İSTANBUL TECHNICAL UNIVERSITY ★ INSTITUTE OF SCIENCE AND TECHNOLOGY

WEB–BASED GROUP DECISION SUPPORT SYSTEMS IN DEFENCE TECHNOLOGIES

M.Sc. Thesis by
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PREFACE

Organizations that are dealing with defence systems have engaged in various business processes (e.g., engineering, research, research and development) are working together by sharing information and making decisions. Technological advances and the myriad of development tools available today are still beset with issues of incompatible machines, platforms and operating system, on top of costly proprietary systems.

A Web-based Decision Support System (DSS) is a built with Web technologies so that the DSS users access it with Web browsers via an Internet connection [9, 52]. Web-based DSS applications developed by companies may be deployed on corporate intranets to support internal business processes or they can be integrated into public corporate Web sites to support their decision making process [52]. Web-based GDSS products provide a more generic approach to solving more complex problems that are less structured. Web – based group support systems provide defence system organizations to engage in their businesses more effectively and efficiently. Therefore, Web GDSS supports these organizations if they have to make decision on any subject matter.

I am pleased to acknowledge the substantial contributions of those who assisted me in completing this thesis. My heartfelt thanks go to the members of my thesis committee, Dr. Cengiz Güngör, Dr. Yusuf İlker Topçu, and Dr. Ahmet Beşkese for their valuable comments and suggestions throughout the writing process of this thesis. I am particularly indebted to my supervisor Dr. Cengiz Güngör for having been a kind advisor, a colleague and a friend. I would like to thank him for his substantial advice, gentle redirections, precious criticisms as well as constant encouragements. I would like to appreciate Dr. Gülcan Erçetin who helped me to conceptualize the theoretical framework and guided me throughout the research process of the thesis with her invaluable comments and suggestions. I would also like to appreciate Dr. Gülcan Erçetin, Dr. Ayşe Gürel, Işıl Erduyan who provided me with students to pilot the instruments. I would like to express my sincere gratitude to my friend Hüseyin Şimşek, Robin Laçinoğlu, Servan Güney, Volkan Bal who helped me to design the software program named as İTÜ-Web GDSS. I am also indebted to my friends and colleagues Nazik Dinçtopal, Nurçin Eğercioğlu for collaborating in data collection and preparing the computer laboratories for the study, Şebnem Yalçın for proof reading of my thesis. They have always welcomed me whenever I needed assistance.Moreover, many thanks to the 2005/2006 freshman, sophomore, senior students at the Department of Foreign Language Education in Boğaziçi University for their willingness to participate in the study. I further extend my gratitude to my family Mert Gösterişli, Yasemin Gösterişli, Gülsen Soylu, who provided me with constant support and patience througout the writing process of the study.

I dedicated this thesis to my mother and my father.

May 2006 Yavuz GÖSTERİŞLİ

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A	**:**	Pair-wise Comparison Matrix
$\mathbf{a_{ij}}$	:	Relative importance of element i over element j
$\mathbf{a_{ik}}$	:	Relative importance of element i over element k
$\mathbf{a_{jk}}$	:	Relative importance of element j over element k
$\mathbf{w_i}$	**:**	Weight of element i
$\mathbf{w_j}$	**:**	Weight of element j
n	**:**	Number of elements
$\boldsymbol{\lambda_{max}}$	**:**	Maximum eigenvalue
w	**:**	Relative importance vector
$\mathbf{A_w}$	**:**	w vector of the relative importance of A matrix
C. I.	**:**	Consistency Index
C. R.	**:**	Consistency Ratio
R. I.	**:**	Random Index

SAVUNMA TEKNOLOJİLERİNDE WEB TABANLI GRUP KARAR DESTEK SİSTEMLERİ

ÖZET

Bu çalışmada, İTÜ – Web GDSS adı altında bir Web tabanlı karar destek sisteminin yapısı ve tasarım detayları anlatılmıştır ve bir karar destek sistemi oluştururken karşılaşılan zorluklardan bahsedilmektedir. İTÜ - Web GDSS çok ölçütlü karar verme metotlarından biri olan Analitik Hiyerarşi Süreci modelini kullanmaktadır. İTÜ – Web GDSS Web tabanlı bir grup karar destek sistemidir. Bu sistem, kullanıcılara bir hedef doğrultusunda kendi kararlarını almalarına yardımcı olmaktadır. İTÜ – Web GDSS, grup kararını da desteklemekte olup kullanıcılara kendi kararlarının yanı sıra grup kararlarını gözlemleyebilmelerini sağlamaktadır. İTÜ – Web GDSS bir yazılım aracıdır ve AHS modelini karar alma sürecinde kullanmaktadır. AHS yöntemi kullanılarak bir problem modellenir, alternatifler göreceli önemlerine göre değerlendirilir, bilgi organize edilir ve değerlendirme hükümleri yapılır. İTÜ – Web GDSS Web de kullanılabilir olup küresel olarak erişime açıktır. Web teknolojilerinin avantajlarını kullanmaktadır. Web kaynaklarına bağlantı kurmak ve çeşitli platform özellikleri sisteme önemli özelliklerinden bazılarıdır.

Karar destek sistemlerini kullanan grupların performansları son 20 yıldır çokça tartışılan bir konudur. Bu yüzden, grup karar destek sistemi kullanan takım üyelerinin tatmini gibi öznel değişkenlere biraz daha odaklanmaya ihtiyaç duyulmaktadır. Deneysel bir çalışma yapılarak İTÜ – Web GDSS'in kullanıcı tatmini rapor halinde hazırlanmıştır. Bu çalışmada, grup kararı alırken çeşitli kullanıcı tatmin öğelerine odaklanılmıştır: sistemden tatmin, süreçten tatmin, karardan tatmin, karar destek sisteminden tatmin.

WEB–BASED GROUP DECISION SUPPORT SYSTEMS IN DEFENCE TECHNOLOGIES

SUMMARY

In this research, the architecture and detailed design of a Web-based GDSS, called İTÜ – Web GDSS are discussed to address the challenges of building a Web-based GDSS. İTÜ - Web GDSS, which uses Analytical Hierarchy Process model in decision process that is for multi-attribute decision making, is a Web-based Group Decision Support System. İTÜ - Web GDSS supports users to decide on their own specified goal. It also provides users to observe their own decision and group decision. İTÜ – Web GDSS is a software tool, which implements the AHP. It uses the AHP methodology to model any problem, evaluate relative desirability of alternatives, and organize information and judgments used in decision making. İTÜ – Web GDSS is deployed on the World Wide Web (WWW) and can be accessed globally. It takes advantages of WWW with wide ability, Web resource integration and cross-platform capabilities.

Performance of groups using group decision support systems has been an issue debated over the last two decade. Yet, there is a need for more focused subjective variables such as the satisfaction of team members with the experience of using a GDSS. An empirical study is reported to assess the user satisfaction of İTÜ – Web GDSS in supporting distributed group. This research focuses on different types of user satisfaction in GDSS based group decision making: system satisfaction, process satisfaction, outcome, and GDSS satisfaction.

1. Introduction

Companies are going global and this is especially important for companies participating in the global supply chain. To become smart enterprises, these companies are deploying virtual teams to carry out short- and long-term projects [45, 46]. Virtual teams are geographically dispersed groups of people sharing common goal to carry out interdependent tasks while working at different locations. They employ computer and communication technologies to communicate ideas and information, coordinate activities, as well as make decisions [13, 42]. For virtual teams to work effectively, it is critical they use collaboration technologies to overcome the barriers of time and space [23, 42].

Group Decision Support Systems (GDSS) and Group Support Systems (GSS) combine communication, computer, and decision support technologies to facilitate the formulation and solution of unstructured problems by a group of people.

In this research, the architecture and detailed design of a Web-based GDSS, called İTÜ – Web GDSS are discussed to address the challenges of building a Web-based GDSS. İTÜ - Web GDSS, which uses Analytical Hierarchy Process model in decision process that is for multi-attribute decision making, is a Web-based Group Decision Support System. İTÜ - Web GDSS supports users to decide on their own specified goal. It also provides users to observe their own decision and group decision. İTÜ – Web GDSS is a software tool, which implements the AHP. It uses the AHP methodology to model any problem, evaluate relative desirability of alternatives, and organize information and judgments used in decision making. İTÜ – Web GDSS is deployed on the World Wide Web (WWW) and can be accessed globally. It takes advantages of WWW with wide ability, Web resource integration and cross-platform capabilities.

Performance of groups using group decision support systems has been an issue debated over the last two decade. Yet, there is need for more focused on subjective variables such as the satisfaction of team members with the experience of using a GDSS. An empirical study is reported to assess the user satisfaction of İTÜ – Web

GDSS in supporting distributed group. This research focuses on different types of user satisfaction in GDSS based group decision making: system satisfaction, process satisfaction, outcome, and GDSS satisfaction.

The remainder of the research report is organized as follows: the next section explains decision making; multi criteria decision analysis and the basic principles of AHP are described in the Sections 3 and 4. Section 5, description of the Decision Support Systems and different types of DSS are explained. Group decision making and different types of GDSS are explained in Section 6. Review of Web-based Decision Support System (Web DSS) and Web-based Group Decision Support System (Web GDSS) are in Section 7.

The Architecture and Design of İTÜ – Web based Group Decision Support System are explained in the Section 8. As research theory development and hypotheses are explained in the Section 9, research method is described in the Section 10. Section 11 provides results and discussion of the research. Conclusion and further research suggestions explained in the final section.

2. Decision Making

Decision making is the cognitive process of selecting from multiple alternatives. Every decision-making process has a final choice. Decision-making is a reasoning process which can be rational or irrational, and can be based on explicit assumptions or tacit assumptions. Decision making is an activity that lies at the heart of management. The assumption of a management role places an individual in the mainstream of an organization's decision-making activity with authority to make decisions and to organize and develop the organization's decision making capability. All the explicit or implicit actions of an organization are the result of management decision making. Decision making is a vital organizational activity.

Decision making is said to be a psychological construct. This means that although we can never "see" a decision, we can infer from observable behavior that a decision has been made. Therefore we conclude that a psychological event that we call "decision making" has occurred. It is a construction that imputes commitment to action. That is, based on observable actions, we assume that people have made a commitment to effect the action.

3. Multiple Criteria Decision Analysis (MCDA)

Managers are faced with problems in projects that are complex in their decision environments. The elements of the problems are numerous, and the interrelationships among the elements are extremely complicated. Relationships between elements of a problem may be highly nonlinear; changes in the elements may not be related by simple proportionality. Furthermore, human value and judgment systems are integral elements of project problems [40]. Therefore, the ability to make sound decisions is very important to the success of a project. In fact, Schuyler [66] makes it a skill that is certainly near the top of the list of project management skills, and notices that few of us have had formal training in decision making.

Multiple criteria decision-making (MCDM) approaches are major parts of decision theory and analysis. They seek to take explicit account of more than one criterion in supporting the decision process [6]. The aim of MCDM methods is to help decision-makers learn about the problems they face, learn about their own and other parties' personal value systems, learn about organizational values and objectives, and through exploring these in the context of the problem, to guide them in identifying a preferred course of action [6, 22, 53, 72, 73 and 76]. In other words, MCDA is useful in circumstances which necessitate the consideration of different courses of action, which can not be evaluated by the measurement of a simple, single dimension [6].

Hwang and Yoon [31] published a comprehensive survey of multiple attribute decision making methods and applications. Two types of the problems that are common in the *project management* that best fit MCDA models are evaluation problems and design problems. The *evaluation problem* is concerned with the evaluation of, and possible choice between, discretely defined alternatives. The *design problem* is concerned with the identification of a preferred alternative from a potentially infinite set of alternatives implicitly defined by a set of constraints [5].

4. The Analytic Hierarchy Process (AHP)

It is believed that life is so complicated that to make decisions people need to think in a complex way. Complex problems usually have many related factors. Simple thinking leads to combinations of collections of ideas which give rise to a structure whose components are strands that are separate, but tangled. When people make their decisions on having an additional child, they would not probably list all the variables that are essential to this decision. In addition to this, people would not probably explicitly compare the significance of each variable. However, it can not be denied that some people are comparing and implicitly indicating preferences among different choices.

The Analytical Hierarchy Process (AHP) is a decision-aiding method developed by Saaty [55, 56, 58 and 62]. It aims at quantifying relative priorities for a given set of alternatives on a ratio scale, based on the judgment of the decision-maker, and stresses the importance of the intuitive judgments of a decision-maker as well as the consistency of the comparison of alternatives in the decision-making process [55]. Since a decision-maker bases judgments on knowledge and experience, then makes decisions accordingly, the AHP approach agrees well with the behavior of a decision-maker. The strength of this approach is that it organizes tangible and intangible factors in a systematic way, and provides a structured yet relatively simple solution to the decision-making problems [67]. In addition, by breaking a problem down in a logical fashion from the large, descending in gradual steps, to the smaller and smaller, one is able to connect, through simple paired comparison judgments, the small to the large.

The Analytic Hierarchy Process (AHP) is a multiple criteria decision-making tool that has been used in almost all the applications related with the decision-making. The Analytic Hierarchy process (AHP), which was developed by Thomas Saaty (1980), is a basic approach to decision making. The strength of the AHP method lies in its ability to structure a complex, multi-attribute, and multi-period problem hierarchically. The Analytic Hierarchy Process (AHP) [54, 56, 57, 61, 63, 64, and

75] is a theory for dealing with complex technological, economic, and socio-political problems. Its mathematical foundations are simple. Its purpose is to make a contribution towards unity in modeling real-world problems, away from the existing fragmentation where each problem tends to have specialized model and terminology. Its major assumptions are that the methods people use to pursue knowledge, to predict, and to control their world are relative, and that the goal that people seek, i.e., knowledge, is itself relative.

The Analytic Hierarchy Process (AHP) is designed to cope with both rational and intuitive judgments to select the best from a number of alternatives evaluated with respect to several criteria. In this process, the decision maker carries out simple pair-wise comparison judgments that are used then used to develop overall priorities for ranking the alternatives. Pair-wise comparisons of the elements, which are usually alternatives and attributes, can be established using a scale indicating the strength with which one element dominates another with respect to higher-level element. This scaling process can be translated into priority weights for comparison of elements. The AHP not only allows for inconsistency in the judgment but also provides a means to improve consistency.

In making decisions, people provide subjective judgments based on feelings and intuition rather than on well work-out logical reasoning. The AHP has been demonstrated to explicate the underlying mental process by which overall judgments are arrived at in situations where in a complexity of goals and criteria are involved. Basically, the AHP is a multi-objective multi-criteria decision-making approach which employs a pair-wise comparison procedure to arrive at a scale of preferences among sets of alternatives. To apply this approach, it is necessary to break down a complex unstructured problem into its component parts; arrange these parts, or variables, into a hierarchic order; assign numerical values to subjective judgments to determine which variables have the highest priority and should be acted upon to influence the outcome.

The breakdown involves structuring the problem as a hierarchy; this describes the ability to understand each part within its appropriate context. Without the hierarchy, each component could be well considered, but consideration would be sterile. Therefore, it can be said that incorporating the findings back into the framework from which they are drawn would not be done. In the Figure 4.1, the simplest form used to structure a decision problem is a hierarchy consisting of three levels:

- The goal of the decision
- The criteria
- The alternatives.

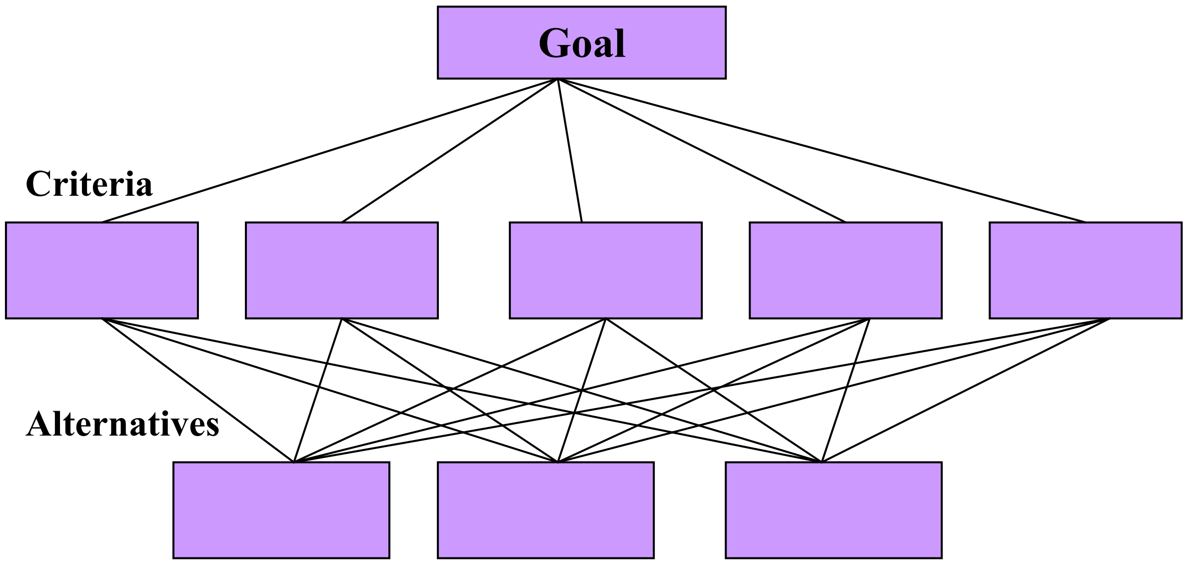


Figure 4.1 : A Three Level Hierarchy

Hierarchical decomposition of complex systems appears to be a basic device used by human mind to cope with diversity. One organizes the factors affecting the decision in gradual steps from the general, in the upper levels of the hierarchy, to particular, in the lower levels. The purpose of the structure is to make it possible to judge the importance of the elements in a given level with respect to some or all of the elements in the adjacent level above. Once the structuring is completed, the AHP is surprisingly simple to apply.

In the application of AHP, it has three fundamental processes:

1. Structuring a hierarchy,
2. Setting the priorities of active factors,
3. Calculating the results.

As it is mentioned before, the Analytic Hierarchy Process is a multiple criteria decision-making tool. This is an Eigen value approach to the pair-wise comparisons. It also provides a methodology to calibrate the numeric scale for the measurement of quantitative as well as qualitative performances. The scales from 1/9 for ‘least valued than’, to 1 for ‘equal’, and to 9 for ‘absolutely more important than’ covering the entire spectrum of the comparison.

Some key and basic steps in this methodology are:

1. State the problem.
2. Broaden the objectives of the problem or consider all actors, objectives and its outcome.
3. Identify the criteria that influence the behavior.
4. Structure the problem in a hierarchy of different levels constituting goal, criteria, sub criteria and alternatives.
5. Compare each element in the corresponding level and calibrate them on the numerical scale. This requires n (n-1)/2 comparisons, where n is the number of elements with the considerations that diagonal elements are equal or ‘1’ and the other elements will simply be the reciprocals of the earlier comparisons.
6. Perform calculations to find the maximum Eigen value, consistency index CI, consistency ratio, and normalized values for each criteria/alternative.
7. If the maximum Eigen value, CI, and CR are satisfactory then decision is based on the normalized values; else the procedure is repeated till these values lie in a desired range.

AHP helps to incorporate a group consensus. Generally this consists of questionnaire for comparisons of each element and geometric mean to arrive at a final solution. The hierarchy method used in AHP has various advantages [55].

Common benefits of the AHP are that:

1. It is simple to use and understand.
2. It necessitates the construction of a hierarchy of attributes, sub attributes, alternatives, and so on, which facilitates communication of the problem and recommend solution.
3. It provides a unique means of quantifying judgmental consistency.

4.1. Construction of Hierarchy

It is believed that the most creative task in making a decision is deciding what factors to include in the hierarchic structure. When constructing hierarchies one must include enough relevant detail to represent the problem as thoroughly as possible, but not so thoroughly as to lose sensitivity to change in the elements. There are important issues while considering a hierarchy:

- considering the environment surrounding the problem,
- identifying the issues or attributes that one feels should contribute to the solution,
- who are the participants associated the problem.

Arranging the goals, attributes, issues, and stakeholders in a hierarchy serves two purposes:

1. it provides an overall view of the complex relationships inherent in the situation and in the judgment process,
2. it also allows the decision maker to assess whether he or she is comparing issues of the same order of magnitude.

The elements being compared should be homogeneous. The hierarchy does not need to be complete; that is, an element in a given level does not have to function as a criterion for all the elements in the level below. Thus a hierarchy can be divided into sub hierarchies sharing only a common topmost element. Further, a decision maker can insert or eliminate levels and elements as necessary to clarify the task of setting priorities or to sharpen the focus on one or more parts of the system. Elements that are of less immediate interest can be represented in general terms at the higher level of the hierarchy and elements of critical importance to the problem at hand can be developed in greater depth and specifity. The task of setting priorities requires that the criteria, the sub criteria, the properties or features of the alternatives be compared among themselves in relation to the elements of the next higher level.

It can not be denied that the basic principle to follow in creating the hierarchy structure is always to see if one can answer the following question: "Can we compare the elements on a lower level in terms of some or all the elements on the next higher level?"

A useful way to proceed is to work down from the goal as far as one can and then work up from the alternatives until the levels of the two processes are linked in such a way as to make comparison possible. Here are some suggestions for an elaborate design.

1. Identify an overall goal. What are you trying to accomplish? What is the main question?
2. Identify sub goals of the overall goal. If relevant, identify time horizons that affect the decision.
3. Identify criteria that must be satisfied in order to fulfill the sub goals of the overall goal.
4. Identify sub criteria under each criterion. Note that criteria or sub criteria may be specified in terms of ranges of values of parameters or in terms of verbal intensities such as high, medium, low.
5. Identify actors involved.
6. Identify actor goals.
7. Identify actor policies.
8. Identify options or outcomes.
9. Take the most preferred outcome and compare the ratio of benefits to costs of making the decision with those of not making it. Do the same when there are several alternatives from which to choose.
10. Do benefit/cost analysis using marginal values. Because people who deal with dominance hierarchies, ask which alternative yields the greatest benefit; for costs, which alternative costs the most.

4.2. Philosophy, Procedure and Application of the AHP

The Analytic Hierarchy Process is a general theory of measurement. It is used to derive ratio scales from both discrete and continuous paired comparisons in multilevel hierarchic structures. These comparisons may be taken from actual measurements or from a fundamental scale that reflects the relative strength of preferences and feelings. The AHP has a special concern with departure from consistency and measurement of this departure, and with dependence within and between groups of elements of its structure. In its general form, the AHP is a nonlinear framework for carrying out both deductive and inductive thinking. This is made possible by taking several factors into consideration simultaneously, allowing for dependence and for feedback, and making numerical tradeoffs to arrive at a synthesis or conclusion.

Hierarchy, essentially, is a special system type; it depends on the assumption that the units, which became into light, may be grouped in different series, and elements in one group affect the factors in the other group. The elements in a group are assumed to be independent of each other. The structure of the hierarchies is linear levels that are differentiated from main goal to alternatives. In the Figure 4.2, a linear hierarchy structure is expressed [60].

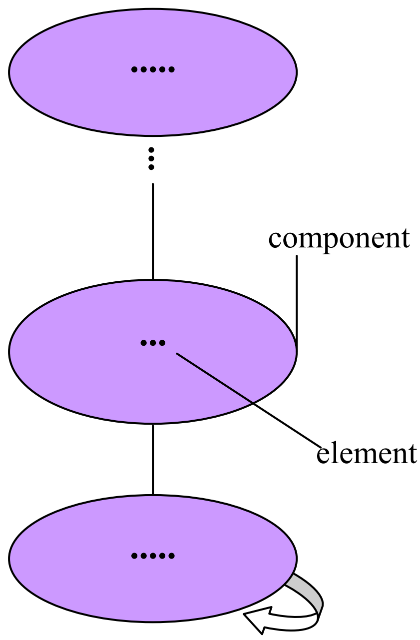


Figure 4.2 : A Linear Hierarchy Structure

As it is figured out above, the hierarchy is a simple structure that is confronted in daily life. Hierarchy is a structure stone for the model of the problems. In the process of constituting the hierarchy structure, decision maker must prepare the model with respect to this basic structure. The hierarchy structure is, therefore, detailed and differentiated according to the goal of problem. In the Figure 4.3 and Figure 4.4, detailed hierarchy structure examples can be seen [50].

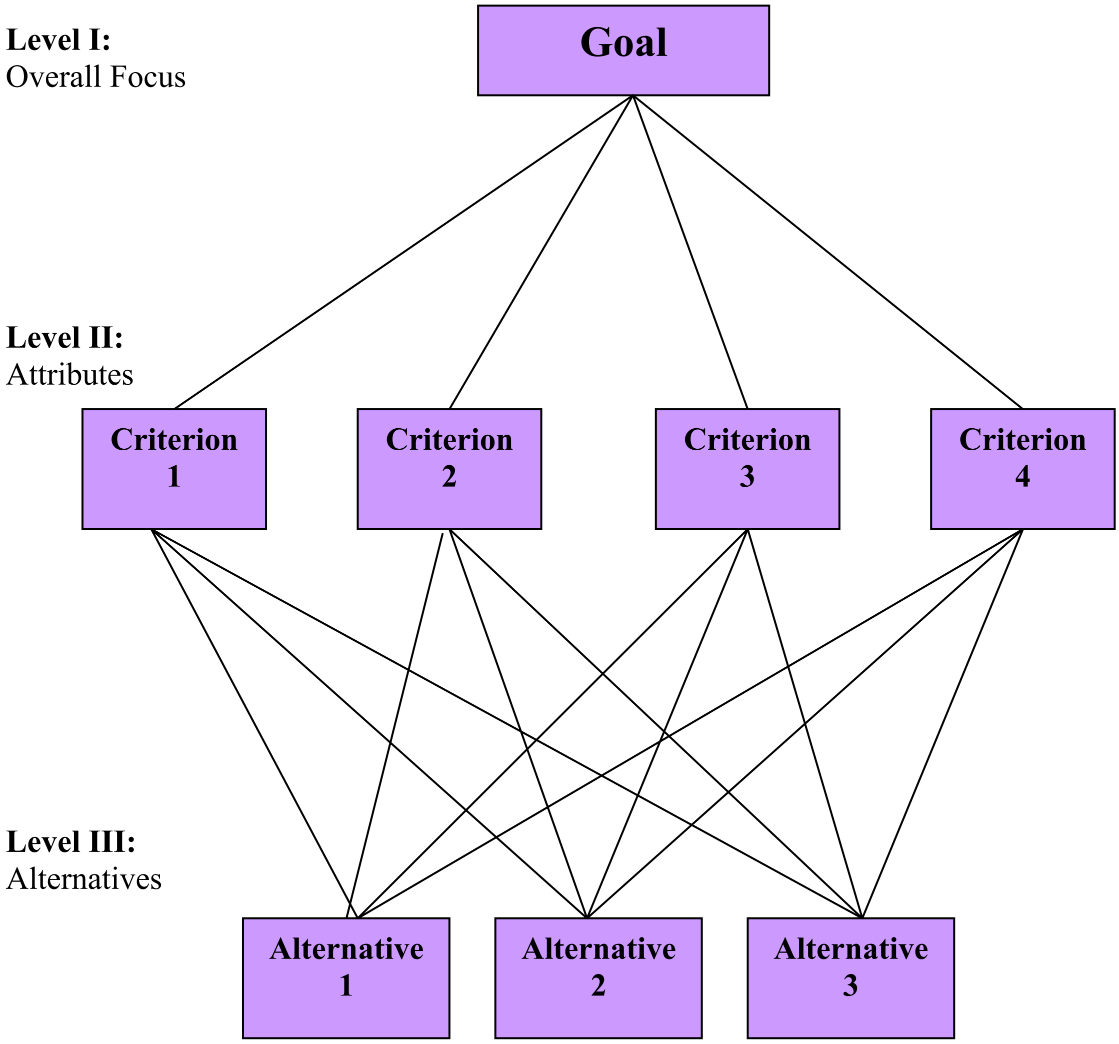


Figure 4.3 : A Detailed Three Level Hierarchy Structure

Figure 4.4 shows a typical four-level hierarchy applied to any problem. Note that, as always, the focus is at the top level and the alternatives are at the lowest level. If any of the sub attributes were further divided into sub-sub attributes, those sub-sub attributes would have constituted a new level. If one felt that the sub attributes are not necessary, that level could be eliminated, thereby making it a three-level problem.

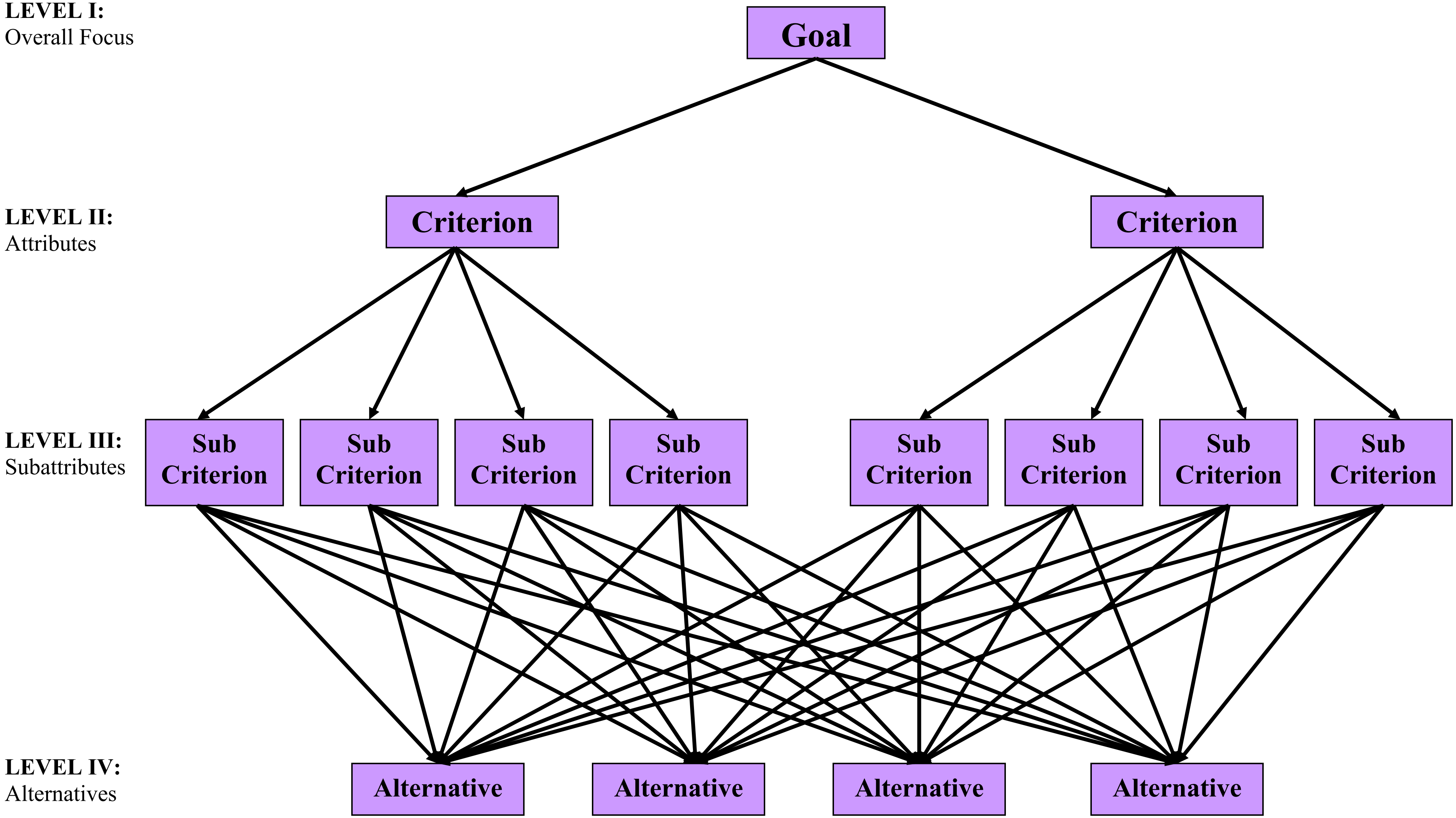


Figure 4.4 : A Detailed Four Level Hierarchy Structure

Up to now, the relationship between the same level components is not considered as important in the hierarchic structure. Linear hierarchic structure is differentiated from main goal to alternatives. However, generally, the component parts at the same level are related to each other in real world. Therefore, this situation is expressed with the *nonlinear network systems* that are special structure for the hierarchic structure. A basic nonlinear network system is shown as in the Figure 4.5. [60].

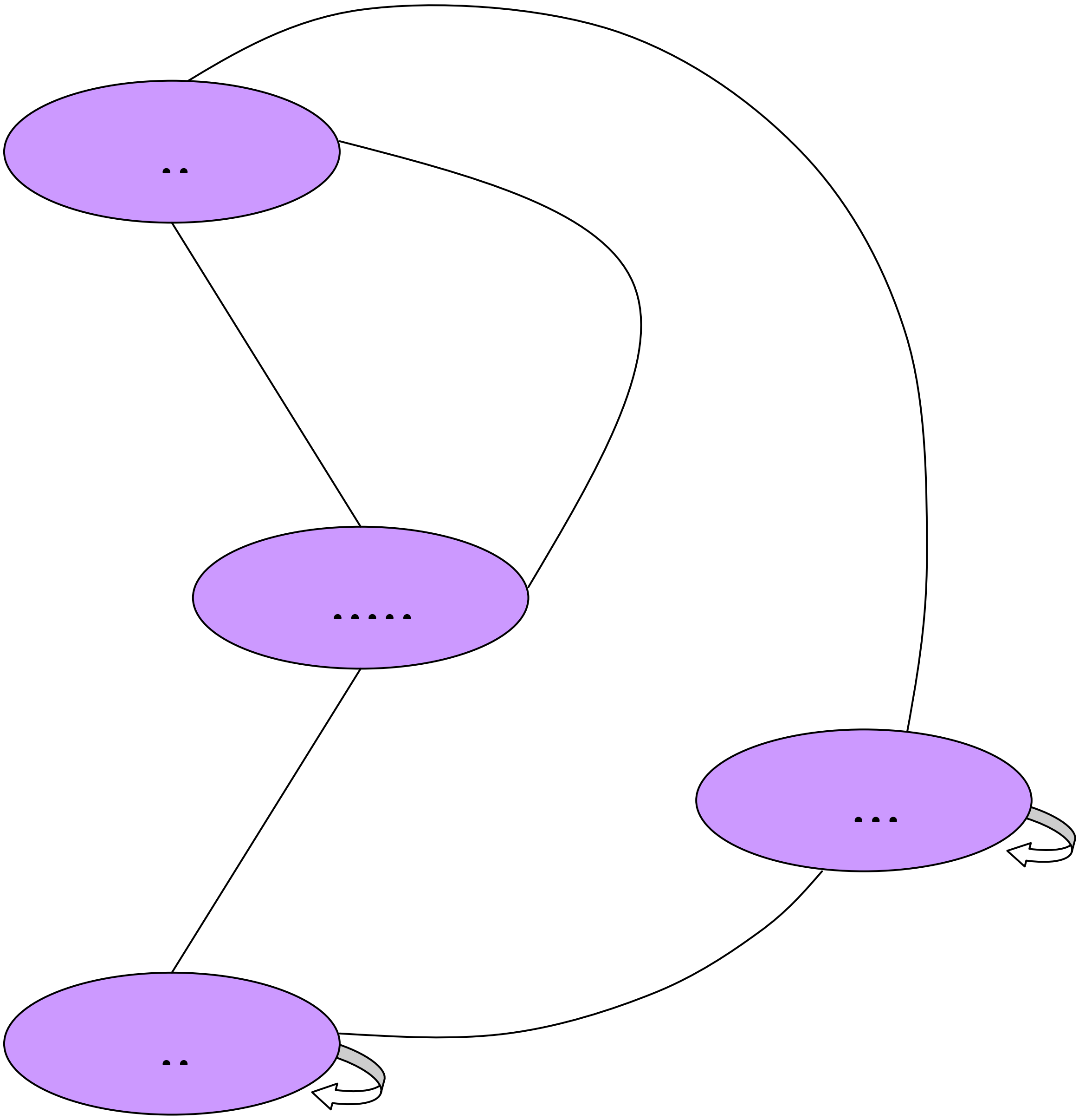


Figure 4.5 : A Nonlinear Network Hierarchy Structure

It is believed that people have been concerned with the measurement of both physical and psychological events. Physical means the field of tangible events that people constitute some kind of objective reality outside the individual conducting the measurement. However, in contrast, psychological events mean the field of intangibles, which comprise the subjective ideas, feelings, and beliefs of the individual and society as a whole. The AHP is a method that can deal with establishing measures in both physical and social domains.

In using the AHP to model a problem, one needs a hierarchic or a network structure to represent that problem, as well as pair-wise comparisons to establish relations with the structure. In particular, there has been special effort in order to characterize the matrices that are resulted in comparisons. Due to the need for a variety of judgments, there has also been considerable work done to deal with the synthesizing group judgments [59].

The structure that is generally composed of dependent relations in models helps to analyze the relationships between the choices with a simple logical algorithm. It can not be denied that any component is absolutely related to prior level component in any network system. Although, the reciprocal influence of components at the same level is *internal consistency*, the interaction between components at the different levels is called as *external consistency*.

In the literature, there is no specified or given procedure for the determination of the goal, criteria, and activities to construct a hierarchy structure that is first step analytic hierarchy process. The steps, which are maintained, depend on the goal that is focused to decompose the complexity of system. In developing a physical model formula, the methods that include the system as a whole may be located in the design methods. In this situation, therefore, the steps may become ineffective while constructing hierarchical structure. Although there have been difficulties in process and concept, construction of a hierarchy structure has advantages as below:

- It is a uniform and elastic structure.
- Natural systems can be stated in this structure.
- The effect of any changes in the upper level on the lower level factors. can be easily seen
- Analyzing lower level factors is a sufficient and required condition to achieve main goal.

4.3. Prioritization of Choices

A hierarchy structure is a mathematical and structural demonstration of real life problems with the least failure. Analytic hierarchy process is a quantitative method that shows the relationships among all of the factors under the established goal. *Prioritization* is a determination of relative importance of pair-wise comparison between all level elements according to the question-answer session. In this step; the main factors that can be considered are the determination of factors' relative importance and the determination of the effects of these importances on main goal. The main problem in this step is to verify the fundamental scale for the measurement of comparisons before constituting pair-wise comparison matrices.

4.3.1. Measurement Scale

The measurement scale during the process of factors' prioritization is very important. It is considered that prioritization is established according to this fundamental scale. Any measurement scale is made up of three elements:

- objects cluster,
- numbers cluster,
- matching objects to numbers.

Unit system that contains all numbers in the range of scale is used in the standard scales. Due to the fact that it prevents the complexity of interpretation of numbers that are in the measurement scale, unit systems are used. Not only do standard scales establish the relationship between the numbers that are from measurement, but also do standard scales minimize the failure which can be occurred from arbitrary scales.

Numerical calculations in a given standard scales are different according to the condition that has been in. When the real problem has been faced with, there is not any established procedure or algorithm in order to make numerical calculations in any standard scale. The same numerical measurements in different scales have different meanings. That is why; it describes the importance of scale that has been used in a given situation. In this manner, standard scales help to understand the meaning of measurement, not the measurement itself.

4.3.1.1. Absolute and Relative Measurement

It is argued that there are two kinds of comparisons that human make: absolute and relative. In absolute comparisons, alternatives are compared with a standard or baseline which exists in one's memory and has been developed through experience. In relative comparisons, alternatives are compared in pairs according to a common attribute. The AHP has been used in both types of comparisons to derive ratio scales of elements. These scales are called as absolute and relative measurement scales.

Absolute measurement is the comparison between the values taken from scales as a unit and the other measurement values. Before preparing the scale, unit value must be determined. In general, scale range is verified before the measurement. Decision maker establishes the unit value that represents the general scale. Absolute measurement is applied to rank the alternatives in terms of either the criteria or the ratings (intensities) of the criteria. After setting priorities for the criteria or sub criteria (if there are any), pair-wise comparisons are also made between the ratings themselves to set priorities for them under each criterion and dividing each of their priorities by the largest rated intensity to get the ideal intensity. Finally, alternatives are scored by checking off their respective ratings under each criterion and summing these ratings for all the criteria. This produces a ratio scale score for the alternative. The scores obtained of the alternatives can in the end be normalized by dividing each one by their sum.

In multi-attribute decision making problems, another scale that has been used is relative scales. Relative measurement w_i, i=1,…, n, of each of n elements is a ratio scale of values assigned to that element and derived by comparing it in pairs with the others. In paired comparisons two elements i and j are compare with each other with respect to a property they have in common. The smaller i is used as the unit and the larger j is estimated as a multiple of that unit in the form $(w_i / w_j) / 1$ where the ratio w_i / w_j is taken from a fundamental scale of absolute values. There are two types of relative measurement that are mentioned in the literature. The first one is called *normalization* which is achieved by dividing measurement by general sum. The second on is *priority scale (fundamental scale)* that is generating from evaluated criteria with respect to main goal after the comparisons that have been made. The relationship between the criteria is committed to the importance of one criterion on the other criterion. Calculated ratio from the measurements and established priority order are fundamentals of the Analytic Hierarchy Process.

4.3.1.2. Fundamental or Priority Scale

Paired comparison judgments in the AHP are applied to pairs of homogeneous elements. Prioritization process can be established by weighting different computations for all of the criteria after taking goal-input ratio of calculated measurement into account. Therefore, it can be said that prioritization scale is a principle of multi-attribute decision making models. In AHP, measurements are monotonously transferred into priority scale. Priority scales being talked of rely on ordering with respect to the choice and the importance of the measurement on main goal for each different measurement. Fundamental scales are needed to determine the priority and choices of each goal to criteria, and each criterion to alternatives.

To convert the measurement values to different scales put forth the differences between two basic scales for consideration. Relative scale is made up of certain number of objects cluster for anyone. In other words, any relative scale constitutes a principal for prioritization procedure about the model that has been studied and constructed by observing and judgments. Therefore, fundamental scale used in AHP was found by Thomas L. Saaty as you can see in Table 4.1 [58].When hierarchical structure and prioritization are established, all measurements can be expressed as comparison matrix before the solution of AHP problem. Then, model problem can be solved with the help of matrixes that are comparisons of factors. The degree of preference or intensity of the decision maker in the choice for each pair-wise comparison is quantified on a scale of 1 to 9, and these quantities are placed in a matrix of comparisons.

Table 4.1: Fundamental Scale

Intensity of Importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
2	Weak	
3	Moderate importance	Experience and judgment slightly favor one activity over another
4	Moderate plus	
5	Strong importance	Experience and judgment strongly favor one activity over another
6	Strong plus	
7	Very strong and demonstrated importance	An activity is favored very strongly over another; its dominance demonstrated in practice.
8	Very very Strong	
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation
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*.	A reasonable assumption
Rationals	Ratios arising from the scale	If consistency were to be forced by obtaining *n* numerical values to span the matrix

4.4. Comparison Matrix and Solutions

Analytic Hierarchy Process requires having judgment on factors that affect decision making after constructing the hierarchy. The effective way of evaluating judgment intensities is pair-wise comparison which means that pair components can be evaluated with respect to only one criterion. While pair-wise comparison is processed according to one criterion, any other criterion does not be cared about.

Assume that there are *n* stones, $A_1,\ldots, A_n$, whose weights $w_1,\ldots,w_n$, respectively, are known. Let us form the matrix **A** of pair-wise ratios whose rows give the ratios of the weights of each stone with respect to all others.

Then, pair-wise comparison matrix is formed as shown in Table 4.2. After obtaining pair-wise judgments, the next step is the computation of a vector of priorities or weighting of elements in the matrix. In terms of matrix algebra, this consists of calculating the "principal vector" (eigenvector) of the matrix, then normalizing it to sum to 1.0 or 100%. In principal, AHP relies on taking the components of one level and only one component of the upper level as data; creating a similar matrix, which is a pair-wise comparison with respect to the relative influence of all components of the lower level on the component of upper level, as shown in Table 4.2; calculating eigenvector that has maximum Eigen value of the matrix.

Table 4.2: Pair-wise Comparison Matrix

	A1	A2	…	An
A1	w1/w1	w1/w2	…	w1/wn
A2	w2/w1	w2/w2	…	w2/w1
…	…	…	…	…
An	wn/w1	wn/w2	…	wn/wn

Although, principal vector, eigenvector, provides the determination of priority series, Eigen value provides the consistency of pair-wise comparisons. By comparing the weight of w_i to w_j sequentially, pair-wise comparison matrix **A** is obtained.

Mathematical expression of this relationship is

$$w_i / w_j = a_{ij} \qquad (i, j = 1, 2, \ldots n) \qquad \textbf{(4.1)}$$

In this manner, all a_{ij} values of the matrix are positive, equal to w_i/w_j values, and have reciprocal values as $a_{ji} = 1/ a_{ij}$.

Under this circumstances, comparison matrix A is transformed as below;

$$\mathbf{A} = \begin{pmatrix} 1 & a_{ij} & \ldots\ldots & \ldots\ldots & a_{in} \\ 1/a_{ij} & 1 & & & : \\ : & & & & : \\ : & & & & : \\ 1/a_{in} & \ldots\ldots & \ldots\ldots & \ldots\ldots & 1 \end{pmatrix}$$

At the same time, the matrix $\mathbf{A} = (a_{ij})$ is said to be consistent and its principal Eigen value is equal to n if the expression (4.2) is obtained.

$$a_{jk} = a_{ik} / a_{ij} \quad \textbf{(4.2)}$$

However, the relationship can not be established in real life. One of the main reasons for this is that people cannot give precise values of comparisons. Another reason is that human can make a mistake about judgments. If there is not a scale at all in the case of some measuring devices, precise values of w_i / w_j can not be given, but only estimates are given. When ideal solution is found as if a_{ij} value equals to value of w_i / w_j, these equations can be found as below:

$$\frac{W_i}{W_1} * w_1 = w_i, \quad \frac{W_i}{W_2} * w_2 = w_i \;\ldots\ldots\; \frac{W_i}{W_n} * w_1 = w_i \quad \textbf{(4.3)}$$

But, in general, values are approximately equal to w_i, not absolutely equal to w_i. Therefore, equalizing w_i to average of these values can be thought as logical. Instead of ideal condition of $w_i/w_j = a_{ij}$, using a general approach of $w_i = \text{average}\ (a_{i1}, a_{i2} \ldots a_{in})$ can be more realistic.

From this moment, expression (4.4) is obtained.

$$w_i = \frac{1}{n} \sum_{j=1}^{n} a_{ij} w j \qquad j = 1, 2, \ldots\ldots n \quad \textbf{(4.4)}$$

In the event a_{ij} is estimated better, the value will be really closer to the value of w_i/w_j. How good is the principal eigenvector estimate w? By solving this problem, $w = (w_1,\ldots, w_n)^T$, obtaining the matrix whose entries are w_i/w_j is a consistent matrix. Consistent matrix is consistent estimate of the matrix **A**. The original matrix itself **A**, needs not to be consistent. In fact, the entries of A need not even be transitive. It is maintained that the factor is a measure of the error due to consistency. When a_{ij} deviates from ideal value, *n* must also be changed in order to have well-adjusted expression (4.4). Thus, "maximum eigen value" (λ_{max}) is used instead of *n*. It turns out that **A** is consistent if and only if $\lambda_{max} = n$ and always $\lambda_{max} \geq n$. In brief, if it deviates from ideal consistency condition, λ_{max} is closer to *n*. In ideal condition, λ_{max} equals to n and equation (4.4) becomes as equation (4.5).

$$w_i = \frac{1}{\lambda_{max}} \sum_{j=1}^{n} a_{ij} w j \qquad j = 1, 2, \ldots\ldots n \qquad \textbf{(4.5)}$$

As a result of generalizing the equations;

$$Aw = \lambda_{max} w \qquad \textbf{(4.6)}$$

is obtained. Therefore, finding relative importance vector w in order to realize the expression of $Aw = \lambda_{max} w$ by starting from A, is the solution of the model.

Pair-wise comparisons matrix is calculated for each level and for the criteria of these levels; levels and criteria create the problem. After these computations, sub criteria or alternatives, which are effective on a main goal with the help of the established matrices, are calculated.

There are two concepts which are being talked of solution steps above. These are the principal eigenvector and consistency.

4.4.1. Eigenvector

The solution algorithm of the Analytic Hierarchy Process depends on principal vector or eigenvector. The computation of a vector of priorities or weighting of elements in the matrix means that this consists of calculating the principal vector (eigenvector) of the matrix, and then normalizing it to sum to 1.0 or 100% in terms of matrix algebra. Standard programs are available for computing principal vector of a matrix.

An easy way to get an approximation to the priorities is to normalize the geometric means of the rows. This result coincides with the eigenvector for $n \leq 3$.

A second way to obtain an approximation is by normalizing the elements in each column of the judgment matrix and averaging over each row: Divide the elements of each column by the sum of that (i.e. normalize the column) and then add the elements in each resulting row and divide this sum by the number of elements in the row.

A simple way to obtain the exact value (or an estimate) of λ_{max} when the exact value (or an estimate) of *w* is available in normalized form is to add the columns of **A** and multiply the resulting vector by the priority vector *w*.

4.4.2. Consistency

Consistency ratio (C.R.) is an approximate mathematical indicator of the consistency of pair-wise comparisons. It is a function of what is called the "maximum Eigen value" and size of the matrix called a "consistency index" which is then compared against similar values if the pair-wise comparisons had been merely random that is called "random index". If the ratio of the consistency index to the random index, which is called "consistency ratio", is no greater than 0.1, it is suggested that the consistency is generally quite acceptable for pragmatic purposes.

The consistency of comparison matrix and the solution algorithm of the model are also depending on Eigen value and eigenvector. It is believed that there is a number of ways to derive the vector of priorities from the matrix (a_{ij}) [58]. Emphasizing on consistency leads to the Eigen value formulation $Aw=nw$. Suppose that the priorities $w= (w_1,\ldots,w_n)$ with respect to a single criterion are known. The matrix of ratio comparisons can be formed and multiplied by on the right by *w* to obtain nw as follows:

$$\begin{pmatrix} w_1/w_1 & w_1/w_2 & \ldots & w_1/w_n \\ w_2/w_1 & w_2/w_2 & \ldots & w_2/w_1 \\ \ldots & \ldots & \ldots & \ldots \\ w_n/w_1 & w_n/w_2\ldots & & w_n/w_n \end{pmatrix} \begin{pmatrix} w_1 \\ w_2 \\ \vdots \\ \vdots \\ w_n \end{pmatrix} = n \begin{pmatrix} w_1 \\ w_2 \\ \vdots \\ \vdots \\ w_n \end{pmatrix}$$

If a_{ij} represents the importance of alternative *i* over alternative *j* and a_{jk} represents the importance of alternative *j* over alternative *k* and a_{ik}, the importance of alternative *i* over alternative *k*, must equal $a_{ij}\, a_{jk}$ or

$$a_{ik} = a_{ij}\, a_{jk} \qquad \textbf{(4.7)}$$

for the judgments to be consistent. To simplify the notation, it can be written $Aw = \lambda_{max} w$ where A is the matrix of pair wise comparisons.

The solution is obtained by raising the matrix to a sufficiently large power, then summing over the rows and normalizing to obtain the priority vector $w = (w_1,\ldots,w_n)$. The process is stopped when the difference between components of the priority vector obtained at the *k*th power and (*k*+1)st power is less than some predetermined small value. The vector of priorities is the derived scale associated with the matrix of comparisons. It is assigned in this scale the value zero to an element that is not comparable with the elements considered.

It is important to note that the principal eigenvector is well estimated. Note that if $w = (w_1,\ldots,w_n)^T$, by solving the problem, is obtained, the matrix whose entries are w_i/w_j is a consistent matrix which is consistent estimate of the matrix A. The original matrix itself **A**, need not be consistent. In fact, the entries of **A** need not even be transitive; i.e., A_1 may be preferred to A_2 and A_2 to A_3 but A_3 may be preferred to A_1. It turns out that A is consistent if and only if $\lambda_{max} = n$ and that always $\lambda_{max} \geq n$.

$$\lambda_i = n \Rightarrow \lambda_{max} = n \qquad \textbf{(4.8)}$$

The consistency index is obtained from a series of calculations. First multiply the matrix of pair-wise comparisons, call it matrix [A], by the principal vector or priority weights calling as matrix [B] to get a new vector [C].

$$[A] \times [B] = [C] \qquad \textbf{(4.9)}$$

Next, divide each element in vector [C] by its corresponding element in vector [B] to find a new vector [D].

$$[C] \div [B] = [D] \qquad \textbf{(4.10)}$$

Now, average the numbers in vector [D]. This is an approximation of what is called the "maximum Eigen value", denoted as λ_{max}.

