Computer Networks

Lab 2 - Computer Networks

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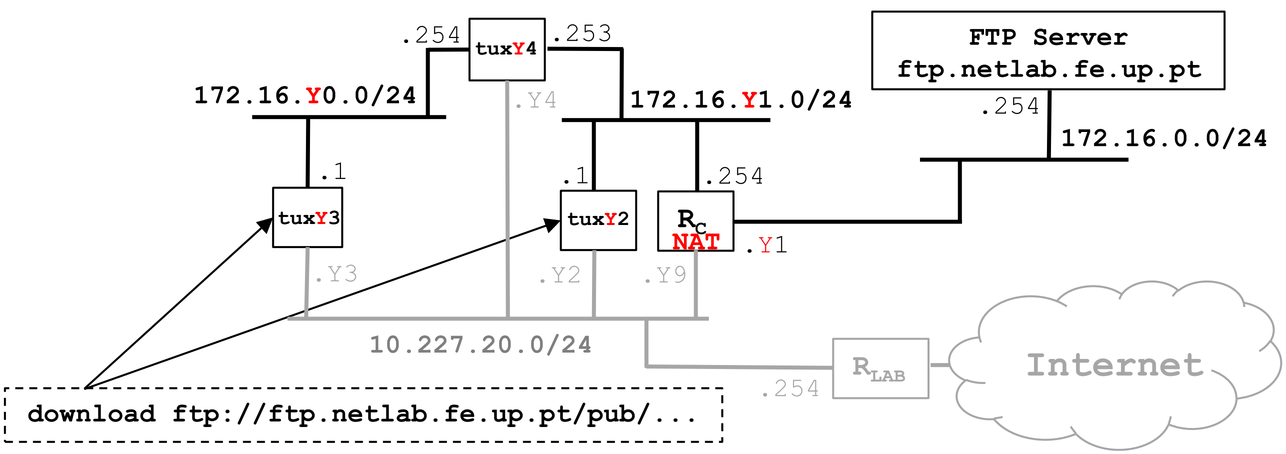
Lab Work - Two parts

- Part 1 - Development of a download application

  download ftp://ftp.netlab.fe.up.pt/pub/...

- Part 2 - Configuration and study of a computer network



Evaluation

- Organization
  - Groups of 2 students
- Evaluation criteria
  - Participation during class (continuous evaluation)
  - Presentation and demonstration of the work
  - Final report
- Demonstration of the work
  - Replicate the network topology described in Part 2 / Exp 6
  - Using different IP addresses for the VLANs (announced before the demonstration starts)

Part 1 - Development of a download application

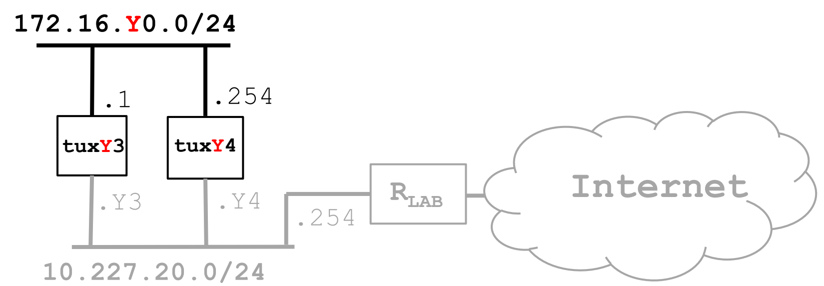
Development of an Application

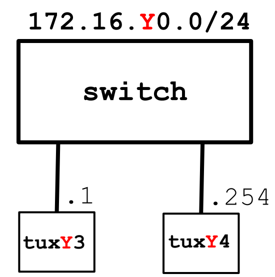
- Develop application **download ftp://ftp.netlab.fe.up.pt/pub/...**
  - Application downloads a single file
  - Implements FTP application protocol, as described in RFC959
  - Adopts URL syntax, as described in RFC1738

    ftp://[<user>:<password>@]<host>/<url-path>
- Steps
  - Experiments using Telnet application (Telnet, SMTP, POP, HTTP and FTP); focus on FTP
  - Specification/design of a download application
    - unique use case: connect, login host, passive, get path, success (file saved in CWD) or un-success (indicating failing phase)
    - challenging programming aspects: gethostbyname, sockets, control connection, passive, data connection
  - Implement a very simple FTP client at home
    - reuse existing programs: **clientTCP.c, getIP.c**
- Learning objectives
  - Describe client - server concept and its peculiarities in TCP/IP
  - Characterize application protocols in general, characterize URL, describe in detail the behaviour of FTP
  - Locate and read RFCs
  - Implement a simple FTP client in C language
  - Use sockets and TCP in C language
  - Understand service provided DNS and use it within a client program

Part 2 - Configuration and Study of a Network

Part 2 / Exp 1- Configure an IP Network

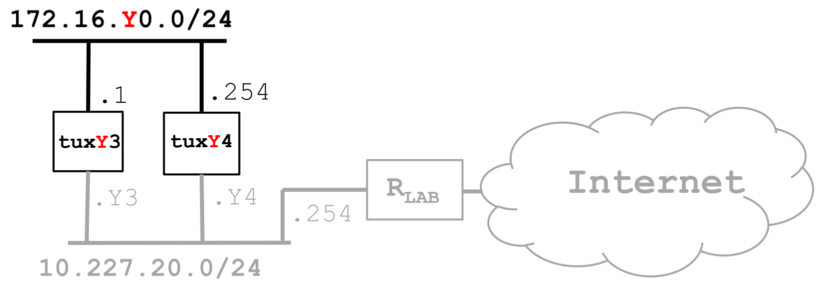


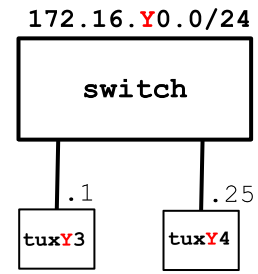


Steps

1. Connect <u>E1 of tuxY3</u> and <u>E1 of tuxY4</u> to the switch
2. Configure <u>eth1interface of tuxY3</u> and <u>eth1 interface of tuxY4</u> using **ifconfig** and **route** commands
3. Register the IP and MAC addresses of the network interfaces
4. Use **ping** command to verify connectivity between these computers
5. Inspect forwarding (***route -n***) and ARP (***arp -a***) tables
6. Delete ARP table entries in <u>tuxY3</u> (***arp -d ipaddress***)
7. Start **Wireshark** in <u>tuxY3.eth1</u> and start capturing packets
8. In <u>tuxY3</u>, **ping** <u>tuxY4</u> for a few seconds
9. Stop capturing packets
10. Save the log and study it at home

Part 2 / Exp 1- Configure an IP Network



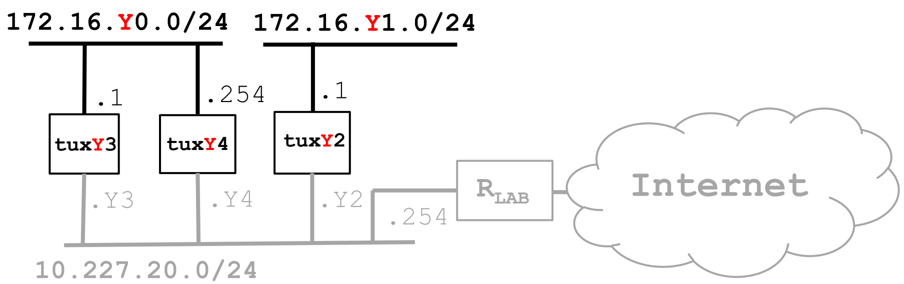


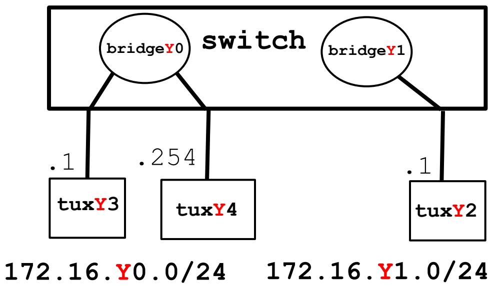
Questions

» What are the commands required to configure this experience?
» What are the ARP packets and what are they used for?
» What are the MAC and IP addresses of ARP packets and why?
» What packets does the ping command generate?
» What are the MAC and IP addresses of the ping packets?
» How to determine if a receiving Ethernet frame is ARP, IP, ICMP?
» How to determine the length of a receiving frame?
» What is the loopback interface and why is it important?

Part 2 / Exp 2 - Implement two bridges in a switch

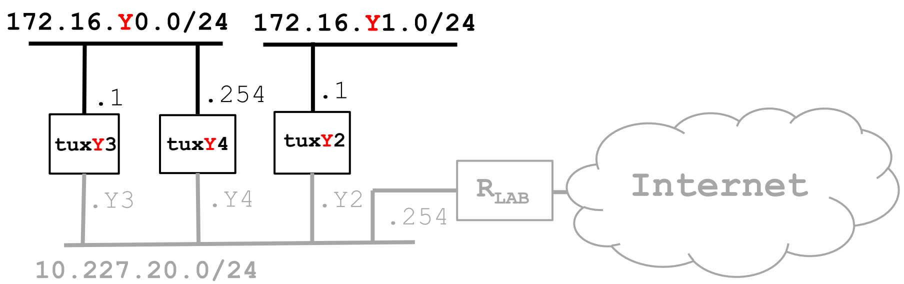
Steps

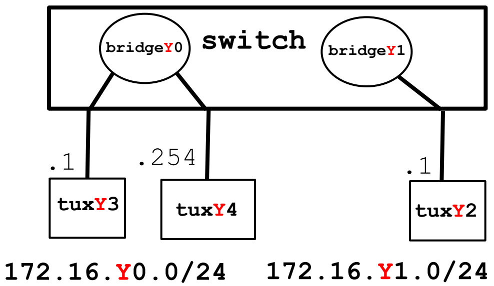




1. Connect and configure E1 of tuxY2 and register its IP and MAC addresses
2. Create two **bridges** in the switch: bridgeY0 and bridgeY1
3. Remove the ports where tuxY3, tuxY4 and tuxY2 are connected from the default bridge (***bridge***) and add them the corresponding ports to bridgeY0 and bridgeY1
4. Start the capture at tuxY3.eth1
5. In tuxY3, ping tuxY4 and then ping tuxY2
6. Stop the capture and save the log
7. Start new captures in tuxY2.eth1, tuxY3.eth1, tuxY4.eth1
8. In tuxY3, do ping broadcast ***(ping -b 172.16.Y0.255)*** for a few seconds
9. Observe the results, stop the captures and save the logs
10. Repeat **steps 7, 8** and **9**, but now do
    - ping broadcast in tuxY2 ***(ping -b 172.16.Y1.255)***

