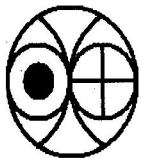


**PRL Technical Note**

**Optimization of Internet Bandwidth  
Utilization**

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# 1. Introduction

The beginnings of Internet connectivity on PRL desktops can be traced to the E-mail facility first configured around 1988-1989 on a Nexas-Apollo 3500 machine. UUCP (Unix to Unix Communication Protocol) on a telephone dial-up line of 9.6Kbps under Sys-V(UNIX) operating system was made operational. This facility was immediately and extensively used by scientific and technical members of PRL. In order to reduce operating costs scripts were written for Auto-Dialing during late night hours to the NCST gateway at Bombay for sending and receiving the electronic mail. As at that time there was no LAN in PRL physical transfer of mails from and to mail-server machine using external media was common. This scenario drastically changed in 1993 after installation of IBM RS-6000/580 machines with a 10 Mbps LAN. Simultaneously, PRL subscribed to DOE - ERNET using their VSAT hub at Bangalore. All these developments brought about dramatic changes in functionality and E-mails, telnet and file transfer facility etc., become available on individual desktops.

The whole of the World Wide Web soon opened up and the bandwidth provided by ERNET VSAT connection was found to be insufficient. PRL then moved on to a 128 Kbps leased line connectivity provided by a local Internet Service Provider (ISP). This bandwidth too soon proved insufficient. This was because of ever increasing need of our scientists as well as the increase of more and more functions provided on the Internet, for example, electronic journals, access to scientific data bases, image files, etc. Furthermore, many of our scientists have both national and international collaborative programmes requiring very large amount of data exchange. Some scientists also use, both nationally and internationally, computers at remote locations for numerical calculations. As the bandwidth requirement was ever increasing, it was thought appropriate to study the usage pattern and then to optimize bandwidth utilization. Such a study required detailed usage statistics by individual users, knowledge of type of data files transferred, size of downloaded research/library material, freeware or third party software, propriety software updates

for our computers. Another important component was information about bandwidth usage frequency during twenty - four hours period.

In the following report we describe various tools used and specially configured to meet our needs. We also give examples of reports obtained. This data then provides a basis for optimization of bandwidth and also for planning future needs. It is felt that this report may be of use to other institutions of a type similar to PRL for bandwidth optimization and its management.



## 2. Internet connectivity

### 2.1 Introduction:

As mentioned before almost all computers in PRL are now connected to the 100 Mbps/1000 Mbps PRL local area network (LAN). In addition, the Thaltej Campus, Mt. Abu Observatory and the Udaipur Solar Observatory are also connected to the PRL-LAN. Details of PRL LAN set up and Internet connectivity are shown in Figure 1. In order that these computers can connect with computers outside of the PRL – LAN they are routed through a router. In case the computers are used to download/upload web objects they access the router and hence the Internet service provider (ISP) via a proxy server. It may be noted in passing that each of the computers on the PRL – LAN may be configured in such a way that each machine can connect to the web independently. This has obvious security problems and moreover, in such a case, bandwidth optimization is extremely difficult and expensive. As Internet bandwidth is a limited resource simply adding more bandwidth to the Internet backbone is not the solution. By storing frequently accessed content at a location closer to the user, a great deal of latency and unpredictable delay in the Internet can be eliminated. This technique is known as **caching**. This saves bandwidth on the Internet connection. For an organization, proxy caching reduces the bandwidth consumption, as sometimes, the same web pages are accessed by several of its users. For example, at PRL, the journal Nature [[www.nature.com](http://www.nature.com)], the American Physical Society web pages [[www.aps.org](http://www.aps.org)] or the web pages of Science Direct [[www.sciencedirect.com](http://www.sciencedirect.com)] are daily accessed by several PRL users. It is for these reasons it was considered optimal to connect the LAN via a proxy server. There are various solutions, both hardware and software, available for bandwidth management which some are available freely and some are commercial. For example, some commercial solutions are:

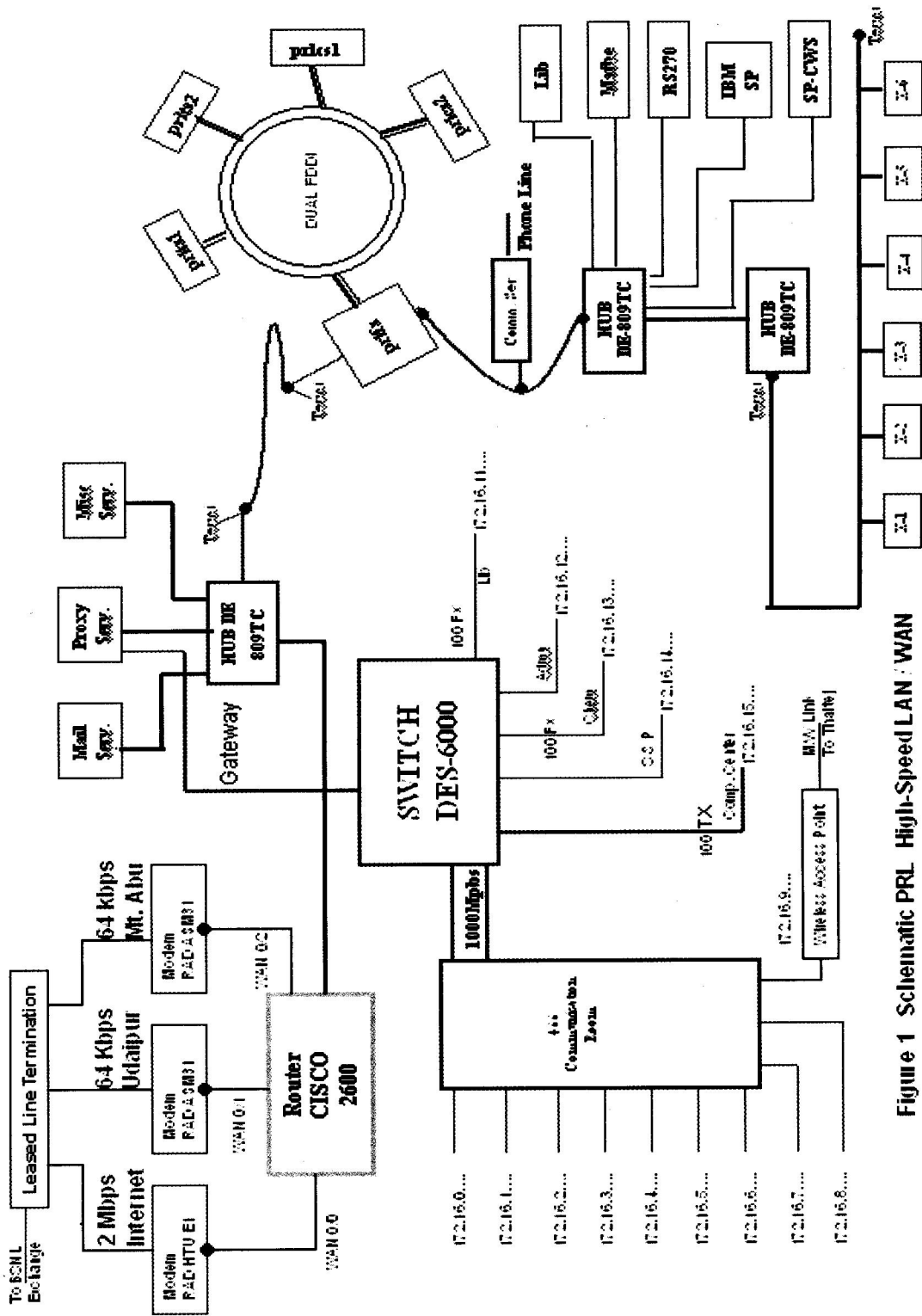


Figure 1 Schematic PRL High-Speed LAN/WAN

- **Sun Open Net Environment Web Proxy Server:**

[http://www.sun.com/software/product/web\\_proxy/home\\_web\\_proxy.html](http://www.sun.com/software/product/web_proxy/home_web_proxy.html)

*Cost:* US \$5000.00/CPU

*Operating System:*

- Sun Solaris 9, 8, and 2.6 Operating Systems (SPARC® Platform Edition)
- Hewlett-Packard HP-UX 11.0
- IBM AIX 4.3.3
- Windows NT 4 Service Pack 6
- Windows 2000 Server Service Pack 1
- Windows 2000 Advanced Server

- **WinProxy5.1:**

[http://www.winproxy.com/english/products/WinProxy/pd\\_Winproxy\\_en.asp](http://www.winproxy.com/english/products/WinProxy/pd_Winproxy_en.asp)

*Cost:* US \$799.95 Unlimited User

*Operating System:*

- Microsoft Windows 95, 98, NT, 2000, ME, XP

- **Automatic Bandwidth Manager:**

<http://www.powernoc.net>

*Cost:* US \$599.00

*Operating System:* Current Version of Red Hat Linux

We begin by describing some essential proxy server features and requirements. We then report in details on our implementation of the *open source* proxy server software.

## 2.2 Proxy Server Implementation:

A fundamental point in proxy deployment is how to deliver requests to the proxy. Basically there are two types of proxy deployment modes.