It is interesting to note that $\lambda_{max} - n / (n - 1)$ is the variance of the error incurred in estimating a_{ij}. The measure of inconsistency can be used to improve the consistency of judgments. As a measure of deviation from consistency, “consistency index” is used:

$$C.I. = \lambda_{max} - n / (n - 1) \quad \textbf{(4.11)}$$

The “consistency ratio” is obtained by comparing the C.I. with the appropriate one of the following set of numbers seen in Table 4.3 each of which is an average random consistency index derived from a sample of randomly generated reciprocal matrices using the scale 1/9, 1/8, …, 1, …, 8, 9. If it is not less than 0.10, the problem must be studied and judgments must be revised again. Random indexes (R.I.) for various matrix sizes, *n*, have been approximated based on large numbers of simulation runs as in Table 4.3.

$$C.R. = C.I. / R.I. \quad \textbf{(4.12)}$$

Consistency ratio can be calculated by dividing consistency index to random index for specified matrix size.

Table 4.3: Average Random Consistency Index (R.I)

n	1	2	3	4	5	6	7	8	9	10	11	..
R.I.	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	..

Based on Saaty’s empirical suggestions that a C.R = 0.10 is acceptable, it would be concluded that the foregoing pair-wise comparisons to obtain attribute weights are reasonably consistent.

5. Decision Support Systems (DSS)

Decision makers' requirements are met with different types of information systems. Management information systems, database management systems (DBMS), on-line analytic processing (OLAP) are just a few examples of systems that provide information used in decision making. It has been suggested that DSS address some or even all of the key requirements.

5.1. Definitions of DSS

Decision support systems (DSS) are computer-based systems used to assist and aid decision makers in their decision making processes. Because of the continuously growing number of different types of computer-based systems, it is important to distinguish among them and position DSSs within the family of information systems used by decision makers. Little (1970) [41], in one of the earliest works on computer-based decision support, proposed that a DSS is "a model-based set of procedures for processing data and judgments to assist a manager in his decision making".

From the inception of DSSs, it has become clear that they aid and assist decision makers but do not replace them. This feature distinguishes a DSS from other IS. Some IS replace decision makers in well structured, routine and recurring decisions; others are used to verify, record or extract data. Keen and Scott-Morton (1978) [34], note that DSS play a different role and propose the following definition:

> "Decision support systems couple the intellectual resources of individuals with the capabilities of computers to improve the quality of decisions. It is a computer-based support for management decision makers who deal with semi-structured problems."

Moore and Chang (1980) [44], define a DSS in terms of its features and use. They view a DSS as a system that is extendable, capable of supporting ad hoc analysis and decision modeling, oriented towards future planning, and of being used at irregular, unplanned intervals.

Bonzeck, Holsapple and Whinston (1980) [10], define DSS in terms of its components. A generic DSS consists of a language system for communication between the user and the DSS, a knowledge system containing problem domain knowledge which consists of data and procedures, and a problem processing system consisting of programs capable of solving decision problems.

The difficulties with defining DSSs were recognized already at the early stage of their introduction. Sprague and Carlson note that some definitions are so restrictive that only a few existing systems satisfy them, while other definitions are broad so that they include almost all computer systems. Systems for extracting, summarizing and displaying data are also viewed as DSSs (McNurlin and Sprague, 1993) [43].

5.2. Characteristics of DSS

The development and implementation of decision support systems (DSS) require knowledge and understanding of managerial decision making, levels of reasoning and problem solving and roles of managers in organizations [43].

These prerequisites for using computerized decision support already constitute a challenge for those contemplating the use of information technology for project management. The mandate for a better future is uncontestable but formulating this mandate in a tractable manner is non-trivial. This justifies the use of any support methodology- computerized or not- to help authorities involved in project management sort out all the decision variables and parameters, problem solving heuristics, and appreciate the impacts of potential policy actions.

The process of developing a DSS often revolves around five building blocks:

1. **Information Resource Management:** In software engineering terms, input data are required for decision analysis and resolution; output data are generated and presented to decision makers for policy making. Effective management of these data constitutes a first major task of any decision support tool.

2. **Model Management:** A model is an abstraction of reality whose purpose is to help decision makers focus on the main elements of a problem.

Multiple objective optimizations under constraints are a classic modeling approach in management science. Qualitative reasoning, expert heuristics, and data mining are alternative methods to formulate decisions. Given a decision problem, the challenge of DSS is to find the best decision method(s) able to suggest a satisfying solution to policy makers.

3. **Interactive Problem Solving:** Direct interaction between the DSS and its user allows for a more responsive and user-centered view of the problem. A good DSS is one that provides the right information to the right person at the right time with full transparency. In addition, DSS should provide some cognitive feedback to decision makers by helping them comprehend dynamic changes in the underlying assumptions.

4. **Communications and Teamwork Support:** Decision making, more often than not, involves more than one decision maker and support for communication and coordination is an important dimension of DSS. Support for information exchange, federated organizational memory, group decision and negotiation is an integral component of organizational decision support.

5. **DSS as Non-Human Co-workers:** In a tightly connected networked world, we postulate a working scenario in which humans will team up with computers as co-workers to optimize execution of business decisions [47]. We envision a new social structure that emerges from the interaction of individuals – both human and non-humans – operating in a goal-oriented environment under rules that place only bounded demands on each individual's information and computational capacity [11].

The immediate value of using these five building blocks is to help the DSS users improve their decision outcomes. DSS should achieve its support mission by lending a hand to its users: More quality input data are expected to provide a more complete assessment of the problem situation and a richer set of decision alternatives. More sophisticated decision algorithms are expected to help decision makers find solutions that could not have been found otherwise. Expansive trade-off analyses and interactive simulation are expected to provide decision makers with further insights. Communications and group decision support are expected to increase the chance of finding a shared vision and socially equitable solution. Finally, computerized coordinated DSS workflow should seamlessly enhance the integration of project management at a national or global scale.

5.3. Types of DSS

It is cleared that DSSs are used to support decision processes as do management information systems (MIS), database management systems (DBMS, on-line analytic processing (OLAP), and also some knowledge-based systems (KBS). All these systems may support decision makers on-line and in an interactive mode so that this feature does not distinguish DSS from other systems.

The main difference between DSS and other information systems lies in the model component: formal quantitative models are integral part of a DSS [5, 19]. These models, for example, statistical, simulation, logic and optimization models are used to represent the decision problem; their solutions are decision alternatives. However, the model need not be defined a priori but may be constructed during the decision making process. Two types of DSS can be distinguished: *model -oriented* DSS and *data -oriented* DSS.

5.3.1. Model-Oriented DSS

Generally, decision support has been model-oriented. A decision problem identified in the intelligence phase led to the selection of a modeling technique. A model is constructed in the design phase and used to determine decision alternatives. To obtain alternatives model parameters were calculated with the use of data stored in databases and user's input. This type of support is centered on user-model interactions.

The sequence of key activities in model-oriented support is presented in Figure 5.1. The interaction between the decision problem and the model describes activities of model selection and fitting. The data is used in as much as it is required to obtain model parameters.

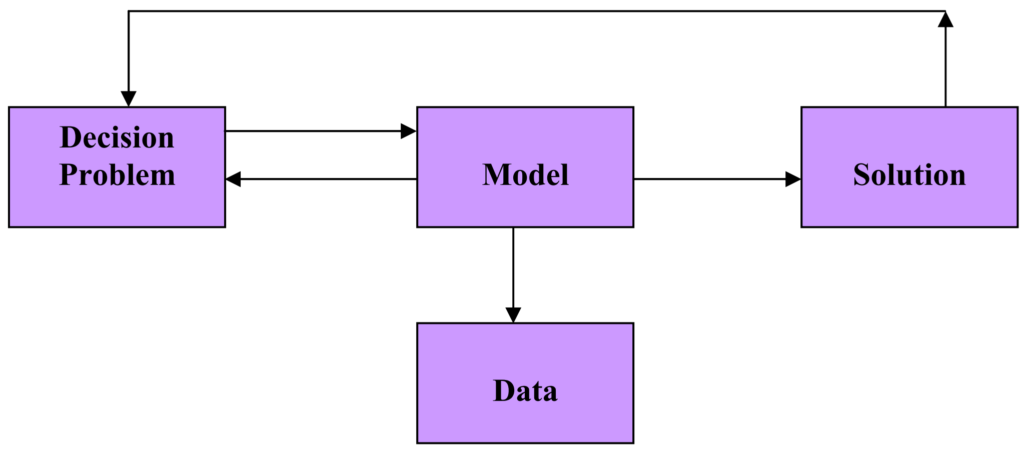


Figure 5.1 : Model-Oriented Support Sequence

Models are used to obtain optimal or efficient decision alternatives, to search through the set of feasible solutions for alternatives with specific characteristics, to conduct sensitivity analyses.

5.3.2. Data-Oriented DSS

Model-oriented support assumes that models exist prior to decision making activities. Developed by researchers and analysts, they are embedded in a support system. In contrast, in data-oriented support on a given model, it is constructed from the analysis of available data. Data mining and knowledge discovery techniques are used to extract knowledge and formulate models. This approach depends on the availability of large datasets, often stored in a data warehouse. The sequence of key activities in this type of support is given in Figure 5.2.

The realization of a decision problem may initiate model construction. This type of support, however, may be initiated by the user but it may also originate with the system itself. A routine analysis conducted, for example, by on-line analytic processing may indicate the existence of a problem and invoke an extensive data analysis with statistical and other data mining techniques leading to model construction and problem formulation. Only at this stage will the decision maker may enter the process of finding a solution to the problem.

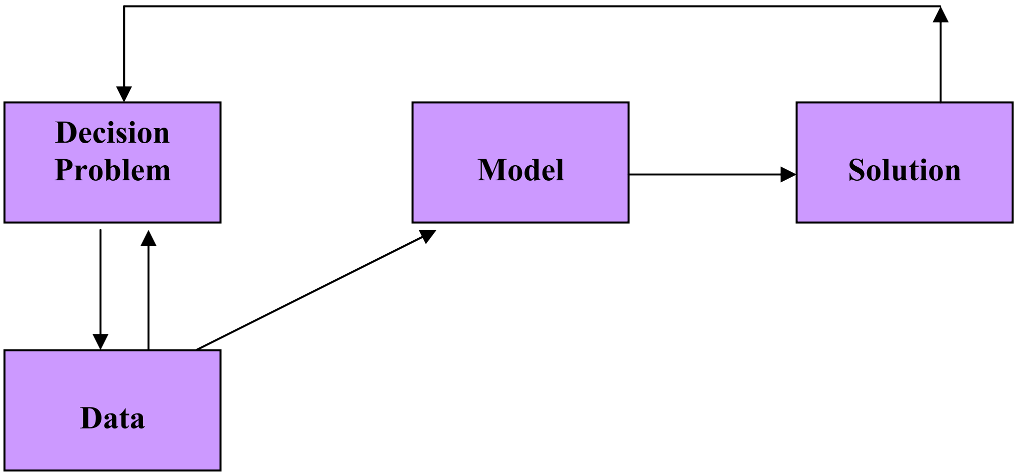


Figure 5.2 : Data-Oriented Support Sequence

It cannot be denied that we may expect that in the future the two types of support will merge. Models generated by data mining techniques will be tested and validated. They can be used to determine parameters for other models or be included in models of an organization, its unit or of a complex activity.

5.4. Functional Requirements of DSS

A support system is used to analyze a problem, determine alternative decisions and select one. Historical data and models are used to generate and evaluate forecasts and decision alternatives.

DSS systems generally require user involvement in the construction of problem representation and model verification. They also require direct user involvement in the analysis of decision problem, evaluation of decision outcomes and preference specifications. These activities involve subjective judgments and, therefore, a DSS should focus on effective support and not on automatic selection. A DSS, to be effective flexible and adaptable to changes in the decision making process.

A DSS participates in the decision process which is controlled and coordinated by the user. Active user involvement requires a DSS to be user friendly and cooperative. This is important in case of episodic fragmented usage. User involvement also requires a DSS to be well integrated in the decision making process. The implementation of a DSS heavily affects the decision making organization and its procedures and, therefore, needs to be flexible and adaptable to changes in the decision making process.

Active user involvement in problem specification and solution also requires a DSS to support decision processes which embrace qualitative as well as quantitative aspects. The quantitative aspect of the problem may be well structured; it is its qualitative nature – including comparison, evaluation and choice – that makes the problem semi–structured or unstructured. Decision alternatives need to be judged by both quantitative and qualitative criteria. The use of qualitative and subjective criteria may mean that a satisfying solution is selected rather than an optimal one. This imposes a requirement on the problem solvers and procedures so that the user is able to inspect optimal and non–optimal solutions.

If a DSS is to aid and assist decision makers it must support one or more phases of the decision making process. The required information is provided by quantitative models and data that describe the entity of interest in order to help identify problems or to generate, evaluate, and compare decision alternatives.

A DSS is used to generate, analyze and compare decision alternatives. Data and the parameters that are used to determine them need to be stored separately. Database containing alternative solutions and other information is called a solution base.

The evaluation of decision alternatives requires their comparison which a DSS should facilitate. The user–system interface should provide facilities for model – and report – generation, and allow for multiple modes of information display.

Models are an important component of a DSS. Many systems are built only one type of model such as systems that incorporate only linear programming models. If a system is designed to support more than one phase of the decision process including the analysis of both data and solutions then a class of models may be required rather than just one. If the problem is semi–structured, only a part of the problem can be captured by one model and complementary models may be required. In these situations multiple models need to be integrated into the system in such a way they can interact each other.

5.5. Difficulties with DSS Development and Use

The problems associated with building and using DSS partly result from the fact that some of the requirements discussed above are ignored or not fully met. Many problems include insufficient access to databases external to the DSS. This may be due to technical problems such as unknown data models, data models of different types or interfacing difficulties. Those problems may also be caused by poor designed data models and lack of consideration for systems' interaction.

Many users of DSS have experienced difficulties in learning how to use a system properly and effectively. Beulens and Van Nunen (1988) list the following reasons for these difficulties [7]:

1. the procedures to be used in the system have little in common with procedures or systems that users normally employ;
2. it is difficult to know the interdependencies of the functions provided by the system;
3. it is difficult to keep track of the consequences of a DSS function usage with respect to decision scenario and the integrity of the database;
4. there are applications that require extensive knowledge of a specific problem domain or technical knowledge such as optimization or forecasting models;
5. users have to deal with several databases and models, each with different data models and resulting translation problems; and
6. users may have to work on several decision scenarios at the same time. As a consequence they have to keep track of what they have done for each of them.

Model building for semi – and unstructured problems is difficult and requires considerable expertise. Therefore, they are often constructed by system analysts and not by the managers who are the direct users of DSSs. Therefore, this may defeat the purpose of the system because it may not meet the managers' requirements, and thus, it is unlikely to participate directly in the decision process. In this manner, when the decision maker is a direct user, the model may be considered as a black box. A friendly interface, e.g., a graphical user interface and extensive reporting capabilities, does not alleviate the difficulty in the user's understanding of the model assumptions and the relationships between data, models, and solutions even though it may make the system easier to access.

5.6. DSS Methods

It is believed that there are six corresponding general support categories that are distinguished [74].

1. *Presentation methods* are computer–graphic, voice and text processing tools to present data and information in a meaningful and suitable form. They are used to make data, information and knowledge used and generated by DSS accessible to the decision maker in terms of the decision maker's own mental representation of the decision process and context.
2. *Information management methods* are used to store, organize, retrieve and summarize data, information and knowledge providing timely and relevant information extending decision makers' ability to access it.
3. *Process modeling methods* are quantitative and qualitative models of real–world processes, and techniques to provide predictions of these processes at future points in time and under different conditions.
4. *Choice modeling methods* are used to select and combine decision attributes, define objectives and goals, determine preferences and trade–offs among objectives and utility or value functions. They are used to determine preference consistency and remove cognitive biases by the consistent use of preferences and trade–offs.
5. *Automated analyses and reasoning methods* are mathematical and logical tools used to automate analytical and reasoning activities fully or partially. They are used to organize the decision process, provide expert knowledge and compensate for situational constraints limiting the unaided decision maker.
6. *Judgment refinement methods* are used to guide decision makers in their efforts, identify and remove systematic inconsistencies and biases that arise from human cognitive limitations. They include aids to structure decision problems, estimate probability distributions, analyze risk and check for consistency of the decision maker's reasoning.

The role of methods is to organize the technology based decision making and give a framework for the system's functional specification. To establish close linkages between the different aspects of managerial decision making and organizational and individual needs, each of the functions needs to be further defined and translated into detailed system requirements.

6. Group Decision Making

Many decisions in an organization are made by not an individual, but by groups of individuals. By its nature, a group enriches the choice process by gathering the knowledge, experience, and probably the different perspectives of several people. The enrichment may allow the group to understand the problem better, spark synergy for creative solutions, and identify errors in the information or process. Finally, since more people are involved, they create a deeper commitment to the choice, and thus less resistance to its implementation.

Business decisions are increasingly being taken by groups. Managerial practice stresses the harnessing of group co-operation and team working. It is difficult to imagine that it will be completely free from some group pressure whenever there is a strong individual input to decision making.

The synergies of group decision making are potentially a great aid to improving the quality of organizational decisions. However, group decision making can detract from effective decision making. It cannot be denied that it is important to know group processes affect decision making, which processes help to create effective decision-making groups.

6.1. Groups and Decision Making

Modern organizations use groups for making decisions. It is claimed that better decisions are likely to emerge from group than from an individual. The group activities performed by teams while working together include communicating ideas, exchanging and sharing information, coordinating activities, discussing issues, and making decisions. There are five major reasons for using group in decision making.

1. *The issue of legitimacy*: If an individual takes decision, the person may be perceived as acting autocratically, without regard to the interest and feelings of others. It may also be perceived as implementing the decision coercion rather than by consent. If this happens decision might be questioned in terms of its legitimacy. It is

generally suggested that a group decision will gain wider support more quickly than a decision taken unilaterally by an individual.

2. T*he group and the quality of a decision*: It can not be denied that a group will generate more alternatives than individual will. There will be greater awareness of both potential solutions and potential problems by applying a wider experience, ability and expertise than an individual can bring. In general, these factors will lead to groups producing higher quality decisions than individual.

3. *Novelty*: The group is seen as superior to the individual in situations which require new ideas, or with problems that require original solutions. It is claimed that a group has been shown to be a more productive source to generate new ideas. Techniques such as brainstorming have been developed in business situations which require creativity and originality in order to reap the benefits of the group.

4. *Shortage of information*: It becomes easier to access the most appropriate and complete information by getting together a group of the best informed people. The group can not have all the information at its disposal. But it leads to a greater sharing of what information is available, and leads to a clearer understanding of what information is lacking.

5. *The issue of morale*: Participation in group decision making is positively related to morale and job satisfaction, negatively related to occupational stress and career dissatisfaction. In groups, people will not only gain some social satisfaction from interacting with the others. Playing a role in decision making can enhance the person's status and self-esteem as well as providing opportunities for self-expression and personal development.

6.2. The Drawbacks of Group Decision Making

Groups can bring a few drawbacks to the decision process. Most group decisions take longer to reach than individual decisions. Groups tend to spend significant nonproductive time waiting, organizing, or repeating what already has been said. Group dynamics can appropriately influence the process if there are substantial differences in the rank of the members. Often, the supporting may abdicate their tasks and responsibilities to others. Finally, there is social pressure to conform to a group position. "Groupthink" can exist in any group and may exacerbate incomplete or inappropriate uses of information.

Groupthink is an agreement-at-any-costs mentality that often results in ineffective group decision making and poor decisions [25]. It is associated with groups having a high degree of conformity and cohesion that are insulated from outside information sources challenging their decisions, that have excessively directive leadership, and that exist in a complex and rapidly changing environment. When groupthink occurs, members ignore limitations or impropriety of their analyses as well as possible consequences of their choice process. In fact, the group collectively rationalizes its choice and process, going so far as to censor itself when group members deviate from the established position, solution, or parameters.

The problem with groupthink is obviously that it can lead to poor decision. In particular, when it is associated with

- incomplete generation of alternatives;
- incomplete understanding of goals;
- failure to examine risks of preferred choices;
- poor research of information;
- bias in the interpretation of information; and
- failure to appraise and reappraise alternatives.

Each of these is associated with bad decision making. Unfortunately, DSSs, as they have been defined to this point, do not provide methods for addressing these problems.

Hence, to support group decision making, a tool needs to have not only the characteristics of decision support systems, but also the hardware, software, and procedures necessary to reveal the positive aspects of the group and inhibit the negative.

Group decision support systems (GDSS) represent the hybrid technology; they combine decision support systems and groupware technologies. GDSS should have the components of a DSS, including the model management system, and mail management system. The system must be able to support the needs of all the decision makers easily. GDSS must have the range of models and model management functions necessary to meet the choice needs of the participants. Further, they must be able to access and aggregate information from a variety of sources in a variety of formats to meet the group's broad information needs. Finally, GDSS must be easy for all users to operate.

The group dynamics themselves block active participation by one or more people and discourage innovative thinking. GDSS must, therefore, include tools that address the group dynamics so that decision makers can gain consensus about a particular problem, and include a group dynamic management system to address special needs of group processes. Group consideration of any problem allows the use of additional information, knowledge, and skills, but only if all participants have equal opportunity to be heard and to have certain ideas received. Since GDSS use the technologies of groupware, it will be examined the concept of Groupware before discussing GDSS.

6.3. Groupware

Groupware or group support systems (GSS) have evolved over time. One definition available in the literature is that GSS are computer-based information systems used to support intellectual, collaborative work [32]. This definition is too broad for one discussion to specifically address the role of the groups. Another definition is "tools designed to support communications among members of a collaborative work group" [26]. Another way to describe a GSS is "the collective of computer-assisted technologies used to aid group efforts directed at identifying and addressing problems, opportunities and issues"[28].

Groupware exists to facilitate the movement of messages or documents, so as to enhance the quality of communication among individuals in remote locations. It provides access to shared databases, document handling, electronic messaging, workflow management, and conferencing. In fact, groupware can be thought of as a development environment in which cooperative applications – including decisions – can be built. Groupware achieves this through the integration of eight distinct technologies: messaging, conferencing, group document, handling, work flow, utilities/development tools, frameworks, services, and vertical market applications. Hence, it provides the foundation for the easy exchange of the data and information among individuals located far apart.

It is believed that groupware, in general, is a set of hardware and software designed to help groups work together. Vendors, consultants, users, and university researchers all have used the term to refer to many different types of software, each of which supports very different types of group work. This form of groupware provides two key functions to groups. First, it enables group members to generate, read, and organize information in a structured manner [49]. Groupware enables groups to edit, move, delete and structure information so that it is presented in a hierarchy that is easy to analyze and can evolve as new information is added.

The second key function of this form of groupware is the ability for group members to rank, rate, or otherwise quantitatively analyze the relative merits of alternatives [49]. Most groupware systems enable users by ranking or rating alternatives. Some support multi criteria decision making, so that a set of alternatives can be evaluated by all members on a series of criteria (E.g. rating cars on gas mileage, acceleration, etc.). Others support more elaborate decision analysis processes. In any case, each participant enters his or her ratings, analyses, or votes, which are then combined with those of all other participants and presented to the group as a whole for further discussion.

6.4. Group Decision Support System (GDSS)

Understanding decision making processes is difficult because there is so much variability across individuals in terms of the phases they adopt, the methods they employ, and the data that are important to them. However, variability in these issues increases tremendously when groups make decisions, thereby making support of a group decision making activity that much more difficult.

While identifying group decision making, it can be referred to several individuals working together to complete some task as a unit. These individuals might be people who always work together, and hence have some shared history of performance. Or they may have been brought together for just this one decision and hence have no appreciation for the skills and knowledge that each brings to the task. Similarly, the group could be in one location meeting together, or in multiple locations meeting via conferencing, or working in one location but at different times. Group decision support system helps to improve better decisions collaboratively for a specific goal.

A group decision support system incorporates groupware technologies with DSS technology. GDSS consist of hardware, software, and procedures for facilitating the generation and evaluation of alternatives as well as features for facilitating to improve group dynamics. However, a GDSS is not a reconfiguration of an existing DSS, but a specially designed system that integrates DSS and groupware technologies.

A typical configuration includes model management, database management, and group management tools interconnected and managed by a facilitator. The purpose of the facilitator is to coordinate the use of the technology so that the focus of the decision makers is on the problem under consideration, not on the use of technology.

6.5. Group Decision Support System (GDSS) using AHP

The AHP procedures are applicable to individual and group decision support systems. In group decision support systems, many methods can be used to conform the judgments of group participants in the priority process. In a common objective context where all participants share the same objectives, there are four ways to set the priorities: consensus, vote or compromise, geometric mean of the individuals' judgments, and separate models or players [18]. *Consensus* refers to the achievement of a consensus of group participants in constructing a hierarchy and making judgments. If a consensus can not be reached, the group may then choose to *vote or compromise* on a judgment. If a consensus can not be achieved and the group is unwilling to vote or to compromise, then a *geometric mean* (average) of the individuals' judgments can be calculated. If the group has significantly different objectives and can not meet to discuss the decision, then each group member can make a judgment separately, based either on *separate models or players*. If it is based on separate models, then each group members enter their judgment into a separate model, which will then be averaged. However, if it is based on separate players, then a combined model is set up with each 'player' evaluating those factors in their part of the combined model.

Many researchers consider the AHP technique to be well suited for group decision making due to its role as a synthesizing mechanism in group decisions. Dyer and Forman [18] remarked that the AHP can (1) be suitable for both tangible and intangible characteristics, individual values and shared values in group decision process, (2) help structure a group decision so that the discussion centers on objectives rather than on alternatives, (3) allow discussion to continue until all available information have been considered and a consensus choice of the alternative most likely to achieve organization's stated objectives is reached. As Bard and Sousk [4] stated, AHP provides an accessible data format and logical means of synthesizing judgment. The consequences of individual responses are easily traced through the computations and can be quickly revised when the situation warrants.

There have been several research studies which have proved the contribution of the application of the AHP to support group decisions. Korpela and Tuominen have applied this technique to evaluate the applicability of the AHP in defining the goals of distribution logistics [36] and to analyze the project's department in group settings [35]. Their findings have validated the AHP as an effective and flexible tool for group decision making because it can form a systematic framework for conducting structured group sessions. Dyer and Forman [18] also believe that the AHP is well suited to group decision making and it can be applied to a variety of group decision contexts. They argued that the AHP can help group decision makers to structure complex decisions, develop measures of utility, and synthesize measures of both tangibles and intangibles with respect to the numerous competing objectives inherent in almost any decision.

The AHP allows group decision making, where group members can use their experience, values and knowledge to break down a problem into a hierarchy and solve it by the AHP steps. Brainstorming and sharing ideas and insights often lead to a more complete representation and understanding of the issues. The following suggestions and recommendations are suggested [20].

1. Group decisions involving participants with common interests are typical of many organizational decisions. Even if we assume a group with common interests, individual group members will each have their own motivations and, hence, will be in conflict on certain issues. Nevertheless, since the group members are 'supposed' to be striving for the same goal and have more in common than in conflict, it is usually best to work as a group and attempt to achieve consensus. This mode maximizes communication as well as each group member's stake in the decision.

2. It is believed that the difficulty problem of 'groupthink' or dominance by a strong member of the group can be minimized. This occurs because attention is focused on a specific aspect of the problem as judgments are being made, eliminating drift from topic to topic as so often happens in group discussions. As a result, a person who may be shy and hesitant to speak up when a group's discussion drifts from topic to topic will feel more comfortable in speaking up when the discussion is organized and attention turns to his area of expertise. Since software programs reduce the influences of groupthink and dominance, other decision processes such as the well known Delphi technique may no longer be attractive. The Delphi technique was designed to alleviate groupthink and dominance problems. However, it also inhibits communication between members of the group.

3. When group session is used, the group can be shown a hierarchy that has been prepared in advance. They can modify it to suit their understanding of the problem. The group defines the issues to be examined and alters the prepared hierarchy or constructs a new hierarchy to cover all the important issues. A group with widely varying perspectives can feel comfortable with a complex issue, when the issue is broken down into different levels. Each member can present his own concerns and definitions. Then, the group can cooperate in identifying the overall structure of the issue. In this way, agreement can be reached on the higher-order and lower-order objectives of the problem by including all the concerns that members have expressed. The group would then provide the judgments. If the group has achieved consensus on some judgment, input only that judgment. If during the process it is impossible to arrive at a consensus on a judgment, the group may use to take the 'average' of the judgments. The group may decide to give all group members equal weight in the project. All calculations are done automatically on the computer screen.

4. The Group Meeting: While there is an ideal tool for generating group decisions through a cohesive, rigorous process, the software does not replace the components necessary for good group facilitation. There are a number of different approaches to group decision-making, some better than others. Above all, it is important to have a meeting in which everyone is engaged.

Some decisions need group judgments that are made by group instead of any person's judgment. There are 2 alternatives in general while group decision is processing. Group meets to discuss the decision together, and they make a decision after consensus is achieved in group. Or, group has significantly different objectives and can not meet to discuss the decision, and then each group member is willing to make a judgment separately.

If group consensus on the project hierarchy is achieved, next step will be the detection of pair-wise comparison matrix for each element in each level. There are 2 ways to detect judgments for each element from the pair-wise comparison matrix:

1. Consensus Decision (Vote)
2. Separate (Combined) Decisions

Not only an example for consensus decision method will be seen in Figure 6.1, but also an example for combined decision method will be seen in Figure 6.2.

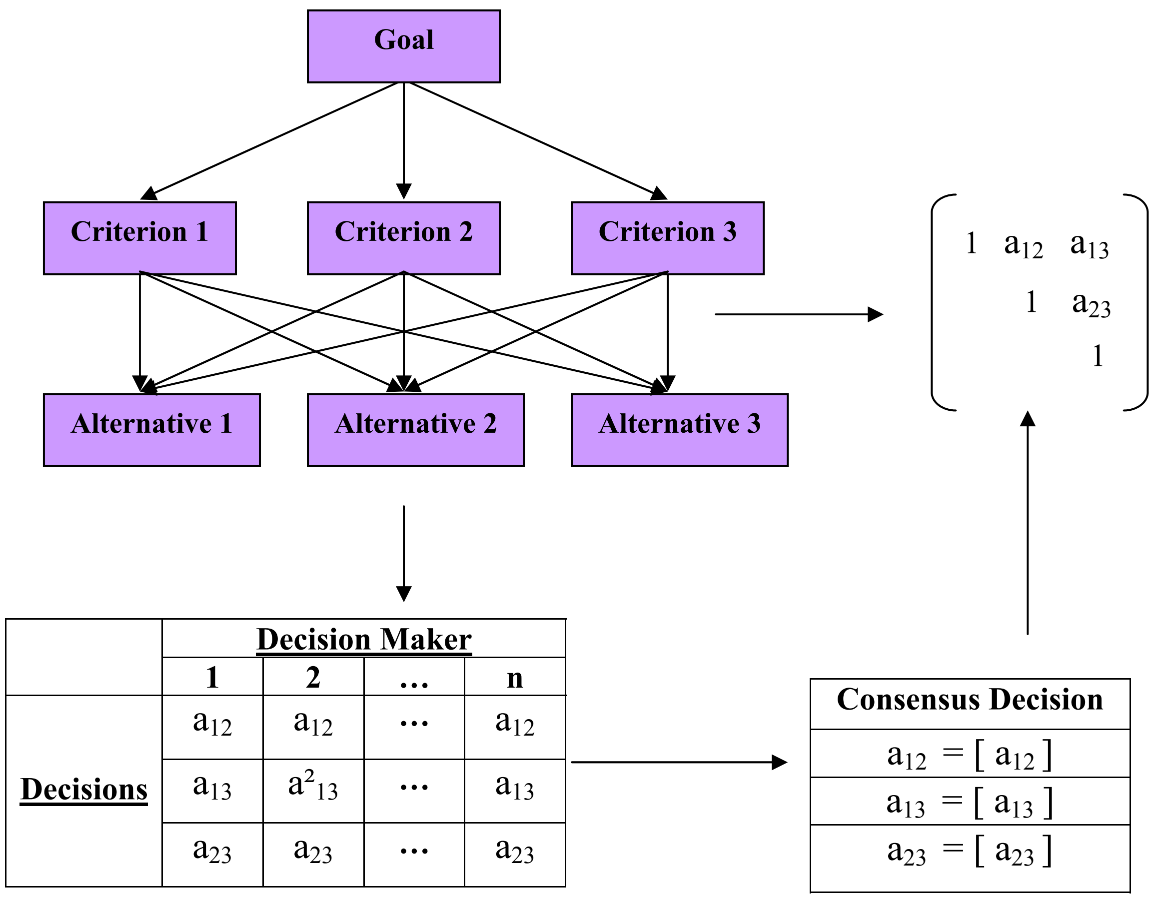
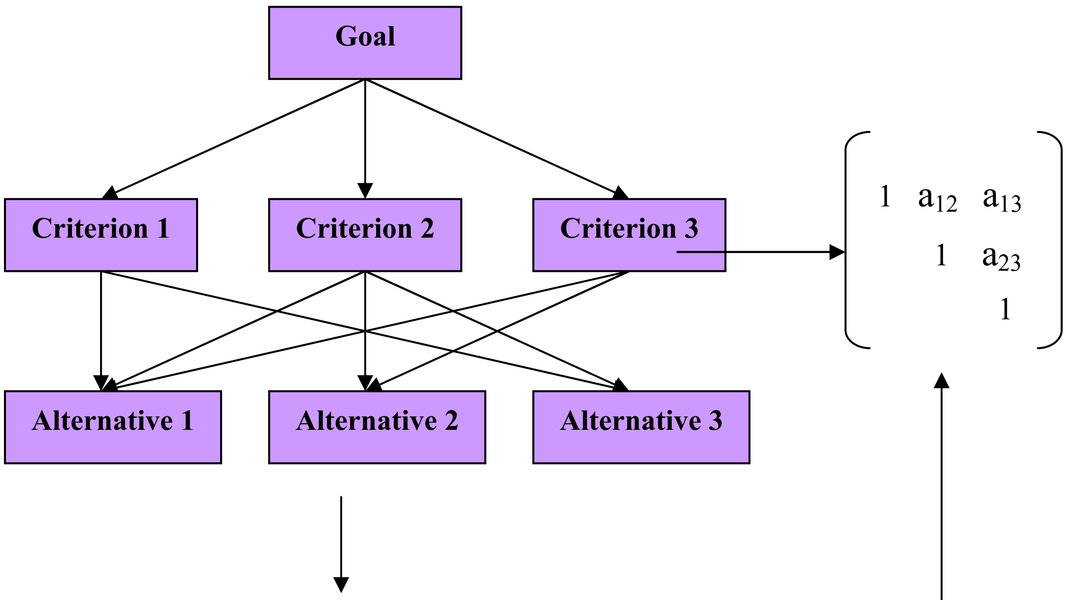


Figure 6.1 : Consensus Decision Method Hierarchy



	Decision Maker			
	1	2	…	n
Decisions	a^1_{12}	a^2_{12}	…	a^n_{12}
	a^1_{13}	a^2_{13}	…	a^n_{13}
	a^1_{23}	a^2_{23}	…	a^n_{23}

Combined Decisions
$a_{12} = [\, a^1_{12} \times a^2_{12} \times \ldots \times a^n_{12} \,]^{1/n}$
$a_{13} = [\, a^1_{13} \times a^2_{13} \times \ldots \times a^n_{13} \,]^{1/n}$
$a_{23} = [\, a^1_{23} \times a^2_{23} \times \ldots \times a^n_{23} \,]^{1/n}$

Figure 6.2 : Separate (Combined) Decisions Method Hierarchy

The first method depends on group consensus on the judgment for each element in the matrix. As in Figure 6.1, group must make judgment with pair-wise comparison of 3 factors for the first level and there should be consensus on each a_{ij} element of the matrix. It is supposed to say that group participants discuss to make judgment for each element of the matrix. The latter in Figure 6.2 is used if a consensus of participants can not be achieved due to huge debate on giving value to make pair-wise comparisons for each elements of matrix. In this method, pair-wise comparison matrix is calculated by averaging (geometric average, not arithmetic) the judgments of each decision maker for each element in the matrix. Each decision maker enters his/her own judgments into a separate model, which will then be averaged. However, if it is based on separate decision makers, then a combined model is set up with each 'decision maker' evaluating those factors in their part of the combined model. Only the geometric average enables matrix to obtain symmetry property of the pair-wise comparisons matrix.

7. Review of Web-based Decision Support System (Web DSS) and Web-based Group Decision Support System (Web GDSS)

People in organizations who have engaged in various business processes (e.g., marketing, engineering, research, research and development) work together by sharing information and making decisions. Organizations use technology to support their tasks. Technological advances and the myriad of development tools available today are still beset with issues of incompatible machines, platforms and operating system, on top of costly proprietary systems. The Internet has offered a new dimension of appreciating and evaluating the opportunities for completely new ways of doing things. It is important to explore this technology to frame and extend the discussion about the role of Internet in the future of DSS, and identify some meaningful and effective use.

Collaboration technologies have evolved from various origins; therefore, people use various terms to describe these technologies, such as groupware [33], group decision support systems (GDSS) [16 , 27], computer-supported cooperative work (CSCW) [24], computer-mediated communication systems (CMCS), and team technologies [2]. Each term has a specific focus; for example, GDSS has a strong decision-making orientation.

7.1. Web-based Decision Support System

Much of the mainstream research into DSS tends to be technologically focused research, and it is still lack of the promise that remains true to what DSS aims to do, that of providing support for ill-structured problems [70]. Humphreys and Nappelbaum [30] argued that there is still an almost complete absence in practical applications at top management level of interactive computer-based systems based on traditional DSS and IS design methodologies [39]. A decade earlier, Humphreys had already raised this concern, and advocated for the development of "techniques for the psychological validation of the decision makers' own problem structuring language than to try to invent a universal problem structuring language that will have to be taught from scratch to high level decision makers" [29]. Alter perhaps provides the best explanation for this state of affairs: simple DSS are easier to understand, implement, control and modify than complicated DSS [3]. The advent of personal computing had led to the natural application of computing power and technology to managerial needs such as in decision making, by making new discoveries in decision methods or decision technology and applying them through creating tools that decision makers might find helpful. Most of these efforts have been in decision analysis and other forms of decision modeling and human information processing through interactive use of computers, electronic storage media, and electronic communications and information display.

This evolution of DSS, which focuses on the development of technologically supported means of collecting, managing, and displaying information might be useful in decision situations [69, 71], also reflected the failure of the traditional DSS/IS approach with complex DSS [3]. GDSS soon came into limelight, stemming in part from the rise of interest in the area of technological support for groups. Much of GDSS research has taken the view that the most fundamental activity group decision making is interpersonal communication to improve group communication activities [15], and is resulting in the development of computer-based workbench environments which facilitate group communication.

But this popular form of DSS/GDSS research did not actually address Phillips [51] identified as the other approach to DSS/GDSS, of studying the decision making itself both at individual and group levels [15] on "*discovering psychological or cognitive process of individuals and groups involved in reaching conclusions and on the sociology of small-group interaction*". This second approach of providing "*a problem solving environment that is group centered and is primarily intended to help managers consider uncertainty, from preferences, make judgments and take decisions*" claimed Phillips, is a more superior approach. Clearly the first approach seems more feasible and less problematic to undertake research than the second, and understandably reiterates Alter's point about dealing with creating simple DSSs. It is easer to build technical aids for decision making than to paint picture of what decision making is. These new technologies are widely adopted and used, but it is not always clear whether they really improve the condition of those whose use them.

7.2. Implementation Challenges of Web DSS

The construction and installation of Web DSS are not everyday occurrences that organizations and individuals can commit themselves easily. They are not only costly undertakings but are also highly specialized applications. The Internet has potential to address some of these implementation challenges. Client-server technology was touted as the technology of choice for distributed organizations as a means to improve productivity, reporting and decision making. Likewise, Groupware technologies were held in the same breath to provide the mechanism for co-ordination and control of group work. Today, both of these are seriously under threat by the Internet development, and may not face up to the more open Internet which provides an inexpensive alternative. The following are some implementation challenges that can be addressed using Internet technology:

- **Distributed Technology:** Internet was borne out of a U.S. military project to address the concern of a nuclear strike wiping out a single-site computer system, it can be a very secure and reliable way of providing distributed working.
- **"Open" Technology:** Development tools and languages such as Flash, provide development of applications which are independent of platform and operating system, and are able to run client application no matter where you are or what machine is being used. Unlike previous "Open Systems" ventures such as those between IBM an Apple (1991), an operating system built on object oriented technology; the push for "Open Systems" has not seen the kind of success that the Internet has achieved in a relatively short period of time. In effect, it is becoming the catalyst for vendors, developers and users to work towards more "open" technology.
- **Promote Reuse:** Scripting programming language promises a new generation of Internet applications that is an example of a true application of object technology. This promotes reuse of objects like assembly blocks when constructing applications.
- **Accessibility:** Even though Internet has been around since 1969, it did not exactly take off until 1992 when the World Wide Web (WWW) came about, a collection of servers working together to form a graphically-based hypertext network. It is through this user interface that the Internet suddenly becomes

accessible to a global community without barriers of language, culture or geographical distinction.

- **Availability:** Today, the Internet has approximately hundred millions users and its exponential growth is expected to continue, with office networked computers expected to have Web access, people buying affordable Internet boxes, and home computers hooked up via Interne Service Providers.
- **Distributed Resources:** There is no need to rely on dedicated resources from one single source. The Internet technology actually addresses the problem of different platforms and operating systems, and have successfully developed protocols to enable different networks to communicate each other. One example of an overwhelming success of this technology is e-mail.
- **Development of Intranet:** The private uses of Internet technology within organizations are known as Intranets, which will provide a seamless application platform for users both inside and outside the organization.
- **Distribution of System/Installation, Version Upgrade and Maintenance:** Unlike Groupware, or other current technologies which have the problem of availability of client program, the right version for a platform and operating system, and keeping it up-to-date, Internet programs need little client-side maintenance.

7.3. Characteristics and Design of Web DSS

In this research, 'Web DSS' can be defined as a DSS on the Internet. Web DSS has a number of differences from the individual DSS and group DSS. Web DSS is connected through the Internet though open information communication. It aims to construct DSS surroundings for anyone easily. Anybody can obtain information for DSS.

Web DSS can make the best use of dispersion models and database which solves problems for decision support applicants or people in an Internet environment. To cover this space we must use a Wide Area Network (WAN) like Internet, which demands an open-door in taking advantage of decision support resources. Fig 7.1 summarizes the evolution of DSS into the Web DSS.

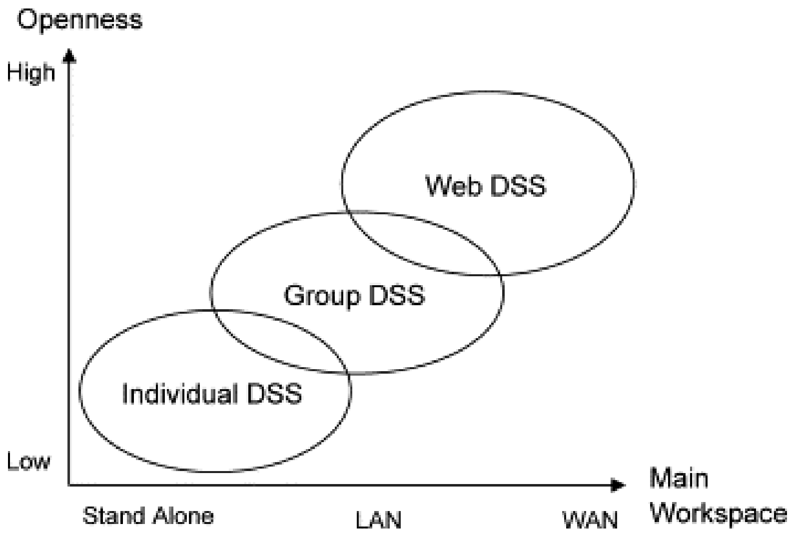


Figure 7.1 : Evolution towards Web DSS

Table 7.1 also describes the comparison between DSS, Group DSS, and Web DSS [37].

Table 7.1 : Comparison of three types of DSS

Individual DSS	**Group DSS**	**Web DSS**
Data base	Data base	Distributed data base
Model base	Model base	Distributed model base
User interface	User interface	HTML based user interface
Individual decision maker	Multiple decision maker	Individual or multiple decision maker
	Group application S/W	Intelligent agent, internet

7.3.1. Web DSS should be usable, useful and used

Research in the DSS area always addresses decision problems, or decision processes, and aims at giving an answer in the form of a computerized artifact to support decision making. In doing so, systems proposed or developed first have to be *usable*; this means that a dialogue understandable by anyone provides ways of getting added value with respect to a decision to be made. However, a Web DSS might be the answer to a non-problem, or give answers based on assumptions that do not correspond to reality, or more frequently, potential users discard it because it lacks important aspects of the decision situation that deciders consider unavoidable.

Therefore, some systems might not be considered *useful*, whether for good or bad reasons. But most DSSs built can be considered useful, or potentially useful. Web DSS might be *used* in the day-to-day organizational context.

A designer can not blame users, managers, executives, or the organization for their inability to understand how useful a system might be. The designer has to put social context in the design methodology from the beginning, and not only during a short period early on when getting data on their needs or behavior. If we regroup under the term "users" that is the set of people and groups for whom the designer works, a constant reference to and participation of users in the whole design process is a necessary. Requirement of users is measurement of success.

7.3.2. Web DSS Design can not be separated from implementation

Design refers to the intellectual process of building up a map of the system conceptually which will be physically built. It is obviously common for designers to take the context which might include the organizational setting, the financial limits, on the technological possibilities into account. These contexts are considered to be constraints to be fulfilled in the end rather than input and components of the design work. If designers aim at producing a Web DSS which will ultimately really be used, then the implementation phase should be planned early in the design.

7.3.3. Web DSS Design is a Change Process

Like many applications of technology to business management, DSS must be seen as the careful planning of the interactions between the technology introduced, organizational structure, activities carried on and behavior of the actors [38]. Success in Web DSS design and implementation means that the social and the technical processes which take place have been carefully managed.

Courbon and Bourgeouis (1980) summarized the various approaches identifiable when trying to couple these two processes and Figure 7.2 shows these two processes [12]. The technical process can be summarized as a first phase in the analysis of the decision situation and ends up ultimately with the evaluation of the system designed, built and used. The social side is a process which is starting with an "awareness" phase. Users knows that some new computerized system is being studied, it is initiative for such a system was taken by the organization. Some social discussions will take place; they will progressively freeze into some attitudes or expectations regarding the final delivered system.

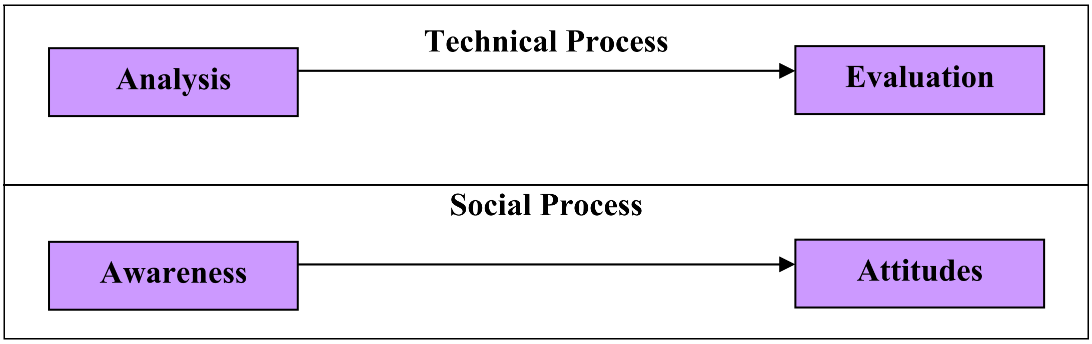


Figure 7.2 : DSS Design and Implementation as a Socio-Technical Process

The main question for the designer is therefore to manage and couple these in order to end up with a final situation where *evaluation* of the system (result of the technical process) is as close as possible to *attitudes and expectations* of users.

There are four main approaches for coupling the technical and social change processes. These approaches are technocratic approach, system's analysis approach, participative approach, and evolutive approach.

7.3.3.1. Technocratic Approach

The *technocratic approach* consists of sequential coupling beginning with the technical process. The designer somewhat "knows" what is good for the users and builds her/his system before any of them knows what is going on. The challenge is then to manage social process later by having users informed about a new system and discuss it so that they come to expect a system with the characteristics of one already available. There are cases where this approach can work, but chances are not users who do not follow the direction of the project manager. In Figure 7.3, technocratic approach can be seen as follows [12].

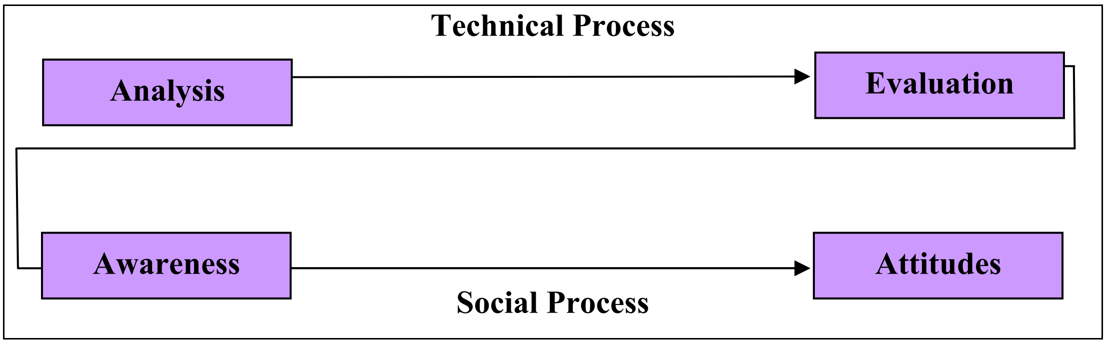


Figure 7.3 : Technocratic Approach

7.3.3.2. System's Analysis Approach

The *system's analysis approach* recognizes that user input is necessary, and couples the two processes sequentially, but does it the other way around. Users are present early on and actually no technical process takes place before users come to an agreement on what the system should do. When the social process is completed, then the designer gets a set of system specifications and s/he expects the users to wait for the specialists to go into their technical process of analysis up to delivery and use quietly. The question in this case is how to freeze this social process, especially if the technical life cycle is long: will not users continue to discus, or change their expectations and attitudes? Figure 7.4 represents the system's analysis approach [12].

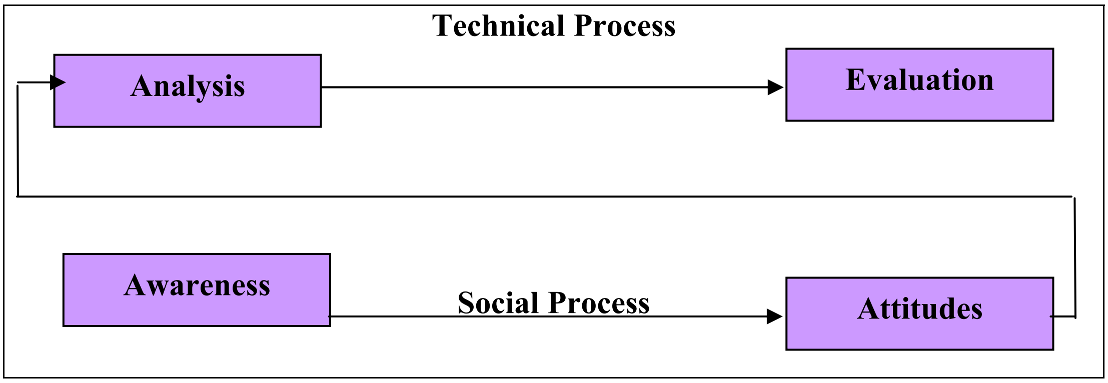


Figure 7.4 : System's Analysis Approach.

7.3.3.2. System's Analysis Approach

The third approach is the *participative* one. There is recognition that these two processes have to be managed parallelly rather than sequentially, that users have to be present at each stage, and that the life cycle of the technical process will permanently be enriched by participation and feedback from users. The chances of a correspondence between the evaluation of the system and users' expectations are often increased. Figure 7.5 illustrates the participative approach [12].