Part 2 / Exp 2 -
Implement two bridges in a switch

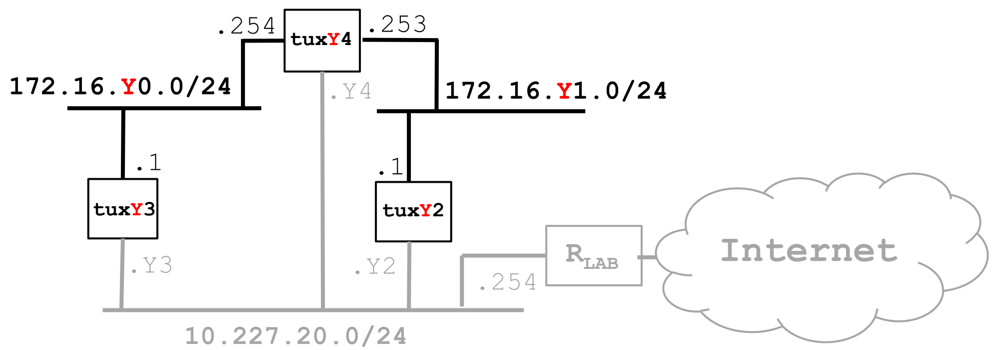


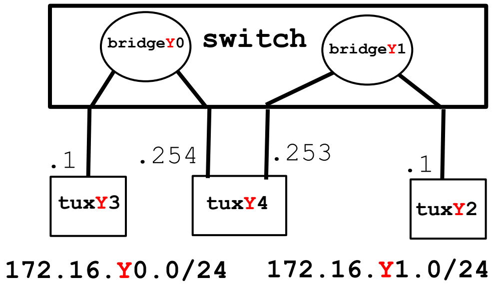


Questions

- How to configure bridgeY0?
- How many broadcast domains are there? How can you conclude it from the logs?

Part 2 / Exp 3 - Configure a Router in Linux

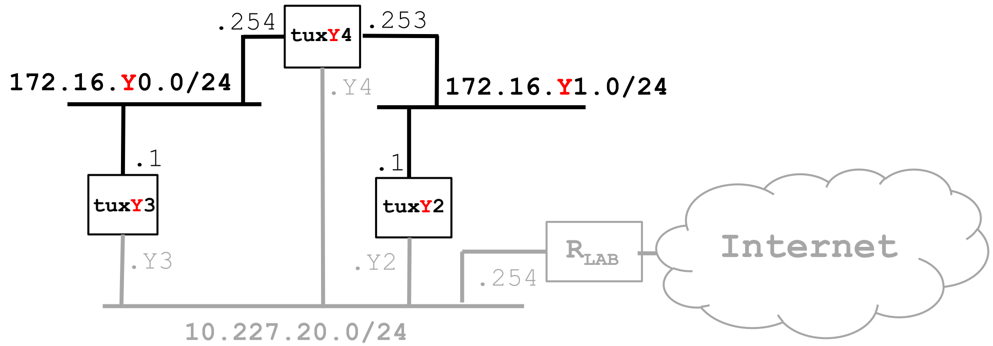


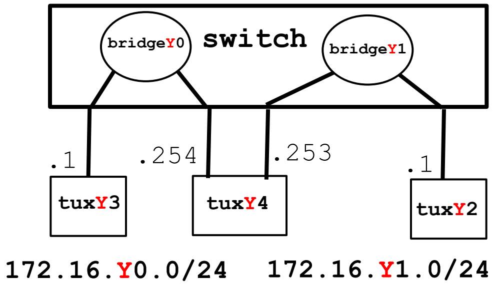


Steps

1. Transform tuxY4 (Linux) into a router
   – Configure also eth2 interface of tuxY4 and add it to bridgeY1
   – Enable IP forwarding
   – Disable ICMP echo-ignore-broadcast
2. Observe MAC addresses and IP addresses in tuxY4.eth1 and tuxY4.eth2
3. Reconfigure tuxY3 and tuxY2 so that each of them can reach the other
4. Observe the routes available at the 3 tuxes (***route -n***)
5. Start capture at tuxY3
6. From tuxY3, ping the other network interfaces (172.16.Y0.254, 172.16.Y1.253, 172.16.Y1.1) and verify if there is connectivity
7. Stop the capture and save the logs

Part 2 / Exp 3 - Configure a Router in Linux

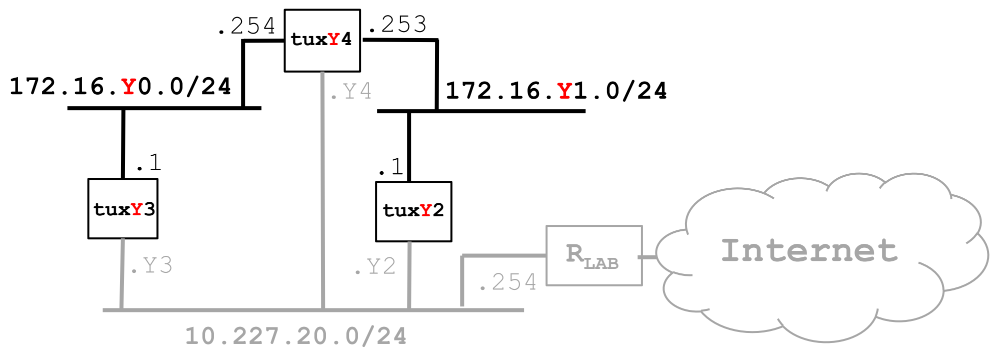


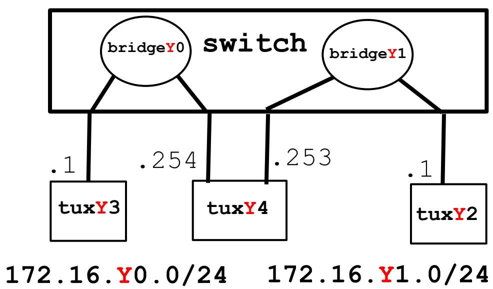


Steps

8. Start capture in tuxY4; use 2 instances of Wireshark, one per network interface
9. Clean the ARP tables in the 3 tuxes
10. In tuxY3, ping tuxY2 for a few seconds.
11. Stop captures in tuxY4 and save logs

Part 2 / Exp 3 -
Configure a Router in Linux

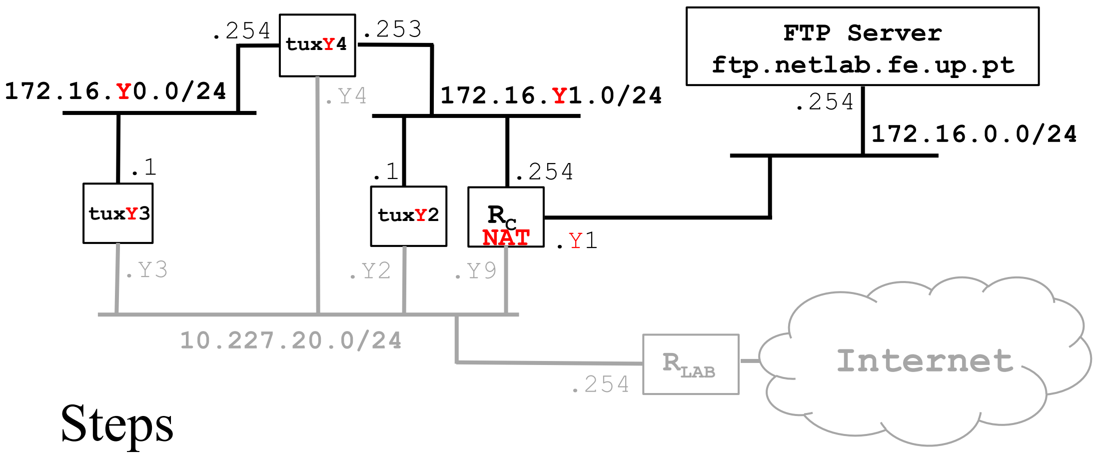


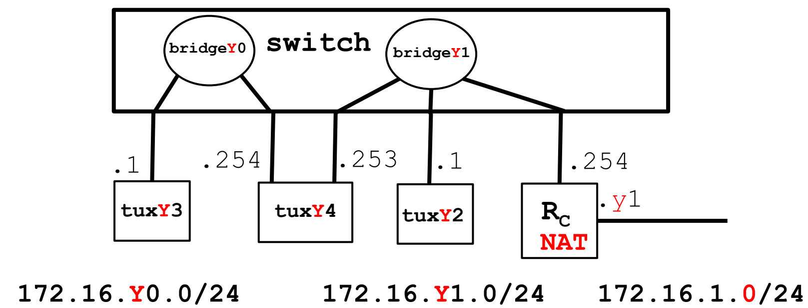


Questions

- » What are the commands required to configure this experience?
- » What routes are there in the tuxes? What are their meaning?
- » What information does an entry of the forwarding table contain?
- » What ARP messages, and associated MAC addresses, are observed and why?
- » What ICMP packets are observed and why?
- » What are the IP and MAC addresses associated to ICMP packets and why?

