

İzmir Institute of Technology

The Graduate School

**WEB BASED USER ACCOUNTING SYSTEM FOR
INTERNET SERVICE PROVIDERS**

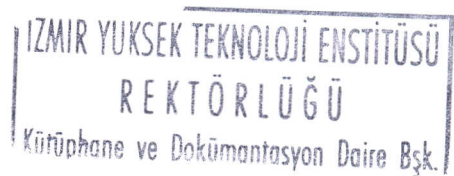
**A Thesis in
Computer Engineering**

**By
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of the Requirements
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ABSTRACT

There are some basic operations, that any Internet Service Provider (ISP) must do, such as adding, removing users, disabling and enabling users, changing user passwords etc. Beside these basic operations, all ISPs must design a accounting system to bill the users. Most of the currently available ISP packages run on Windows NT or UNIX systems and in client side a specific client program is developed, which runs only on specific operating system (OS) (say Windows NT). If ISP want to access these ISP operations from an another OS (say from UNIX (with hundreds of its derivatives), OS/2, MacOS etc.), client program must be ported to each of the OS. Although this is possible in theory, in practice it is very difficult and *not cost effective*.

In this thesis to solve this problem, a Web based user accounting system is proposed. In a Web based system anyone who has a regular Web browser can access the ISP data, manage and view them (ofcourse securely) no-matter where he is in the world, which OS he uses. This approach makes ISP accounting easy and cost effective. Additionally making the system in Turkish, increases the useability of the system for the Turkish users.

ÖZET

Tüm Internet Servis Sağlayıcılarının (ISS) yapması gereken bazı temel işlemler vardır, örneğin kullanıcı ekleme, silme, gecici olarak kapama ve açma, şifre değiştirme vb. Bunlara ek olarak, her ISS'in gözetleme ve ücretleme sistemi oluşturması gerekir. Şuanda piyasada bulunan ISS paketlerinin tamamına yakın kısmı Windows NT yada UNIX ortamında çalışmaktadır ve istemci tarafında bu işletim sistemleri için yazılmış istemci yazılımları çalışmaktadır (örneğin Windows NT için). Eğer bir ISS kullanıcısı ISS işlemlerini başka bir işletim sisteminden yapmak isterse (örneğin UNIX (yüzlerce türeyle birlikte), OS/2 yada MacOS) istemci programının tüm bu istemci işletim sistemlerine uyarlanması gerekir. Hernekadar teoride bu işlemin yapılması mümkün olsada, pratikte bunun yapılması çok zordur ve maliyeti çok yüksektir.

Bu sorunu çözmek için bu tezde Web tabanlı bir gözetleme sistemi önerilmektedir Web tabanlı bir sistemde herhangi bir Web tarayıcısına sahip olan herkes kolayca ISS datasına erişebilir, üzerinde değişiklik yapabilir ve görüntüleyebilir (tabii güvenli bir şekilde). Bu sistemde istemcinin dünyanın neresinde olduğunun yada hangi işletim sistemini kullandığının bir önemi yoktur. Bu yaklaşım ISS gözetleme işlemini oldukça kolaylaştırmakta ve maliyeti düşürmektedir. Ayrıca sistemin Türkçe hazırlanmasından dolayı Türk kullanıcılar için oldukça pratik ve kullanışlıdır.

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İZMİR YÜKSEK TEKNOLOJİ ENSTİTÜSÜ
REKTÖRLÜĞÜ
Kütüphane ve Dokümantasyon Daire Bşk.

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION TO THE PROBLEM

The Internet can be considered as the biggest library and communication environment. Since the 1980's, due to its extensive benefits and ease of use to reach information, it has been expanded and today millions of people are using the Internet, somehow.

There are many ways to get connected to the Internet and use it. At the beginning, only a few research groups and universities were using it. But since the 1980's, it has been very popular, and many people are accessing the Internet from their homes, although many of them are still accessing from their companies or from campus networks.

To use the Internet from your home, you usually must have:

- A computer (PC, Mac, Amiga etc.)
- A modem
- A telephone line
- An Internet Service Provider (ISP)

When you want to get connected to the Internet from your home using your own computer you usually get the Internet service from an Internet Service Provider (ISP). The ISPs are the companies (or institutions) who allow people to reach Internet by the help of their hardware, software and human resources.

There are many requirements of being an ISP, but the most important problem in an ISP environment is to construct a user tracking system, which ranges from defining a

user to constructing a robust billing and accounting system. In this thesis an improved user accounting system for ISPs will be proposed and constructed especially for Turkish ISPs.

Due to its distributed structure, Internet is growing continuously and consequently the information present in Internet grows rapidly. In this project Internet is used as a primary resource, due to the nature of thesis, which is directly related to Internet, and the newest available resources are present in the Internet.

Using the Internet as a resource brings some problems in terms of pinpointing the source of information. Due to nature of the Internet, the information and the places it is found changes very rapidly. For example, when you pinpoint an Internet resource (like a Web page), there is no a guarantee that, this resource will be still there after one year (even after one month!). It might be moved to a different place, changed with a newer one, or might be deleted! Although you may find the resource in some other places, you might get the source from the owner of this thesis.

1.2 Definition of the Problem and Proposed Solutions

All of the ISPs must do some basic operations, such as

- Adding new user accounts(for e-mail or Internet connectivity)
- Deleting user accounts (when a user does not need a user account anymore)
- Disable user accounts (when a user does not pay for the service)
- Enable user accounts (when a user re-paid for the service)
- Refill user accounts (when the user want to continue the service)
- Change user passwords
- Gather basic information about users, such as address, telephone and fax numbers, billing info, modem info etc. (for billing purposes as helpdesk purposes)

In addition to these basic operations, the other part of the ISP tracking system is the accounting and billing process, since the ISPs are usually commercial institutions and

they must earn money from their customers for their services (like Internet access, e-mail access etc.). At that point keeping track of user activities becomes an essential to survive. How users are using resources? How long they use resources? For knowing the user's billing information and history is very important in the billing process. In addition, this obtained information somehow must be analysed and future investments must be planned. In planning future investments, the past information is very valuable, and must be extracted from log files, and analysed. Above all, all of these tasks must be done automatically, and continuously.

The accounting and the billing process are usually done by analysing the activity logs. The activity logs changes from one system to another, depending on the hardware, and mostly the software that is used by the ISP. These activity logs are produced, usually, by three main authentication systems:

- Radius
- TACACS
- NetBlazer (Syslog)

The type of authentication system that an ISP use changes the basic user operations process and of course analysis of activity logs changes completely. An ISP may use one of these three systems, and get some logs to analyse. But an ISP environment might be very complex (for example in big ISPs) and might contain any of these three systems. This makes the basic user operations and accounting process much more complex. For this reason most of the similar ISP tracking packages use either of the three authentication systems. But using a different package for each of the authentication system is not cost effective and probably not practical. In this thesis all of the three main authentication system will be supported.

Today there are some user accounting systems doing ISP tasks in many ways. Usually they are working in Windows NT and UNIX servers. When you want to reach a specific user information (say how long this user used the resources between 4th and 7th of February of a particular year?) you usually use special client program, usually written for that Operating System (OS). For example, if you are making accounting processes in

a Windows NT server, you usually use a MS-Windows based client, or if you are using a UNIX server, you use UNIX based client program. When you want to reach that data from an another operating system (for example when you want to reach accounting information which is in a Windows NT server, from a UNIX workstation probably you will be in trouble. Because most probably program vendor does not have a UNIX client program!) you probably will not be able to reach data. If you imagine that there are many different operating systems (like DOS, Windows, Windows 95, Windows NT, OS/2, MacOS, UNIX (with hundreds of its derivatives)) you will see that it is almost impossible to make a client program for all of these platforms. Even if it is possible in theory, in practice it is very difficult, and *not cost effective*.

The easiest way to solve that problem is to build a **web based** user accounting system. In this model, a web server program will work in the server, that contains user accounting data and this web server program will use user data. On the client side, a regular web browser (like Netscape, MS Internet Explorer, Mosaic etc.) will connect to a web server, when he wants to use the accounting data in the server. This model is very suitable for this problem. This eliminates the need for developing client programs for every different operating system. Of course this brings *much lower costs*. In this project web based access and management systems will be supported.

The other advantage of this model is that, there will not be physical restrictions that are originating from distance. Since web server and client programs uses TCP/IP protocol, and Internet, anyone connected to Internet, would be able to reach user accounting information. It is not important whether he is in Europe, or the US. The only important thing is to be connected to Internet. In this thesis Internet access will be supported and anyone connected to Internet will reach the ISP data from anywhere in the world, of course securely!

There are some similar programs (ready to use commercial packages) in the world, which are using the Web as the medium. On the accounting server side, a Web server is also running, and on the client side any Web browser run. Most of these applications run in a Windows NT server. But most of the available Internet servers are hosted in UNIX servers. In this thesis UNIX system is used as Web and accounting server. Since almost

all of the coding done in a portable language (mainly in PERL) it is very easy to export the code to different UNIX clones.

When you use the Internet to transfer data, you can always met with some security problems, especially if you are using critical and valuable data, like credit card numbers. Due to nature of the web based accounting system, you will transfer the valuable accounting data via an insecure path. To solve this security problem, SSL (Secure Socket Layer) protocol will be used to crypt the data transferred.

This project is done totally in Turkish language. It uses Turkish character sets and dialog boxes are in Turkish. This makes the package much more easy-to-use and practical for Turkish users.

1.3 Definition of the Model

In this model, all user (both end-user and administrator) interactions will be via a secure web page. Users will be able to reach any part of the utilities by a correct user/password combination. This will bring ease of use and cost effective access.

All the system will be in a modular structure, so system will be:

- Easy to develop a code
- Easy to debug
- Efficient in terms of resource use

Moreover, almost all of the parts will be independent from each other. Adding/removing features and modules will be independent from existent modules. This will bring a ready-to-develop environment and over all system will be ready for feature enhancements without extensive work.

There will be mainly two types of code in the system:

- HTML codes
- Programming codes (Mainly in Perl)

Since both of the coding does not need a compilation, application development and future enhancements will be easy.

System will be developed in UNIX environment. Using UNIX as a developing and application environment will make the overall performance and reliability very high.

In addition to basic ISP requirements, the system will have a billing module that will use three main types of activity logs:

- Radius
- TACACS
- NetBlazer Syslog

Since a complex ISP environment may have combination of these three types of authentication system, combined billing will be possible and integrated with the basic ISP processes.

All the system will be written in Turkish and will have Turkish character set. This will make the system easy to use and understand, especially for Turkish people.

As seen from Figure 1.1, there will be mainly three sides of the system:

- Administrative side
- Accountant side
- End-user side

All sides will be available by a correct username/password combination and will have definite access rights for each.

In administration side, basic user operations, such as adding, removing, refilling users, listing user information, sending e-mail to all of the users is held, as well as billing information. In accounting operations side, basic billing processes, like listing billing history, is done. This part is just for billing purposes, usually proper for accountants. Lastly, at the end-user side, end-users will be able to learn their billing histories, and can change their passwords. All these processes are done securely. There is a password in all of the steps. Only authorised people can do the operations with a

proper password. For example a person from accounting can not do the operations of administrative people.

In the centre, there is a Web server, which is serving Web documents. With the help of CGI, Web server reaches the user database and can manage, search and analyse on it.

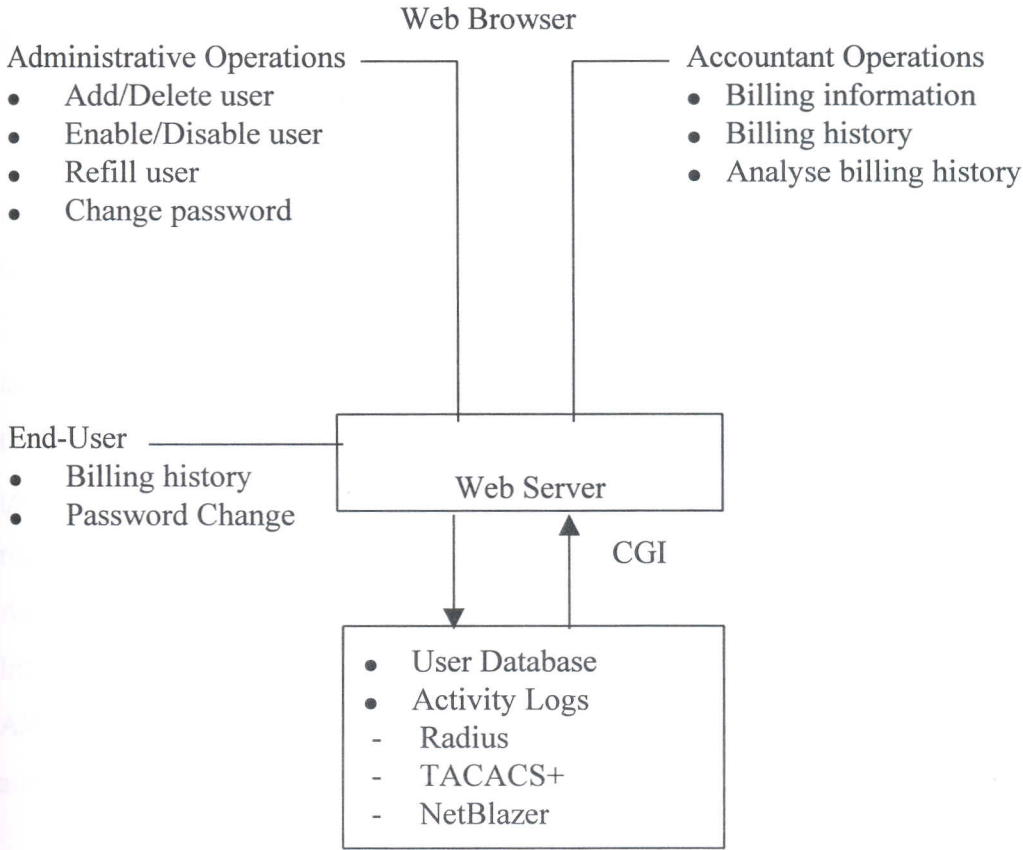


Figure 1.1 General overview of proposed web based user accounting system.

CHAPTER 2

DEFINITION OF BASIC CONCEPTS AND TERMS

2.1 Internet

The Internet can be defined as *network of networks*. It contains many different networks, but they interchange data with each other by standard protocols (TCP/IP). It is independent from hardware and operating system.

History of Internet backs to late 1960s as a US Defence Department project. The aim was to construct a network structure that would be running after a military attack. In theory it was possible to construct such a network structure by *dynamic* routing of data (*package*) between nodes. If a node fails, the path of packages would be dynamically re-routed and the traffic flow would not be disturbed. To realise that theory the Defence Advanced Research Projects Agency (DARPA) had started a program called DARPA Internet Program with 4 computers and in December,1969 Internet (formerly called ARPANET) went on air (Tanenbaum 1989 p.35). In 1975 the working model was announced and until 1980's the protocols used today (like TCP and IP) were developed.

Initially TCP/IP was used to connect ARPANET, the Packet Radio Net (PRNET), and the Packet Satellite Net (SATNET). Most user computers and large mainframes with terminals attached through terminal access servers. As ARPANET grew, the Department of Defense decided to split it into two networks. The another network was named MILNET and was set up for military purposes. ARPANET continued to be used for its original purpose: A network to support research and develop applications. By the mid-1980s, the "ARPA Internet" was called "the Internet".

Perhaps one of the most significant development in TCP/IP was DARPA's decision to implement TCP/IP around the UNIX operating system. Of equal importance, the University of California at Berkeley was selected to distribute the TCP/IP code. Some implementors have said that releasing such complex and functionally rich code was a

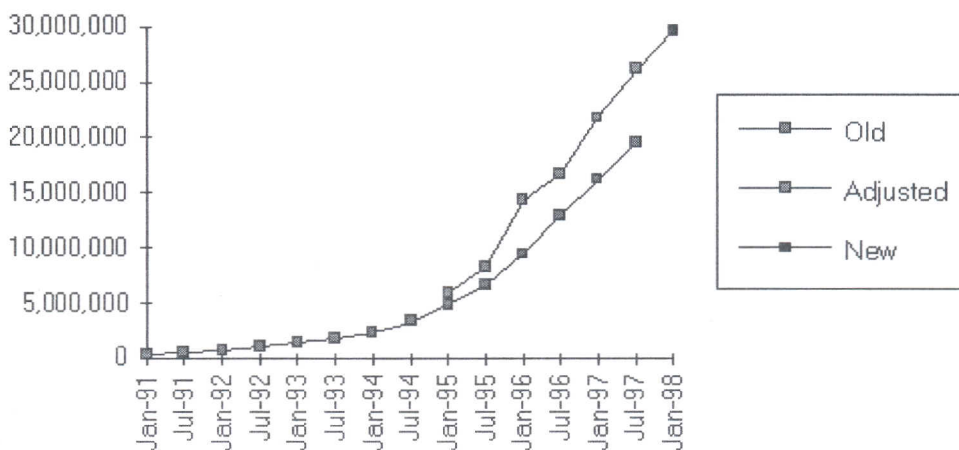


“license to steal”. Whatever one’s view on the matter is, it was a very significant and positive move in the industry. Because the TCP/IP code was nonproprietary, it spread rapidly among universities, private companies, and research centers. Indeed, TCP/IP has become the standard suite of data communications protocol for UNIX-based computers.

During this period, other networks were coming into existence using TCP/IP based on funding from the U.S. government and other research agencies. The NFSnet was established as a high-capacity network by the National Science Foundation. NFS has played a key role both in the development of Internet and in funding the strategic guidance as well. It provided a communications backbone principally for scientific and research centers, initially in the United States, and then in other parts of the world. Its high-capacity lines were designed to support supercomputer transmissions. The supercomputer centers serve as backbones to which lower-speed networks are attached.(Black, 1995 p.3)

At the beginning, the new network consisted of only military and educational institutions. But the real expansion of the Internet has occurred when commercial institutions joined the Internet in the beginning of 80’s. (Table 2.1 and Figure 2.1)

Internet Domain Survey Host Count



Source: Network Wizards, www.nw.com

Figure 2.1 Exponential growth of hosts connected to Internet.

Table 2.1 Internet Growth

<http://www.nw.com/zone/host-count-history>

Date Hosts Source

08/81 213 host table
05/82 235
08/83 562
10/84 1,024
10/85 1,961
02/86 2,308
11/86 5,089
12/87 28,174 old domain survey
07/88 33,000
10/88 56,000
01/89 80,000
07/89 130,000
10/89 159,000
10/90 313,000
01/91 376,000
07/91 535,000
10/91 617,000
01/92 727,000
04/92 890,000
07/92 992,000
10/92 1,136,000
01/93 1,313,000
04/93 1,486,000
07/93 1,776,000
10/93 2,056,000
01/94 2,217,000
07/94 3,212,000
10/94 3,864,000
01/95 4,852,000
07/95 6,642,000
01/96 9,472,000
07/96 12,881,000
01/97 16,146,000
07/97 19,540,000
01/98 29,670,000 new domain survey

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There are many answers to the question of why Internet has expanded so quickly despite its distributed structure, in-dependence of hardware and operating system and its services.

Today Internet includes many governmental, military, educational, commercial, and research institutions and many individuals in a well defined hierarchy. At the centre of this hierarchy lie providers. The Internet's various providers (like MCI, SPRINT, UUNET etc.) connect their networks to form the worldwide backbone for the Internet. Individual provider networks may be limited to small geographic regions or they may span entire continents.

2.2 Internet Address Formatting

Transferring a data over the Internet requires the identification of the remote site, where data will reach. Every host connected to Internet has a unique Internet address and routing is done according to that address. Today this identification is done by 32 bit address formatting (called Ipv4). In theory by using 32 bit addressing, you may have 2^{32} (4.294.967.296) addresses. This number seems to be very big, but in early 1990s, TCP/IP engineers saw an approaching crisis, that of available number of Internet addresses being exhausting, and some time between 2005 and 2011 available number of addresses will have run out. (Thomas 1996 p.2)

2.3 Internet Services

One of the most important reason of the Internet growth is its extensive, powerful services. There are many services used on the Internet, like

- SMTP - Send Mail Transfer Protocol
- FTP - File Transfer Protocol
- WWW - World Wide Web
- NNTP - Network News Transfer Protocol

SMTP service is used to exchange electronic mail on the Internet. Anyone connected to Internet can use this service (of course with proper software) to communicate with other Internet users, even by the help of mail-gateways, they can send and receive electronic mail from other networks (BITNET, UUNET etc.)

FTP (File Transfer Protocol) is used to transfer files over the Internet. This service, like most of the others, works on client-server architecture. By the help of this service, Internet users may reach huge file archives, which usually include shareware and freeware softwares.

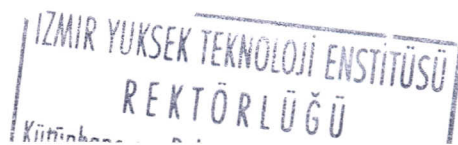
WWW (World Wide Web) is the most famous and powerful Internet service. By the help of WWW browsers, Internet users can surf over the Internet easily. WWW can include multimedia items (like text, image, sound, video etc.). People using WWW browsers can jump from one topic to another just by clicking one item. By that way, they can travel over the Internet easily.

NNTP (Network News Transfer Protocol) is a service for discussion groups. By the help of discussion groups, many people can discuss without seeing each other. Since these discussions are stored and archived, these databases can be searched and used even after many years.

2.4 Internet In Turkey

Beside its benefits and high distribution rate, until 1993, Internet was not used widely in Turkey. Till that year, another network, BITNET (mostly in academic institutions) was used. In 1993, after the cooperative works of Middle East Technical University (METU) and TUBİTAK a direct 64 Kbps Internet connection was constructed between METU and US. Another 64 Kbps direct link between Ege University and Germany has followed this first Internet connection in the next year. For a long time these two academic Internet connections were used all over Turkey.