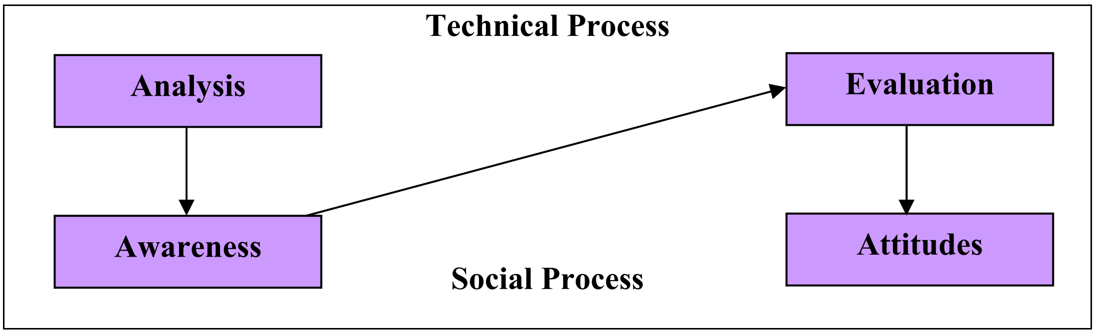


Figure 7.5 : Participative Approach.

7.3.3.4. Evolutive Approach

The evolutive approach is an extension of the participative one [12]. The iterative process is expressed by the loop through the four stages of the technical and social processes, which are therefore coupled in a continuous fashion rather than sequentially or in parallelly. Hopefully, the recurring phases of the active user's participation at each cycle will close the gap between his/her expectations and the final stabilized system delivered.

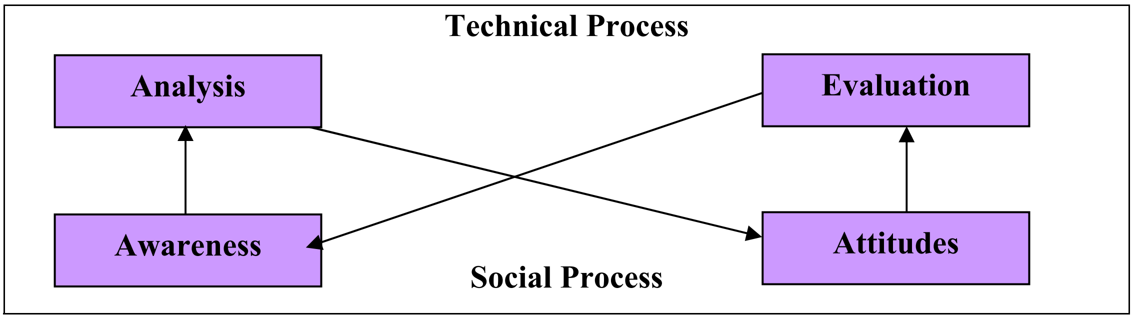


Figure 7.6 : Evolutive Approach.

7.3.4. Decision and Web DSS Design are both Learning Process

A closer look at the last approach in the preceding section, it points to an interesting aspect of what a user-centered approach really is. Each cycle or interaction in prototype building is in fact a sequence of 1) *action* – whenever the designer implements a new version and the user works with it – and 2) *reflexion*, i.e. the feedback where the user and the designer think about what should be done next based on the preceding active use.

Action and reflexion are the two basic components of learning. In Piaget's terms, we acquire knowledge, starting from the date of our birth, by a first mechanism – *accommodation* – where we learn from "objects" we interact with and from which we empirically build adapted responses, or routines, to them ("schemes" as Piaget call them). Then, a second mechanism takes place – *reflective abstraction* – which happens when a mental reconstruction of all the schemes at a new level of abstraction becomes necessary. There are also situations where new "objects" can not fit anymore with the available routines at a new level of abstraction to deal with these new, unmanageable situations.

User-centered design approach becomes dual learning process. On one side, it allows the designer to learn about the user, his/her problem and behavior; this gives the designer the opportunity to understand, the nature of the decision support to be provided more clearly. On the other hand, the user, through his/her repeated use and analysis of it comes to learn about the system progressively built, thus increasing the probability of appropriation of the DSS by the user. Moreover, during this process, the user will also learn about his/her decision making abilities and/or shortcomings. Often, being implicated in the design and implementation of the DSS will be, for the user, as valuable as the finished product.

7.4. Web-based Group Decision Support System

A Web-based Decision Support System (DSS) is built with Web technologies so that the DSS users access it with Web browsers via an Internet connection [9, 52].Web-based DSS applications developed by companies may be deployed on corporate intranets to support internal business processes or they can be integrated into public corporate Web sites to enhance services to trading partners [52]. Web-based DSS are mostly individual DSS systems [8, 17]. Web-based GDSS products, on the other hand, provide a more generic approach to solving more complex problems that are less structured.

GroupSystems, which is one of the first generation GDSS products, is client-server-based. It supports decision making over local area networks. It is maintained that Web supports collaboration, decision making and communication among distributed groups. However, few Web-based GDSS products are available due to the lack of user-friendly applications. TCBWorks, which was developed by Alan Dennis et al.

while at the University of George in the mid-1990s [14], was designed to allow group members to interact, discuss issues, and make decisions. TCBWorks that used the first generation Web technologies for building Web-based GDSS combined structured discussions and multi-criteria decision making into one tool and did not support group decision-making process.

There are many Web-based GDSS decision-making tools available. Facilitate.com 8.0 provides support to the group decision-making process with various types of tools such as Brainstorming, Categorizing, Voting, Surveying, etc., [21].

In this area, it can not be denied that there are also challenges of supporting distributed groups which are faced with. It can be said that it is difficult for distributed groups to arrange face-to-face meetings or to meet at the same time virtually. Collaborative tools need to support either synchronous or asynchronous modes of communication, or both. Therefore, Web technologies are used to build these tools rather than using, client-server technologies. The need for group decision support for distributed groups and lack of affordable Web-based GDSS systems have motivated us in developing our Web-based GDSS system. Thus, we can guide research on the decision and collaboration behaviors of distributed groups.

İTÜ – Web Group Decision Support System (İTÜ- Web GDSS) was developed as a Web-based group decision-making and decision-support system for distributed groups. The architecture and design of İTÜ- Web GDSS is presented in the next section.

8. İTÜ – Web GDSS: The Architecture and Design of a Web- based Group Decision Support System

İTÜ - Web GDSS, which uses Analytical Hierarchy Process model in decision process that is for multi-attribute decision making, is a Web-based Group Decision Support System. İTÜ - Web GDSS supports users to decide on their own specified goal. It also provides users to observe their own decision and group decision.

8.1. The Architecture and Design of İ.T.Ü. – Web GDSS

The architecture of İTÜ – Web GDSS is shown in Figure 8.1. The design and structuring of group decision processes have been shown to be an important element if distributed groups are to succeed. Therefore, groups meet for any project by sending e-mail to group members or sending messages to discussion board in İTÜ – Web GDSS.

İTÜ – Web GDSS is designed to support both group and individual decision making process. The support system uses Analytical Hierarchy Process for multi-attribute decision making process for any decision problem. It also provides asynchronous communication for group meeting such as sending e-mail, announcements, and discussion board.

The overview of the system is shown in the Figure 8.2. Users are classified into three different roles: system manager, project users and project managers. A system manager creates project managers and also manages project users. Therefore, there is only one system manager. A project manager creates the projects and selects the project members. Each project user has different projects and project managers because each project manager selects the group users oneself.

Before the project manager creates a new project, s/he announces the details, descriptions, objectives of the project in the Announcement of İTÜ – Web GDSS. Project manager asks project users to write their suggestions on the project in the Discussion Board after project folder is created by the project manager. When all the criteria and alternatives are discussed, the project manager creates AHP hierarchy tree and sends it to all selected project members. Project users evaluate the hierarchy tree by pair-wise comparisons of the project hierarchy elements. Project users observe their own decisions when evaluation is finished. Project manager creates group decision when all the group members finish their evaluation of the project. Then, project users can see the group decision. Group decision is calculated by using geometric average of the project users' pair-wise comparisons. Project managers have abilitiy to see, observe the project users' decisions. Project manager can see the project users' performances, time they spent on the project.

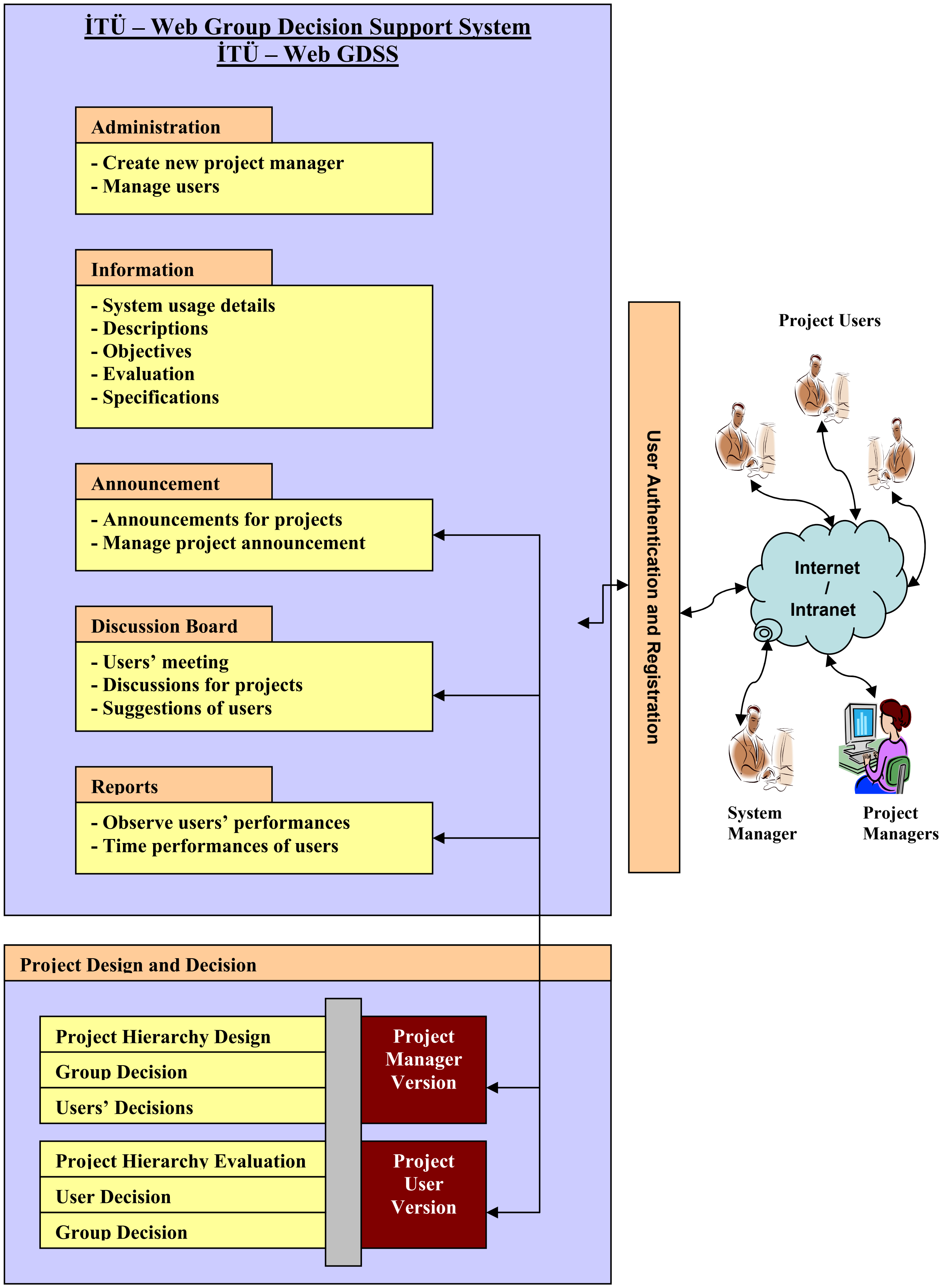


Figure 8.1 : The Architecture of İTÜ – Web GDSS

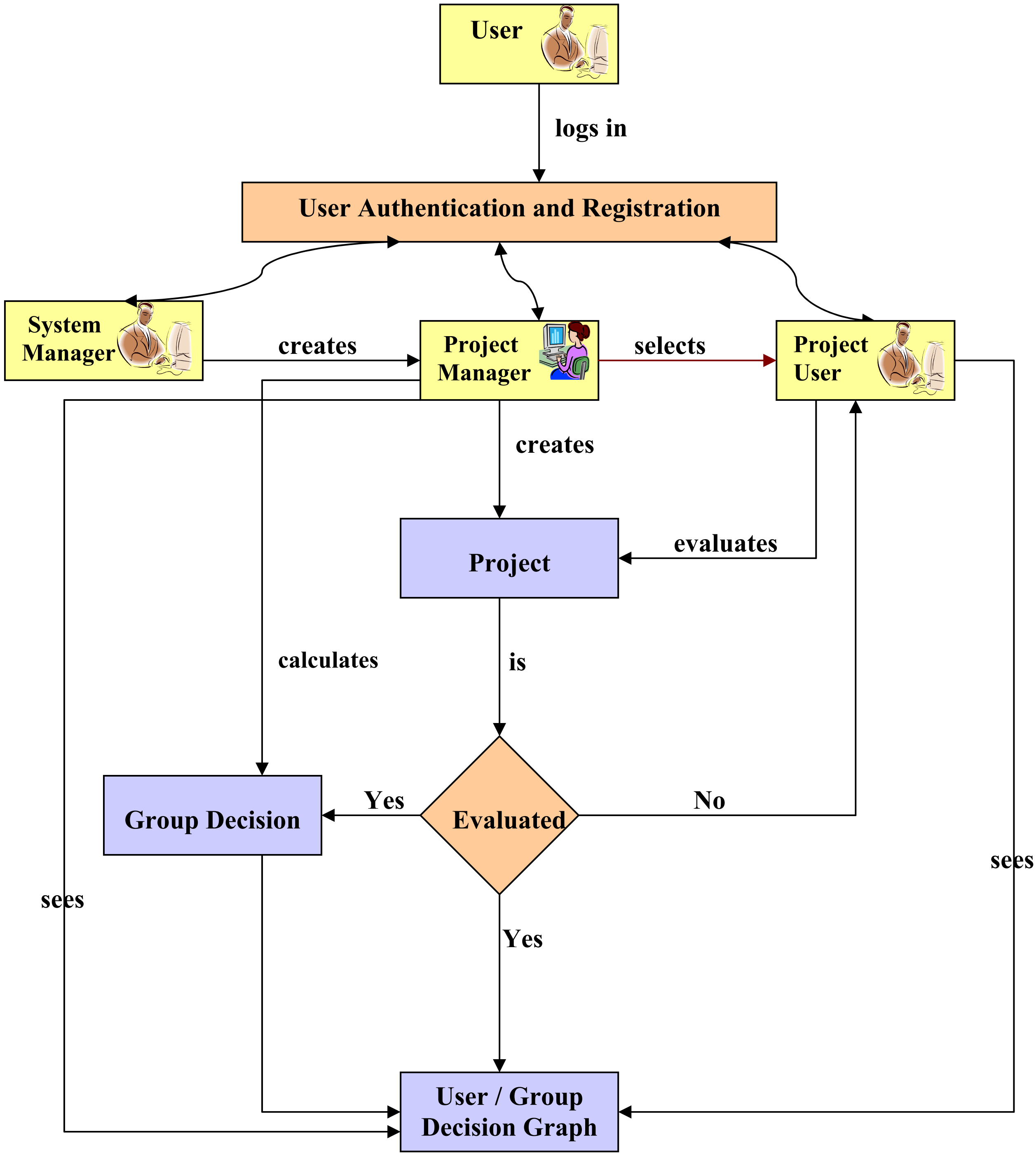


Figure 8.2 : Overview of Project Design and Evaluation

The major components of İTÜ – Web GDSS architecture is the following:

1. User Authentication and Registration: This function checks a user's username and password to determine the projects that the user can participate in or facilitate. It also allows new users to register themselves online, or they can be registered by a system manager, or a project manager.

2. Communication tool for Users: In the system, not only system manager sends e-mail to all users but also project manager sends e-mail to project users to contact them. In announcement, project manager announces the project and its details such as criteria and alternatives of the project hierarchy for multi-attribute decision making. After then, project manager creates a folder for the project of discussions, or suggestions of project users and project manager on the project details in the Discussion Board. If the project manager sends a message about project details, objectives, project users will reply to the message to provide suggestions on the project details.

3. Project Design and Evaluation: This tool provides project creation and evaluation. The project manager maintains the details of the project to be decided. Project period, project name and project hierarchy tree structure are obtained from the project manager. When project manager selects the project users, s/he sends the project to the project users. Then, project users are responsible to make pair-wise comparisons based on the criteria of the project. When project users complete their pair-wise comparisons, the calculations for the AHP will be done. Group decision will be created by project manager when all the group members finish their evaluations. The project manager checks the project users whether they have completed their evaluation procedures or not before creating the group decision.

4. Project Decision: User decision and group decision can be observed with 3–dimension graphical support. Project manager observes the group decision and project users' decisions of the project. In addition, project users not only see their own decisions but also see the group decision after it is created in 3 – D graphs.

5. Reports: Project manager controls the project user's project performance by observing the user's time spent in the project.

8.1.1. The Development Framework for İTÜ – Web GDSS

The traditional DSS development framework proposed by Sprague includes user interface, database, and model base [69]. The development of İTÜ – Web GDSS is consistent with the traditional DSS development framework. Special considerations for İTÜ – Web GDSS development based on the framework are discussed in the following:

1. User Interface: The Web-based GDSS's user interface consists of UI elements (i.e., Web pages) for end users, managers, and system administrators. In İTÜ – Web GDSS, the traditional notion of a "public screen" concept is implemented via "group view"" to allow users to switch from an individual workspace to a group view to observe group results. Pop-up browser windows are used to keep the active browser window open to simulate project pages such as hierarchy, graphs in the traditional Windows environment. ASP Web pages are used to create dynamic Web pages. ASP Web pages provide interaction between users and the system dynamically. HTML frame is used in the creation and evaluation of the project. Flash MX 2004 helps to provide interactive user interface while the manager is creating project hierarchy for AHP of the project and user is evaluating the project. Decision results also can be supported by 3 – Dimension graphs that are created by Flash MX 2004 to show user friendly interface. Animated help Web pages that are created with Flash MX 2004 are available to guide users in İTÜ – Web GDSS.

2. Database: A relational database is used to implement the projects in İTÜ – Web GDSS. A project that is contributed by the project manager is created and stored with a project ID. Therefore, it is possible to recreate a private screen for the individual user and generate a group view based on projects that are created before. Project hierarchy tree which is created by manager has an objective, criteria, alternatives for any project. All the elements of the project hierarchy tree are created and stored with a project ID in XML file. Project users' judgments and evaluations are all stored in XML file. XML file is used to maintain users' data and to create a hierarchy tree easily. ASP.NET Web page is used for AHP calculation of the project according the project users' judgments. In addition to this, ASP.NET Web page is used to create group decision by calculating geometric average of users' judgments. Microsoft Access, DBMS software provides the concurrency control of data accessed by managers and users.

3. Model Base: In İTÜ – Web GDSS, Analytical Hierarchy Process is used for multi-attribute decision making. Projects are evaluated or decided according to AHP model based on the users' judgments. All the calculations for AHP are described in Section 4. Project managers need to set up the project hierarchy tree by using interactive ASP page that is designed in Flash MX 2004. Project users evaluate the project user version of the same page. When users' decisions are calculated, Project Decision Web page which is designed in Flash MX 2004 could be observed. It supports the 3 – D graphs and texts. Users can see their own project decision result. If all the project members finish their evaluations, project manager will calculate the group decision. Group decision is created as calculating geometric average of the project users' judgments. After all, group decision can be viewed by project users and project manager. Project manager also observes project users' own decisions.

İTÜ – Web GDSS is designed and implemented as an integrated, communications-driven DSS with various subsystems to enhance its functionalities. It has communication-driven DSS features because it supports decision-making activities by connecting decision makers who might be separated in space or time via a set of group tools to share opinions and decisions in an integrated environment.

8.1.2. Implementation of İTÜ – Web GDSS

İTÜ – Web GDSS is developed in different types of implementation language. ASP, JavaScript, HTML programming languages are used to create dynamic Web pages for decision support such as Announcements, Discussion Board. ASP.NET using Visual Basic.NET as the implementation programming language is used for AHP calculation of the project. Group evaluation and user evaluation which are created with using ASP.NET pages are calculated according to AHP. User judgments and group judgments are saved in a XML file under the project folder that is named as project ID. When the user or group judgments are calculated, results will be saved into the XML file. In addition, Flash MX 2004 is used for creating project hierarchy, evaluation of project hierarchy, and project decisions. Action Script Programming language for Flash MX 2004. İTÜ – Web GDSS can be deployed on a computer running Microsoft Windows 2003 Serve Web Server with Internet Information Server (IIS) and Microsoft.NET Framework SDK installed. Managers and participants only need to use Web browsers to manage projects or participate in group decision. Limited client-side JavaScript, ASP code is used in the implementation of İTÜ – Web GDSS to provide local data validation to reduce the unnecessary interactions between the Web client and the İTÜ – Web GDSS programs running on the server.

İTÜ – Web GDSS is implemented as an internationalized software product. All the string literals of various pages, including error messages, are externalized and stored in resource files. Currently, an English version and Turkish version are built.

8.2. Storyboard for İTÜ – Web GDSS Design

The title of the web site is İTÜ – Web Group Decision Support System. The homepage has user name and password text boxes where a user must enter to login to the İTÜ – Web GDSS. To create a user account, the user can reach the web site by entering its address to the browser in the Internet.

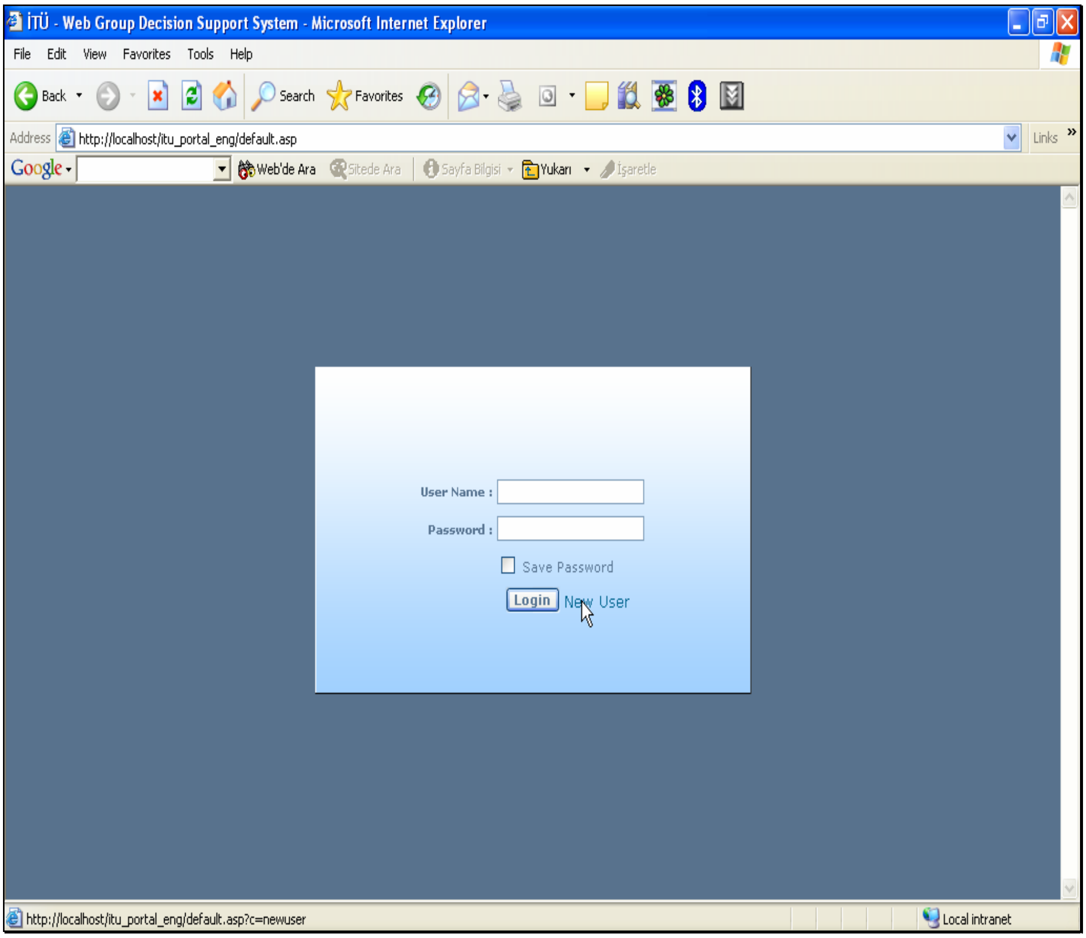


Figure 8.3 : Home Page of İTÜ – Web GDSS

Clicking "New User" link provides the user to get a new account for İTÜ – Web GDSS. When the user clicks the link, the new web page where the user must enter the user details into the system to get an account appears as seen in Figure 8.4. User enters a user name, a name, a surname, an e-mail, a secret question and an answer for the question. If a user chooses user name that is chosen before, the warning message which is "The user name you have requested is chosen by another user before, please choose a different user name" will be seen in the web page.

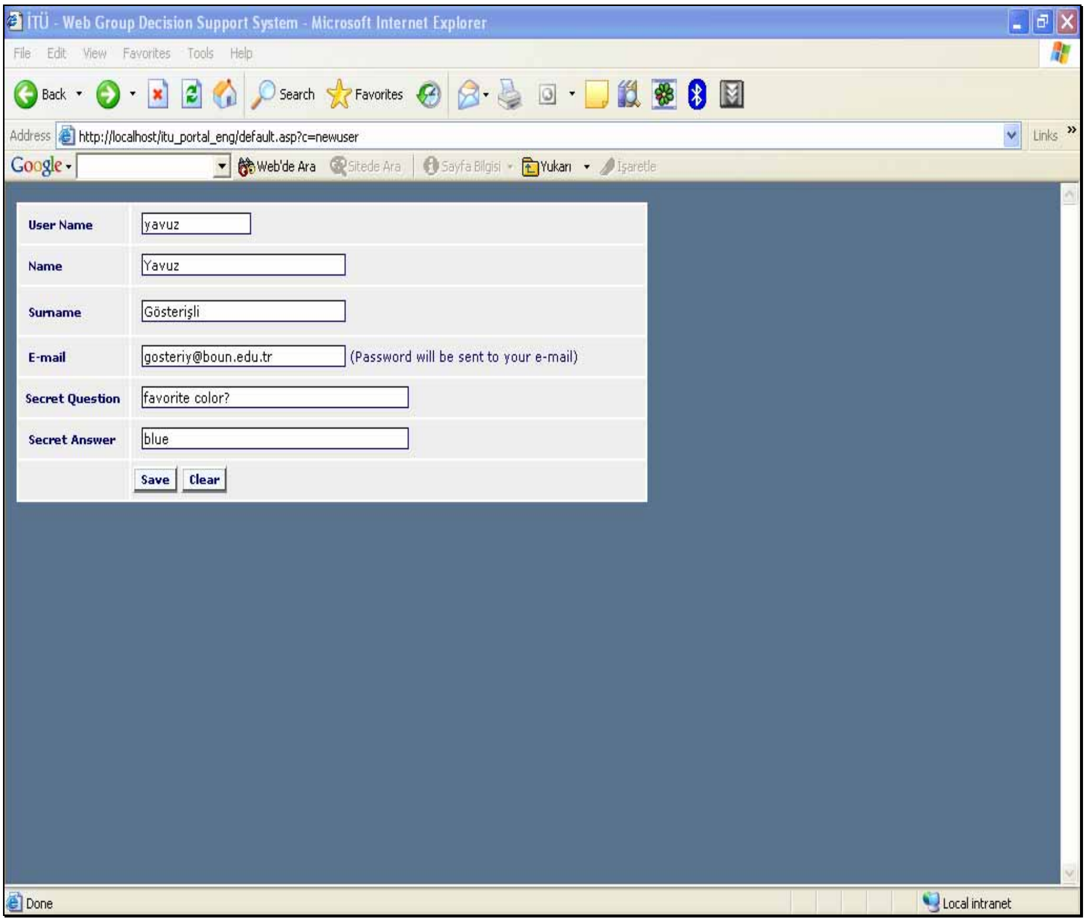


Figure 8.4 : User creates account

A user must fill the fields that can not be blank to create the user account. There are different types of warnings which can be activated are "User Name can not be blank", "Name and Surname fields can not be blank", "E-mail address is invalid" if there is a problem while the user is saving user account details. If the user saves his/her own account details, a user password that is created automatically by the system will be sent to the user's e-mail address. Now, the user is ready to login to the İTÜ - Web GDSS. If a problem occurs in sending password to user, warning message which is "Your password could not be sent to your e-mail address due to system failure:YEl7SegU. <<-- Click here to Log in! --> Your registration is successfully completed, your password will be sent to your e-mail address." Will be seen and password will be observed by the user.

İTÜ – Web GDSS has tree different types of users who have different responsibilities:

- System Manager
- Project Manager
- Project User.

8.2.1. Storyboard for System Manager

When a system manager logs in the İTÜ – Web GDSS, System Administration Page, where only the system manager can open appears. As it is mentioned before, the system manager has responsibilities and abilities while the manager is using İTÜ – Web GDSS. Home page which is seen in Figure 8.5 for the system manager welcomes the system manager, and it also shows the last log in date of the system manager.

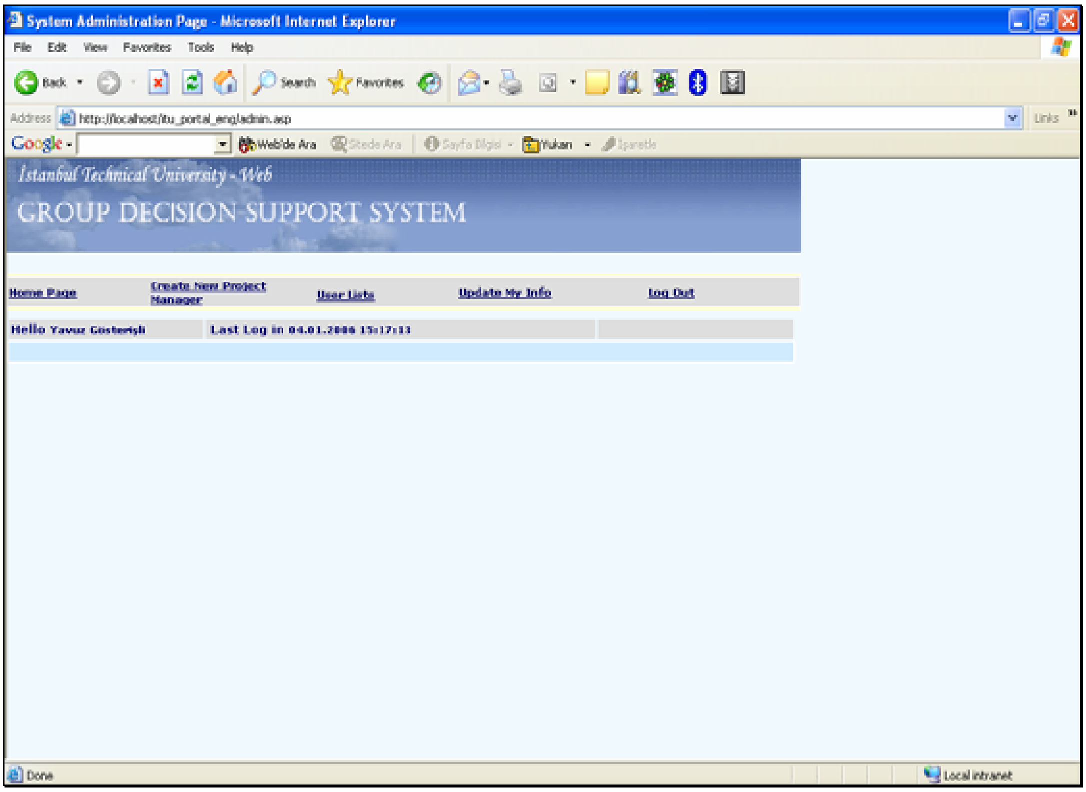


Figure 8.5 : System Administration Page

System Manager's Abilities or Responsibilities in İTÜ – Web GDSS in Figure 8.10:

- Creating a new project manager
- Updating his/her own information
- Listing system users
    - Sending e-mail to users
    - Updating user's information
- Log out

A system manager may create new Project Manager after clicking "Create New Project Manager" link. When "İTÜ – Web Group Decision Support Systems – Add New Project Manager" page appears as in Figure 8.6, the system manager creates a new project manager by entering the project manager's information.

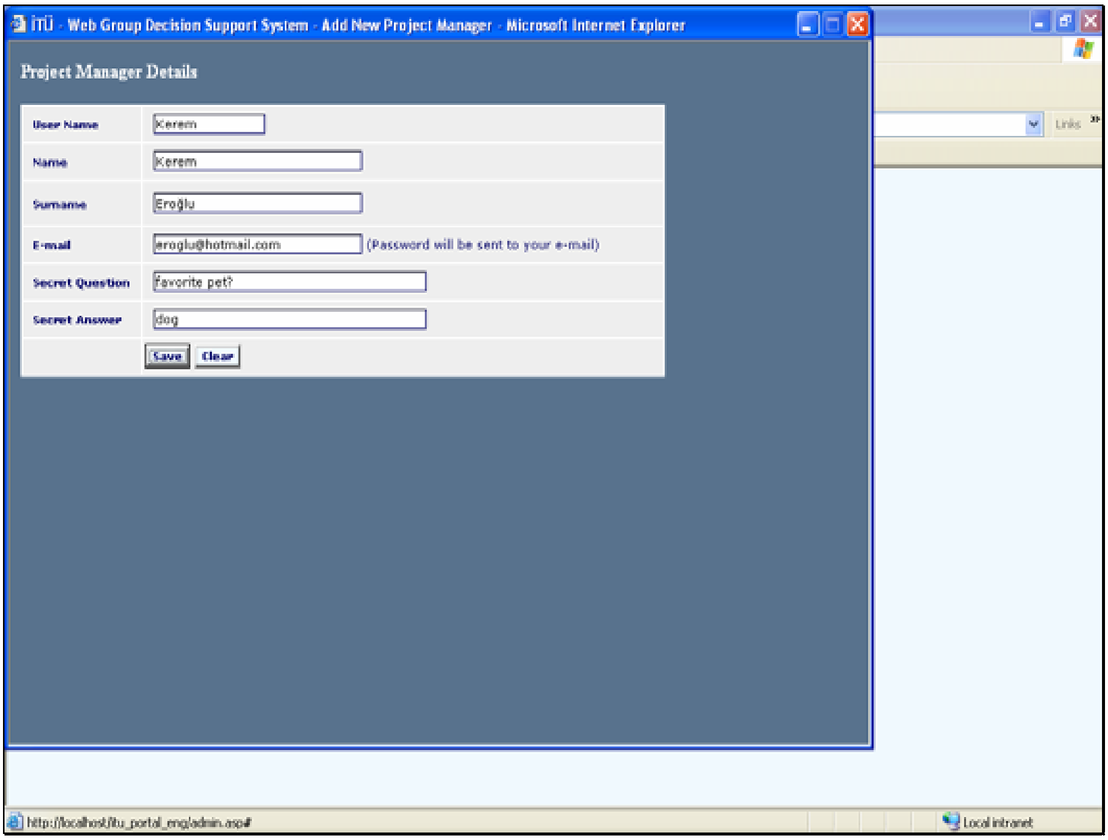


Figure 8.6 : İTÜ – Web Group Decision Support System – Add New Project Manager Page

The system manager must fill the fields that can not be blank to create project manager account. There are different types of warnings like "User Name can not be blank”, “Name and Surname fields can not be blank”, “E-mail address is invalid” if there is problem while system manager is saving project manager’s account information. These warnings appear on the screen. If there is no problem in saving project manager’s information, project manager’s password that is created automatically by the system will be sent to the project manager’s e-mail address. When the password is received, project manager will be ready to login to the İTÜ - Web GDSS.

The system manager can also list system users in İTÜ – Web GDSS by clicking “User Lists” link from the menu. Users’ List page appears in web browser as shown in Figure 8.7. Therefore, system manager observes the users’ list which includes user’s details such as user name, name, surname, status, and e – mail address. As it is mentioned, there are three types of users which are System Manager, Project Manager, and Project User. Status shows the user type in the system that the user belongs to.

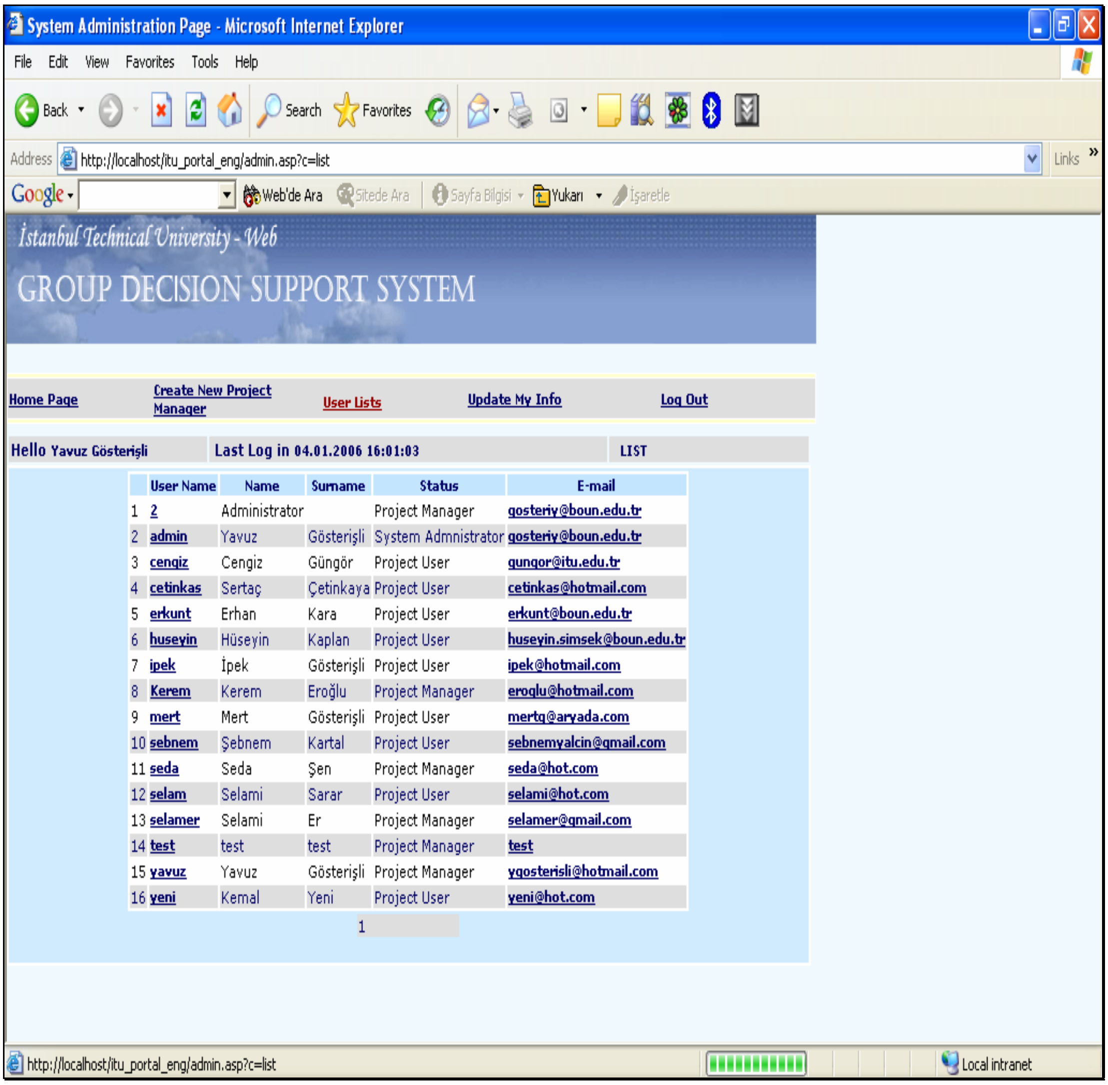


Figure 8.7 : Users List Page

The system Manager can update user information by clicking the link under the "User Name" column for any user. When the system manager clicks on any user name link, the "Update User Information" page will appear as it is in Figure 8.8.a. When updating information is completed successfully, feedback will be seen at the same page. Warnings are also seen in this page if there are problems in updating failure.

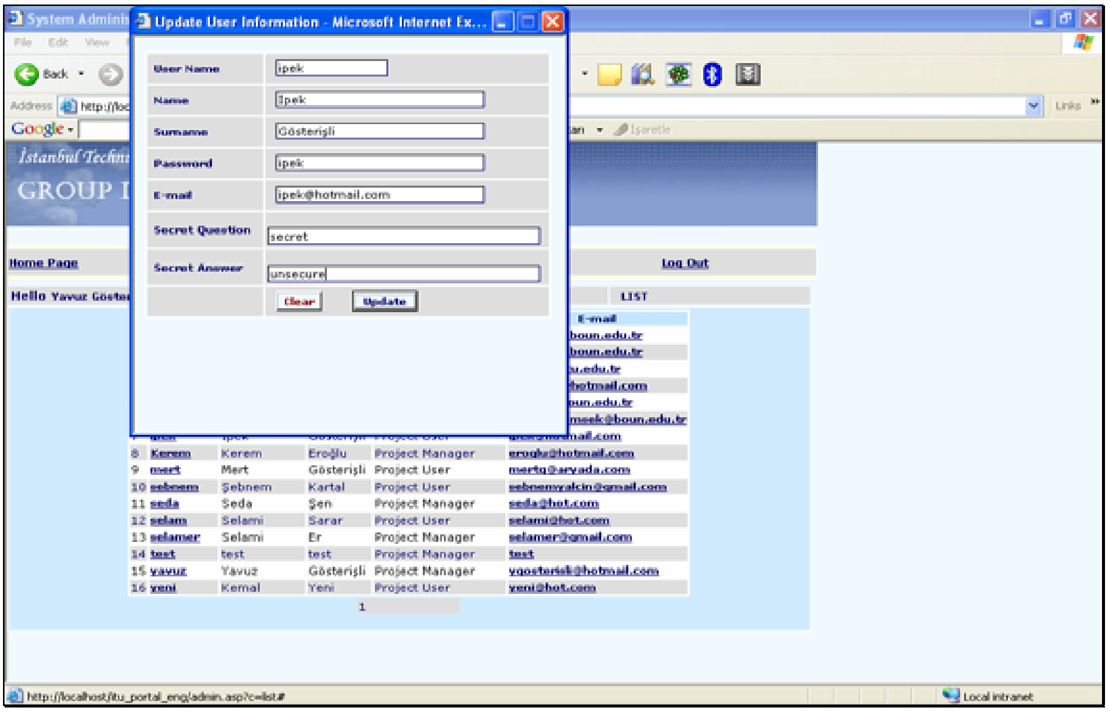


Figure 8.8.a : Update User Information Page

System Manager can not only update user information, but also can send e-mail to a user. System Manager sends e-mail to a user by clicking user e-mail link under the column of "E-mail" in Users List Page in Figure 8.7. "Send E-mail" page appears as it is shown in Figure 8.8.b.

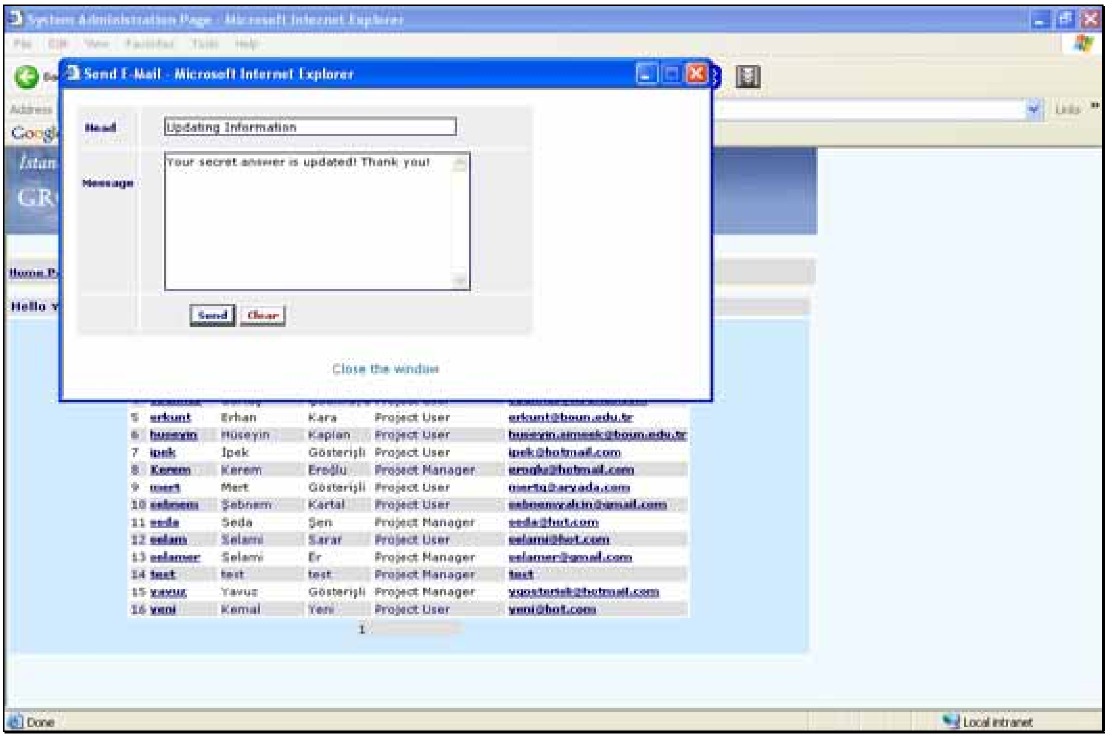


Figure 8.8.b : Send E-mail Page

If the System Manager needs to update his/her own account information, s/he must click “Update My Info” link from menu in order to edit account information. Only Password, E-mail, Secret Question and Answer fields can be changed by the System Manager. User Name, Name, Surname fields can not be changed as shown in Figure 8.9.

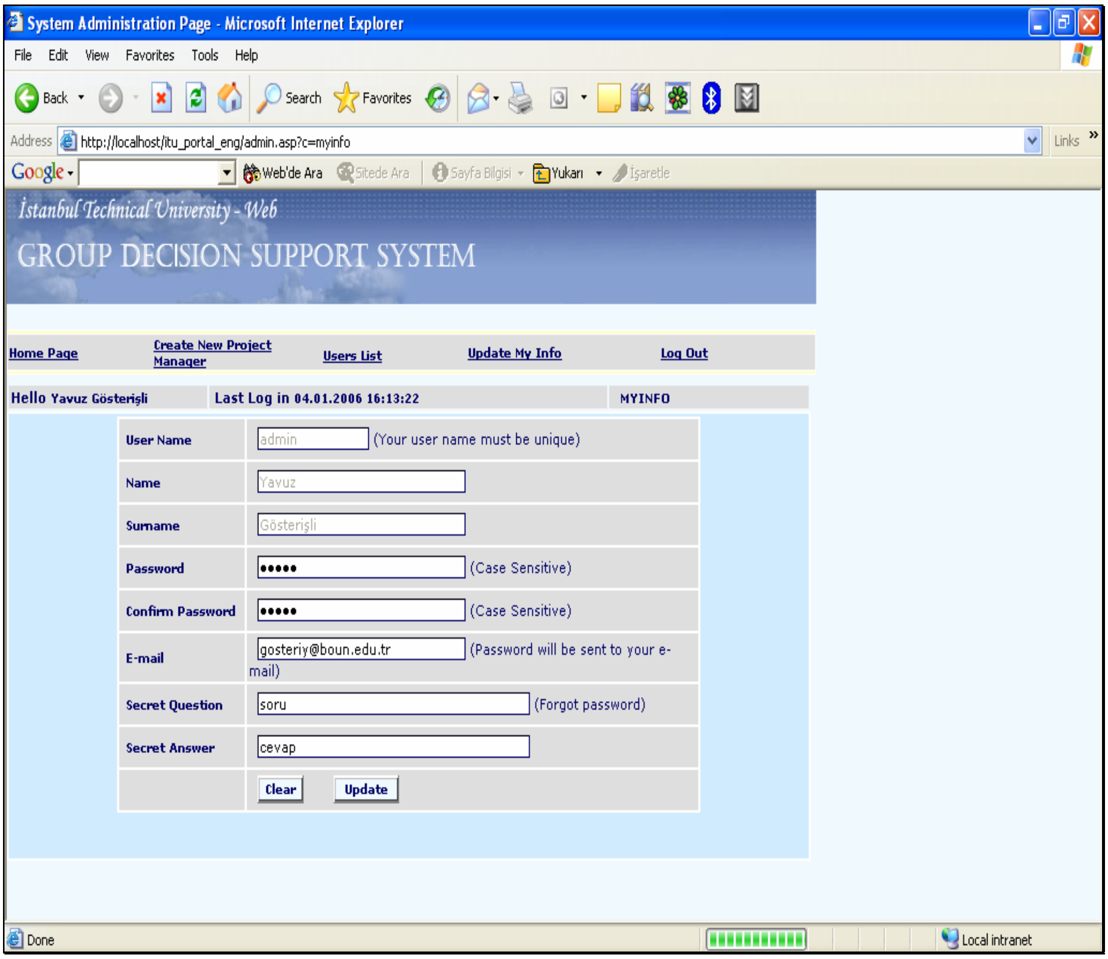


Figure 8.9 : Update My Info Page

System manager logs out to log off the system by clicking on “Log Out” button in the menu. Thus, Home Page appears in the user browser as in Figure 8.3.

The System Map for System Manager of İTÜ – Web GDSS:

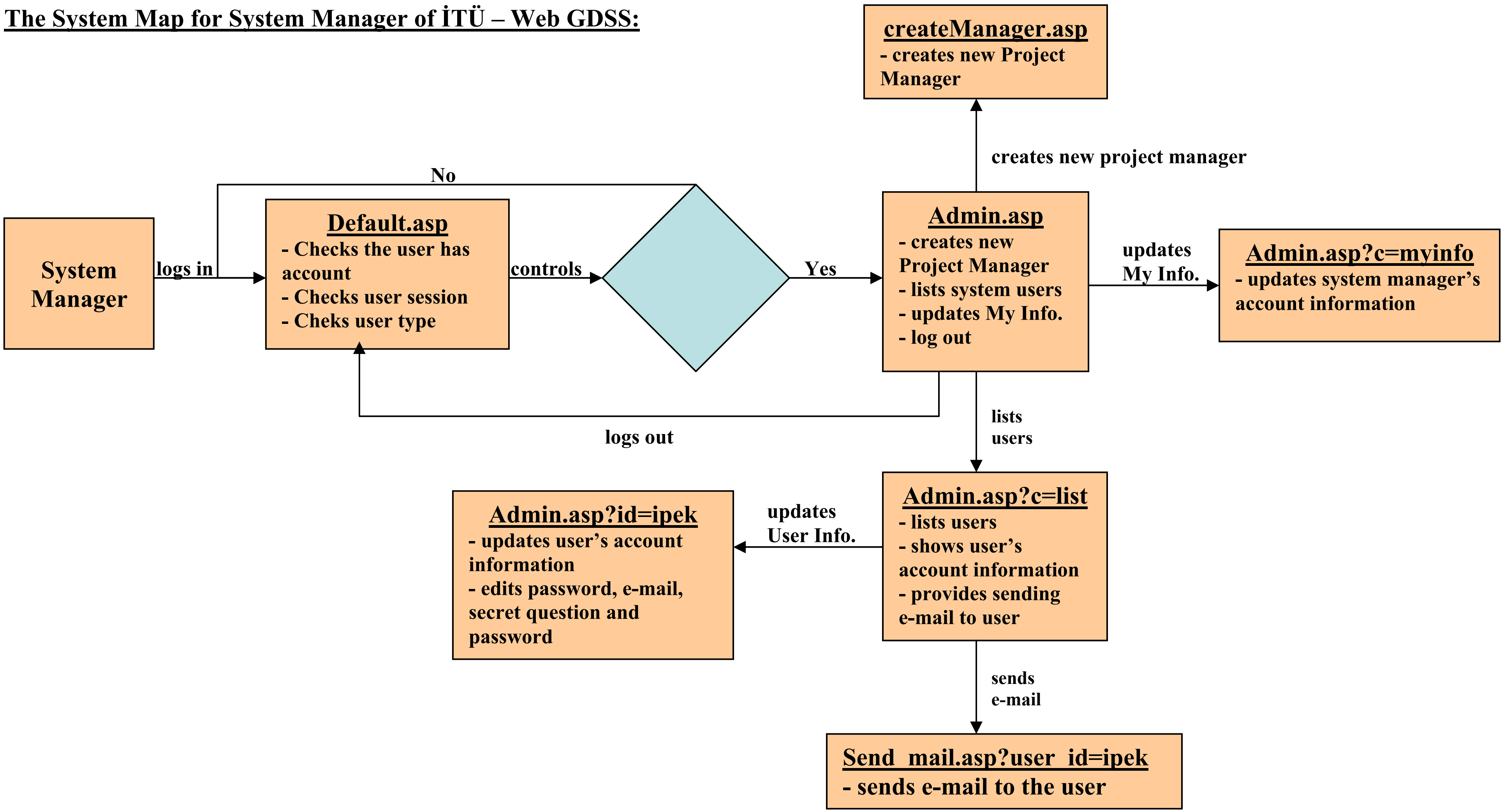


Figure 8.10 : The System Map for System Manager of İTÜ – Web GDSS

8.2.2. Storyboard for Project Manager and Project User

When a project manager or a user opens the homepage of İTÜ – Web GDSS by entering its address to the browser in the Internet, the user will have to enter his/her own username and password to login to the system as shown in Figure 8.3. After the project manager entered the system, Project Design and Evaluation page for Project Manager opens as in Figure 8.11. If a project user enters the system, Project Design and Evaluation page for the project user which is similar to project manager's page will be opened. Project user can only see the "Start" button because the project user has not allowed creating, editing, deleting a project and selecting users.