Part 2 / Exp 4 -
Configure a Commercial Router and Implement NAT

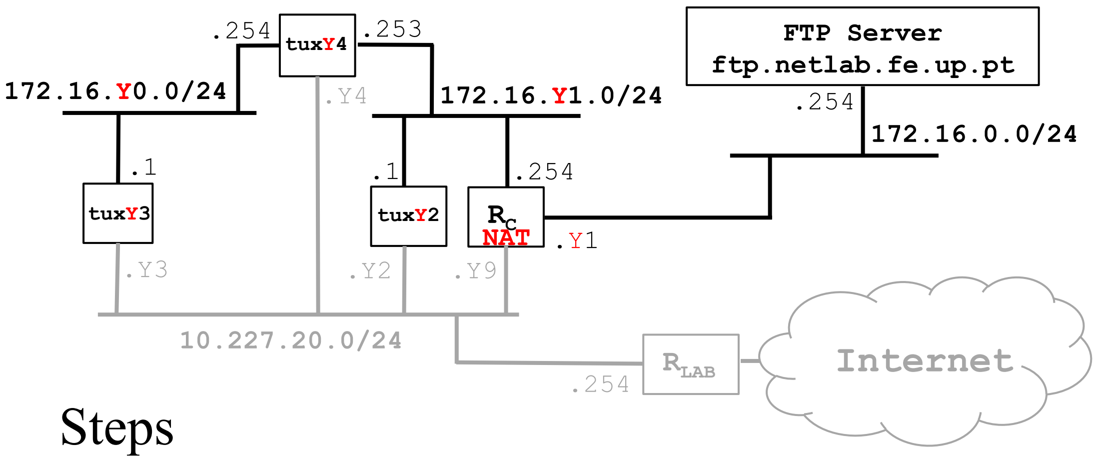


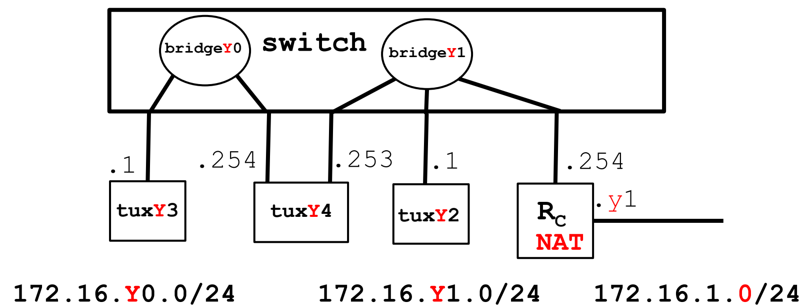


Steps

1. Connect ether1 of $\mathbf{R_C}$ to the *lab network* on **PY.12** (**with NAT enabled by default**) and ether2 of $\mathbf{R_C}$ to a port on bridgeY1. Configure the IP addresses of $\mathbf{R_C}$ through the router serial console
2. Verify routes
   – tuxY4 as **default router** of tuxY3;
   – $\mathbf{R_C}$ as **default router** for tuxY2 and tuxY4
   – in tuxY2 and $\mathbf{R_C}$ add routes for 172.16.Y0.0/24
3. Using **ping** commands and **Wireshark**, verify if tuxY3 can ping all the network interfaces of tuxY2, tuxY4 and $\mathbf{R_C}$

Part 2 / Exp 4 - Configure a Commercial Router and Implement NAT

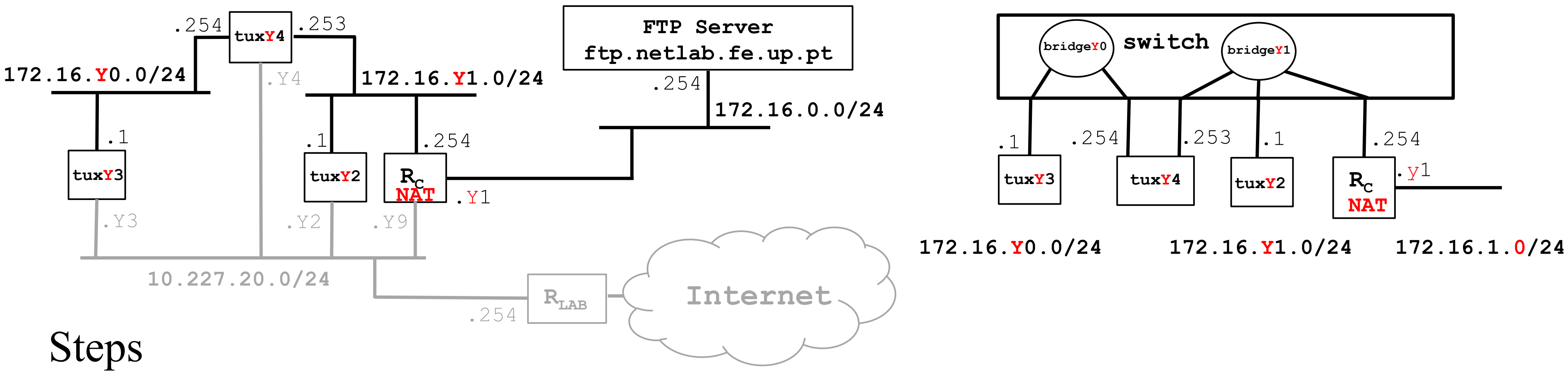




Steps

4. In tuxY2
   - Do the following:
     - *sysctl net.ipv4.conf.eth0.accept_redirects=0*
     - *sysctl net.ipv4.conf.all.accept_redirects=0*
   - remove the route to 172.16.Y0.0/24 via tuxY4
   - In tuxY2, ping tuxY3
   - Using capture at tuxY2, try to understand the path followed by ICMP ECHO and ECHO-REPLY packets (look at MAC addresses)
   - In tuxY2, do **traceroute tuxY3**
   - In tuxY2, add again the route to 172.16.Y0.0/24 via tuxY4 and do **traceroute tuxY3**
   - Activate the acceptance of ICMP redirect at tuxY2 when there is no route to 172.16.Y0.0/24 via tuxY4 and try to understand what happens

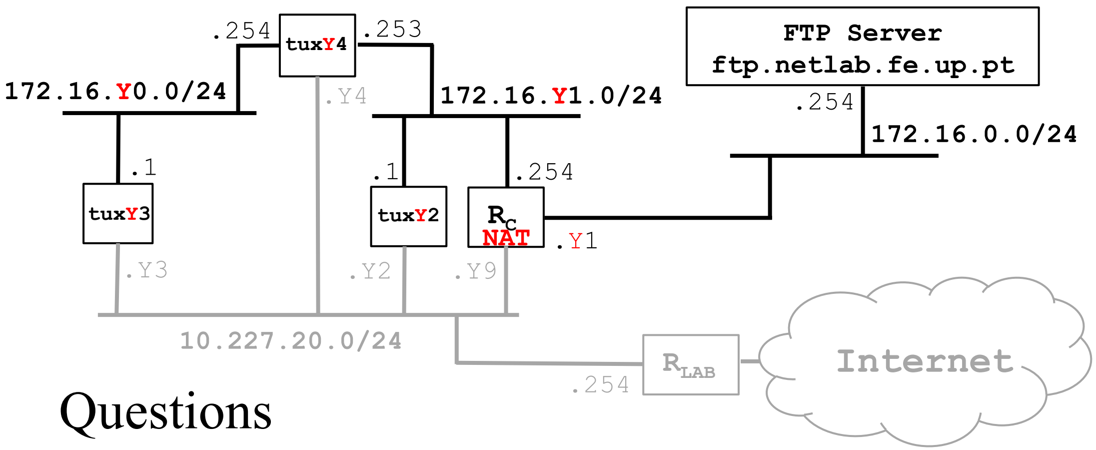
Part 2 / Exp 4 - Configure a Commercial Router and Implement NAT

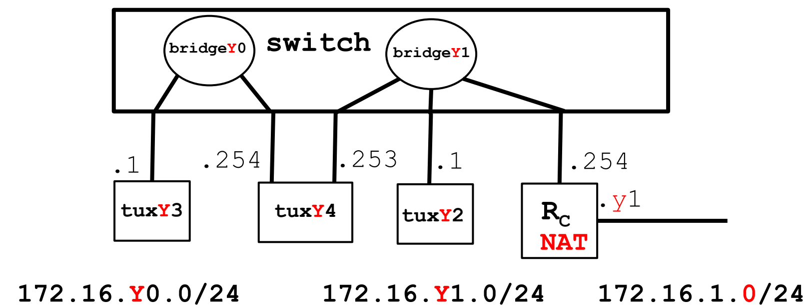


Steps

5. In <u>tuxY3</u>, ping the FTP server (172.16.1.254) and try to understand what happens
6. Disable **NAT** functionality in router $\mathbf{R_C}$
7. In <u>tuxY3</u> ping 172.16.1.254, verify if there is connectivity, and try to understand what happens

Part 2 / Exp 4 - Configure a Commercial Router and Implement NAT

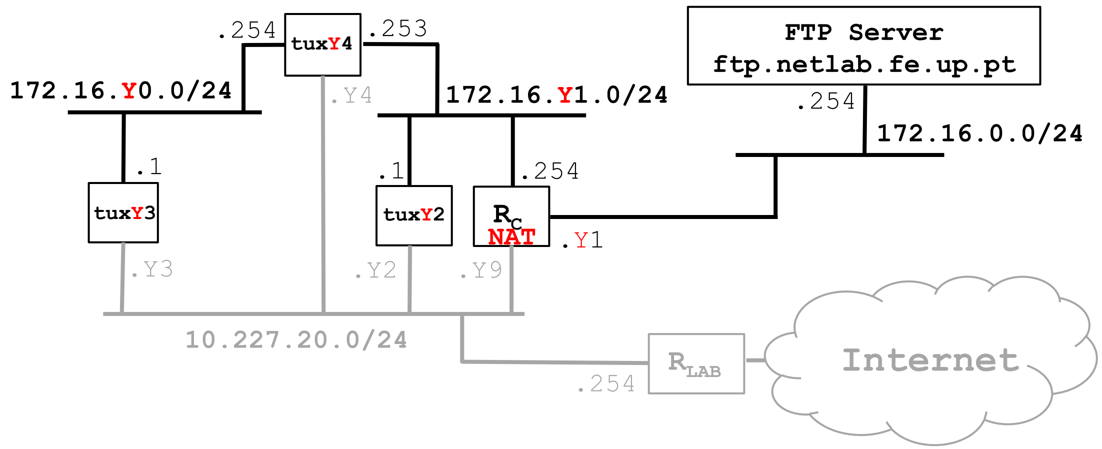




Questions

- How to configure a static route in a commercial router?
- What are the paths followed by the packets in the experiments carried out and why?
- How to configure NAT in a commercial router?
- What does NAT do?

