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Decision Model for Assessing Healthcare ICT Support Implications: User Perception

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Abstract: This paper presents a multi-criteria decision model based upon user judgments to assist the evaluation process of an Information and Communication Technology (ICT) network system in health care to improve the quality of service (QoS). Measuring quality in health care services is not an easy task, as there are many competing goals involved, human, economic, communications technology, governmental and others. Integrating multiple criteria decision analysis (MCDA) methodology with modeling and simulation through Optimization Network Engineering Tool (OPNET) platform permit to characterize main ICT user and identify priority applications to examine network QoS requirements and implications. The proposed approach permitted to identify the main users, to elaborate a profile and characterization of the ICT support requirements according to their main daily task in answer to a service requirement. The results generate evidence related to the important factors effecting quality in hospital requirement as availability of services and the need for ubiquitous access to integrated information. The stakeholder interface perception and resources for ICT network support are investigated through a case study for Chilean hospitals.
Keywords: MCDA, Decision support, User perception, ICT Healthcare.

1 Introduction

Information and communications technology appears as an emerging concept in health care undertaking an important role for healthcare-related activities [3]. An information technology system provides stakeholders with several applications to support their duties in clinic care, medical research and administrative issues. These applications rely on the ICT network infrastructure and its performance. An ICT system should be a facilitator for health care users since they need to access all types of data existing on all types of systems. There is evidence [7], [9] that an ICT network system implementation generates an effect on the service and health care providers. In this sense it has become important to consider, [1], [2] evaluation mechanisms for ICT healthcare support and applications. The Health ICT design, implementation and its management has to consider risk for quality and efficiency on patient care and be in agreement with the type of user needs that could be attained through user profiling and requirements analysis.

The study is concerned with the development of an exploratory assessment model incorporating empirical data collected from the main users of the health network system.The model will be of assistance to find out user perception of quality of the service related to the communications system in a healthcare institution, to identify critical areas for QoS of each user type, to provide a decision making tool as a guidance to analyse and evaluate a networked system for health related activities, to compare the different requirements and to enable trade-offs in accordance to the institution necessity. With the purpose to recognize the properties of the system that could subsequently affect the degree of satisfaction with the ICT system in unanimity with user activities, a multi- criteria approach is utilised, modelling with AHP [13]. The obtained data allows generating user profiles and applications profiles to support the design of models for evaluating ICT healthcare network QoS through the Optimization Network Engineering Tool (OPNET) simulation platform to examine the network behaviour and performance.

Section 2 introduces the proposed evaluation approach. Section 3 gives notions of the applied AHP method. Following the case study description and its results is presented in section 4 providing information that is not currently available. In section 5, the conclusions are provided.

2 Healthcare ICT Network System Evaluation Approach

The evaluation approach considers integrating user perception modelling through AHP with network modelling and simulation to observe the network and examine performance. QoS offered by a particular network could be established by technical parameters that can be measured objectively. However, it is a difficult task to find a set of universal parameters for every type of service because there are many and dissimilar parameters involved in the performance evaluation. The QoS technical metrics related to each attribute has to be defined together with the applications profile. These profiles are influenced by healthcare user requests for developing a specific task. The user perception depends upon their needs, their precise applications and their expectations. Concerning stakeholder's perception, AHP modelling plays an important role generating network attributes of the system. It is of great utility to analyze which of the parameters would be relevant when considering the user perception for a determined service. The organization must then define a service level agreement (SLA) for their main applications. Once healthcare service application and user profiles are characterized it follows to model, design and simulate through Optimization Network Engineering Tool to examine the potential network performance.

This paper is focused on presenting the perception model related to the communications system and its results for recognizing priority health activities and distinguishing the critical IT network support resources that could lead to the improvement of the service. The results will reveal key QoS parameters that generate user and activities profiles to support the assessment of communications resources of Local Area Networks (LAN) in a hospital.