1. **Transparent proxy mode:** It relies on some network element (a router or a switch) to intercept all traffic from web clients to web servers and divert it to a proxy server instead of its actual destination.
2. **Nontransparent proxy mode:** It refers to deployment in which client software is made aware of the proxy's existence. This type of proxy deployment is also known as explicit proxy. There are different ways of making clients aware of the nontransparent proxy.

We have found that the nontransparent proxy mode is suitable for our setup and hence we shall not further discuss the transparent proxy mode. There are several different ways of making clients aware of the nontransparent proxy. In particular, the ***Explicit Client Configuration*** has been implemented at PRL. It has the following features:

- It is flexible to use. User can bypass the proxy, by simply changing their browser configuration in the dial connectivity mode.
- The server can be deployed at any convenient place on the network.

An important issue related with proxy deployment is about security. Proxies are generally high-performance, well-connected computers running software. This makes them prime candidates for hackers to break into and thus to access any machine on the LAN. The other issue is the security of client browsing the web. The Secure Socket Layer (SSL) protocol is generally used to secure traffic between a client and a web server and requires a proxy server.

## 2.3 Proxy Software:

As we discussed, several commercial web proxy servers and bandwidth management tools are available in market. But among *Open Source* proxy server software, *Squid* software is most suitable for our requirements. *Squid* software is copyrighted by the University of California San Diego and is licensed under the terms of the GNU General Public License. The proxy server running *Squid* software is optimal due to the following reasons:

- (1) It is free and easy to install and maintain and since it is *Open Source* Software its upgrades and patches are easily available.
- (2) It is Linux / Unix based and thus, in general, has less security and virus problems.
- (3) It supports SSL.
- (4) Logging of clients and access to the Internet reports and statistics.
- (5) It allows External web access control.
- (6) *WEBMIN*<sup>[4]</sup> configuration tool allow *Squid* to be employed for bandwidth optimization.

## 2.4 Squid implementation:

*Squid* implementation requires the following minimum hardware and software requirement on the server:

### Hardware:

- P-IV, 2GHz or Better
- 256 MB RAM
- 80 GB SCSI HDD
- Two Ethernet Cards (10/100/1000 Mbps)
- 24 GB DAT Drive
- CD-R/W Drive

**Software:**

The *Squid* software is designed to operate on any of the following operating systems:

- Linux
- Free BSD
- HP-UX
- AIX
- SunOS/Solaris
- SCO Unix
- MAC OS/X

While choosing the flavor of Linux, the kernel version plays an important role. The minimum kernel version should be 2.4x. PRL proxy server is currently running on Red Hat Linux 7.1 (Kernel Version 2.4).

**2.5 Compilation of *Squid* software:**

In *Appendix I* we give details of downloading, extracting and compilation of this software.

***Squid* Configuration :**

All the *Squid* configuration files are kept in the directory, "/usr/local/src/squid/etc". The "squid.conf" file is used for proxy server configuration. For basic configuration see *Appendix II*.

**Authentication:**

The *Squid* source code comes with a few authentication programs. PRL proxy server is currently configured with NCSA authentication program. Further configuration details are given in *Appendix III*.

**Access Control List:**

For the access of Internet environment a level of access control system is required. ACL allows the following:

- Allow/Deny based on username and password
- Allow/Deny access based on Time of Day, day of week, date etc...
- Allow/Deny from listed MAC address.
- Bandwidth allocation based on IP address, file extension, URL etc...
- Allow/Deny access based on port number, protocol etc...
- Allow/Deny access to some URLs.

Further details are given in *Appendix IV*

In order to remotely manage the system using *Squid* we have also configured a third party software know as Webmin <sup>[4]</sup>. This is freely downloadable from the Internet.

## 2.6 Options Implemented At PRL:

The PRL proxy server is currently configured with the following access rules:

- (1) Allow/Block specific IP address: This is used to check IP address of client's machine and based on the rule it allows/deny Internet access.
- (2) User Authentication : This is used to check the username and password. Based on correct username and password it allows Internet access [*Appendix -V*].
- (3) Access Time :This is used to define access time for specific *users* [*Appendix -VI*].
- (4) Allow/Block URLs : This is used to blocked URL based on keyword and key phrases [*Appendix -VII*].
- (5) Bandwidth Allocation : Bandwidth can be allocated to a specific IP address, to a specific file type ( for example, \*.jpg, \*.gif file type) and even to a specific URL . A tag, 'delay pools', is used to allocate a bandwidth at individual level or at group level.

The following rules can also be implemented and this is being done.

- (1) **Allow/Block specific MAC address**: This works on MAC address rather than IP address.
- (2) **Virus Scan**: By integrating public domain software “*viralator*” and appropriate third party virus scanner, all downloads will be scanned on the proxy server.