In 1996, Turkish Telecom Company constituted a backbone, especially for commercial companies and Internet Service Providers. This backbone is now known as TURNET (<http://www.turnet.net.tr>). There are three main sites of TURNET; Ankara, İstanbul and İzmir. All these sites are connected with 2 Mbits data lines and they behave as frames for this backbone. At the beginning there were two international Internet



links, one from Ankara (512 Kbit) and one from İstanbul (512 Kbit). Although Turnet has announced that this capacity would be increased when current needs exceed 70% of the capacity, it is not sustained and for a long time. For this reason many Internet Service Providers (like Turk.Net, SuperOnline, EscortNet etc.) have decided to construct their own direct Internet connections, usually satellite connections. Today there are many ISPs who have their own Internet backbone.

In 1996, a new governmental institution called ULAKBİM was constituted. The aim of ULAKBİM was to construct a rigid Internet backbone among Turkish universities and connect that backbone to the main Internet backbone. In a short time, ULAKBİM reached most of its aims. In one year, 80 universities were connected to ULAKNET (name of the network of ULAKBİM). There are three international links of ULAKNET, two of them to the UUNET, and one to the EBONE. (<http://www.ulak.net.tr/ulaknet/index.html>)

Beside its short, 5-year history, the Internet in Turkey has spread widely. Today there are many institutions that use the Internet somehow. (A comprehensive list of Turkish Internet constitutions can be found at <http://www.metu.edu.tr/Turkey/inet-turkey.html>)

2.5 Internet Service Provider

Most people are connected to the Internet by Internet Service Providers (ISPs), which are the companies that connect individuals or institutions to the Internet. They may give various services to its customers like:

- Dial-up access
- Dedicated Internet access
- Web hosting

They are connected to the Internet backbone via dedicated lines, and their customers connect to ISPs via telephone, ISDN or dedicated lines.

Usually most of the users are connected to the Internet by telephone lines, using their modem and PCs. In this case the speed and vendor of the modem used by customer are of primary importance in the quality of connection. ISPs give either PPP or SLIP access services to customers. Since the PPP is the better one, it's preferred. Most ISPs give

- E-mail
- News
- Web

services to its customers. Additional services are pluses for ISPs.

There are many criteria that increase the competitiveness of a particular ISP over the other ISPs:

- Additional services supplied (like personal web page hosting)
- Modem number / User number ratio (usually 1/10 or lower is preferred)
- Connection speed (eg. how fast surfing on the web?)
- Existence of proxy server (increases the *surf speed* considerably!)
- Technical support (eg. how fast the problem of the user solved?)

For those reasons, to some extent all ISPs must take these facts into consideration to survive.

Usually there are mainly 3 items found in all ISPs:

- Router (to connect to Internet backbone)
- Terminal server and modem pool (for dial-up users)
- Internet server(s) (for authentication, billing, e-mail, WWW etc.)

If an ISP gives dedicated Internet access, it may need extra routers or access servers.

2.6 User Accounting

User accounting is the keeping track of the user activities. This may include which command(s) a user has executed (which is not explained in this thesis), when he/she has logged in/out to/from the computer system, which resources have been used etc. Although this kind of accounting can be used for billing purposes, it can be used for future planning purposes too.

User accounting process is usually done by analysing available logs. In this project, activities of dial-up users are analysed by using many log files, including TACACS+, Radius, Telebit NetBlazer Syslog.

Accounting plays a very important role in the billing process. To bill someone, you must know how much resource (connection time, data transferred etc.) he consumed. In addition, when some one exceeds the limits (eg. Payed connection time), you may want to prevent this user accessing the resource (getting connected to the Internet). Although this can be done manually, it is very difficult to do so in bigger ISPs with users over 5.000! For this reason, a good accounting system must do such things automatically. For future planning purposes, it is necessary to get statistics of activities too.

2.7 Authentication

Internet Service Providers usually use different authentication methods according to their access servers. In this thesis, 3 main authentication methods are examined:

- Radius
- TACACS+
- Telebit NetBlazer routers

2.7.1 Radius

Radius is one of the most important authentication systems used in the world. In addition to its secure authentication properties, its extensive accounting properties made it widely used. Beside its native password file structure, in big ISPs, native UNIX password files are usually used. In this case, the user passwords are held in UNIX servers in UNIX password file format. When a user tries to log in, the access server communicates with the UNIX host, in which Radius server daemon is running, and checks compares the user-supplied password with the password in UNIX host. If everything goes well, user logs in and connects to the Internet.

Native UNIX password file is (usually) located in /etc/passwd. The file format is as follows:

Userid:password:ID:GID:User Name:Login Dir:User Shell

Where:

Userid : At most 8-character long userid
Password : 13 character long encrypted password (locked if it contains a "*")
ID : ID number of the user
GID : Group ID number
User Name : User's real name
Login Dir : User's login directory.
User Shell : User's UNIX shell

For example a real password file might contain a record like the following:

balci:g1wgW74QoyH0k:1000:100:Murat Balci,,,:/home/balci:/bin/tcsh

(If shadow password used, it is located at /etc/shadow. In the shadow password system, both /etc/passwd and /etc/shadow are present, but in the /etc/passwd file, the password field contains a "x" or "**")

2.7.2 TACACS+

TACACS+ is usually used among CISCO based access or terminal servers for authentication purposes. In many ways, it is similar to Radius. TACACS+ may use a UNIX or Windows NT server, for authentication purposes. Although it may use a special password file format (which is very similar to UNIX password file) predominantly, native UNIX password file (or shadow password file) is used for simplicity. (Format of UNIX password file is given in section 2.7.1)

2.7.3 Telebit NetBlazer Routers

NetBlazer routers are both a router and a terminal server (if optional hardware installed). For that reason, some ISPs use those routers as a terminal server. NetBlazer family terminal servers use a few kinds of authentication mechanisms. The most common one is to use UNIX native password file. But in some cases, some ISPs may want to use a separate password file for dial-up access. For example, an ISP may not want to allow some UNIX users (usually e-mail users) to connect as a dial-up user. Or, an ISP may want that the dial-up and e-mail passwords must be different than each other due to security reasons. In these cases, an alternative method, and an alternative password file might be used. The NetBlazer password file format is as follows:

Userid:password:ID:GID:Special Flag:Empty>User Cmd

Where:

Userid : At most 8-character long userid

Password : 13 character long encrypted password (locked if it contains a '*')

ID : ID number of the user

GID : Group ID number

Special Flag : A special field for NetBlazer. For example *multi* flag prevents multiple logins.

Empty : This field is empty. (Compatibility reasons with UNIX password file)

User Cmd : User's login command. This command is executed, if user-supplied password is correct, in NetBlazer router. If a command that's not available in NtBlazer executed, then user will be logged out. This is usually used to disable a user.

An example NetBlazer password file record is as follows:

```
cosar:aebVgfpOz0kBo:2:,,multi ::activate ppp;logout
```

This password file is located in a UNIX host, and whenever NetBlazer requires an authentication, the passwords are obtained from UNIX host by TFTP (a special kind of FTP protocol). The location of that file may change from one system to another. This is configured in both UNIX and the Router side.

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CHAPTER 3

ISP PACKAGES USED IN THE MARKET

3.1 Livingston Radius ABM

One of the best users accounting system of ISP's is RADIUS ABM, which is developed by Livingston, which is the inventor of Radius authentication system. RADIUS ABM is a family of authentication and billing management software solutions that helps Internet service providers in their authentication, billing and analysis processes.

RADIUS ABM can handle many businesses and technical management functions of remote access networks and includes the following capabilities:

- Universal Service Provisioning of all network-based services from a single application interface
- Advanced RADIUS security and accounting
- Integrated Billing of customers including flexible configuration of pricing, taxes, currencies, and automated invoicing.
- Trend Builder statistical network and service analysis tools
- Centralised Filter Administration to ease the management of security and access control filters.

Open Interface Environment

RADIUS ABM provides a full set of features along with an extensive set of customization capabilities through documented APIs, RMI, standard SQL/ODBC/JDBC interfaces, Java class file extensions, and an extensible database schema. This combination allows service providers to capitalise on off-the-shelf functionality and

premium support, while retaining control over the technology and the ability to customise RADIUS ABM to their own environment. The Open Interface Environment allows remote access operators to implement a cost-effective software investment strategy that eliminates the need to build systems from the ground up, maximises in-house programming personnel, and speeds deployment of new functionality.

There are many platform that Radius ABM support, such as Sun Solaris, Windows NT, and UNIX operating systems supporting the Java Run Time Environment version 1.1; Oracle, Microsoft SQL Server, Microsoft Access database support.

3.2 Advanced Database Designs' ISP Accounting

(<http://www.addesigns.com/ispacctg.html>)

ISP Accounting, written specifically for Internet Service Providers, is the most robust accounts receivable system available on the Internet today. Designed with flexibility and individual customization in mind, ISP Accounting provides the ability to track an unlimited number of customer accounts, as well as standard accounts plans, discount and promotional plans and complete management reports. The application is also multi-user ready.

ISP Accounting keeps track of detailed customer information, such as customer name and address, account name, account type, credit card information, billing information, usage, storage, miscellaneous charges, credits and payments, and notes. This information can be retrieved using account name, account number, last name, or credit card number.

Currently, such major Internet Service Providers as the Well and Hooked use ISP Accounting for its detailed reporting and account tracking capabilities in order to manage their many customer accounts.

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Customer Features:

- Track your customer's personal information, credit information and account information
- Search for accounts by: account name, account number, last name, or credit card number
- Tracks complete billing history and usage history for each customer
- Daily updating of new customer information
- Daily updating of changes to existing customer information
- Updating of daily customer usage information
- Monthly updating of entire customer account information

Administration and Management Features:

- Secured database requiring employees to sign in using a user ID and password
- Create mailing lists and mailing labels using customer account information
- Create unlimited billing plans to tailor to your customer's needs
- Track accounts sold by salesperson to review performance
- Management reports to show current growth and trends

3.3 ISP Power

(<http://www.isppower.com/Products/overview.html>)

Introduction

ISP Power is a Microsoft Windows based application designed to integrate with both Windows NT and UNIX servers to automate and streamline the operations of Internet Service Providers. Much more than just a billing system, ISP Power is aimed at helping you gain control over your business. ISP Power lets you make better use of your resources and thus gives you time to focus on growth.

The main ISP Power programs are 32-bit Windows programs and run on Windows 95 or Windows NT. Depending on your needs, and which database and ISP Power add-ons you use, some UNIX and/or Web programs may also comprise the system. The programs maintain a relational database containing your system usage, accounts receivable and customer service information.

ISP Power is implemented in Microsoft Visual Basic using a highly scalable transaction-based client-server programming model and is designed to meet the needs of the smallest to the largest service provider. Although currently implemented using the Microsoft JET engine for database access, the system is highly portable and can be ported to other database platforms such as Microsoft SQL Server, Oracle, or Sybase. Please inquire if you are interested in using the system with a database platform other than Microsoft Access

Features

- Track response from advertising
- Track performance of salespeople
- Configurable customer account classes and services
- Define one time charges, periodic fixed charges and periodic usage-based charges
- Track time on-line, disk space used, and Web traffic
- Automatic calculation of customer charges
- Automatic generation of billing statements via e-mail or postal mail
- Automatic collection via credit card
- Automatic collection via checking account withdrawal
- Web interface for customer account inquiry
- Customer contact management
- Customer problem tracking
- Easy-to-use Windows interface

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Usage Log Transfer/Import

ISP Power automatically collects login, disk, and web usage log files from your servers on a nightly basis. The log files are parsed and the information is imported into the ISP Power database for further processing.

Customer Service

ISP Power is designed to be a full customer service system instead of just a simple billing system. Not only does ISP Power log all charges, payments, and account and service changes, but it also allows you to record all phone call, e-mail, and postal mail contact with your customers. Using the customer history screen in ISP Power, you can easily review your complete relationship with your customers and ensure that their needs are being met.

Web Interface

ISP Power can give you the "extra edge" over your competitors by giving your customers the ability to query their account status via the Web. The Web interface add-on not only gives your customers the feeling that you are providing a professional service but it also reduces your customer service needs by automating some of your customer inquiries.

The Web Interface Add-On will require Microsoft's Internet Information Server (IIS) and Active Server Pages (ASP) running on an NT 4.0 machine.

3.4 User Registration, Information, and Billing System (URIBS)

- User Registration

- Web form for support staff to enter new user account information into.
- Usernames are checked to make sure they do not conflict with current users.
- Passwords are checked to make sure they are not easily crackable.

- Allows for different account terms (monthly rate, number of free hours per month or day, price per hour after limit has been reached)
- Allows for e-mail only (shell), dial-up only (RADIUS), and combined accounts.
- Creates PPP and SLIP dial-up accounts, and allows for any RADIUS attributes to be used.
- Creates UNIX shell accounts, including arbitrary home directory setup files.
- Creates a database file for the user's information.
- Optionally adds the user to a majordomo mailing list for system announcements.
- Checks entered credit card numbers to make sure they are plausible.
- Handles more UNIX shell types (including support for WU-FTPD style home directories for enhanced security of FTP accounts).
- Allows per-user customization of RADIUS attributes. Also does more checking of RADIUS entry formats.
- Allows customised Dial-Up Packages information to be stored for better client tracking.
- Expiration dates can be set for arbitrary time periods (i.e. 10 days, 1 month, 6 months, 3 years, etc.)
- Supports Post.Office mail server. Will automatically add users to Post.Office database.
- Supports Microsoft Internet Explorer Administration Kit. This allows you to send out disks to millions of people just like AOL!

User Information for Users

Web forms, which allow users to:

- Change their shell/email and RADIUS passwords using a forms-capable browser (rather than in the UNIX shell).
- Check their daily, month-to-date, or previous month login time.
- Check their daily, month-to-date, or previous month detailed login/logout records.
- See who else is currently logged on (with client pull so you can leave it on and watch termserver activity).

User Information and Modification for Staff

Web forms, which allow your staff to:

- List the account times for all the users on the system along with the user's RADIUS username, e-mail address, and real name. Each entry is a link to that person's modification form.
- Review detailed login/logout times for a user.
- Modify user accounts
 - All user information can be modified, including account terms.
 - Expiration date may be changed or incremented by arbitrary amounts.
 - Payments and Charges may be added. Sales tax will be calculated and added if desired.

Automatic Billing and Accounting

- Every night the monthly usage for each user is updated and stored.
 - Optional: Any user who is within 5 hours of their monthly limit is sent email telling them this (once per month).
- At the end of the billing period:
 - The usage logs are archived.
 - Bills are generated and e-mailed.
 - Billing information is stored in the user database.

CHAPTER 4

TOOLS USED

4.1 WWW

World Wide Web (shortly “Web”) is a collection of information stored in computers all over the world that are connected to the Internet. Each piece of information on the Web is known as *resource* and can be associated with other resources via hyperlinks. By that way you can move from one topic to another quickly. Any kind of information can be a resource, such as text, graphics, audio, video etc. Information published on the Web is presented to the end user in a graphical and textual format, making the information not only accessible but also interesting to review. Not only can the Web present text and graphics, it can also let a user view video and audio clips as well as query databases, run programs, send mail, and many more. In short, the Web offers information architecture for presenting, viewing, and retrieving information. In just a few short years the Web has been in active use, it has really changed the face of digital publishing, which is using the Internet as a distribution media (Johnson, 1996 p.15).

The Web is the largest, most comprehensive and the most widely used electronic information system in the world and it is very popular. It is very easy to use. You can move from one topic to a new topic just by clicking a mouse button, or by pressing a key. There is no an authority that decides what will or will not be on the Web. Anyone having some information can put this information to the Web. You only need a Web server. By putting your information to the Web you allow other people to reach your information from anywhere in the world (Deep and Holfelder, 1996 p.2).

The history of the Web dates to the 1990’s. Tim Berners-Lee from the European Center for Nuclear Physics Research (CERN) developed the World Wide Web hypertext system. His goal was to improve the flow of information among the members

of the high-energy physics research community. At that time, a large amount of information was available in electronic form but there were some problems in using it fully. Information was distributed among many individual machines, without sufficient means to tie related materials together. Furthermore, each type of resources was associated with a different protocol and could be retrieved only by a program that “spoke” that protocol. If you wanted to download a file, you had to learn a file transfer program.

The World Wide Web uses the following components to solve these problems:

- The URL (Universal Resource Language), naming system that compactly describes the location of every resource on the Internet and protocol used to retrieve it.
- HTML (HyperText Markup Language), a language for “making” hypertext links and other important features of a document.
- HTTP (HyperText Transfer Protocol), a protocol for transferring hypertext documents and other resources
- Web clients or Web browsers, programs that combine a variety of information retrieval abilities under one interface, making it easier to retrieve and use resources
- Web servers, programs that send resources to Web clients when requested.

(Deep and Holfelder, 1996 p.2)

Due to its ease-of-use, WWW expanded very rapidly. In classical systems (like FTP) users usually supply some set of information, and all the things go in a text-based media. But in WWW, you are not required to supply much input. You just give an address, and then start surfing. Different kinds of information (text, image, sound, video etc.) are embedded in a Web page. You just click on the browser and travel from one topic to another. Hypertext allows readers to navigate the Web in a point and click fashion easily without having to know much of the Internet. The hypertext format that documents on the World Wide Web use HTML or HyperText Markup Language. In order for information to be accessible on the Web it first must be converted to HTML. Once the information is in HTML format, it can be accessed by anyone on the Internet

using a Web browser like Mosaic, Netscape, MS Internet Explorer. Web browsers are the tools that give people the ability to interact with a Web site by supporting the graphical and hypertext formats of the Web. (Johnson, 1996 p.577)

At the beginning, there were only text-based browsers, like *lynx* in UNIX systems. But later on, graphical Web browsers, like Mosaic, Cello, Netscape, Internet Explorer, have evolved and surfing on the Web became much more easier. In this project, the Web is used to make the data easily accessible.

4.2 WEB BROWSERS

In 1992, CERN released much of its technology into the public domain. This caused development of Web servers and browsers at other organisations. A team led by Marc Andreessen at National Center for Supercomputing Applications (NCSA) at the University of Illinois-Urbana/Champaign took advantage of this technology to create Mosaic, the first graphical Web browser, which was released in 1993. Mosaic has thousands of users and has spawned. Later on the inventor of Mosaic Marc Andreessen and other members of the original NCSA Mosaic development group has created the one of the most widely used Web browser, Netscape's Navigator. Today millions of people use graphical browsers, which have changed the face (and the size) of the Web.

Graphical Web browsers make it easier than ever before to retrieve Internet resources. You can activate a hyperlink, download a file, or read Usenet news article with a single mouse click.

Another key feature of Mosaic, Netscape and other graphical browsers is that they are designed to work in partnership with *helper applications*. Any type of information can be a Web resource: sound, graphics, animation, video and text. It would be difficult to write a browser that could handle all of these resources by itself. Most of the browsers can only handle text in HTML and plain text ASCII formats, and graphics in GIF and JPEG formats. Helper applications are separate programs that handle data that are not understood by browsers. (Deep and Holfelder, 1996 p.3)

Today there are many Web browsers running in different architecture and operating system including Windows 95/98, Windows NT, Windows 3.x, DOS, OS/2, MacOS,

UNIX, Amiga. Although there are many Web browsers used today in the market, only two of them (Microsoft's Internet Explorer and Netscape's Navigator) are dominant. In this project, all the browsers that are supporting SSL are supported as end-user client program. This made the system very cost effective and easy-to-use.

4.3 WEB SERVERS

The Web server program is the software that sits between a physical Web page and the Web browsers that are used to view that page. A Web server responds to requests through the Internet for Web pages to view and sends out copies of the Web page as requested. There are two basic approaches to Web servers: the conventional or static Web page server and dynamic content server.

A conventional Web server or static Web page server is the type of Web server that much of the WWW is based on. This type of server sends out the Web pages stored in ASCII files on the server's hard disc. With this type of server, Web pages are prebuilt and stored as physical files. The problem with that type of server is that, it is poorly suited to applications composed of thousands of pages. This limitation is primarily due to overhead and problems with managing thousands of files on a hard disc. The second approach to Web servers is the dynamic content server. Under this approach, content is stored in a central database of some sort and HTML pages are generated dynamically when requested. This type of approach typically works with a conventional Web server to pass the HTML pages on to the Web browser. For a good example of this, consider putting the Oxford Dictionary & Thesaurus onto the Web. With dictionary type content, the typical approach is to make each term a single Web page. But, with over 190.000 words in the Oxford dictionary, this is an incredible quantity of individual Web pages to manage. Additionally, the disk space overhead for this large number of files is huge and will have severe performance overhead. The solution is a dynamic content database whereby when the user looks up an individual word, an HTML page is generated on the fly and sent to the user's browser through a conventional Web server. (Johnson, 1996 p.55)

Web servers are expected to be reliable since they are serving important information 24 hours a day, and 365 days a year and your server is accessible at any hours, day or night from all over the world. For this reason when you want to build a Web server, you must have a physical “Web server” which is fast, easy to maintain, and reliable (the machine does not crash). According to these criteria, there are many options available. In the order of decreasing desirability these are:

- UNIX, VMS, Windows NT
- OS/2 or Novell servers
- Windows 3.1, Windows 95, MacOS

For commercial applications, you will also consider the data encryption. In general, data processing over the Internet can be intercepted easily and read, which is not pleasant since you may transmit confidential documents or financial information such as credit card numbers. If you want to request such information from your visitors, you should run a Web server allowing secure transmission of data over the Internet. Currently there are many Web server software, such as Netscape Commerce Server or Apache (with additional patches), allows data encryption using Secure Socket Layer (SSL) encryption technology. Encryption only works if the browser supports the technology.

Web server is the program running in a server machine, and serving the WWW html files to browsers. There are many Web servers present in different operating systems. The most famous ones are NCSA, Apache, Netscape and Microsoft Web servers.

In this project Apache is used which is freely available, as a Web server, but there should not be any problems, in using NCSA Web server.

4.3.1 UNIX Web Servers

The consensus among the WWW administrators is that a UNIX machine, combined with a commercial or well-supported non-commercial server (for example Apache, CERN, or NCSA servers) is an ideal package for distributing hypertext materials. There

are several reasons for this choice. First, the UNIX operating system is designed to run many simultaneous processes (multitasking), so that a well-designed UNIX server can almost effortlessly respond to many simultaneous HTTP service requests. Also, UNIX is designed to isolate the server and user processes from the management level of the operating system, which ensures reliable operation even under heavy loads. Lastly, many of the original server packages (Netscape Netsite, CERN, NCSA, Apache and others) were originally written for UNIX machines.