Part 2 / Exp 5 - DNS



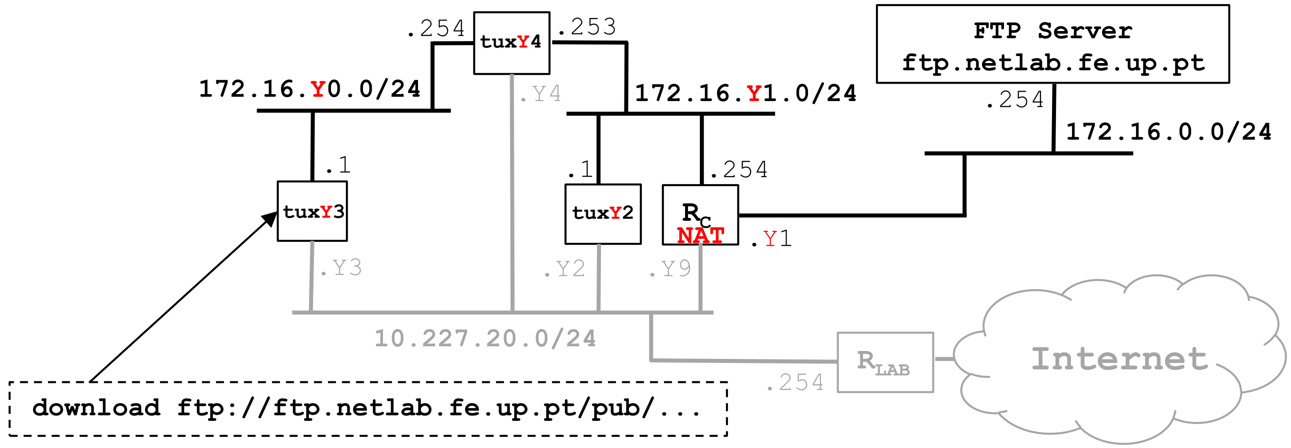
Steps

1. Configure DNS at <u>tuxY3</u>, <u>tuxY4</u>, <u>tuxY2</u>
   (use DNS server *services.netlab.fe.up.pt (10.227.20.3)*)
2. Verify if names can be used in these hosts (e.g., **ping** hostname, use browser)
3. Execute **ping (new-hostname-in-the-Internet)**; observe DNS related packets in **Wireshark**

Questions

» How to configure the DNS service in a host?
» What packets are exchanged by DNS and what information is transported

Part 2 / Exp 6 - TCP connections

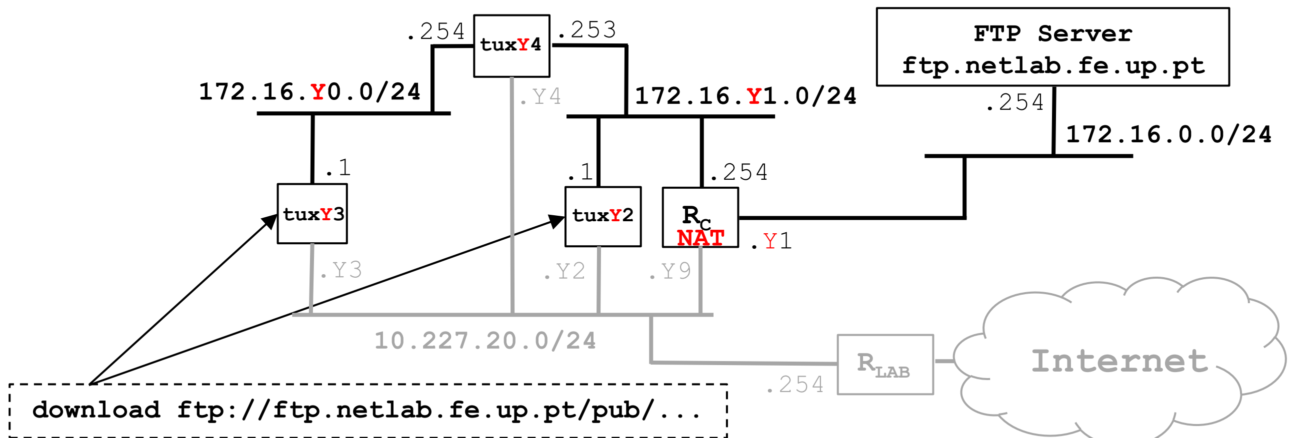


Steps

1. Compile your download application in <u>tuxY3</u>
2. In <u>tuxY3</u>, restart capturing with Wireshark and run your application
3. Verify if file has arrived correctly, stop capturing and save the log

Part 2 / Exp 6 - TCP connections

Steps



4. Using **Wireshark**, observe packets exchanged including:
   - TCP control and data connections, and its phases (establishment, data, termination)
   - Data transferred through the FTP control connection
   - TCP ARQ mechanism
   - TCP congestion control mechanism in action
   - Note: use also the Wireshark Statistics tools (menu) to study the TCP phases, ARQ and congestion control mechanism
5. Repeat the download in <u>tuxY3</u> but now, in the middle of the transfer, start a new download in <u>tuxY2</u>
   - Use the Wireshark statistics tools to understand how the throughput of a TCP connection varies along the time

Part 2 / Exp 6 - TCP connections

Questions

- » How many TCP connections are opened by your FTP application?
- » In what connection is transported the FTP control information?
- » What are the phases of a TCP connection?
- » How does the ARQ TCP mechanism work? What are the relevant TCP fields? What relevant information can be observed in the logs?
- » How does the TCP congestion control mechanism work? What are the relevant fields. How did the throughput of the data connection evolve along the time? Is it according to the TCP congestion control mechanism?
- » Is the throughput of a TCP data connections disturbed by the appearance of a second TCP connection? How?

Workplan

- 1st class - Part 1
  - » experiments using Telnet, focus on FTP
  - » usage of gethostbyname and socket functions
  - » client architecture; main use case
- 2nd class - Part 2: Steps 1 e 2
  - » linux, lab, cables, ipconfig, route, arp, wireshark, capture and log analysis
- Next classes - Part 2: Steps 2, 3, 4, 5 e 6
- Last week
  - » Demonstration of download application, downloading a file from netlab FTP server (ftp.netlab.fe.up.pt)
  - » Delivery of report (use moodle for upload)

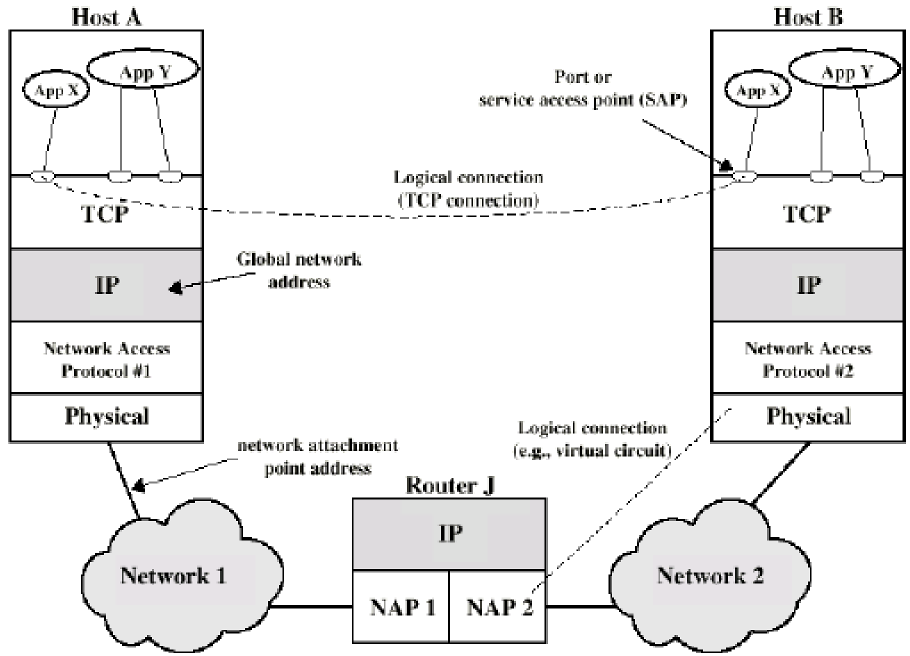
Final Report

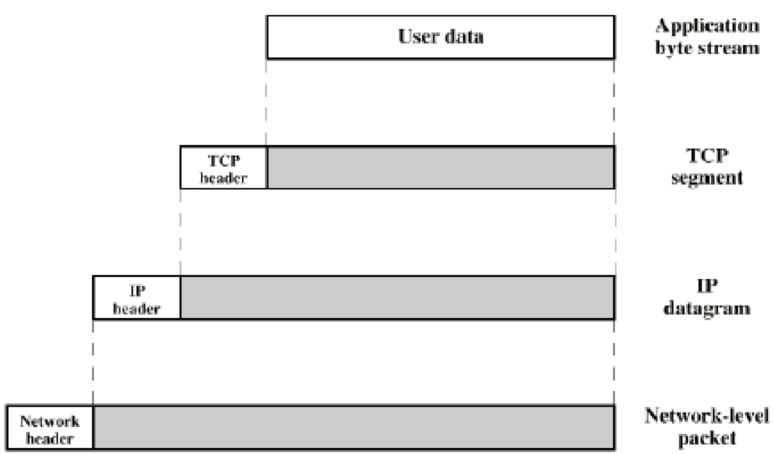
- Report must contain
  - Title, Authors, Summary
  - Introduction
  - Part 1 - Download application
    - Architecture of the download application
    - Report of a successful download, including print-screen of Wireshark logs showing the FTP packets
  - Part 2 - Network configuration and analysis
    - For each experiment (1 to 6)
      - Network architecture, experiment objectives, main configuration commands, relevant logs
      - **Analysis of the logs captured that are relevant for the learning objectives**
  - Conclusions
  - References
  - Annexes: code of the download application, configuration commands, logs captured
- Maximum length of 8 pages A4, font 11pt
- Upload through Moodle

