

**DOKUZ EYLÜL UNIVERSITY**  
**GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES**

**LABORATORY INFORMATION SYSTEM**  
**SOFTWARE**

**by**  
**Münevver ÇALIŞ**

**October, 2014**

**İZMİR**

# **LABORATORY INFORMATION SYSTEM SOFTWARE**

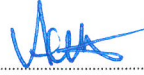
**A Thesis Submitted to the  
Graduate School of Natural and Applied Sciences of Dokuz Eylül University  
In Partial Fulfillment of the Requirements for the Degree of Master of Science  
in Computer Engineering, Computer Engineering Program**

**by  
Münevver ÇALIŞ**

**October, 2014  
İZMİR**

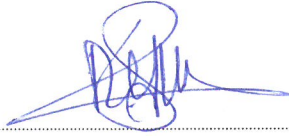
## M.Sc THESIS EXAMINATION RESULT FORM

We have read the thesis entitled “**LABORATORY INFORMATION SYSTEM SOFTWARE**” completed by **MÜNEVVER ÇALIŞ** under supervision of **PROF. DR. ALP KUT** and we certify that in our opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Science.



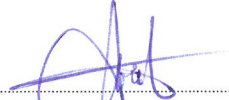
Prof. Dr. Alp Kut

Supervisor



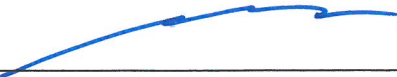
Asst. Prof. Dr. Reyat Yılmaz

(Jury Member)



Asst. Prof. Dr. Deniz Arslan

(Jury Member)



Prof. Dr. Ayşe OKUR

Director

Graduate School of Natural and Applied Sciences

## **ACKNOWLEDGMENTS**

I would like to thank to my thesis advisor Prof. Dr. Alp Kut for his help, suggestions and guidance.

I also thank to my family and my sincere friends for their patience and support.

Münevver ÇALIŞ

# **LABORATORY INFORMATION SYSTEM SOFTWARE**

## **ABSTRACT**

Laboratory services, due to their contribution to treatment is considered an important part of health. Workload and responsibilities of laboratory is increasing each day. Therefore, a large amount of laboratory data collection and preparation as a summary of this information as quickly as possible and transportation to doctors are difficult.

The aim of this study is to realize functions which are to transfer time of taking sample, testing processes and completed test results to units which request test, to get periodically reports which are given to patients, to prepare to statistics, to keep records for management of laboratory operations and quality control processes as online web application.

This study has been designed and implemented in Central Laboratory at Dokuz Eylül University Faculty of Medicine. Information of test, patient and process which belong to examination request are taken from Hospital Information Management System (HIMS) which is used at Dokuz Eylül University Faculty of Medicine via web services. Results of examination request are sent to Hospital Information Management System via web services after they are analyzed.

**Keywords:** Web application, Laboratory Information System (LIS), Hospital Information Management System (HIMS)

# LABORATUVAR BİLGİ SİSTEMİ YAZILIMI

## ÖZ

Laboratuvar hizmetleri, tedaviye sağladıkları katkı nedeniyle sağlığın önemli bir parçası sayılıyor. Laboratuvarların her geçen gün iş yükü ve sorumluluğu artmaktadır. Bu nedenle çok fazla miktarda laboratuvar bilgisinin toplanması, bu bilgilerin olabildiğince hızlı özet halinde hazırlanması ve hekimlere ulaşması zorlaşmaktadır.

Bu çalışmanın amacı örneklerin alınma zamanlarının, test süreçlerinin ve sonuçlanan test sonuçlarının istemi yapan polikliniklere iletilmesi, hastalara verilen bütün test sonuçlarının belirli aralıklarla raporlarının alınması, istatistiklerin hazırlanması, laboratuvar süreçlerinin yönetimi ve kalite kontrol süreçleri için kayıtların tutulması işlevlerini web uygulaması olarak gerçekleştirmektir.

Bu çalışma Dokuz Eylül Üniversitesi Tıp Fakültesi Merkez Laboratuvarı'nda yapılmıştır ve kullanılmaktadır. Tetkik istemlerine ait test, hasta ve süreç bilgileri Dokuz Eylül Üniversitesi Tıp Fakültesinde kullanılmakta olan hastane bilgi yönetim sisteminden web servisler aracılığıyla alınmaktadır. Tetkik istemlerinin sonuçları incelendikten sonra web servisler aracılığıyla hastane bilgi yönetim sistemine gönderilmektedir.

**Anahtar kelimeler:** Web uygulaması, Laboratuvar Bilgi Sistemi (LBS), Hastane Bilgi Yönetim Sistemi (HBYS)

## CONTENTS

	<b>Page</b>
M.Sc THESIS EXAMINATION RESULT FORM.....	ii
ACKNOWLEDGMENTS .....	iii
ABSTRACT.....	iv
ÖZ .....	v
LIST OF FIGURES .....	viii
 <b>CHAPTER ONE - INTRODUCTION .....</b>	 <b>1</b>
1.1 What is Laboratory Information System (LIS) .....	1
1.2 Aim of the Thesis .....	1
1.3 Organization of the Thesis .....	2
 <b>CHAPTER TWO - RELATED WORK.....</b>	 <b>3</b>
2.1 Literature Review of LIS andLIMS .....	3
2.2 Literature Review of SSADM.....	6
 <b>CHAPTER THREE -DEVELOPMENT PROCESSES .....</b>	 <b>9</b>
3.1 User Scenarios .....	9
3.2 Data Flow Diagram .....	12
3.2.1 Data Flow .....	12
3.2.2 Processes .....	12
3.2.3 External Entity .....	13
3.2.4 Data Store.....	13
3.3 Data Flow Diagram of LIS .....	14
3.4 Database Model of LIS.....	18
3.5 Infrastructure Planning .....	23

<b>CHAPTER FOUR -USED TECHNOLOGIES .....</b>	<b>25</b>
4.1 Visual Studio 2013 Asp.net.....	25
4.1.1 Team Foundation Server .....	26
4.2 Microsoft SQL Server .....	26
4.3 DevExpress ASP.NET AJAX Controls.....	26
4.4 Microsoft Visio.....	26
<b>CHAPTER FIVE -IMPLEMENTATION .....</b>	<b>28</b>
5.1 Implementation of LIS .....	28
5.2 Code Analysis of Implementation .....	45
<b>CHAPTER SIX -CONCLUSION AND DISCUSSION .....</b>	<b>47</b>
<b>REFERENCES .....</b>	<b>48</b>



## LIST OF FIGURES

	<b>Page</b>
Figure 2.1 The database diagram .....	4
Figure 2.2 The system architecture .....	5
Figure 2.3 Development processes of SSADM .....	7
Figure 3.1 Data flow symbol .....	12
Figure 3.2 Process symbol .....	12
Figure 3.3 External entity symbol.....	13
Figure 3.4 Data store symbol .....	13
Figure 3.5 Basic processes .....	14
Figure 3.6 Test request entry processes .....	15
Figure 3.7 Acceptance processes-1 .....	16
Figure 3.8 Acceptance processes-2.....	16
Figure 3.9 Analysis processes-1 .....	17
Figure 3.10 Analysis processes-2 .....	17
Figure 3.11 Result processes.....	18
Figure 3.12 Users and delegations in the system are gathered to one diagram .....	19
Figure 3.13 Device connection .....	20
Figure 3.14 Test connection.....	21
Figure 3.15 Test request connection .....	22
Figure 3.16 Antibiotic-Microorganism connection .....	23
Figure 3.17 Database connection for LIS and HIS in the previous system .....	23
Figure 3.18 Database connection for LIS and HIS in the current system.....	24
Figure 5.1 Login page .....	28
Figure 5.2 Date criteria is selected.....	29
Figure 5.3 Criteria list .....	30
Figure 5.4 Criteria of pending approval (concluded).....	30
Figure 5.5 Accepted laboratory (working tests) .....	31
Figure 5.6 Work sheet for test information.....	31
Figure 5.7 Criteria of accepted laboratory (all) .....	32
Figure 5.8 Criteria of waiting acceptance to laboratory .....	32

Figure 5.9 Authority laboratory lists.....	33
Figure 5.10 Editing information popup window.....	33
Figure 5.11 Barcode example .....	34
Figure 5.12 Sample acceptance page .....	34
Figure 5.13 Central acceptance page .....	35
Figure 5.14 Take back central acceptance page.....	35
Figure 5.15 Central acceptance lists .....	36
Figure 5.16 Laboratory acceptance page .....	36
Figure 5.17 Cancelling popup window .....	37
Figure 5.18 Cancelled tests list .....	37
Figure 5.19 Result report .....	38
Figure 5.20 Report of end of day .....	39
Figure 5.21 Bacteriology work sheet .....	39
Figure 5.22 Critical notification list.....	40
Figure 5.23 Evaluation of the results page.....	40
Figure 5.24 Pending approval (tests which are resultd).....	41
Figure 5.25 Example of manual entry.....	42
Figure 5.26 Copy entry .....	42
Figure 5.27 Criteria of laboratory (all tests) .....	43
Figure 5.28 Add test page .....	43
Figure 5.29 Managerial tools (test page) .....	44
Figure 5.30 Managerial tools (task page) .....	44
Figure 5.31 Session design .....	45
Figure 5.32 Base page ‘onLoad’ Event.....	46
Figure 5.33 ‘PageSession’ method .....	46

# **CHAPTER ONE**

## **INTRODUCTION**

### **1.1 What is Laboratory Information System (LIS)**

A Laboratory Information System(LIS) is a kind of tool that receives, processes and keeps information that is developed in a medical or research laboratory. LIS is a laboratory information management system that follows up from deciding on testing to reporting the test.

Test results of laboratory are very important for doctors. The doctors can require test for diagnosing, for guiding a treatment of a known disease, and for completely control purpose. The first function of laboratory is to obtain information from samples that are taken from patients, to make sense of this information, to interpret, and to transfer this information. Service quality of laboratory depends on not only accuracy or precision of test results but also being accessible of the test results and being completed on time.

Clinical laboratories started to use computers for helping to laboratory workers who encountered with increasing test count towards the end of 1950 Sümen & Zayim, (2005). Laboratory Information System (LIS) was needed because of increasing laboratory and complexity of being obtained information. Since the 1970s, LIS has been important tool for laboratories(Sepulveda & Young, 2013).

### **1.2 Aim of the Thesis**

- Provide to record accurately to test requests of patients which are taken from HIMS via web services,
- Keep stage, location and time information of samples which are taken from patients for observing,
- Show previous results of patients for laboratory physicians,

- Take report over all of test requests and to send results of tests to HIMS safely.

### **1.3 Organization of the Thesis**

In the second chapter resources about LIS, LIMS, and SSADM are studied and information about each resource is explained.

In the third chapter, user scenarios are clearly explained. What is the data flow diagram is described in detail. Images of data flow diagrams which are drawn after analyzing are shown. The screenshots of LIS are shown and are explained by grouping. Infrastructure planning is drawn that this is compared previous system and current system.

In the fourth chapter, technologies used in this application are explained in detail. Visual Studio 2013 Asp.net, Team Foundation Server, Microsoft SQL Server, Dev Express ASP.NET AJAX Controls, and Microsoft Visio technologies are presented.

In the fifth chapter, implementation of LIS is presented with screenshots which are belongs to implementation. The important parts of the code are explained by giving samples.

In the last part of thesis, conclusion and discussion of this thesis are explained. What was obtained and what can do in the future are described.

## **CHAPTER TWO**

### **RELATED WORK**

The use of LIS in the hospital is increasing day by day. The benefits of this software are known by laboratory physicians more than before. In this chapter, some studies about this subject and Structured Systems Analysis and Design Method (SSADM) which is used to this project when preparing are reviewed. The literature review is given and previous works at the LIS, LIMS and SSADM are explained.

#### **2.1 Literature Review of LIS and LIMS**

A lot of data of test results collect in the modern laboratories day by day. LIMS (Laboratory Information Management System) solve problems which are related to increased data. LIMS include all child processes of laboratory.

Clinic Information System which has used in underdeveloped is inadequate for serious diseases. LIS decrease turn-around-times of test results in the laboratory and it provides faster access for health institutes (Blaya et al., 2007)(Tagger, 2011).

Blaya et al., (2007) explains design and implementation of a web based laboratory information system (e-Chasqui) that aimed to accelerate communication of DST (Drug Susceptibility Test) results between central, local laboratories and clinical facilities. Diagnosis of multi-drug resistant tuberculosis which is chronic infection disease require DTS. E-Chasqui created a national tuberculosis laboratory network in Peru to ease the transmission and analysis of all bacteriological results nationwide.

Hai & Thuan, (2010) explains a work which is implemented for saving laboratory data of patients to database via computers in Vietnam. Aims of this implementation are to integrate new laboratory equipment which is purchased hematology analyzer, biochemical analyzer, immunology analyzer, urine analyzer, microbiological analyzer, endocrine analyzer and cellular analyzer with the development of technology, to manage to test data of patients which is obtained from laboratory

equipment, to use to saved data for diagnosing to patients, to be able to be accessed to these data, test, diagnosis, and treatment information of patient by laboratory workers and doctors later too. Analysis of Hai & Thuan, (2010) show that previous system is based on paper and this situation complicate to be managed data.