The non-commercial packages are freely available, with precompiled executable versions often available for UNIX computers from Sun, Hewlett-Packard, Silicon Graphics and others. Also, the source code is usually publicly available, so you can download and compile it your self according to your needs.

If you use UNIX server, but use machines such as Macintoshes or PCs for your document development, you can make the server filesystems accessible to these machines by remote-mounting the HTTP server directories on the PCs or Macintoshes. For example, PC-NFS allows PCs to mount UNIX filesystems, while CAP (Columbia AppleTalk Protocol) allows similar access for a Macintosh. Setting up a development environment such as this requires some extra care, originating from systems (for example DOS based PCs allows only eight-character filenames and three-character filename extensions), but this networked approach is useful integrating a WWW development environment into a heterogenous collection of computers.

Setting up a UNIX server is not expensive. Although buying a machine from a vendor such as Sun or HP is one option, you can also purchase a standard PC clone and install the freeware UNIX clone Linux or BSD386. The NCSA and Apache servers have been successfully ported to Linux, so that you can set up a Linux-based HTTP server for little more than the cost of a PC. For this reason, Linux has become one of the most widely used operating system in Web server hosting, especially in educational institutions and Internet service providers (ISP). Today there are many ISP that use Linux as a Web server in Turkey. Beside its low costs, the flexibility and high performance/cost ratios are the main reasons of this popularity. Also if you have a powerful computer, like a server having an Alpha CPU, it is a good idea to install Linux on it and host many virtual Web server without any suffering.

The downside of UNIX approach is complexity. UNIX is a sophisticated operating system and can be difficult to learn and manage.

4.3.2 Windows NT or OS/2 Web Servers

Windows NT and OS/2 are the next-best choice for hosting an HTTP server (Graham 1996 p.562). Both Microsoft's Windows NT and IBM's OS/2 efficiently run simultaneous processes and also carefully separate user processes (such as an HTTP server) from the management level of the operating system. These systems are also generally easier to configure than a UNIX system, in particular for those coming from a PC background. It is certainly true that both OS/2 and Windows NT are easily integrated into PC networks, since this was a major goal of their system designs. In addition, several Windows NT-based servers now supports data encryption technologies, making these platforms favourite for commercial server activities.

4.3.3 Windows or Macintosh Web Servers

There are number of packages available for PCs running Windows 3.x or Windows 95, and for Macintoshes. Several of these are quite full-featured. The Windows or Macintosh option is at the bottom of the list because of the limitations of the operating systems. DOS, Windows 3.x (and to some degree Windows 95) and the Macintosh System 7 operating systems are not designed for multitasking, nor they are designed to safely separate the management level of the operating system from user processes. The first limitation means that it is difficult to write an efficient Web server. In general, these servers quickly crash when the number of HTTP requests grows large. The second limitation is the reason PC and Macintosh computers often crash while running spreadsheets or word processing programs which are executed when working on that PCs. At this time, WWW users trying to access that Web server can't reach your server.

If somehow, it is desired to run a Web server on a Windows or Macintosh, it must be a dedicated machine specifically for that task. This means not letting anyone use it to do other tasks, since extra user programs significantly increase the risk of a system crash. In addition, you should regularly test that system is *alive*. (Graham, 1996)

4.4 HTML

HTML (HyperText Markup Language) can be tough as the language of WWW. It contains many *tags* and when you create a Web page, you use this language. Web pages are plain text files, and can be viewed/edited by any text editor. Web browsers are designed to *interpret* HTML files. They read it and display information in a user-friendly graphical medium. HTML codes are set of symbols, which specify the structure of the document. It is not related with the content of the document.

There are many element of this language, such as titles, headings, body text, ordered lists, unordered lists, hyperlinks etc. The elements of an HTML document have a hierarchical structure, like an outline. Each element is marked by a *start tag* at the beginning of the element and by an *end tag* at the end of the element. Start tags are enclosed within the < and > characters; for example <HEAD> is an example tag. End tags are enclosed within the </ and > characters, like </HEAD>. Tags are not case sensitive.

4.5 SECURE SOCKET LAYER (SSL)

The Secure Socket Layer protocol is designed as an encryption layer below the HTTP protocol. Thus, HTTP messages are unaffected, with encryption occurring just prior to converting the messages into TCP/IP packets for transmission over the Internet. To indicate the special nature of this connection Netscape Communications created the new URL scheme *https* (HTTP-Secure). Https URLs are encoded identically to http URLs. The default port for https URLs is 443, not 80. So in a single machine, both secure and nonsecure servers can run.

In principle, SSL can be used for any Internet tools that use the underlying TCP/IP protocol for data communications. For example, Netscape Communications Inc. has released an NNTP news server employing SSL, and intends to implement SSL more widely in the future.

SSL works at several levels. At the encryption level, the protocol employs a sophisticated security handshake protocol: when a client contacts a secure server, they

exchange encryption keys, which are subsequently used to encrypt all data passed between the server and client. Encryption keys are never reused, to ensure that keys cannot be intercepted and used by an unauthorised party. The server also sends the client a cryptographic certificate that tells the client which server it is in contact with, and that is used to validate that the server is indeed who he claims to be. Finally, client and server send ahead of the transmitted data, a message digest calculated from the data; the receiving party uses this message digest to ensure that data content has not been modified in some way by any intervening party.

The Netscape Navigator contains built-in support for SSL, but only for short (40-bit) encryption keys (this is the maximum size allowed for encryption products exported outside of the United States). The Netscape Commerce Server and Apache Web Server (with some patches) supports server encryption (with 128-bit keys) and server cryptographic certificates. To sustain maximum security Apache server with SSL is used to server user accounting data.

4.6 PERL

Perl is a perfect tool in text file processes. Scanning the text, extracting the necessary information is much more easy and powerful in Perl. The functions that Perl has, makes very complex tasks easily which are very difficult in other languages.

Perl's author, Larry Wall, describes Perl this way:

“Perl is an interpreted language optimised for scanning arbitrary text files, extracting information from those text files, and printing reports based on that information. It's also a good language for many system management tasks. The language is intended to be practical (easy to use, efficient, complete) rather than beautiful (tiny, elegant, minimal). It combines (in the author's opinion, anyway) some of the best features of C, sed, awk, and sh, so people familiar with those languages should have little difficulty with it. (Language historians will also note some vestiges of csh, Pascal, and even BASIC-PLUS.) Expression syntax corresponds quite closely to C expression syntax. Unlike

most Unix utilities, Perl does not arbitrarily limit the size of your data--if you've got the memory, Perl can slurp in your whole file as a single string. Recursion is of unlimited depth. And the hash tables used by associative arrays grow as necessary to prevent degraded performance. Perl uses sophisticated pattern matching techniques to scan large amounts of data very quickly. Although optimised for scanning text, Perl can also deal with binary data, and can make dbm files look like associative arrays (where dbm is available). Setuid Perl scripts are safer than C programs through a dataflow tracing mechanism which prevents many stupid security holes. If you have a problem that would ordinarily use sed or awk or sh, but it exceeds their capabilities or must run a little faster, and you don't want to write the silly thing in C, then Perl may be for you. There are also translators to turn your sed and awk scripts into Perl scripts.”

(<http://language.perl.com/info/synopsis.html>)

Perl is now one of the most powerful and popular language among system administrators, CGI programmers and Web administrators due to four reasons:

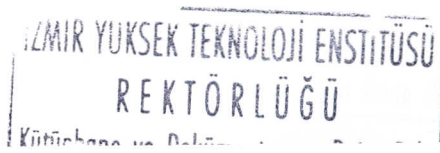
- It combines into one tool some of the best features of Bourne shell scripting, C programming, and UNIX utilities sed, awk, and grep.
- It avoids many of the limitations of the preceding tools.
- It is available for, and works identically on, a wide variety of platforms.
- It is free, though Larry Wall, the author of Perl, holds the copyright.

(Deep and Holfelder 1996 p.81)

Also Perl does a great timesaving job due to its simple syntax. Since it is an interpreter, not compiler, running and debugging time is very short. Since most of the user accounting data in ISP system is in text form, Perl is used to extract necessary data from plain text files.

4.7 UNIX

UNIX is a multi-user and multi-tasking operating system. It was developed in Bell Laboratories at the end of 1969's. Due to its open and robust structure it is widely used all over the world. Since its code is available, it is modified and developed in different



countries and institutions (especially in universities). As a result many *UNIX derivatives* are available now. Some of the UNIX derivatives are:

- SUNOS
- Digital UNIX
- IBM AIX
- HP-UX
- SCO UNIX
- Linux

All of these derivatives are binary incompatible. But, since most of the applications are written in C language, most of the applications can be exported from one UNIX derivative to another.

The history of UNIX goes back to the mid-1960s, when American Telephone and Telegraph, Honeywell, General Electric, and the Massachusetts Institute of Technology started to a project to develop an information utility. The project called Multics (stands for *Multiplexed Information and Computing Service*), was heavily funded by the Department of Defense Advanced Research Projects Agency (then known as ARPA). Most of the research took place in Cambridge, Massachusetts, at MIT. Multics was a modular system built from banks of high-speed processors, memory, and communications equipment. By design, parts of the computer could be shut down for service without affecting other parts of the users. The goal was to provide computer service 24 hours a day, 365 days a year. Multics was also designed with military security in mind. Multics was designed both to be resistant to external attacks and to protect the users on the system from each others. Multics supported the concept of multi-level security: Top secret, secret, confidential and unclassified information could all coexist in the same computer. Multics provided a level of security and service that is still unequalled by most of today's computer systems-including UNIX.

But in 1969, Multics was far behind schedule; its creators had promised far more than they could deliver within the projected timeframe. Already at a disadvantage

because of the distance between its New Jersey laboratories and MIT, AT&T decided to pull out the Multics Project.

That year Ken Thompson, an AT&T researcher who had worked on the Multics project, took an unused PDP-7 computer to work on some of the Multics ideas in his own. Dennis Ritchie, who also worked on the Multics project, later joined to Thompson. Brain suggested the name UNIX for the new system. UNIX was operational several months before Multics. Two years later, Thompson and Ritchie rewrote UNIX for Digital's new PDP-11 computer.

As the two scientists added new features to their system through the 1970s, UNIX evolved into a programmer's dream. The system was based on compact programs, called tools, each of which performed a single function. By putting tools together, programmers could do complicated things.

In 1973, Thompson rewrote UNIX in Ritchie's newly invented C programming language. C was designed to be a simple, portable language. Programs written in C could be moved easily from one kind of computer to another. On the other hand, C programs run nearly as fast as programs coded directly in a computer's native machine language, at least in theory.

UNIX had become a popular operating system in many universities and was already being marketed by several companies. UNIX had become more than just a research curiosity. As early as 1973, there were 25 different computers at Bell Labs running the operating system. UNIX soon spread outside of the telephone company. Thompson and Ritchie presented a paper on operating system at a conference at Purdue University in November, 1973. Two months later, the university of California at Berkeley ordered a copy of the operating system to run on its new PDP-11/45 computer. By 1977, more than 500 sites were running the operating system; 125 of them was universities.

At Berkeley, UNIX took a new term. Like the other schools, Berkeley had paid \$400 for a tape that included the complete source code to the operating system. But instead of merely running UNIX, two of Berkeley's bright graduate students, Bill Joy and Chuck Haley, started making modifications. In 1977, Joy sent out 30 free copies of

the “Berkeley Software Distribution”, a collection of programs and modifications to the UNIX system.

Over the next six years, in an effort funded by DARPA, the so called BSD UNIX grew into an operating system of its own that offered significant improvements over AT&T’s. for example a programmer using BSD UNIX could switch between multiple programs running at the same time. AT&T’s UNIX allowed the names of files to be only 14 letters long, but Berkeley’s allowed names of up to 255 characters. Berkeley also developed software to connect many UNIX computers together using high-speed networks. But perhaps the most important of the Berkeley improvements was the 4.2 UNIX networking software, which made it easy to connect UNIX computers to local area networks. For all of these reasons, the Berkeley version of UNIX become very popular with the research and academic communities.

Today there are millions of computers running UNIX over the world. Versions of UNIX run on nearly every computer in existence, from IBM PCs to Crays. Since it is so easily adapted to new kinds of computers, UNIX is the operating system of choice for many today’s high performance microprocessors. (Garfinkel and Spafford, 1994 p.6)

Internet was developed on UNIX systems and due to historical reasons, UNIX has very powerful Internet applications. There are many Internet servers that can run on a UNIX system, like SMTP, WWW, Gopher, FTP, NNTP, WAIS etc. Beside, the historical reasons, why UNIX is a preferable Internet server is that, it is a secure and powerful operating system. Even if you run many Internet servers, UNIX can easily handle heavy tasks quickly. For this reason, most of the Internet Service Providers prefer UNIX as Internet server. In this project a UNIX clone, Linux is used as operating system that handle all server side accounting operations. However, there should not be any problem in porting the accounting system the other UNIX clones.

4.8 CGI

The Common Gateway Interface (CGI) is a standard to interface the external applications with Web servers. Most of the Web pages are static. That means their content does not changes from time to time. Each time you get a Web page, you get the

same thing. But if you use a CGI program, you run that program in Web server each time, and get information intellectually in real time.

Search engines are very good examples of CGI programming. Each time you enter a different keyword, a CGI program query the database, and gives you the results. All these events occur in real time, and displayed page changes from keyword to keyword.

Since a CGI program is executable, it is basically the equivalent of letting the world run a program on your system, which isn't the safest thing to do. Therefore, there are some security precautions that need to be implemented when it comes to using CGI programs. Probably the one that will affect the typical Web user the most is the fact that CGI programs need to reside in a special directory, so that the Web server knows to execute the program rather than just display it to the browser. This directory is usually under direct control of the Webmaster, prohibiting the average user from creating CGI programs. There are other ways to allow access to CGI scripts, but it is up to your Webmaster to set these up for you. At this point, you may want to contact them about the feasibility of allowing CGI access.

A CGI program can be written in any language that allows it to be executed on the system, such as:

C/C++

Fortran

PERL

TCL

Any Unix shell

Visual Basic

AppleScript

It just depends what you have available on your system. If you use a programming language like C or Fortran, you know that you must compile the program before it will run. (<http://hoohoo.ncsa.uiuc.edu/cgi/intro.html>)

CHAPTER 5

WEB INTEGRATION OF ISP PROCESSES

5.1 General Terms

The aim of this thesis is to construct a Web based user accounting system for Internet Service Providers (ISPs). For this reason all the user and administration processes are managed by regular Web browser, such as Netscape Navigator, Microsoft Internet Explorer etc. Theoretically all browsers supporting Secure Socket Layer (SSL) can use this system to view and manage ISP data. Since recently most of the Web browsers support SSL, practically anyone can use this system, who has an Internet access.

In the system we developed, most of the processes are held in background in a UNIX system. In this project, Linux (a UNIX clone) is used to develop and run the whole system, but it is not difficult to port the whole system to another UNIX clone.

Apache Web server is used as Web server to serve the accounting data and run cgi scripts. Beside Apache Web server, with minimal modifications, NCSA Web server should work (but it is not tested)

PERL was the main programming language in developing the accounting system. In most of the UNIX systems, PERL comes as a part of the Operating System, but if it is not, since PERL is a free tool, any system administrators can get the source code (or binary) from the Internet and install it to his UNIX system.

İZMİR YÜKSEK TEKNOLOJİ ENSTİTÜSÜ
REKTÖRLÜĞÜ
Kütüphane ve Dokümantasyon Daire Bşk

5.2 Basic ISP Operations

The operations in an ISP environment are divided into three parts (Figure 5.1) in this project.

- Administrative operations
- Accountant operations
- End user operations

Users or administrators can jump in anyone of the operations from this page. (Of course if they have enough permission!).

Reaching for this page is under the control of Web Server. System administrator can build access list according to IP address of client browsers. By this way, you can prevent users, who are not in ISP's domain, accessing ISP operations and data. This property is very useful especially to prevent unauthorised attacks coming from Internet.

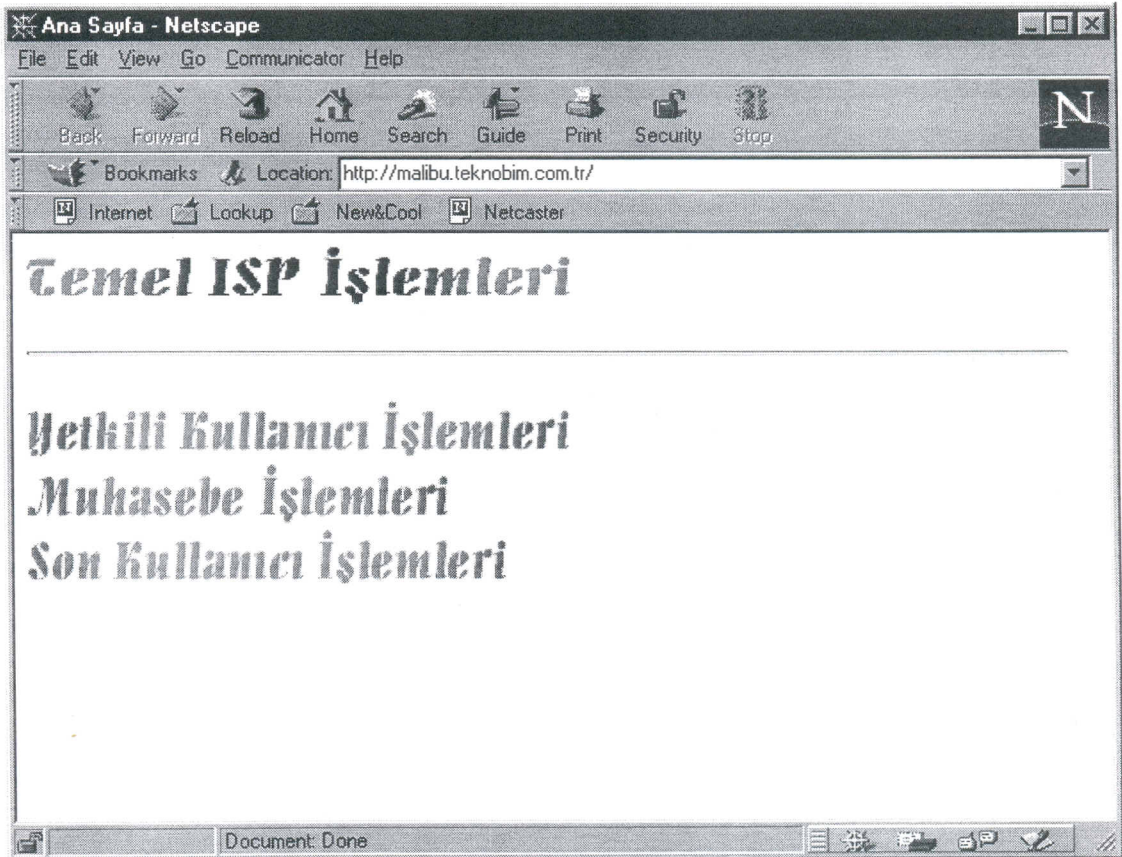


Figure 5.1 Basic ISP Operations page

5.3 SSL Certification

Due to its nature, Internet is an insecure environment. In general, there is no guarantee that your information transfer in Internet is securely transferred. Some people (with proper hardware and software) may intercept your transfers and can "see" what's going on. Surely this is not an acceptable property. Especially when money or private information is concerned, the importance of secure transactions becomes very high. Transferring valuable information (such as credit card numbers, passwords etc.) in Internet insecurely is a potential problem of Internet. To overcome this problem, some secure communication systems are devised. Secure Socket Layer is one of them. In this system, some encryption methods are used. When a client contacts a secure server, they exchange encryption keys, which are subsequently used to encrypt all data passed between the server and client. Encryption keys are never reused, to ensure that keys cannot be intercepted and used by an unauthorised party. The server also sends the client a cryptographic certificate (Figure 5.2) that tells the client which server it is in contact with, and that is used to validate that the server is indeed who it claims to be. Finally, client and server send ahead of the transmitted data, a message digest calculated from the data; the receiving party uses this message digest to ensure that data content has not been modified in some way by any intervening parties.

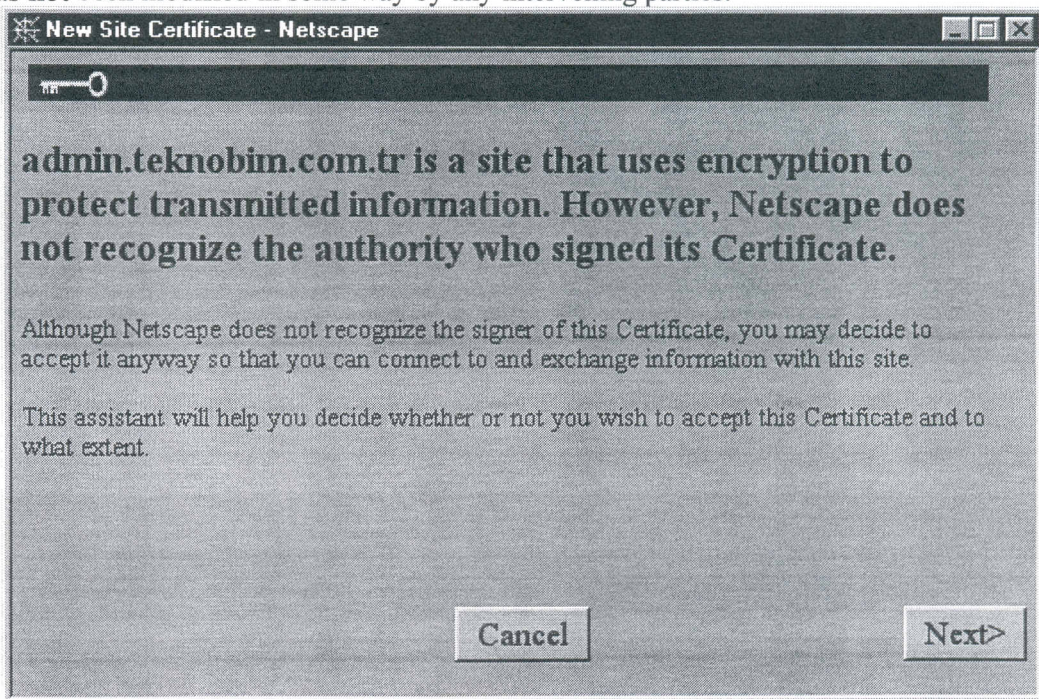


Figure 5.2 SSL Certificate

When for the first time a user wants to connect to ISP's secure Web server and ISP database, browser and Web server interchange encryption keys. This key may change from one browser to another. Due to US export laws, regular Web browsers (like Netscape and MS explorer) supports 40-bit key for encryption. (Figure 5.3) But most of the Web servers (like Apache Web Server) can support 128-bit key for encryption. That means, if a user has a browser supporting 128-bit key, he may make much more secure transactions with the server. Although using 128-bit key is much more secure than using a 40-bit key, it is difficult to decode 40-bit key and intercept the transections (but with today's technology!). Since every time browsers use a different key (Figure 5.4), even 40-bit keys provide acceptable security.