TCP/IP and Application Protocols

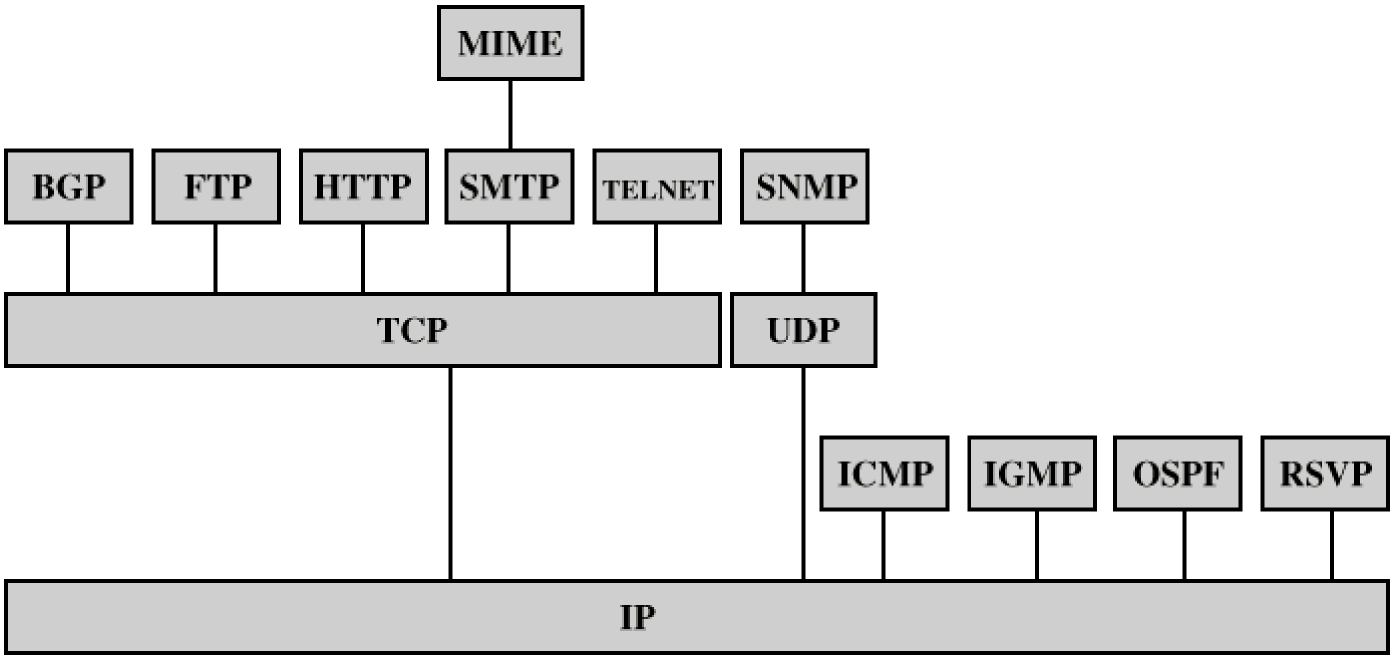
Some characteristics of TCP/IP

- IP (*Internet Protocol*) is implemented on all computers (*hosts*) and routers
- Each computer has a unique IP address on each subnet it belongs to
- Each process on a computer has a unique address (port)





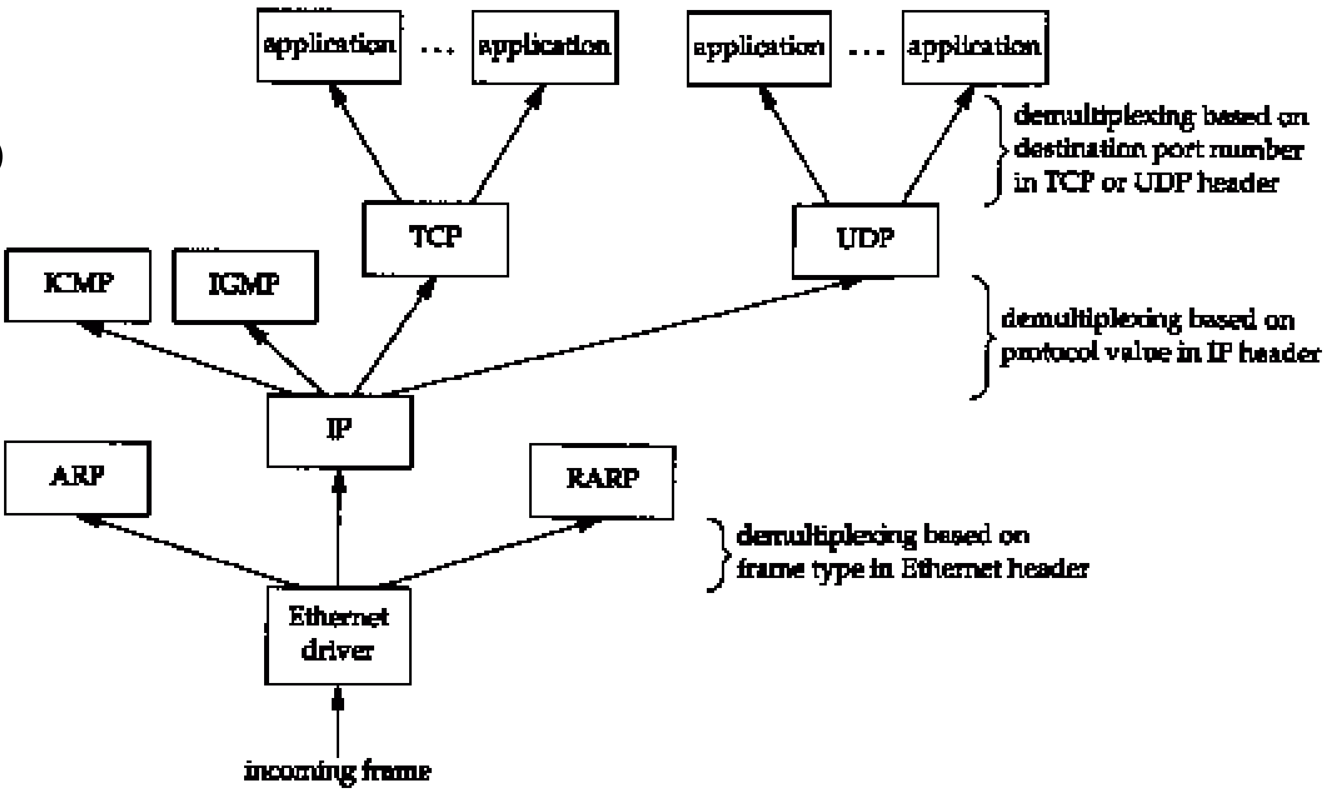
TCP/IP Protocols



BGP	=	Border Gateway Protocol
FTP	=	File Transfer Protocol
HTTP	=	Hypertext Transfer Protocol
ICMP	=	Internet Control Message Protocol
IGMP	=	Internet Group Management Protocol
IP	=	Internet Protocol
MIME	=	Multi-Purpose Internet Mail Extension
OSPF	=	Open Shortest Path First
RSVP	=	Resource ReSerVation Protocol
SMTP	=	Simple Mail Transfer Protocol
SNMP	=	Simple Network Management Protocol
TCP	=	Transmission Control Protocol
UDP	=	User Datagram Protocol

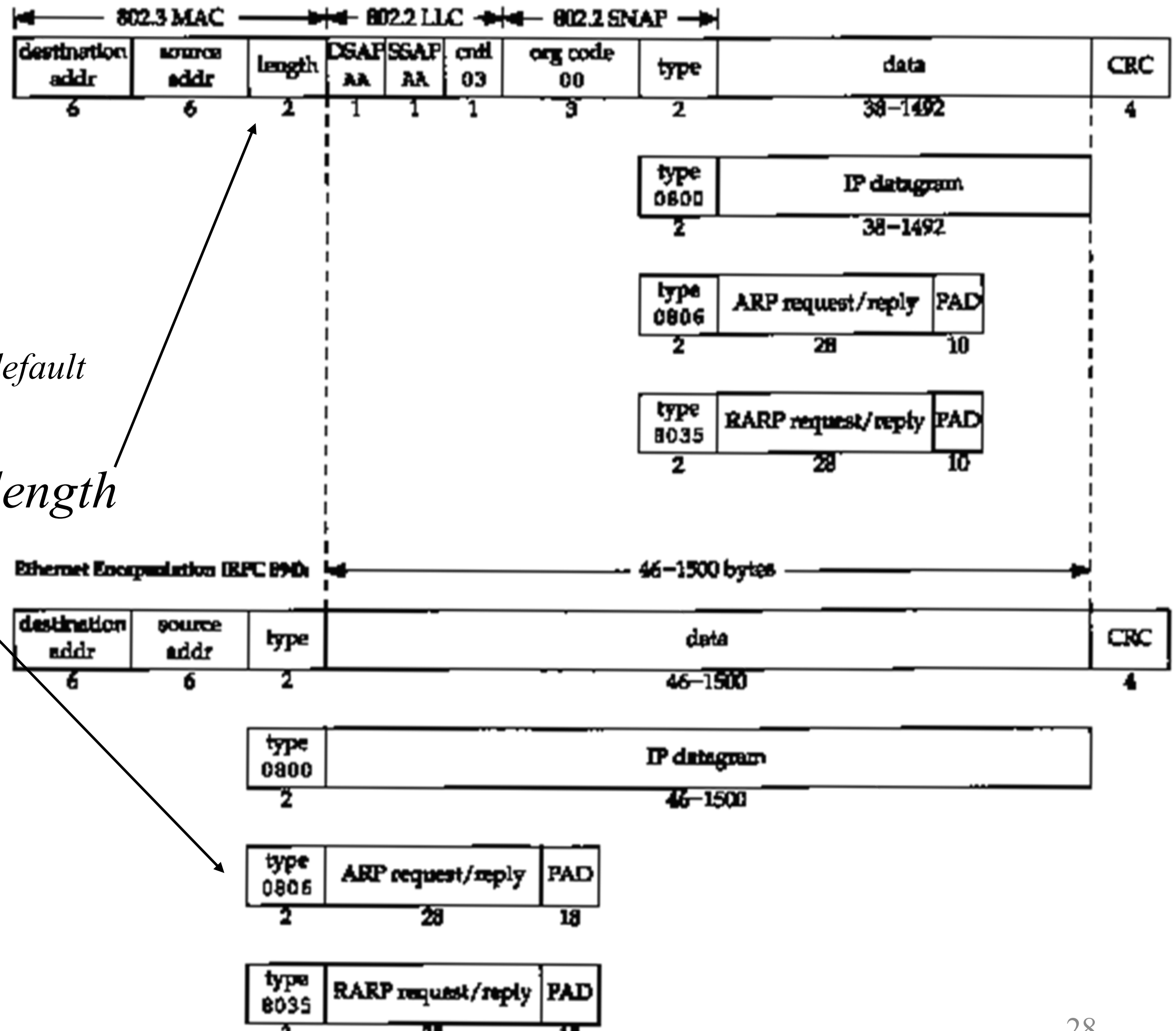
Demultiplexing

- » TCP/UDP header (port)
  - – FTP → 21
  - – Telnet → 23
  - – ...
- » IP header (protocol)
  - – ICMP → 1
  - – IGMP → 2
  - – TCP → 6
  - – UDP → 17
- » Ethernet header (type)
  - – IP → 0x0800
  - – ARP → 0x0806
  - – RARP → 0x8053