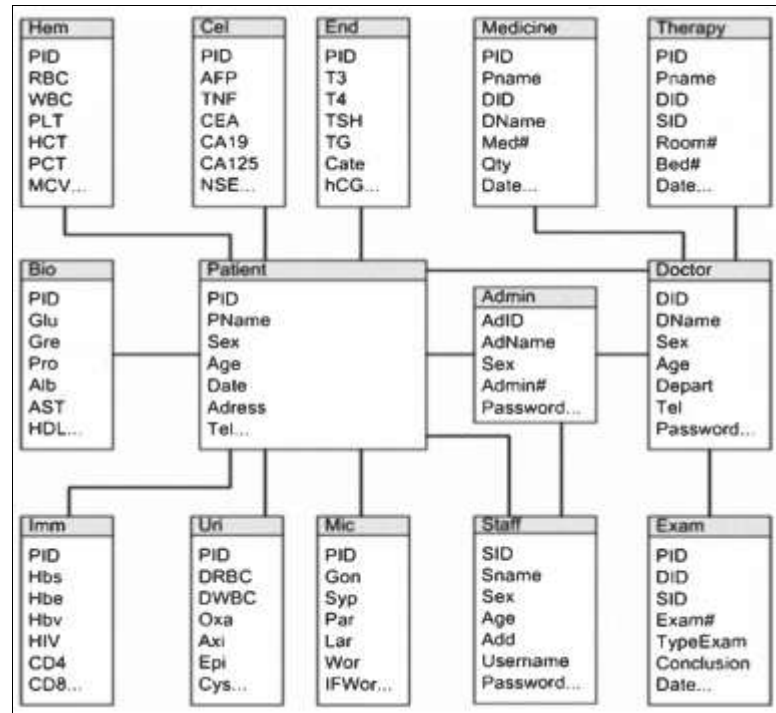


Figure 2.1 The database diagram

System of Hai & Thuan, (2010) used VB.net, C++ and C# language and used SQL Server2000 for storing data. In this system, each patient has a PID (Patient ID) and information of patient is able to access via this PID. At database structure of the system, each laboratory analyzer is stored district tables. All of these tables have PID. There are tables of patient, laboratory workers, doctor, medicine therapy and examination. Patient table is connected to all tables.

Quo, Wu, & Wang, (2005) shares with a case study which implements eOncoLIMS over a collaborative cancer research project. EOncoLIMS is data and project management system. Contrary to current LIMS which are based on individual research and have limited scope, this system provides collaboration for researchers and clinicians between independent laboratories.

EOncoLIMS implement, which is explained in Quo et al., (2005), is using PHP programming language and is also using MySQL for storage. These are open-source software and database. This system is web based system because of being able to access resources on the Internet. This implement include five module which are web protocols, resNet, infoShare, picViewer, eventManager.

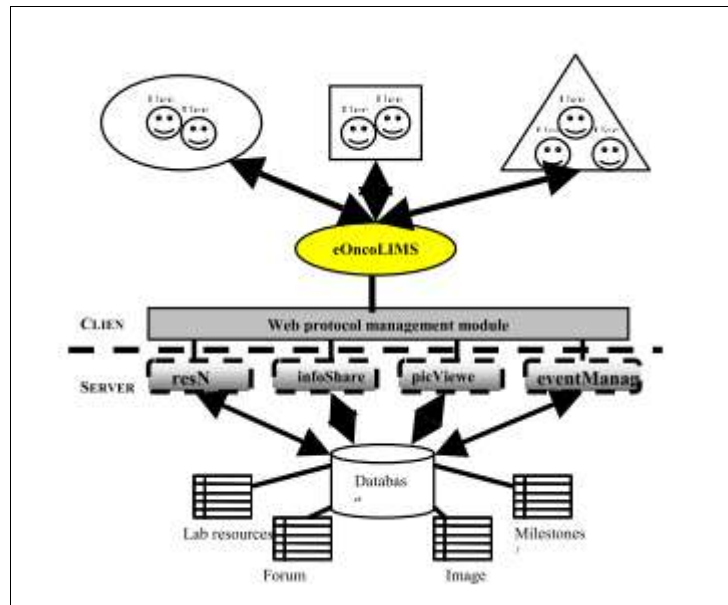


Figure 2.2 The system architecture

Web Protocols module is related to web issues which are to authorize users according to relevant project information, to resolve discrepancies of different web browsers, to test security of this online system. ResNet module is resource management module which is storing resources of hardware, software and updates, sharing between authorized users, providing to be purchased necessary equipment specifications. InfoShare module provide that clinicians and researchers exchange their ideas. This situation shares with authorized users. Users are authorized public and private according to relevant forums. PicViewer is managing experimental results imagines of patient which are x-ray, computed tomography etc. These imagines are annotated by clinicians because researchers give the meaning. EventManager module is planning collaborative projects. This is done by project directors and investigators according to stages of projects.

Laboratories hope that LIS should always be improved with developing the health sector Luttinger, (2002). Changes are inevitable for LIS because LIS is no longer indispensable product for laboratories. There are three main reasons for these changes which are market economic forces, technologic forces and health care policy changes.

According to Luttinger, (2002), LIS includes three processes which are pre-analytical, analytical, and post-analytical. The pre-analytical process can determine what user wants from LIS and what can it for this. At this process, it is important to determine the priority of tests. At analytical process, reflex test is performed, wide Quality Control (QC) program is used, and auto verification is performed. The post-analytical process includes various examination reports, results reporting, statistical package, storage capacity of system etc.

Results of tests can be evaluated two ways Luttinger, (2002). At the first one of these, technology experts can manually evaluate and verify to these tests. The evaluated test is saved with username of technology expert. The second one of these is auto verification. Auto verification is self-checking which is performed by equipment. This equipment is used by laboratories. For auto verification, reference ranges are defined to equipment of laboratories. These reference ranges are generally numeric.

So computable tests can automatically verify. If tests are in reference ranges, be shown that the tests were verified by instrument interface management. If tests are in review ranges which are not reference ranges, be shown that the tests were verified by rules and by the Discern Expect Code generated by the LIS. The auto verification provides time saving. So experts can have much more time for emergency tests.

## **2.2 Literature Review of SSADM**

Structured Systems Analysis and Design Method (SSADM) is a method which is used based on waterfall model. SSADM includes all stages before programing. This



occurs two basic stages which are analysis and design stages. At the analysis stage, all requirements are determined. At the design stage, these requirements are determined how to.

There are three techniques which are used for SSADM. These are Logical Data Modeling, Data Flow Modeling, Entity Behavior Modeling Lano & Haughton, (1993). Logical Data Modeling is a process which provides definition, modeling and reporting of requirements of system at the design stage. This model includes relations and qualities of entities. Data Flow Modeling is a process which defines, models, and reports how data move at the system. This model examines actions, which are transfer of data from place to place, data storages, external entities (what is sent to system and what is received from system), and work flows. Entity Behavior Modeling defines, models, and reports conditions which are affecting each of entity.

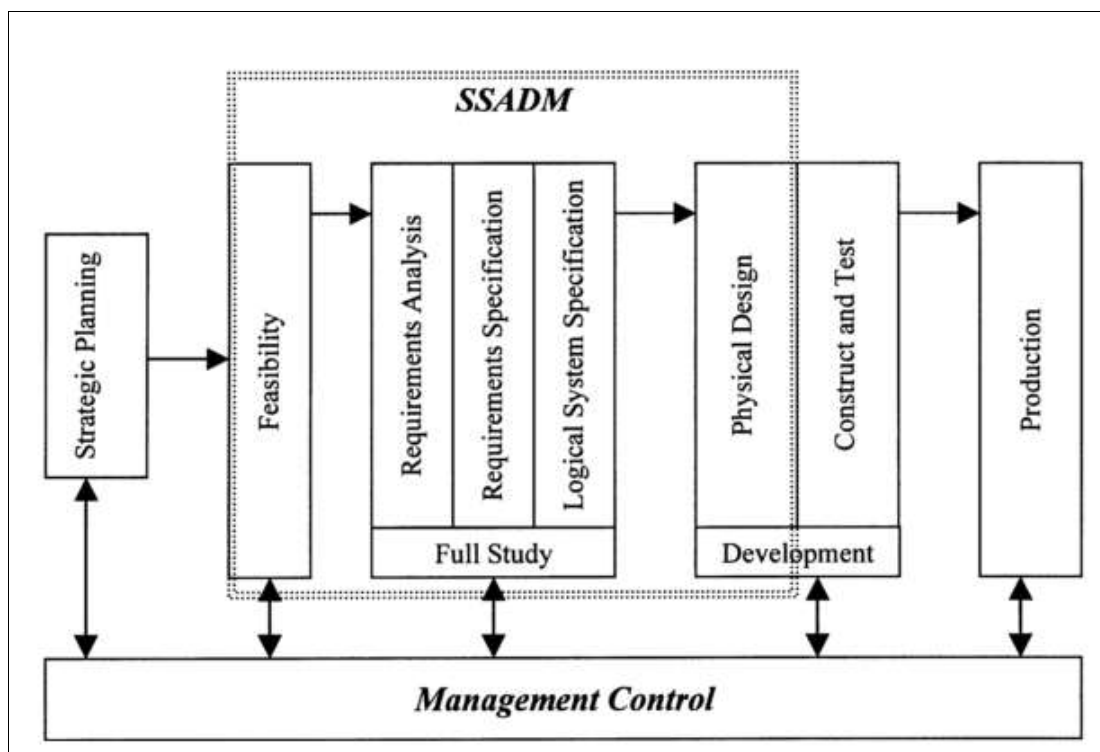


Figure 2.3 Development processes of SSADM

Figure 2.3 shows development processes of SSADM. These processes are explained clearly at Rogerson & Simpson, (2000). At the Feasibility, requirements and users are analyzed for being prepared some business features and for detail of

technical implementation. At the Requirements Analysis, requirements and problem are defined for modeling system. In order to express physical system, Data Flow Diagrams (DFD) and LDS (Logical Data Structure) are created. BSO (Business Systems Options) are defined. So a model of necessary system is created and the model is examined with users. At the Requirements Specification, functional and non-functional requirements are defined BSOs can be supported with technical documentation. At the Logical System Specification, relations of users with system are important. This process includes data catalog and logical data structure. At the Physical Design, a physical design is created with being defined processes, data, inputs and outputs. Program features are defined particularly.

## **CHAPTER THREE**

### **DEVELOPMENT PROCESSES**

Laboratory Information System (LIS) works depending on Hospital Information System (HIS). Information of test, patient, barcode and process are acquired by HIS. When tests are ended, they are shown to users by HIS. Information of test includes which tests and how many tests are made. Information of patient includes age, gender, name, surname and diagnosis. Information of process include when test are required, when, in which process and by whom samples of patient are taken. Information which are sent to HIS include results of tests (which can be manually by laboratory experts and automatically by devices), all of processes of test and time information.

#### **3.1 User Scenarios**

There are three main processes for this system in the hospital. First one is test request process. Tests can be requested by doctors in the polyclinics, where patients are examined, or in the services, where there are hospitalized patients. When the polyclinics are observed, doctors diagnose patients and choose tests, which are needed for health of patient, on the screen. They always cannot need to test and cannot request. After they request tests, they print barcode which is belonging to patient. When the services are observed, test request process continues like polyclinics. Tests can be requested by some secretaries in the central laboratory. The secretaries request tests for patients which are come from contracted hospitals. The secretaries previously save patient to system if this patient have not entry in the system. Then they request tests from system. These patients also have their samples. To repeat sampling is not need.

Second one of main processes is sampling and acceptance of laboratory process. After patients take barcode from doctors, they come central laboratory for sampling. First step is to take order for recording secretary. Samples partition as blood and external blood samples. Distinct order is taken for blood and external blood samples.

Second step is to make acceptance of secretarial in order for blood samples according to barcode of patient. After the secretary makes acceptance of secretarial, empty blood tubes whose numbers and color can change according to tests are given to patients. The secretary takes barcodes for each tests and one of them is order of taking blood. The first three digits of codes over barcodes express code of test. These barcodes paste over empty blood tubes. External blood samples are usually taken by doctors or nurses. Urine sample which is one of external blood samples is taken by the patient himself. After for urine sample secretaries make to acceptance of secretarial, they give empty tube to patient. Third step is to be taken blood sample. Nurses take blood samples of patients according to order. After they take, they show tubes to barcode reader which is connected to computers. So information of nurse, time and tubes can be saved to system. This step is passed for external blood samples. Forth step is to accept blood and external blood samples to laboratory. This is make for external blood sample after acceptance of secretarial. The filled tubes which are blood samples and are carried to central laboratory are accepted and some tubes are separated by blood separation device. Then all of samples are distributed in the laboratories which are defined according to tests.

Third and the most important one of main processes is analyzing samples and sending results of tests. Processes of each laboratory are partially different. They previously make acceptance of laboratory for all of coming test over system via barcodes of tubes. There are generally three states for all of them while analyzing. At the process of manual entry which is one of three states, test results are saved to system by laboratory experts. Bacteriology Laboratory, Tuberculosis Laboratory, Mycology Laboratory, Metabolism Laboratory, Tissue Type Laboratory, Molecular Biology Laboratory, Parasitology Laboratory can save test results via manual entry. At the process of automatic entry which is one of three states, test results are saved to system by device which is related to code of test. At the same time, these tests automatically send to HIS if they are in the reference ranges which are defined for each tests. If not, these tests are repeated. Urine tests in the Urine Laboratory, hemogram tests in the Hematology Laboratory and Emergency Biochemistry Laboratory is automatically send to HIS without approval of the expert who is

responsible of laboratory. At the process of testing as manually and with device which is one of three states, The results of tests which are came from device can manually be changed by laboratory experts or laboratory technicians. These tests are manually saved to system. After tests are ended, they are confirmed in the system by laboratory experts who are different for each laboratory.

