. It was obtained an appreciation about stakeholder and users (patient, medical paramedics, staff, etc.) perception regarding the communication network quality when facing healthcare requirement. The multicriterio approach facilitated to elaborate a profile and characterization of the ICT support requirements according to a service requirement. OPNET simulation helped to analyze network performance, examining behavior for different traffic load and new applications and to predict planning for reacting to critical network issues using real-time network visualization and troubleshooting.

The results constitute an input for designing a new model and characterizing user profiles for simulating through the Optimization Network Engineering Tool (OPNET) simulation platform to examine the network behavior and performance.

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