## 2.7 Squid/Proxy Log Analysis :

A crucial task for the system administrator is the log analysis. For *Squid* log analysis, we have written some programmes in PERL which give outputs in the following format :

- Daily Internet Usage and Top 10 users of the day [*Appendix -VIII*]
- Daily Internet Usages of all divisions [*Appendix -IX*]

In addition, the following public domain software *SARG* is employed and gives a more detailed analysis of the access log analysis and gives,

- Daily Internet usage [*Appendix -X*]
- Internet usages of users (total accessed time, byte transferred, Internet used time etc.) [*Appendix -XI*]
- Hourly bytes transferred by a user [*Appendix -XII*]
- Top accessed web sites daily [*Appendix -XIII*]
- Daily Internet usage—September 2003 [*Appendix-XIV*]
- Typical Internet usage [*Appendix-XV*]



### **3.Security Aspects**

The configuration described in this report integrates well with the security policy including firewall and IDS. In fact proxy server acts as a kind of firewall, which isolates the entire internal network. Our proxy server is the only machine, which is connected to the Internet. It has well defined rules for other services/machines to protect, detect and isolate our LAN. We also use TCP-wrappers for additional security. Proxy server runs only a proxy application. It has no user accounts and all TCP-ports are disabled. Thus, to reiterate, deployment of this proxy configuration not only integrates well with security, but also enhances it by providing isolation, detection and auditing functions. Our proxy server allows access only from inside the protected network but is completely inaccessible from outside. This means no server from outside can talk or make connection to the inside machines. A powerful feature of Squid/Proxy is Access Control List (ACL) as discussed. We have configured ACL to suitably implement our security policy to define subset of IP address, ports, protocols, destination URL's etc. Our experience over last few years in using this is very encouraging. We have thus been able to provide optimal service within our security policy framework, which is appropriate to a basic science and research institution like PRL.

## 4. Conclusion

This report has outlined the method of implementing *Squid* in the *Nontransparent* proxy mode. This method has advantages as discussed earlier, however, the choice proxy deployment mode is left to the implementation team. Proxy server generates data which can form the basis on which Internet bandwidth management policy can be guided. For example, for a scientific research laboratory, priority may be given to a particular research project for a specified time window. Also policy can be formed for cases where clearly large bandwidth is required at specific times of the day (e.g. downloading of some live experimental data etc.). Longer term trends of bandwidth usage may be analyzed which helps in appropriate future planning. Bandwidth management technologies optimize bandwidth consumption and there is no need to increase bandwidth until necessary. Finally, bandwidth management technologies can improve users satisfaction by ensuring that all users get their required share of network bandwidth.

## 5. Acknowledgements

My special thanks to Mr. G.G. Dholakia for in-depth technical discussions during this work and for his critical comments and suggestions during the preparation of this report. I am indebted to Prof. V.B. Sheorey, for encouragement, support and guidance. Mr. A.D. Bobra, helped with his comments and suggestions as also my colleagues, Mr. Tajender Ahuja and Mr. Dinesh Mehta, their contributions are gratefully acknowledged.

## 6. References

- [1] *A internal technical report on design and implementation of the new high speed LAN at PRL by Bobra, A. D., 2002*
- [2] *Squid Home Page* : <http://www.squid-cache.org>
- [3] *Web Caching And Replication*, by Michael Rabinovich and Oliver Spatscheck, Addison-Wesley
- [4] *Webmin Home Page* : <http://www.webmin.com>

## 7. Glossary

ACL	- Access Control List
DOE	- Department of Electronics
ERNET	- Education and Research Network
ISP	- Internet Service Provider
LAN	- Local Area Network
MAC	- Medium Access Control
NCST	- National Center for Software Technology, Mumbai
RAID	- Redundant Array Of Independent Disks
SSL	- Secure Socket Layer
URL	- Uniform Resource Locator
UUCP	- Unix to Unix Communication Protocol

# Appendix - I

## Downloading and compiling Squid:

- Download a source archive file of the form Squid-x.y.z-src.tar.gz (For Example, Squid-2.4.STABLE6-src.tar.gz) i.e. latest version from <http://www.squid-cache.org/Versions/v2/2.5/>
- Untar the file and change working directory and give following commands
  - i) ./configure. For further detail use ./configure --help
  - ii) make
  - iii) make install

# Appendix - II

Some basic Configuration has to be done in squid.conf file.

## ***HTTP port:***

The first option in the “squid.conf” file sets the HTTP port (1) that Squid will listen to for incoming request, default is 3128.

```
http -port 3128
```

*(Any port number may be selected but it must not be assigned to any other service)*

## ***Storage of cache data:***

The cache-dir operator in the squid.conf file is used to specify storage areas for this data.