After all of tests are ended, their samples are kept for two days in the cabinet. Because some of tests can repeat according to requests of doctors. Tubes of samples are saved to system as barcode, code of keeping cabinet and code of keeping saddle.

The tests cannot be ended correctly. Sometimes samples are inadequate, are not suitable for devices and testing. In this state, tests are rejected with cause of rejection and send to HIS. The results of tests sometimes are outside of reference ranges. In this state, laboratory experts or laboratory technicians report as panic test and they call and inform doctors who request these tests about panic tests. In advance causes of rejection are defined by experts. Laboratory experts or laboratory technicians can select in these causes or write new cause themselves while rejecting.

Laboratory experts or laboratory technicians need to other tests as results of tests. In this state, they call and tell needed test to doctors. They cannot test without requests of tests. Because request of tests are important from billing. This state generally occurs in the Bacteriology Laboratory, Tuberculosis Laboratory, and Mycology Laboratory. If bacteria proliferate according to result of culture tests, laboratory experts or laboratory technicians can need to work antibiotic which affect this bacteria.

In the most of laboratories, laboratory experts or laboratory technicians can use templates for results of tests, breeding bacteria, and antibiotic which affect these breeding bacteria. Because there are a lot of bacteria and antibiotic and a lot of results for some tests. It is impossible to know all of them.

## 3.2 Data Flow Diagram

Data Flow Diagram (DFD) is one of basic methods which is used for analyzing of systems based on data. DFD exposes infrastructure logic of system. DFD provides that relations between system and sub-systems are shown. DFD basically uses four symbols for showing data flow graphically.

### 3.2.1 Data Flow

A data flow shows a data which moves from one place to another place. The data flow is shown with an arrow and on this arrow content of data flow is written. This content can be single data or composite data.



Figure 3.1 Data flow symbol

### 3.2.2 Processes

Processes define a function or an activity. They have generally a name and a number. As name of process is used imperative sentences. In the process incoming data flow turns to outgoing data flow.

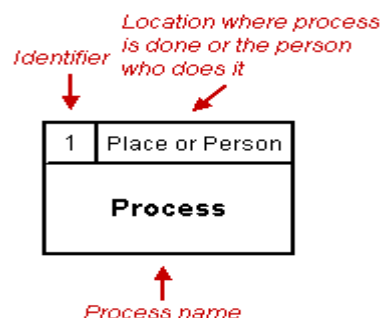


Figure 3.2 Process symbol

### 3.2.3 External Entity

An external entity is a place in which a data/an information or data/information source goes. A person who provides data for system or takes data from system is an example for this definition. The name of entity is written to into the symbol as individual.

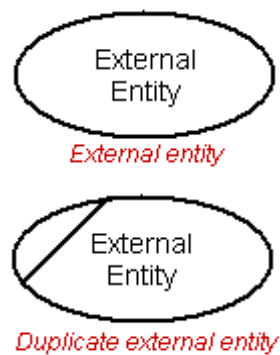


Figure 3.3 External entity symbol

### 3.2.4 Data Store

In the analysis process, data store provides to storing data. This can be a shelf or a computer file or a file cabinet. Each of data store is defined as D and D takes next to one number for reference. At the same time each of data store takes a name.

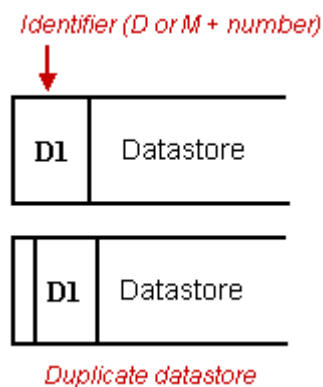


Figure 3.4 Data store symbol

### 3.3 Data Flow Diagram of LIS

Process starts with patient coming in the hospital. Previously all information of patient is taken by secretaries who work at the polyclinics. Then information of patients hide over **PROTOCOL\_NO**, **PATIENT\_NO**, and **PATIENT\_TRACKING\_NO**. Figure 3.5 shows that system has three basic processes. One of these which is H1 is related to HIS, third of these which are L1, L2, and L3 are related to laboratory, and last of these which is A1 is related to works of administrator.

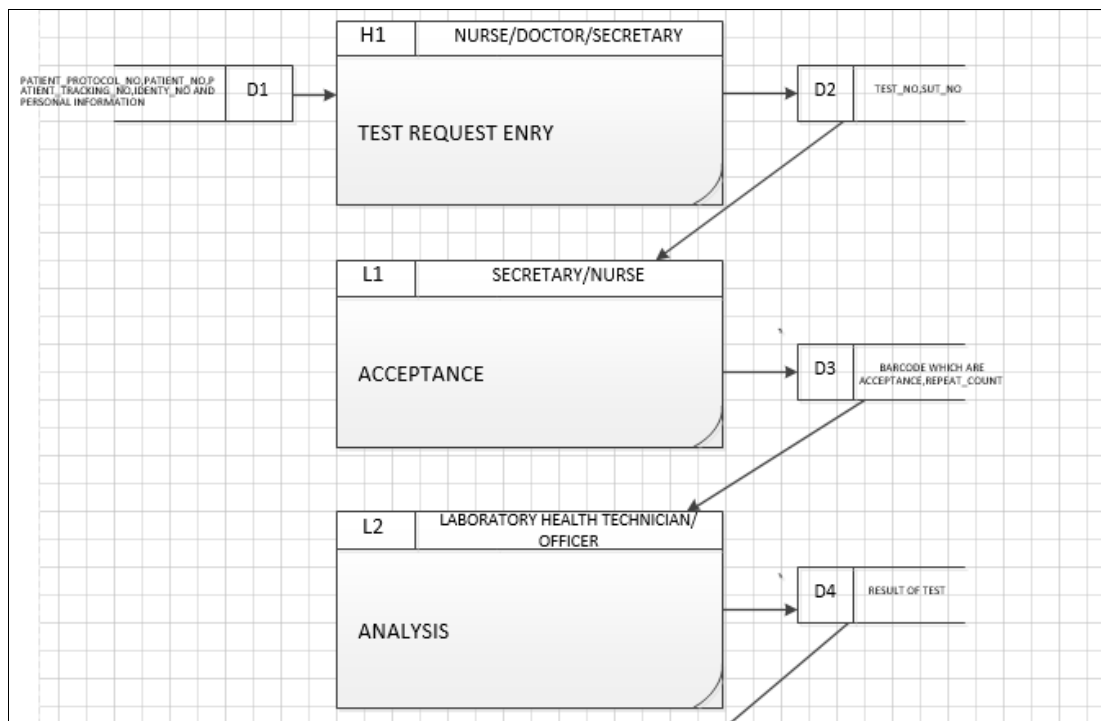


Figure 3.5 Basic processes

The process of administrative tools provide that the administrators can add, update and delete tests, devices, result templates, laboratory, user of laboratory, responsible of laboratory, parameters of tests, pairing of device-parameter, kind of microorganism and antibiotic. There is star figure on the corner of the process of administrative tools. This means that this process will not divide into sub-processes. But other processes divide into sub-processes.



Figure 3.6 shows sub-processes of test request entry. This process occurs from three sub-processes. These processes are polyclinic test request entry, service test request entry, and negotiated test request entry. At the polyclinic test request entry, doctors can require tests from patients who come for examining. At the service test request entry, doctors can require tests from patients who are hospitalized. At the negotiated test request entry, central laboratory secretary requires tests from patients who are come from negotiated hospitals.

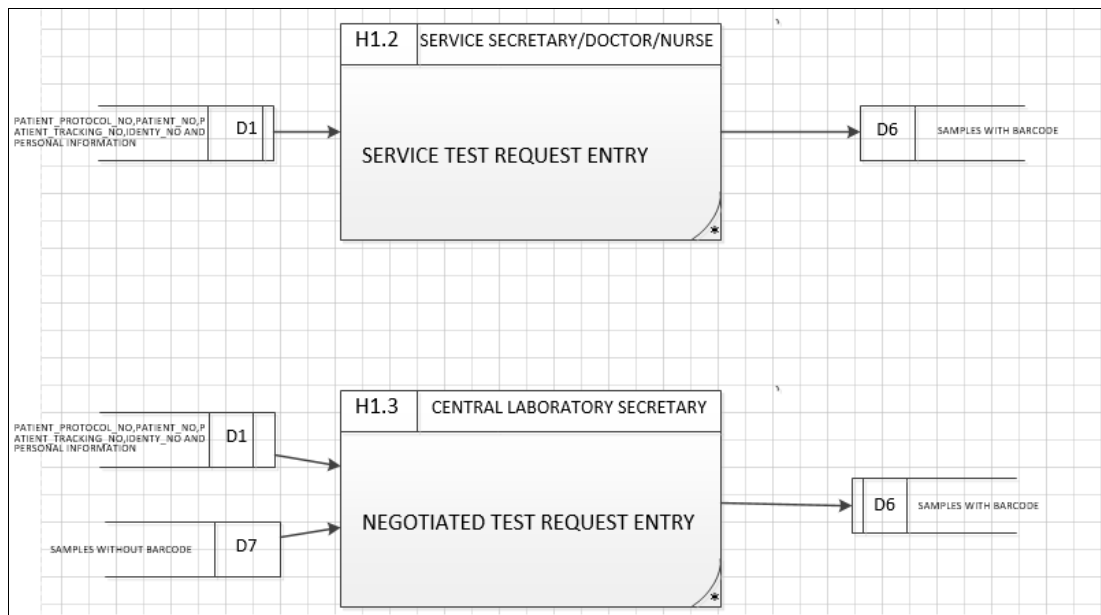


Figure 3.6 Test request entry processes

Figure 3.7 shows sub-processes of acceptance. This process occurs from five sub-processes. These processes are secretarial acceptance, sample acceptance, service acceptance, laboratory pre-acceptance, and laboratory acceptance.

At the secretarial acceptance, secretaries give empty tubes with unique barcode to patients and they save to system while reading patient barcode. The first three digits of unique barcode are id of test. At the sample acceptance, Information of obtained samples is saved to system. At the service acceptance, this process is similar to process of sample acceptance but the only difference is that this process makes at the services.

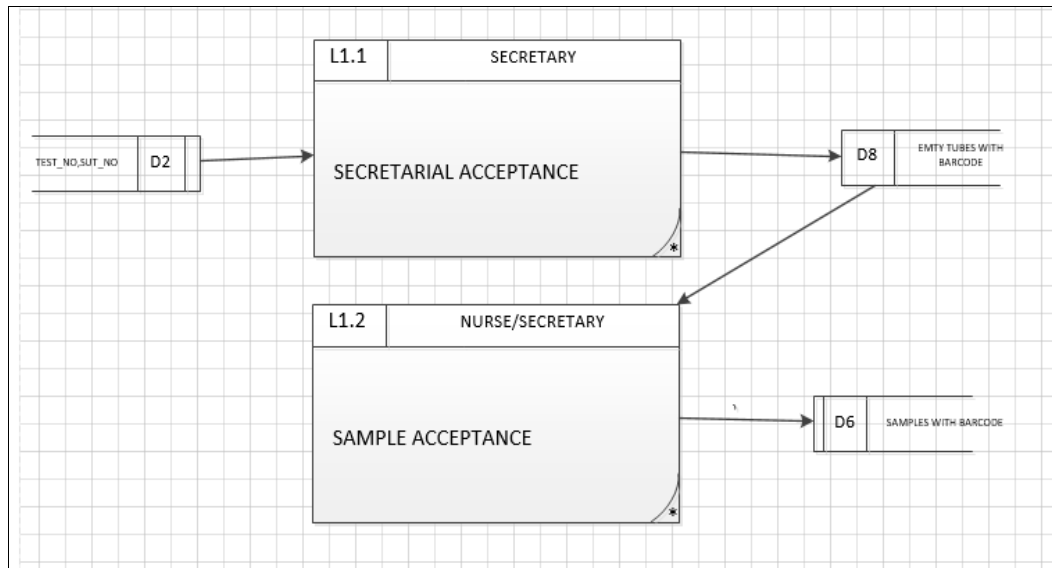


Figure 3.7 Acceptance processes-1

At the laboratory pre-acceptance, all of samples accept to central laboratory, samples are distributed to related laboratories, and some samples can divide other tubes for different tests. These divided tubes take barcode whom first three digits are different from other. The first three digits changes according to laboratory.