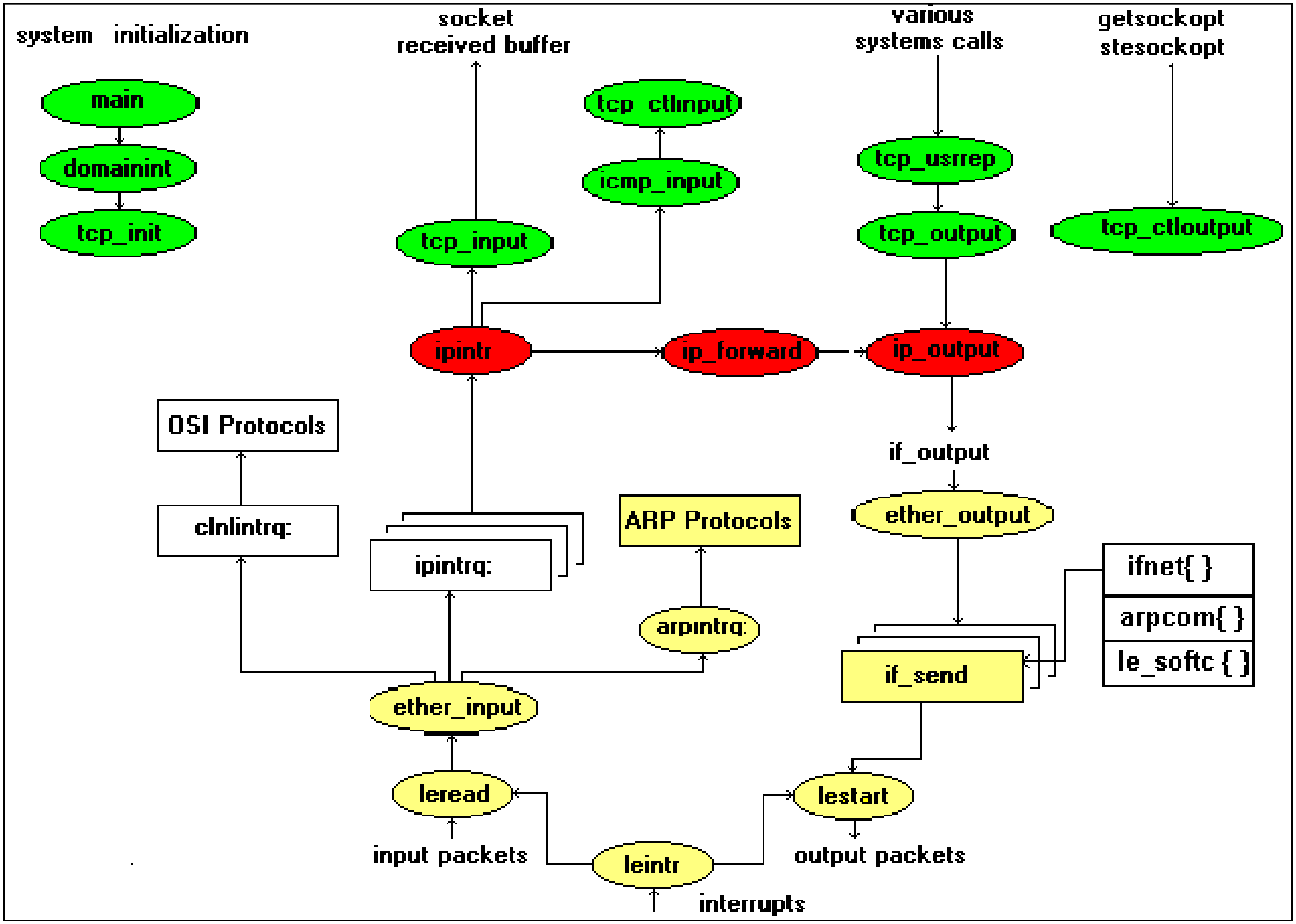


Ethernet encapsulation

- Ethernet cards
  - » Must receive
    - – IEEE 802 encapsulation
    - – Ethernet encapsulation
  - » If able to send the 2 types
    - – Ethernet encapsulation → *default*
- Valid values for *IEEE 802 length*
  - » Differenet from valid type
    - – E.g., 0800 = 2048

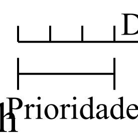


TCP/IP Stack Functions

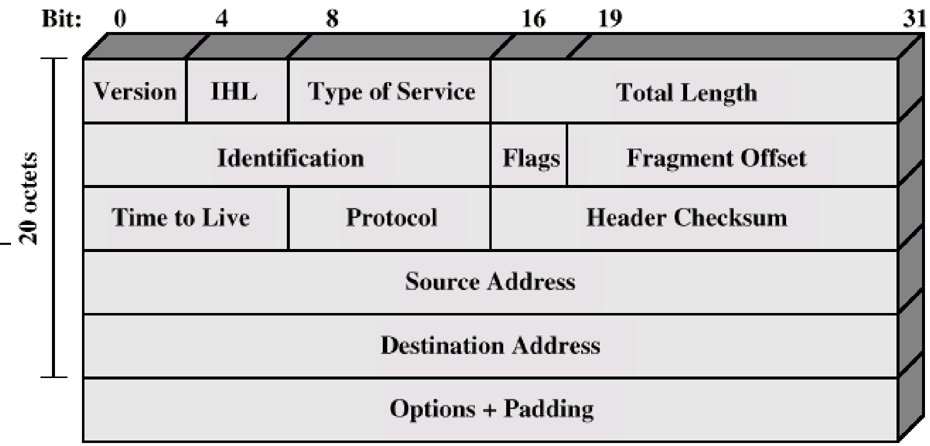


IP Protocol

- **Version** - protocol version (v4)
- **IHL** - header length (in 32-bit words); 20..60 octets
- **Type of Service** - type of service to be provided over the network



- **Total Length** - total datagram length (max. 65535 octets)
- **Identification** - identifier common to all fragments of a datagram
- **DF** - *Don't Fragment*
- **MF** - *More Fragments*
- **Fragment Offset**
- **Time To Live (TTL)** - limits the life of a packet; decremented each time it passes through a router; when it reaches 0 the packet is eliminated

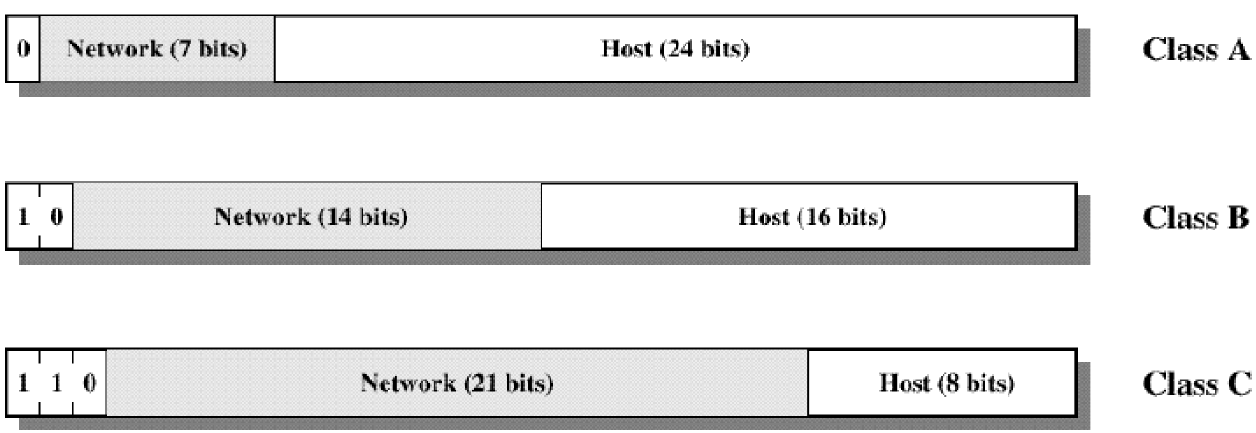


- Protocol - encapsulated transport layer protocol (e.g., TCP, UDP)
- Source Address - sender address
- Destination address - destination address
- Options - 1 octet identifies the option; 1 octet contains the length (optional); e.g: Record Route

IP - Addresses

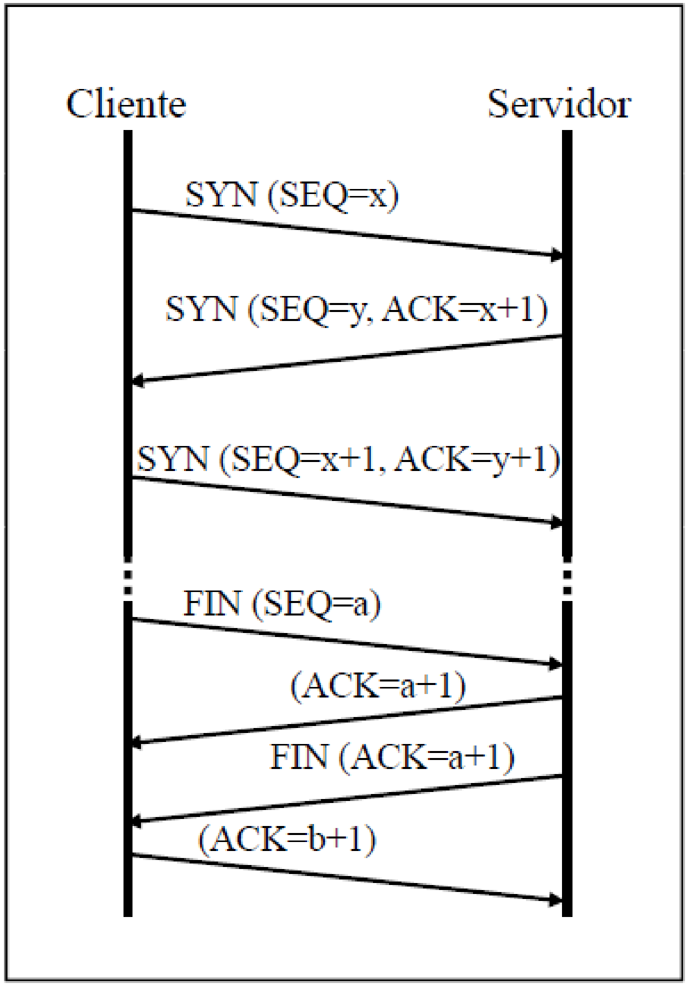
- 32-bit global addresses, structured in two parts: network (netid) and host (hostid)
  - » Originally addresses were based on classes (A, B, C, D E)
    - – Fixed-length network prefix
  - » Classless addresses (CIDR)
    - – Variable length network prefix

Classe	Valores
A	0.0.0.0 → 127.255.255.255
B	128.0.0.0 → 191.255.255.255
C	192.0.0.0 → 223.255.255.255
D	224.0.0.0 → 239.255.255.255
E	240.0.0.0 → 247.255.255.255