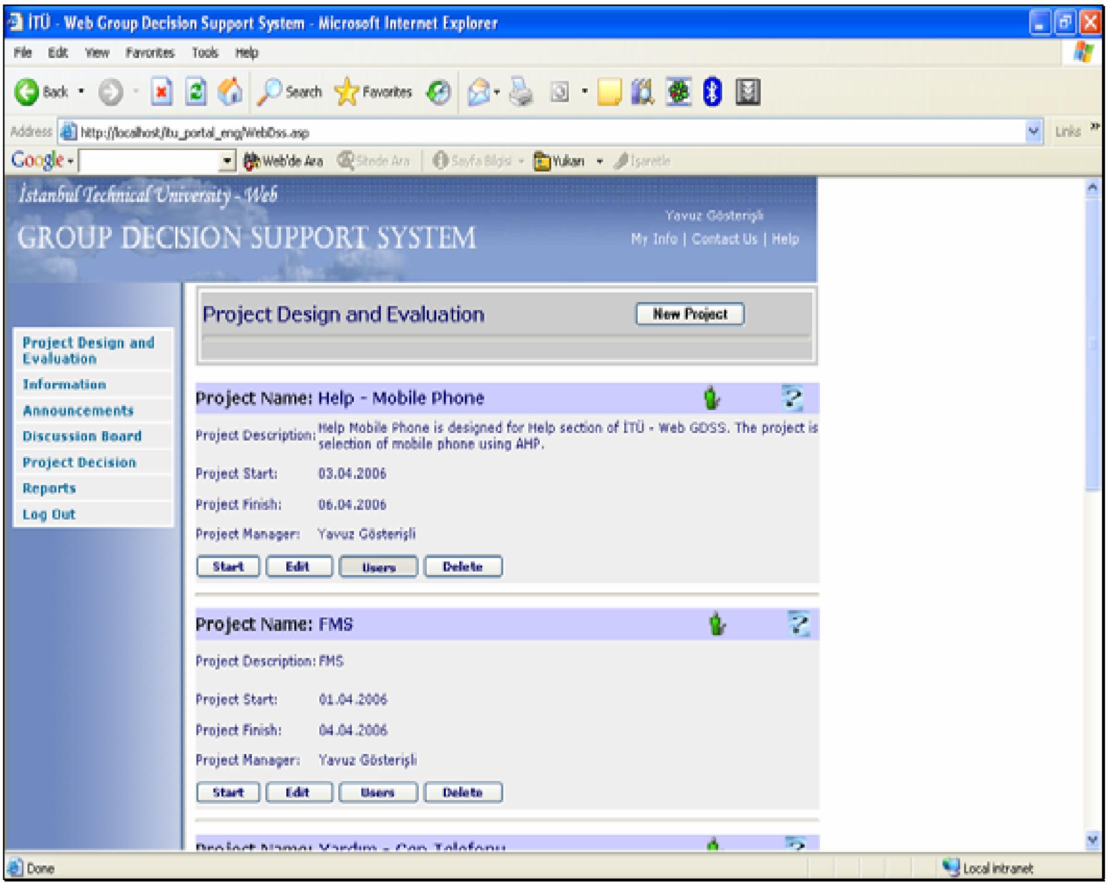


Figure 8.11 : Project Design and Evaluation Page for Project Manager

In Project Design and Evaluation page, the projects that are created by the project manager are listed with detailed information. At the top of page, the project manager or the project user can see his/her own name and surname until s/he logs out.The project manager or the user clicks on "My Info" link to open Update My Info page which helps the project manager or the user to edit information about oneself as in Figure 8.12. The project manager or the user may update information except user name because it is unique. Therefore, it can not be changed at any time after it is once created.

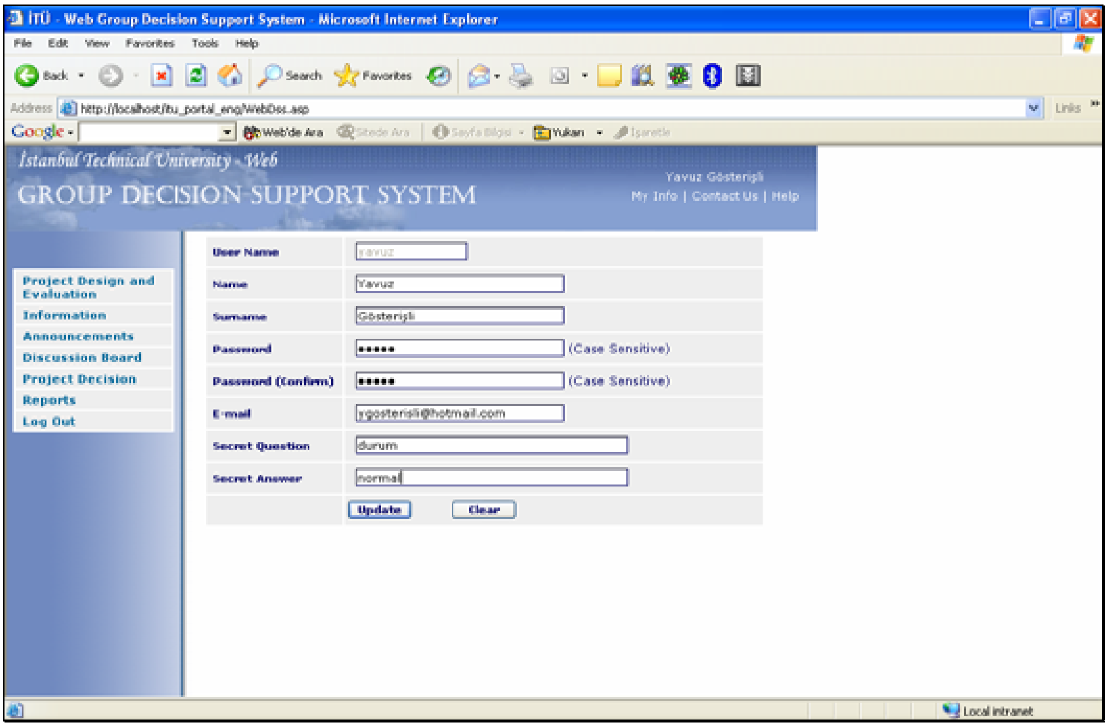


Figure 8.12 : Update My Info Page

Project Manager clicks “Contact Us” link to open Contact Us page which helps the project manager to send mail as in Figure 8.13.

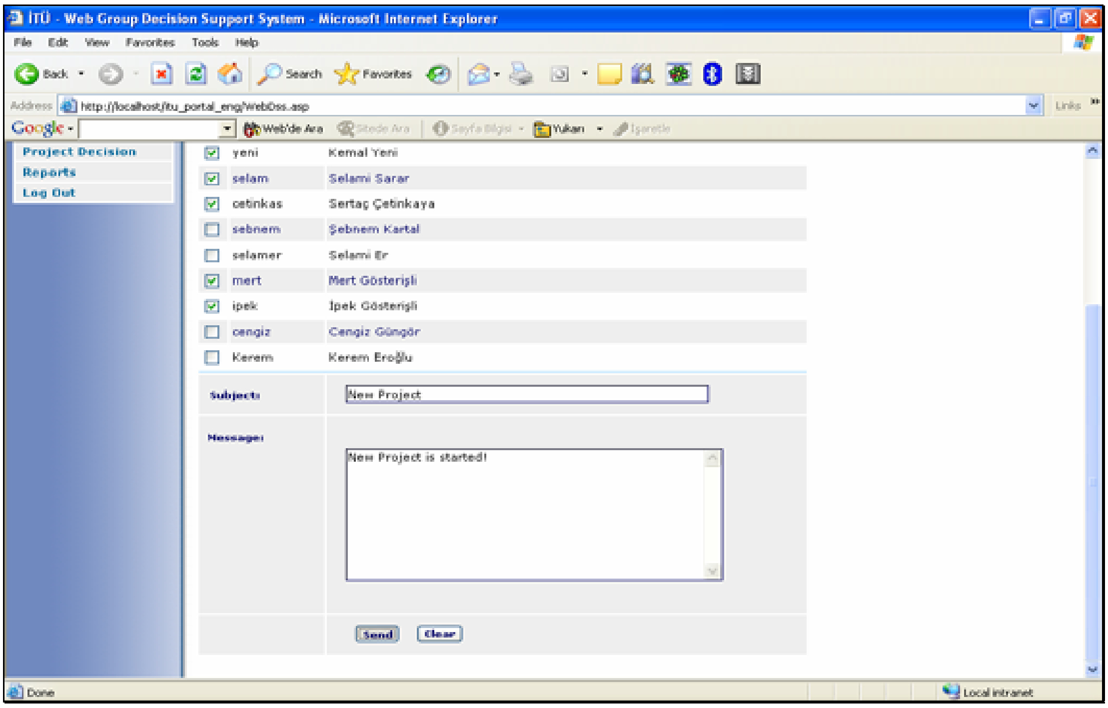


Figure 8.13 : Contact Us Page

System users are listed in this page. The project manager writes an e-mail to users. Then, the project manager checks the users to whom project manager wants to send an e-mail from check list of users. The project manager creates the mail and sends it to users that are selected by the project manager from checklist in Contact Us page as in Figure 8.13. The project user clicks “Contact Us” link to open Contact Us page that helps project user to send mail to project manager. But, the project user could not see users’ list to send mail to all users as project manager did in Figure 8.13. “Help” link provides useful help information for users.

In Figure 8.14, it can be considered that pages are indexed and each page has 5 projects. Therefore, it is claimed that page index provides navigation through the projects easily by users.

As it is seen, there are two icons of a man and a question mark used in this page. And also, there are two types of man icon: Green man, Red man icons.

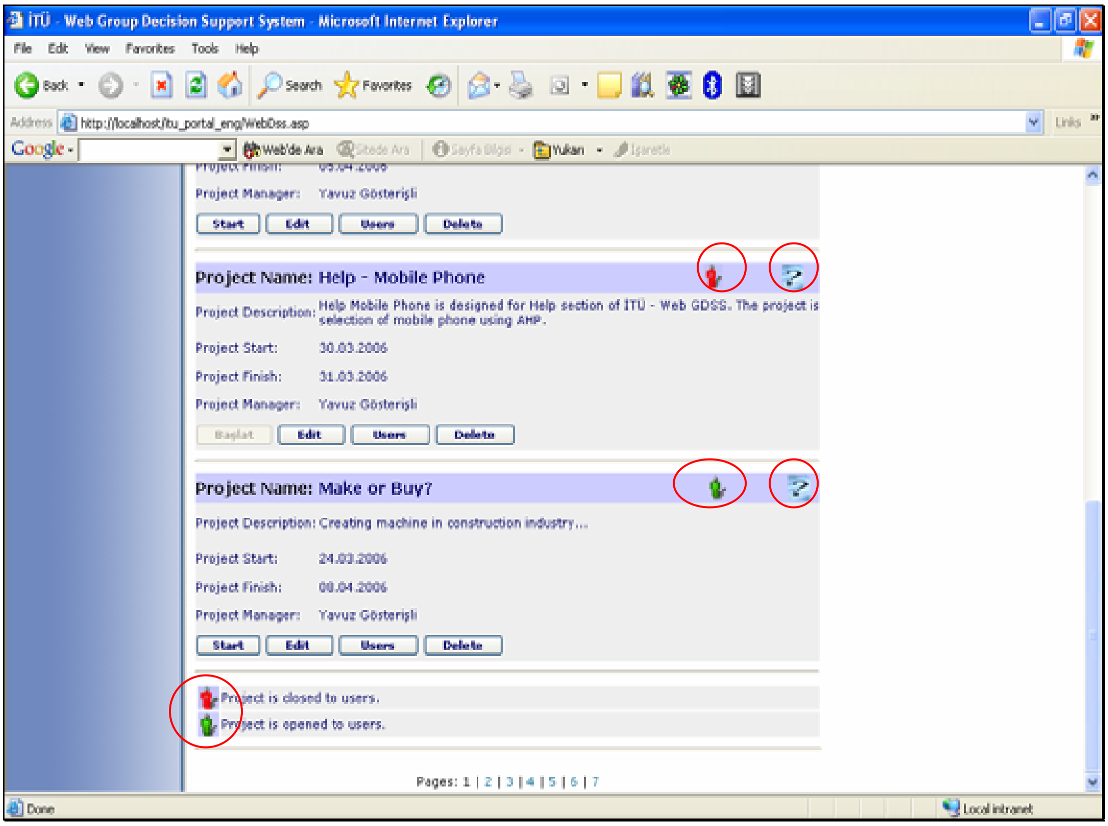


Figure 8.14 : Page Design for Project Design and Evaluation of İTÜ – Web GDSS

Green man icon means that the project is opened to project users. Project is not closed, so project users have rights to evaluate the project. Red man icon means that project is closed to project users. Project users could not evaluate the project because project period is exceeded. Only the project manager has the authorization to change the project time. If the project manager renews the project time, the color of man icon will turn from red to green. Visualizing exceeded project period provides users better understanding of project status, improves usability.

“Help” icon is linked to help page that provides the project manager to create a new project, and to create hierarchy; and it also provides the project user to evaluate the project. Help page shows the project manager actions animatedly how to create new project and create decision hierarchy tree for Analytic Hierarchy Process for the project evaluation. Help page for project user describes the evaluation of the AHP hierarchical decision tree of the project animatedly. Help pages are designed with Flash MX 2004 which enables creating animation, run on the web page as html format. Help pages use animation for all steps of using system. Animated Help pages help users learn system usage easily. In the Project Decision of İTÜ – Web GDSS, the same format, which is animated help, is used for “Help” pages.

8.2.2.1. Project Manager Creates New Project

Project manager creates a new project by clicking the “New Project” button in the Project Design and Evaluation page for Project Manager as seen in Figure 8.11. Project Details page for the new project appears in Figure 8.15.

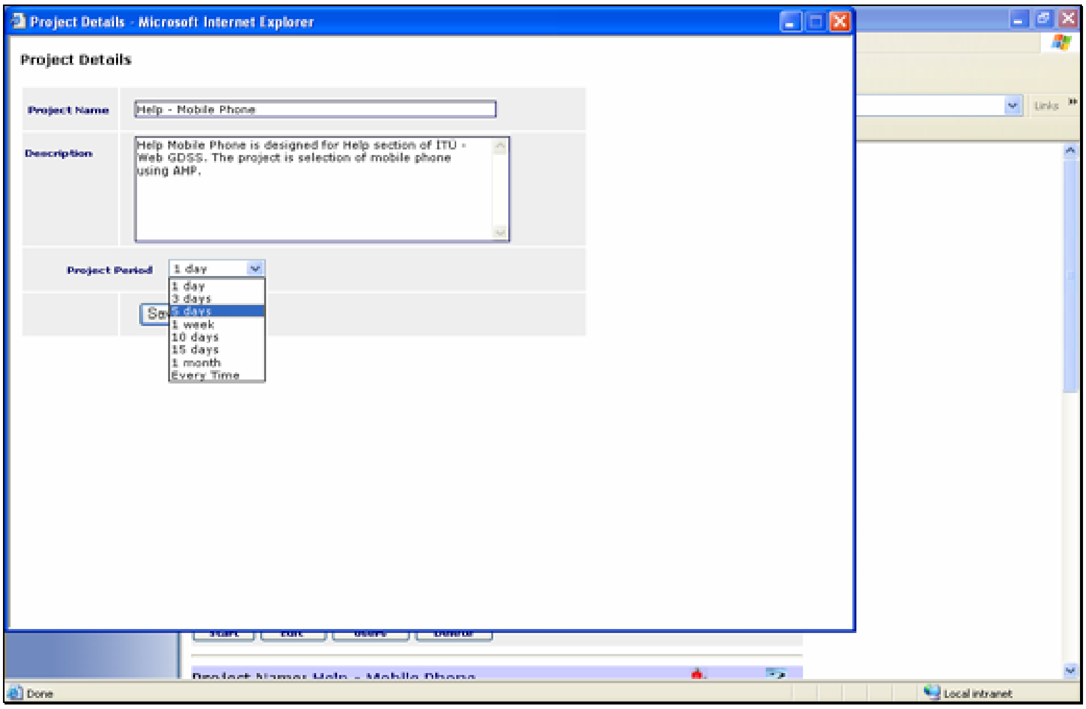


Figure 8.15 : New Project Details Page

Project manager fills up the textboxes for the project details such as project name, project description. Project Period can be chosen from the combo box that includes duration period from 1 day to 1 year (Every Time). When the project manager saves the project, the warning message “Project is Saved!” is seen. The new project can be seen in the project list from Project Design and Evaluation page as in Figure 8.11, if the manager closes the project details pop-up window. The project manager clicks “Users” button to select and add project users. Project manager selects users from users list in Users Page as shown in Figure 8.16. The manager can either delete or add any user for the project. When selection of users for the project is finished, manager closes the pop-up window.

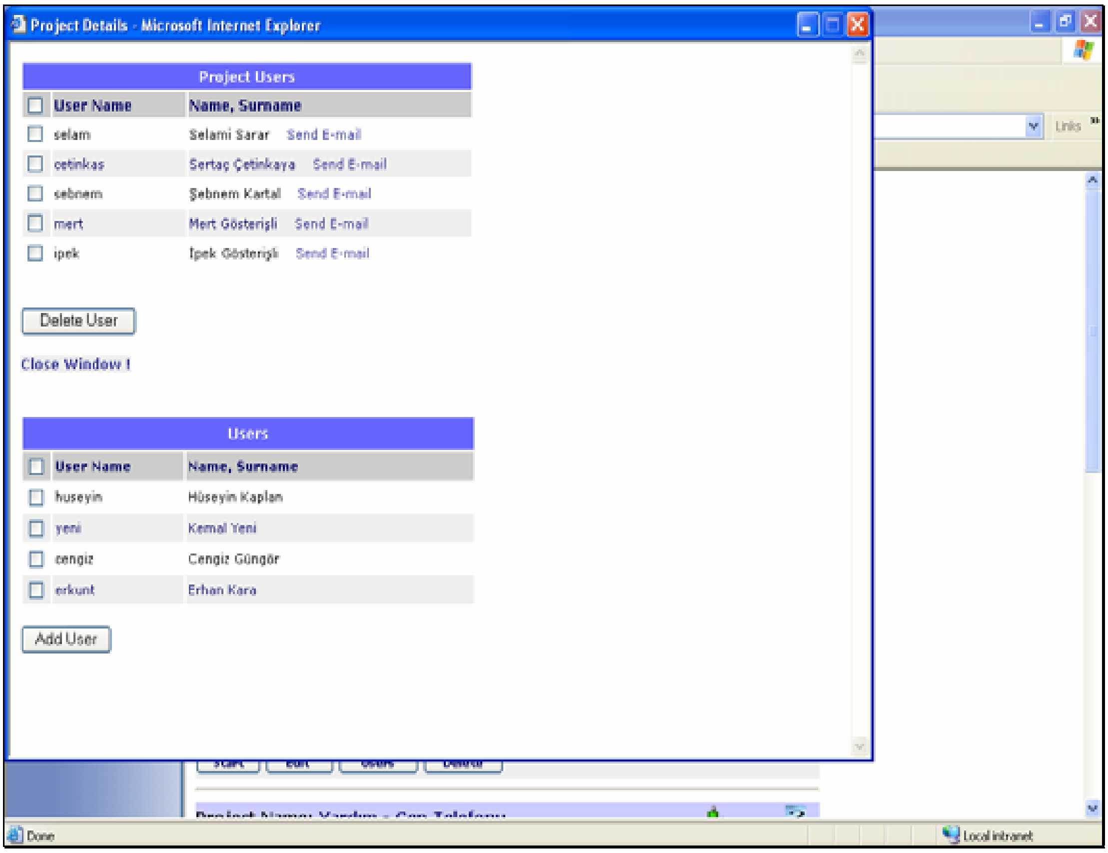


Figure 8.16 : Users Page

If Project Manager wants to edit the project details, s/he clicks “Edit” button in the Design and Evaluation page in Figure 8.11. Then, Project Details page appears in pop-up window in Figure 8.15. The project manager edits information about the project and saves it. If the manager wants to delete the project, it is necessary to click “Delete” button for the project. When the manager clicks the button, a warning message “Project is Deleted!” can be seen. By this way, the project is deleted from the project list in the Project Design and Evaluation page.

8.2.2.2. Project Manager Creates Hierarchy Decision Tree for AHP of Project

Project manager clicks “Start” button in Project Design and Evaluation page as it is in Figure 8.8 to create decision tree of the project for analytic hierarchy process evaluation. “Project Hierarchy” page appears as shown in Figure 8.17. Decision makers have to deal with reaching a goal or deciding with respect to the criteria and alternatives.

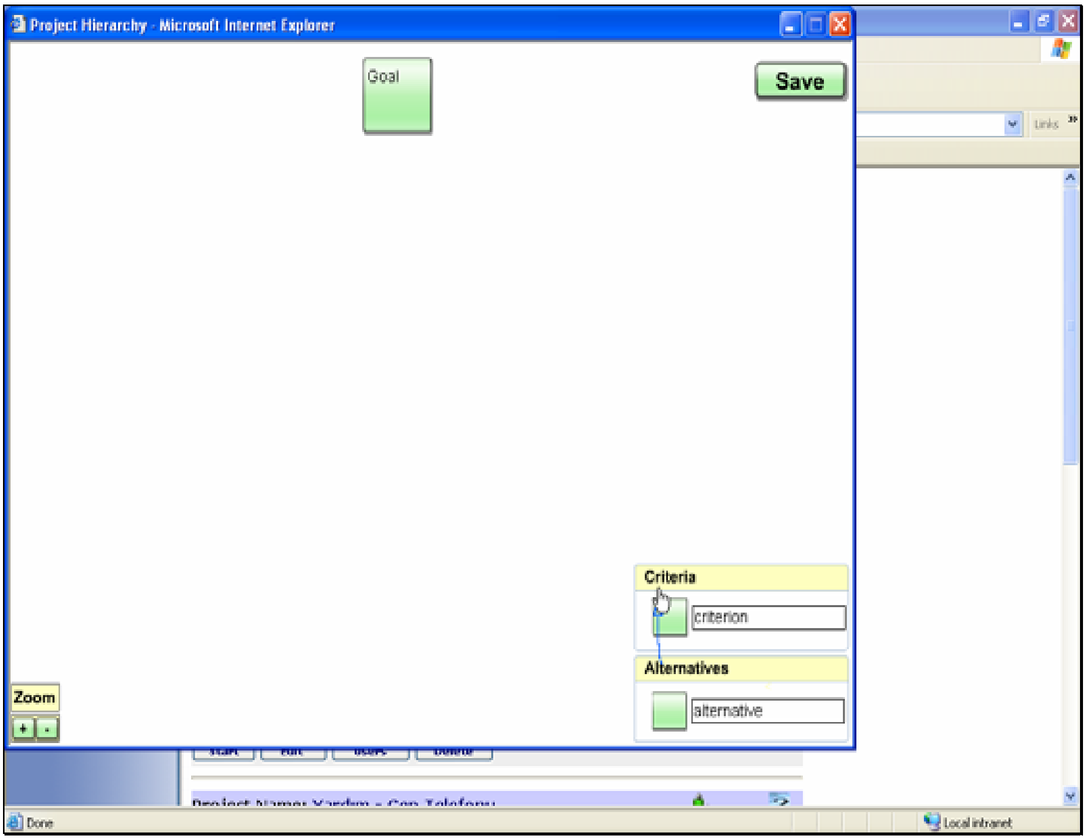


Figure 8.17 : Creating Hierarchical Decision Tree of Project Page

This page is designed by the help of Flash MX 2004 program to support drag and drop activities to create hierarchy. Flash MX 2004 enables the project manager an easy creation of hierarchy tree and helps to improve the user interface with the program. Therefore, the program is usable for users with a user friendly interface. The project manager creates a hierarchy decision tree for the project. There is a decision problem to decide or goal to reach at top of the page of Project Hierarchy. To overcome any multi-attribute decision making problem, there are alternatives and criteria. To create hierarchy, the project manager uses buttons of criteria and alternatives.

To add a criterion for the project under any element, the project manager clicks the criterion button from "Criteria" and drags it to any element. After that, the project manager drops the criterion button on target element. In example of the Figure 8.18, the project manager clicks the criterion button from "Criteria" buttons, and drags the criterion to the target element of "Goal" of the project.

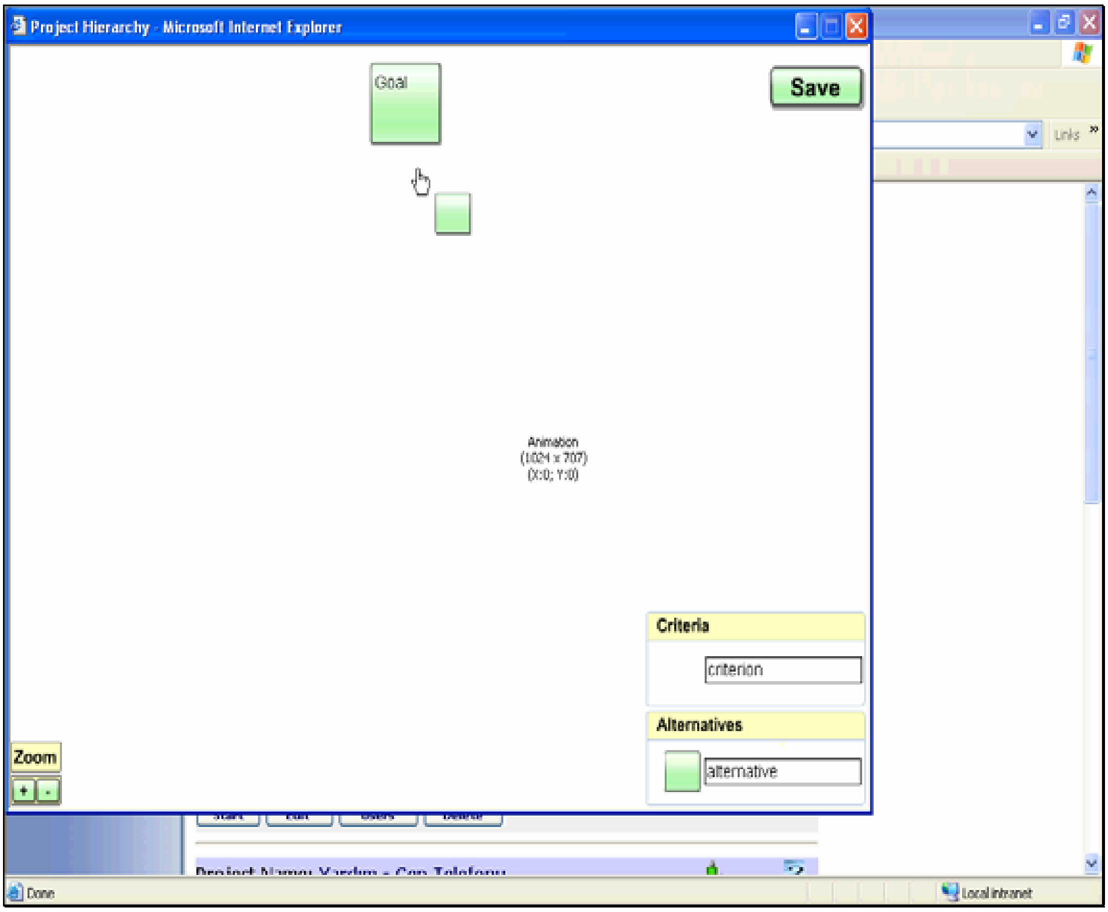


Figure 8.18 : Drag Criterion

When the project manager drops the criterion into the "Goal" element of project, the criterion is added to "Goal" element as shown in Figure 8.19. The criterion is positioned under the "Goal" element with red line which is drawn to show the connection between these two elements. Red line which is drawn automatically between these two elements provides a user friendly interface tree hierarchy. It can not be denied that user friendly hierarchy decision tree maintains user interaction in the project and the system. User satisfaction might be high while creating a hierarchy using drag and drop activities. Project manager adds criteria as s/he wishes. There is not any limit in adding criteria and alternatives while the manager is creating a hierarchy.

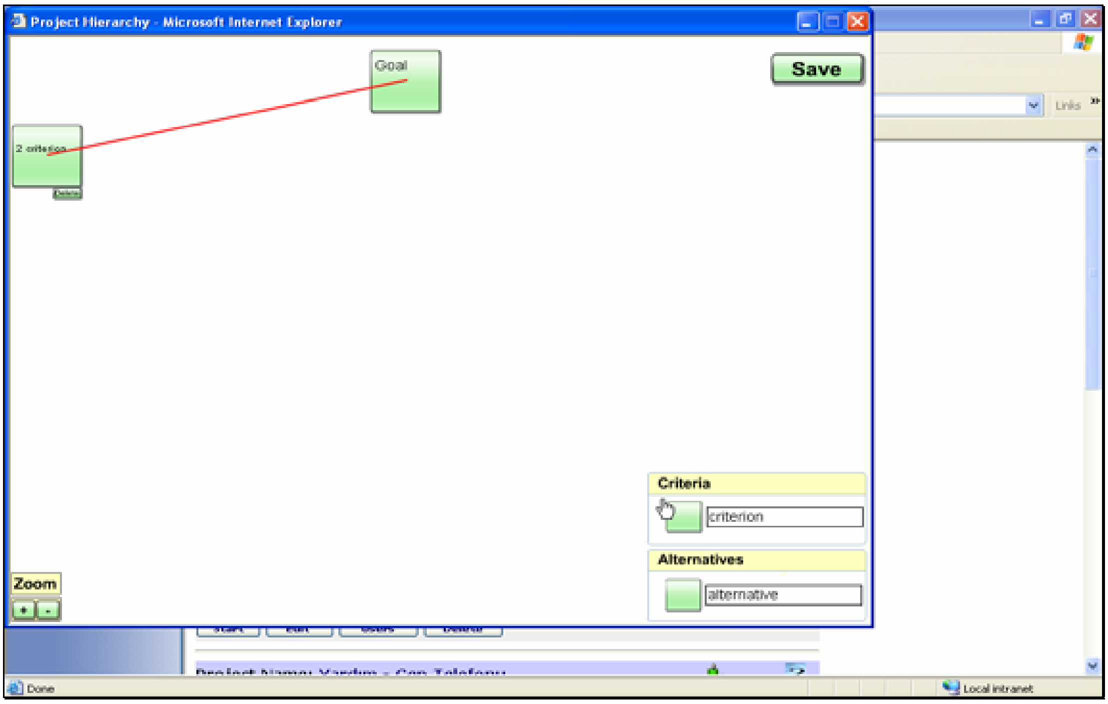


Figure 8.19 : Drop Criterion

The project manager has ability to create any sub criteria by using drag criterion and drop it to target element as in Figure 8.20.

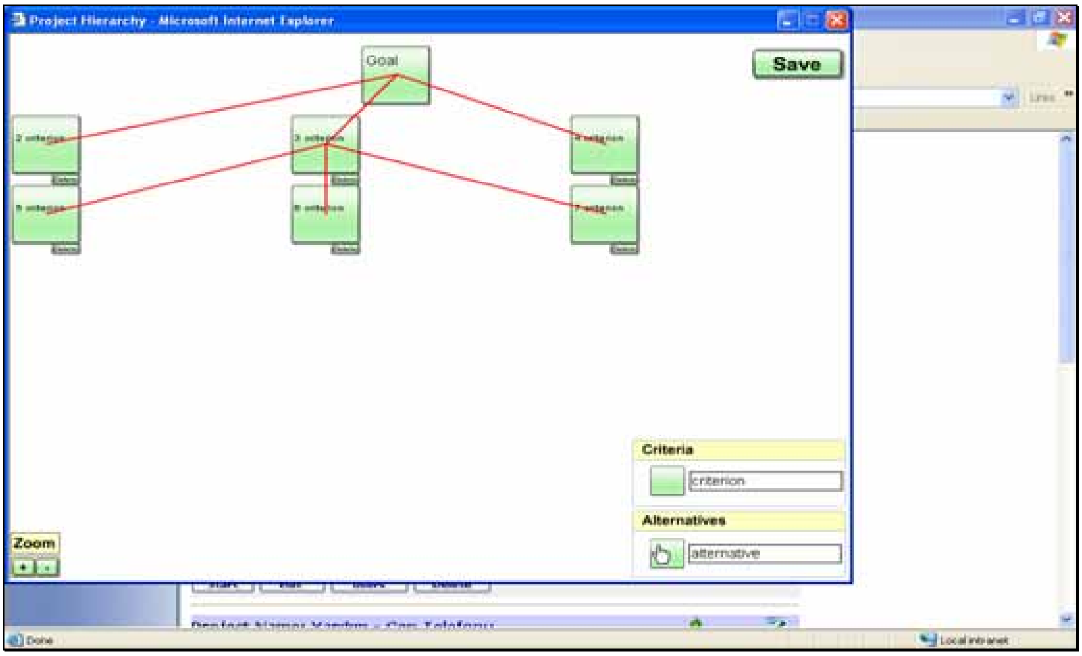


Figure 8.20 : Sub-Criteria of Hierarchy

The project manager clicks button from Alternatives to add alternatives for the project. There is no need to drag and drop activities for adding alternatives. While the manager adds a criterion, the user determines the target element for the criterion. Therefore, drag and drop activities are necessary, useful and user friendly to create a hierarchy tree for users. However, the project manager clicks alternative button from Alternatives to add alternative to the project. Clicking alternative button instead of drag and drop activities is enough to create alternatives. Because there will be no more level for the hierarchy. The last level for the AHP hierarchy tree is alternatives. That's why; it is possible to say that project manager adds alternatives just only by clicking alternative button from "Alternatives".

When the project manager adds an alternative, the red line is immediately drawn that shows the connection between the criteria and alternative as shown in Figure 8.21.

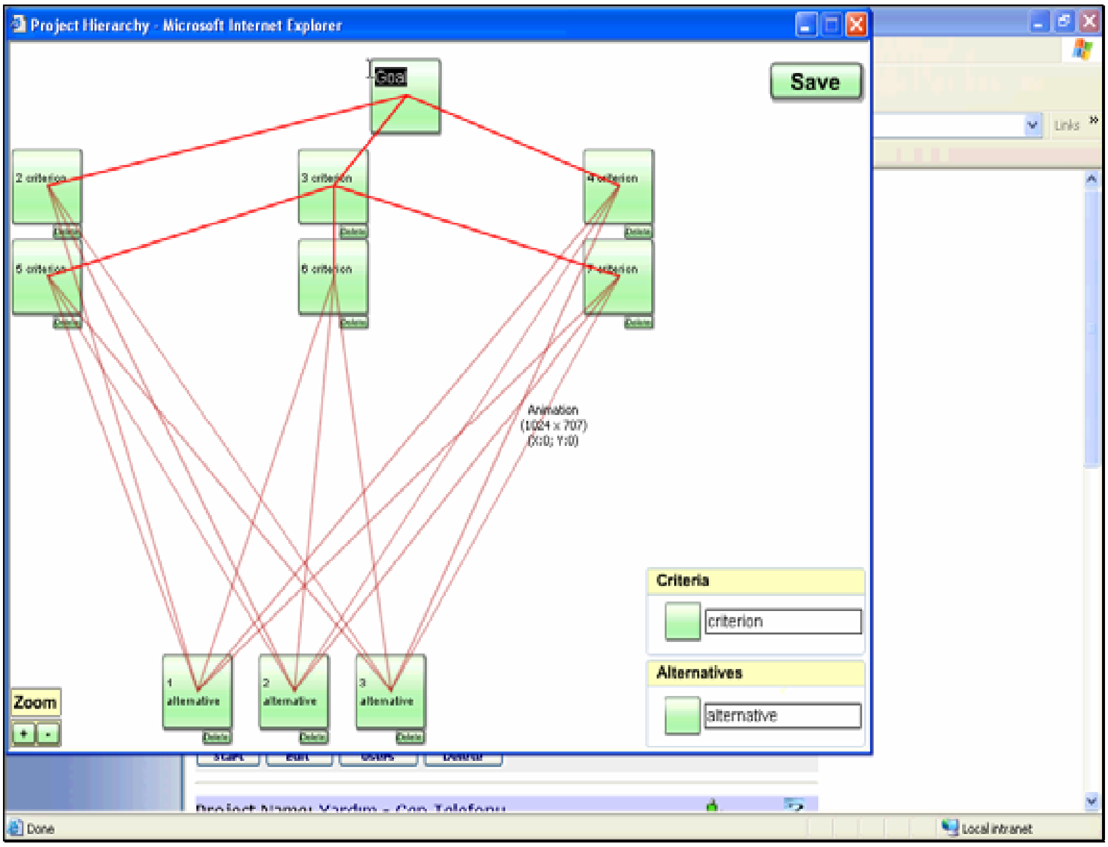


Figure 8.21 : The Hierarchy Tree

The project manager changes the name of goal, criteria, and alternatives of the project by editing textboxes after it is selected. In the hierarchy tree, elements have text fields that the manager has ability to edit, change names. The final hierarchy tree for the project is seen in the Figure 8.22. “Zoom” provides users to see the hierarchy tree zoom in or zoom out. Clicking “+” button enables users to see zoom in. When user clicks “-” button, zoom out of hierarchy can be observed. The project manager saves the hierarchy by clicking “Save” button.

Project manager deletes criteria or alternatives by clicking “Delete” button under the criterion or alternative element. Criterion or alternative element is deleted, and red line disappears between connected elements.

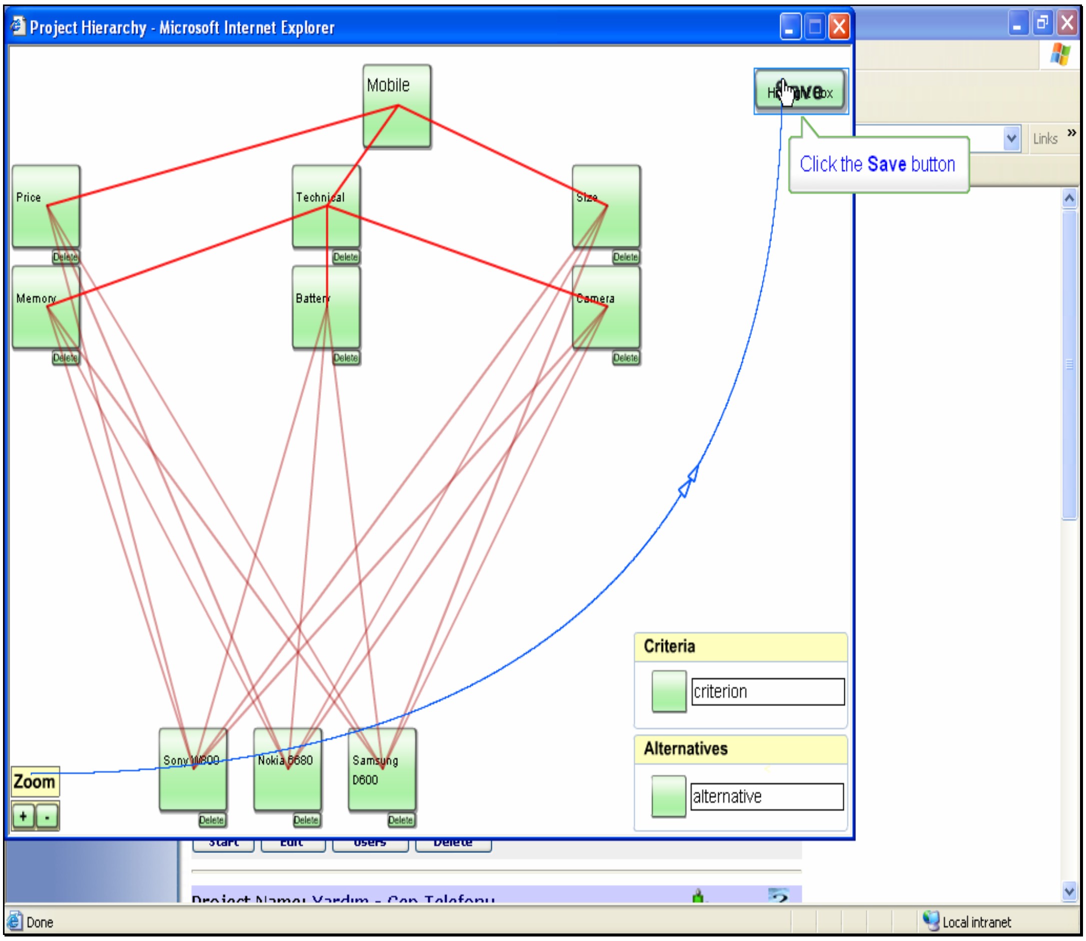


Figure 8.22 : The Project Hierarchy Tree

Project manager saves a hierarchy tree and sends it to project users after clicking “OK” button as in Figure 8.23.

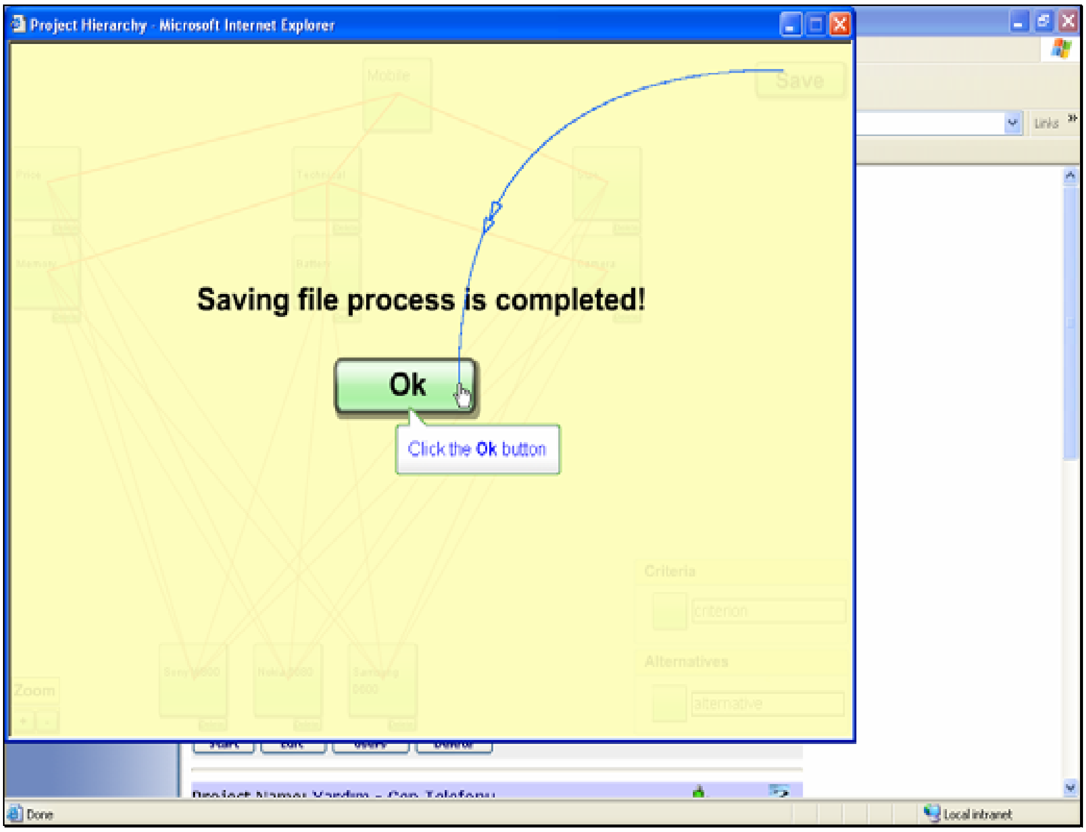


Figure 8.23 : Saving Project Hierarchy Tree

8.2.2.3. Project User Evaluates Hierarchy Decision Tree for AHP of Project

Any project user can see the projects that have been appointed by the project manager in the Project Design and Evaluation page as in the Figure 8.24. The project user is responsible for evaluating hierarchy decision tree of the project by using the fundamental evaluation scale as shown in Table 4.1. The project user clicks “Start” button to start evaluating the project within the basis of fundamental scale.

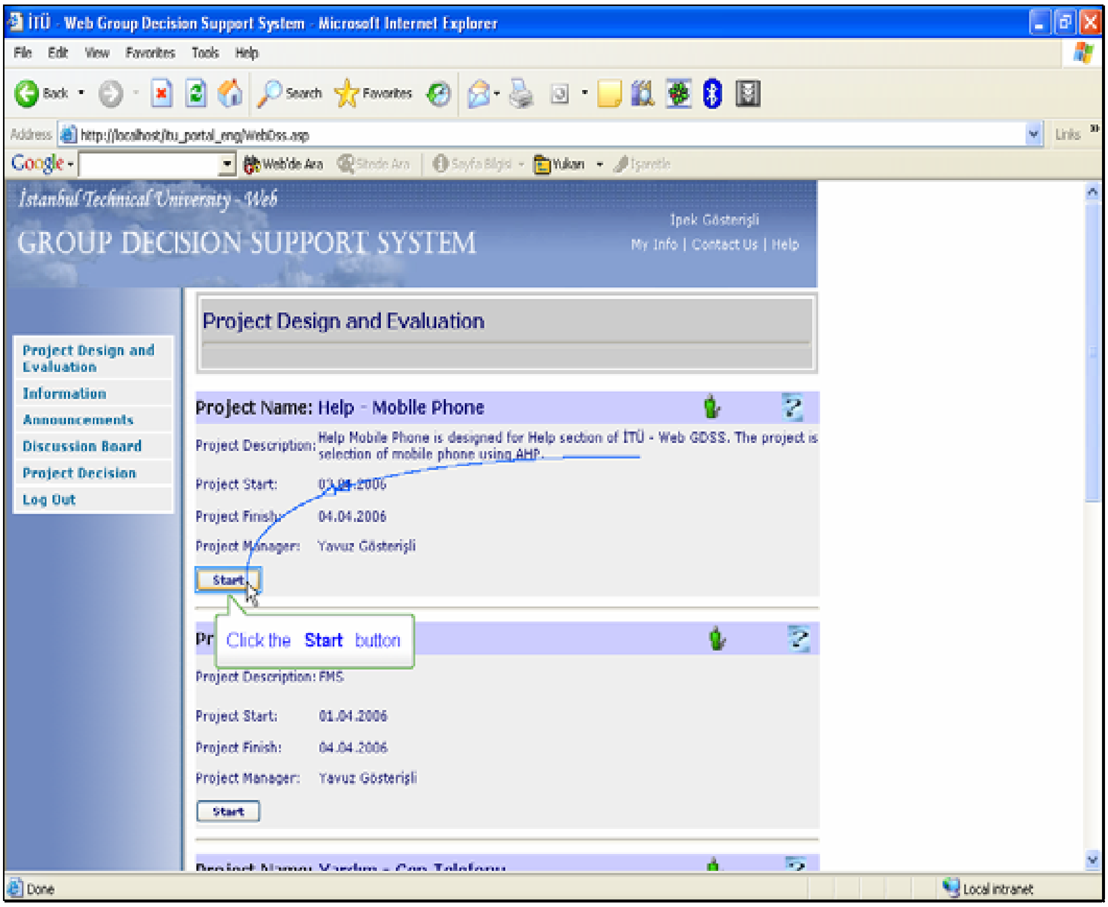


Figure 8.24 : Project Design and Evaluation Page for Project User

While Project Hierarchy page for project user is opening, the user sees the hierarchy of decision tree to evaluate the project as in Figure 8.25. Project Hierarchy page is designed with Flash MX 2004 program that provides a user-friendly hierarchy decision tree for users to evaluate the project.

The project user evaluates any element by clicking “Data” button under the element. To evaluate an element such as goal of the project that is called “Mobile”, the user clicks “Data” button for the goal of the project, “Mobile” element. “Mobile” element has 3 criteria, user compares the criteria with each other within the basis of fundamental scale. Evaluation of the element is completed after pair-wise comparisons have been done. It can be maintained that the user friendly evaluation matrix and evaluation scale helps users to complete their evaluations quickly and easily.

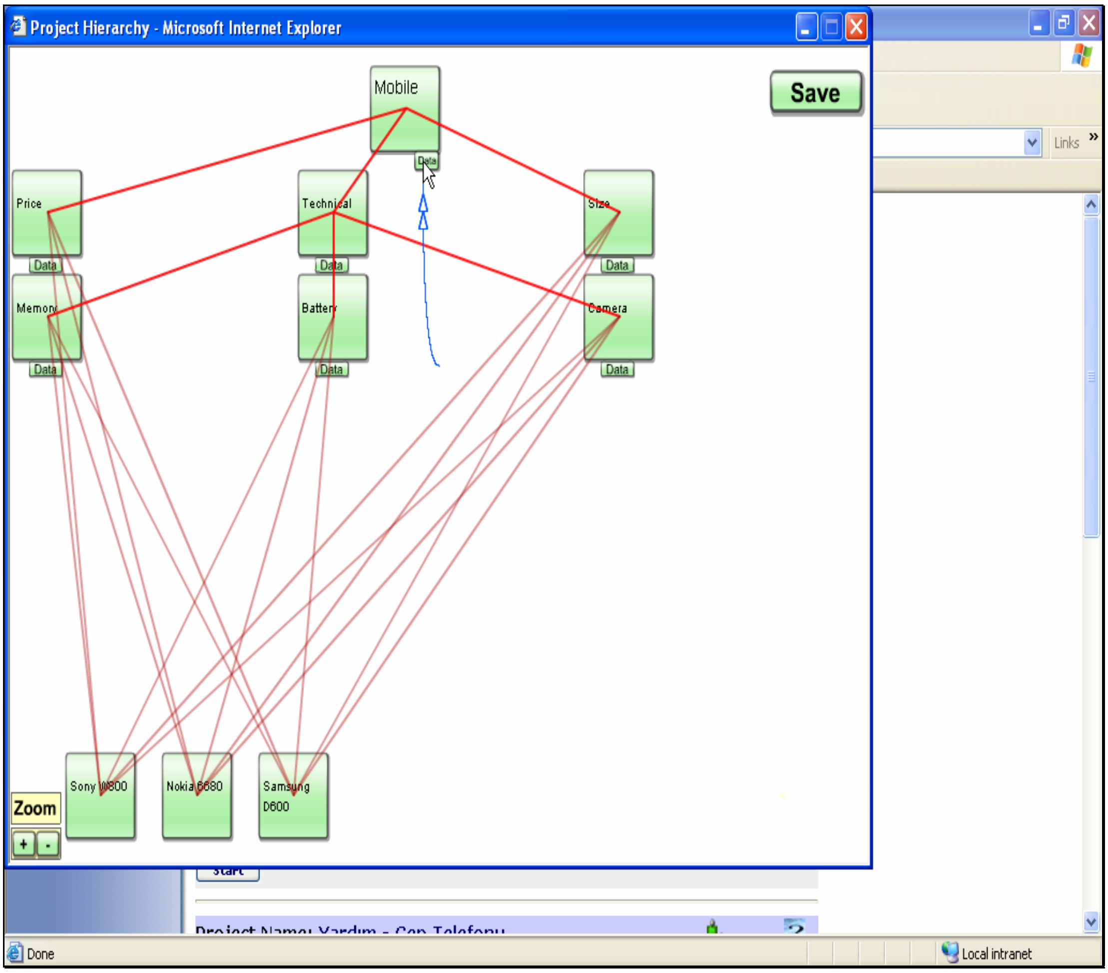


Figure 8.25 : Project Hierarchy for Project User

When the project user clicks the "Data" button, the page that has evaluation frame for the element appears on the user page as in Figure 8.26. At the top of the page, there is an evaluation scale that is adapted from fundamental scale as Table 4.1. Pair-wise comparisons can be done by clicking numbers on the evaluation scale after the user clicks the first box to evaluate.