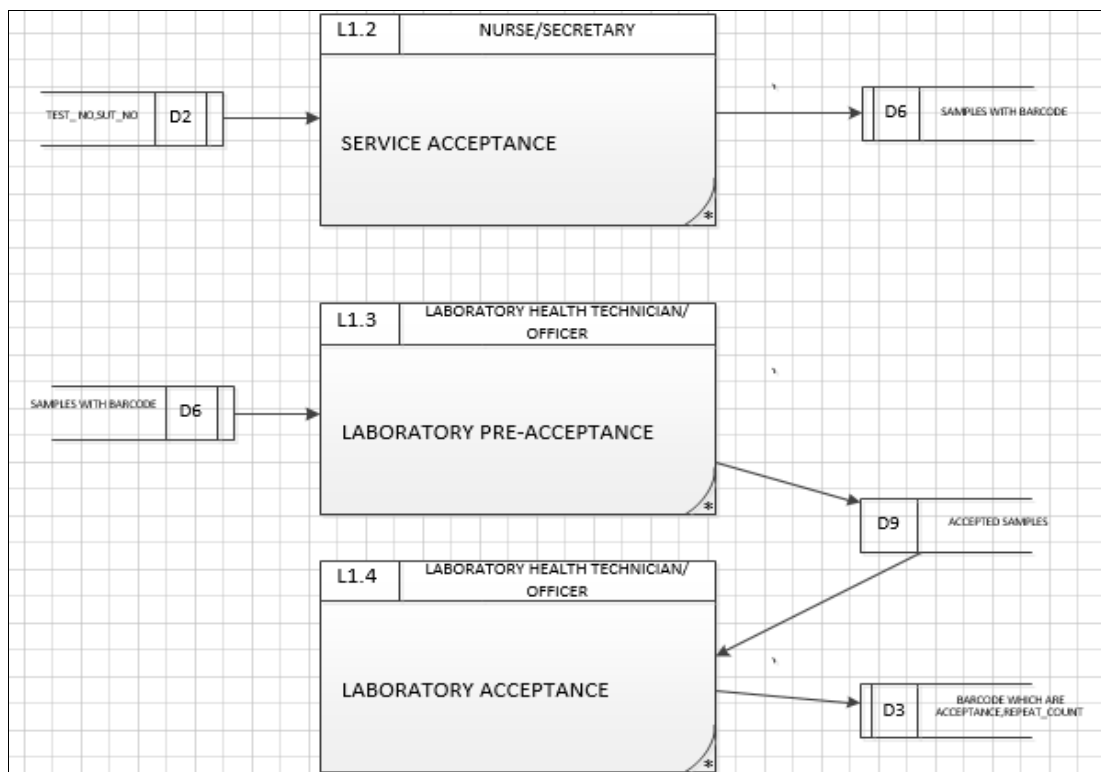


Figure 3.8 Acceptance processes-2

Figure 3.9 shows sub-processes of analysis. This process occurs from three sub-processes. These processes are manual testing, testing via devices, manual testing and testing via devices. At the manual testing, laboratory workers analyze samples and save results of tests to system themselves. At the testing via devices, tests are analyzed via devices automatically and saved to system via software of devices.

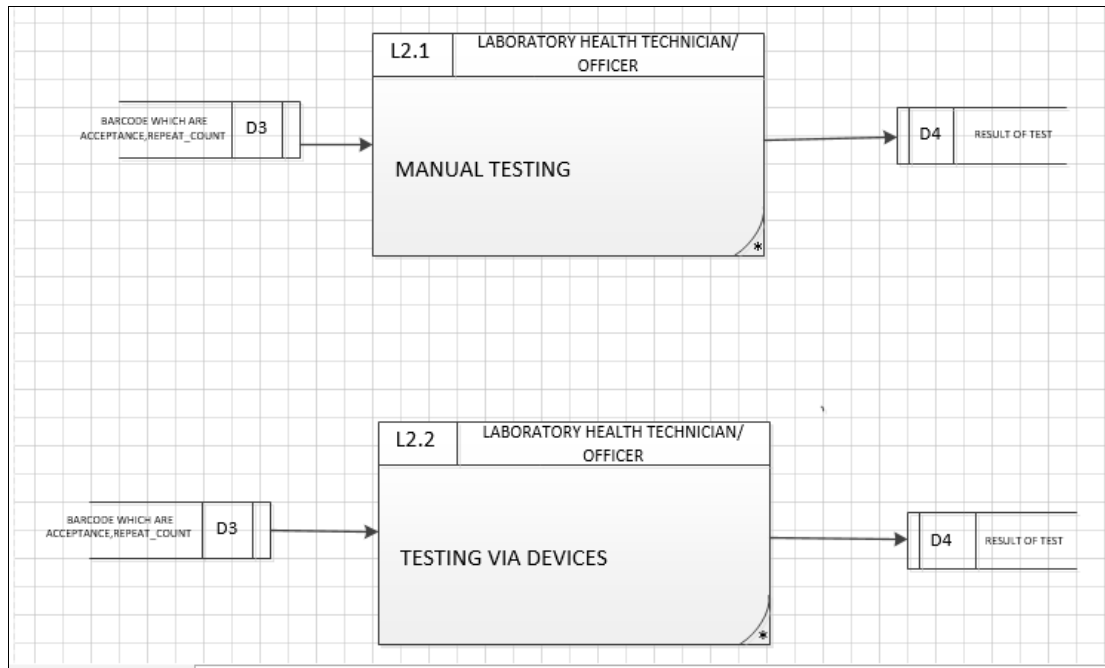


Figure 3.9 Analysis processes-1

At the manual testing and testing via devices, samples are analyzed both by laboratory workers and via devices.

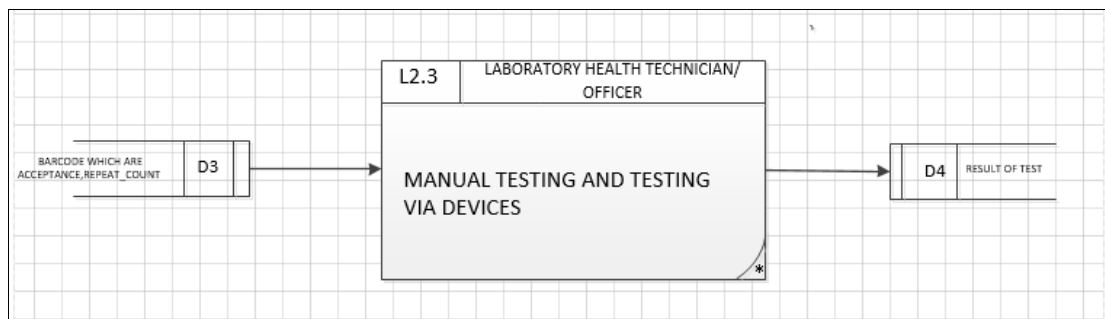


Figure 3.10 Analysis processes-2

Figure 3.11 shows sub-processes of result. This process occurs from two sub-processes. These processes are controlling result of test and reporting results of tests. At the controlling result of test, laboratory experts control test results. According to this control, the results of tests can be approved or be repeated or be rejected from system. The approved results send to HIS from system automatically. At the reporting results of tests, approved results of test can be reported by laboratory experts.

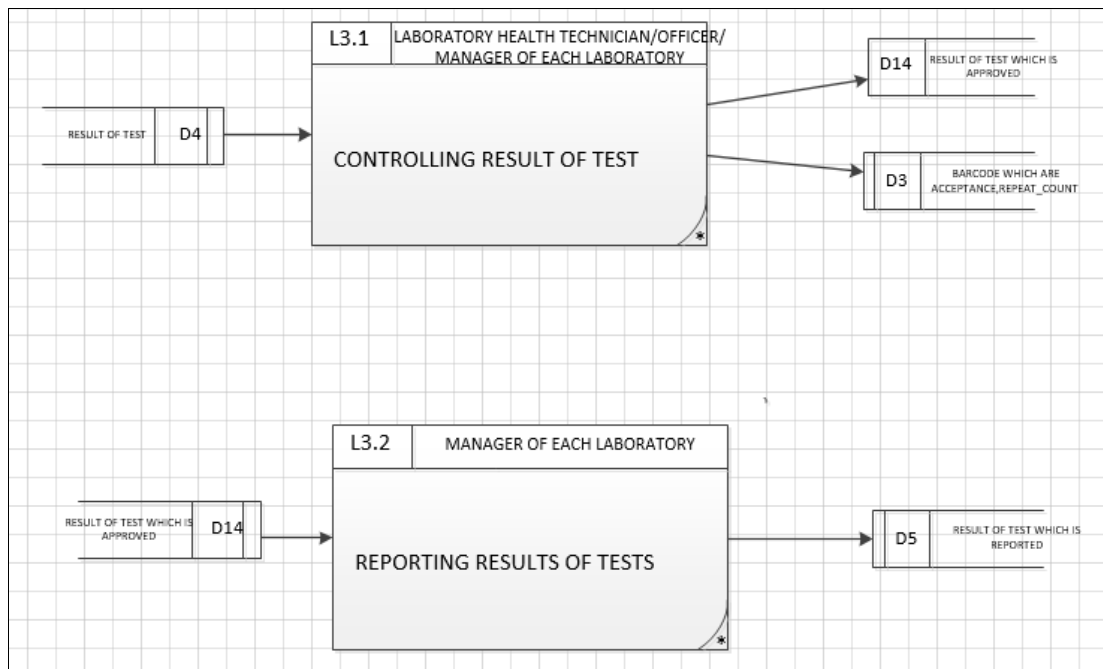


Figure 3.11 Result processes

### 3.4 Database Model of LIS

The database model can separate four parts for being understood. First part of them is authority and person tables. There are two type people who are laboratory workers and patients. This system can be used by laboratory workers. Tests are belongs to patients. Each of people is related to one unit of laboratory and they have a position because users are capacitated according to position and unit of laboratory. At the same time, each of users has a title. As shown in the Figure 3.10, users and delegations in the system are gathered to one diagram.

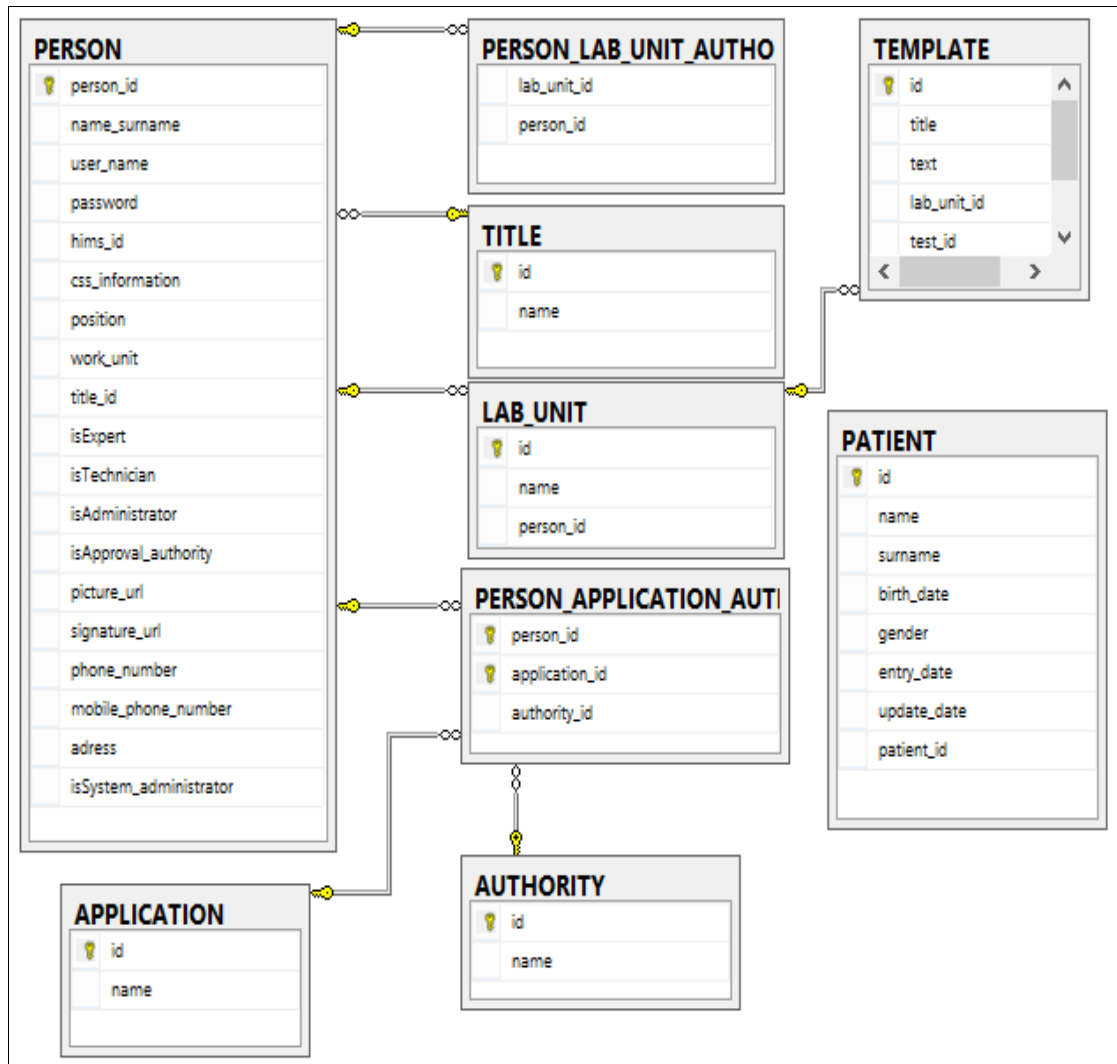


Figure 3.12 Users and delegations in the system are gathered to one diagram

In the laboratories, each device has some properties and a unique id and these are in a table. In a device, a test group can be worked. This test group occurs tests and these tests occur parameters. Periodically devices are tested by users of devices. Aim of this is to give correct results of tests. Each parameter has different result and the person who test is saved in the system. The device calibration is made by giving max value and min value for each parameter.