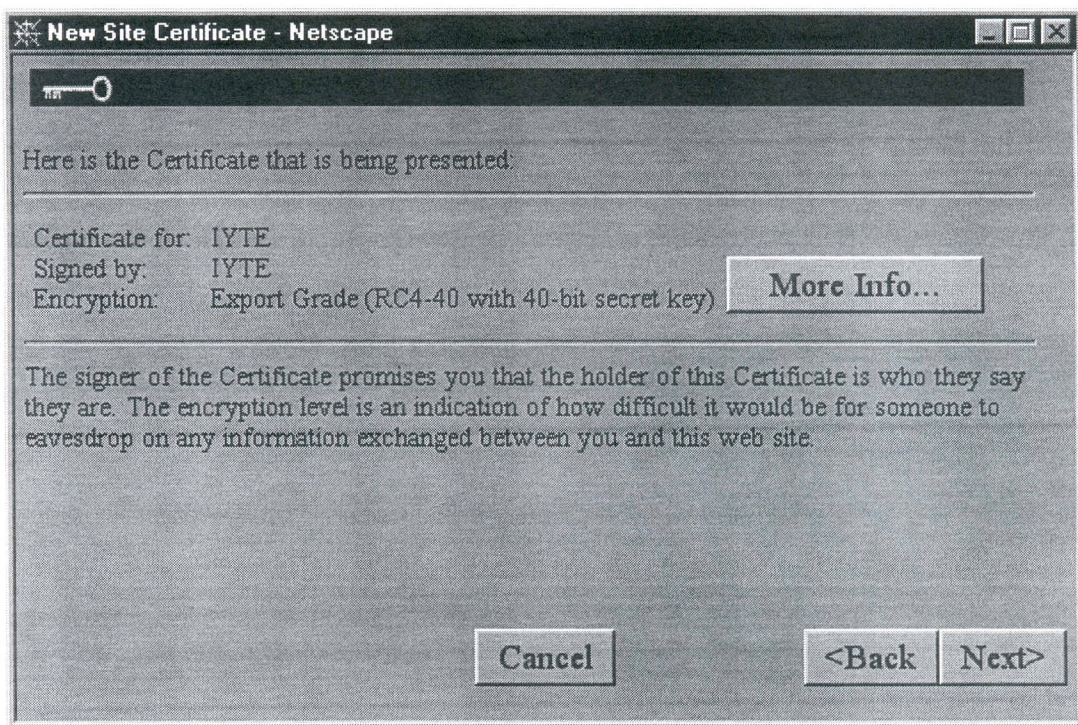


Figure 5.3 SSL certificate (Continued)

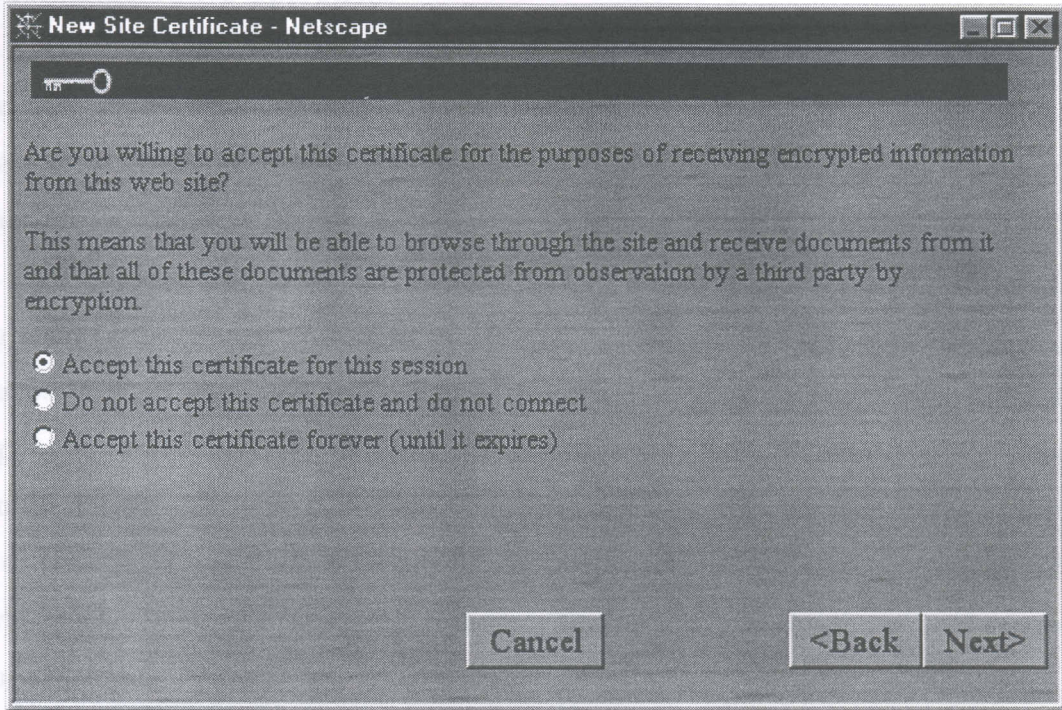


Figure 5.4 Acceptation of SSL certificate

After the completion of certification between browser and Web server, users are ready to use ISP accounting system according to their permission. From now on, all the transaction between user and Web server will be encrypted. (Figure 5.5)

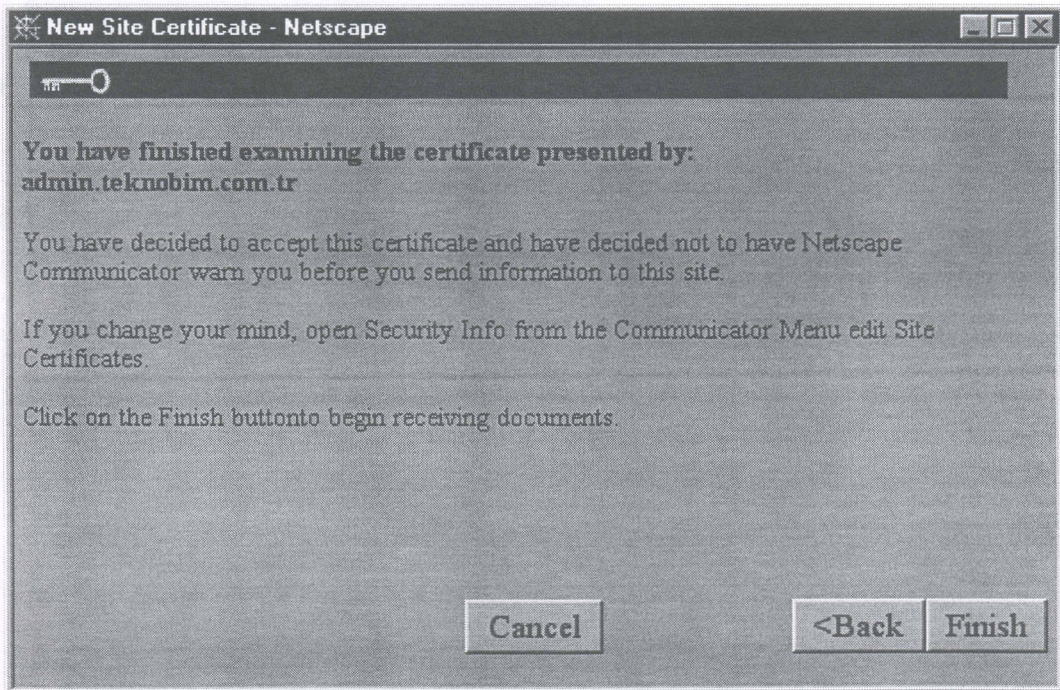


Figure 5.5 Finishing of SSL certificate

5.4 Administrative Operations

There are some routine operations that all ISPs must do, such as adding new users, deleting users, disabling/enabling users, adding extra time for users, changing user passwords (when necessary) and view user information (address, telephone, company, modem, OS use etc.).

All these operations should be done only by a system administrator who has rights to manage the system. When someone tries to manage all these operations, he must supply a valid username and password (Figure 5.6). In Web server site, ISP has the option to limit accessing this administrative page only from definite IP's. For example, an ISP might want to do administrative operations only from his domain (eg. *.ISP.net), or even from a definite local and secure host machine (eg. Admin_terminal.ISP.net) which is known that this terminal is secure. This option increases the general security of the accounting system.

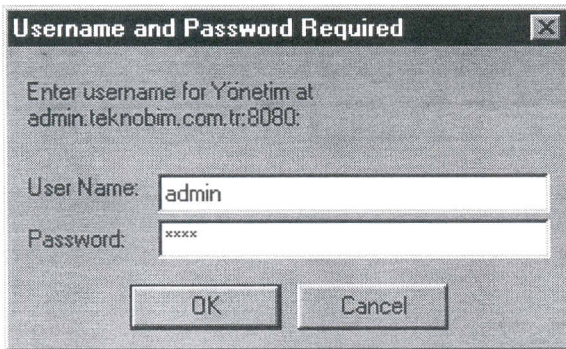


Figure 5.6 Administrative username/password control.

Once username and passwords are checked, system admin is ready to make all administrative operations. (Figure 5.7)

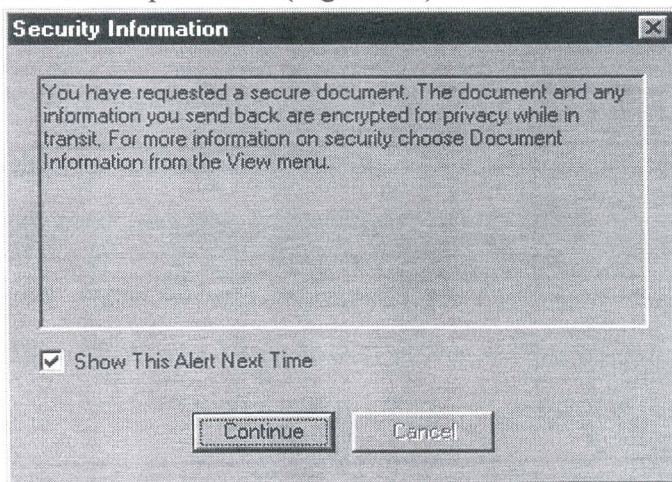


Figure 5.7 Starting of Secure Transactions

In this project, ISP administrative operations is divided into 3 (Figure 5.8) :

- Basic user operations
- User information
- User connection info

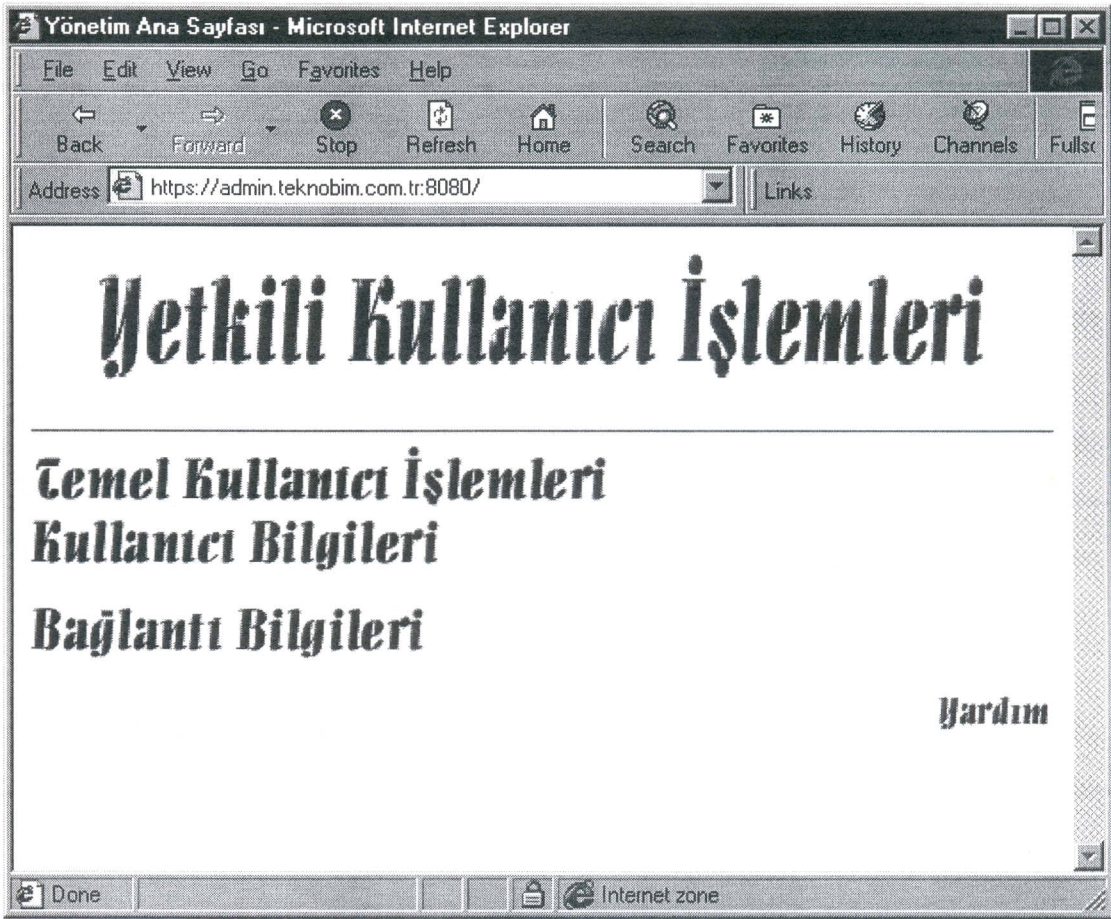


Figure 5.8 Administrative user operations page

Notice the middle bottom of the figure that, a lock figure is appeared, which is not available in normal Web surfing. This lock figure shows that, you are in a secure Internet zone, and your transactions are encrypted.

5.4.1 Basic User Operations

The basic user operations, such as adding/removing users, enabling/disabling users adding extra usage time, and changing user passwords when necessary is the most important parts of system administrators. From this point (Figure 5.9) system administrators can do all these stuff easily.

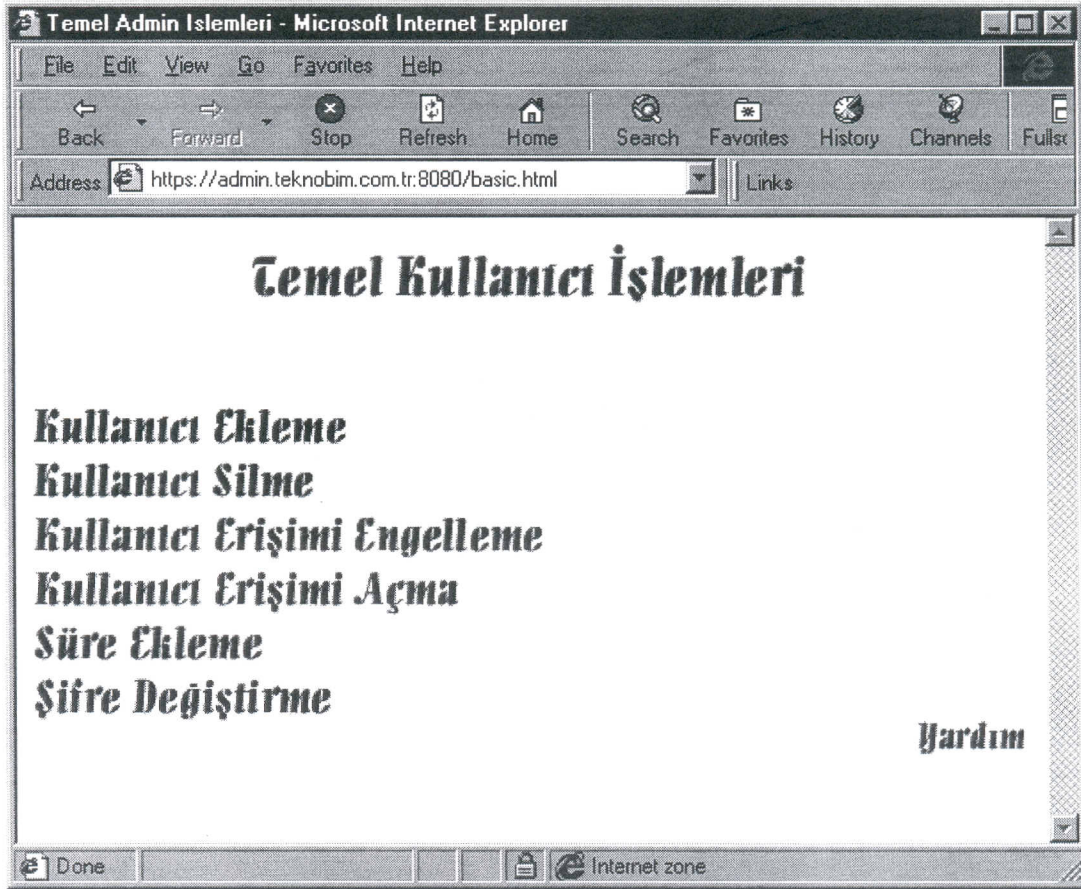


Figure 5.9 Basic administrative user operations main page.

Adding new users to the ISP system may be the most important part of ISP stuff. In this step all the necessary information about user (such as name, surname, user-id, password, address, telephone and fax number, company, visa number, his modem info (type and speed of modem), the OS used by the user etc.) is entered to the database of ISP system (Figure 5.10). Some of these information is directly used to define user (such as username, password etc.) and some others (such as address, telephone number,

modem info etc.) is stored for future uses. In addition, the accountant information (such as visa number, tax number etc.) is obtained here to use in billing process.

In this step, system administrator has the choice of adding different kinds of e-mail and dial-up users to the system. For example system administrator may add shadow and non-shadow users for e-mail and may chose Radius, TACACS+ and Netblazer authentication systems according to their available system. This property is especially useful for big ISPs, who has different types of e-mail and dial-up users. Another advantage of this availability is that many different ISPs (with many different kinds of e-mail and dial-up systems) may use this Web based accounting system without any changes.

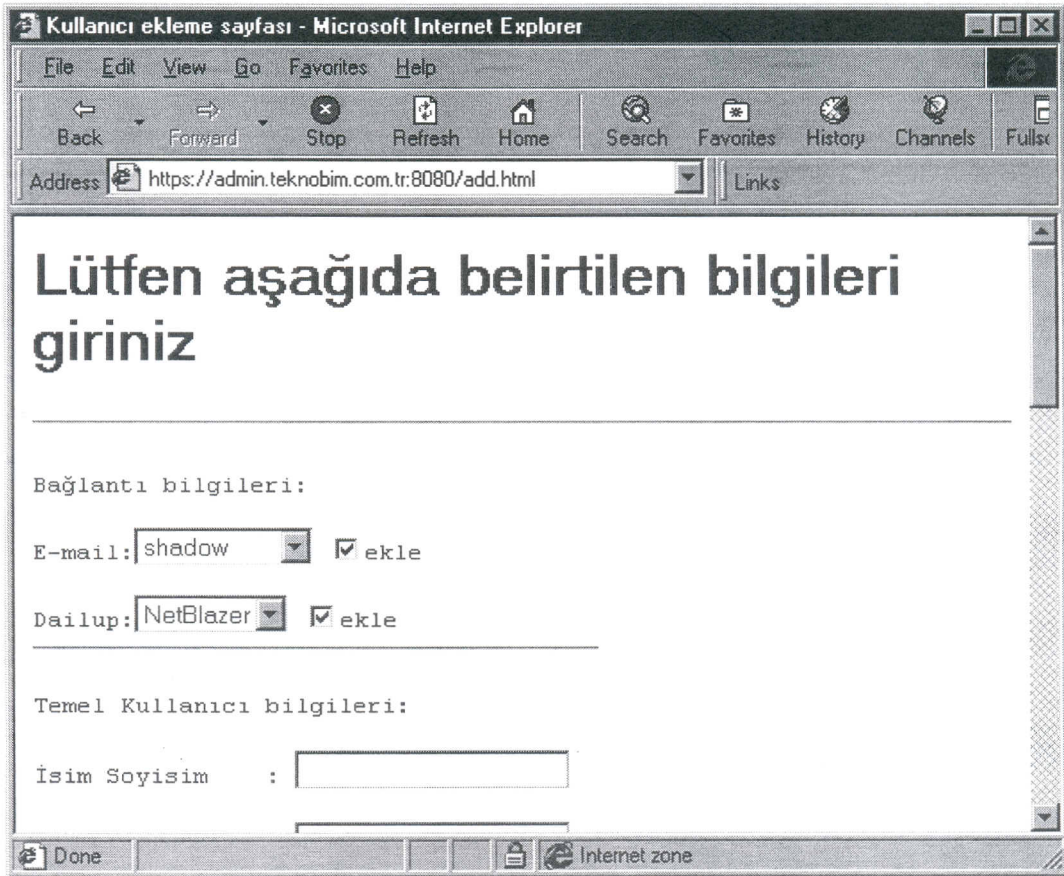


Figure 5.10 Adding new user to ISP system.