As it is seen in Figure 8.26, there is an evaluation matrix for the goal of the project. "Mobile" element, showed in red circle, has three criteria; Size, Technical, Prize. Pair-wise comparison matrix is established in this frame. After the user clicks the first textbox to evaluate and compare Technical and Size criteria, the background color of textbox turns from white to red to specify which criteria are evaluated. Therefore, the user's attention is attracted to evaluate pair-wise comparison between Technical and Size criteria due to changing background color of the textbox. The user comprehends the pair-wise comparison of the criteria that has to be made.

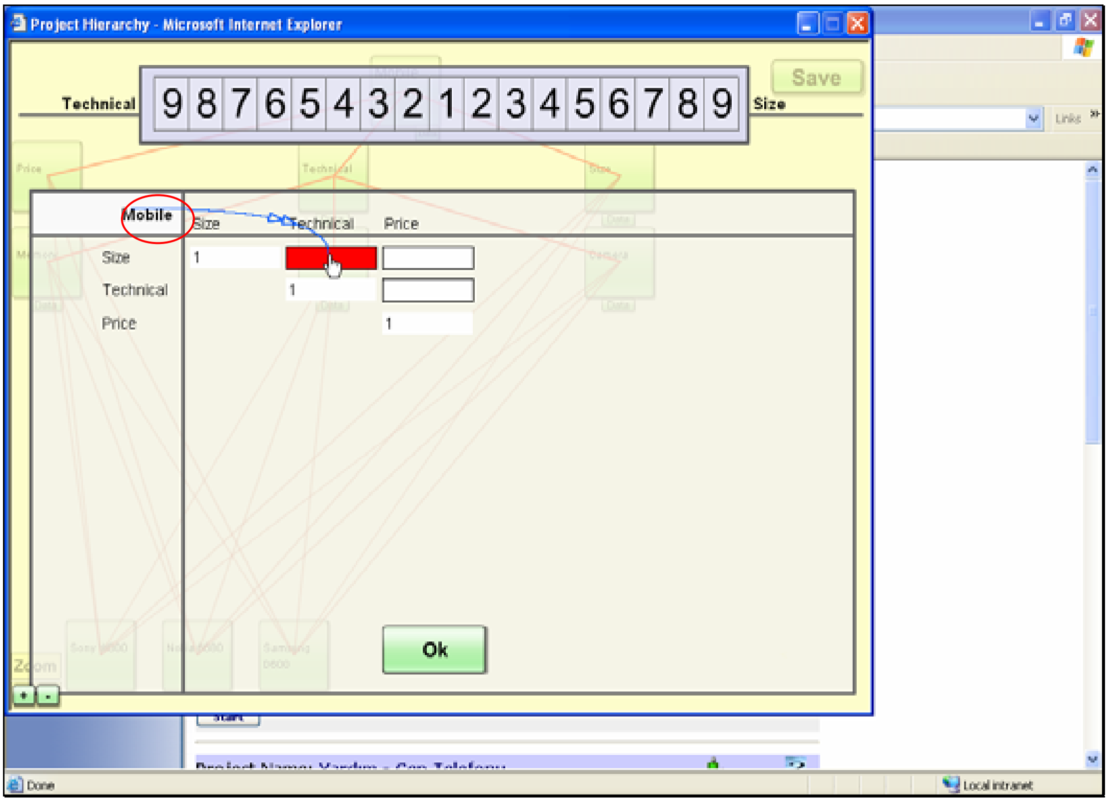


Figure 8.26 : Evaluation Frame for an Element in Project User Evaluation

After clicking textbox, the project user is ready to compare criteria. The project user compares Technical criterion with Size criterion. As it is seen in Figure 8.27, the user makes comparison between criteria by clicking numbers on the buttons to give value for evaluation on the Evaluation Scale. To make comparison, the user sees the first criterion as Technical is at the left side of the Evaluation Scale, whereas the second criterion, Size, is at the right side of the Evaluation Scale. If the user makes judgment for these two criteria, the numbers in the matrix are the AHP scale evaluations. Numbers correspond to the judgments obtained by comparing the elements in the top row with the elements in the left-hand column. When an element is considered as less favorably than the other, the judgment becomes a fraction. It should be noted that when comparing one element with itself, the comparison must have the value of 1. Therefore, the diagonal values of a pair-wise comparison matrix are always 1. A pair-wise comparison matrix is also reciprocal. The judgments are only needed for the upper triangular part of a matrix. The lower triangular part is their reciprocals. The user makes his/her own judgments only for upper triangular part of a matrix in the evaluation. Therefore, fewer judgments make the project user feel comfortable while comparison in the processing.

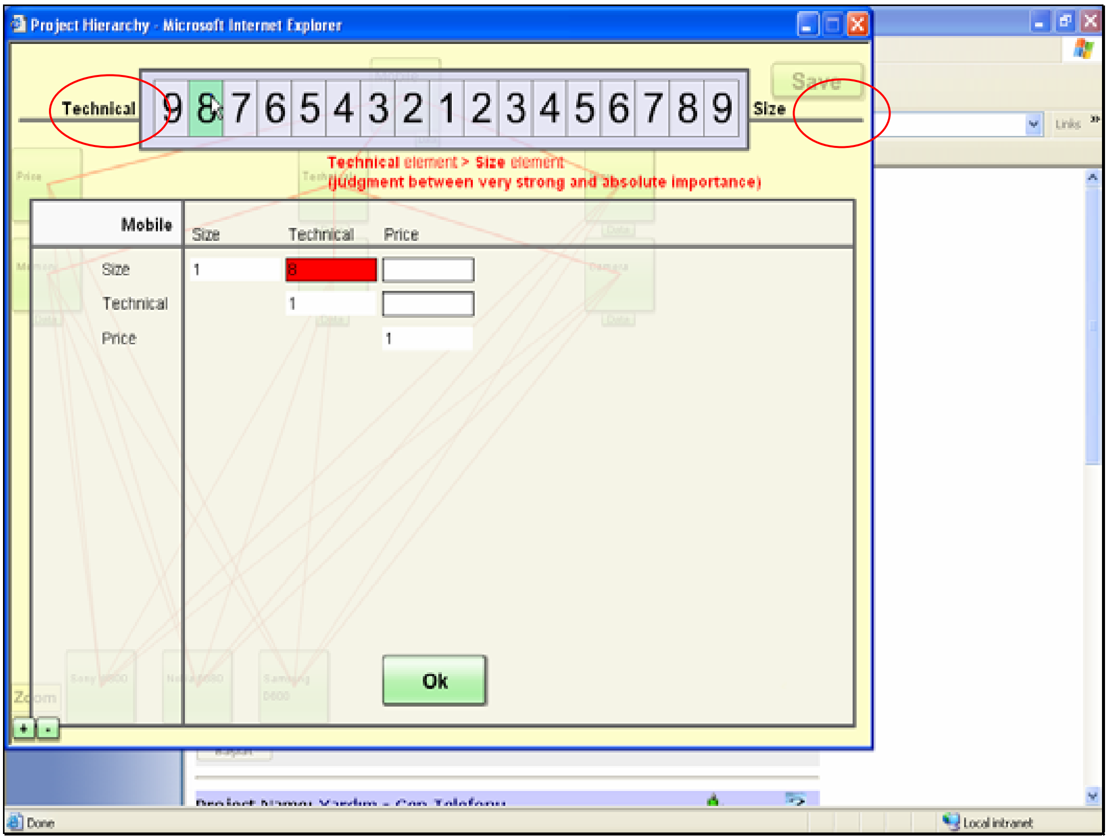


Figure 8.27 : First Pair-wise Comparison for Element in Project User Evaluation

It is claimed that a user-friendly interface for making comparisons provides a user to maintain comparisons more efficiently. When a user clicks the button for "8" as above in the Figure 8.27, it means that Technical element is important than Size element for this user and its value is "8". The value, "8", is intermediate value between very strong and absolute judgments. User observes the written mode of judgment below the Evaluation Scale when s/he moves the mouse over the numbers. Numerical and explanation means are used for user judgments to increase the user perception while the user interacts with the program.

The project user understands what he is comparing and is aware of his/her own judgments in the evaluation process. The interface is simple an easy to comprehend. Therefore, the user can feel comfortable while s/he is making comparison with respect to the criterion, objective.

When the first pair-wise comparison is finished, cursor goes to next pair-wise comparison automatically as it is seen in Figure 8.28. The second pair-wise is obtained by comparing Price element with Technical element. The user judges this comparison by clicking on button of “5” that means Price element is strong importance than Technical element for user.

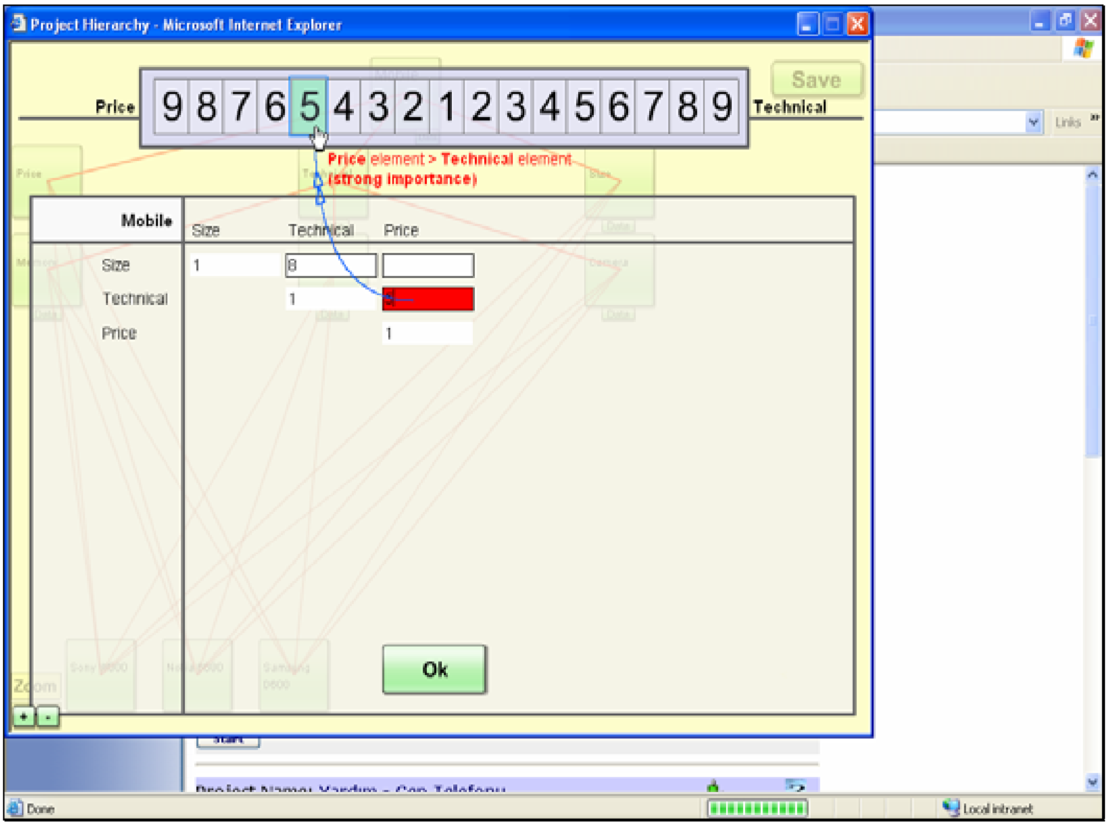


Figure 8.28 : Second Pair-wise Comparison for Element in Project User Evaluation

When the second pair-wise comparison is finished, cursor goes to next comparison automatically as it is seen in Figure 8.29.

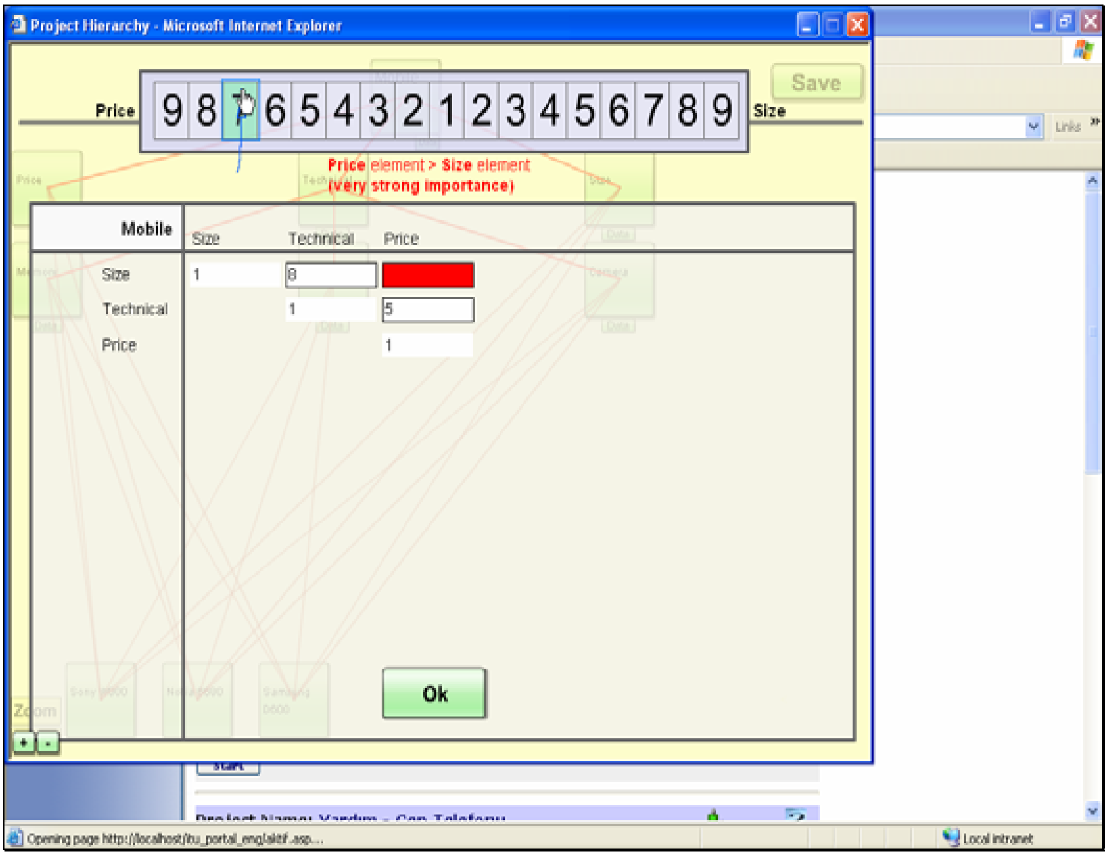


Figure 8.29 : Third Pair-wise Comparison for Element in Project User Evaluation

The third pair-wise comparison is obtained by comparing Price element with Size element. User judges this comparison by clicking on button of "7" that means Price element has more importance than Technical element for user.

The project user clicks "OK" button to finish pair-wise comparisons of the element. When all the pair-wise comparisons are finished for any element, the color of element turns from green to blue. Specifically, the color of element will be blue if the user finishes pair-wise comparisons of the element. In the Figure 8.30, it can be seen that all the elements of the project are evaluated. All the pair-wise comparisons for elements should be done before saving a file. The project user saves evaluation for the project by clicking "Save" button.

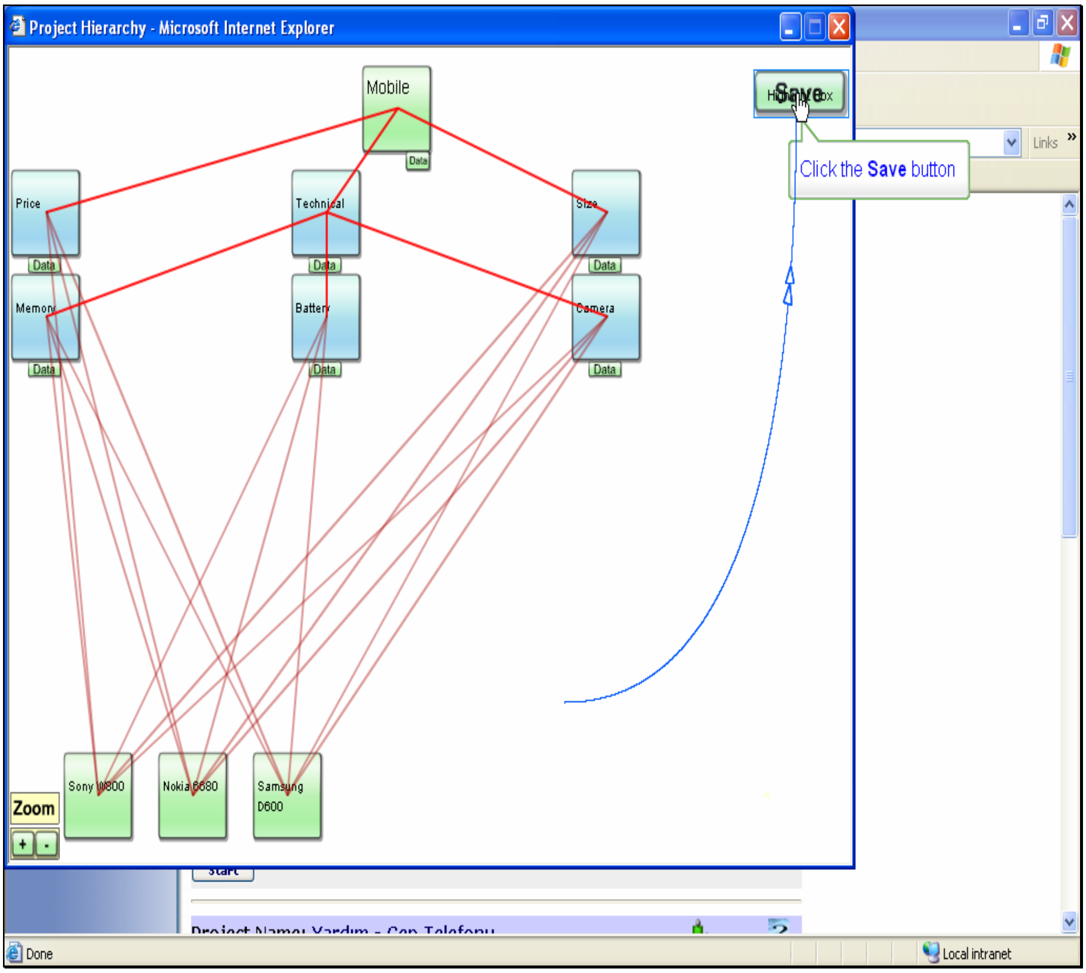


Figure 8.30 : Completed Pair-wise Comparison of Project User

The project user gets a confirmation message which is “Saving a File is completed!” in the Figure 8.14. When user clicks to “OK” button, user’s comparisons or judgments are saved in a XML file that is named as the combination of project id and username of the user under the folder of project id in the XML folder.

8.2.2.4. Information

Information for İTÜ – Web GDSS page appears, when project manager or user clicks “Information” button from the menu on the left side of the page as it is shown in Figure 8.31. Information for System Manager Details, descriptions, objectives, evaluation, and other specifications of İTÜ – Web GDSS provides users to learn and comprehend the system usage. Only the project manager can edit information for İTÜ – Web GDSS.

The project manager can change the details for İTÜ – Web GDSS by clicking “Edit Information” button. Edit Information page which enables project manager to change information from the editing form appears. However, a project user can not edit information. Since, a project user is not allowed to change information for İTÜ – Web GDSS. Therefore, “Edit Information” button is never seen for the project user.

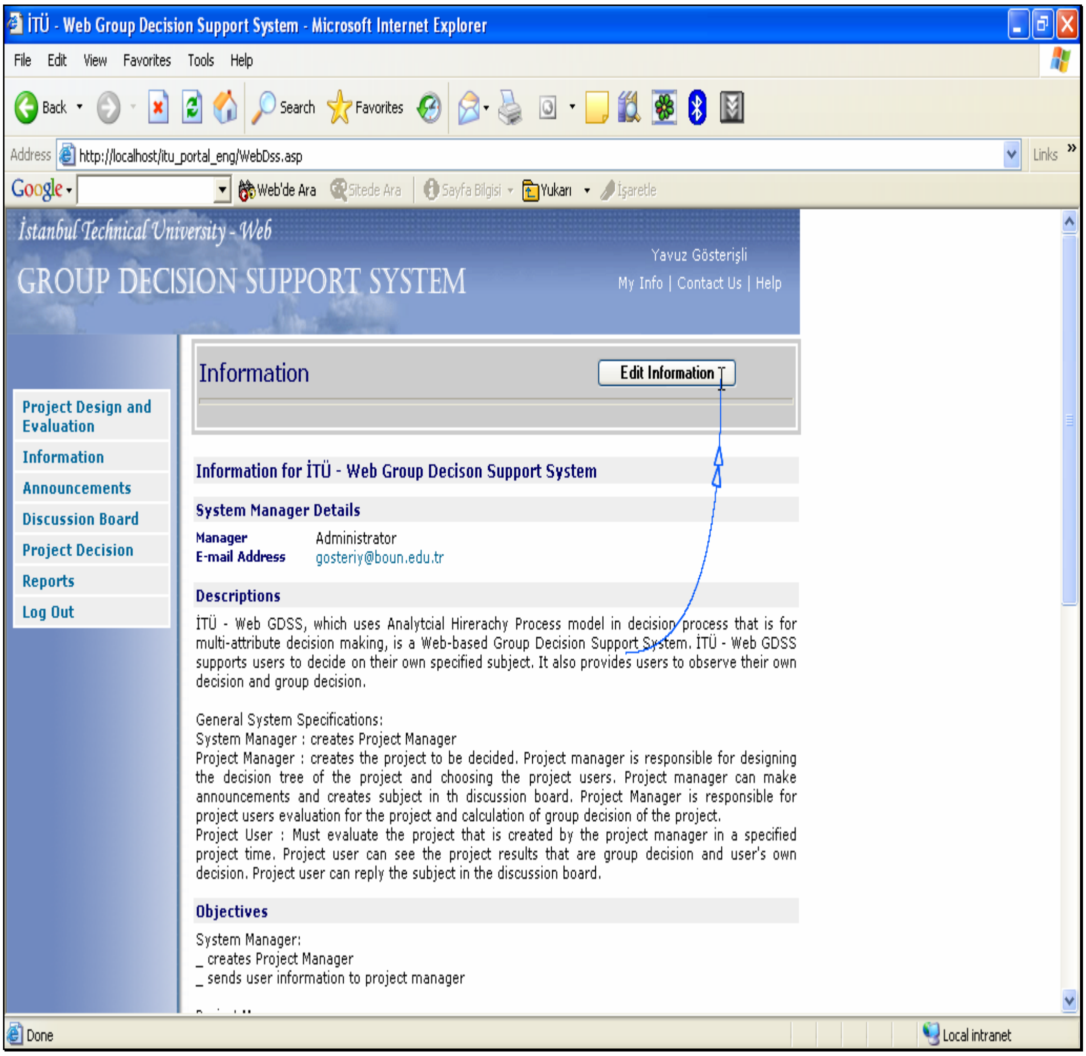


Figure 8.31 : Information for İTÜ – Web GDSS Page

8.2.2.5. Announcements

Project Announcements page, which both project manager and user see the announcements for the projects, appears by clicking “Announcements” link from the menu. Each announcement has a title, and details. Announcement creation date is observed below the “Date” column as it is seen in the Figure 8.32. The project manager creates a new announcement when the new project created by the project manager. The project manager clicks “New Announcement” button to create a new announcement.

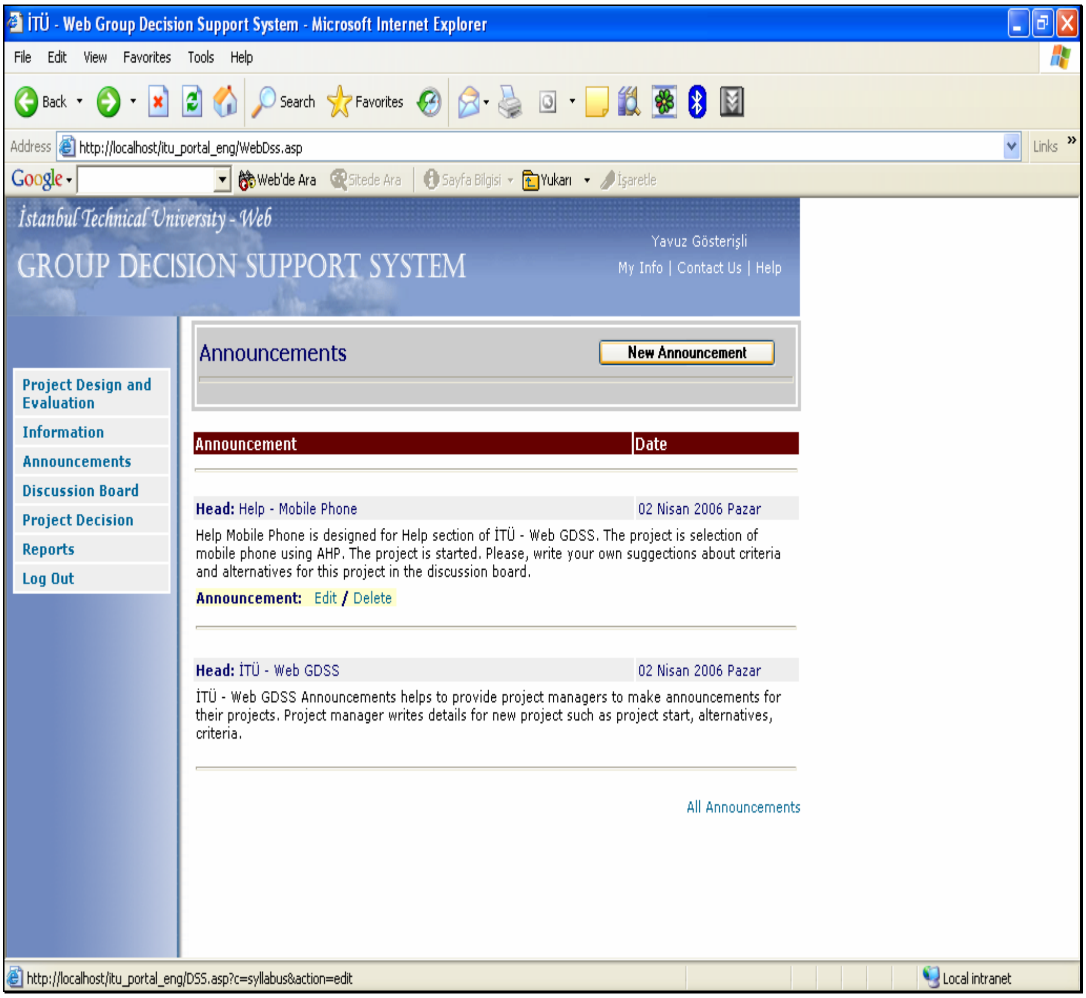


Figure 8.32 : Announcements for Projects Page

Only the project manager is allowed to create new announcements and only the author of the announcement can edit, and delete the announcement. The author who is the project manager can edit an announcement by clicking “Edit” link in the announcement. The author can edit and save the announcement as seen in the Figure 8.33. The author can also delete the announcement by clicking the “Delete” button.

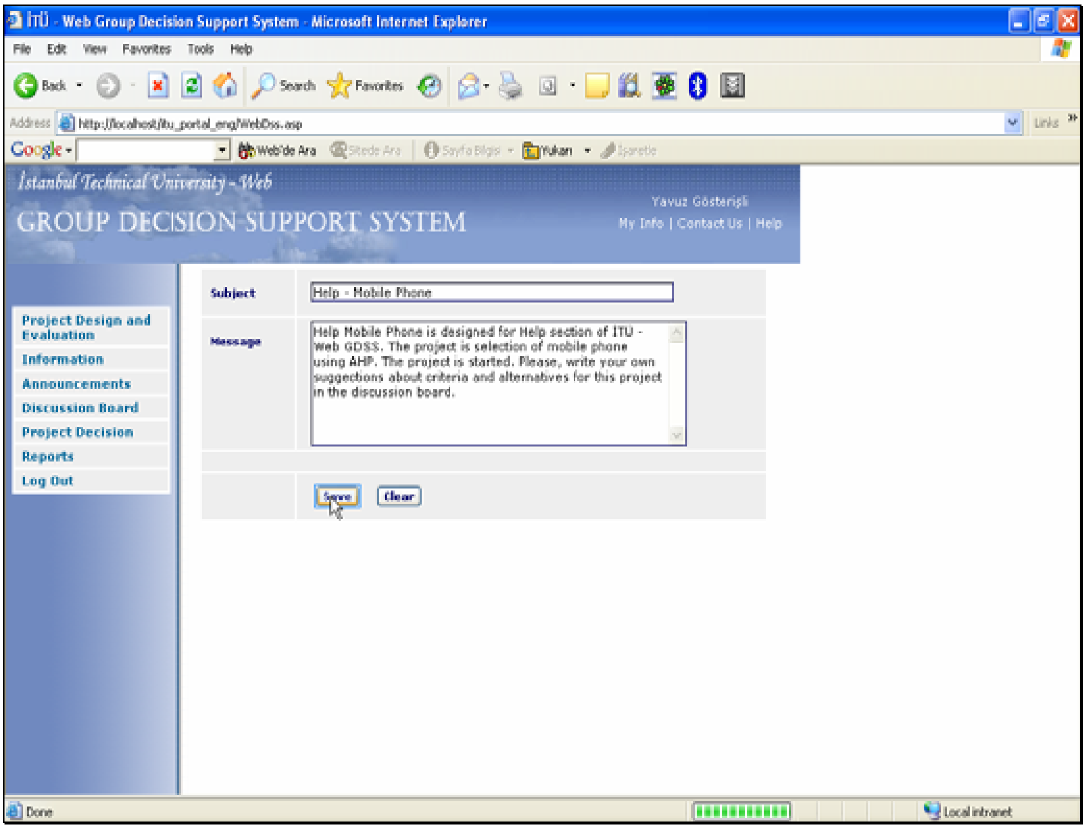


Figure 8.33 : New & Edit Announcement Page

8.2.2.6. Discussion Board

The project manager creates a folder for new project so that project users will discuss the details of the project in this folder. Suggestions and discussions for the project should be mentioned in its own folder which is generally named as the project name. Not only the project manager, but also the project user is allowed to create a new subject to discuss about. Therefore, the project manager and the user have ability to create subject in the "Discussion Board".

The project manager clicks "New Subject" button or link to create new subject for new project that the user discusses about. It should not be forgotten that the project manager must mention the subject name and message for the subject.

In the Figure 8.34, the project manager has created folder such as "Help – Mobile Phone" folder for the project of Help – Mobile Phone. Users will see the folder: its author, who is project manager, and the number of replies to the message for the subject in a table. Total number of folders is given at the top of table. As it is seen in Figure 8.34, there are two folders whose names are "Help – Mobile Phone" and "test". It is seen that there are two folder icons. Red-colored folder icon means that the subject is replied by any project user. Yellow-colored folder icon tells users that there is no replied message. Project users have not just replied to the subject.

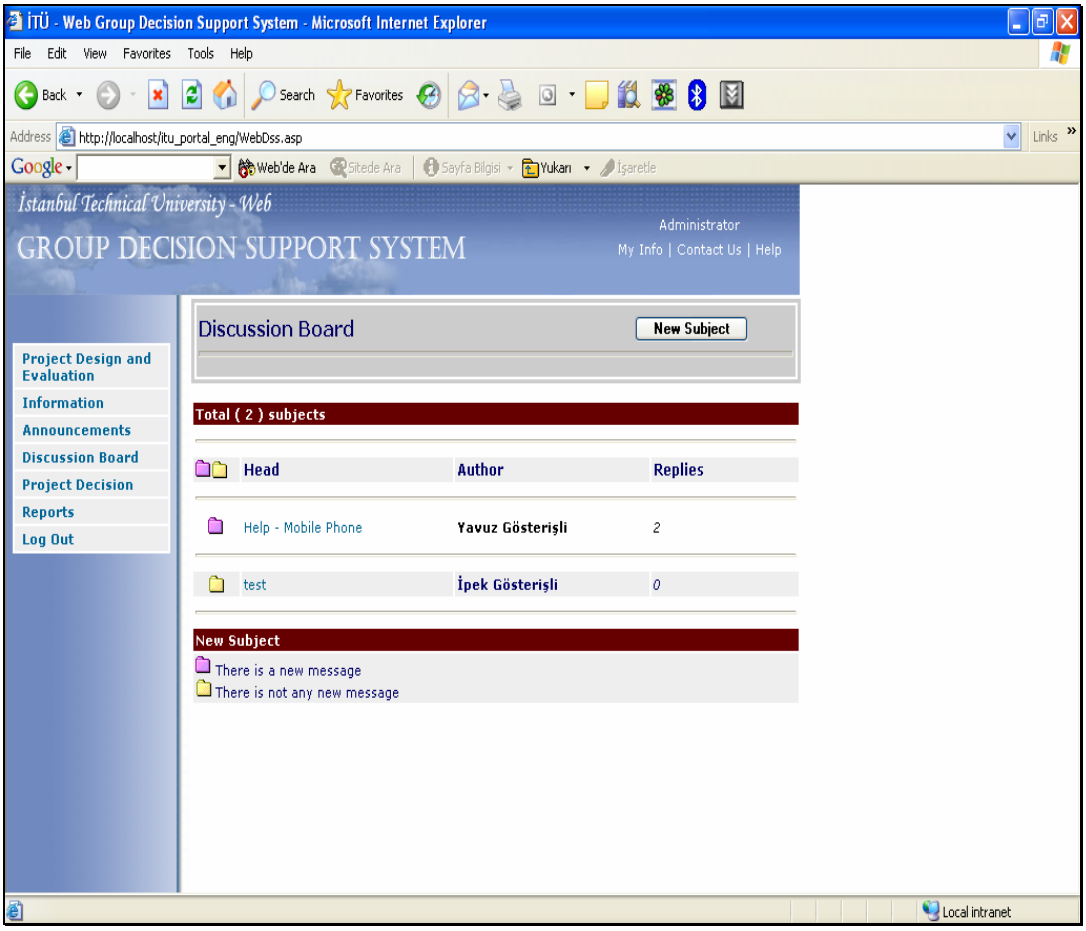


Figure 8.34 : Discussion Board Page

When the user clicks the folder of "Help – Mobile Phone", s/he will see the page as it is shown in the Figure 8.35. The message of the author who's the creator of the folder will be seen at the beginning, and the replied messages will be seen below the author's message by users.

It should be mentioned that subject name, message, author, creation date will be seen in the message. Only the project manager is allowed to edit or delete the message which is sent to discussion board. If the project manager edits the message, editing time and editor will be observed in the message such as "Edited at 02.04.2006 21:10:39, by Yavuz Gösterişli".

If the project user wants to reply the subject or message, the user will click “Reply” link at the bottom bar. The project user must have never forgotten to write title, and message for the subject.

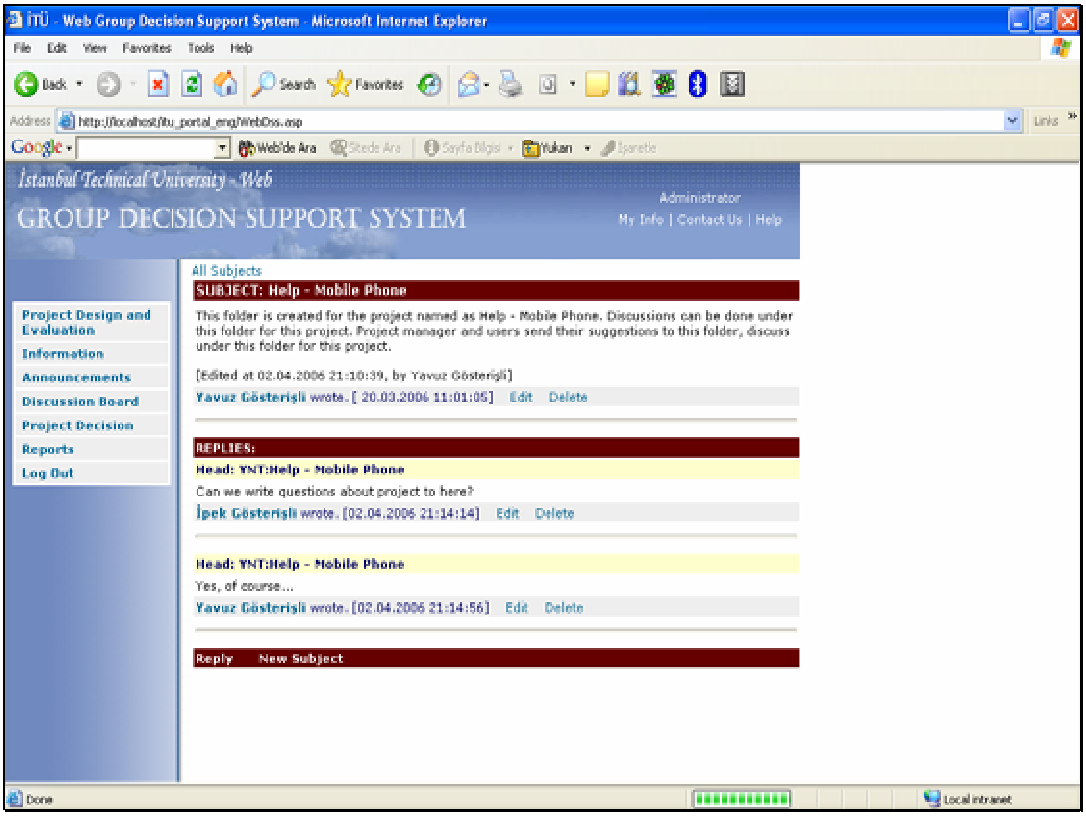


Figure 8.35 : Discussions Page

When reply message is completed, user will send it to discussion board by clicking “Save” button in the Figure 8.36.

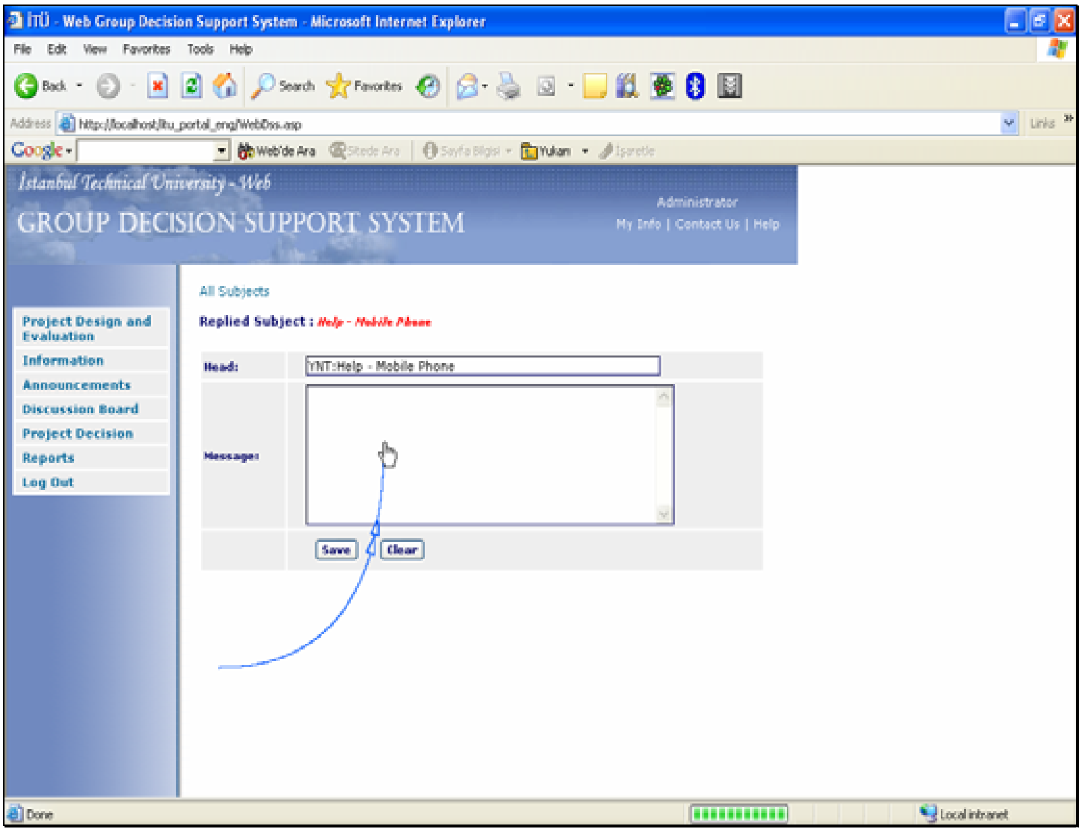


Figure 8.36 : Reply Subject Page

8.2.2.7. Project Decision for Project Manager

Project decision which is evaluated according to the method of Analytic Hierarchy Process calculation procedures for multi-attribute decision making as it is discussed in detail in section 4. Users' decisions that are pair-wise comparisons for the project are used in the process of calculating users own decisions and group decision of the project.

Project user clicks "User & Group Decision" button to see the project users' decision on the project as shown in the Figure 8.37.

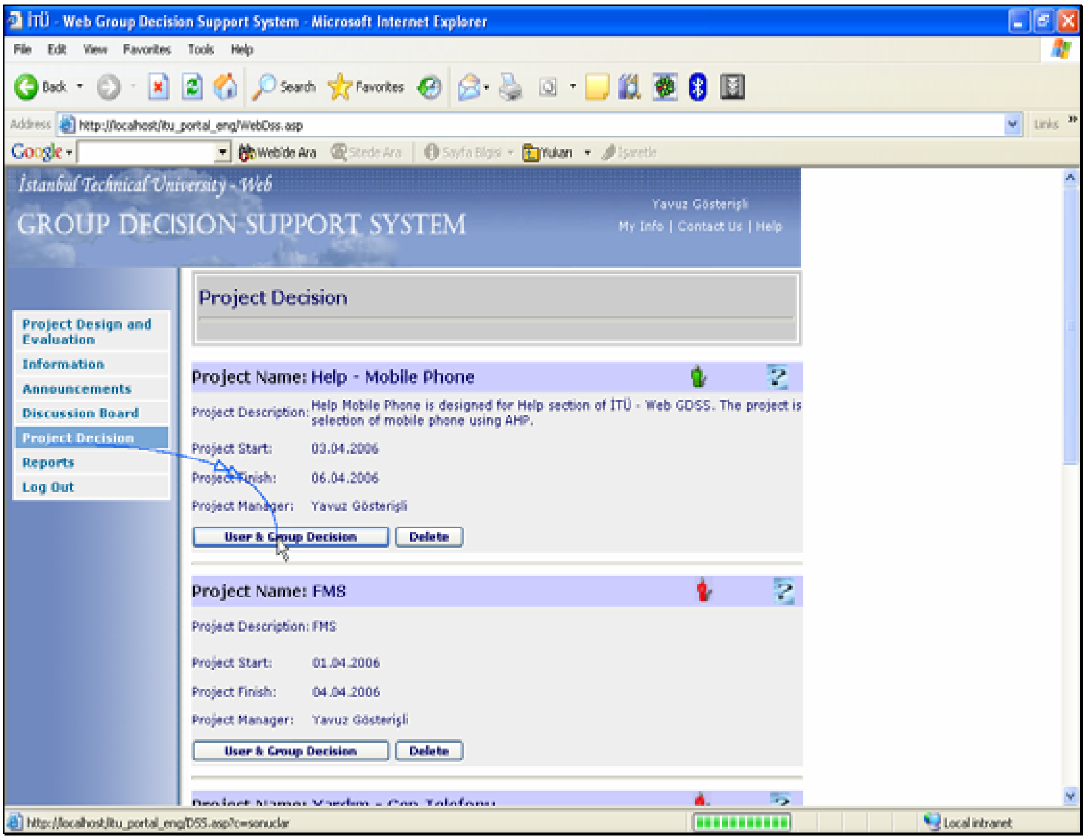


Figure 8.37 : Project Decision for Project Manager Page

Then, Project Users' Decision page which is shown in Figure 8.38 appears. In the page, project manager follows the status of the project users' evaluations on the project. Not only the name, the surname, and the username of the project user, but also the status of the user decision which means that user has completed the evaluation process for the project will be observed.

The table for project users' decisions status provides the manager to see which the user has finished the decision process by looking at the "Status" column. If the user finishes the project comparisons, the status of the project is written as "Completed!" If the user does not finish evaluation of the project, status of user decision will be seen as "Not Completed!"

There are two icons that are red-man and green-man under the column of "User Decision" in the Figure 8.38. Red-man icon means that the user has not completed the decision process. However, green-man icon shows that the user has completed the decision process. If the project manager wants to see the user's decision, the project manager will click the green-man icon of the user. Therefore, the project manager will see the user's decision.

Project manager clicks user's decision icon, green man icon, which is linked to the page of user's own decision, to see the decision result of the user in Figure 8.38.

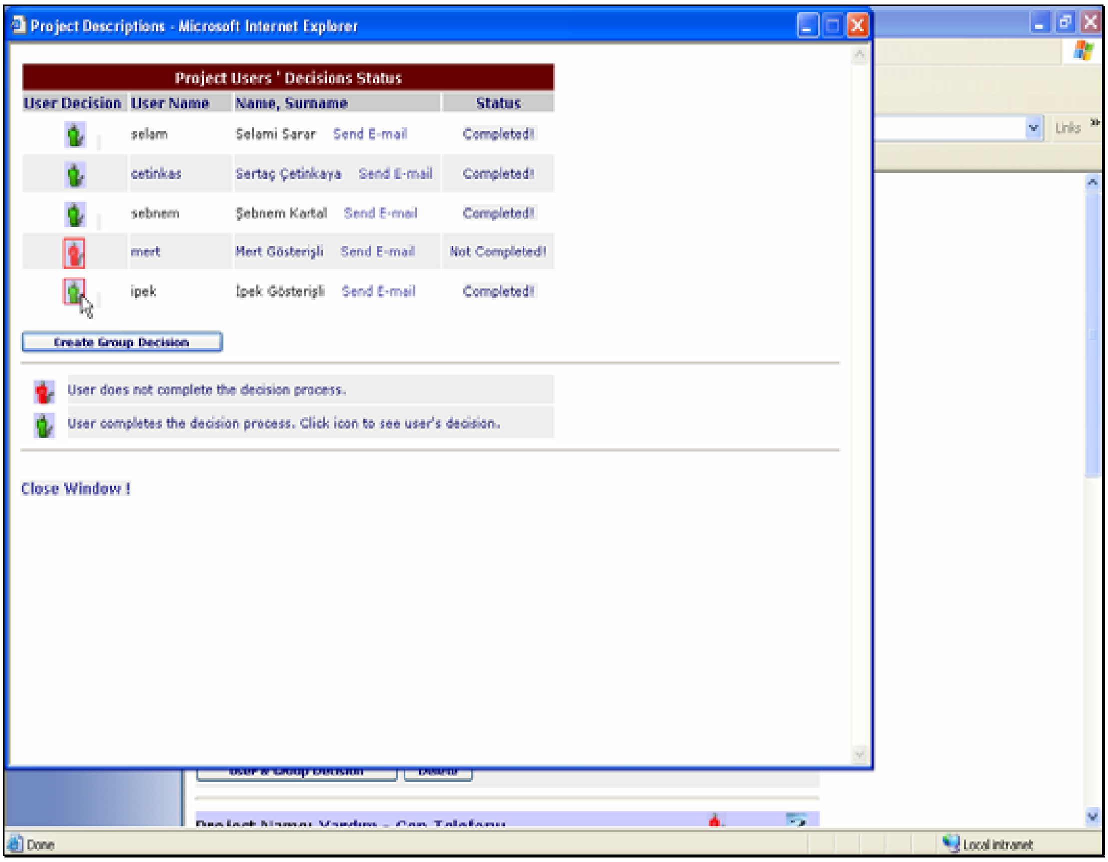


Figure 8.38 : Project Users' Decisions Status Page

When green man icon for any user is clicked, the page which is to show user's decision appears as it is seen in the Figure 8.39. Project name and project user name is mentioned at the top of the page. It is seen that alternatives of the project are sorted in a descending order according to their values, results in the "Alternatives / Values" table. It should be mentioned that alternatives and their values are shown in 3 – dimension pie chart graph. Graphical presentation of alternatives and their values help users to comprehend the result efficiently and quickly. When the user clicks button for any alternative, the pie chart of the alternative will break away from the pie of the rest. Thus, the user perception will increase due to user friendly 3 – dimension graph. Final decision of the user is also given in written format as "Decision=" and alternative and its value. In the graph, alternatives' values that are percentages will be seen.

Finally, the user will see the results in 3 – dimension graph and in written format. It also helps user perception increase, and better comprehension. In addition to this, user's attention to the project result will be increased by using graphs and texts together.

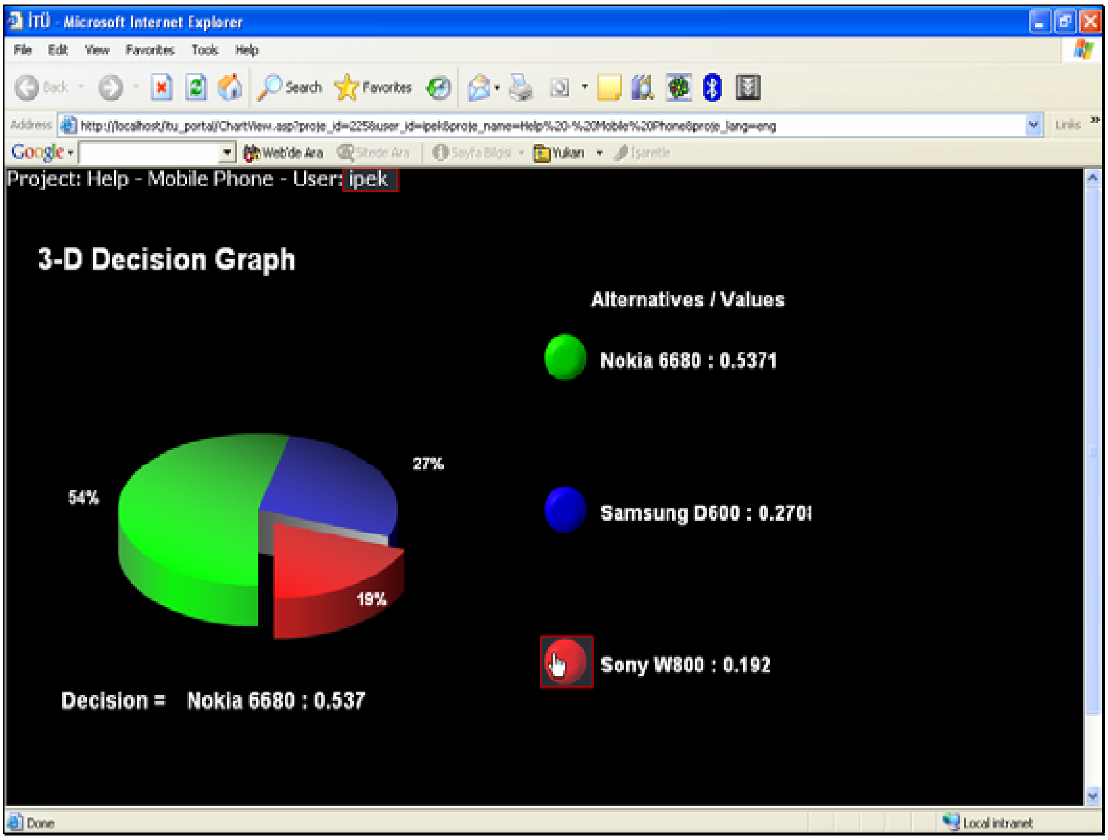


Figure 8.39 : Project User's Decision on Project Page

When all decisions are made by project users, the project manager is ready to create a group decision. If all the project users complete their evaluations for the project, project manager will create group decision by clicking "Create Group Decision" button as it is seen in the Figure 8.38. Group decision is created by the calculations of a geometric mean (average) of the individuals' judgments. Group decision is calculated from users' judgments, and then it is presented with 3 – dimension graph support as it is showed in Figure 8.40. The user name is "group" to show the group decision for the project.