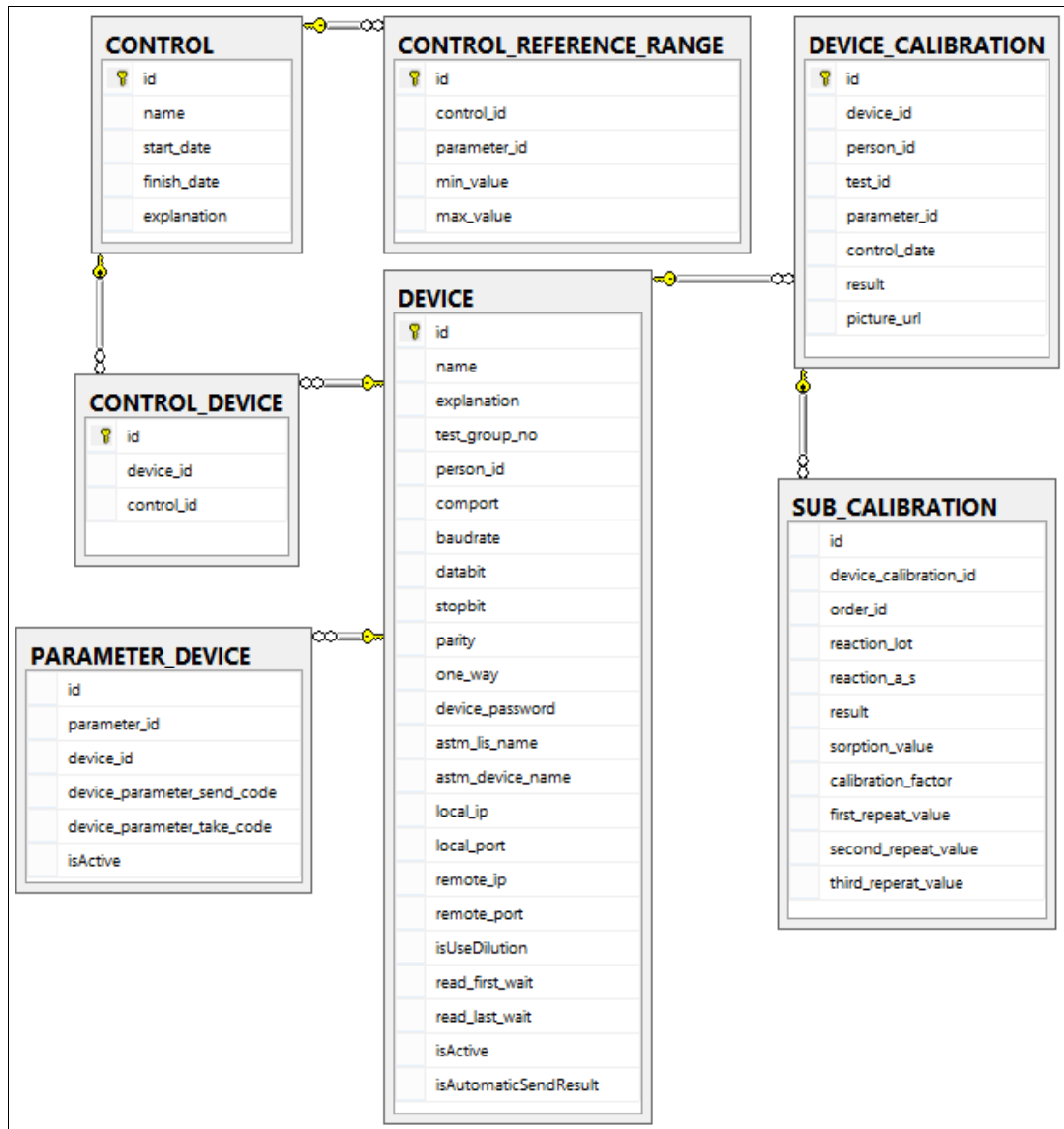


Figure 3.13 Device connection

The laboratories have test groups. This relation is saved in the table of LAB\_UNIT\_TEST\_GROUP. Test groups occur tests, the tests occur parameters, and the each parameters have reference ranges according to Figure 3.12. Tests can be evaluated as parameter or as test or as parameter. Tests can be copied from other place or a device which is not attached to this system. This information is saved tables of test group or test or parameter. The reference ranges can be change according to age and gender. They cannot be numeric and have numeric ranges. They can be string values or devices can send different reference ranges.

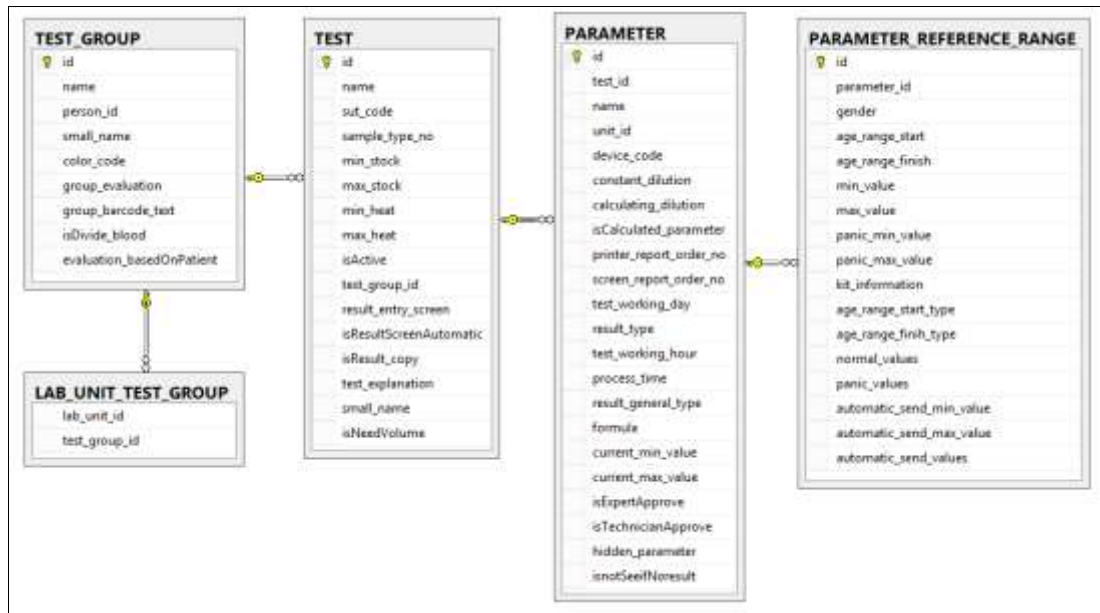


Figure 3.14 Test connection

The requests which are come from HIMS via web services are saved table of REQUEST. This request can include one or more test. The details of these requests are saved to table of REQUEST\_DETAIL. This table includes information of states which are states of samples up to be accepted each laboratories. They are person and date information for each state. At the same time this table includes task information which shows communication status information with HIMS. The table of ADD\_TEST\_REQUEST uses for request from this system and request information is send to HIMS. The table which is saved results of tests, state information of results is table of RESULT. This table includes reference ranges of results that time, reject information, and repeat information. The information which is come from device is saved to this table. Because laboratory workers can want to this information. If result of test repeat, old result is still kept in the table. The diagnosis of patients are kept in the another table. Because a patient has a lot of diagnosis. The laboratory workers want to see these diagnosis while results of test is being approved. REQUEST, REQUEST\_DETAIL, RESULT, and related tables are shown at the Figure 3.13.

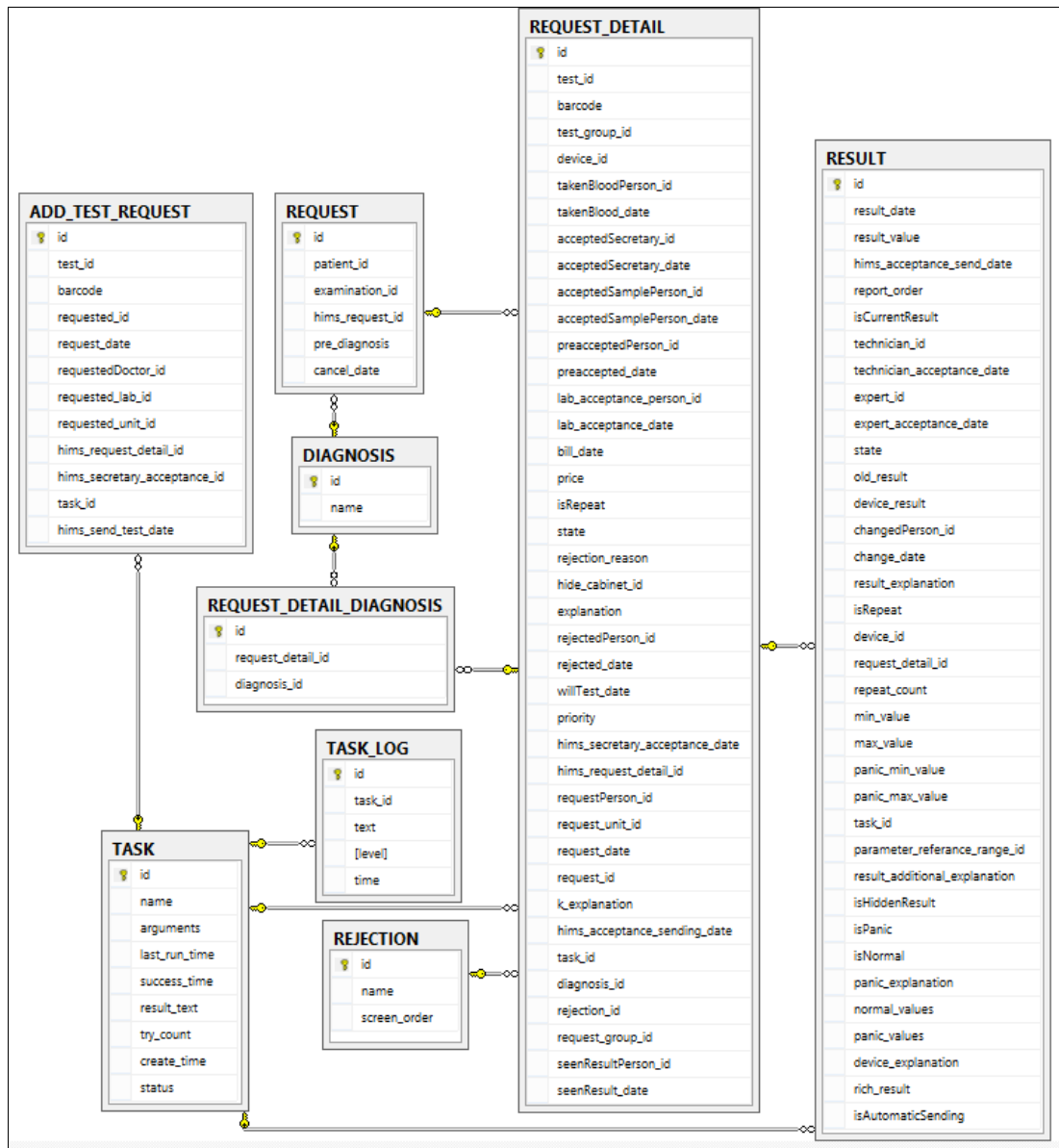


Figure 3.15 Test request connection

Figure 3.14 shows that the results which need to aspect and culture tests are saved to these tables. The finding microorganism in the results of tests are saved to table of **RESULT\_MIKROORGANISM**. If antibiotic is applied upon this result, result of the antibiotic is saved to table of **RESULT\_ANTIBIOTIC**.



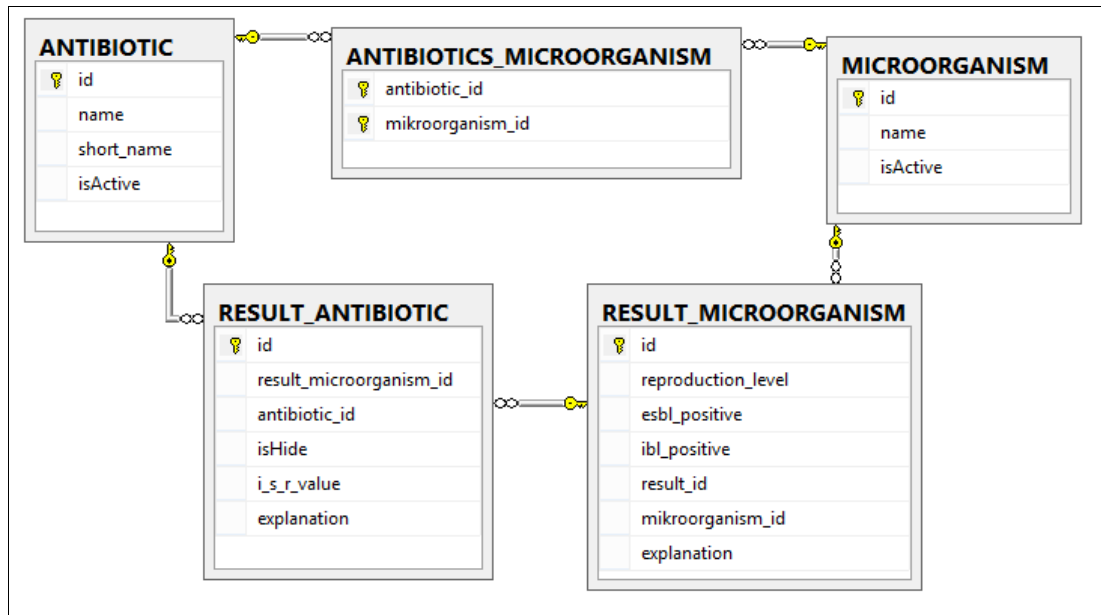


Figure 3.16 Antibiotic-Microorganism connection

### 3.5 Infrastructure Planning

Before this project started, present system had examined. HIS and LIS use same database. They communicate through .exe file. This case causes some losses which are for example samples. Because of this, samples cannot test, and patients cannot reach their tests and laboratory management suffers from a financial perspective.