## ***Effective User and Group:***

Make sure that you have created squid user and group.

```
Cache_effective_user squid
```

```
Cache_effective_group squid
```

## ***Http\_access:***

Default configuration deny all access. It should be allowed to the users.

```
http_access allow all
```

## Appendix - III

Open "squid.conf" file and modify the below line

```
authenticate_program /usr/local/src/squid/bin/ncsa_auth    /usr/local/etc/password  
authenticate_children 25
```

# Appendix - IV

Some typical examples of configurations are given:

- **Access to a specific IP address:**

```
acl local src 172.16.0.0/255.255.0.0
http_access allow local
http_access deny all
```

- **Access to some users for 24 hours and to some for limited period:**

```
acl limited proxy_auth_regex "/usr/local/squid/limited"
acl office time 16:00-18:00
acl pass proxy_auth_regex "/usr/local/squid/fulltime"

http_access allow limited office
http_access allow pass
http_access deny limited
```

*(Rules are read from top to bottom. The first rule matched will be used. Other rules won't be applied)*

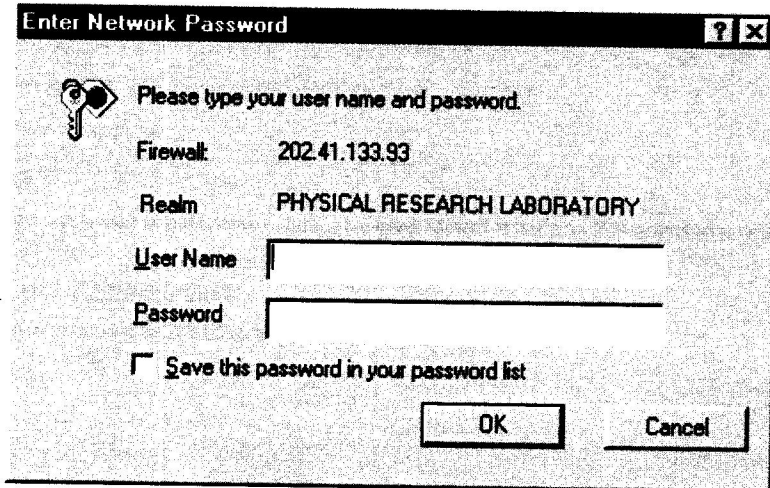
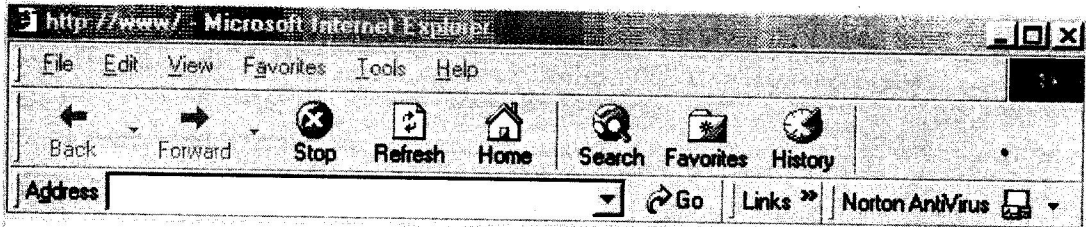
For example:

```
acl morning time 08:00-11:30
acl lunch time 12:30-14:30

http_access allow xyz morning
http_access deny xyz
http_access allow xyz lunch
```

If xyz tries to access something in the morning(during specified time, access will be granted. But if he tries to access something at lunchtime, access will be denied. It will be denied by the deny xyz rule, that was matched before the 'xyz lunch' rule.

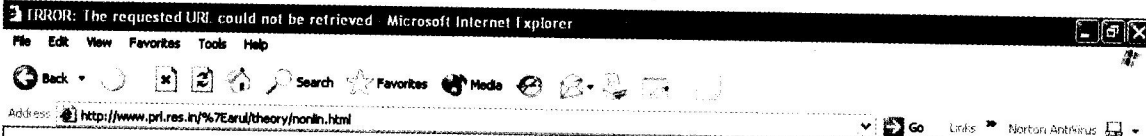
# Appendix - V



Connecting to site www



# Appendix - VI



## ERROR

### The requested URL could not be retrieved

While trying to retrieve the URL: <http://www.prl.res.in/%7Earu/theory/nonlin.html>

The following error was encountered:

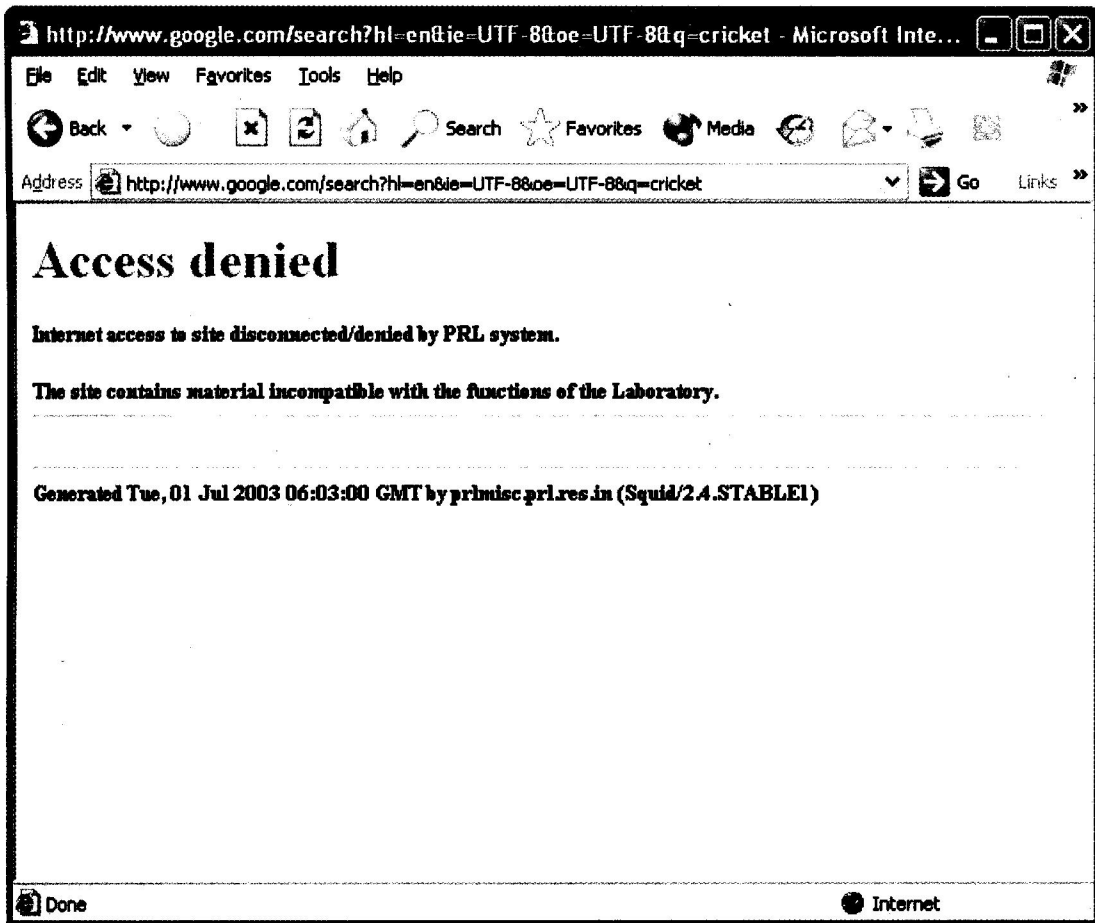
- **Access Denied.**

Access control configuration prevents your request from being allowed at this time. Please contact your service provider if you feel this is incorrect.

Your cache administrator is [www@prl.ernet.in](http://www.prl.ernet.in).

Generated Mon, 20 Oct 2003 10:47:32 GMT by prlmisc.prl.res.in (Squid/2.4.STABLE1)

# Appendix - VII



## Appendix -VIII

### Daily Internet Usage and Top 10 Users

Username	Bytes	Sun	Jun	1	TotalBytes	449.5925	MB
user1	2.45E+08						
user2	17853075						
user3	16551083						
user4	14403888						
user5	10660945						
user6	10414999						
user7	10182707						
user8	9094725						
user9	9008371						
user10	8467256						

Username	Bytes	Mon	Jun	2	TotalBytes	811.8792	MB
user1	88401626						
user2	25621712						
user3	21648706						
user4	20670449						
user5	19272231						
user6	16681659						
user7	15077080						
user8	14351556						
user9	13493938						
user10	12940037						

Username	Bytes	Tue	Jun	3	TotalBytes	1253.667	MB
user1	3.59E+08						
user2	1.75E+08						
user3	32591393						
user4	24979431						
user5	23258893						
user6	21306504						
user7	18922026						
user8	18445715						
user9	15834700						
user10	15174405						

Username	Bytes	Wed	Jun	4	TotalBytes	1125.712	MB
user1	1.78E+08						
user2	82097457						
user3	76356985						
user4	37451074						
user5	32766702						
user6	24131789						
user7	21296127						
user8	18843372						
user9	16001349						
user10	13919135						