When the group decision is calculated, "Group Decision" will appear for the project in Project Decision.

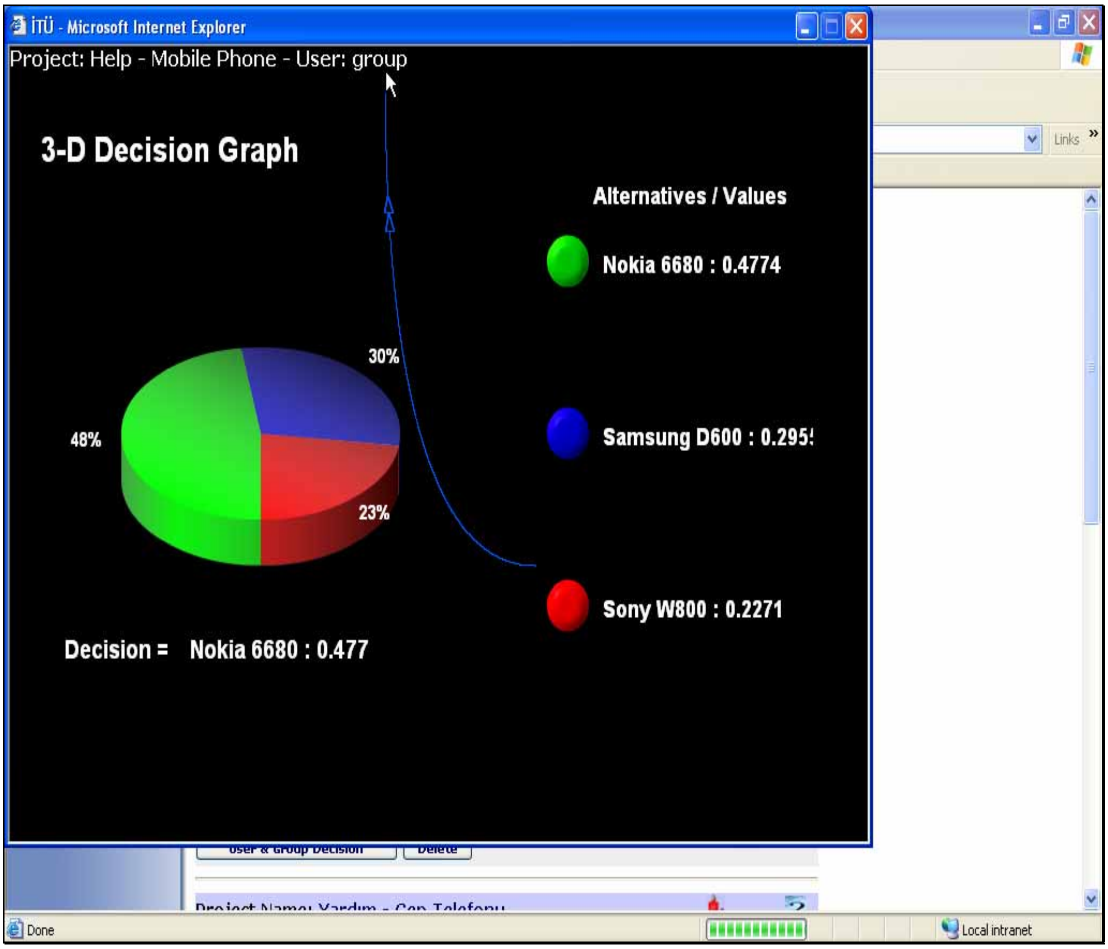


Figure 8.40 : Group Decision Page

8.2.2.8. Project Decision for Project User

The project user sees his/her own decision on the project by clicking on the button of "My Decision" as it is seen in the Figure 8.41. When the user clicks "My Decision", user's decision will be observed by the project user as in Figure 8.39.

The project user will see the "Group Decision" button in the Figure 8.41 if project user creates a group decision for the project. When it is seen, the user clicks "Group Decision" button to see the group decision of the project as in Figure 8.40.

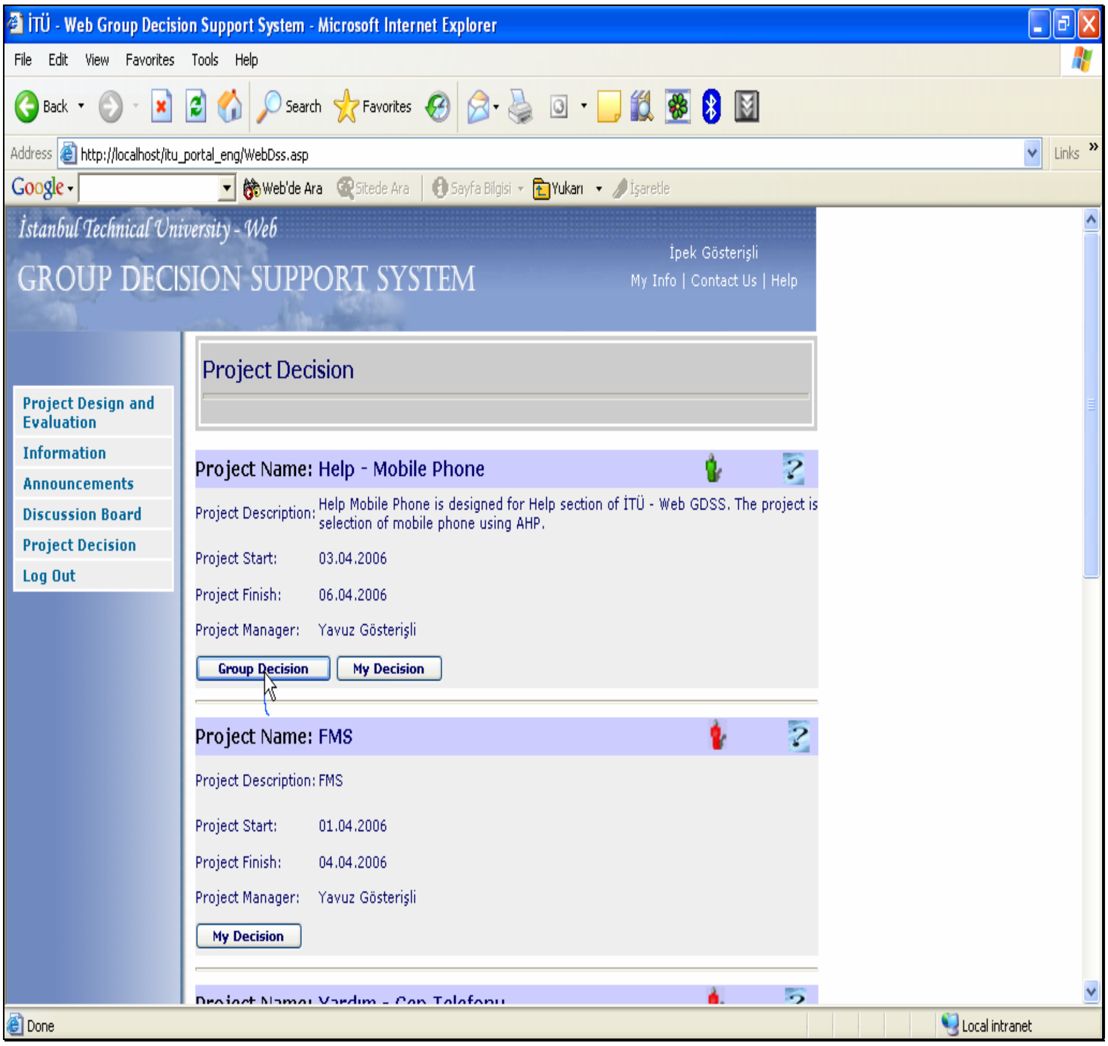


Figure 8.41 : Project User Decision Page

8.2.2.9. Reports for Project Manager

Reports page will help project manager to observe the users' interactions with the system and project. The project manager observes the project users by clicking "Reports" link from the menu at left side of the page as it can be seen in the Figure 8.42. In the Reports page, the project manager sees the total time that project users have spent in the project and the system. The name and surname, user name, the total time spent in the project are observed by the project user. Project manager may send e-mail by clicking "E-mail" link.

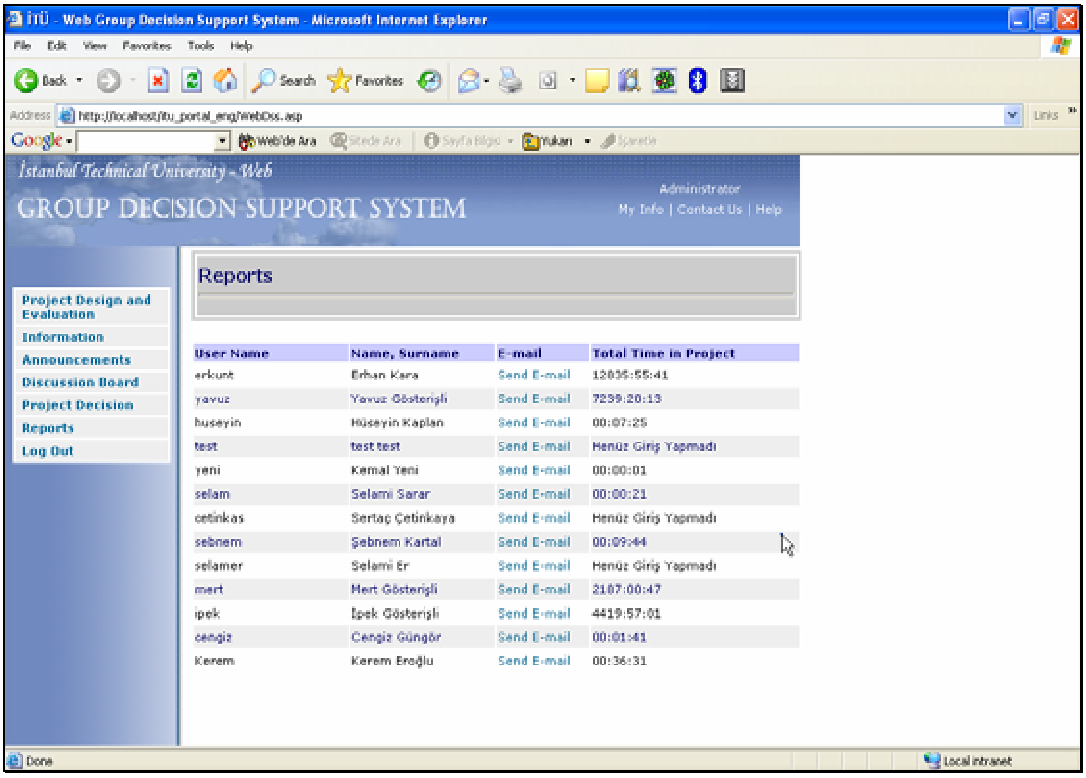


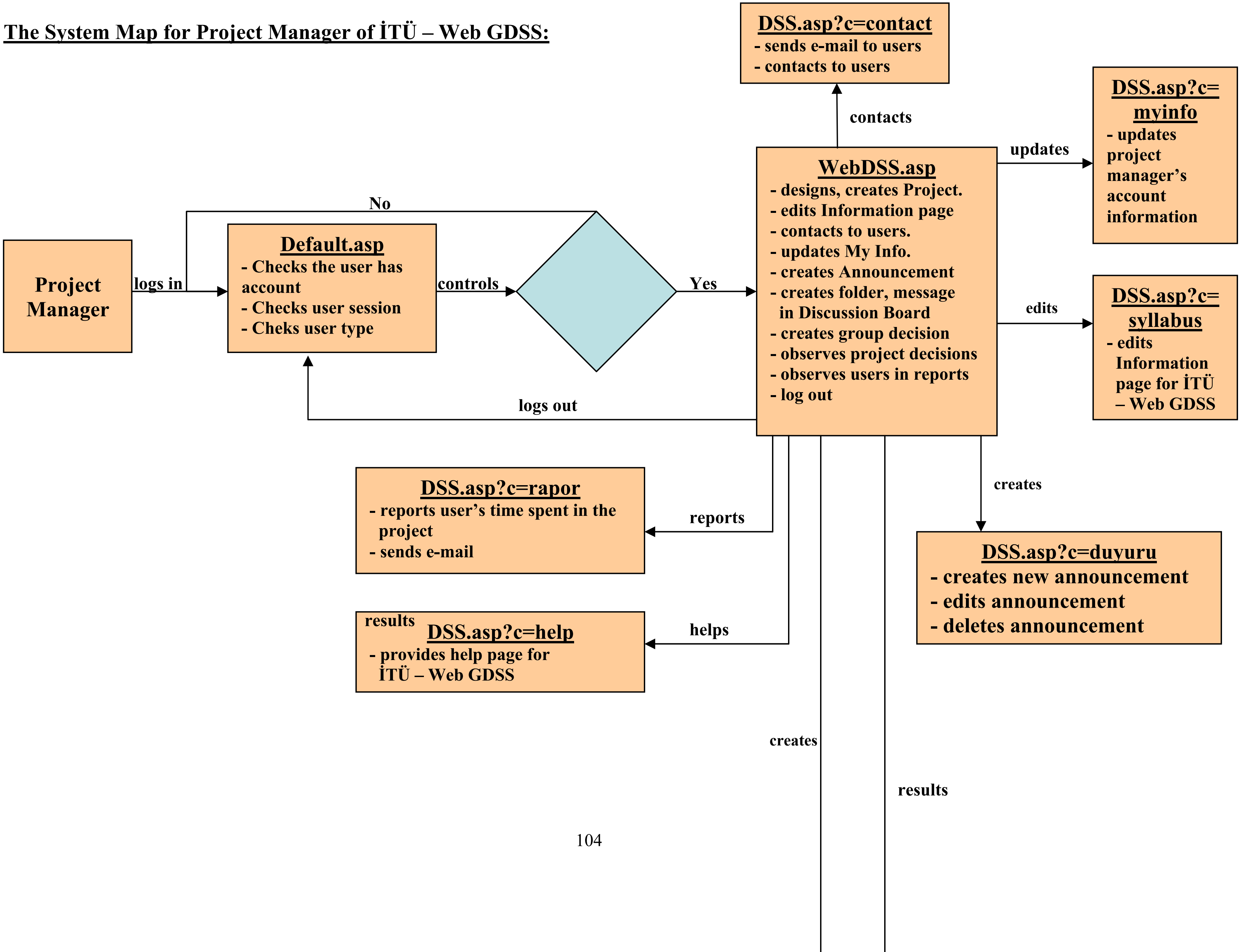
Figure 8.42 : Reports Page

8.2.3.10. Project Manager’s Responsibilities

In Figure 8.43, the responsibilities of project managers are

- creating new Project
    - creating project details
    - designing project hierarchy
    - selecting project users
    - deleting project
- editing Information page
- contacting to users.
- updating account information, My Info.
- creating Announcement
    - creating new announcement
    - editing announcement
    - deleting announcement
- creating folder, message in Discussion Board
- creating group decision
    - calculating geometric average of the project users’ decisions
    - listing users’ decisions and their status
- observing project decisions
    - obtaining graphical presentation of results
    - observing group decision
    - observing each user’s decision
- observing users in reports
- logging out

The System Map for Project Manager of İTÜ – Web GDSS:



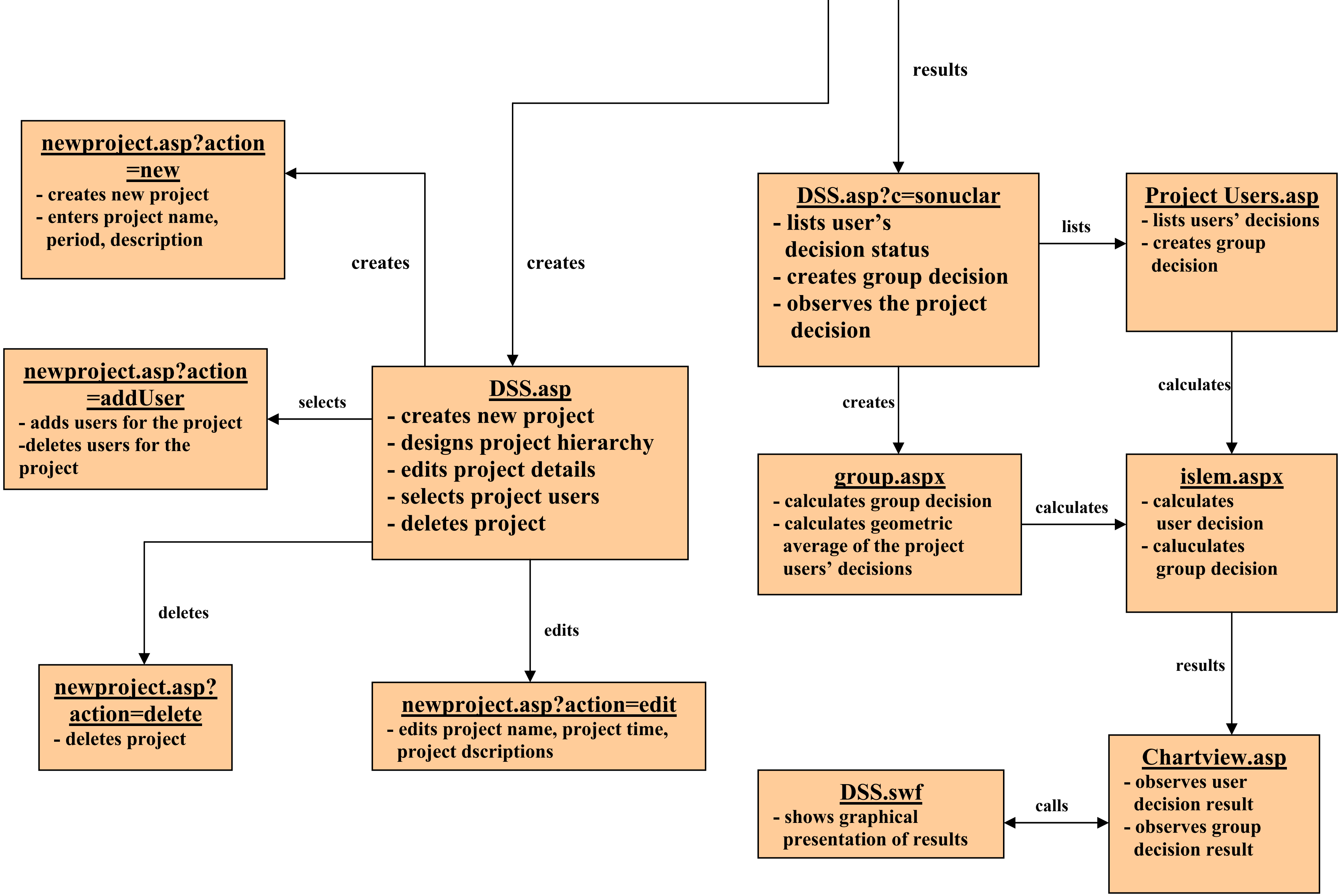


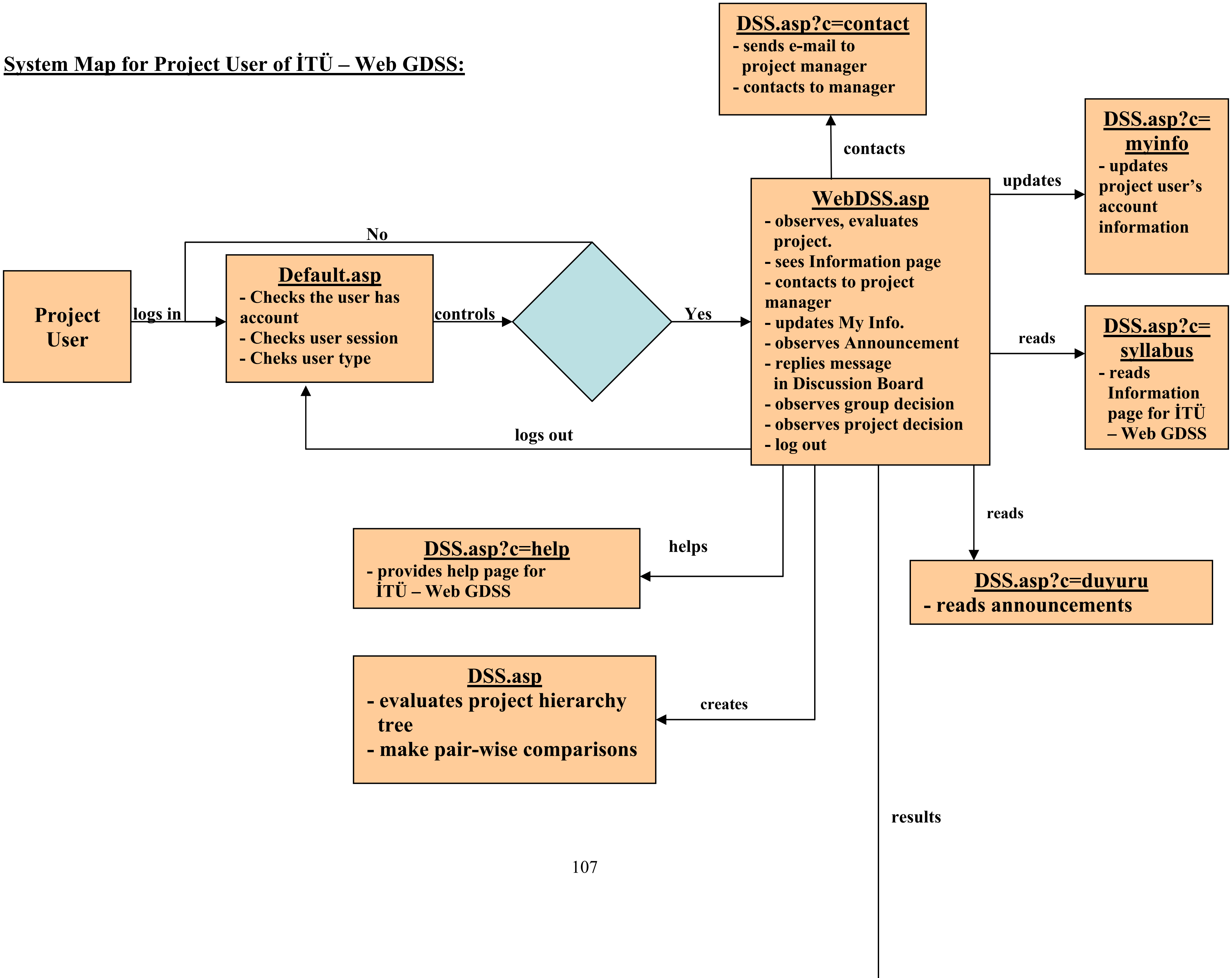
Figure 8.43 : The System Map for Project Manager of İTÜ – Web GDSS

8.2.3.11. Project User's Responsibilities

As it can be seen in Figure 8.44, the responsibilities of project users are

- listing projects
- evaluating project
    - making pair-wise comparisons of each element in the project
    - evaluating project's hierarchy tree
- reading Information page of İTÜ – Web GDSS
- contacting with project manager
    - sending e-mail to project manager
- updating account information, My Info.
- reading Announcements of projects
    - checking new announcements of projects
- replying messages in Discussion Board
- obtaining the project's result
    - observing project's group decision result
    - observing user's own decision of project
    - logging out

System Map for Project User of İTÜ – Web GDSS:



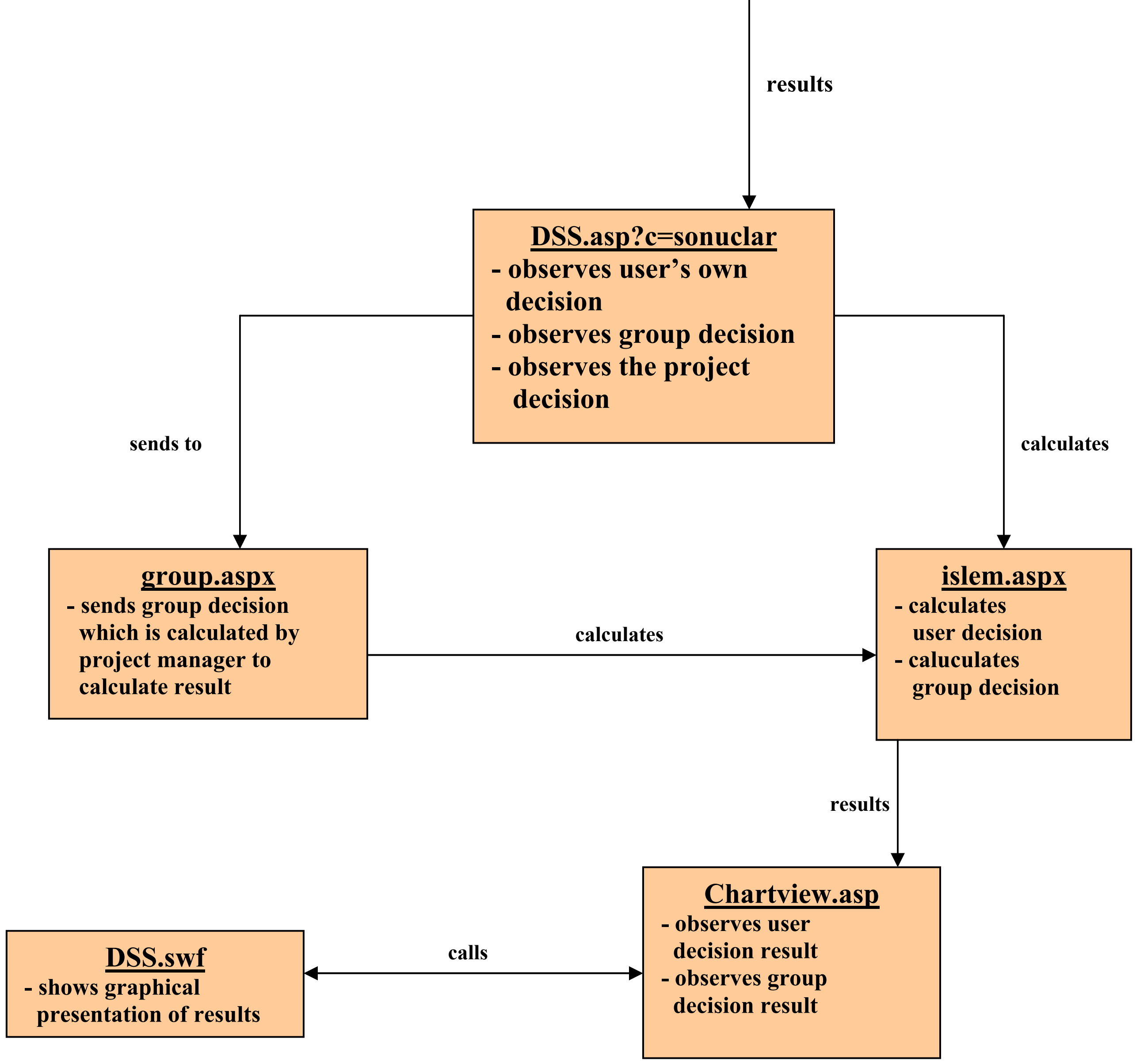


Figure 8.44 : The System Map for Project User of İTÜ – Web GDSS

9. Theory Development and Research Hypotheses

This research explores how the performance of GDSS supported groups influences various dimensions of satisfaction. This research focuses on different types of user satisfaction in Group Decision Support System based meetings: system satisfaction, process satisfaction, and outcome satisfaction; and explores interrelationships among them. Experiment studies are necessary to determine if İTÜ – Web GDSS is able to achieve its design objectives and if the components of the system achieve their respective functions.

In this research study, İTÜ- Web Group Decision Support System (İTÜ- Web GDSS) was developed as a Web-based group decision support system for distributed groups. In İTÜ – Web GDSS, Analytic Hierarchy Process model is used for multi attribute decision making. Pair-wise comparison process for AHP is used in the system by making judgments verbally and numerically. A graphical judgment for pair-wise comparison is not allowed. Rating method for pair-wise comparison and sensitivity modules are not supported in this system.

In this experiment design, it is claimed that it is needed a reliable system which is Expert Choice to determine whether the İTÜ – Web GDSS is reliable or not. By comparing İTÜ – Web GDSS with Expert Choice 11, which is a well known, world wide software tool using AHP for multi attribute decision making according to satisfaction indicators, research will examine the test users' satisfaction on İTÜ – Web GDSS.

9.1. Statement of Research Problems

- Is there any significant difference between the satisfaction of a İTÜ – Web GDSS group with the system used by its members and the satisfaction of an Expert Choice group with the system used by its members?
- Is there any significant difference between the satisfaction of a İTÜ – Web GDSS group with decision making process and the satisfaction of an Expert Choice group with decision making process?

- Is there any significant difference between the satisfaction of a İTÜ – Web GDSS group with decision outcome and the satisfaction of an Expert Choice group with decision outcome?
- Is there any significant difference between overall GDSS satisfaction of a İTÜ – Web GDSS group and overall GDSS satisfaction of an Expert Choice group?

9.2. Hypotheses

Hypothesis testing is procedures that will help the researcher determine whether or not a treatment effect occurred. The research hypothesis is final possible decision about the research according to the analysis of data and the result of collected data.

9.2.1. Null Hypotheses (H_0)

- **$H1_0$:** There is not any significant difference between the satisfaction of a İTÜ – Web GDSS group with the system used by its members and the satisfaction of an Expert Choice group with the system used by its members.
- **$H2_0$:** There is not any significant difference between the satisfaction of a İTÜ – Web GDSS group with decision making process and the satisfaction of an Expert Choice group with decision making process.
- **$H3_0$:** There is not any significant difference between the satisfaction of a İTÜ – Web GDSS group with decision outcome and the satisfaction of an Expert Choice group with decision outcome.
- **$H4_0$:** There is not any significant difference between overall GDSS satisfaction of a İTÜ – Web GDSS group and overall GDSS satisfaction of an Expert Choice group.

9.2.2. Alternative Hypotheses (H_1)

- **$H1_1$:** There is a significant difference between the satisfaction of a İTÜ – Web GDSS group with the system used by its members and the satisfaction of an Expert Choice group with the system used by its members.
- **$H2_1$:** There is a significant difference between the satisfaction of a İTÜ – Web GDSS group with decision making process and the satisfaction of an Expert Choice group with decision making process.

- **$H3_1$:** There is a significant difference between the satisfaction of a İTÜ – Web GDSS group with decision outcome and the satisfaction of an Expert Choice group with decision outcome.
- **$H4_1$:** There is a significant difference between overall GDSS satisfaction of a İTÜ – Web GDSS group and overall GDSS satisfaction of an Expert Choice group.

10. Research Method

This section of the research discusses the following: research design and subjects, task identification, variable identification, description of an experiment.

10.1. Research Design and Subjects

In this research, a laboratory experiment was conducted to test the hypotheses. The subjects were undergraduate students from the department of foreign language education at a state university in Istanbul in the experiment. Students of freshman year (N=44), sophomore year (N=18), senior year (N=30) attended the experiment. Totally, 92 students participated in the experiments. Participation was voluntary; the subjects could withdraw at any time during the experiment. Subject to the time constraints indicated by the students, participants were randomly assigned to the groups in the experiment. All subjects were experienced with information technology, including basic office-type skills as well as internet/Web skills as measured by a questionnaire completed by them. Also, all subjects had never experienced using group decision support system before.

10.2. Task Identification and Description

A number of different tasks were discussed by the researchers. However, given that the participants were students, it was felt that the involvement of the students would be stronger if the task was one to which they would be easily relate. Accordingly, the task chosen in this research was the selection of a mobile phone. Task problem that was conducted in the experiment was selection of a mobile phone based on criteria and alternatives as it is seen in Appendix A. Selection of a mobile phone problem task was provided to make students involved in decision problem and it was easy to maintain and comprehend for students. A four-levels hierarchy was created for pair wise comparisons of AHP decision process by using criteria and alternatives. Groups were asked to determine hierarchy of the task problem according to the criteria and alternatives as it was seen in Appendix A. Facilitator created the hierarchy of the task problem for students' pair-wise comparisons for AHP. Then, facilitator sent the hierarchy tree to the students to make students pair-wise comparisons. Criteria and alternatives of the task were given to the group members before they started their experiments as seen in Appendix A. It provided help to make pair-comparisons easily by observing specifications of alternatives according to given criteria. Groups determined the same hierarchy tree for the project evaluation. Goal is selection of a mobile phone. Price, technical features and size are criteria for goal. Memory, camera, battery are sub criteria of technical features in hierarchy tree of task problem.

10.3. Variable Identification

Three different satisfactions with GDSS meetings were measured and they are identified in details in Appendix B. Evaluation study considered four different topics: Satisfaction with system, satisfaction with decision making process, satisfaction with decision outcome, and satisfaction with overall GDSS. To collect data, a rating scale (Appendix B) was developed, using and adapting the guidelines outlined in Scheneidermann [65], Akpınar [1], Souren, etc, [68]. Satisfaction with the system part of the survey was developed, adapting the guidelines in Akpınar [1] which was used in evaluating usability issues of the BULMS Learning Management System with the coefficient (alpha) of the scale as 0.91. Adapting the guidelines in Souren, etc. [68] provided evaluating satisfaction with system which found an alpha of 0.823, satisfaction with decision making process which found an alpha of 0.713, and satisfaction with decision outcome which found an alpha of 0.773. The data collection tool use a Likert scale-rating scheme (five-point) based on the suitability of the tool for performing various tasks. The scale included 40 items, its key is as follows: (1) Strongly disagree, (2) Disagree, (3) Neutral, (4) Agree, (5) Strongly agree.

Satisfaction with system was the first dependent variable. This was measured by 21 items using a Likert-type scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). Satisfaction with system was assessed by summing up the first 21 items. A second dependent variable was satisfaction with the decision making process. This was measured by 10 items (from item 22 to item 31) using a Likert-type scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). Satisfaction with the decision making process was assessed by summing up these 10 items. The third dependent variable was satisfaction with decision outcome. It was assessed by summing up the last 9 items (from 32 item to item 40) using a Likert-type scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). Satisfaction with GDSS is assessed by summing up overall 40 items in the survey to determine scale using a Likert-type scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree).

10.4. Experimental Procedures

Experimental sessions were conducted in a computer laboratory which had 23 computers. The experimental sessions were carried out over a 2-day period. The group members were engaged in two different types of GDSS in this experiment: (1) İTÜ – Web GDSS, (2) Expert Choice 11. Each group had a coordinator who was the researcher. Face-to-face communication among the group members was discouraged. However, communication between the coordinator and the other members of the group was allowed but only at some specific steps to indicate transition from one activity to another (such as end of browsing the Internet web pages, end of pair-wise comparisons, beginning next activity, and ending of experiment). Each experiment session could last up to one hour. Four sessions were scheduled in the first day, 2 sessions were scheduled in the second day.

Pilot sessions were held before conducting the actual experiment sessions. The participants in the pilot sessions did not have any difficulty in working with the DSSs. Based on the performance of the participants in the pilot sessions, it was decided that one-hour session would be adequate for conducting the study. Most of the participating groups in the pilot tests as well as in the actual experiments completed their task well within half an hour.

Each class of undergraduate students was divided into two groups. Groups at the same class had equal number of members and each group was engaged in different GDSS. Selection of groups and selection of GDSS programs were held on randomly. To select groups, equal number of papers which were named as A and B were put into a bag. The number of papers A and the number of papers B in the bag were equal. Then, students in the class were asked to choose only one paper. When all the students chose their papers, groups were created by random assignment. Then, it was time to select the GDSS that group conducted in the experiment. Researcher tossed a coin to select GDSS for each group. Firstly, a coin was tossed to select the first group which was conducted the experiment. Head was Group A, and tail was Group B. Head came and so, A was the first group and B was the second group to assign the GDSS. For group A, coin was tossed to choose GDSS. Head is İTÜ – Web GDSS and tail was Expert Choice 11. Head of coin came. It meant that group A was conducted İTÜ – Web GDSS and group B were conducted Expert Choice 11. It was claimed that groups and GDSSs were assigned randomly. Distribution of students over groups can be seen as in Table 10.1.

Table 10.1: Distribution of Students over GDSS groups

Students (N*) / Group	**Class**			
	Freshman	**Sophomore**	**Senior**	**Total**
Group A: İTÜ–Web GDSS	22	9	15	46
Group B: Expert Choice	22	9	15	46
Total:	44	18	30	92

(*) N: number of students

The experimental procedure was as follows:

1. Participants were given a hand-out for the task that they accomplished as it is seen in Appendix A. They completed a consent form. They could withdraw from the study then.

2. The participants were given a brief instruction about using the GDSS programs. Each group was shown how to use own GDSS system in the experiment.

3. Questions were asked by students to facilitator by group members about using the systems. All questions were answered.

4. The facilitator created task decision hierarchy tree. Then, the participants were asked to start to complete their task by using the system which they had been assigned before. When the participants entered the system, they were asked to write their start time into given own hand-outs.

5. The participants completed their pair-wise comparison, and observed their results. They were asked to wait for group results.

6. The facilitator created group decision and group results when all the group members completed their evaluations. Then, facilitator announced the group results.

7. The participants were asked to observe group results in the system.

8. When the participants completed their task by using the system, they were asked to write their own finish time to given hand-outs.

9. The participants were asked to complete the given questionnaire. The questionnaire completed by each participant provided data on his or her satisfaction with the system, decision making process, and decision outcome. In addition, some demographic data such as age, gender, computer skills were also collected with the help of the questionnaire.

10. Hand-outs and questionnaires were collected from the participants.

The participants were not allowed to take the instruction sheet with them after the experiment and were advised not to discuss about the experiment with their classmates. Interaction between groups was not allowed.

11. Results and Discussion

The students (N=92) at freshman (N=44), sophomore (N=18), senior (N=30) year answered the rating scale. 76 girls and 16 boys were answered the rating scale. Most of them rated themselves as experienced computer users. None of them was experienced group decision support system. Reliability assessments were calculated for the self-reported variables of satisfaction with system, satisfaction with decision making process, and perceived decision quality. Subsequently, Cronbach Alpha coefficients were calculated. Since the measurement scales used had not been tested and validated before and in view of the exploratory nature of the this research, a cut-off value 0.70 was considered acceptable [48]. An alpha of 0.871 was found for satisfaction with system as in Appendix C, 0.857 for satisfaction with decision making process as it is seen in Appendix D, 0.882 for satisfaction with the decision as seen in Appendix E, and 0.935 for satisfaction with overall GDSS as it can be seen in Appendix F.

Independent Samples T-Test analyses were employed to test the hypotheses using a level of significance of 0.05. The T-test model procedures of SPSS were used to analyze the data from two different group types (the group using the İTÜ – Web GDSS and the group using the Expert Choice 11) in this study. Statistical tests were carried out to ensure that dependent variables (i.e. satisfaction with system, process, outcome, and GDSS) did not vary significantly across the two group types. Statistics for İTÜ – Web GDSS and Expert Choice are shown in Table 11.1

Table 11.1: Group Statistics for Dependent Variables

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Satisfaction with System	ITÜ Web GDSS	46	89.3913	7.95118	1.17234
	Expert Choice	46	86.5000	11.69948	1.72499
Satisfaction with Decision Making Process	ITÜ Web GDSS	46	39.7391	5.10091	.75209
	Expert Choice	46	38.3043	6.70612	.98876
Satisfaction with Decision	ITÜ Web GDSS	46	34.0217	5.29775	.78111
	Expert Choice	46	33.4565	7.65276	1.12834
Satisfaction with GDSS	ITÜ Web GDSS	46	163.1522	15.31298	2.25778
	Expert Choice	46	158.2609	23.49225	3.46374

Table 11.2: Independent Samples T-test

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Satisfaction with S	Equal variances assumed	5.005	.028	1.386	90	.169	2.89130	2.08566	.25222	7.03483
	Equal variances not assumed			1.386	79.260	.170	2.89130	2.08566	.25989	7.04250
Satisfaction with D Making Process	Equal variances assumed	1.562	.215	1.155	90	.251	1.43478	1.24229	.03325	3.90281
	Equal variances not assumed			1.155	84.012	.251	1.43478	1.24229	.03565	3.90521
Satisfaction with D	Equal variances assumed	5.890	.017	.412	90	.681	.56522	1.37233	2.16115	3.29158
	Equal variances not assumed			.412	80.075	.682	.56522	1.37233	2.16576	3.29620
Satisfaction with G	Equal variances assumed	3.234	.075	1.183	90	.240	4.89130	4.13462	3.32284	3.10545
	Equal variances not assumed			1.183	77.392	.240	4.89130	4.13462	3.34111	3.12372

Levene's Test for Equality of variances and t-test for equality means for independent samples can be seen in the Table 11.2. The results of hypotheses are obtained from analyses results as in Appendix M. The analyses demonstrate that alternative hypotheses are rejected. In hypothesis 1, significance value is (p=0.170) is greater than significance level of 0.05. Therefore, there is not any significant difference between the satisfaction of a İTÜ – Web GDSS group with the system used by its members and the satisfaction of an Expert Choice group with the system used by its members. In hypothesis 2, significance value is (p=0.251) greater than significance level of 0.05. It is claimed that alternative hypothesis 2 is rejected. There is not any significant difference between the satisfaction of a İTÜ – Web GDSS group with decision making process and the satisfaction of an Expert Choice group with decision making process. Hypothesis 3 claims users' satisfaction with decision outcome. Alternative hypothesis is rejected according to significance value (p=0.682). So, it can be said that there is not any significant difference between the satisfaction of a İTÜ – Web GDSS group with decision outcome and the satisfaction of an Expert Choice group with decision outcome. Overall, in hypothesis 4, alternative hypothesis is rejected due to significance level (p=0.240). Thus, there is not any significant difference between overall GDSS satisfaction of a İTÜ – Web GDSS group and overall GDSS satisfaction of an Expert Choice group.

The results show that there is not any significant difference between the İTÜ – Web GDSS group and Expert Choice group according to the dependent variables that are satisfaction with system, decision making process, decision, and overall GDSS. To analyze that students are satisfied based on the dependent variables, One Sample T-test analysis which was run on the SPSS was used for all students. Test value was given to the system according to Likert type scale. As it can be seen in the Appendix P, significance levels (p= 0.000) are lower than significance level of 0.05. It can be maintained that students are satisfied with system that they used, decision making process, decision, and the overall GDSS. One sample T-test analysis was also used for İTÜ – Web GDSS. Results can be seen from Appendix O. significance levels (p= 0.000) are lower than significance level of 0.05. It can be maintained that students using İTÜ – Web GDSS are satisfied with system that they used, decision making process, decision, and the overall GDSS.

11.1. Satisfaction with System:

As it is mentioned before, in Hypothesis 1, there is not any significant difference between the satisfaction of a İTÜ – Web GDSS group with the system used by its members and the satisfaction of an Expert Choice group with the system used by its members.

The mean of satisfaction with system for İTÜ – Web GDSS group which is 89.391 is slightly greater than the mean of satisfaction with system for Expert Choice group which is 86.500. Means of the satisfaction with system between the groups can be seen in the Figure 11.1. By observing the graph, it can be claimed that students using İTÜ – Web GDSS are more satisfied with the system than students using Expert Choice. But it should be noted that there is not any significant difference between the groups based on the satisfaction with the system.

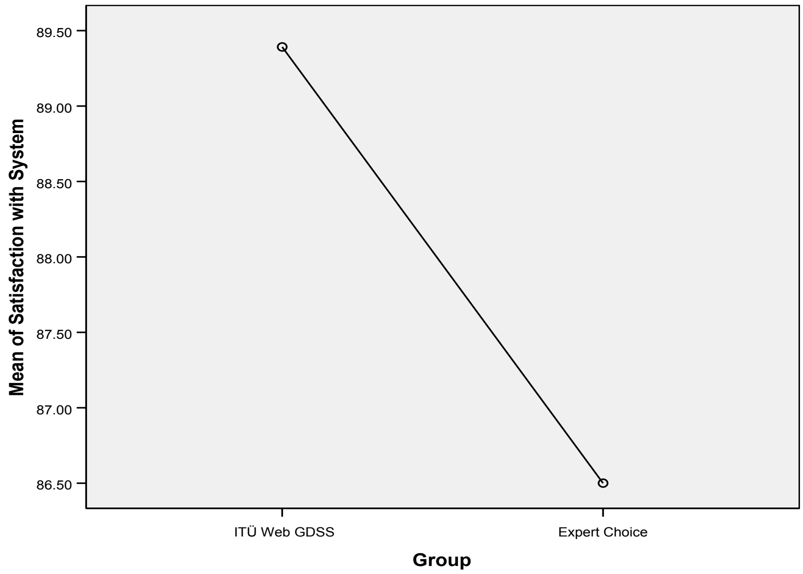


Figure 11.1 : Graph for Means of Satisfaction with System

11.2. Satisfaction with Decision Making Process:

In Hypothesis 2, results demonstrate that there is not any significant difference between the satisfaction of a İTÜ – Web GDSS group with decision making process and the satisfaction of an Expert Choice group with decision making process.

The mean of satisfaction with decision making process for İTÜ – Web GDSS group which is 39.739 is slightly greater than the mean of satisfaction with decision making process for Expert Choice group which is 38.304. Means of the satisfaction with decision making process between the groups can be seen in the Figure 11.2. It can be claimed that students using İTÜ – Web GDSS are more satisfied with decision making process than students using Expert Choice. But it should be noted that there is not any significant difference between the groups based on the satisfaction with decision making process.

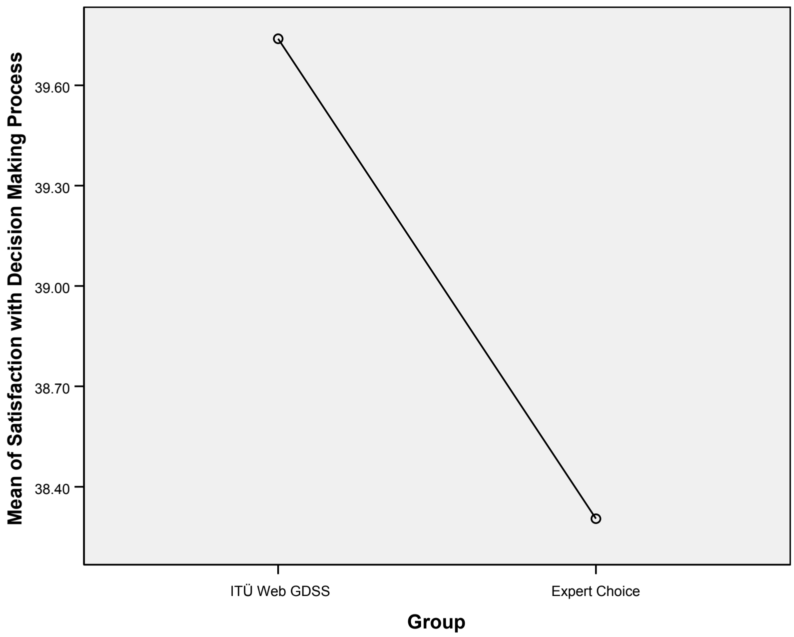


Figure 11.2 : Graph for Means of Satisfaction with Decision Making Process

11.3. Satisfaction with Decision:

Results show that there is not any significant difference between the satisfaction of a İTÜ – Web GDSS group with decision outcome and the satisfaction of an Expert Choice group with decision outcome in hypothesis 3.

The mean for satisfaction with decision outcome for İTÜ – Web GDSS group which is 34.021 is slightly greater than the mean of satisfaction with decision outcome for Expert Choice group which is 33.739. Means of groups can be best viewed by graph as in Figure 11.3. İTÜ – Web GDSS group are slightly more satisfied with decision outcome than Expert Choice group. It is claimed that there is not any significant differences between these two groups.

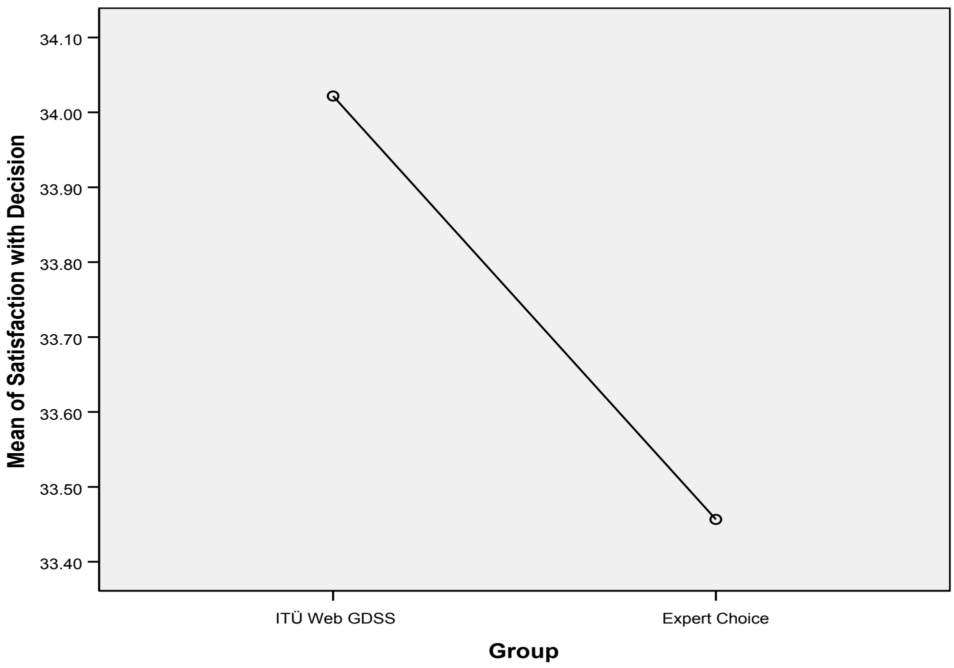


Figure 11.3 : Graph for Means of Satisfaction with Decision

11.4. Satisfaction with Overall GDSS:

Analyses results demonstrate that there is not any significant difference between the satisfaction of a İTÜ – Web GDSS group with GDSS and the satisfaction of an Expert Choice group with GDSS in hypothesis 4.

The mean of satisfaction with GDSS for İTÜ – Web GDSS group which is 163.152 is slightly greater than the mean of satisfaction with GDSS for Expert Choice group which is 158.261. Means of groups can be best viewed by graph as in Figure 11.4. İTÜ – Web GDSS group are slightly more satisfied with GDSS than Expert Choice group. It must be maintained that there is not any significant difference between the satisfaction of İTÜ – Web GDSS group with GDSS and the satisfaction of an Expert Choice group with GDSS.

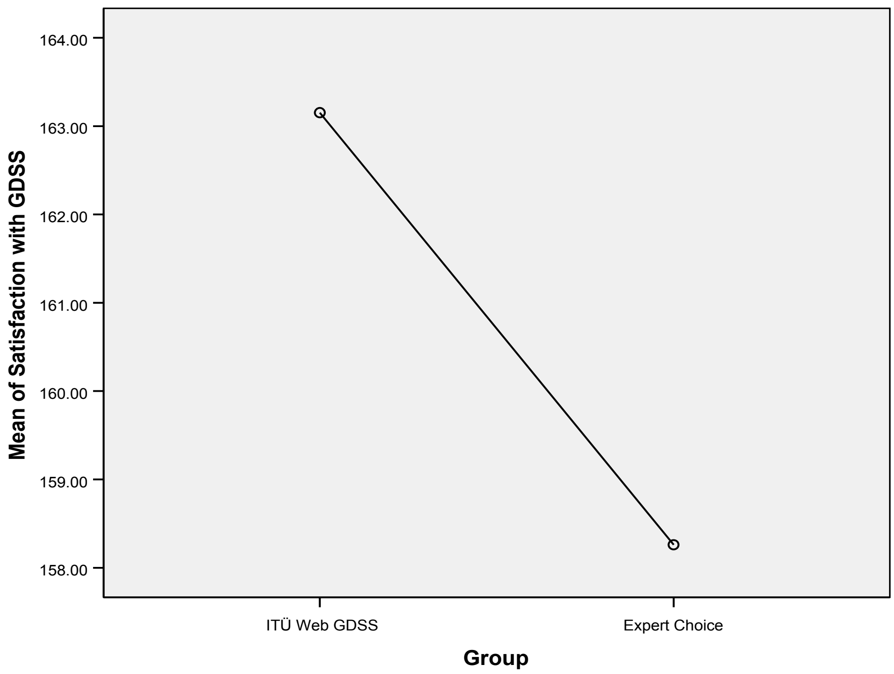


Figure 11.4 : Graph for Means of Satisfaction with GDSS

To sum up, students using İTÜ – Web GDSS are more slightly satisfied than students using Expert Choice with dependent variables; system, decision making process, decision, GDSS. However, there is not any significant difference between the İTÜ – Web GDSS group and Expert Choice group.