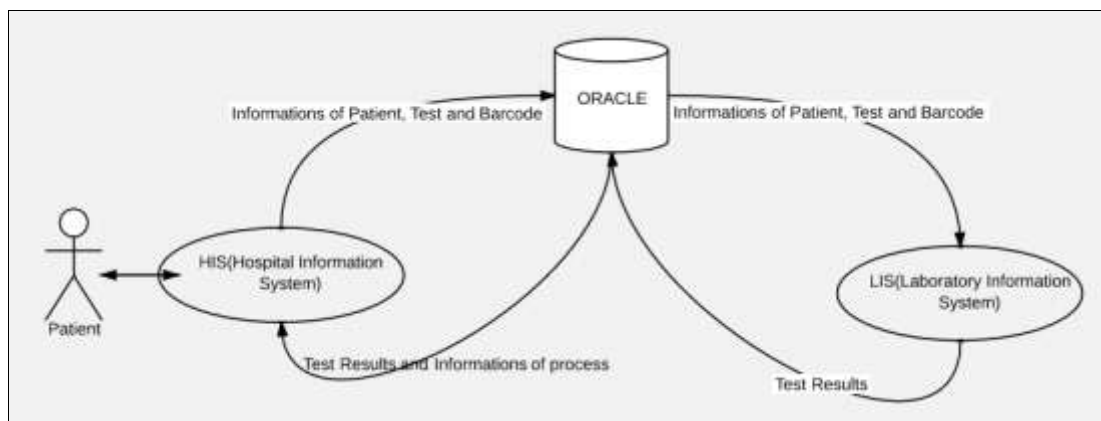


Figure 3.17 Database connection for LIS and HIS in the previous system

This project is planning based on web services. The using database for LIS is separated from the using database for HIS. The communication between these systems is provided through web services.

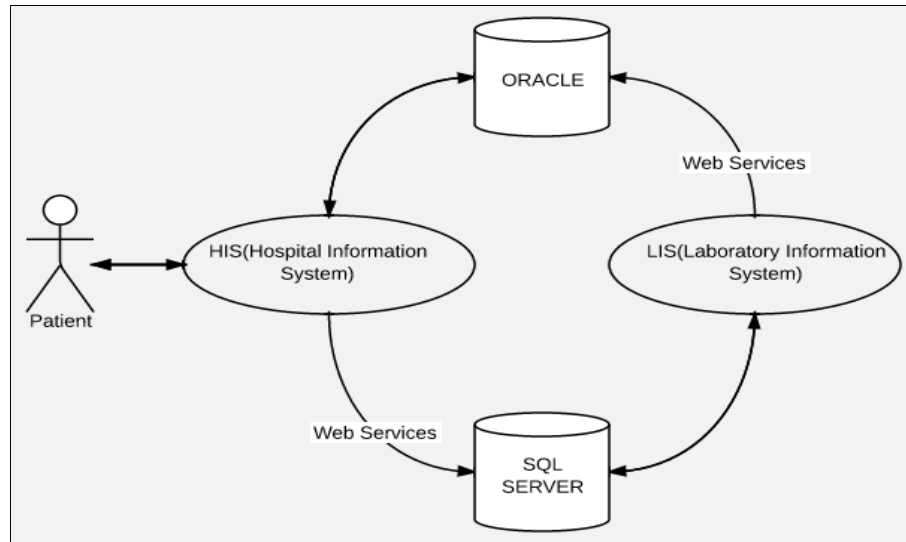


Figure 3.18 Database connection for LIS and HIS in the current system

## **CHAPTER FOUR**

### **USED TECHNOLOGIES**

#### **4.1 Visual Studio 2013 Asp.net**

ASP.NET which is made over ASP programming language by Microsoft is web application development technology. ASP.NET works over .NET Framework. .NET Framework which is improved by Windows provides interoperability between different programming languages for developing based on Windows application.(Janssen, n.d.) All programming languages which are supported by .NET can be used for developing ASP.NET applications. C# is used for this LIS application. There are features which are come with ASP.NET Scott Workman, (2013). They are:

- Fast as ASP.
- Supports a lot of technologies which are XML, Web Services, Database Interaction and E-mail Interaction etc. and is supported by them.
- Debugging, Caching, Extensibility
- Code and UI(User Interface) are separated
- Session management
- Maintains page state
- Complete object model
- There are Master page and Theme structure in order to occur modern web application interfaces
- Include Code Behind feature. Thanks to this feature, programming elements and design elements are located on separate pages.
- New application models
- Improved Performance and Scalability, Easy Deployment
- Enhanced Reliability

#### ***4.1.1 Team Foundation Server***

Team Foundation Server (TFS) is a Microsoft Product which allows to be increased yield and communication within the team for working as a team. Thanks to this, management of projects facilitates. At the TFS project is kept on a common server and project workers can access from here. TFS always shows the most recent version and provides an opportunity to see previous versions.

#### **4.2 Microsoft SQL Server**

Database is regular collection of data. Microsoft SQL Server (MS SQL) is the most widely used database software. MS SQL is a Relational Database Management System (RDBMS) which allows to be occurred and to be managed to database Rouse, (2006). It is improved by Microsoft. At the RDBMS, data is kept via tables and tables can be linked with each other in the sense of relational. On a Windows platform (using .NET or ASP) MS SQL is the database of select for web applications. These languages can connect to a MS SQL database easily.

#### **4.3 DevExpress ASP.NET AJAX Controls**

Dev Express is a component of .NET platform. This component visually provides very good arrangements for workers who develop applications with .NET platform. It has a lot of controls for ASP.NET and Windows Forms Applications. It provide how the Dev Express Win forms controls helped us develop advanced software applications for our clients and helped us generate more revenue for our business(T Manjaly, 2013).

#### **4.4 Microsoft Visio**

Microsoft Visio is a vector drawing software which is developed by Microsoft. Information Technology and business professionals to visualize complex

information, comprehend and communicate is a program that facilitates(Benny Taylor, n.d.).

Microsoft Visio is used for:

- visualizing and streamlining business processes
- tracking projects and resources
- drawing an organization chart
- creating the network map
- pouring construction sites to diagram
- optimizing to systems

## CHAPTER FOUR

### IMPLEMENTATION

#### 5.1 Implementation of LIS

Turkish is used for this application because of applying in the Turkish hospital. The images which are used for this thesis are belongs to Dokuz Eylül University Faculty of Medicine-LABBEST application. The implementation is used by secretaries, health technicians, laboratory experts, laboratory directors, and system administrators. All users can entry system from one page. Users in the system are searched by user name. User name is different for each user. The pages which users can entry are determined according to their authority. Figure 5.1 shows login page.



DOKUZ EYLÜL ÜNİVERSİTESİ  
H A S T A N E S İ

**MERKEZ**  
LABORATUVARI

Kullanıcı :

Şifre :

Figure 5.1 Login page

All users firstly are redirected to home page. According to authority of login user, the user can access tests of patients. At this page users can:

- search by criteria
- see all states of tests
- print barcode for selected tests
- print list according to result of searching
- access page of evaluation of the results for selected tests
- grouping according to the columns which are determined
- filter in the columns
- write explanation for each test

Figure 5.2 Date criteria is selected



Figure 5.3 Criteria list

The criteria of pending approval (concluded) are shown at the Figure 5.4. The tests have ten statuses. These situations hide in the constant class and their types are int32. Each status has different color. According to color, row color is changing. This facilitate that the users understand.

Test	Hasta	Durum	Adı Soyadı	Doğum Tarihi	Sonuç Kabul	Örnek Kabul	Merkez Kabul	Kabul Tarihi	Onay	Raporlar	İstedi Yapan Biri	Açıklama
232731405	232 18628	BOYALIZ	232731405	12/11/1977								
232731790	232 18628	BOYALIZ	232731790	12/11/1977								
232731897	232 18628	BOYALIZ	232731897	12/11/1977								
232731898	232 18628	BOYALIZ	232731898	12/11/1977								
232731449	232 18628	BOYALIZ	232731449	12/11/1977								
232731405	232 18628	BOYALIZ	232731405	12/11/1977								
232731807	232 18628	BOYALIZ	232731807	12/11/1977								
232731808	232 18628	BOYALIZ	232731808	12/11/1977								

Figure 5.4 Criteria of pending approval (concluded)

The criteria of accepted laboratory (working tests) are shown at the Figure 5.5. According to laboratory processes, column information is changing. If the process is



finished, person which is making this process and process date and time are written to column. For laboratory workers, date and time are very important. Because samples can give different results according to time. At this process, there are date controls and a different button. Because laboratory workers cannot work some tests that day. They are planning according to tests and printing list of these tests.

Figure 5.5 Accepted laboratory (working tests)

The printing button which allow printing work sheet. This work sheet is shown at the Figure 5.6. This includes barcode, patient name and surname, and test name. While the laboratory workers are read to barcode, they can access information of test.

Figure 5.6 Work sheet for test information

The criteria of accepted laboratory (all) is shown at the Figure 5.7. This criteria includes subsequent situations after accepted laboratory situation.





Figure 5.9 Authority laboratory lists

The users can change their user information by clicking on the link which is belongs to their name and surname. The Figure 5.10 shows that home number, mobile number, address, password, and theme information can change via popup window.

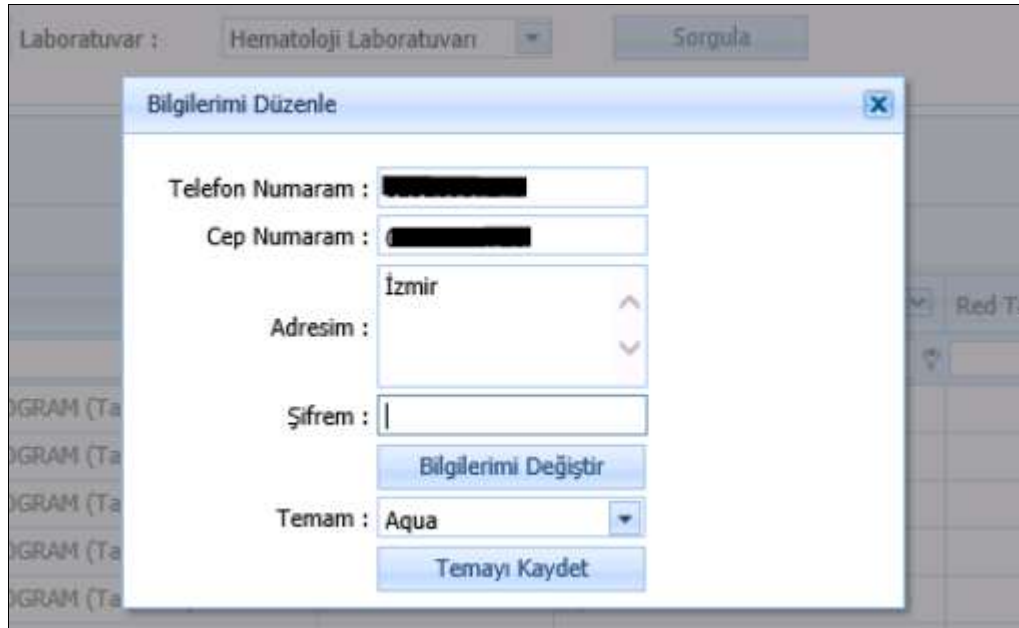


Figure 5.10 Editing information popup window

The users can print barcode via barcode link. The barcodes of tests which are selected according to the user's needs are printed. Barcode example is shown at the Figure 5.11. There are the short name of test, barcode, name and surname of patient, protocol number of patient, request date and laboratory name over the barcode.

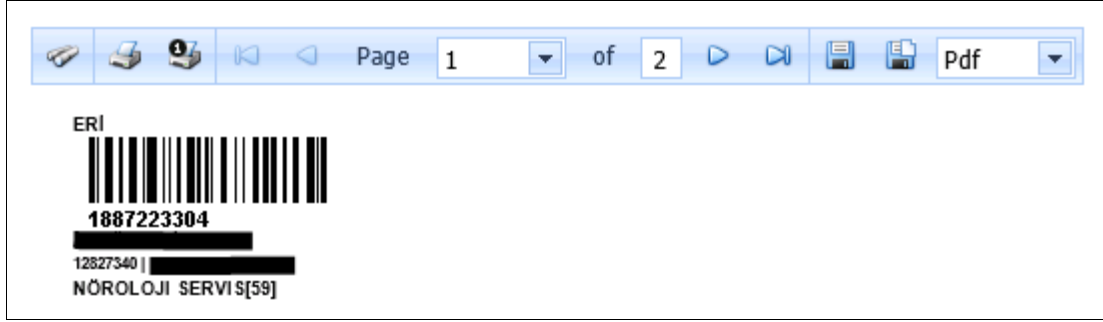


Figure 5.11 Barcode example

The next menu item from laboratory notebook page is sample acceptance. There are sample acceptance and sample acceptance list in this menu item. Sample acceptance process is first process in the laboratory. The users save samples by reading barcodes via barcodes reader or by write barcode to textbox. So user information and date information is saved system. The user can see and filter information which is belongs to barcode on the grid. When users need a barcode, they can print barcode in this page. The sample acceptance page is shown at the Figure 5.12.