3 The Analytic Hierarchy Process Methodology

The AHP involves decision-makers (DM) in breaking down a decision into smaller parts, proceeding from the goal to criteria to sub-criteria down to the alternative courses of action. DMs then make pair-wise comparison judgements throughout the hierarchy to arrive at overall priorities for the alternatives [13]. This approach provides the structure and the mathematics to support decision-makers make rational decisions. The basic principles of AHP are: Hierarchy representation and decomposition, which is a representation of a complex problem in a multilevel structure whose first level is the goal followed successively by levels of factors, criteria, and sub criteria, and so on down to a bottom level of alternatives. Figure 1 shows an illustration of a

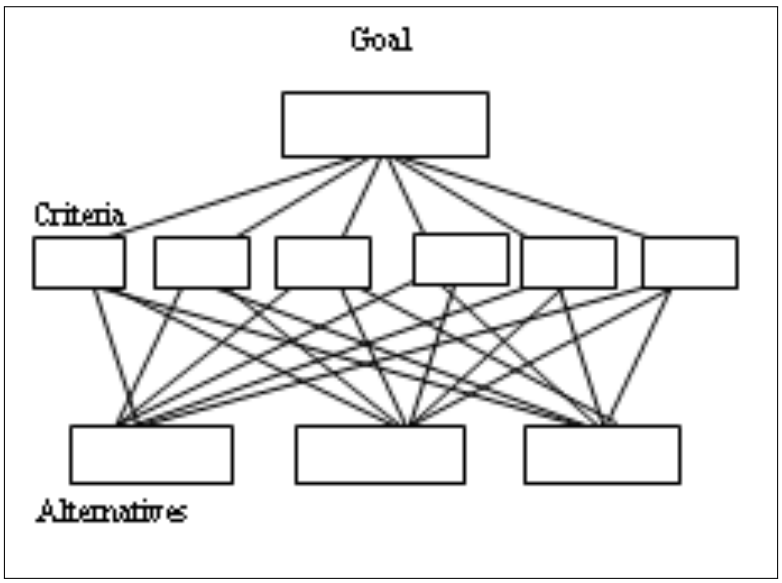

Figure 1: Generic Decomposition of a Problem into a Hierarchy

simple three level hierarchy. The object of a hierarchy is to assess the impact of the elements of a higher level on those of a lower level or alternatively the contribution of elements in the lower level to the importance or fulfillment of the elements in the level above. This type of assessment is usually made by paired comparisons responding to an appropriately posed question eliciting the judgement. The mathematical definition of a hierarchy is given in Saaty's Book [13].

Setting priorities in a hierarchy requires that we perform measurements throughout the structure. We must then synthesize these measurements to obtain priorities for the bottom level alternatives. The AHP is based on ranking activities in terms of relative ratio scales. In the paired comparison approach of the AHP, one estimates ratios by using a fundamental scale of absolute numbers in comparing two alternatives with respect to an attribute and one uses the smaller value as the unit for that attribute. To estimate the larger one as a multiple of that unit, assign to it an absolute number from a fundamental scale shown in table 1.

Table 1: Saaty's Fundamental Scale

Importance Intensity	**Definition**
1	Equal Importance
3	Moderate Importance
5	Strong Importance
7	Very strong or demonstrated Importance
9	Extreme importance
Reciprocals of above	If activity i has one of the above nonzero numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i

This process is done for every pair. Thus, instead of assigning two numbers w_i and w_j and forming the ratio w_i/w_j we assign a single number drawn from the fundamental $1-9$ scale to represent the ratio $(w_i/w_j) : 1$. The absolute number from the scale is an approximation to the ratio w_i/w_j. The derived scale tells us what the w_i and w_j are. Let W be a matrix (1)

whose row elements are ratios of the measurements *wi* of each of n items with respect to all others.

$$W = \begin{bmatrix} w_1/w_1 & \cdots & w_1/w_n \\ w_2/w_1 & \cdots & w_2/w_n \\ \vdots & \ddots & \vdots \\ w_n/w_1 & \cdots & w_n/w_n \end{bmatrix} \tag{1}$$

A number in the matrix is a dominance judgment. A judgment of 1.0 means that two activities contribute equally to the objective or goal, a judgment of 3.0 means that slightly favour one activity over another or three times as much (if you are dealing with measurable), a judgment of 5.0 means that judgement strongly favour one activity over another, a judgment of 7 means that activity is strongly favoured over another; its dominance is demonstrated in practice and 9.0 means that the evidence favouring one activity over another is of the highest possible order of affirmation. You should group your elements into homogeneous clusters so that it is not necessary to use a number larger than 9. In this way, we can interpret all ratios as absolute numbers or dominance units. The AHP provides guidelines for a test of consistency of judgments to ensure that elements are grouped logically and ranked consistently according to a logical criterion. In general, the ratio should be in the neighborhood of 0.10 [13]. Too great a departure from the perfectly consistent value indicates a need to improve the judgments or to restructure the hierarchy.