12. Conclusion and Further Research

This research highlights that the performance GDSS supported groups impacts members' satisfaction with system, process, and decision outcome. İTÜ – Web GDSS group and Expert Choice group are tested in this study and results indicate that group members' are satisfied with the GDSS systems.

The AHP provides a methodology to help decision makers to systematically identify objectives, and priorities, and develop alternatives to achieve the objectives. İTÜ – Web GDSS offers a platform for implementing the AHP methodology with wide accessibility and cross-platform abilities.

Generally, İTÜ – Web GDSS can help decision maker groups:

1. identify decision objectives;

2. structure decision problems by expressing the interaction and hierarchy of objectives, criteria, and alternatives;

3. assess the relative importance of achieving the objectives by using value judgments;

4. synthesize the value judgments to obtain an overall measure of the desirability of each alternative.

İTÜ – Web GDSS implements the AHP. It uses the AHP methodology to model any problem, evaluate relative desirability of alternatives, and organize information and judgments used in decision making. In addition, pair-wise comparison module is created and implemented to the users. However, rating methodology of AHP is not used in this research. It can be claimed that İTÜ – Web GDSS has not supported sensitivity analyses for AHP.

It provides a computer-based tool for individual and group as well as group decision support with a high degree of interoperability (the ability to operate it on various platforms) and sharability (the ability to access and share decision models, information, and decision analysis technologies).

By taking advantage of the WWW, İTÜ – Web GDSS places minimal constraints on users' hardware and software environments while allowing them to use decision analyses technologies without the introduction of additional software. The associated web links can provide multimedia information to help users make judgments and improve quality of decision making.

İTÜ – Web GDSS is deployed on the World Wide Web (WWW) and can be accessed globally. It takes advantages of WWW with wide ability, Web resource integration and cross-platform capabilities. Project manager function of the İTÜ – Web GDSS facilitates the decision project. Therefore, group members understand the project without having trouble with the system. Group members understand what they have to do in the project evaluation. Expert Choice does not support the facilitator function in any project. On the other hand, Expert Choice is a software tool which runs on the computer if the program is installed on the computer. Expert Choice must be installed into the computer where the user is provided to use the program. It should be noted that Web based GDSS provides users with independence of time and place. In the experiment study, Expert Choice group members ask more questions than İTÜ – Web GDSS group members according to usability of the system and comprehension of the task.

In a few words, İTÜ- Web GDSS provides a decision analyses portal with wide ability, global access, efficient maintenance and WWW integration.

For future research, rating scale of AHP and Sensitivity Analyses modules could be added to İTÜ – Web GDSS. Not only AHP, but also other multi-attribute decision making method such as Analytical Neural Process, Fuzzy AHP, Fuzzy ANP, Topsis, and Electre should be used in the Web based group decision support system. One important aspect of that may be explored in future is the impact of decision time on satisfaction with system and decision process. Future research may attempt to assess decision time that results optimal satisfaction. Another important aspect that may be explored is the depth of decision making and its impact on group members' satisfaction with decision outcome. In addition, the relationships between thoroughness of decision making and satisfaction with decision outcome may be studied in the future research.

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APPENDIXES

Appendix A: Problem Task

Name:

Group Name:

Start Time:

Finish Time:

Technical Specifications			
	Sony Ericsson W800	**Nokia 6680**	**Samsung D600**
1. Price	439,00 € + VAT	377,00 € + VAT	415,00 € +VAT
2. Technical Features:			
2.1. Memory	512 Mb - 34 Mb shared	64 Mb - 10 Mb shared	72 Mb - 4 Mb shared
2.2. Camera	2 MP, 1632x1224 pixels, auto focus, video, flash	1.3 MP, 1280x960 pixels, video (QCIF), flash; VGA camera	2 MP, 1600x1200 pixels, video, flash
2.3. Battery:			
2.3.1. Talk Time	up to 9 h	up to 6 h	up to 7 h
2.3.2. Stand-by	up to 400 h	up to 240 h	up to 300 h
3. Size			
3.1. Weight	99 g.	133 g.	103 g.
3.2. Dimension			
3.2.1. Length	100 mm.	108.6 mm.	96 mm.
3.2.2. Height	46 mm.	55.2 mm.	46.5 m.
3.2.3. Width	20.5 mm.	20.5 mm.	21.5 mm.

Appendix B: Questionnaire

Questionnaire

This questionnaire measures your satisfaction with the system, decision making process, and decision. Your evaluation will greatly help us to improve the system. Please rate all items sincerely. Thank you for your contribution.

Your department:.. **Class**:…………

Age: …........

Gender: Male ( ) Female ( )

How do you rate your experience with computers?

Novice ( ) Experienced ( ) Expert ( )

Have you ever used decision support system before?

Yes ( ) No ( )

Please read the following statements and rate the system by selecting appropriate slot across the statement. **A. Satisfaction with system**	**Strongly disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
1) I understand the system I used					
2) The system was easy to use					
3) My overall reactions to the system is satisfying					
4) Reading characters on the screen is easy					
5) Highlighting and button actions on the screen were helpful					
6) The screen layouts were helpful					
7) Arrangements of information on the screen were logical					
8) Throughout the system, terms were used consistently					
9) I have confidence in the system I used					
10) I should have had more training on the system					
11) Learning to navigate the system was easy					
12) Messages appearing on the screen were clear					
13) Messages appearing on the screen were consistent					
14) Response time of the system was relatively fast enough					
15) Pair-wise comparison facility was easy to use					
16) Pair-wise comparison was satisfactory					
17) Use of graphics in the system was sufficient					
18) Hierarchy tree structure helped me to understand the decision problem					
19) Hierarchy tree was satisfying					
20) Help was sufficient					
21) Overall, I am satisfied with the system we used to arrive at the final decision					
B. Satisfaction with decision making proces					
22) I participated extensively in the decision making process					
23) I was able to evaluate a number of alternatives during the decision making session					
24) I believe my contribution to be significant in our group arriving at the final decision					
25) I did not rush to provide my solutions					
26) I was not rushed by others in the session					
27) Overall, as a member of our team, I am satisfied with the process I employed in arriving at the final decision					
28) Overall, I am satisfied with the solution process our group employed to arrive at the final decision					
29) I am satisfied with observing my final decision after evaluation is completed					
30) I am satisfied with observing group decision when it is created					
31) The system process was satisfying					
C. Satisfaction with decision					
32) The output was relevant to me					
33) The output was useful for me					
34) The output was comprehensive					
35) The output generated was reliable					
36) I have confidence in the accuracy of the output					
37) I will use this output in the future in making my decision if the same decision problem is asked to me again					
38) Overall, I am satisfied with the output we generated in the decision making session					
39) Group decision output was satisfying					
40) My decision was satisfying					

Appendix C: Reliability Analysis for Satisfaction with System

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
,871	,881	21

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
83,91	88,542	9,410	21

		N	%
Cases	Valid	92	100,0
	Excluded[a]	0	,0
	Total	92	100,0

a. Listwise deletion based on all variables in the procedure.

Item Statistics

	Mean	Std. Deviation	N
A1	4,13	,801	92
A2	4,12	,810	92
A3	3,82	,913	92
A4	4,11	,907	92
A5	4,22	,708	92
A6	3,97	,818	92
A7	4,04	,755	92
A8	4,07	,676	92
A9	3,67	,939	92
A10	3,18	1,249	92
A11	3,86	,897	92
A12	4,04	,876	92
A13	4,11	,777	92
A14	4,55	,685	92
A15	3,97	,805	92
A16	3,91	,807	92
A17	4,11	,895	92
A18	3,97	,733	92
A19	3,89	,805	92
A20	4,14	,846	92
A21	4,03	,943	92

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
A1	79,78	80,875	,487	,562	,864
A2	79,79	79,792	,559	,581	,862
A3	80,10	76,990	,669	,655	,857
A4	79,80	79,785	,489	,578	,864
A5	79,70	79,379	,686	,631	,859
A6	79,95	78,623	,638	,691	,859
A7	79,87	80,554	,548	,444	,862
A8	79,85	83,515	,370	,359	,868
A9	80,24	78,843	,529	,519	,862
A10	80,73	91,431	-,186	,270	,896
A11	80,05	80,645	,440	,415	,866
A12	79,87	77,170	,689	,631	,857
A13	79,80	79,434	,614	,564	,860
A14	79,36	84,870	,254	,311	,871
A15	79,95	80,843	,487	,722	,864
A16	80,00	80,396	,518	,684	,863
A17	79,80	79,060	,545	,515	,862
A18	79,95	83,261	,355	,536	,868
A19	80,02	82,351	,380	,507	,868
A20	79,77	81,804	,393	,441	,867
A21	79,88	77,799	,592	,632	,860

Appendix D: Reliability Analysis for Satisfaction with Decision Making Process

Case Processing Summary

		N	%
Cases	Valid	92	100,0
	Excluded[a]	0	,0
	Total	92	100,0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
,857	,857	10

Item Statistics

	Mean	Std. Deviation	N
B1	3,87	,841	92
B2	4,09	,751	92
B3	3,65	,988	92
B4	3,89	,791	92
B5	4,01	,920	92
B6	3,95	,942	92
B7	3,78	,981	92
B8	3,98	,926	92
B9	3,74	1,015	92
B10	4,07	,836	92

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
B1	35,15	29,933	,541	,526	,845
B2	34,93	30,237	,584	,465	,843
B3	35,37	28,521	,581	,487	,842
B4	35,13	31,433	,402	,281	,855
B5	35,01	30,626	,408	,295	,856
B6	35,08	27,961	,680	,577	,833
B7	35,24	28,470	,591	,503	,841
B8	35,04	28,042	,686	,530	,832
B9	35,28	28,293	,584	,397	,842
B10	34,96	29,646	,580	,381	,842

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
39,02	35,626	5,969	10

Appendix E: Reliability Analysis for Satisfaction with Decision

Case Processing Summary

		N	%
Cases	Valid	92	100,0
	Excluded[a]	0	,0
	Total	92	100,0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
,882	,882	9

Item Statistics

	Mean	Std. Deviation	N
C1	3,72	1,234	92
C2	3,63	1,056	92
C3	3,86	,897	92
C4	3,86	,956	92
C5	3,75	1,023	92
C6	3,49	1,094	92
C7	3,83	,933	92
C8	3,63	,991	92
C9	3,98	,902	92

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
C1	30,02	31,582	,707	,637	,863
C2	30,11	33,065	,720	,667	,861
C3	29,88	35,865	,582	,418	,873
C4	29,88	34,019	,716	,613	,862
C5	29,99	33,286	,727	,668	,861
C6	30,25	34,343	,575	,491	,874
C7	29,91	35,377	,601	,453	,872
C8	30,11	35,966	,502	,362	,880
C9	29,76	36,206	,544	,335	,876

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
33,74	42,920	6,551	9

Appendix F: Reliability Analysis for Satisfaction with GDSS

Case Processing Summary

		N	%
Cases	Valid	92	100,0
	Excluded[a]	0	,0
	Total	92	100,0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
,935	,937	40

Item Statistics

	Mean	Std. Deviation	N
A1	4,13	,801	92
A2	4,12	,810	92
A3	3,82	,913	92
A4	4,11	,907	92
A5	4,22	,708	92
A6	3,97	,818	92
A7	4,04	,755	92
A8	4,07	,676	92
A9	3,67	,939	92
A10	3,18	1,249	92
A11	3,86	,897	92
A12	4,04	,876	92
A13	4,11	,777	92
A14	4,55	,685	92
A15	3,97	,805	92
A16	3,91	,807	92
A17	4,11	,895	92
A18	3,97	,733	92
A19	3,89	,805	92
A20	4,14	,846	92
A21	4,03	,943	92
B1	3,87	,841	92
B2	4,09	,751	92
B3	3,65	,988	92
B4	3,89	,791	92
B5	4,01	,920	92
B6	3,95	,942	92
B7	3,78	,981	92
B8	3,98	,926	92
B9	3,74	1,015	92
B10	4,07	,836	92
C1	3,72	1,234	92
C2	3,63	1,056	92
C3	3,86	,897	92
C4	3,86	,956	92
C5	3,75	1,023	92
C6	3,49	1,094	92
C7	3,83	,933	92
C8	3,63	,991	92
C9	3,98	,902	92

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
A1	152,54	354,053	,427	.	,934
A2	152,55	350,645	,536	.	,933
A3	152,86	345,529	,625	.	,932
A4	152,57	353,985	,374	.	,934
A5	152,46	350,646	,619	.	,933
A6	152,71	350,232	,544	.	,933
A7	152,63	353,928	,460	.	,934
A8	152,61	357,010	,395	.	,934
A9	153,00	346,088	,590	.	,932
A10	153,49	372,538	-,136	.	,941
A11	152,82	353,669	,388	.	,934
A12	152,63	346,214	,631	.	,932
A13	152,57	352,248	,505	.	,933
A14	152,12	358,304	,339	.	,934
A15	152,71	354,276	,417	.	,934
A16	152,76	352,470	,476	.	,933
A17	152,57	349,259	,523	.	,933
A18	152,71	359,133	,284	.	,935
A19	152,78	357,469	,310	.	,935
A20	152,53	352,581	,449	.	,934
A21	152,64	341,991	,708	.	,931
B1	152,80	349,280	,559	.	,933
B2	152,59	349,586	,620	.	,932
B3	153,02	345,758	,567	.	,933
B4	152,78	354,963	,402	.	,934
B5	152,66	353,676	,377	.	,934
B6	152,73	345,343	,609	.	,932
B7	152,89	347,614	,519	.	,933
B8	152,70	344,588	,644	.	,932
B9	152,93	345,974	,545	.	,933
B10	152,61	345,362	,692	.	,932
C1	152,96	340,218	,567	.	,933
C2	153,04	344,613	,557	.	,933
C3	152,82	346,196	,616	.	,932
C4	152,82	345,845	,585	.	,932
C5	152,92	341,763	,654	.	,932
C6	153,18	345,889	,503	.	,933
C7	152,85	345,339	,616	.	,932
C8	153,04	346,987	,530	.	,933
C9	152,70	348,676	,537	.	,933

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
156,67	367,563	19,172	40

Appendix G: Descriptives of Group

Case Processing Summary

	Group	Cases					
		Valid		Missing		Total	
		N	Percent	N	Percent	N	Percent
Satisfaction with Sy	ITÜ Web GD	46	100.0%	0	.0%	46	100.0%
	Expert Choi	46	100.0%	0	.0%	46	100.0%
Satisfaction with De Making Process	ITÜ Web GD	46	100.0%	0	.0%	46	100.0%
	Expert Choi	46	100.0%	0	.0%	46	100.0%
Satisfaction with De	ITÜ Web GD	46	100.0%	0	.0%	46	100.0%
	Expert Choi	46	100.0%	0	.0%	46	100.0%
Satisfaction with GD	ITÜ Web GD	46	100.0%	0	.0%	46	100.0%
	Expert Choi	46	100.0%	0	.0%	46	100.0%

Tests of Normality

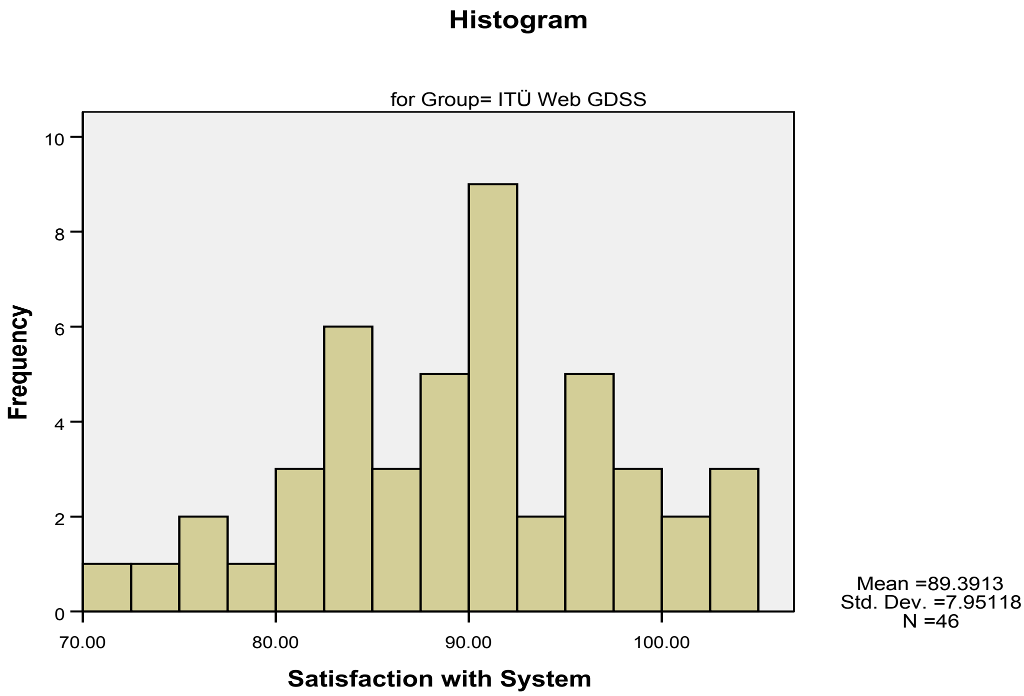
	Group	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Satisfaction with Sys	ITÜ Web GD	.077	46	.200*	.986	46	.851
	Expert Choic	.101	46	.200*	.961	46	.124
Satisfaction with De Making Process	ITÜ Web GD	.096	46	.200*	.973	46	.359
	Expert Choic	.087	46	.200*	.964	46	.165
Satisfaction with De	ITÜ Web GD	.103	46	.200*	.972	46	.323
	Expert Choic	.098	46	.200*	.955	46	.071
Satisfaction with GD	ITÜ Web GD	.085	46	.200*	.968	46	.230
	Expert Choic	.124	46	.075	.967	46	.205

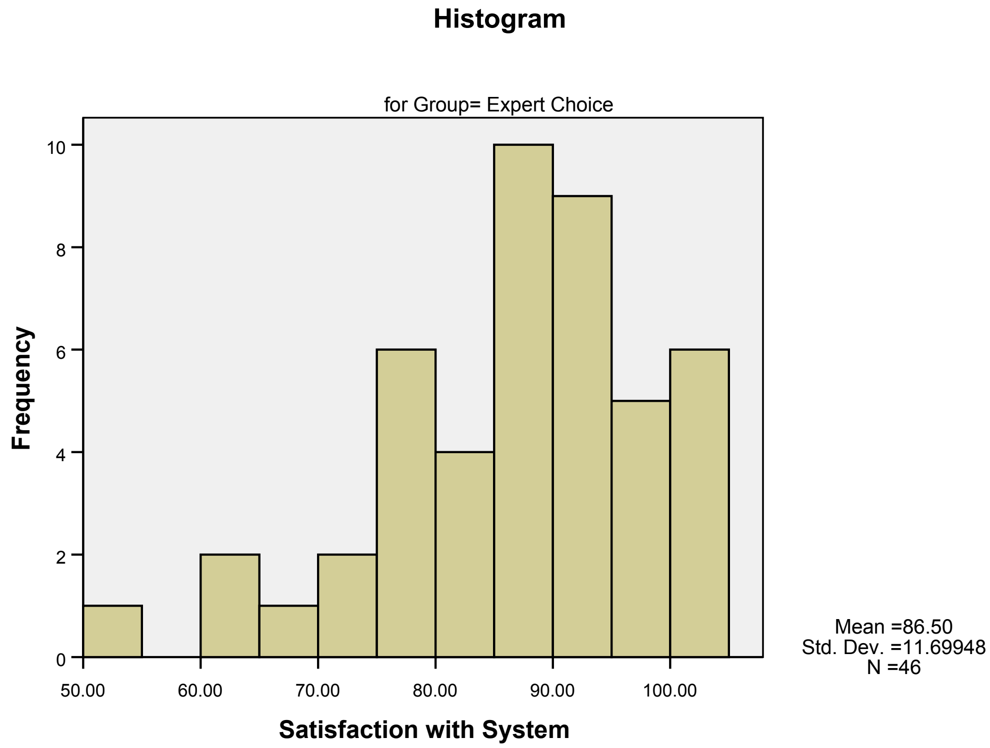
*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

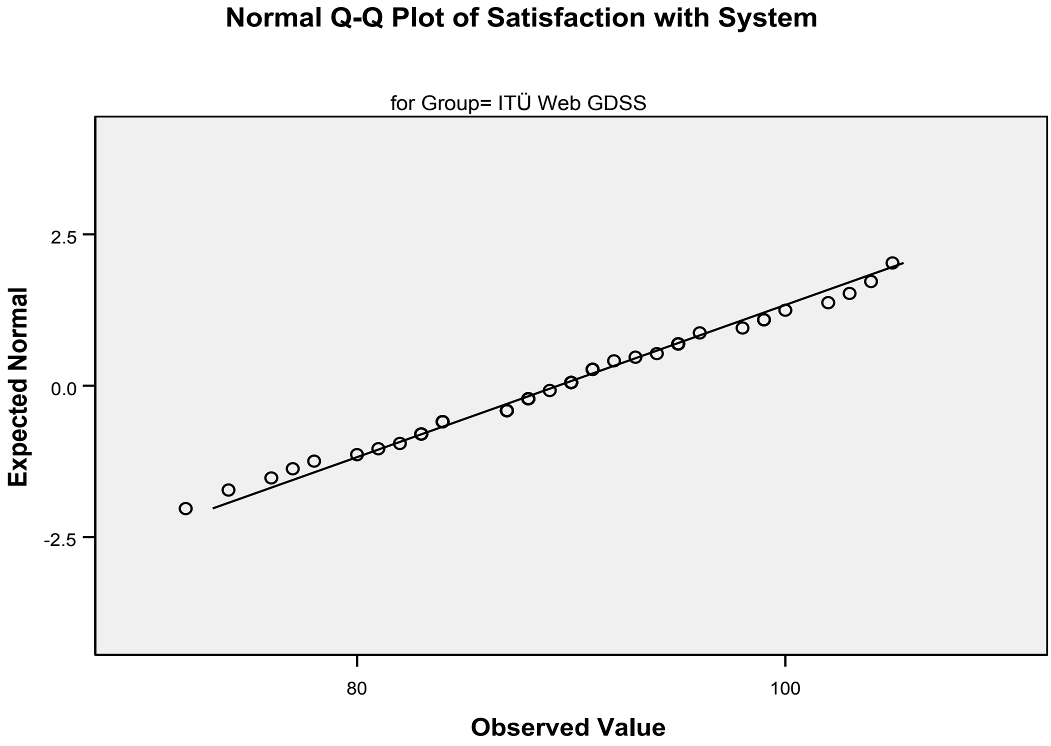
Appendix H: Graphs of Satisfaction with System

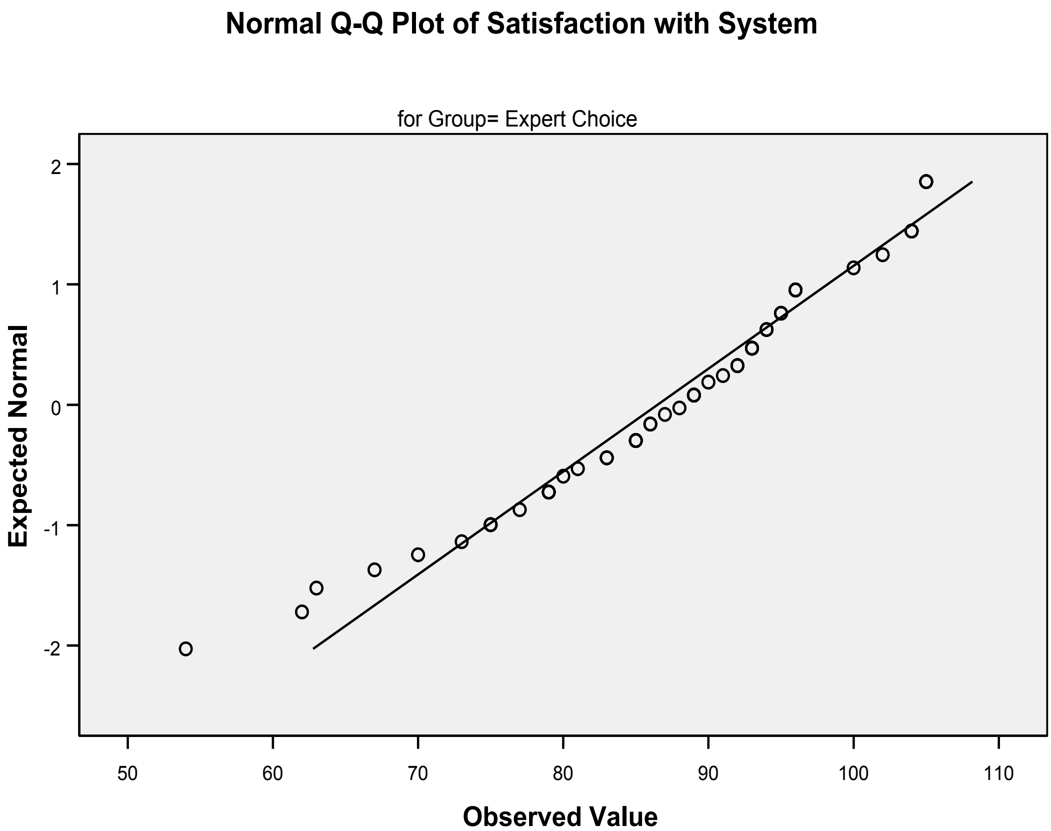
Appendix H1: Histograms of Satisfaction with System



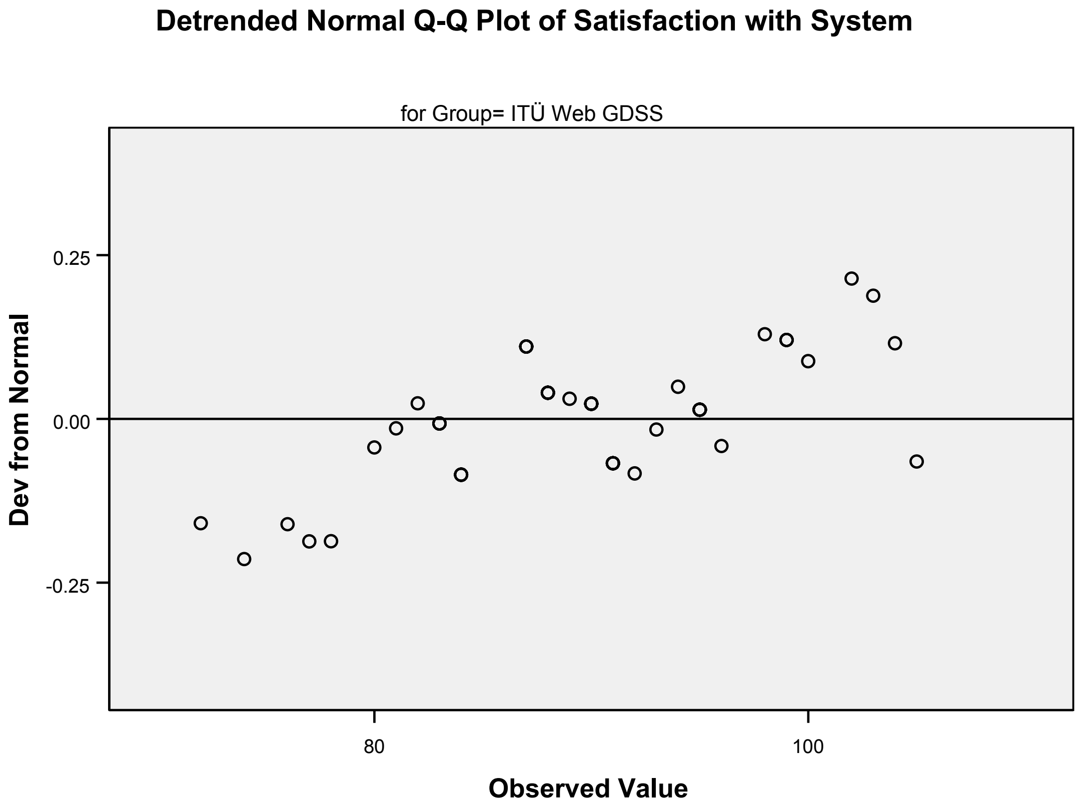


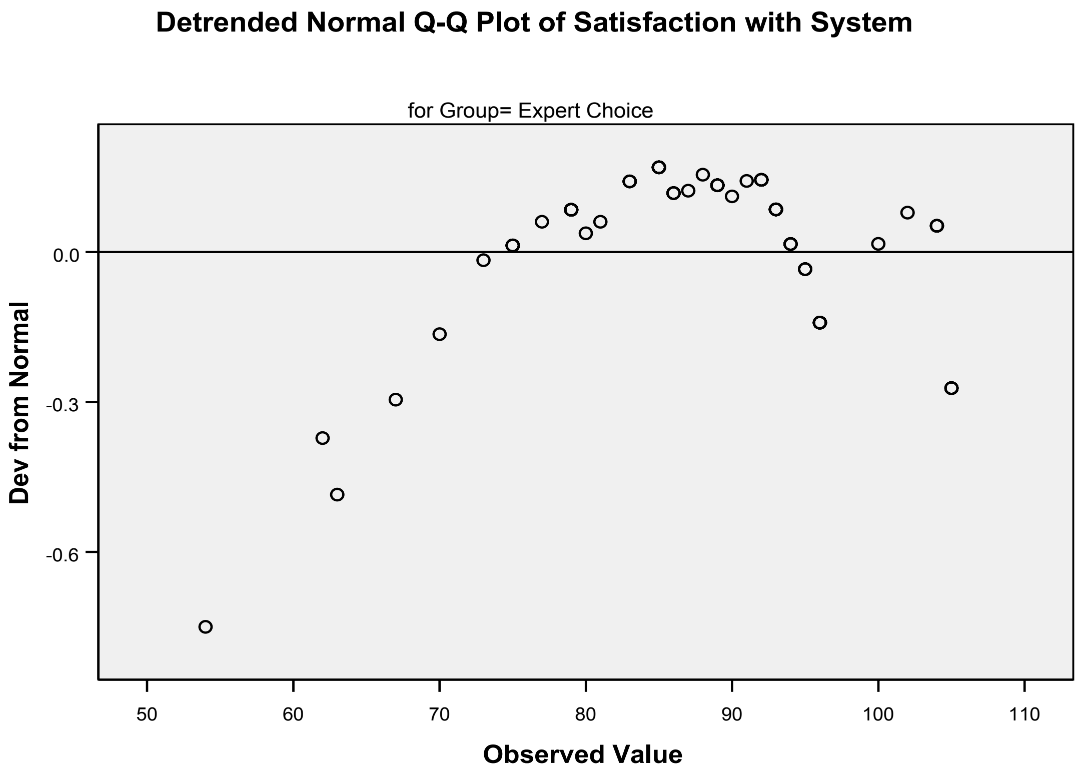
Appendix H2: Normal Q-Q Plots of Satisfaction with System



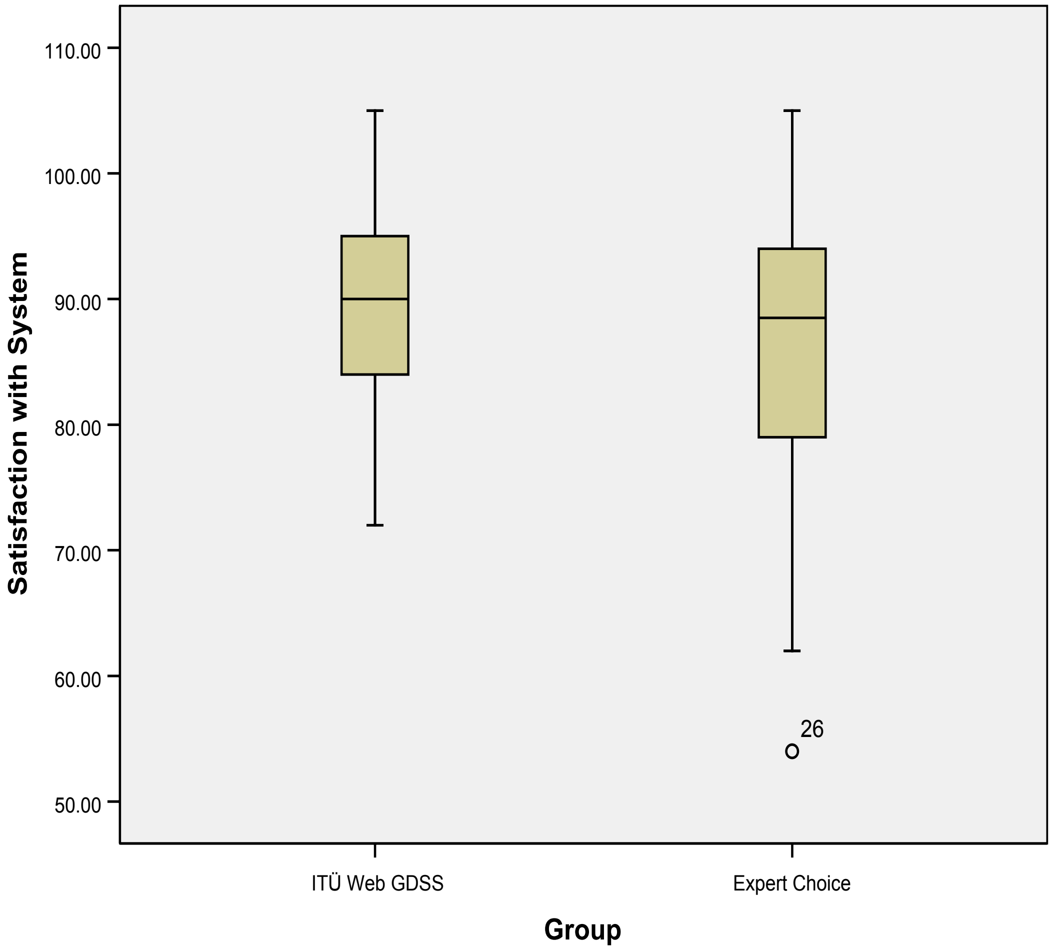


Appendix H3: Detrended Normal Q-Q Plots of Satisfaction with System



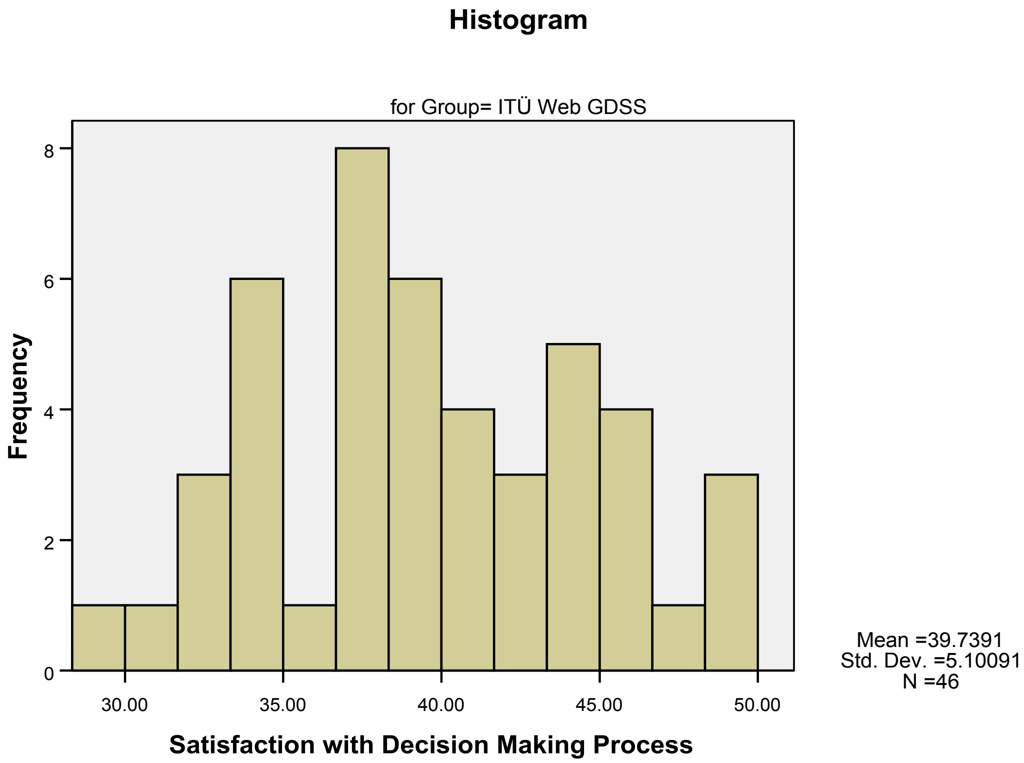


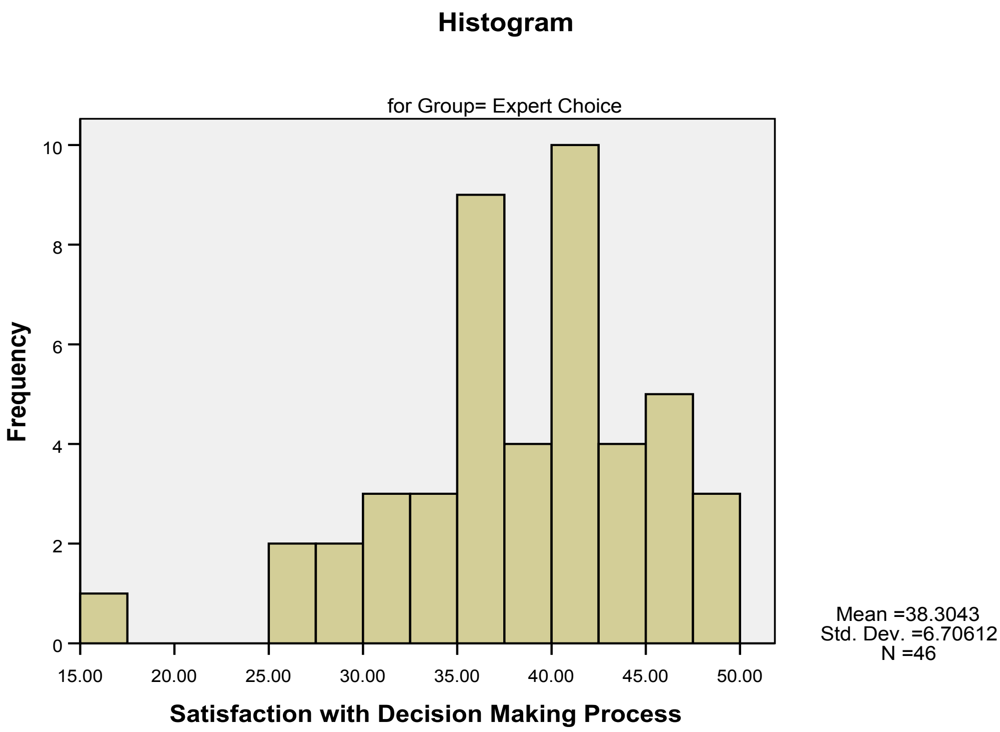
Appendix H4: Boxplot of Satisfaction with System



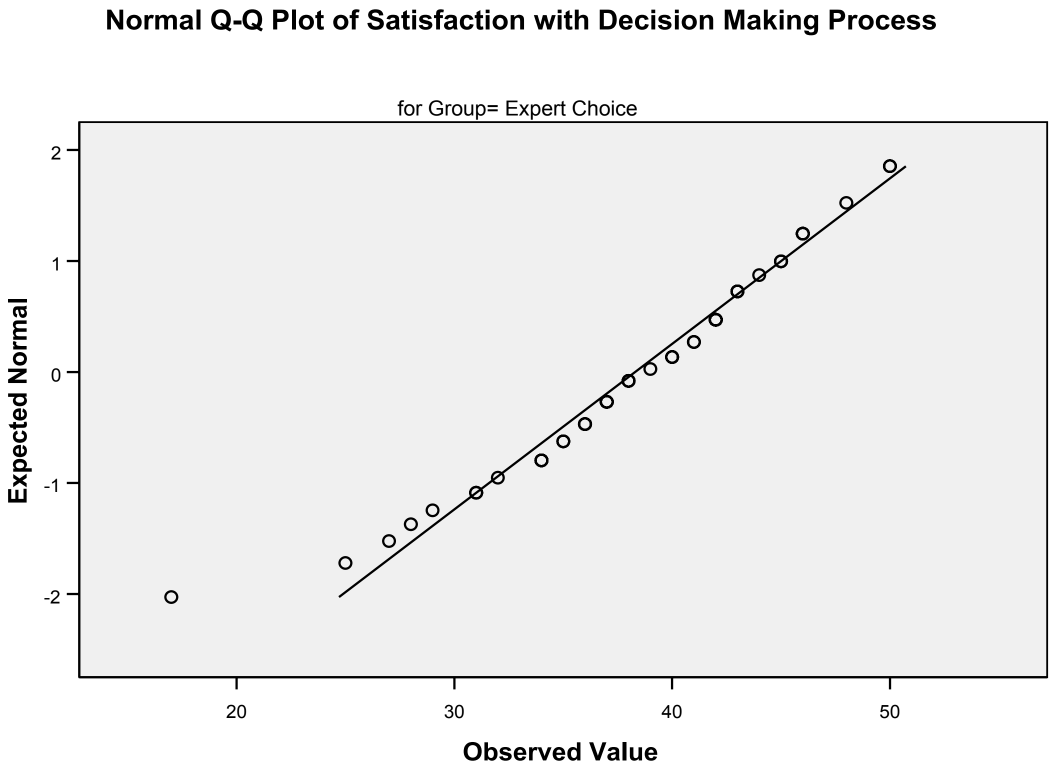
Appendix J: Graphs of Satisfaction with Decision Making Process

Appendix J1: Histograms of Satisfaction with Decision Making Process

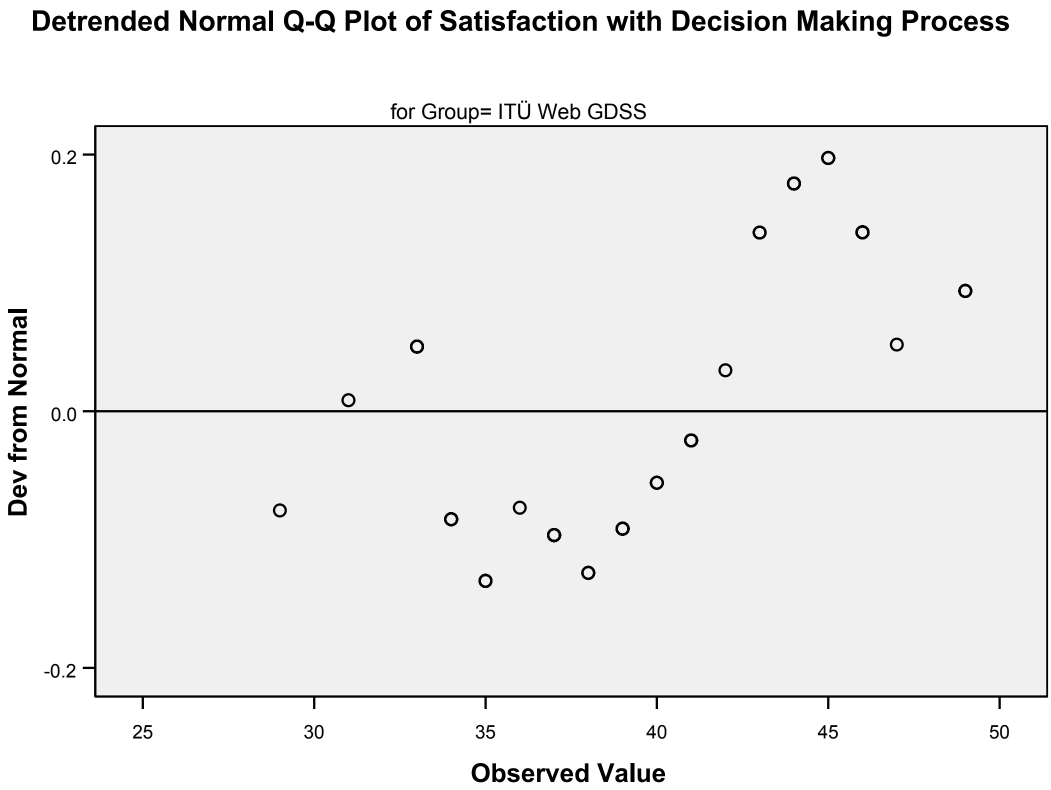




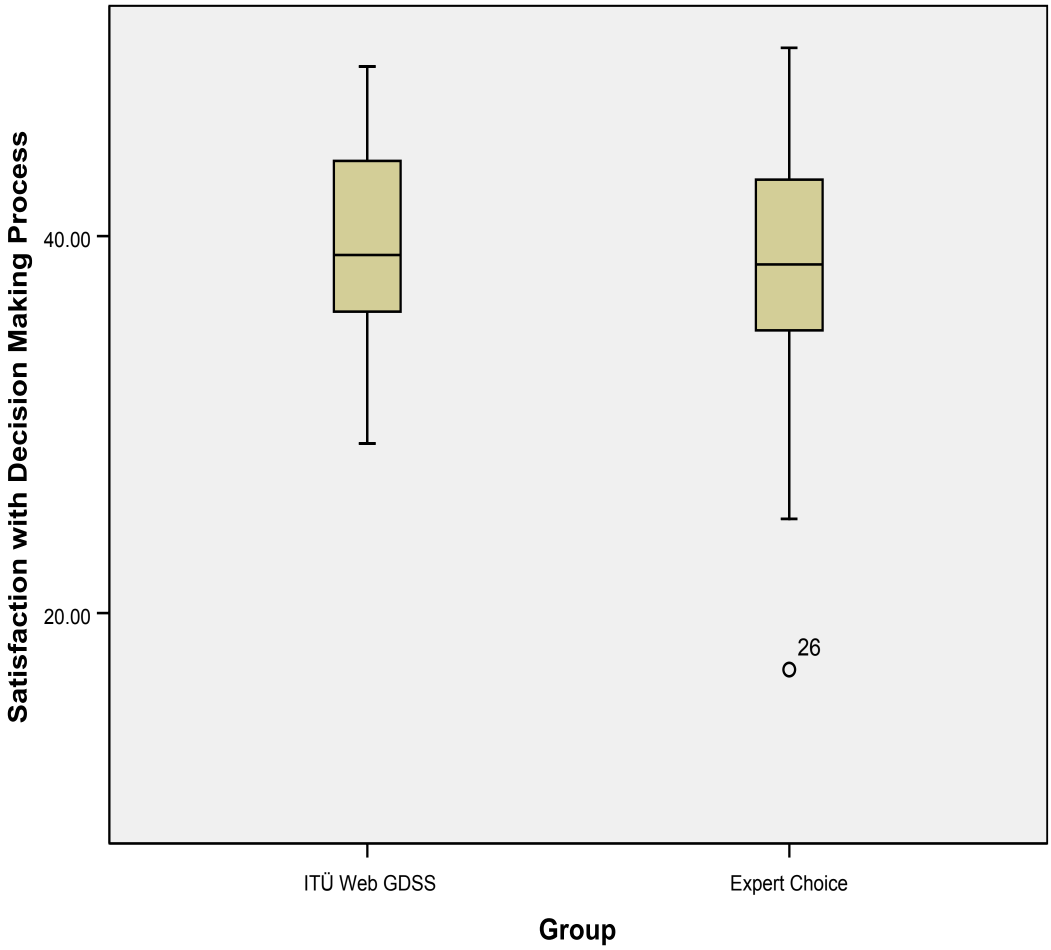
Appendix J2: Normal Q-Q Plots of Satisfaction with Decision Making Process



Appendix J3: Detrended Normal Q-Q Plots of Satisfaction with Decision Making Process

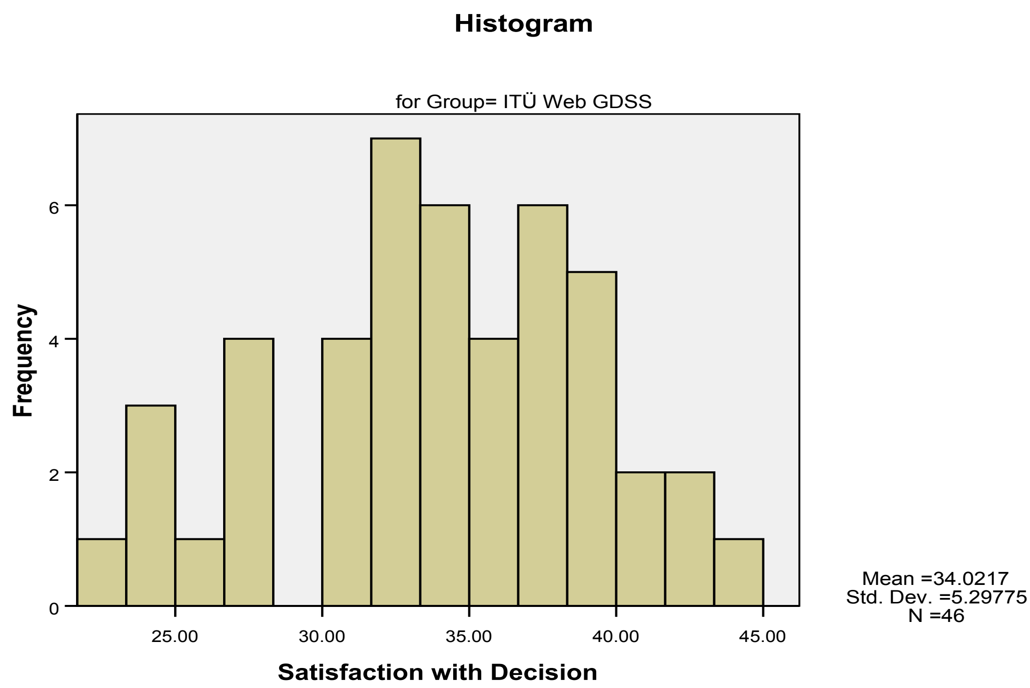


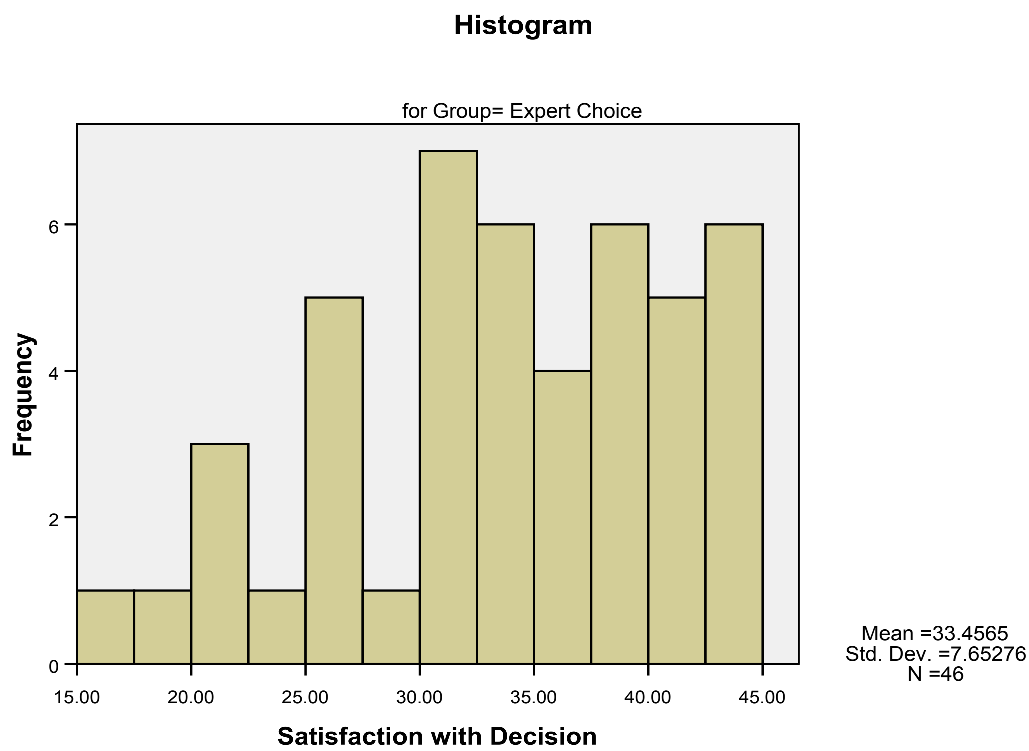
Appendix J4: Boxplot of Satisfaction with Decision Making Process