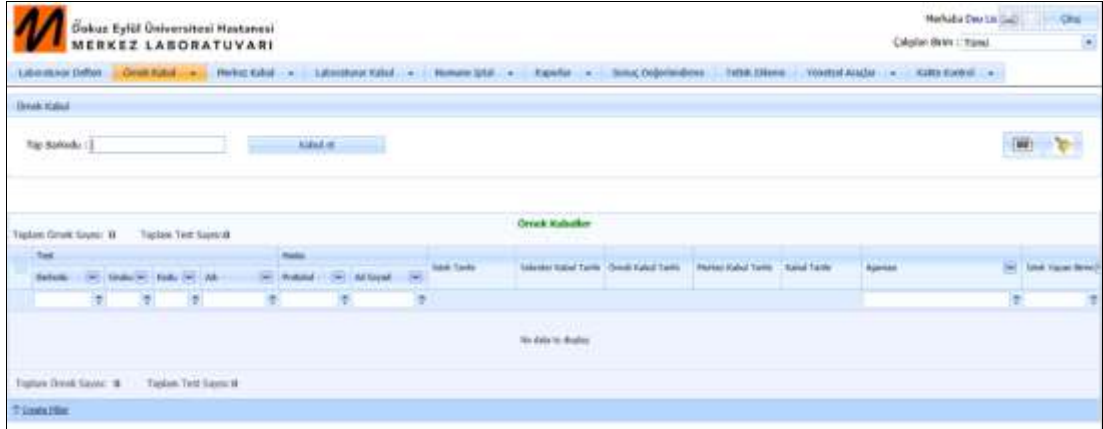


Figure 5.12 Sample acceptance page

The next menu item from sample acceptance is central acceptance. There are central acceptance, central acceptance retrieval and central acceptance list in this menu item. Central acceptance process is second process in the laboratory. The users accept samples to central laboratory by reading barcodes via barcodes reader or by write barcode to textbox. The samples sometimes can be separated by blood

separation device for different laboratories. This information is hidden in the test properties. So user information and date information is saved system. The user can see and filter information which is belongs to barcode on the grid. When users need a barcode, they can print barcode in this page. The central acceptance page is shown at the Figure 5.13.

Figure 5.13 Central acceptance page

The users can take back tests which are accepted to central laboratory at the Figure 5.14. While these processes are coming true, at the same time the acceptance information and acceptance retrieval information are send to HIMS via web services.

Figure 5.14 Take back central acceptance page

The users sometimes need to central acceptance lists for printing barcode and filtering at the determined date ranges. An example list is shown at the Figure 5.15.

Figure 5.15 Central acceptance lists

The next menu item from central acceptance is laboratory acceptance. There are laboratory acceptance, laboratory retrieval and laboratory acceptance list in this menu item. Laboratory acceptance process is third process in the laboratory. The users save samples to laboratory by reading barcodes via barcodes reader or by write barcode to textbox. So user information and date information is saved system. The user can see and filter information which is belongs to barcode on the grid. When users need a barcode, they can print barcode in this page. The laboratory acceptance page is shown at the Figure 5.16. Laboratory retrieval and laboratory acceptance list processes are same as central laboratory processes.

Figure 5.16 Laboratory acceptance page

The some samples can be cancelled for some reason. The users can cancel samples in the all acceptance processes. All tests or some tests which are belongs to patient are cancelled. The cause of cancelled has to write by selecting defined causes

or by defining themselves. The cause of cancelling, date of cancelling and date are saved system and are send to HIMS via web services. The cancelling popup window is shown Figure 5.17.

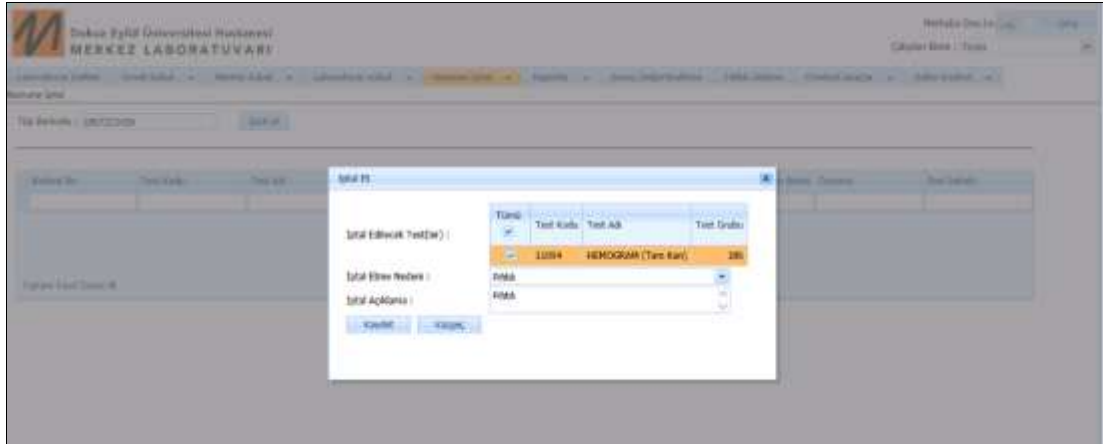


Figure 5.17 Cancelling popup window

The user wants to see cancelled tests list for user and date information. This list shows another page which is at the Figure 5.18.

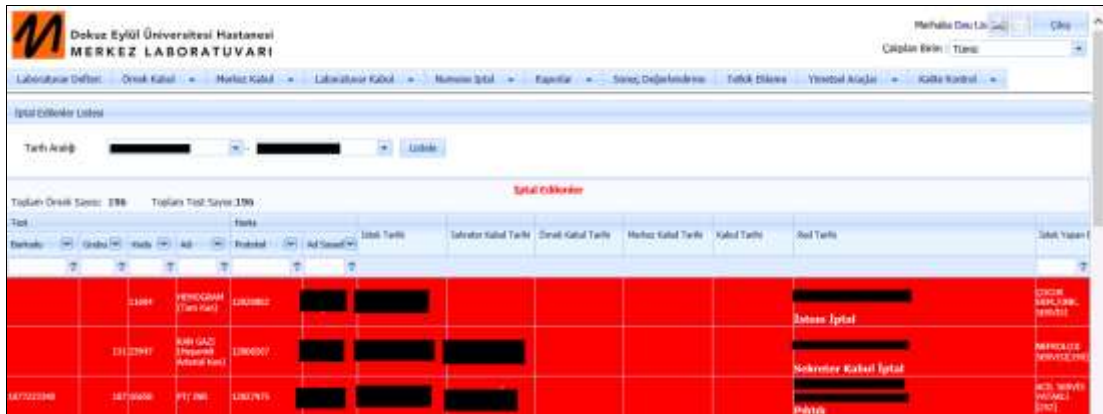



Figure 5.18 Cancelled tests list

The next menu item from sample cancelling is reports. Reports include all reports which are requested by laboratory workers. They are result report, report of end of day, bacteriology work sheet, critical notification list, printing barcode form.

The result report is one of the most important reports in the laboratory. The experts and doctors who request tests can see this report. When tests are resulted, this




report can see. This report is also important for accreditation. An example of this report is shown at the Figure 5.19.



**M ERKEZ**  
LABORATUVARI

**TURKAK**  
TÜRK AKREDİTASYON KURUMU  
TURKISH ACCREDITATION AGENCY  
Tarihinde akredite edilmiştir.  
T.C.  
DOKUZ EYLÜL ÜNİVERSİTESİ  
MERKEZ LABORATUVARI



**TÜRKAK**  
TÜRK AKREDİTASYON KURUMU  
TURKISH ACCREDITATION AGENCY  
Tarihinde akredite edilmiştir.


**Tıbbi İnceleme Raporu /Medical Examination Report**

Protokol No : 12827754  
T.C. Kimlik No : [REDACTED]  
Cinsiyet : ERKEK

İsteyen Hekim: [REDACTED]  
Barkod Zamanı: [REDACTED]  
Onay Zamanı: [REDACTED]  
Test : 11004- HEMOGRAM (Tam Kan)


İsim Soyisim : [REDACTED]  
Doğum Tarihi : 11.09.1920  
Tanı : [REDACTED]

İsteyen Birim: ACİL SERVİS P. (YETİSKİN) (251)  
Kan Alım Zamanı : [REDACTED]  
Lab Kabul Zamanı: [REDACTED]



1867222009

Parametre	Sonuç	Açıklama	Referans Aralığı
WBC	8.7 10 <sup>3</sup> /µL		4-10.3
NEU%	↑ 78.2 %		41-73
LYM%	↓ 11.5 %		19.4-44.9
MONO%	8.6 %		5.1-10.9
EOS%	1.5 %		0.9-6
BASO%	↓ 0.2 %		0.3-1.5
NEU#	↑ 6.8 10 <sup>3</sup> /µL		2.1-6.1
LYM#	↓ 1.0 10 <sup>3</sup> /µL		1.3-3.5
MONO#	0.7 10 <sup>3</sup> /µL		0.3-0.9
EOS#	0.1 10 <sup>3</sup> /µL		0-0.5
BASO#	0.0 10 <sup>3</sup> /µL		0-0.2
RBC	↓ 3.53 10 <sup>6</sup> /µL		4-5.77
HGB	↓ 8.4 g/dL		13.5-17.5
HCT	↓ 27.4 %		41-53
MCV	↓ 77.8 fL		80.7-95.5
MCH	↓ 23.9 pg		27.2-33.5
MCHC	↓ 30.7 g/dL		32.7-35.6
RDW	↑ 14.9 %		11.8-14.3
PLT	199 10 <sup>3</sup> /µL		156-373
MPV	9.2 fL		6.9-10.8
PCT	0.183 %		




1877222013

İsteyen Hekim: [REDACTED]  
Barkod Zamanı: [REDACTED]  
Onay Zamanı: [REDACTED]  
Test : 10658- PT/ INR

İsteyen Birim: ACİL SERVİS P. (YETİSKİN) (251)  
Kan Alım Zamanı : [REDACTED]  
Lab Kabul Zamanı: [REDACTED]

Parametre	Sonuç	Açıklama	Referans Aralığı
* PT(Plasma)	11.478 sn		11.23-14.44
* INR(Plasma)	1.060		



1877222013

İsteyen Hekim: [REDACTED]

İsteyen Birim: ACİL SERVİS P. (YETİSKİN) (251)

Figure 5.19 Result report

The report of end of day shows test counts which change according to date ranges, laboratory, and states of tests. The laboratory experts can need this report. An example of this report is shown at the Figure 5.20.



Test Grubu	Test Adı	Subtili Yapılanlar Sayısı	Sonuç Hızı (Görülenler Sayısı)	Total Edilenler Sayısı	* R.X.S.A	* R.T.S.A	* R.C.L.A	* P.T.L.A
180	180-OR-GOFF (3.0K)	0	0	0	0	0	0	0
181	17 - OR PROGESTERON	0	0	0	0	0	0	0
182	17 - OR PROGESTERON (125.0K Kan)	0	0	0	0	0	0	0
183	17 - OR PROGESTERON (125.0K Kan)	0	0	0	0	0	0	0
184	17 - OR PROGESTERON (180.0K Kan)	0	0	0	0	0	0	0
185	17 - OR PROGESTERON (30.0K Kan)	0	0	0	0	0	0	0
186	17 - OR PROGESTERON (95.0K Kan)	0	0	0	0	0	0	0
187	17 - OR PROGESTERON (95.0K Kan)	0	0	0	0	0	0	0
188	17 - OR PROGESTERON (95.0K Kan)	0	0	0	0	0	0	0
189	17 - OR PROGESTERON (95.0K Kan)	0	0	0	0	0	0	0
190	17 - OR PROGESTERON (95.0K Kan)	0	0	0	0	0	0	0

Figure 5.20 Report of end of day

Bacteriology work sheet is prepared for bacteriology laboratory. Users generally use this work sheet for urine culture. The bacteriology laboratory works manually. This work sheet is useful for writing result of patient. An example of this report is shown Figure 5.21.

Rapor Tarihi: 01.07.2014 12:30  
Deu Lis  
Sayfa: 1/1

**SONUÇ RAPORU**

Hasta : 4392955 [Redacted]  
Örnek No : 2327223381  
Cinsiyet : BAYAN  
Doğum Tarihi : 01.07.1934

Örnek Alım Zamanı :  
Rapor Basım Zamanı : 01.07.2014 12:30  
Doktor : [Redacted]  
Tanı :

Test Grubu : AEROP İDRAR KÜLTÜRÜ  
Servis : ORTOPEDI SERVİSİ[81]

İstem Zaman : 01.07.2014 12:30  
Lab Kabul Zamanı :

2327223381

Figure 5.21 Bacteriology work sheet

The critical notification list is list of physicians reported results which are critical. This report is daily and includes reported person, date, and reporting person. An example of this report is shown Figure 5.22.