In this step system administrator may use Turkish characters (such as ı,ğ,ü,ç,ö etc.) in most of the fields. Later on system administrator may search the users by using these Turkish characters. This property is useful especially for Turkish ISPs.

When a user does not use the ISP system or want to be removed from ISP system, he must be removed from ISP database, and all related records must be updated accordingly. In "User Removal Operation" part, system administrator may delete user from e-mail or dial-up (or from both) database and prevent that user from using ISP services.

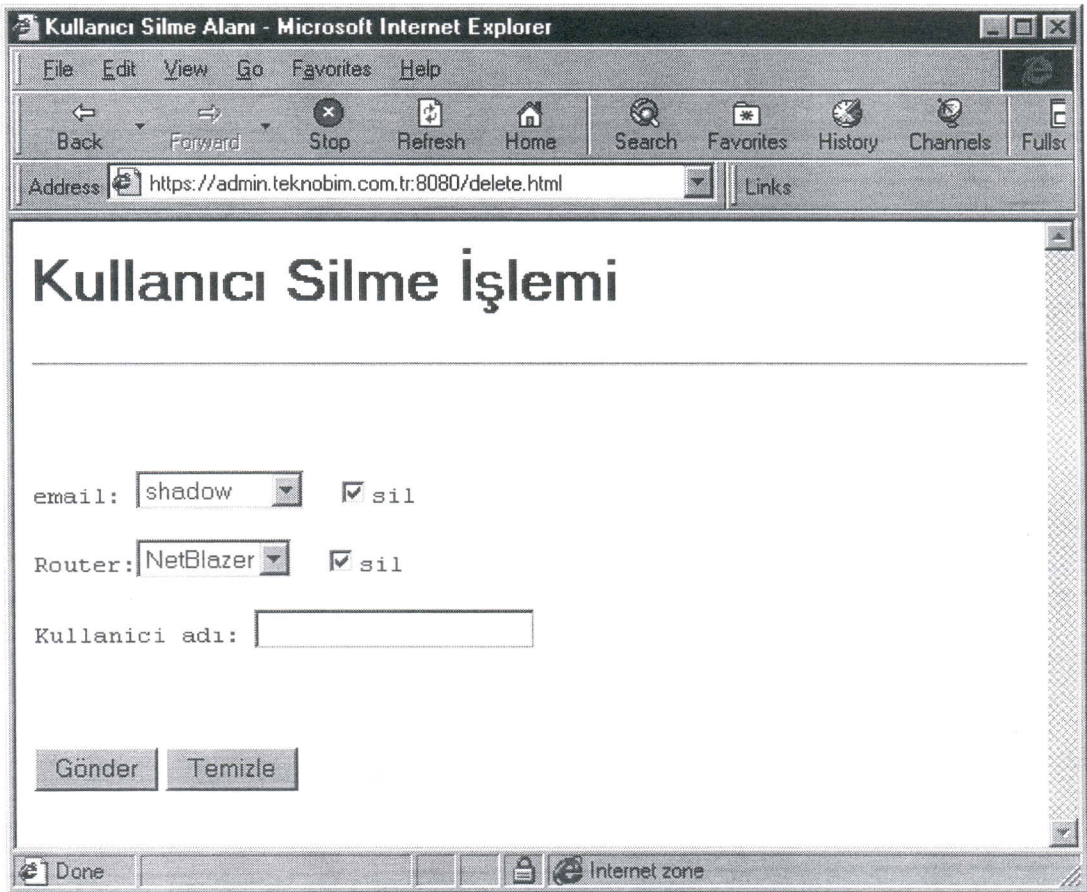


Figure 5.11 User removal operation.

Usually when the usage limit of a user is exhausted, it is necessary to disable the user from accessing ISP services, such as accessing his e-mails, or surfing the Web temporarily (Figure 5.12). This is not the same case of removing the user from the ISP system, instead in this case the user rights are temporarily disabled. In this case, only

thing done in the server site, is to add a "*" to the password field of the password file for that user.

System administrator has the ability to disable either e-mail or dial-up (or both) rights of the user.

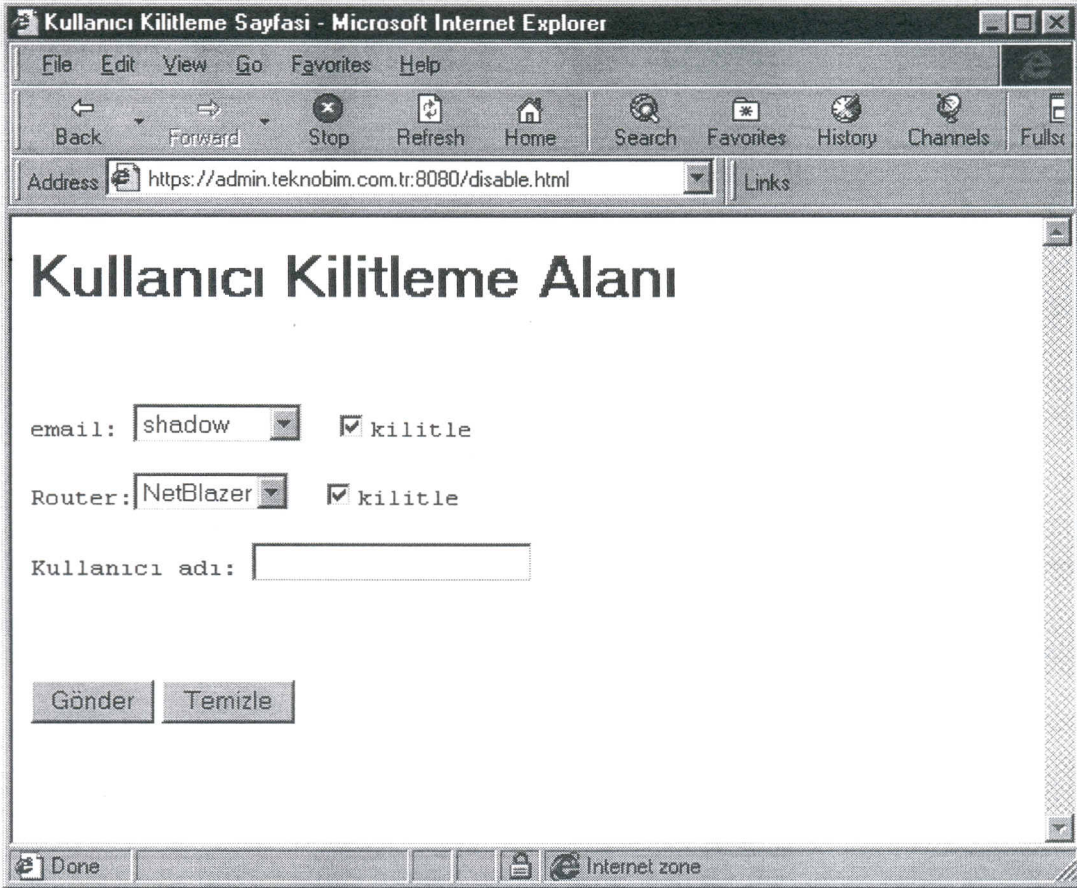


Figure 5.12 User disabling operation

When a user, which is disabled, buys extra credit, he must be re-activated (enabled). The reverse of user disabling process is enabling user process (Figure 5.13). In this process, the things are exactly the reverse of the previous process ; the "*" sign in the password field of password file for the user removed and consequently user again has the rights to use Internet services, like Web, e-mail, FTP etc.

Once again, system administrator has the ability to enable either e-mail or dial-up access (or both).

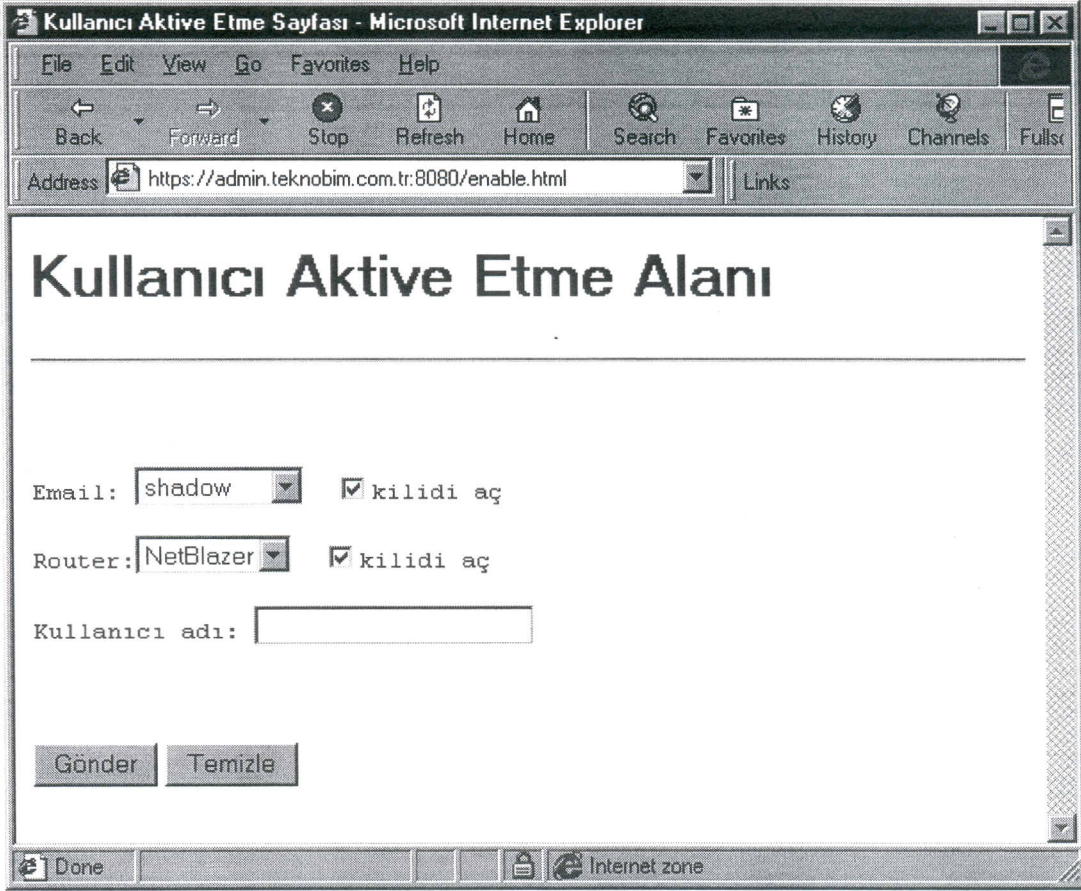


Figure 5.13 Enabling user access process.

When a user first defined to the ISP system, usually some credit (like 1 month unlimited usage or 100 hours limited usage) is defined for that user. These are all credit for that user. When either of them exhausted, the access of this user to the Internet services is disabled. But if this user buys extra usage time, he may prevent his account from being disabled. This process for adding extra usage time (credit) is called "refill".

When system administrator want to add more credit for user, first he enters username of that user (Figure 5.14). In this stage, once again system administrator has the ability to add extra time for different authentication systems (Radius, TACACS, Netblazer).

Once, system administrator enters username of the user, Web server searches for ISP database using cgi and find user's current access rights. When he enter the amount that will be added, user refill process is over (Figure 5.15).

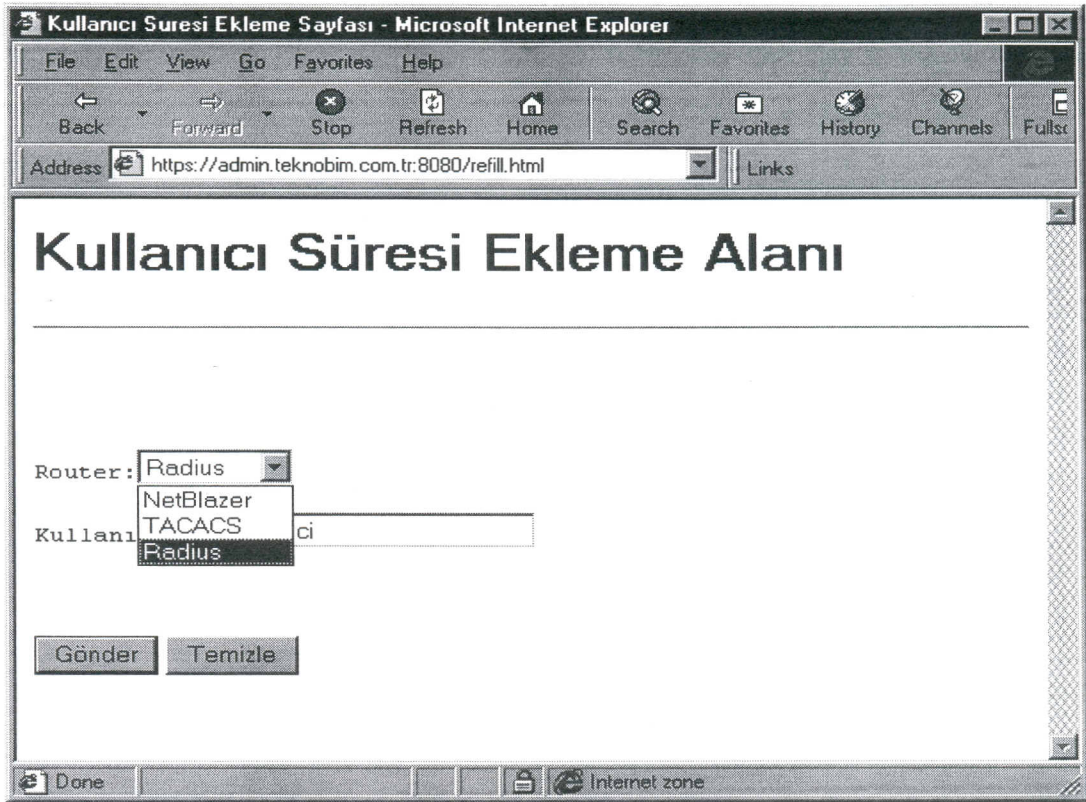


Figure 5.14 Adding extra credit (time) for user.

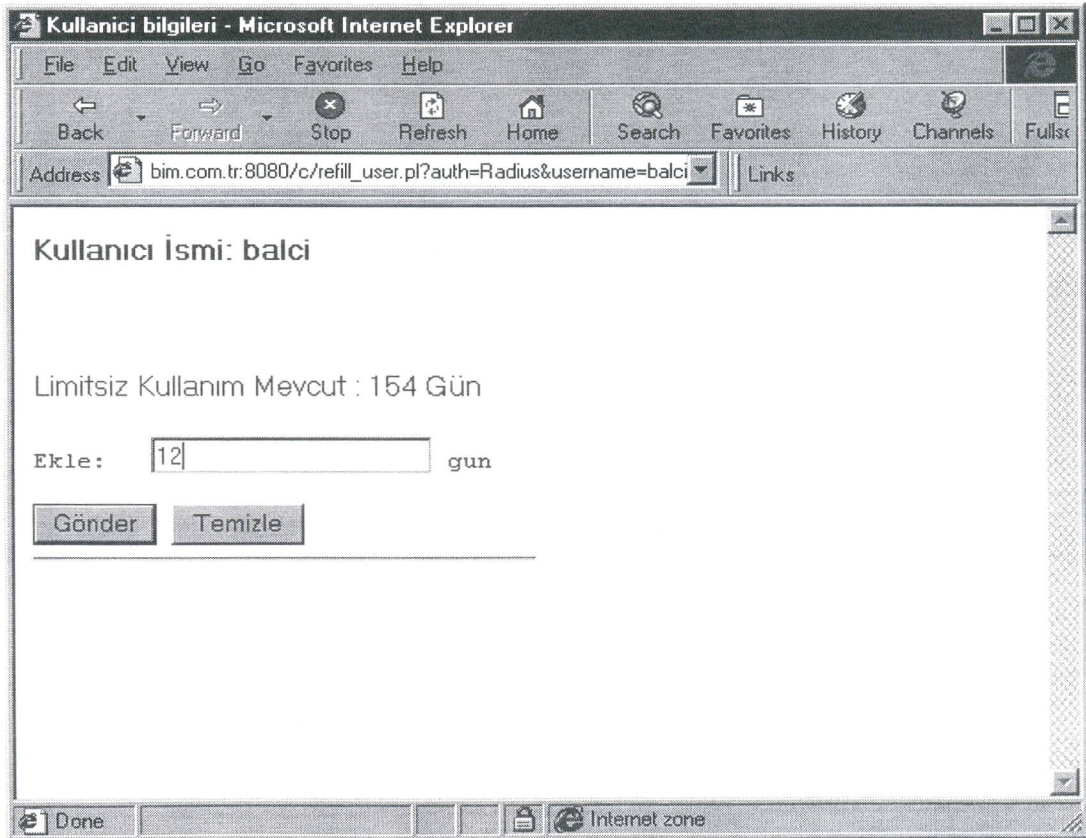


Figure 5.15 Adding extra credit (time) for user (continued).

Frequently users forget their passwords (both e-mail and dial-up). In this case system administrator must supply a *new* password for that user. By using admin user password change service, system administrator can change user passwords without knowing user's old password (Figure 5.16).

Yetkili Kullanıcı Şifre Değişirme Sayfası - Microsoft Internet Explorer

File Edit View Go Favorites Help

Back Forward Stop Refresh Home Search Favorites History Channels Fullsc

Address <https://admin.teknobim.com.tr:8080/password.html> Links

Yetkili Kullanıcı Şifre Değişirme Alanı

Kullanıcı adı:

Email: shadow Yeni Şifre :

Router: NetBlazer Yeni Şifre :

NetBlazer
TACACS
Radius

Done Internet zone

Figure 5.16 Admin user password change page.

5.4.2 User Information

In order to reach personal user information when necessary, ISP must develop some mechanisms, which make user accounting and helpdesk easy and efficient.

In this project, this stuff is held in "User Information" part (Figure 5.17).

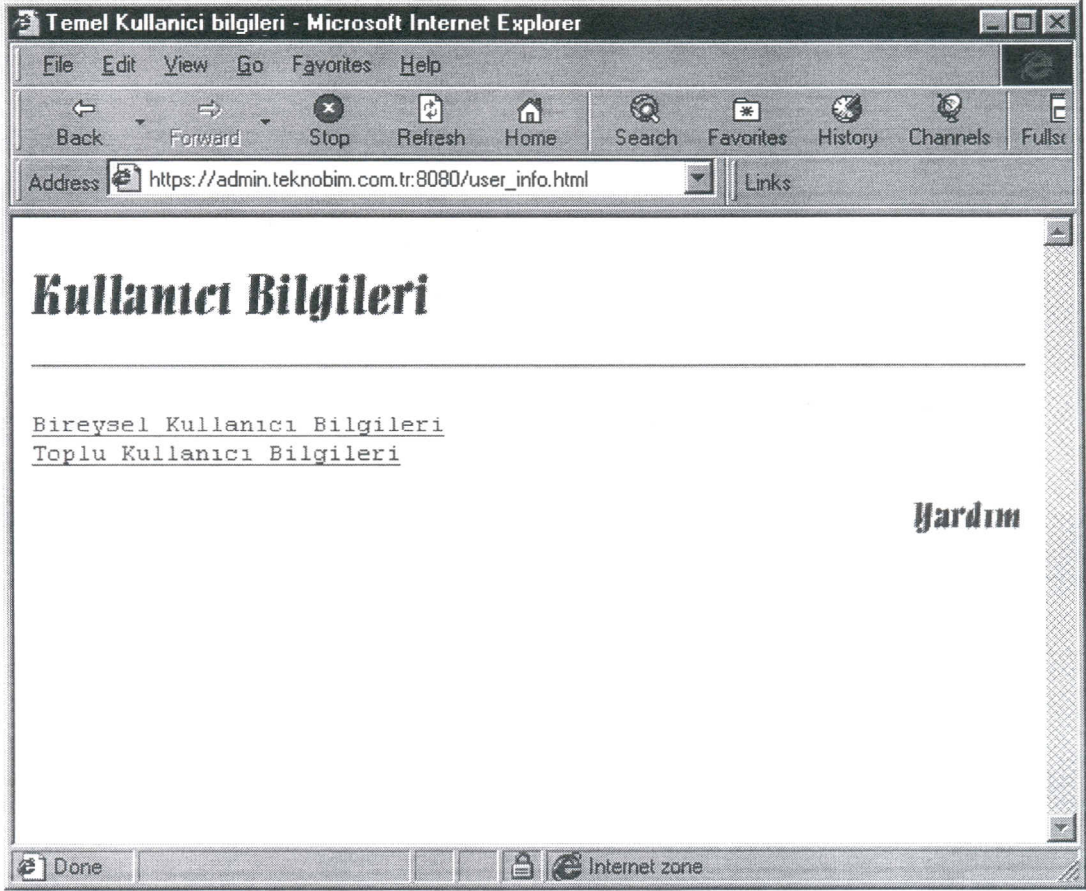


Figure 5.17 User information main page.