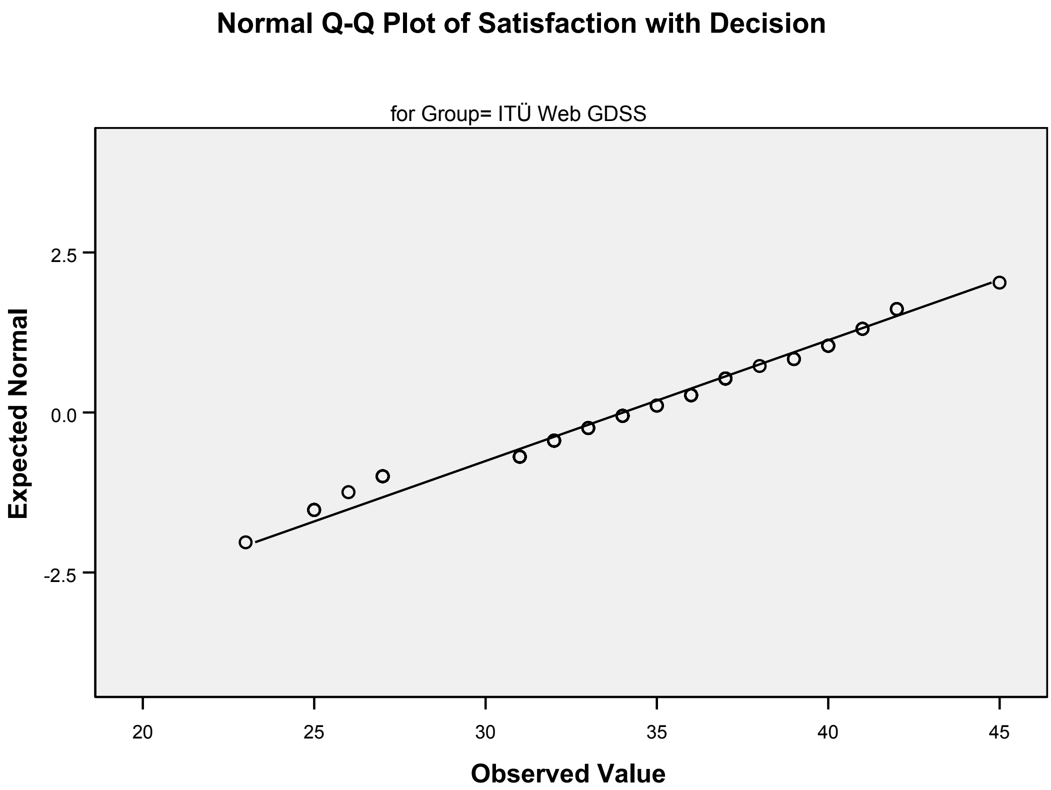
Appendix K: Graphs of Satisfaction with Decision

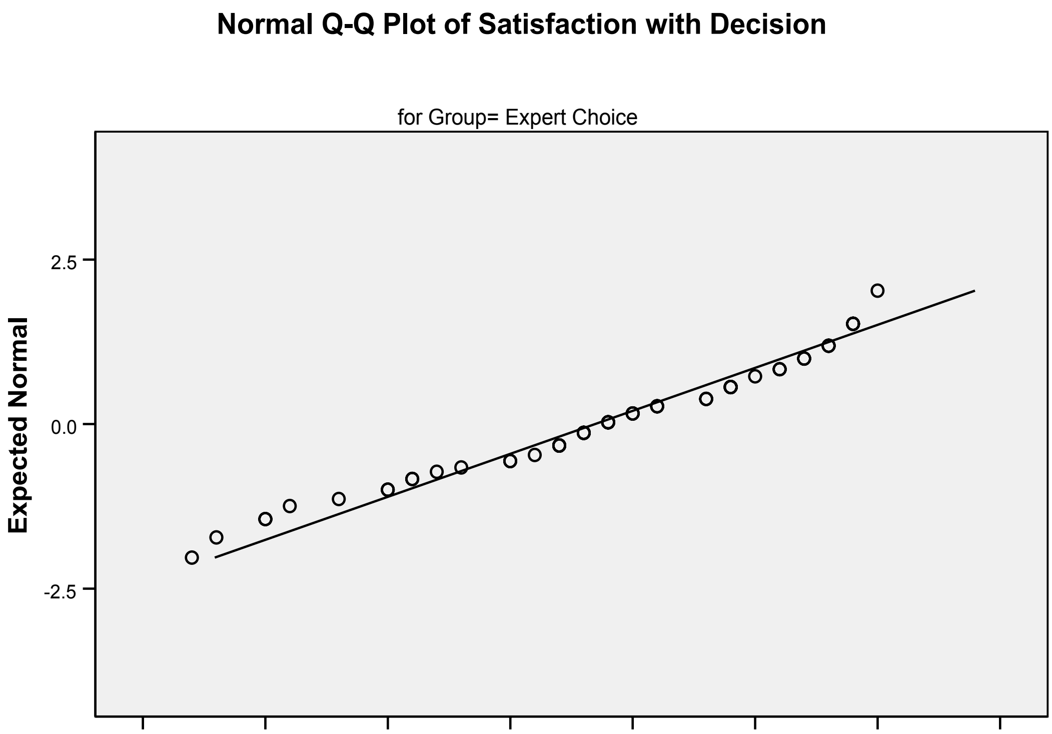
Appendix K1: Histograms of Satisfaction with Decision



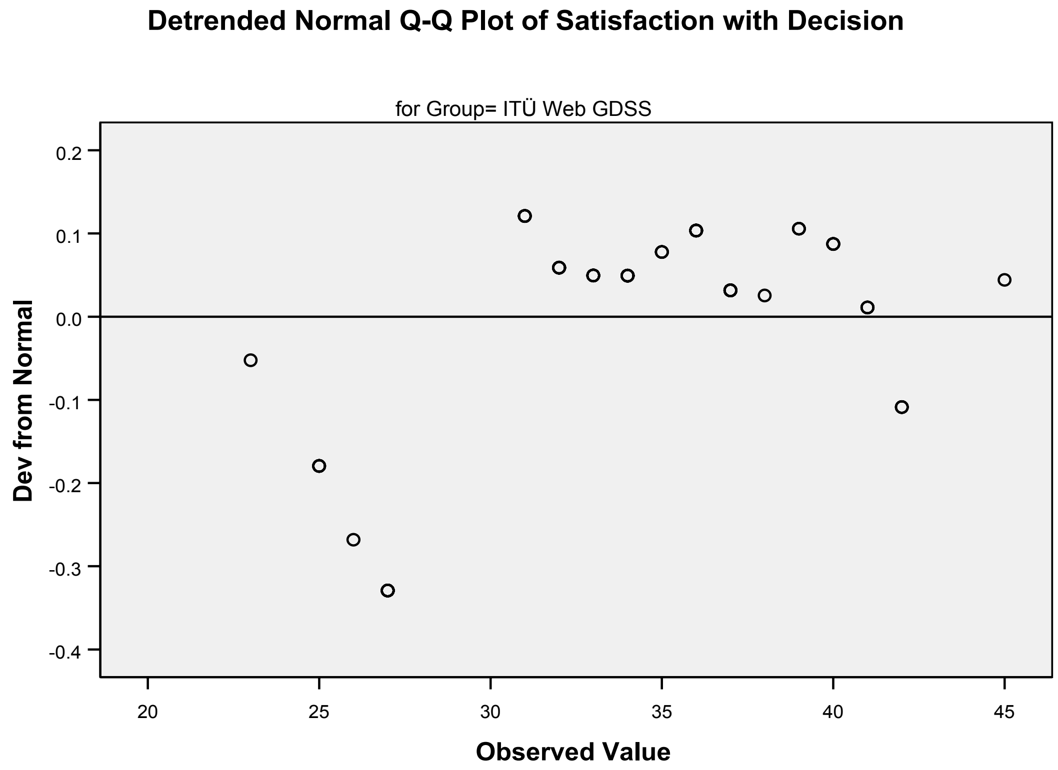


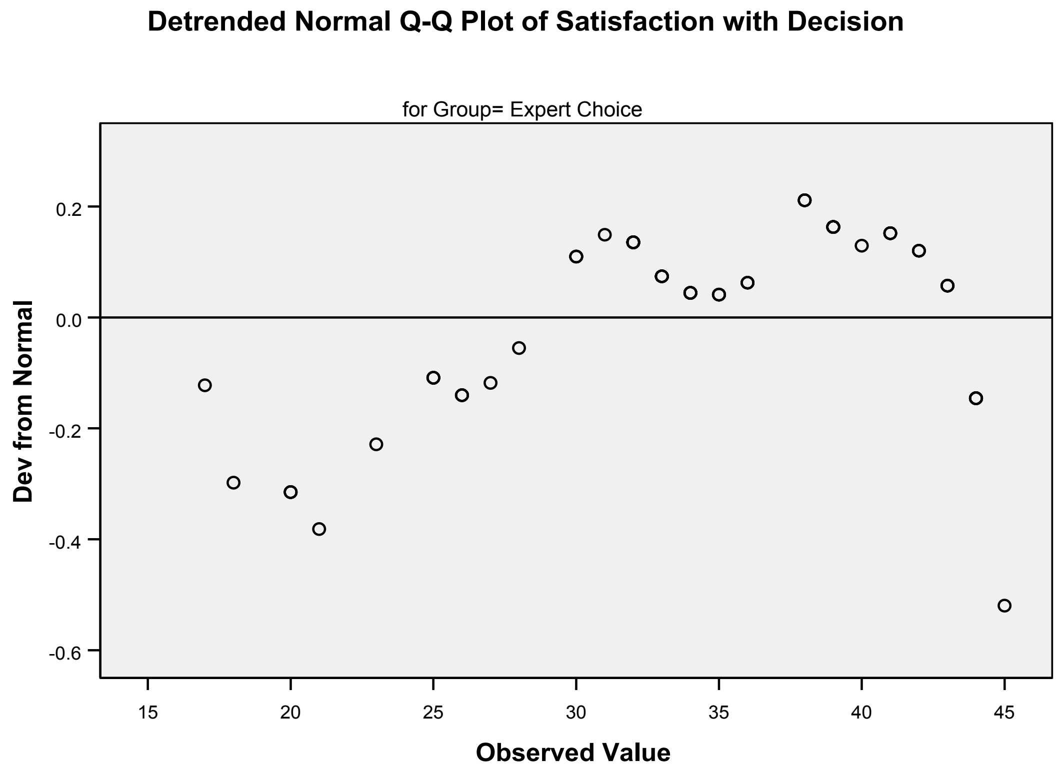
Appendix K2: Normal Q-Q Plots of Satisfaction with Decision



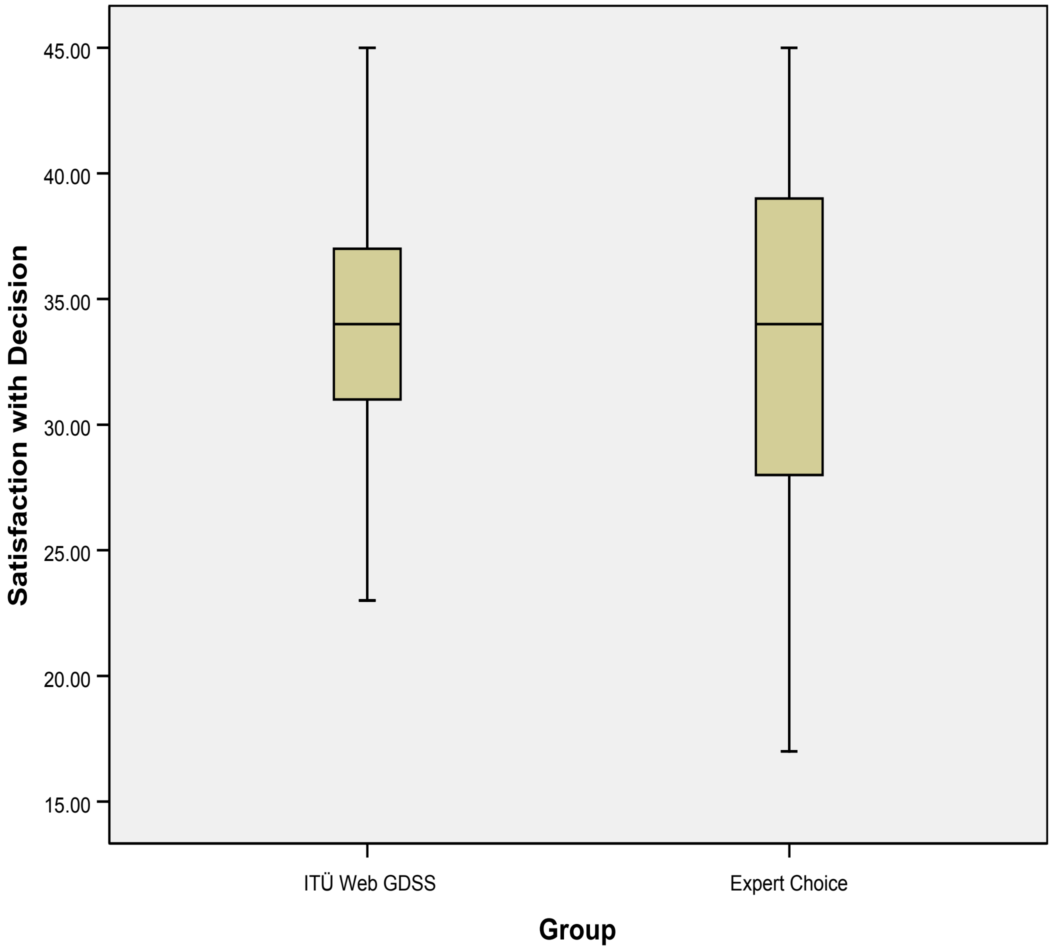


Appendix K3: Detrended Normal Q-Q Plots of Satisfaction with Decision



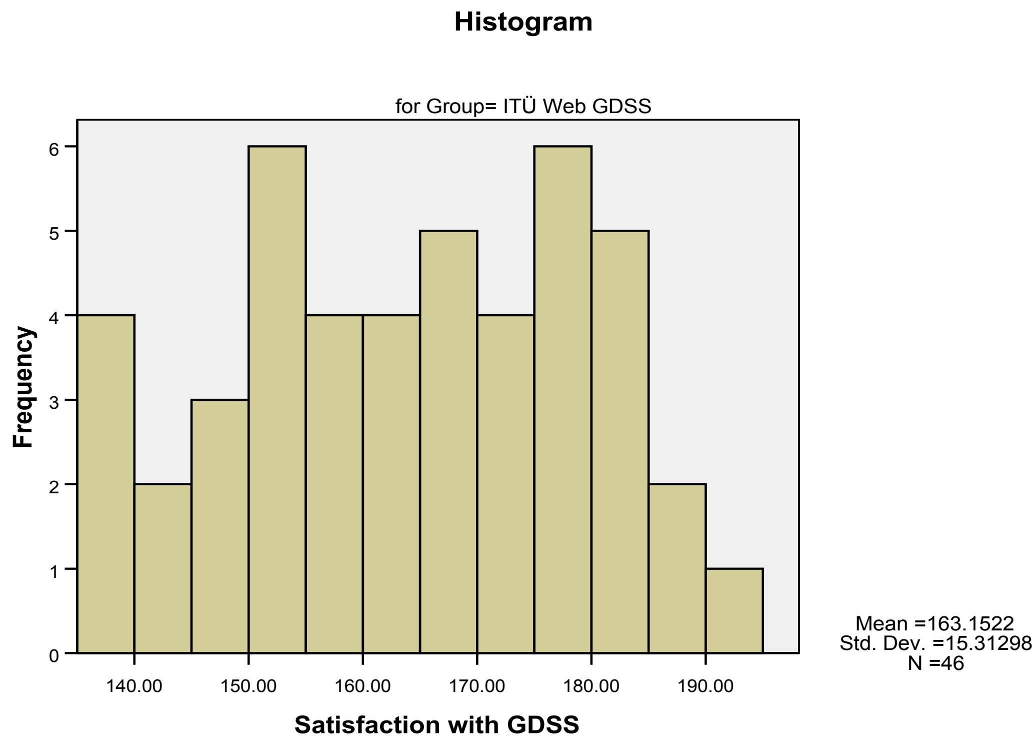


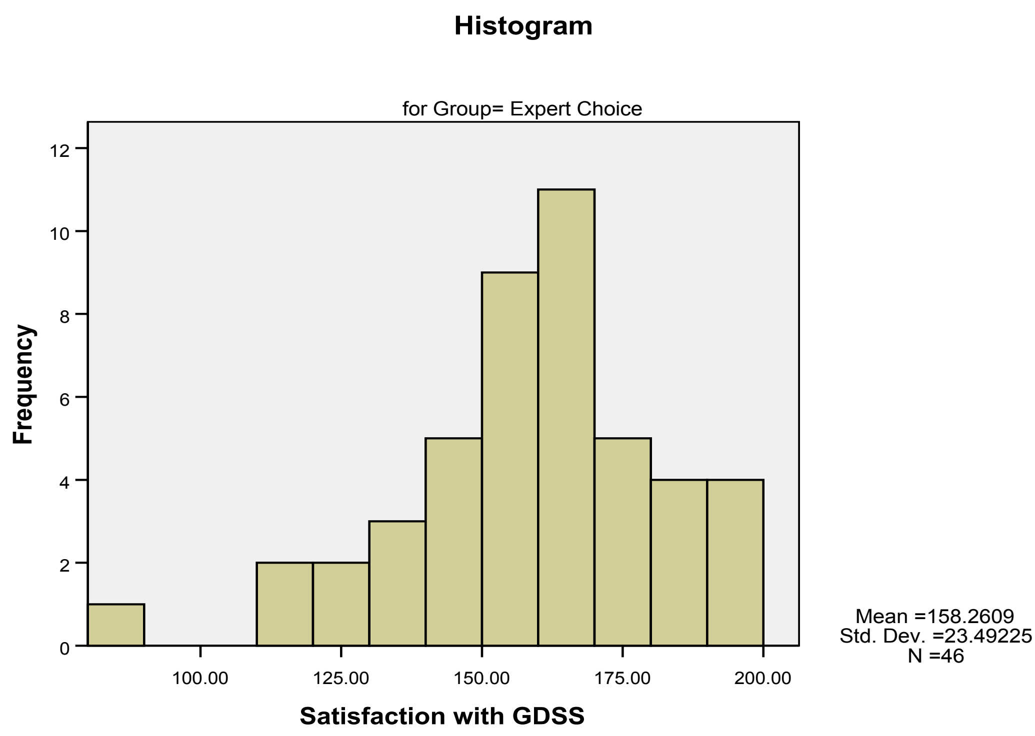
Appendix K4: Boxplot of Satisfaction with Decision



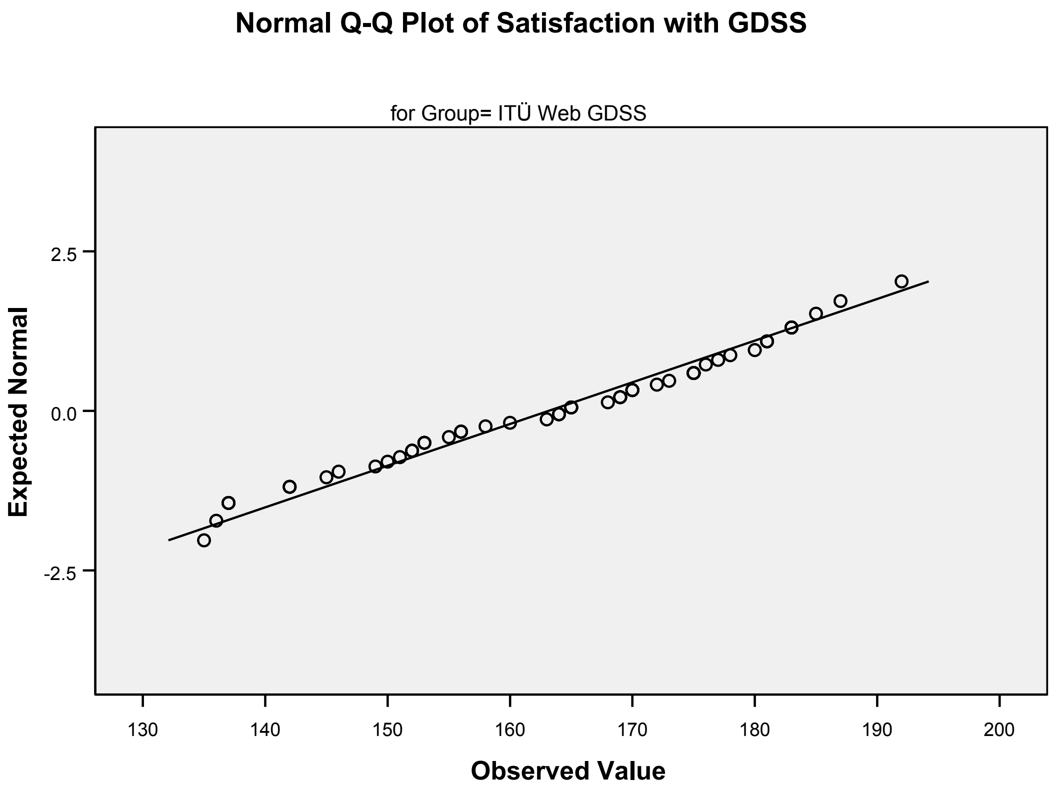
Appendix L: Graphs of Satisfaction with GDSS

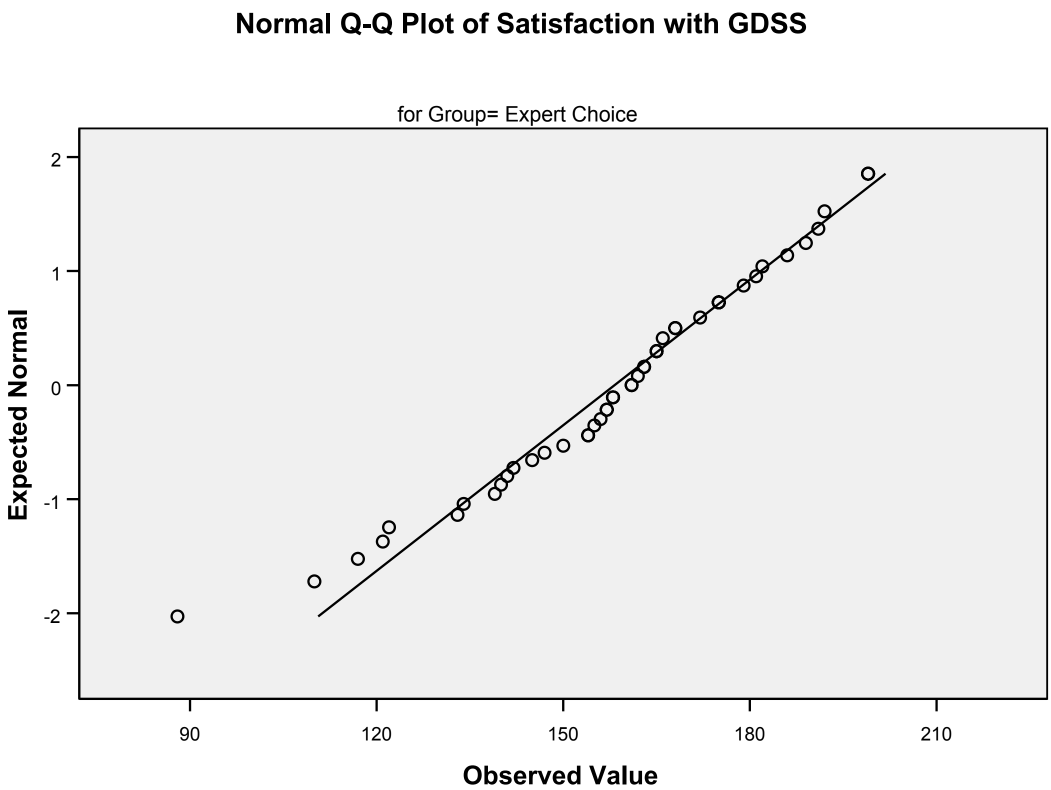
Appendix L1: Histograms of Satisfaction with GDSS



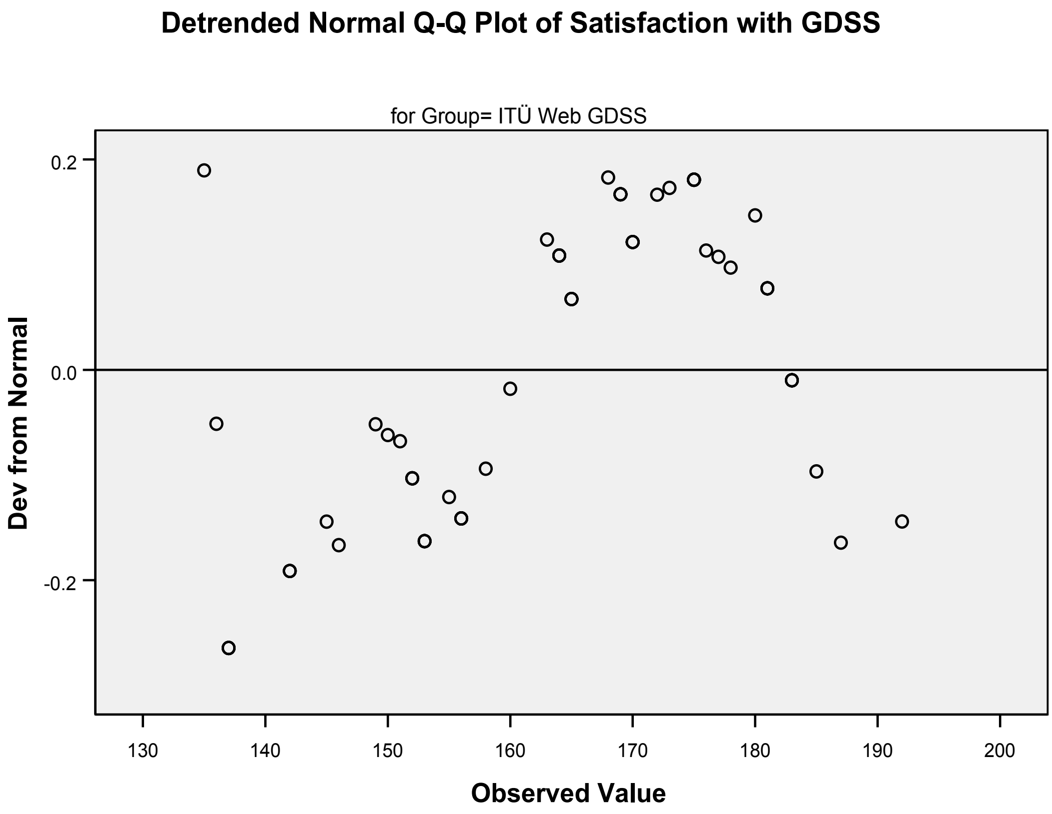


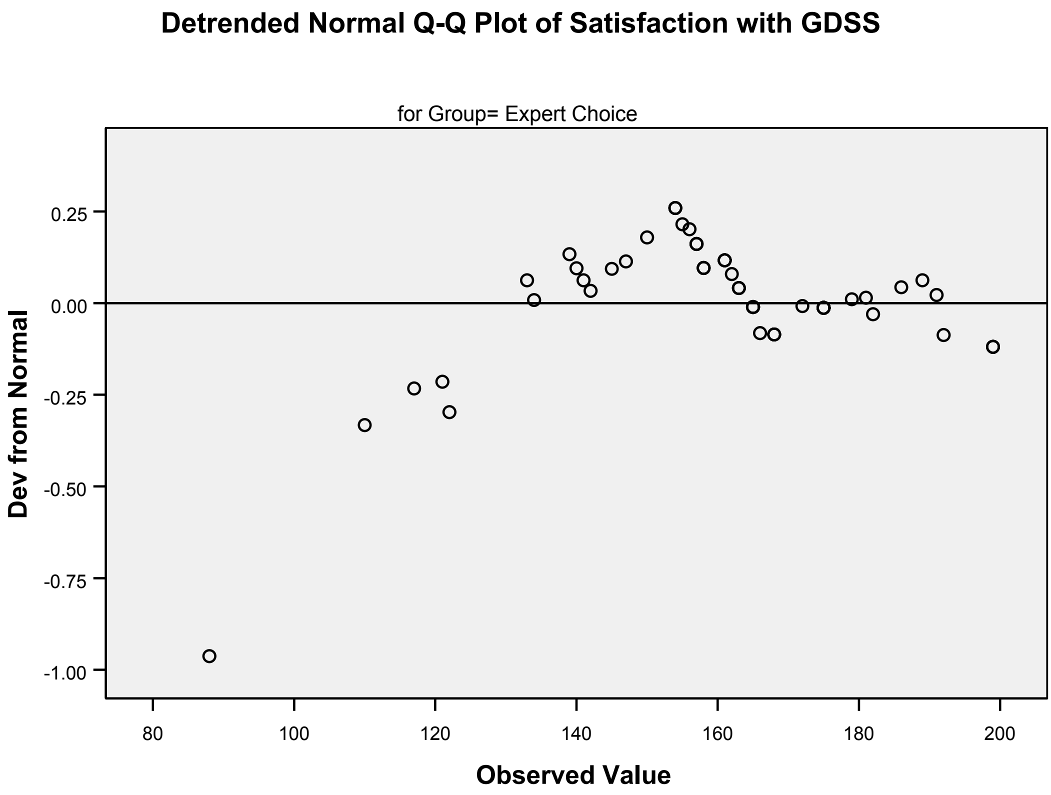
Appendix L2: Normal Q-Q Plots of Satisfaction with GDSS



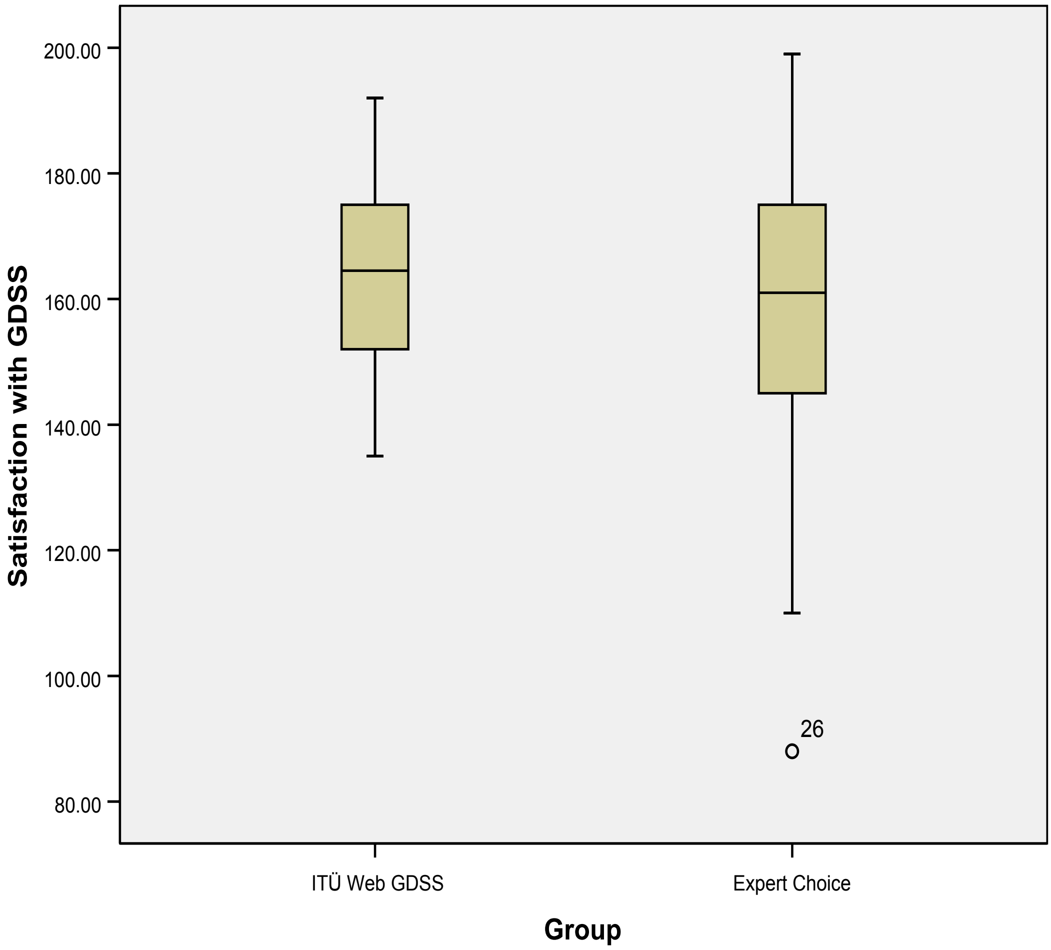


Appendix L3: Detrended Normal Q-Q Plots of Satisfaction with GDSS





Appendix L4: Boxplot of Satisfaction with GDSS



Appendix M: Independent Samples T – Test

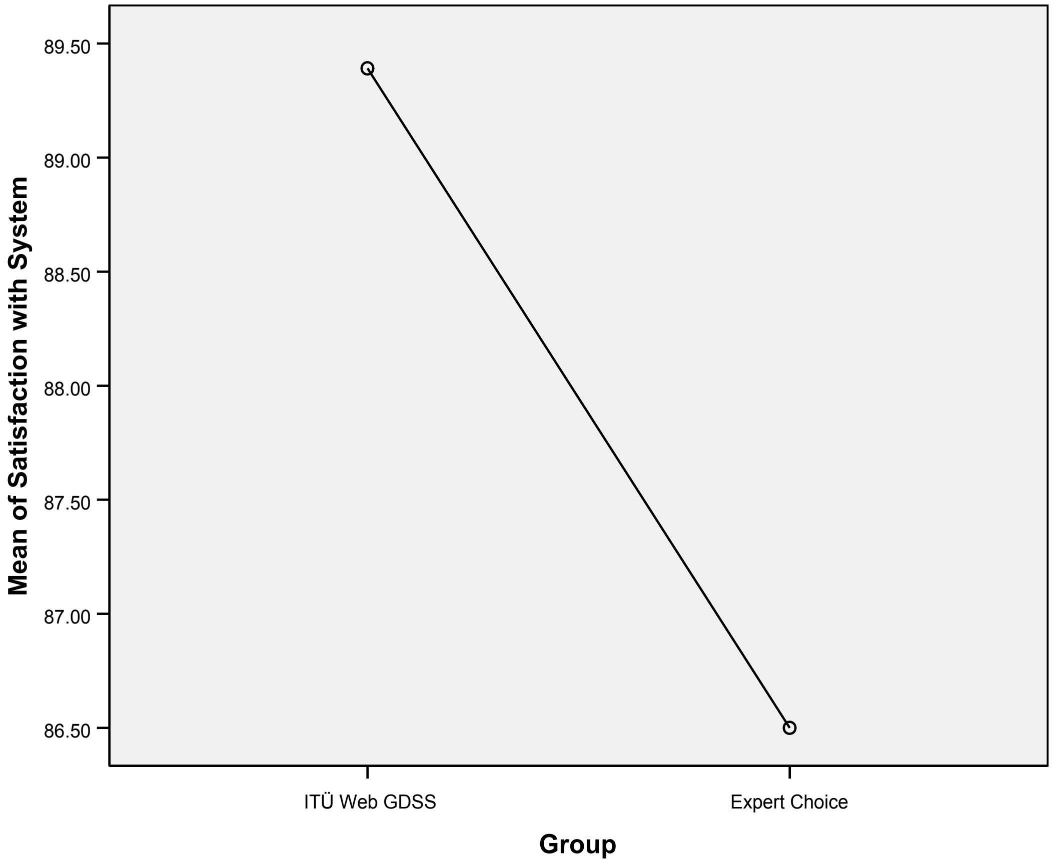
Group Statistics

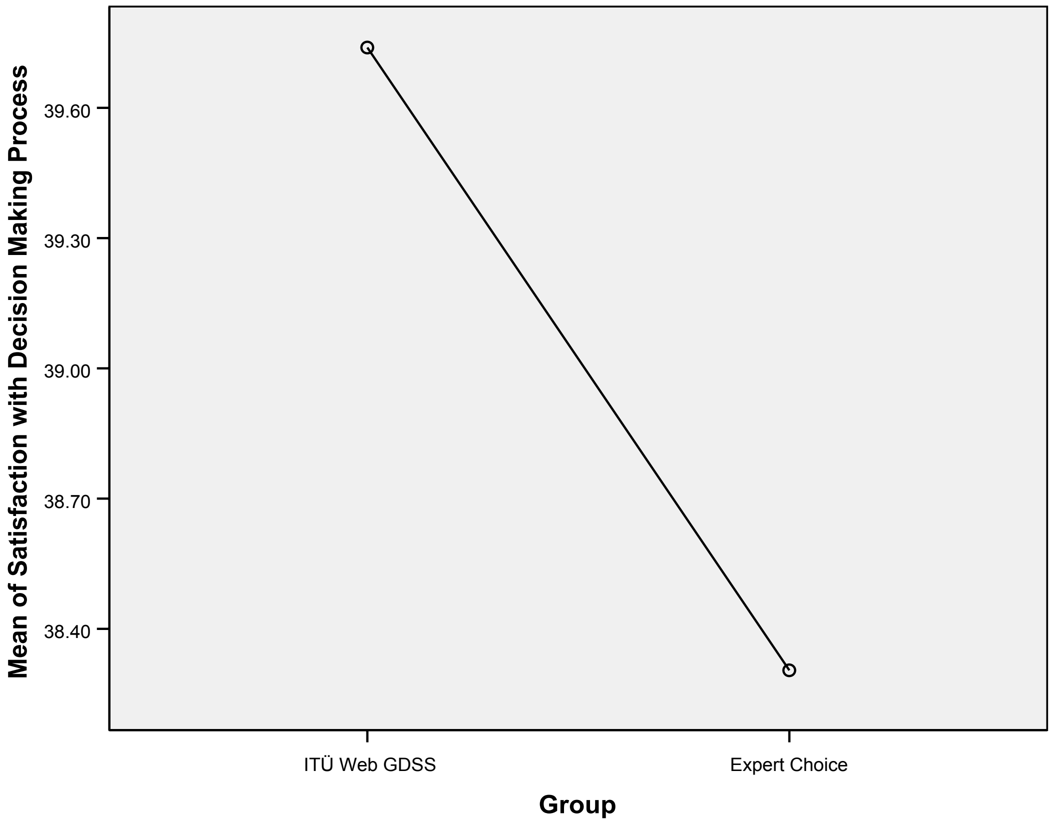
	Group	N	Mean	Std. Deviation	Std. Error Mean
Satisfaction with System	ITÜ Web GDSS	46	89.3913	7.95118	1.17234
	Expert Choice	46	86.5000	11.69948	1.72499
Satisfaction with Decision Making Process	ITÜ Web GDSS	46	39.7391	5.10091	.75209
	Expert Choice	46	38.3043	6.70612	.98876
Satisfaction with Decision	ITÜ Web GDSS	46	34.0217	5.29775	.78111
	Expert Choice	46	33.4565	7.65276	1.12834
Satisfaction with GDSS	ITÜ Web GDSS	46	163.1522	15.31298	2.25778
	Expert Choice	46	158.2609	23.49225	3.46374

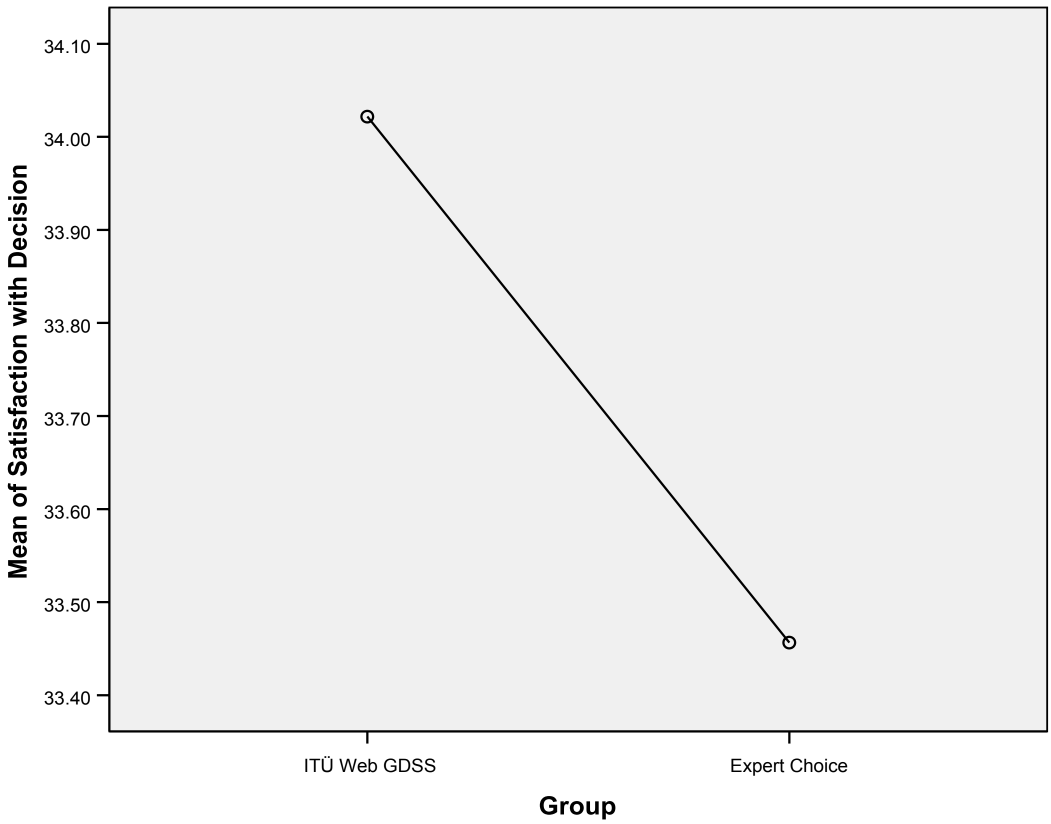
Independent Samples Test

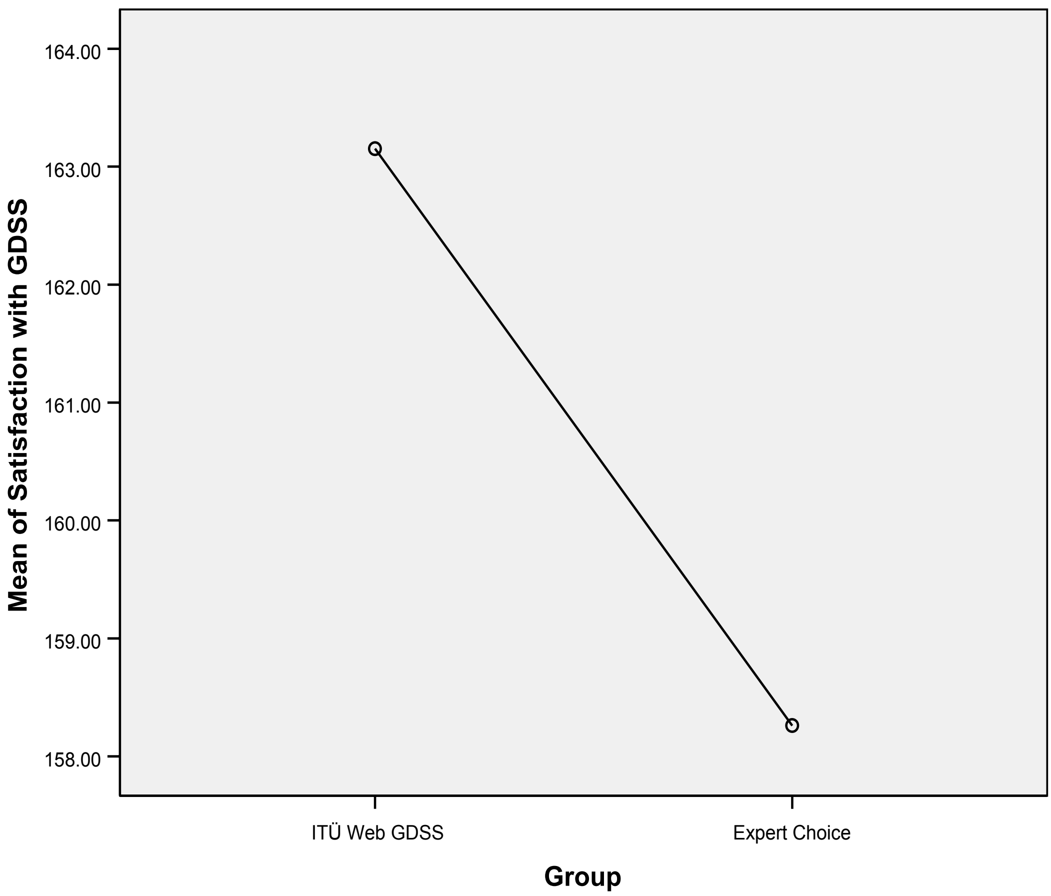
		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Satisfaction with System	Equal variances assumed	5.005	.028	1.386	90	.169	2.89130	2.08566	-1.25222	7.03483
	Equal variances not assumed			1.386	79.260	.170	2.89130	2.08566	-1.25989	7.04250
Satisfaction with Decision Making Process	Equal variances assumed	1.562	.215	1.155	90	.251	1.43478	1.24229	-1.03325	3.90281
	Equal variances not assumed			1.155	84.012	.251	1.43478	1.24229	-1.03565	3.90521
Satisfaction with Decision	Equal variances assumed	5.890	.017	.412	90	.681	.56522	1.37233	-2.16115	3.29158
	Equal variances not assumed			.412	80.075	.682	.56522	1.37233	-2.16576	3.29620
Satisfaction with GDSS	Equal variances assumed	3.234	.075	1.183	90	.240	4.89130	4.13462	-3.32284	13.10545
	Equal variances not assumed			1.183	77.392	.240	4.89130	4.13462	-3.34111	13.12372

Appendix N: Means Plots of Independent Samples T – Test






Mean of Satisfaction with Decision
34.10
34.00
33.90
33.80
33.70
33.60
33.50
33.40
ITÜ Web GDSS
Expert Choice
Group


Mean of Satisfaction with GDSS
164.00
163.00
162.00
161.00
160.00
159.00
158.00
ITÜ Web GDSS
Expert Choice
Group

Appendix O: One Sample T – Test of İTÜ – Web GDSS Group

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Satisfaction with System	46	89.3913	7.95118	1.17234
Satisfaction with Decision Making Process	46	39.7391	5.10091	.75209
Satisfaction with Decision	46	34.0217	5.29775	.78111
Satisfaction with GDSS	46	163.1522	15.31298	2.25778

One-Sample Test

	Test Value = 3					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Satisfaction with System	73.691	45	.000	86.39130	84.0301	88.7525
Satisfaction with Decision Making Process	48.849	45	.000	36.73913	35.2243	38.2539
Satisfaction with Decision	39.715	45	.000	31.02174	29.4485	32.5950
Satisfaction with GDSS	70.934	45	.000	160.15217	155.6048	164.6996

Appendix P: One Sample T – Test of Groups

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Satisfaction with System	92	87.9457	10.05301	1.04810
Satisfaction with Decision Making Process	92	39.0217	5.96874	.62228
Satisfaction with Decision	92	33.7391	6.55135	.68303
Satisfaction with GDSS	92	160.7065	19.87242	2.07184

One-Sample Test

	Test Value = 3					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Satisfaction with System	81.047	91	.000	84.94565	82.8637	87.0276
Satisfaction with Decision Making Process	57.886	91	.000	36.02174	34.7856	37.2578
Satisfaction with Decision	45.004	91	.000	30.73913	29.3824	32.0959
Satisfaction with GDSS	76.119	91	.000	157.70652	153.5911	161.8220

CURRICULUM VITAE

Yavuz GÖSTERİŞLİ

PERSONAL INFORMATION

- **Date of Birth** **:** March, 08, 1981
- **Place of Birth** **:** Düzce
- **Marital Status** **:** Single
- **Driver Licence** **:** Class B, Class A2 (1998)
- **Military Service :** Postponed until 2007

EDUCATION

- **2003-Present** **:** Istanbul Technical University,
  Master of Strategy Development Technology
- **1998- 2003** **:** Boğaziçi University, Faculty of Education,
  Department of Computer Education and Educational Technology
- **1991-1998** **:** Düzce Anatolian High School

LANGUAGES

- English (Fluent),
- German (Intermediate)

WORK EXPERIENCE

- **2003-PRESENT :**

BOĞAZİÇİ UNIVERSITY, Department of Foreign Language Education, Istanbul / Turkey

Research Assistant

- Actively took part in research studies conducted in the Department of Foreign Language Education. Prepared and administered tests, and analyzed data with relevant computer software

- Created the resource database and the website of the department, worked as the web master (i.e., http://fled.boun.edu.tr) and took part in preparing the website of the Faculty of Education (i.e. http://fed.boun.edu.tr)

Teaching Assistant

- Offered laboratory sessions of the following courses:

  - FLED 103 **-** English Composition (2004/2005-1):

    Introduction to Computer, Microsoft Office

- FLED 483 – Special Topic in Quality in ELT (2004/2005-2):

  Macromedia, Web Design

- FLED 411 – Special Topic in Quality in ELT

  Microsoft Publisher

- **JUNE- AUGUST 2003**:
  INTEL Teach to The Future Project –
  http://www.intel.com/cd/corporate/education/emea/tur/index.htm

  Intel aimed at educating teachers in Turkey about the subject matter of effective use of information systems in schools. We prepared the Cd and book which are used in this education. Teachers learned how to use information systems with their students in their courses by applying themselves.

- **JANUARY - FEBRUARY, 2002:**
  LBS (Logo Business Solutions) – Software Development Trainee
  Software Development for Small-Medium Enterprise Department

PRESENTED PROJECTS

- **Fraction's World:** It is an software program which is created by authoring tool Macromedia Flash 5. The courseware helps Grade 5 level students to learn addition of fraction while they are studying with the interactive environment tool. (2003)
- **Designing WML Pages:** It is an e-learning project that provides user to learn how to create WML/ WAP pages. In this project, there are also animations and simulations for better learning for user. (2003)
- **Designing Network Project:** This project includes network design between two campuses that are 2 km away each other. (2002)
- **Online Assessment:** In this project, user can learn the types of online assessment and how assessment can be applied. It is designed by authoring tool Click2Learn Toolbook 8.5 program. It has an interactive learning environment for better learning. (2002)
- **E-Stock.com:** It is B2B and B2C e-commerce project. There is a report to establish the organization which provides e-commerce service over the internet. Stock.com provides its users better quality with a cheap price. (2004)
- **R&D Project - Venture Project:** It is a venture project. It is a report which includes feasibility plan, business plan and strategies to have taken to setup the firm. Products are couches, tables, furniture that are made up of cellulose. SWOT analysis also was made. (2004)
- **IMKB Project:** This project researches strategy affects the performance by analysing 1998-2004 IMKB data in the Informatics sector and Chemistry sector that are registered to IMKB. Between 1998-2004 years, all the decisions that were made by firms were analysed. To reach the results, Cluster Analysis and Cross-Tab Analysis were used in this project. (2004)
- **Strategic Planning for PWC Turkey:** This report is to develop a strategic planning for Pwc (Price Waterhouse Coopers) Turkey. General environment analysis, SWOT analysis, balanced-score cards were used in this strategic planning. (2004)

RESEARCH PROJECTS:

Research Project: "The Effectiveness of Computer Based Instruction on Grade 4 Students who have Low Socio-Economic Conditions". Designing, applying and evaluating educational software that is programmed with Macromedia Flash, at the level of 5 grade students. (2003, Undergraduate Thesis)
Research Project: "Web-based Group Decision Support Systems in Defence Technologies". Web portal is designed that includes interactive decision making progress module and applied the sample group. Analysis and results will be evaluated. (2004-2006, Master Thesis)