Page 1 Pdf

Rapor Tarihi: [Redacted] Deu Lis Sayfa 1/5

**Dokuz Eylül Üniversitesi Hastanesi**  
**MERKEZ LABORATUVARI**

**İDRAR LABORATUVARI KRİTİK BİLDİRİM LİSTESİ**

İsim Soyisim	Test	Parametre	Sonuç	*KRA	Kritik Açıklama	Yapıldığı Tarih	Yapan kişi
[Redacted]	11021- TAM İDRAR ANALİZİ (Otomatik)	* Glukoz	>=56 mmol/L	0-55.9	XX	[Redacted]	[Redacted]
[Redacted]	11021- TAM İDRAR ANALİZİ (Otomatik)	* Glukoz	>=56 mmol/L	0-55.9	XX	[Redacted]	[Redacted]
[Redacted]	11021- TAM İDRAR ANALİZİ (Otomatik)	* Glukoz	>=56 mmol/L	0-55.9	ulaşamadı	[Redacted]	[Redacted]
[Redacted]	11021- TAM İDRAR ANALİZİ (Otomatik)	* Glukoz	>=56 mmol/L	0-55.9	GÖRÜLDÜ	[Redacted]	[Redacted]
[Redacted]	11021- TAM İDRAR ANALİZİ (Otomatik)	* Glukoz	>=56 mmol/L	0-55.9	ULAŞILAMADI	[Redacted]	[Redacted]
[Redacted]	11021- TAM İDRAR ANALİZİ (Otomatik)	* Glukoz	>=56 mmol/L	0-55.9	ulaşamadı	[Redacted]	[Redacted]
[Redacted]	11021- TAM İDRAR ANALİZİ (Otomatik)	* Glukoz	>=56 mmol/L	0-55.9	DRASLI	[Redacted]	[Redacted]
[Redacted]	11021- TAM İDRAR ANALİZİ (Otomatik)	* Glukoz	>=56 mmol/L	0-55.9	dr kudret	[Redacted]	[Redacted]
[Redacted]	11021- TAM İDRAR ANALİZİ (Otomatik)	* Keton	>15 mmol/L	0-14.9	plk	[Redacted]	[Redacted]
[Redacted]	11021- TAM İDRAR ANALİZİ (Otomatik)	* Glukoz	>=56 mmol/L	0-55.9	plk	[Redacted]	[Redacted]
[Redacted]	11021- TAM İDRAR ANALİZİ (Otomatik)	* Glukoz	>=56 mmol/L	0-55.9	plk	[Redacted]	[Redacted]
[Redacted]	11021- TAM İDRAR ANALİZİ (Otomatik)	* Glukoz	>=56 mmol/L	0-55.9	dr hlm	[Redacted]	[Redacted]
[Redacted]	11021- TAM İDRAR ANALİZİ (Otomatik)	* Glukoz	>=56 mmol/L	0-55.9	plk	[Redacted]	[Redacted]
[Redacted]	11021- TAM İDRAR ANALİZİ (Otomatik)	* Glukoz	>=56 mmol/L	0-55.9	dr halice	[Redacted]	[Redacted]
[Redacted]	11021- TAM İDRAR ANALİZİ (Otomatik)	* Glukoz	>=56 mmol/L	0-55.9	xxx	[Redacted]	[Redacted]

\*KRA=Kritik Referans Analizi

Figure 5.22 Critical notification list

The evaluation of the results page is one of the most important pages. This page include evaluation of result process and approving process. There are five search criteria and test group criteria. Test group can change according to user's request. Figure 5.23 shows to these criteria.

**Dokuz Eylül Üniversitesi Hastanesi**  
**MERKEZ LABORATUVARI**

Laboratuvar Defteri Örnek Kabul Merkez Kabul Laboratuvar Kabul Numune İptal Raporlar **Sonuç Değerlendirme**

Sonuç Değerlendirme

Arama Kriteri: Laboratuvara Kabul Edilenler(Çalışılacaklar) [Redacted] - [Redacted] Sorgula

Test Grubu: Barkod Onay Bekleyenler (Sonucu Çıkanlar) Laboratuvara Kabul Edilenler(Çalışılacaklar) Laboratuvara Kabul Edilenler(Tümü)

Toplam Örn: [Redacted]

Tümü Onaylananlar Protokol

Durumu	Hasta Protokol	Ad Soyad	Doğum Tarihi

Figure 5.23 Evaluation of the results page

The first one is barcode criteria. Users sometimes want to look a barcode of patient for learning state or for seeing where it is or for entering result. The barcode criteria provide these situations.

The second one is pending approval (tests which are resulted). When the page is first opened, tests comes as these criteria. At this situation, tests are resulted and they are awaiting approval by laboratory experts. The laboratory experts can approve, reject, and repeat to sample as result of test. This page is used by laboratory technicians and experts. So only laboratory experts have approval, rejection, and repetition authority. The laboratory workers can make these processes but they're made on behalf of the authorities. An example of these criteria is shown Figure 5.24. This figure is taken from metabolism laboratory.

Figure 5.24 Pending approval (tests which are resulted)

The third one is accepted to the laboratory (tests which are studied). This criteria shows tests which are not resulted. There are four different ways for entering results. These are by manual, device, copy, rich result. The users can test some samples themselves or can change some test results or can add explanation to test at the manual entry. The Figure 5.24 shows that each test occur parameters. The users can enter result to parameters by clicking detail button. The users can enter result, critical state of parameter, explanation and additional explanation from detail part. So user which enters result information is saved to system with date and user information. If result is critical, user has to enter critical notification note. Figure 5.25 shows an example of manual entry.





[illegible]

Figure 5.29 Managerial tools (test page)

[illegible]

Figure 5.30 Managerial tools (task page)

## 5.2 Code Analysis of Implementation

The security is very important for patient knowledge and results of tests. The obtaining knowledge of the patient or the making mistake while resulting can lead to a disaster. So implementation has to be secure.

Data which are changed or obtained is too much. Data are hidden by Asp.NET session state. Session is used for transferring data between pages. Dataset which you don't want to can be hidden in the session. Asp.NET is creating a unique cookie for each user, the cookie is sent to the user's computer and it contains knowledge that identifies the user. This is named Session(Jana, 2009).

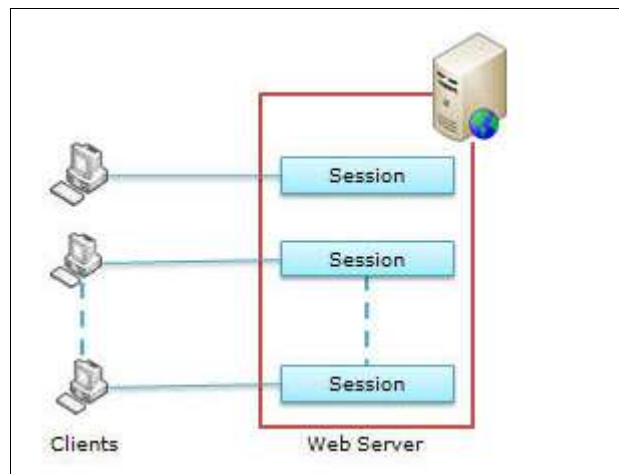


Figure 5.31 Session design

Session object hides data up to end session. But session for each page is needed for this application. The data which are hidden to session object will end when page is closed. So page session which is belongs to page and user session which continue during session are occurred. At first, unique page guid for each page is occurred in the 'OnLoad' Event of base page. Because of 'OnLoad' Event, 'ViewState' is not occurred in the 'Pre-Init' and 'Init' Events. Code lines which occurred unique page guid are shown at the Figure 5.32.

```

protected override void OnLoad(EventArgs e)
{
    if (ViewState["PageGuid"] == null)
    {
        string pageGuid = Request.QueryString["PageGuid"];
        if (pageGuid == null)
        {
            pageGuid = Guid.NewGuid().ToString();
        }
        ViewState["PageGuid"] = pageGuid;
    }
    PageGuid = ViewState["PageGuid"].ToString();

    base.OnLoad(e);
}

```

Figure 5.32 Base page 'onLoad' Event

After unique page guid is occurred, new page session is occurred with HTTP session and unique guid. The method of page session is shown at the Figure 5.33.

```

public PageSession(HttpSessionState session, string pageGuid)
{
    m_session = session;
    m_pageGuid = pageGuid;
}

```

Figure 5.33 'PageSession' method



## **CHAPTER SIX**

### **CONCLUSION AND DISCUSSION**

The expectations of hospitals are increasing with technologies day by day. Today implementation of this thesis provides users to enter results of tests, to see results, to analyze, and report over test results. In the future these capabilities won't be sufficient.

The new devices are emerged with technological advances. This case needs to change in the LIS. At this implementation, different coding is occurred for each device. Dynamic structure for each device can be created in the future. So all hospitals can use only one LIS.

The test results of patients are not hidden in a one place. So doctor or laboratory workers cannot see other results of patients in the other hospitals. Laboratory tests results can be hidden in a place.

The test results are increasing day by day. This data accumulates at the hospitals. Thanks to data mining technology, this data can analyze and diagnosis of patients can be determined without doctors. The data mining enables to predict about future for huge data stack.

This implementation works with HIMS. Test requests are taken from HIMS via web services. In the future, tests can be requested in the LIS. Patient information can be taken from HIMS. Because test requests during day are too much and traffic between HIMS and LIS is intense. So data may be loss.

In this thesis, test results, laboratory workers information, device information are stored in Microsoft SQL Server 2008. Traffic between HIMS and LIS is provided on a WCF (Windows Communication Foundation) service project using Microsoft Visual Studio 2013. The result of the implementation is presented using ASP.Net technology.

## REFERENCES

- Blaya, J. A., Shin, S. S., Yagui, M. J. A., Yale, G., Suarez, C. Z., Asencios, L. L., et.al. (2007). A web-based laboratory information system to improve quality of care of tuberculosis patients in Peru: functional requirements, implementation and usage statistics. *BMC Medical Informatics and Decision Making*, 7, 33. doi:10.1186/1472-6947-7-33
- Hai, V. D., & Thuan, N. D. (2010). Design of laboratory information system for healthcare in Vietnam BK-LIS, In *Communications and Electronics (ICCE), 2010 Third International Conference*, 110-114.
- Jana, A. (2009). *Exploring session in ASP.NET - CodeProject*. Retrieved June 01, 2014, from <http://www.codeproject.com/Articles/32545/Exploring-Session-in-ASP-Net>
- Janssen, C. (n.d.). *What is ASP.NET? - Definition from techopedia*. Retrieved May 19, 2014, from <http://www.techopedia.com/definition/3213/asp-net>
- Lano, K., & Haughton, H. (1993). Integrating formal and structured methods in reverse-engineering. *Proceedings Working Conference on Reverse Engineering*. doi:10.1109/WCRE.1993.287782
- Lutinger, I. (2002). Getting the most from your laboratory information system in the hematology laboratory. *Accreditation and Quality Assurance*, 7(11), 494–497. doi:10.1007/s00769-002-0539-y
- Manjaly, T. (2013). *Review of devExpress winforms controls - CodeProject*. November 12. Retrieved May 25, 2014, from <http://www.codeproject.com/Articles/410847/Review-of-DevExpress-WinForms-Controls>

- Quo, C. F., Wu, B., & Wang, M. D. (2005). Development of a laboratory information System for cancer collaboration projects, In *Engineering in Medicine and Biology Society. IEEE-EMBS 2005. 27th Annual International Conference*, 2859-2862
- Rogerson, S., & Simpson, C. (2000). The Australian computer society 's code of ethics and SSADM, an ethical review of information systems development. *Information Technology & People*, 13(2), 121–136.
- Rouse, M. (2006). *What is SQL Server? - Definition from WhatIs.com*. Retrieved May 19, 2014, from <http://searchsqlserver.techtarget.com/definition/SQL-Server>
- Sepulveda, J. L., & Young, D. S. (2013). The ideal laboratory information system. *Archives of Pathology & Laboratory Medicine*, 137(8), 1129–40. doi:10.5858/arpa.2012-0362-RA
- Skidmore, S., Farmer, R., & Mills, G. (1992). SSADM version 4 models and methods. NCC, Manchester.
- Sümen, E., Zayim, N., & Saka, O. (2005). *Laboratuar bilgi sistemi (LBS) uygulaması: Benimseme ve kullanıcı memnuniyeti*. Retrieved February 22, 2014, from <http://www.turkmia.org/kongre/cd/pdf/21.pdf>
- Tagger, B. (2011). *An introduction and guide to successfully implementing a LIMS (Laboratory information management system)*. Retrieved February 22, 2014, from <http://www0.cs.ucl.ac.uk/staff/B.Tagger/LimsPaper.pdf>
- Taylor, B. (n.d.). *What is Microsoft Visio? / Science - Opposing Views*. Retrieved May 25, 2014, from <http://science.opposingviews.com/microsoft-visio-12332.html>

Workman, S. (2013). *Why use ASP.NET for website & web app development / BitWise solutions. February 7.* Retrieved May 19, 2014, from <http://www.bitwisesolutions.com/about-bitwise/resources/blog/february-2013/why-use-asp-net-for-website-and-web-app-development>