TCP - Transmission Control Protocol

- RFC 793
- Characteristics
  - » Ensures reliable end-to-end octet flow over unreliable support
  - » Connection oriented protocol
  - » *Full-duplex* connections
  - » Positive Acknowledgment (ACK)
  - » Recovers from losses and errors (retransmissions) after *time-out*
  - » Orderly delivery of data to the application
  - » Flow and congestion control
  - » Multiplexing multiple TCP connections over the same IP address
- TCP connection establishment
  - » *3-way handshake*
  - » Client-server model



TCP - Transmission Control Protocol

Source Port - port of origin

Destination Port - port of destination

Sequence Number - identifies, in the sender stream, the sequence of octets sent

Acknowledgement Number - corresponds to the octet number expected to receive

HLEN - the length of the TCP header (in 32-bit words)

URG - informs whether the Urgent Pointer field should be interpreted

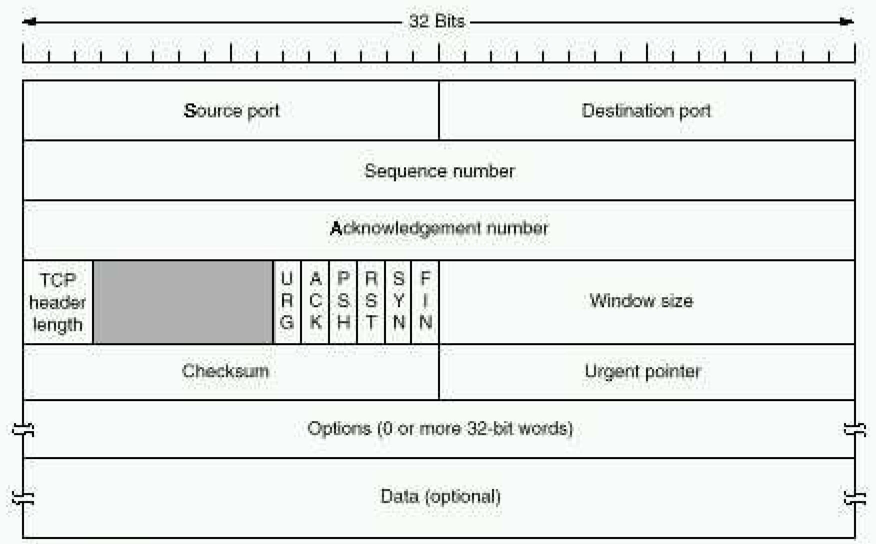
ACK - informs whether the Ack number field is valid

PSH - allows to disable buffering

RST - used to reset a connection

SYN - allows to establish a connection

FIN - allows to close a connection



The TCP header.

Window Size - number of bytes the communication peer can send without acknowledgment (flow control)

Checksum - covers header, data, and pseudo-header

Berkeley Sockets

- API - Application Programming Interface
  - operating system: UNIX
  - programming language: C
  - communication protocols
    - TCP/IP
    - UNIX
    - XNS
  - Address data structures
  - Primitives: socket(), bind(), connect(), listen(), accept(), recvfrom(), sendto(), close()
  - Association - *socket* pair

Berkeley Sockets

- Address data structures
  - BSD

```
<sys/socket.h>
struct sockaddr {
    u_short   sa_family;   /*Address family - ex: AF_INET*/
    char      sa_data[14]; /*Protocol address*/
};
```

  - Internet

```
<netinet/in.h>
struct in_addr {
    u_long        s_addr;
};
struct sockaddr_in {
    short     sin_family;        /*AF_INET*/
    u_short   sin_port;          /*Port number*/
    struct    in_addr sin_addr;  /*32 bit netid/hosdtid*/
    char      sin_zero[8];       /*unused*/
};
```

Berkeley Sockets

```
➔ int socket(int family, int type, int protocol)
```

family: AF_INET, AF_UNIX
type: SOCK_STREAM, SOCK_DGRAM, SOCK_RAW
protocol: protocol to use (with the value 0 is determined by the system)

» Returns
  - *socket* descriptor
  - -1 in case of error

```
➔ int bind(int sockfd, struct sockaddr* myaddr, int addrlen)
```

sockfd: *socket* descriptor
myaddr: local address (IP + port)
addrlen: myaddr structure length

» Returns
  - 0 in case of success
  - -1 in case of error

» This primitive associates the *socket* with the local address myaddr

Berkeley Sockets

```
➔ int connect(int sockfd, struct sockaddr* serveraddr, int addrlen)
```

serveraddr: remote server address (IP + port)

» Returns
  - 0 in case of success
  - -1 in case of error

» TCP: remote server connection establishment

» UDP: *serveraddr* address storage

```
➔ int listen(int sockfd, int backlog)
```

backlog: number of queued call requests

» Returns
  - 0 in case of success
  - -1 in case of error

» Primitive specifies the maximum number of queued calls

Berkeley Sockets

```
➔ int accept(int sockfd, struct sockaddr* peeraddr, int* addrlen)
```

peeraddr: structure used to store the client address (IP + port)

addrlen: pointer to the length of the peeraddr structure

» Returns
  - accepted socket descriptor, client address and length
  - -1 in case of error

» Primitive listens for connection requests and creates another socket with the same properties as *sockfd*

```
➔ int send(int sockfd, const void* buf, int len, unsigned int flags)
➔ int recv(int sockfd, void* buf, int len, unsigned int flags)
```

buf: pointer to the memory location that contains/will contain the data

flags: MSG_OOB, MSG_PEEK, MSG_DONTROUTE

» Returns
  - number of octets written/read
  - 0 in case the connection was closed
  - -1 in case of error em caso de erro

» These primitives allow sending and receiving data from the network

Berkeley Sockets

```
➔ int sendto(int sockfd, const void* buf, int len,
             unsigned int flags,
             struct sockaddr* to, int tolen)

➔ int recvfrom(int sockfd, void* buf, int len,
               unsigned int flags,
               struct sockaddr* from, int* fromlen)
```

» to: packet destination address

» from: sender address present in received packet

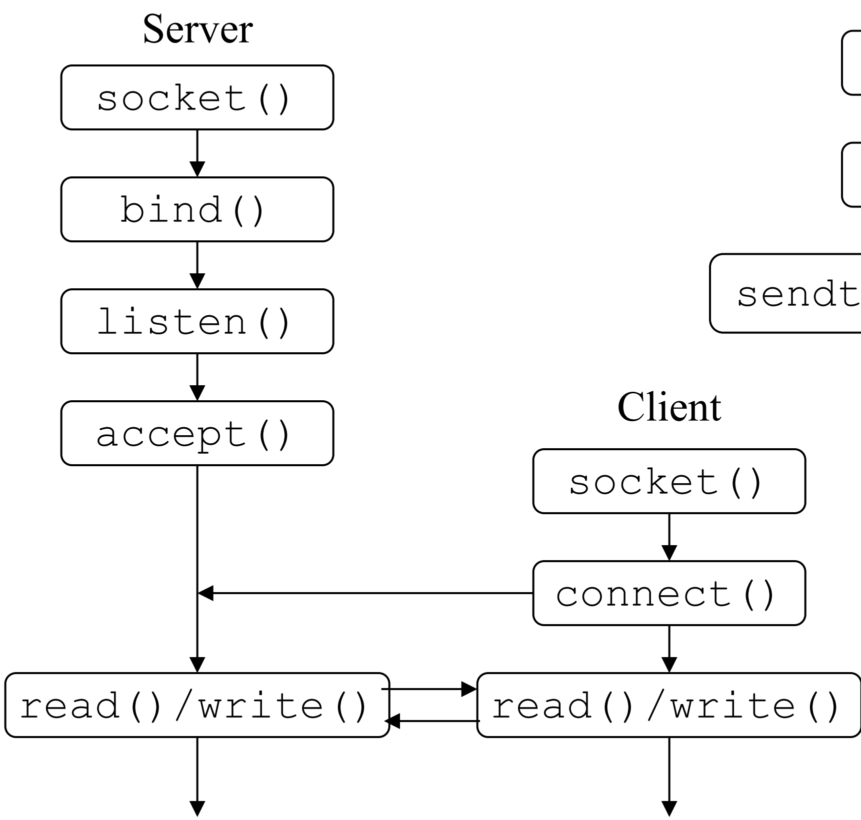
» these primitives are similar to *send()/recv()* but additionally allow the sending of messages in connectionless (UDP) scenarios, without any connection establishment

```
➔ int close(int sockfd)
```

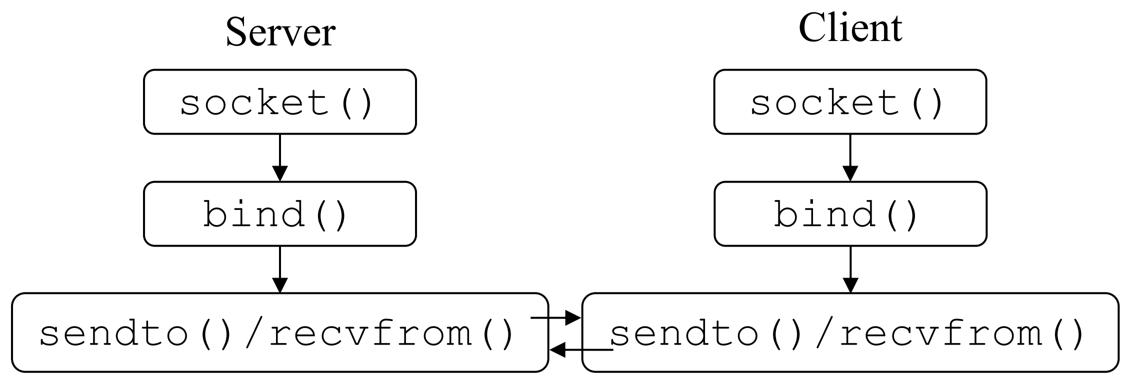
» this primitive is used to close the socket

Berkeley Sockets

connection-oriented protocol



Non-connection-oriented protocol



Note: the client of a TCP connection can call the *bind()* primitive before establishing the connection

Berkeley Sockets

- Ordering of octets
  - » varies with architecture (e.g., Intel is *little endian*, Motorola is *big endian*)
    - – Little endian → little end firt; Big endian → big end first
  - » network byte order → *big endian*
  - » conversion primitives (long - 32 bits, short - 16 bits):

→ **`u_long htonl(u_long hostlong)`**

→ **`u_short htons(u_short hostshort)`**

→ **`u_long ntohl(u_long netlong)`**

→ **`u_short ntohs(u_short netshort)`**

- Conversion between address formats
  - » *dotted decimal notation* for 32-bit Internet address with network ordering