4 The Case Study and AHP application

The stakeholder interface perception and resources for ICT network support are investigated through a case study for Chilean hospitals. A pilot study has been carried out collecting data from health Institutions in Chile (private, public, regional) to examine ICT infrastructure, ICT network provision and stakeholders perception related to ICT network system. An AHP model is constructed to determine user perspective related to the ICT support importance in developing their work. For this study, we classified the main ICT network system users into three groups: those who develop activities in clinic care, who would make use of ICT to deliver a service (Physician, nurses, paramedics, etc.); the medical research group, who develop health research, collecting disease statistic and/or investigate new drugs and new devices and a third group integrated by users who perform administrative activities, billing, products distribution, and inventory control or other connected. For this study patients were not considered since from previous work, [10] ICT support showed to have a lower impact on patient [1]. Figure 2 show the AHP process results. ICT support reflects the greatest impact on supplying clinical care service.

The next step is concentrated in finding out the relevant ICT application for each type of healthcare users that would support to perform a better service. Initial data was collected from 480 participants; following an expert team of 36 is grouped comprising representatives from each category from all of the three types of hospitals considered. The ICT applications to be supported by a server are: Email, Web Browsing (Http 1.1), File transfer, Database Access, File Print, Video Conferencing, and Voice.

A new AHP model is developed and processed. The pairwise results from the three group representatives indicated the *relative importance* of ICT system application for performing their

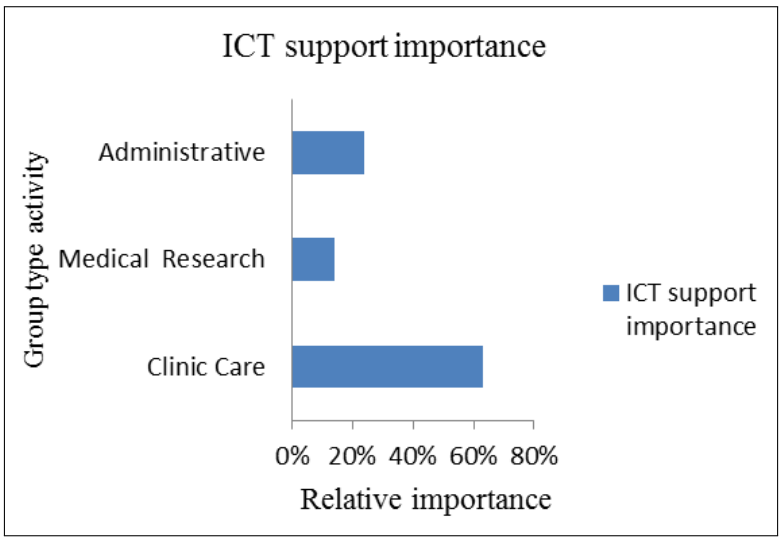

Figure 2: Relative ICT Support Importance for User Type Group

Table 2: Overall Relative Importance Priority for ICT Applications

Application	**Priority**
Data base access	51, 1
Web browsing	16, 5
FTP	2, 9
E mail	14, 5
Video and Voice	2, 9

activities as seen in table (2).

Though, when analysing separately, the clinical care group revealed a strong tendency, to rely on database applications to have access to patient records throughout email services. The research group indicated a strong interaction with Web Browsing application and data base application. This result would be in concordance to the nature of their work. While from administration group perspective, the preferences are for data base and file transfer protocol. The activities such as, delivering and obtaining test and exams results, within the institution implies interaction with database application. The applications relative importance according to ICT user group for each application is depicted in figure 3.

Regarding to current ICT applications usage in Healthcare Institutions there is a gap between current usages compared to what users declare important. From data collected and author's observations the application, e-mail, appears to be mostly employed and there is little usage of the others. Figure 4 shows the usage according to different health Institutions. In this sense there is work to be done, moreover, the results analysis suggests that health ICT network users expectations are that network will help to deliver a service with the required functionality on time and within the budget.

Consequently, a new AHP model is developed, to bring about information related to the most important network attributes to develop the applications. The essential QoS attributes to meet the ICT support requirement for each defined activity has to be established. It follows the