There are two areas in this part;

- Personal user information
- Personalised user information

The "Personal user information" section is designed to list all the user information of a particular user. When user-id of a user is entered (Figure 5.18), Web server searches for ISP user database and displays most commonly used user information, like name/surname, address, telephone/fax number, visa/tax number, company, OS, modem, modem speed etc. (Figure 5.19)

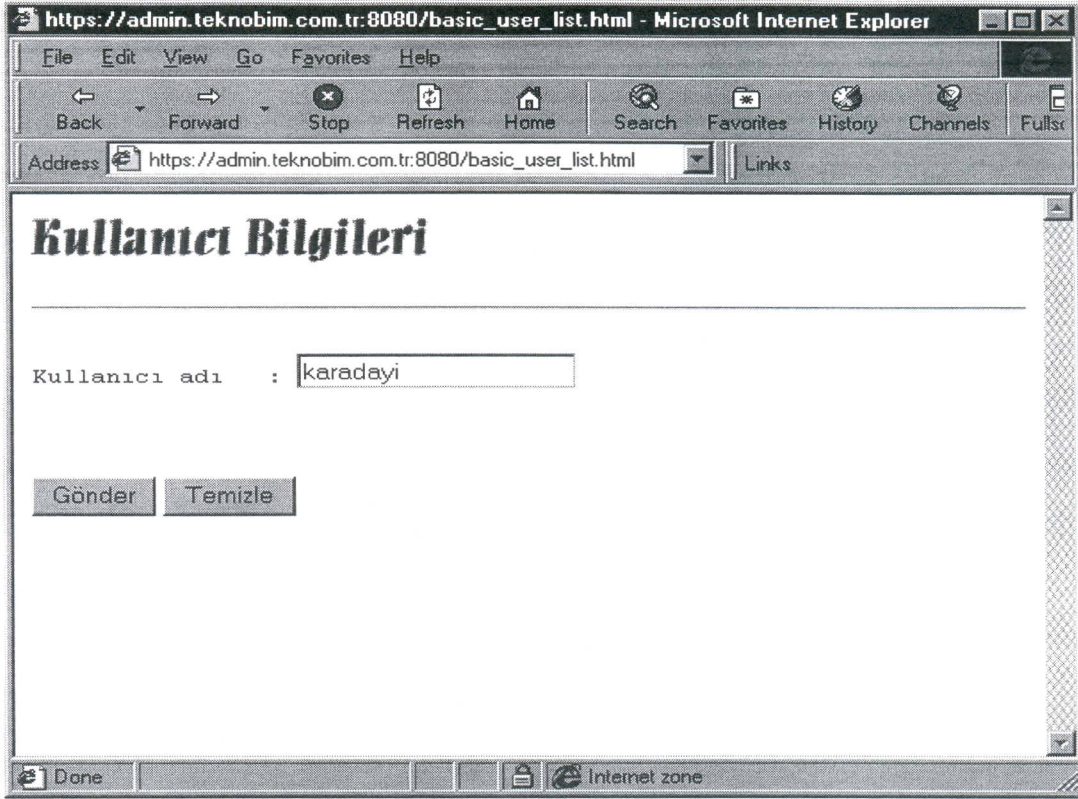


Figure 5.18 Personal user information page.

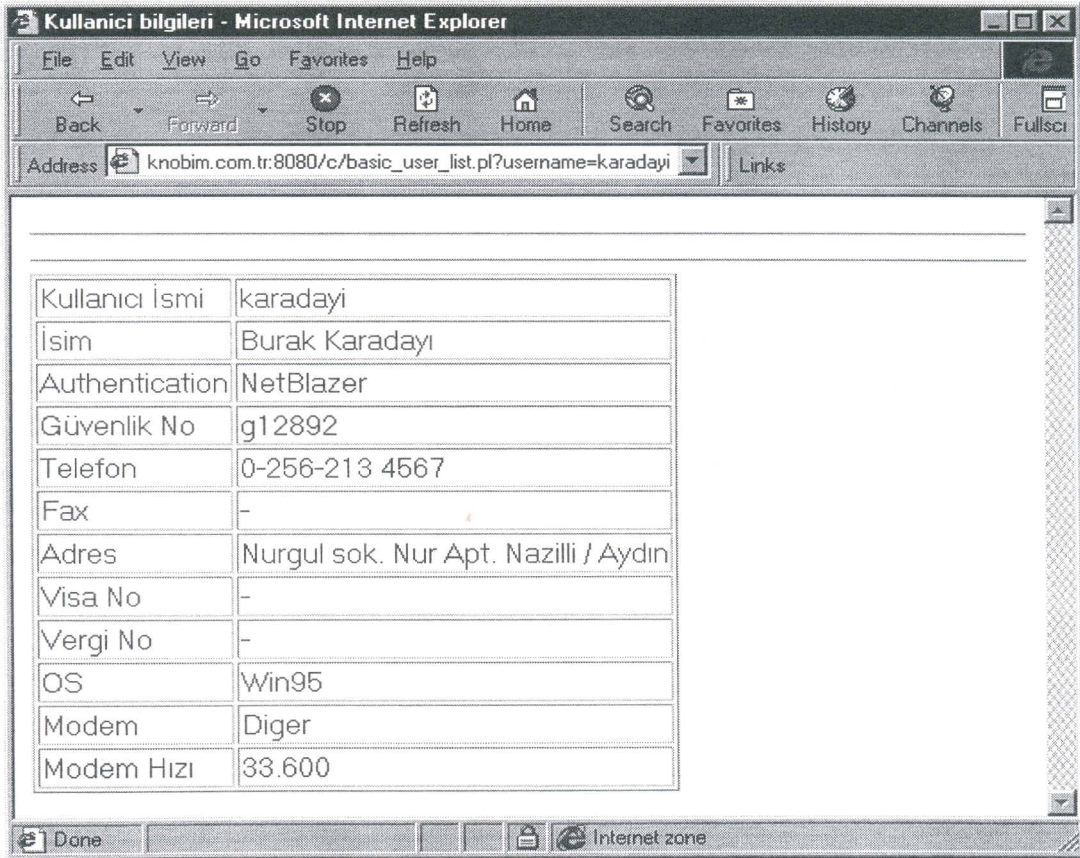


Figure 5.19 Personal user information result page.

Personal user information area is useful to learn all the necessary information about a *known* user. But usually system administrators need more. For example, a system administrator may want to know all the users from a definite company, or he may want to know the users, whose modem type is Zyxel ! (Figure 5.20 & Figure 5.21) In addition, he may want to view only definite user fields, he chooses. This property is especially important when a system administrator does not want to see unnecessary user information. For example, assume that a system administrator wants to see the users, whose OS is Win95, but system administrator does not need the visa and tax number for users. In this case, just by clicking the necessary fields, he may filter the unnecessary data fields (Figure 5.22). In contrast, in the same way system administrator can enlarge user information fields in the result page.

Surely, system administrator can get a printout of the result page easily from a printer which is in the local machine or network.

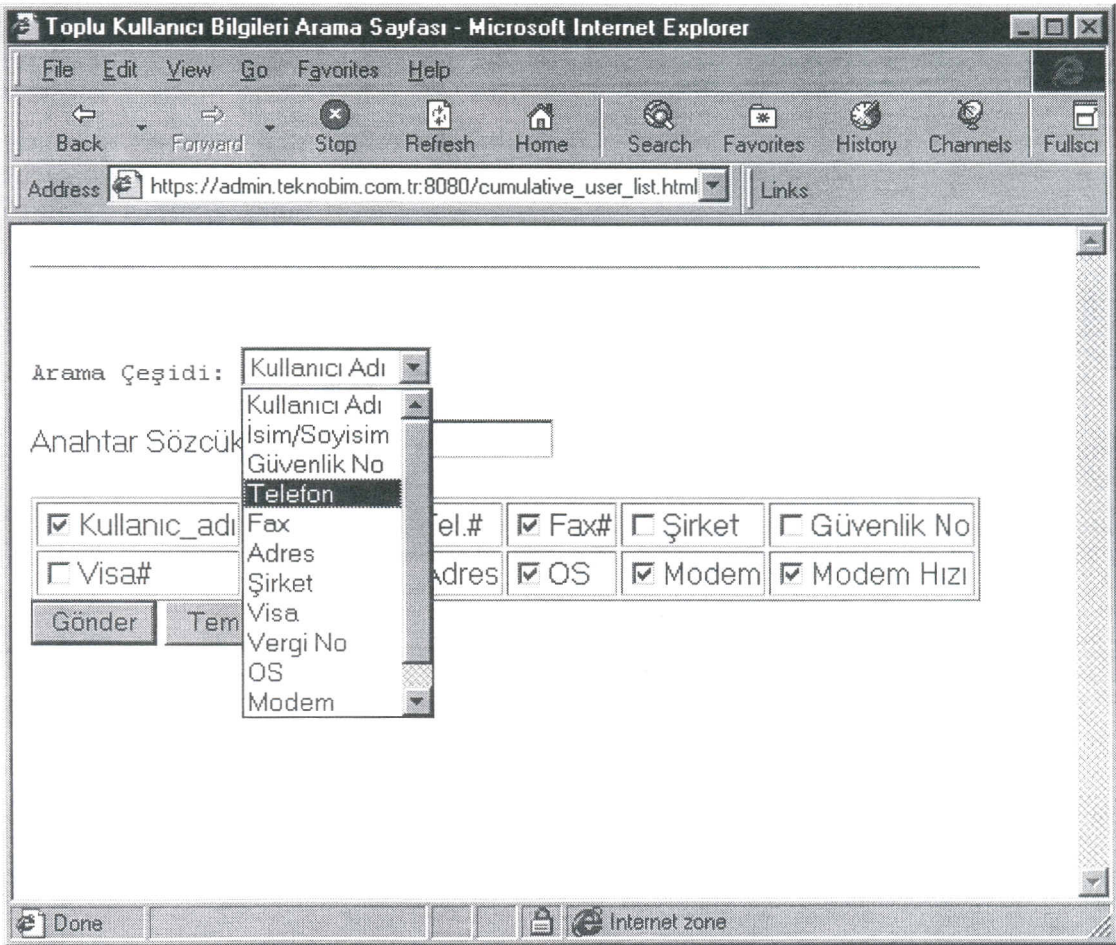


Figure 5.20 Personalised user information page - I

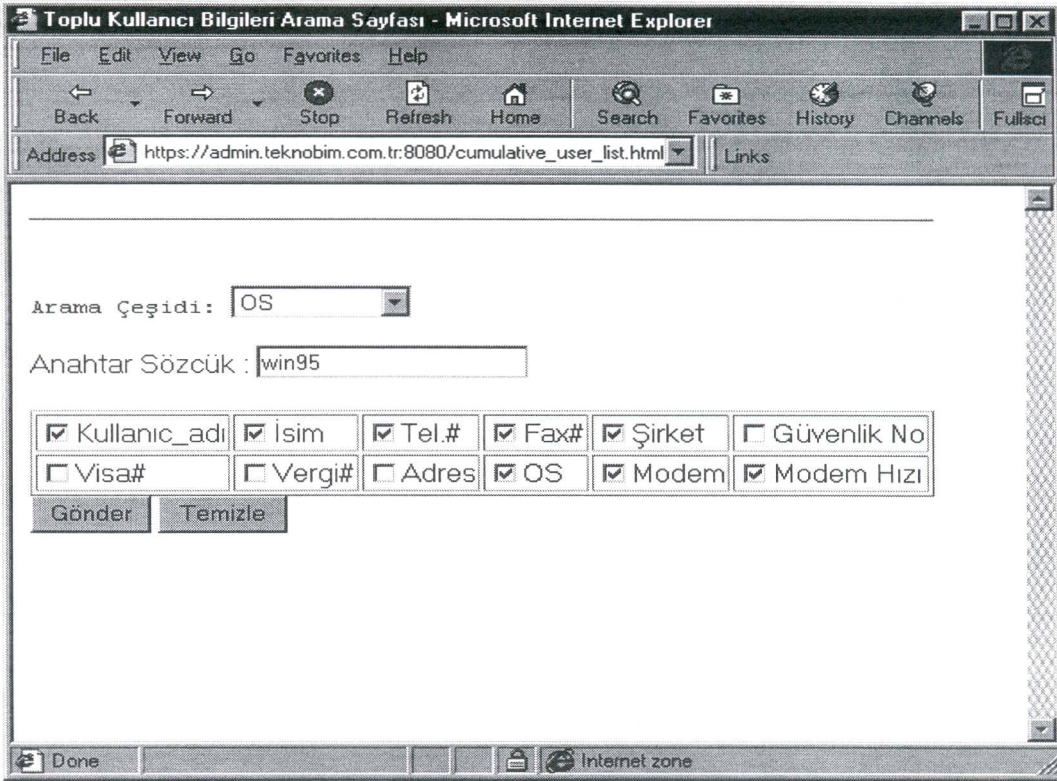


Figure 5.21 Personalised user information page - II

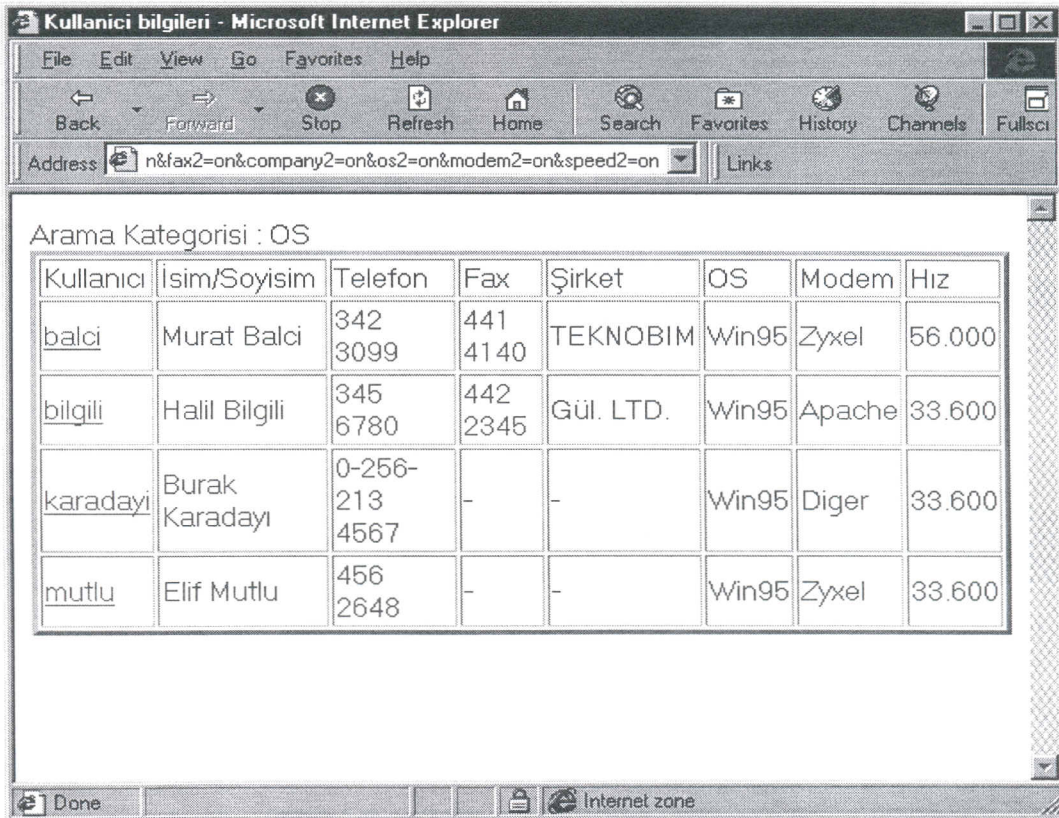


Figure 5.22 Result page of personalised user information.

5.4.3 User Connection Information

In ISP system administration process, it is necessary to examine the connection logs of users. The format of these logs changes from one authentication system (Radius, TACACS, NetBlazer) to another.

A system administrator usually needs to examine connection logs according to different criteria, such as user-id, name of the connection line, month, day and hour of the connection etc (Figure 5.23). By examining these logs, system administrator can get some statistics about connections and these statistics might be used in future hardware/software investment planning (Figure 5.24).

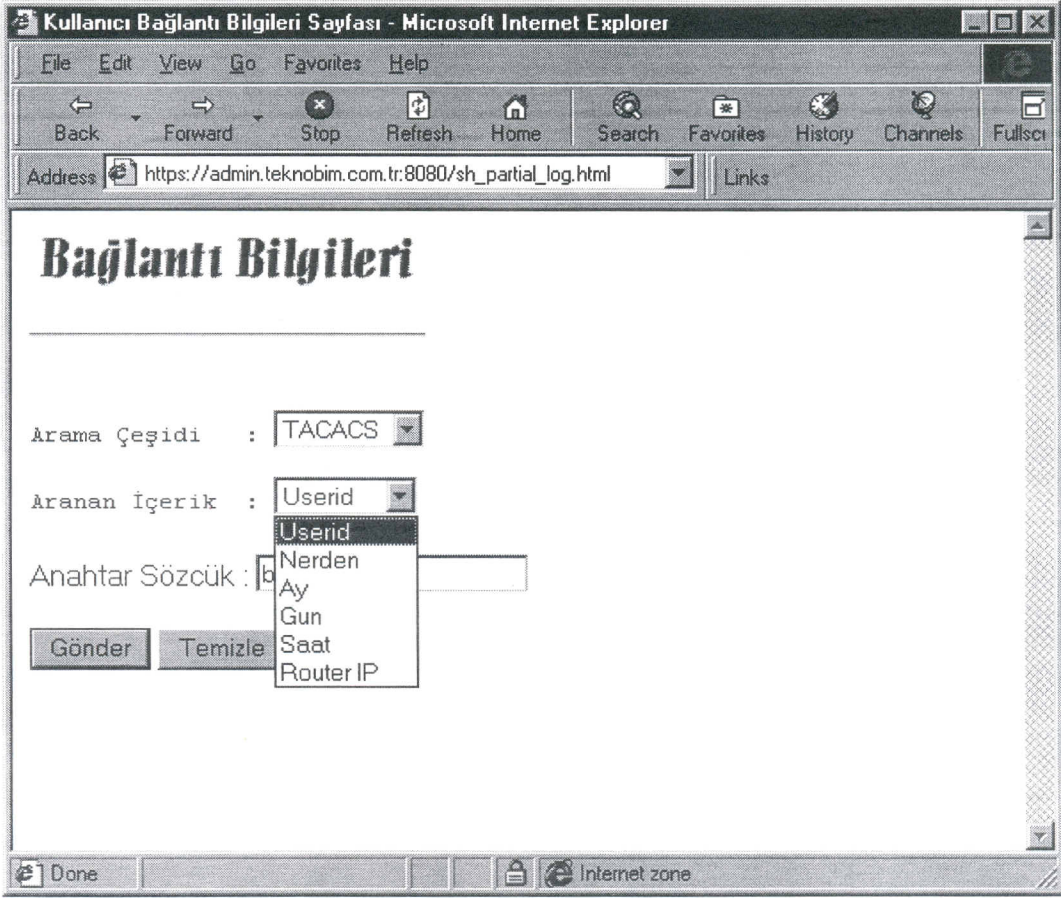


Figure 5.23 User connection information page.

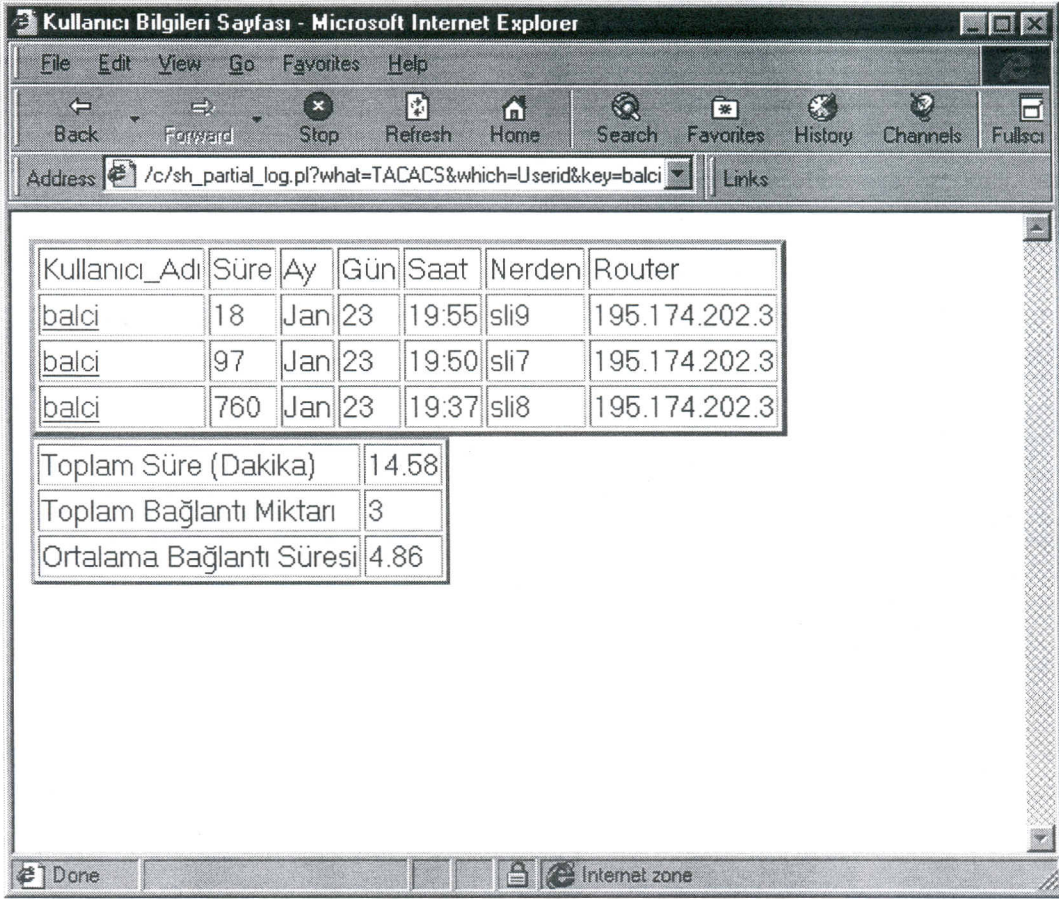


Figure 5.24 Result page of user connection information.

5.5 Accountant Operations

In order to survive, all ISPs must construct a proper accounting and billing system. Most of the billing operations are usually done by accountants. For this reason, they must have some rights to view accounting information, which will be used in billing process. But, notice that accountant people should *not* do administrative stuff, like adding/removing new users, changing user passwords etc. All these operations must be done by a few administrative people, for security reasons. So, ISP accounting system, must supply a *level* for viewing accounting and billing info of the users. Surely, that level must be accessed securely (Figure 5.25) and must require a username/password (Figure 5.26). After the sustention of a secure communication environment, necessary accountant operations can be done (Figure 5.27).