# Appendix -IX

## TYPICAL OUTPUT FOR DAILY INTERNET USAGE

Department 1	
USER	BYTES
User1	1374167
User 2	0
User 3	158775
User 4	0
User 5	7975370
User 6	6695599
User 7	2695320
User 8	3397661
User 9	87983
User 10	0
User 11	0
User 12	0
User 13	0
User 14	0
User 15	0
User 16	2306
User 17	3235822
User 18	0
User 19	712164
User 20	7337693
User 21	3797776
User 22	0
User 23	0
User 24	18547593
User 25	0
User 26	0
User 28	11312217
User 29	10970556
User 30	0
User 31	56526684
User 32	0
User 33	0

Department 2	
USER	BYTES
User1	0
User 2	0
User 3	0
User 4	0
User 5	99055
User 6	0
User 7	334554
User 8	0
User 9	5148051
User 10	404746
User 11	10555446
User 12	4603444
User 13	3403579
User 14	294
User 15	0
User 16	0
User 17	3344193
User 18	13379414
User 19	6299113
User 20	1823944

Department 5	
User1	1652008
User 2	1437286
User 3	3831494
User 4	252073
User 5	0
User 6	0
User 7	2283470
User 8	60258
User 9	0
User 10	4026103
User 11	208727
User 12	837719

Department 3	
User1	2653681
User 2	0
User 3	0

Department 4	
User1	652923
User 2	0
User 3	2016941
User 4	547987
User 5	0
User 6	0
User 7	464207
User 8	6541643
User 9	0
User 10	490774
User 11	10891432
User 12	1613497
User 13	3944563
User 14	3841690
User 15	0
User 16	0
User 17	0
User 18	0

Department 6	
User1	0
User 2	596813
User 3	1625

# Appendix - X

## SARG report : Total usage

FILE/PERIOD	CREATION DATE	USERS	BYTES	AVERAGE
<u>2003Jun16-2003Jun17</u>	Tue Jun 17 12:15:36 IST 2003	405	1.247.399.944	3.079.999

# Appendix - XI

Period: 2003Jun16-2003Jun17

## SARG report: Top 10 users

NUM	USERID	CONNECT	BYTES	%BYTES	IN-CACHE- OUT	USED TIME	MILISEC	%TIME
1	date/time User1	10.551	339.775.274	27.24%	5.71% 94.29%	12:30:49	45.049.289	12.14%
2	date/time User2	2.518	56.526.684	4.53%	4.12% 95.88%	03:59:32	14.372.481	3.87%
3	date/time User3	6.380	46.568.638	3.73%	3.92% 96.08%	03:28:26	12.506.333	3.37%
4	date/time User4	248	32.436.963	2.60%	0.33% 99.67%	01:55:04	6.904.388	1.86%
5	date/time User5	1.346	23.055.472	1.85%	39.11% 60.89%	02:07:49	7.669.864	2.07%
6	date/time User6	1.630	20.285.807	1.63%	4.06% 95.94%	02:04:11	7.451.940	2.01%
7	date/time User7	1.965	19.633.307	1.57%	9.24% 90.76%	03:43:42	13.422.567	3.62%
8	date/time User8	1.829	18.547.593	1.49%	6.12% 93.88%	02:17:56	8.276.894	2.23%
9	date/time User9	888	15.631.447	1.25%	21.78% 78.22%	00:56:18	3.378.169	0.91%
10	date/time User10	1.216	15.234.381	1.22%	9.84% 90.16%	00:58:52	3.532.795	0.95%

## Appendix - XII

### SARG report-Hourly User Access Report

Period: 2003Jun16-2003Jun17

User: User1

	00 BYTES	01 BYTES	02 BYTES	03 BYTES	04 BYTES	05 BYTES	06 BYTES	07 BYTES	08 BYTES	09 BYTES	10 BYTES	11 BYTES	12 BYTES
06/17/2003	0	0	0	0	0	0	0	0	0	5.975.417	6.145.587	8.228.334	70.005.742
TOTAL	0	0	0	0	0	0	0	0	0	5.975.417	6.145.587	8.228.334	70.005.742

13 BYTES	14 BYTES	15 BYTES	16 BYTES	17 BYTES	18 BYTES	19 BYTES	20 BYTES	21 BYTES	22 BYTES	23 BYTES	TOTAL BYTES
4.899.622	21.446.364	15.212.976	9.600.603	14.669.721	10.462.492	8.078.248	2.427.660	161.199.427	0	1.423.081	339.775.274
4.899.622	21.446.364	15.212.976	9.600.603	14.669.721	10.462.492	8.078.248	2.427.660	161.199.427	0	1.423.081	339.775.274