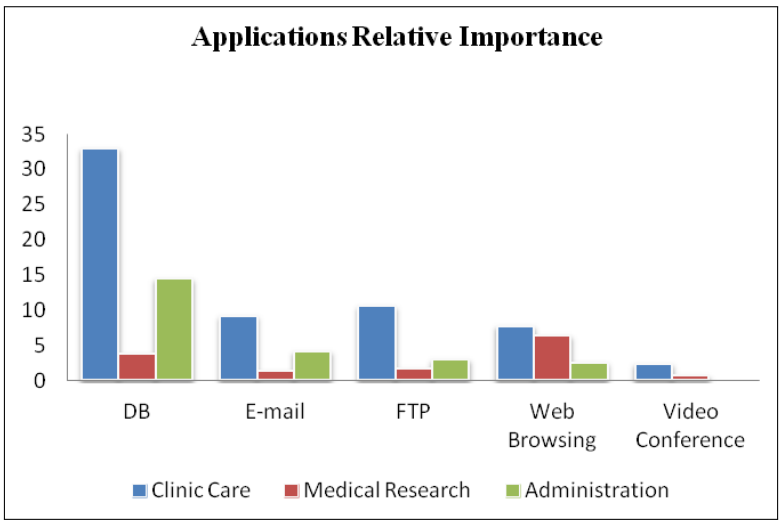

Figure 3: Relative ICT Support Importance for User Type Group

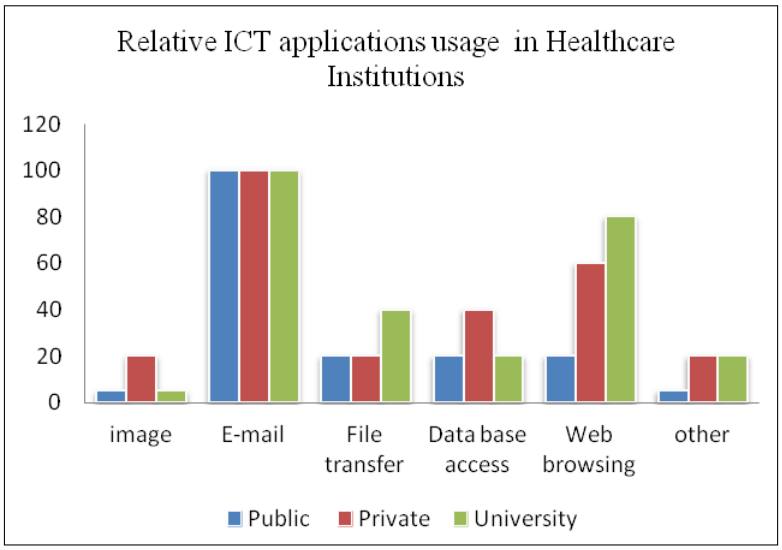

Figure 4: Applications Usage in Healthcare Institutions

process to determine the QoS attribute relative importance for applications according to user type expectation. This refers to the ICT support, user perceives about service satisfaction. For example: success in the connection, accessibility, velocity, etc. ICT system users expect that the network will help to deliver a service on time with the required functionality and within the budget.

Then the hierarchy structure should consider the attributes that would improve/ensure a better performance. The attributes considered are based on standard ISO [6] quality software model: Functionality, Efficiency, Reliability, Availability, and Serviceability. Even though, the five attributes are essential, it was possible to detect some differences in relation to the type of user. The two overall most important QoS attributes concomitant to the ICT applications in performing their health related activities system are *availability* and *reliability*. The attribute *availability* is most important for the group who develop task in Clinic care. In effect, clinic care professionals require having information on their patients including those elaborated by others, as, complementary tests results, at the moment and at the place of attendance. *Availability* of

ICT support is critical, when dealing with an emergency situation. Figure 5 shows the overall relative importance for attributes that the panel of experts indicated.