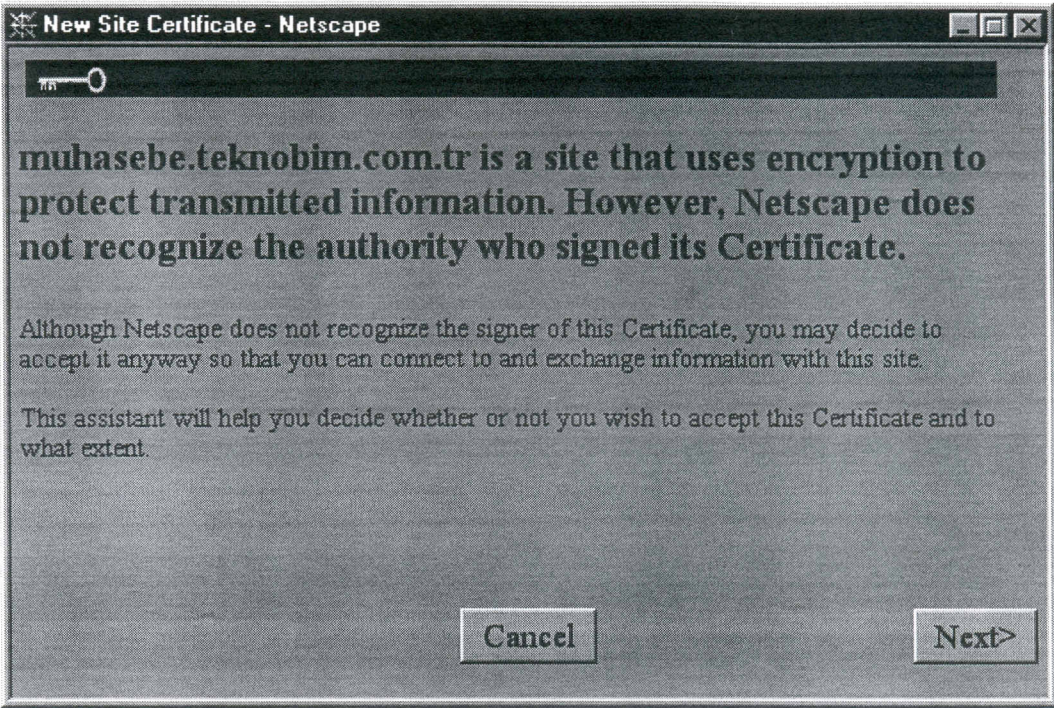


Figure 5.25 Accountant SSL certificate starting page.

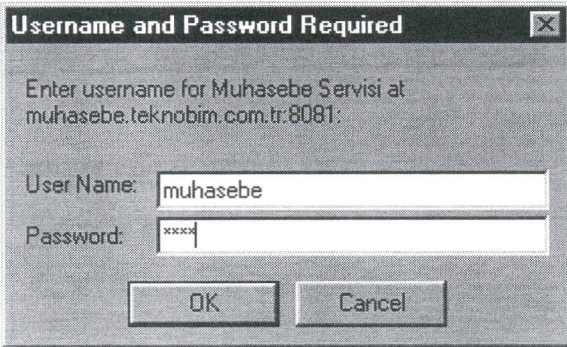


Figure 5.26 Accountant operations username/password control page.

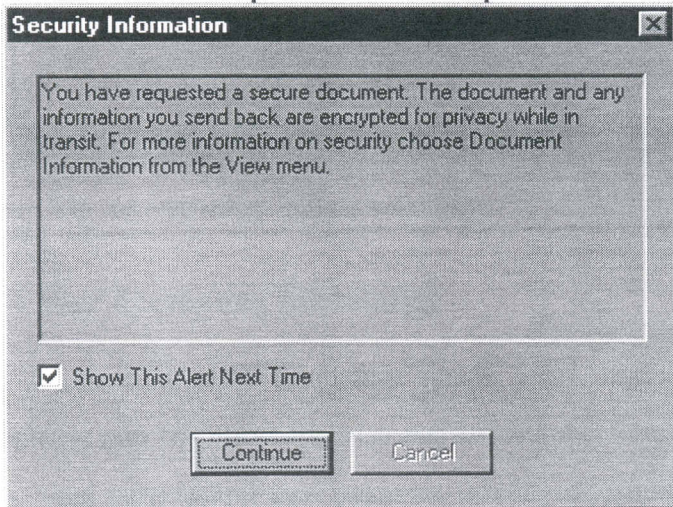


Figure 5.27 Finishing of SSL certification and password control process.

Accountant operations are divided into three sections;

- User accounting information
- Old payment information
- Current billing information

In each of these sections, accountant staff get accounting and billing information of users (Figure 5.28).

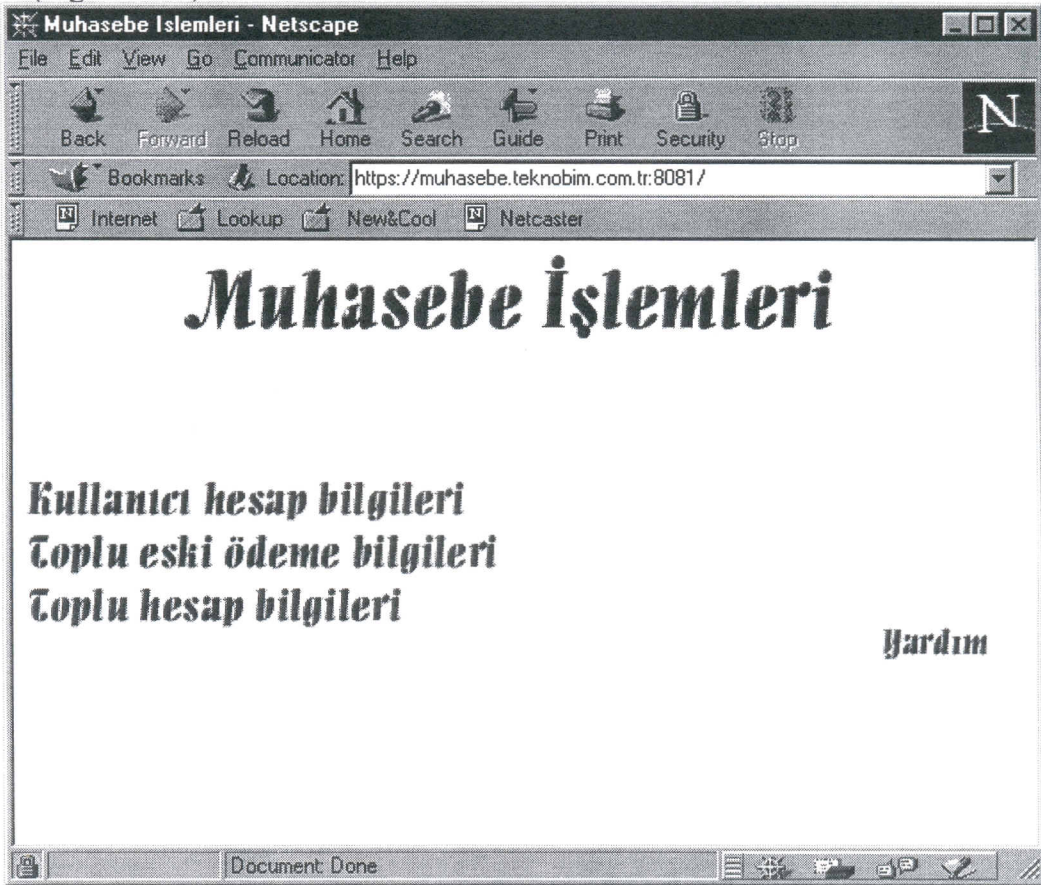


Figure 5.28 Accountant operations main page.

5.5.1 User Accounting Information

Accountant staff frequently needs some basic information, like user address, telephone and fax numbers, visa and tax numbers etc. Beside these basic information, they need current and past payment (credit) information of users. This information is important especially when there is a conflict in user payments. As it is seen from "User

accounting information" page (Figure 5.29), accountant staff has the ability to increase and decrease the information displayed, just by filling or emptying the check boxes.



Figure 5.29 User accounting information page.

When the accountant staff enters the username concerned, he gets all the necessary information he desired (Figure 5.30). Notice that, it is not asked a password for user information. Accountant staff's permission level is enough to view these data. Only username/password supplied by that staff is their accountant-username and passwords asked at the beginning of the session.

As it is seen from the result page, user-billing history is displayed as a part of the results. This information is important in tracking of payment conflicts.

All these results can be printed by using browser's printing utility and can be sent to someone else.

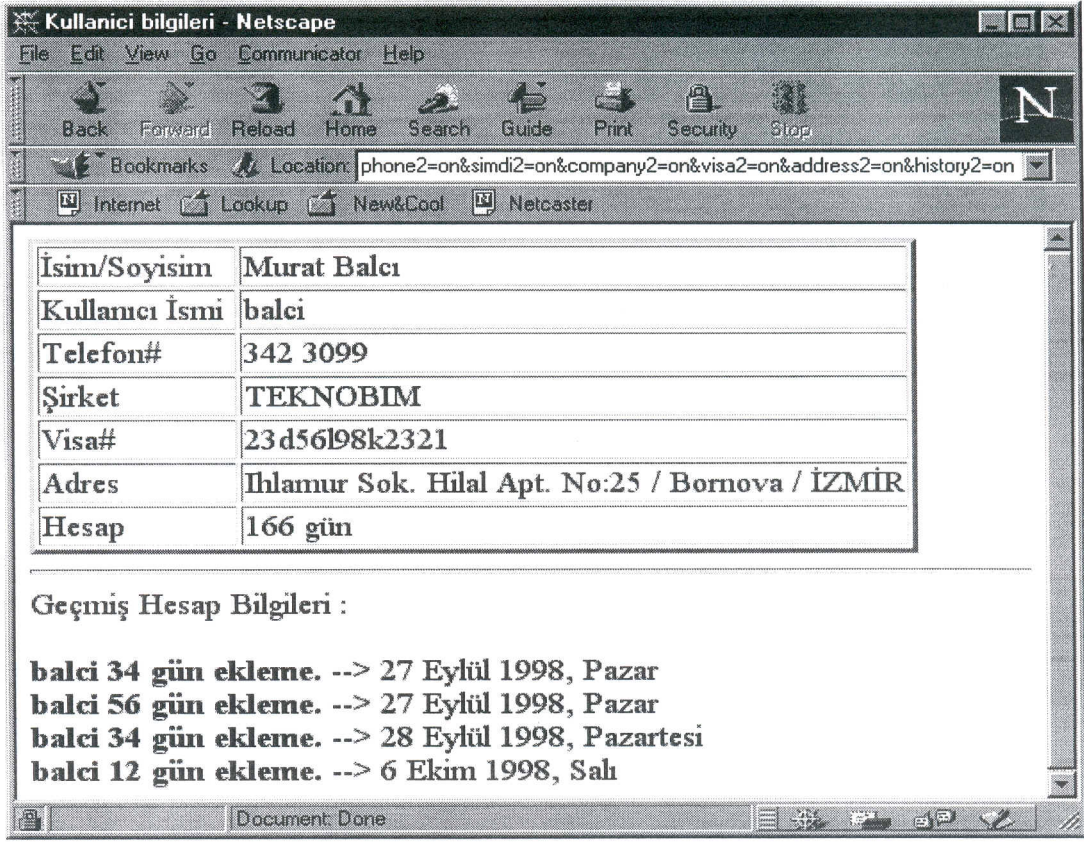


Figure 5.30 Result page of "User accounting information" process.

5.5.2 Old Payment Information

Accountant stuff may need an information like ; "..the payment history of all the users during September, 1997" or "..the payment history of all the users in the year 1998". This kind of information is usually needed when revising old payments or when tracking a payment conflict.

When accountant stuff needs such an information, only thing he must do is just to choose the month and year (Figure 5.31). In this case, he has the ability to chose *all* the events in both month and year fields.

After the selection of the month and year, Web server runs a proper cgi-script and lists all the history according to given month and year criteria (Figure 5.32).

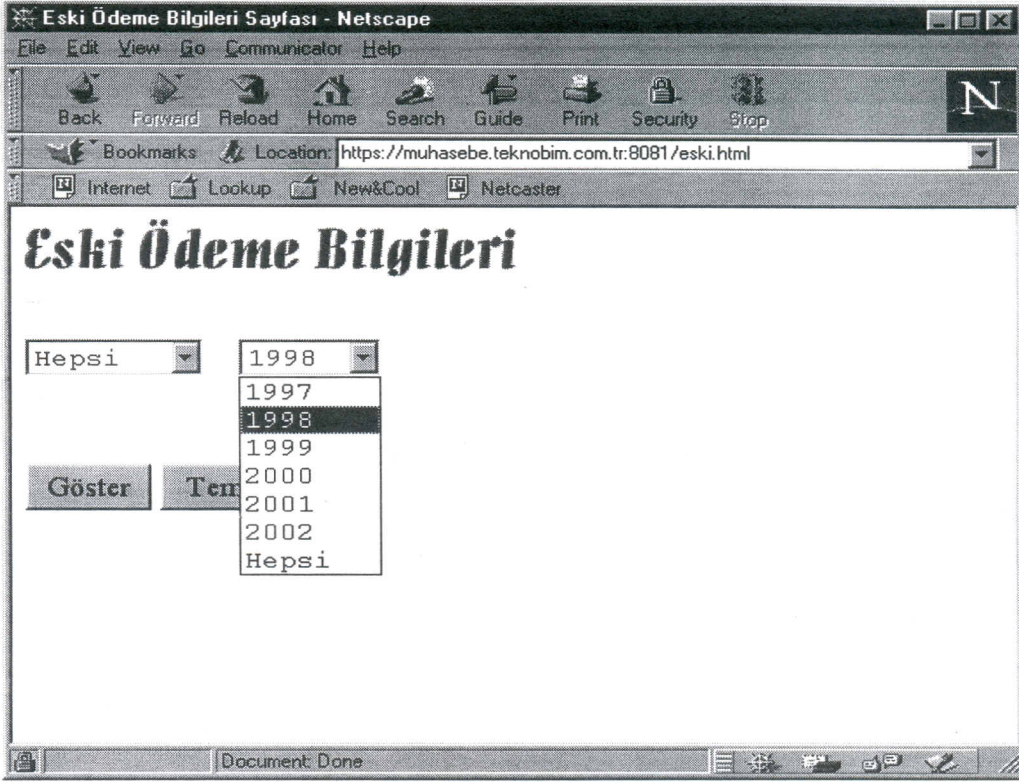


Figure 5.31 Old payment information page.

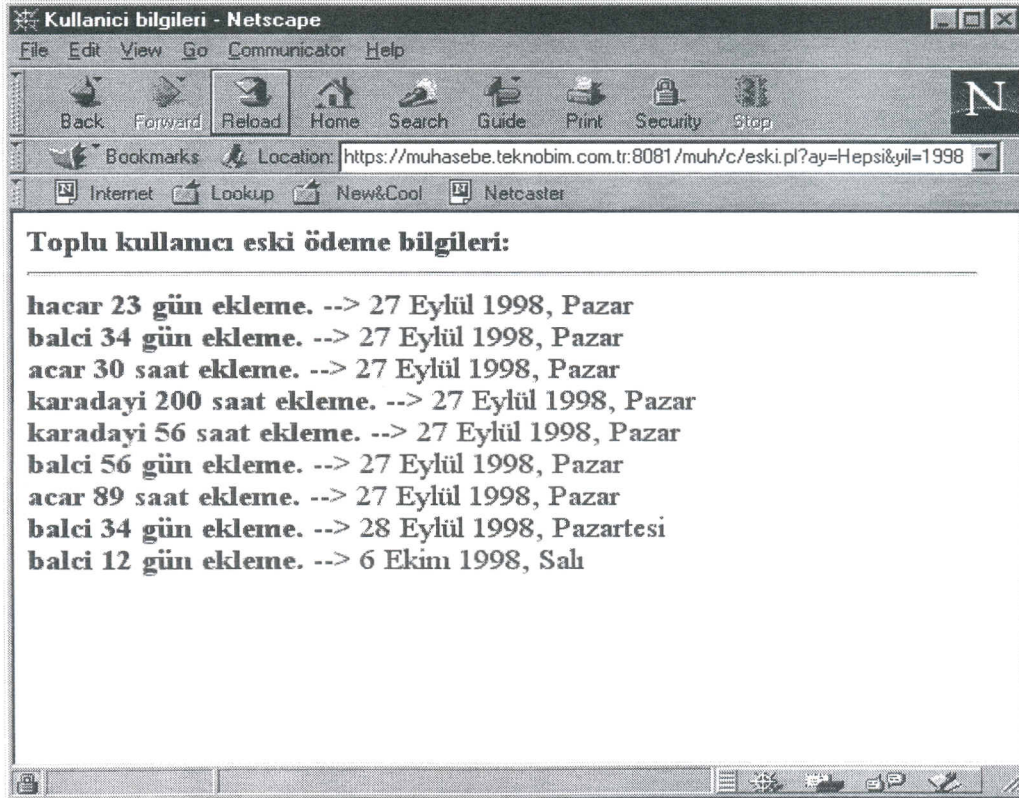


Figure 5.32 Old payment information result page.

5.5.3 Current Payment Information

Although it may change from one ISP to another, there are mainly two types of billing system. In one system, user buys a definite time slice (say 100 hours). As the user connects to Internet and uses ISP's services, this time is consumed, and when his time slice (credit) is exhausted his access rights to use Internet is disabled. This kind of billing system is called "Limited" (user pays only when he uses). In the other billing system, user buys a definite time slice (say 1 month = 30 days) and every day his credit is decreased by *one* even if he did not connected to the Internet. This kind of billing system is called "Unlimited".

An ISP may choose either of these two billing systems. But some may choose to use both concurrently. In this case, billing process is more complicated.

In the "Current payment information" section, accountant staff has the ability to view payment status of both limited and unlimited users (Figure 5.33). When he chooses the type of billing he gets appropriate information in a Web page, as usual (Figure 5.34).

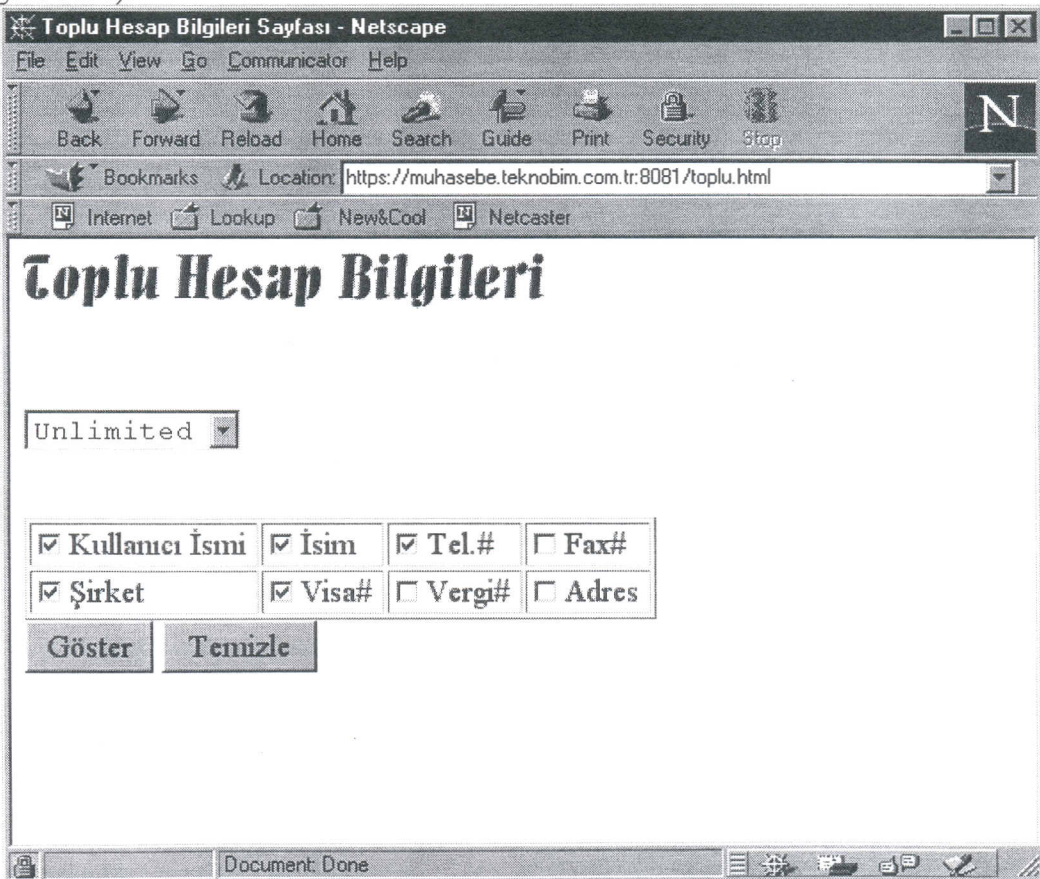


Figure 5.33 Current payment information page.

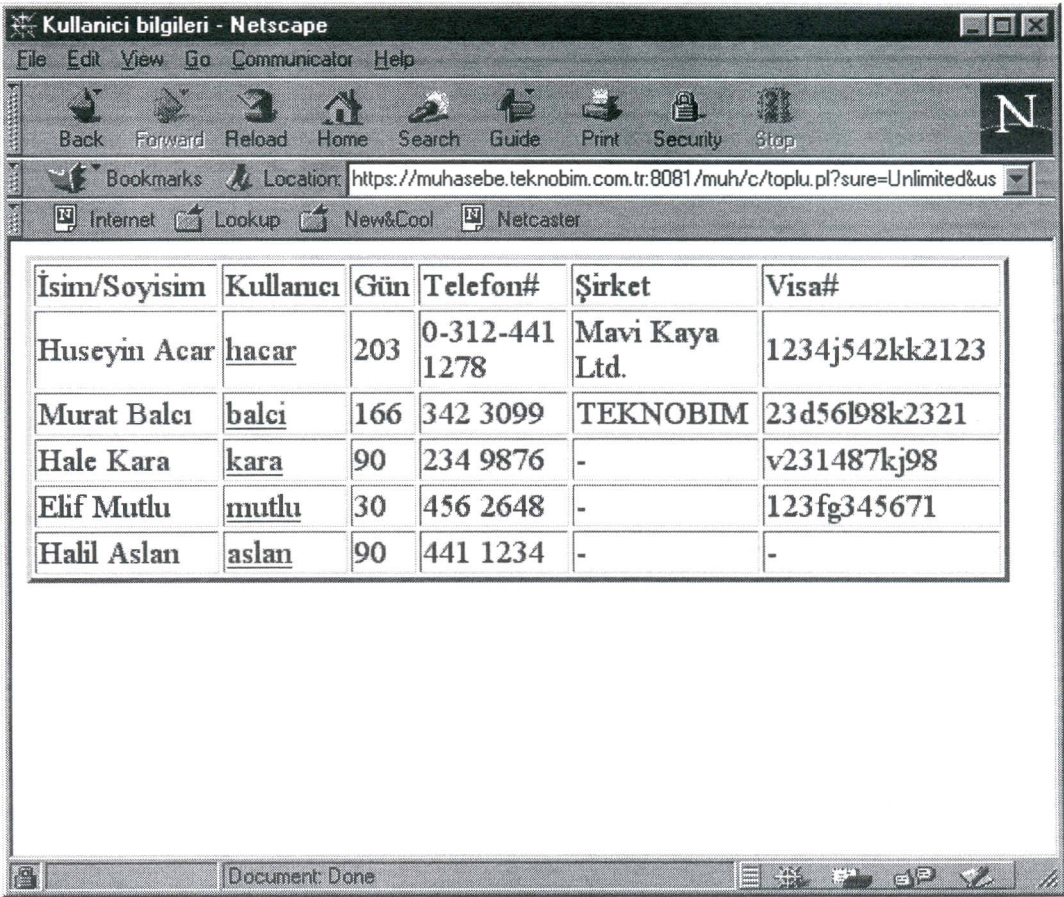


Figure 5.34 Current payment information result page.