## Appendix - XIII

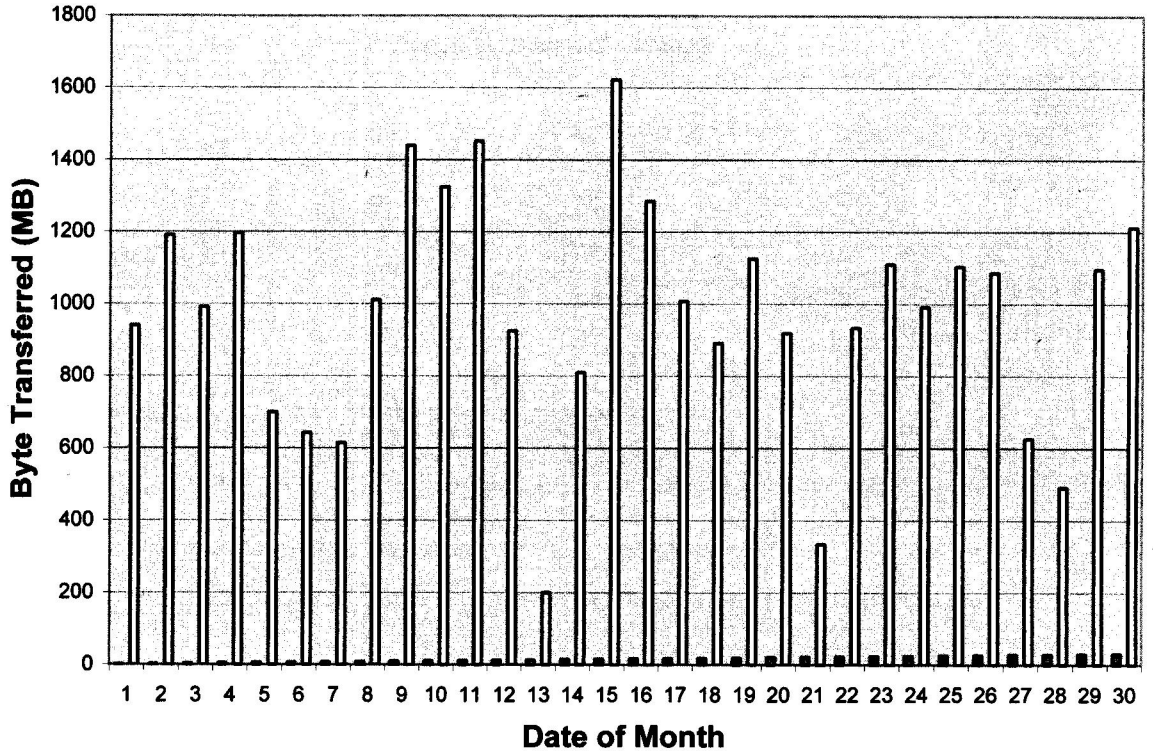
### SARG report- Top sites contacted

Period: 2003Jun16-2003Jun17

	ACCESSED SITE	CONNECT	BYTES
1	www.tradeexit.com	18.457	25.839.800
2	gatorcme.gator.com	17.071	25.606.132
3	www.google.com	3.075	15.710.905
4	us.i1.yimg.com	2.990	2.734.809
5	www.sciencedirect.com	2.660	38.886.532
6	shttp.msg.yahoo.com	2.604	1.612.459
7	www.prl.ernet.in	2.587	21.181.149
8	images.google.com	2.486	11.065.576
9	bannerserver.gator.com	1.958	2.553.060
10	us.js1.yimg.com	1.752	1.489.887
11	immail.rediff.com	1.744	3.274.468
12	liveupdate.symantecliveupdate.com	1.731	17.179.960
13	liveupdate.symantec.com	1.596	2.280.651
14	channels.real.com	1.586	2.247.362
15	us.a1.yimg.com	1.524	12.629.497
16	www.nature.com	1.505	4.978.462
17	in.yimg.com	1.464	9.047.369
18	www.prl.res.in	1.200	4.939.615
19	f2mail.rediff.com	1.163	5.280.352
20	im.rediff.com	1.149	2.089.245
21	202.41.133.77	1.038	3.595.682
22	skyandtelescope.com	900	5.451.041
23	www.msn.co.in	854	3.535.054
24	www.solarviews.com	843	3.683.264
25	servedby.advertising.com	786	3.816.228
26	login.yahoo.com	776	3.590.240
27	email.indiatimes.com	699	1.903.807
28	204.177.92.204	658	927.038
29	ads.mediaturf.net	651	1.420.810
30	www.niscair.res.in	638	1.218.654

# Appendix - XIV

## Daily Internet Usage--September 2003





## Appendix - XV

### Typical Internet Usage