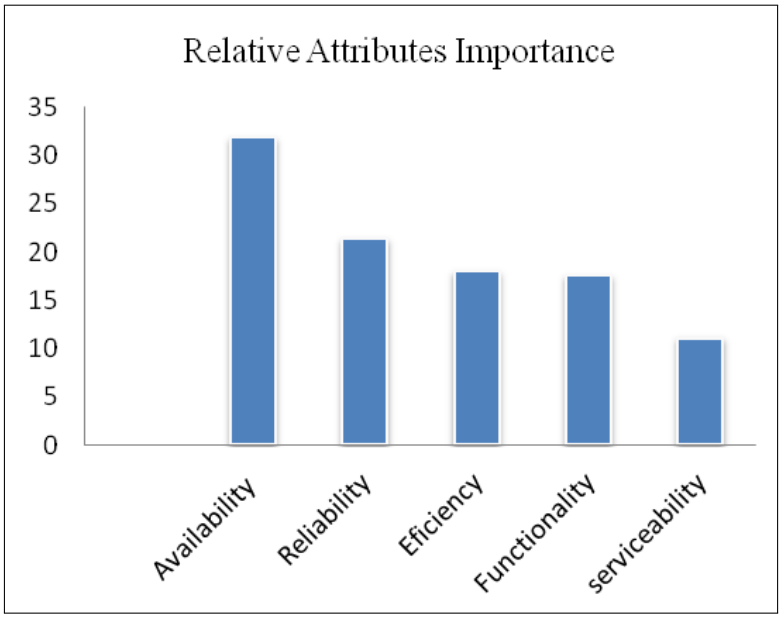

Figure 5: User relative importance for attributes

Through the AHP it was possible to identify applications priority and to characterize main ICT system users. The relative importance of ICT network support for each activity to deliver a better service is obtained. At this point, the QoS technical metrics that would guarantee a service related to each attribute are defined together with the applications profile. Technical requirement demanded for the different activities the group perform is shown in figure 6.

This information and data obtained by author's research and extensive collaboration with the IT network and management teams from a range of hospitals which differ in size and category as public, university, private is used for configuring profiles which will be the input for modelling and simulation to examine ICT network technical aspects and behaviour through OPNET methodology [11].
Then the next step is to set up profile applications according to each user type which is based on the AHP results obtained. According to OPNET methodology, initially a topology has to be selected from a hospital zone as a first approach to analyze technology infrastructure and network performance. Continuing with traffic configuration where every workstation will have a profile application consistent with the users' main role. Once applications and profiles are defined, then different scenarios are characterized for each study case to visualize how sensible network performance is, related to changes. Then, simulations are ran increasing the number of ICT network user, formulating scenarios, varying the number of users and/or varying the links (Ethernet connections) between workstations and switches, to obtain the point to point throughput in bits/secs. and utilization (link usage %). The Utilization percentage of link usage is expressed as:

$$\frac{Point - to - point.Throughput(bits/sec) * 100}{Ethernetconnection(Mbps)} \tag{2}$$

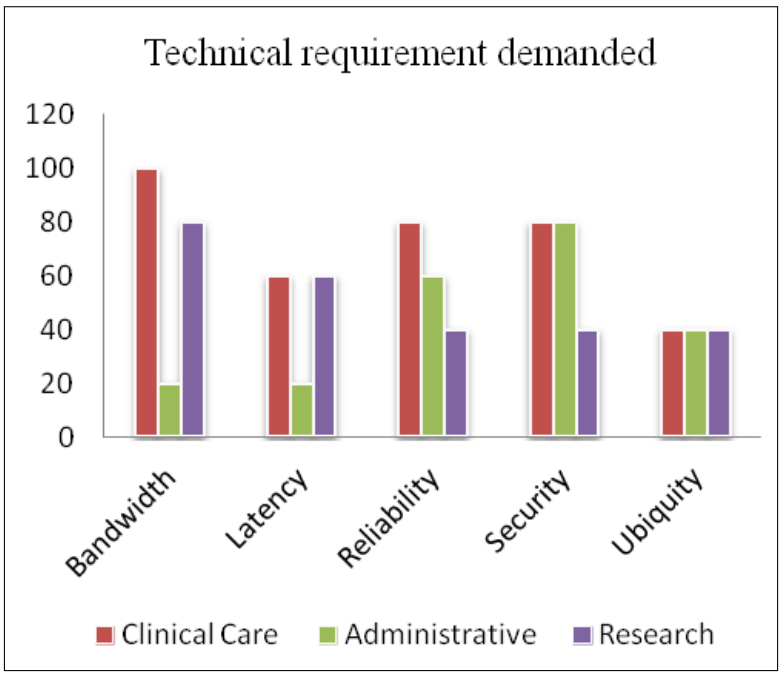

Figure 6: User Relative Technical Requirement Demanded

5 Conclusions

The existing competing objectives for improving quality of service in Health Institution increase complexity when analysing ICT support. The utilisation of a scientific multicriterial decision method AHP was beneficial for identifying high-priority requirements of an ICT system in health related activities.

The attribute for measuring quality in Clinic healthcare system, availability and the need for ubiquitous access to integrated information are considered most important. The combination of fixed and wireless network support can facilitate to obtain the timely information needed. This issue is critical in healthcare institution operation mainly for the clinic care group and work has to be done in this sense.

The MCDA approach allowed elaborating a profile and characterization of the ICT support requirements in healthcare service. The use of AHP modelling and empirical evaluation permits to capture human perspective. This allowed designing profiles characterization that would help to configure network traffic and different scenarios for simulating and evaluating network behaviour.

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