5.6 End-User Operations

End-users are the customers of the ISP who buy the ISP services. End-users usually use their modems to connect to the Internet. When they first start using ISP's services, ISP builds a unique user-id, both for e-mail and dial-up access, and assigns passwords for them. Also ISP gives a credit (time limit, say 1 month of unlimited access) to the end-user.

In end-user side there are a few basic operations(Figure 5.35), such as :

- Changing e-mail password
- Changing dial-up password
- Learning accounting information

All these operations must be done by requiring a valid username/password and surely must be carried out securely.

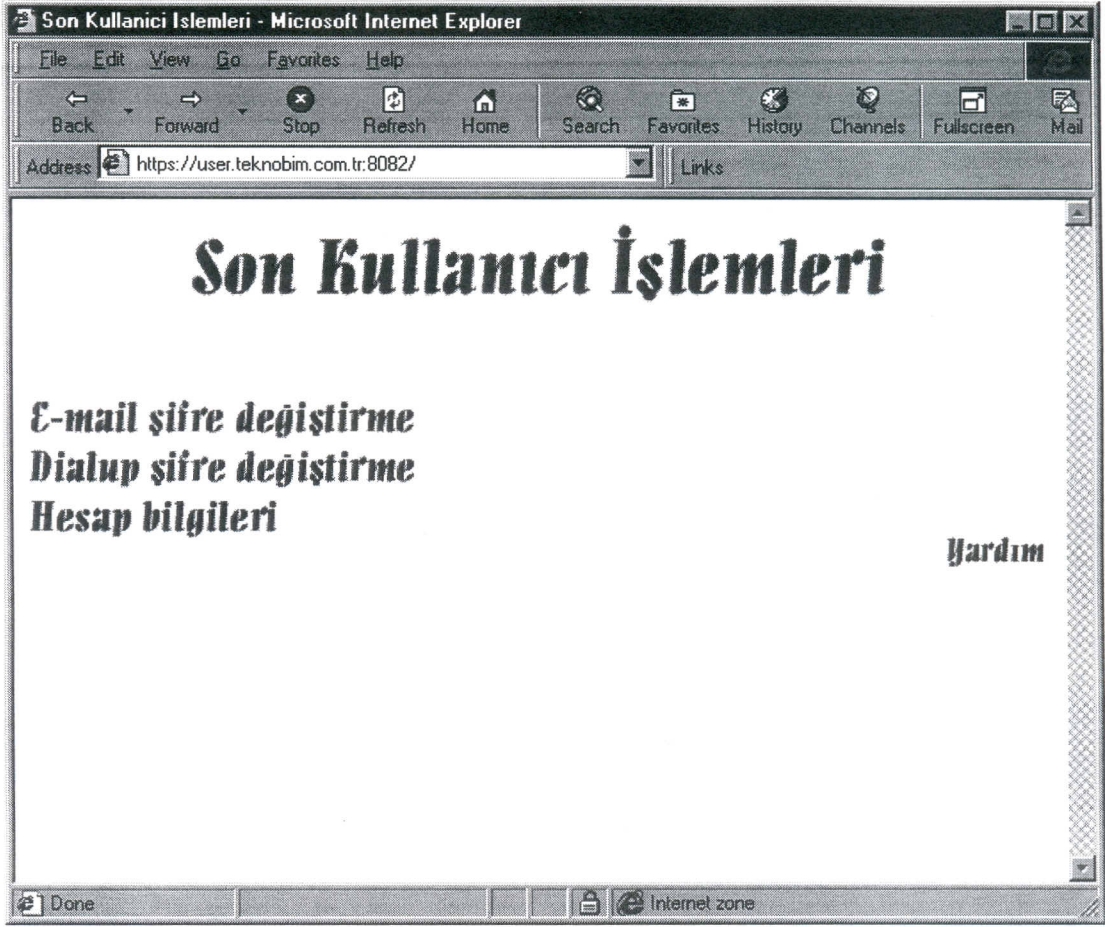


Figure 5.35 End-user operations main page.

5.6.1 E-mail Password Change

Users sometimes may want to change their e-mail passwords. In this case there are two options :

- 1- Call the administrative staff and require, changing his password
- 2- Change their passwords by themself.

Surely the second option is easier, and practical. In this case, the workload on the system administrators drops dramatically.

Users change their passwords by using "E-mail password change" operation. This operation, like the other operations, all the transections is held using SSL protocol and securely.

When a user wants to change his e-mail password, he first supplies his unique username. Then he enters his old password and enters his new password twice (Figure

5.36). If he can't enter his old password or he can't enter his new password correctly, user gets a warning message and can't change his password.

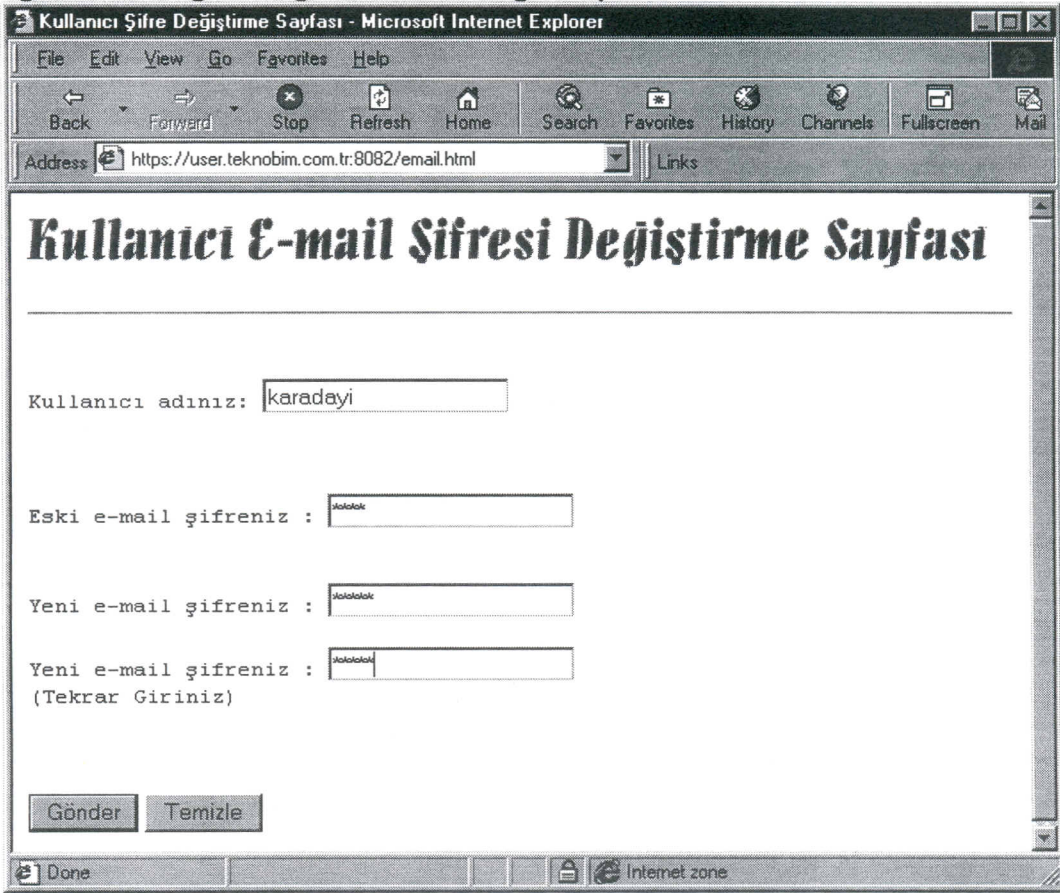


Figure 5.36 User e-mail password change page.

5.6.2 Dial-up Password Change

End-users connect to the Internet by using their dial-up accounts and passwords. E-mail passwords sometimes might be the same as dial-up passwords, but usually they are different from each other.

Frequently users want to change their dial-up passwords, like their e-mail passwords. For this reason, an opportunity for end-users must be supplied to change their dial-up passwords.

Changing dial-up passwords process is very similar to the changing e-mail passwords process. Only difference is that users enter their dial-up passwords, instead of their e-mail passwords (Figure 5.37).

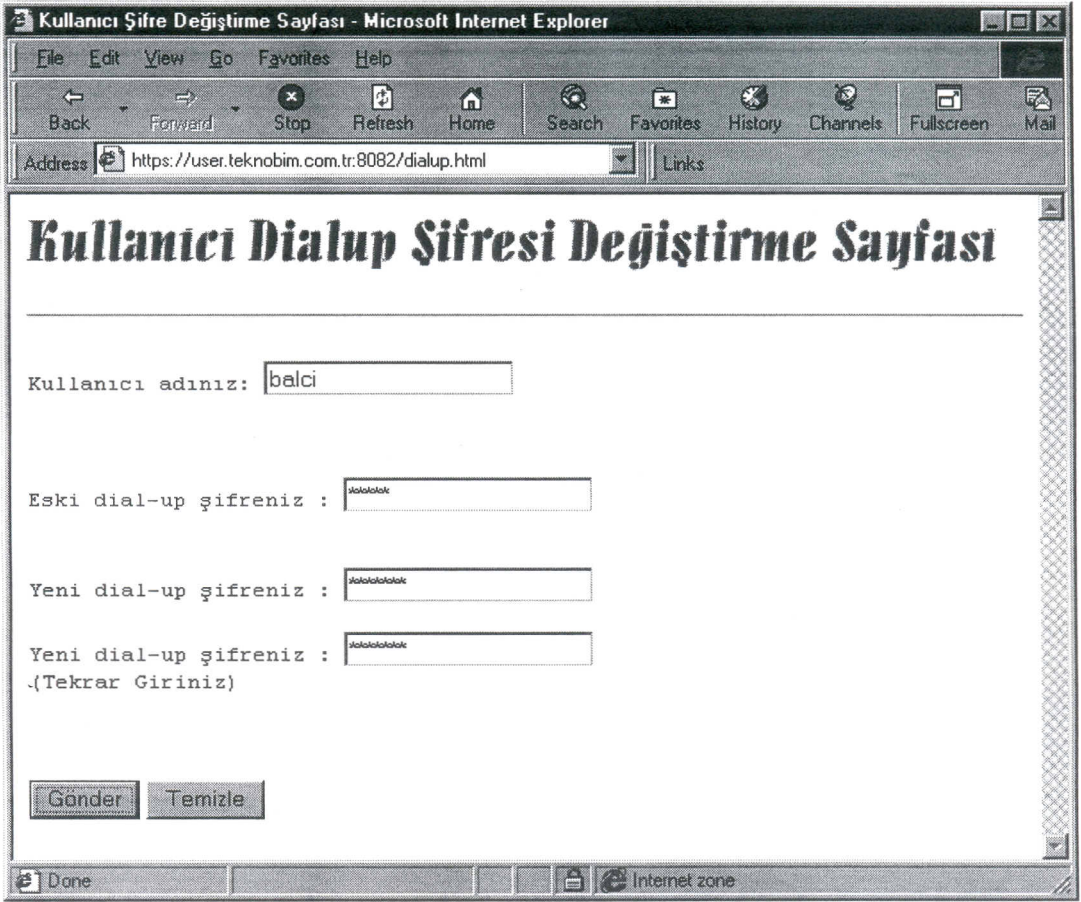


Figure 5.37 User dial-up password change page.

5.6.3 Learning Accounting Information

Users frequently want to know the current state of their accounting information, like how much credit (time slice) is available to use for them? Also they might wonder their billing history.

All these operations can be carried out by end-users by using "Learning Accounting Information". In this section, users just enter their usernames and dial-up passwords. Also they may learn their billing histories as an option, in this process (Figure 5.38 and Figure 5.39).

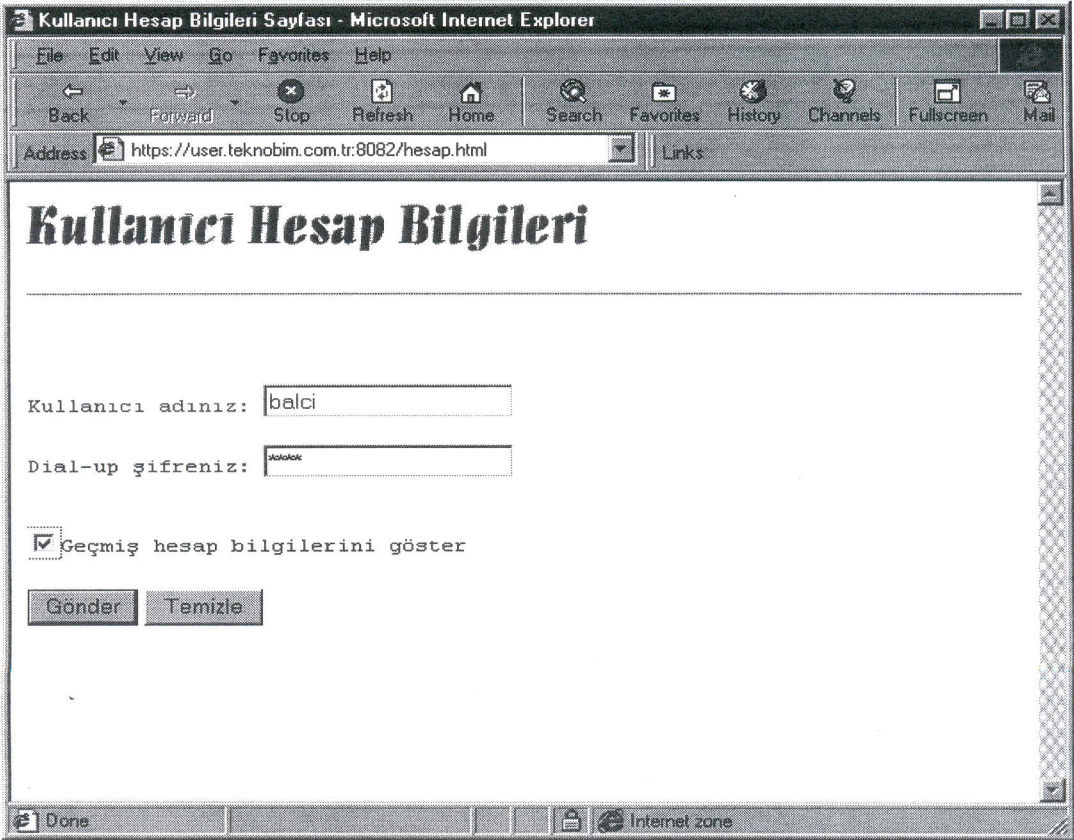


Figure 5.38 User accounting information page.

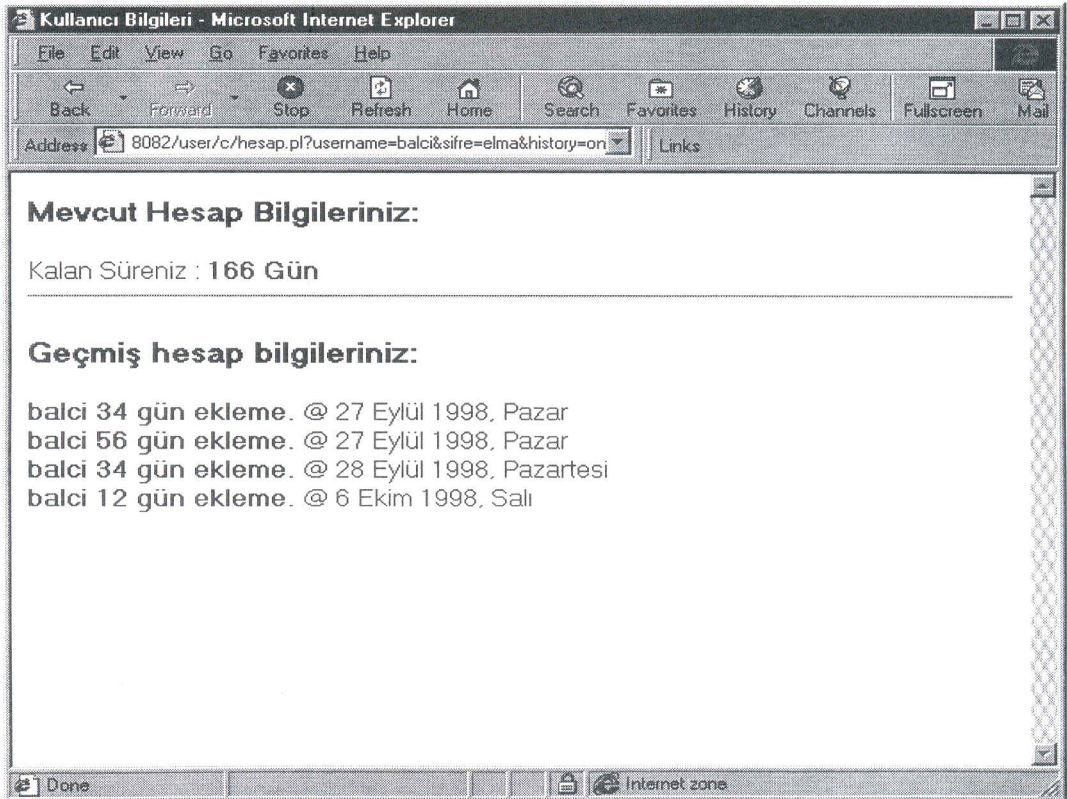


Figure 5.39 User accounting information result page.

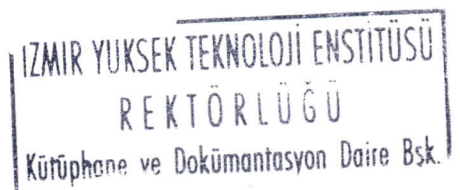
CHAPTER 6

COMMENTS AND FUTURE WORK

6.1 Comments

A robust and practical accounting and billing system is one of the most important part of ISP system. Without a reliable accounting and billing system, ISPs can't survive. For this reason every ISP uses some sort of "home-made" or ready-to-use ISP billing and accounting system. There are some good ISP systems currently available in the market. The aim of this project was to design an ISP system that makes improvements (like full Web integration, support for most widely used three authentication mechanism (Radius, TACACS and NetBlazer), SSL security, integration of these properties with UNIX's reliability) especially for Turkish ISPs.

To make ISP billing and accounting tasks easy, secure and cost effective a Web based system is designed. The advantages of such a Web based system are numerous. First of all, this system is "universal". Everyone who has access to the Internet (no matter where he is!) can do all ISP processes (of course securely). This property is very useful especially for the system administrators. A system administrator can add/remove, enable/disable, refill, change passwords and get various information about users easily just by using a standard Web browser (also accountant staff end end-users makes proper operations in the same way). This makes management easy and practical. This system uses standard Web browsers (Netscape, Explorer etc.), which are available in almost all of the popular operating systems (like Windows 95/98/NT, UNIX, OS/2, MacOS, etc.) so no client development and installation is necessary. This makes ISP processes cost effective and easy. In this project, full Web integration is sustained and advantages of using a Web based system is used. The another advantage of this system is that, when a modification or new component is added to the ISP accounting system, there is no need to develop a proper client, since the front-end is a standard Web browser for all users.



Most of the current ISP packages support either of the three authentication mechanisms (Radius, TACACS and NetBlazer). An ISP environment sometimes might be more complex and might need to use both or three of them. In this project all of the three authentication mechanism is supported concurrently, so, most of the ISPs might use this project without further investment and time consuming tasks. Since all of the accounting system is designed in a modular manner new authentication mechanisms can be embedded to the system easily. This property makes the overall system "open" for future needs.

When it is necessary to transfer some valuable data (like ISP data), security concerns must be overcome. In this project, Secure Socket Layer (SSL) is used in all of the transactions (in all administrative, accountant and end-user processes). This made overall system much more secure.

All these valuable and important processes must be carried out in a reliable server and OS. For this reason, all these staff is carried out in UNIX environment. The other advantage of using UNIX as an ISP development and serving environment is that, due to its nature, UNIX is a open system and, with minimal changes, all of the system can be ported to different UNIX clones easily.

Most of the commercial ISP packages available in the market are completely in English, so especially end-users have some problems in using the services. This ISP system is written totally in Turkish and supports Turkish character set. This property made the system more user-friendlier and practical, especially for Turkish Internet users.

6.2 Limitations And Future Work

This ISP accounting and billing system is designed for the UNIX systems that use shadow or non-shadow password system (support both). But is not designed for the UNIX systems that use C2 level security. Future work can be done to include support for C2 level security.

In this thesis, there were mainly three parts: Administrative, accountant and end-user side. In addition to these sides, a new part for ISP's decision makers might be

added. In this part, overall trends, overall money transections might be presented especially for bosses. This new part can be added to current ISP system just by adding a new module. Future work can be done to include this property.

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