→ **`unsigned long inet_addr(char * cp)`**

  - » 32-bit Internet address with network ordering for *dotted decimal notation*

→ **`char* inet_ntoa(struct in_addr in)`**

Berkeley Sockets

- *sockets* options
  - **`setsockopt()`**
  - **`getsockopt()`**
  - **`fcntl()`**
  - **`ioctl()`**
- Asynchronous input/output
  - » use of signs
- Input/Output Multiplexing
  - » **`select()`** routine

- *Domain Name Service*
  - » allows obtaining the address of a host from its name

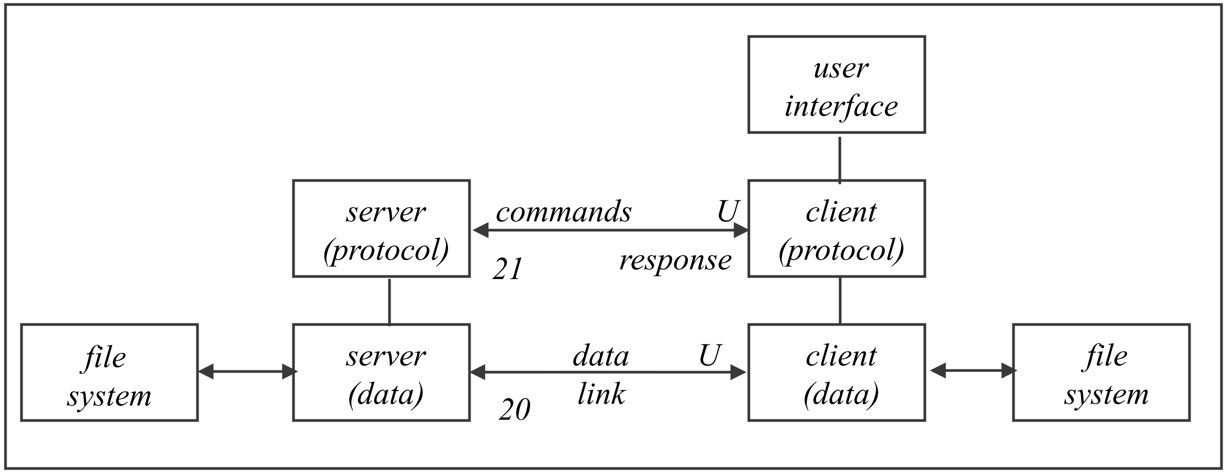
```
struct hostent*
gethostbyname (const char* name);

struct hostent{
      char*  hname;       /*nome oficial*/
      char** haliases;
      int    h_addrtype; /*AF_INET*/
      int    h_length;
      char** h_addr_list;
};

#define h_addr h_addr_list[0]
```

FTP - File Transfer Protocol

- FTP - File Transfer Protocol
  - file transfer between computers (ASCII and binary)
- Client-Server Communication Model
  - independent TCP connections for connection control and data transfer
  - RFC 959



Example: Passive Mode FTP Session

First “response” came split into two packets.

A response ends with a line containing the code, a space, optional text, and CRLF

```
220-Welcome to the University of Porto's mirror archive (mirrors.up.pt)
220------------------------------------------------------------------
220-
220-All connections and transfers are logged. The max number of connections is 200.
220-
220
USER anonymous
331 Please specify the password.
PASS anonymous@
230 Login successful.
CWD debian
250 Directory successfully changed.
TYPE I
200 Switching to Binary mode.
SIZE README
213 1328
PASV
227 Entering Passive Mode (193,137,29,15,198,138).
RETR README
150 Opening BINARY mode data connection for README (1328 bytes).
226 Transfer complete.
QUIT
221 Goodbye.
```

File size in bytes

Server IP addr.

Server IP port for file transfer = 256×198 + 138 = 50826

Client makes connection to 193.137.29.15:50826

Server transfers file and closes data connection

Preliminary reply (code 1xy)

Final reply (1st digit of code > 1)

Server and client close control connection

NOTE: In a C string, CR is '\r' and LF is '\n'. For example, the QUIT command would be sent as "QUIT\r\n". Telnet does this by default.

Network Configuration Examples

Network Configurations on Linux (examples)

- Restart the networking service
  - » systemctl restart networking
- Configuration of tux
  - » Activate interface eth0
    - o ifconfig eth0 up
  - » List current network interfaces configurations
    - o ifconfig
  - » Configure eth0 with IP Address 192.168.0.1 and mask of 16 bits
    - o ifconfig eth0 192.168.0.1/16
  - » Add a route to a subnetwork
    - o route add -net 192.168.1.0/24 gw 172.16.4.254
  - » Add default route
    - o route add default gw 192.168.1.1
  - » List current routes
    - o route -n

Network Configurations on Linux (examples)

- » Enable IP forwarding
  - o sysctl net.ipv4.ip_forward=1
- » Disable ICMP echo ignore broadcast
  - o sysctl net.ipv4.icmp_echo_ignore_broadcasts=0

- ♦ NAT configuration on Linux
  - » iptables -t nat -A POSTROUTING -o eth1 -j MASQUERADE
    iptables -A FORWARD -i eth1 -m state --state NEW,INVALID -j DROP
    iptables -L
    iptables -t nat -L

- ♦ Configuration of DNS
  - » Edit /etc/resolv.conf, clean the file and add the IP address of the DNS server

    nameserver xxx.xxx.xxx.xxx

Reset the Mikrotik switch

- Connect to the switch
  - » Serial port **/dev/ttyS0** on one of the tux using o **GTKterm**
    - – Connect S0 port to RS232 on the patch panel and from RS232 to the console port of the switch
    - – Set the Baudrate to 115200 bps
    - – Username - admin
    - – Password - (blank)

- After loggin in with GTKterm
  - » /system reset-configuration
    - – y
    - – [ENTER]

Reset the Mikrotik router

- Connect to the router
  - Serial port **/dev/ttyS0** on one of the tux using o **GTKterm**
    - Connect S0 port to RS232 on the patch panel and from RS232 to the Router MTIK
    - Set the Baudrate to 115200 bps
    - Username - admin
    - Password - (blank)

- After loggin in with GTKterm
  - /system reset-configuration
    - y
    - [ENTER]

Handling Bridges in Mikrotik Switch

- Creating a bridge (bridgeY0)
  - » /interface bridge add name=bridgeY0
  - » /interface bridge print

- Remove a bridge (bridgeY0)
  - » /interface bridge remove bridgeY0
  - » /interface bridge print

- Add port1 to bridgeY0
  - » /interface bridge port add bridge=bridgeY0 interface=ether1
  - » /interface bridge port print

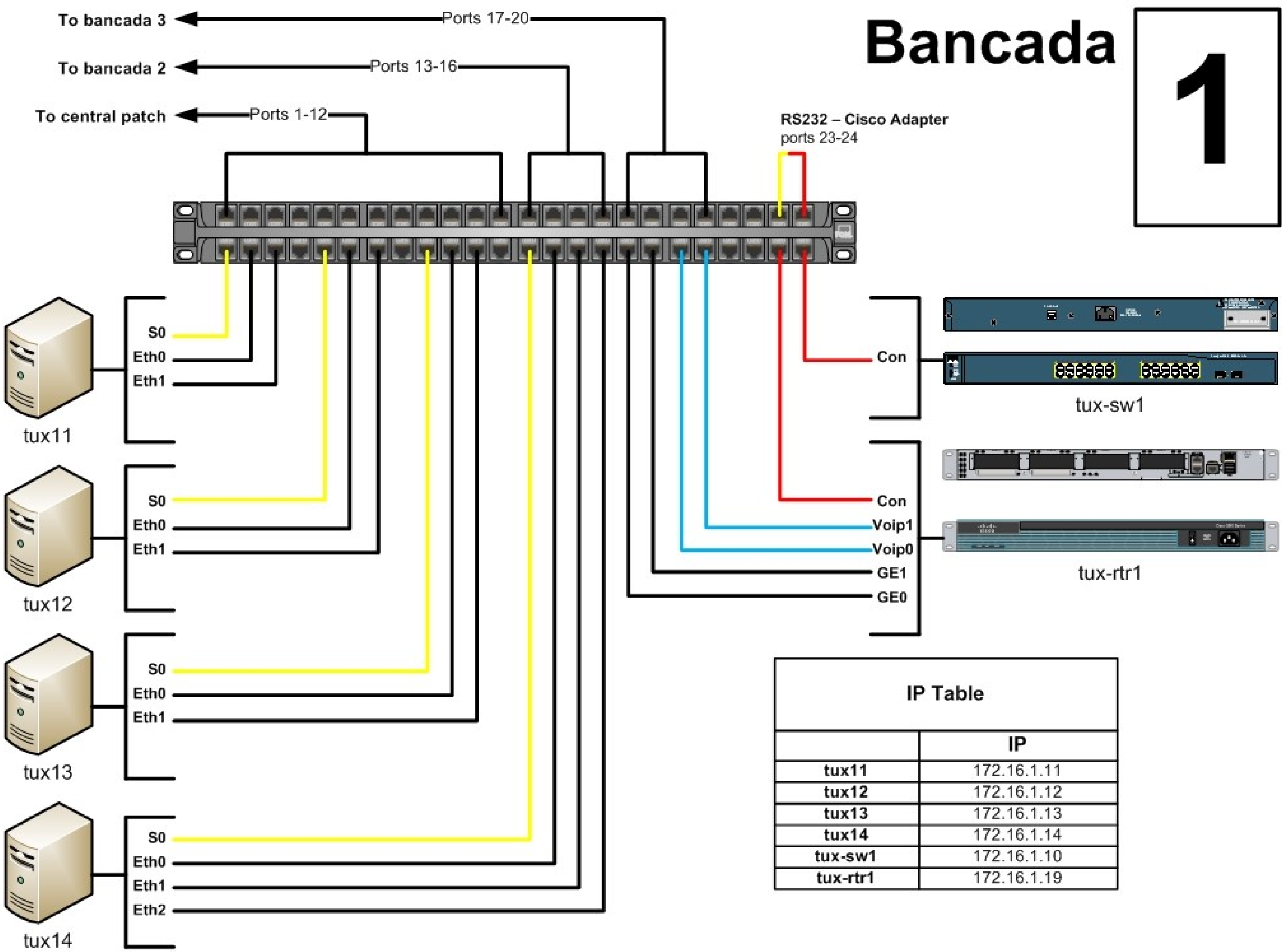
- Remove port1 from bridge
  - » /interface bridge port remove [find interface =ether1]
  - » /interface bridge port print

- Show bridges and ports
  - » /interface bridge port print brief

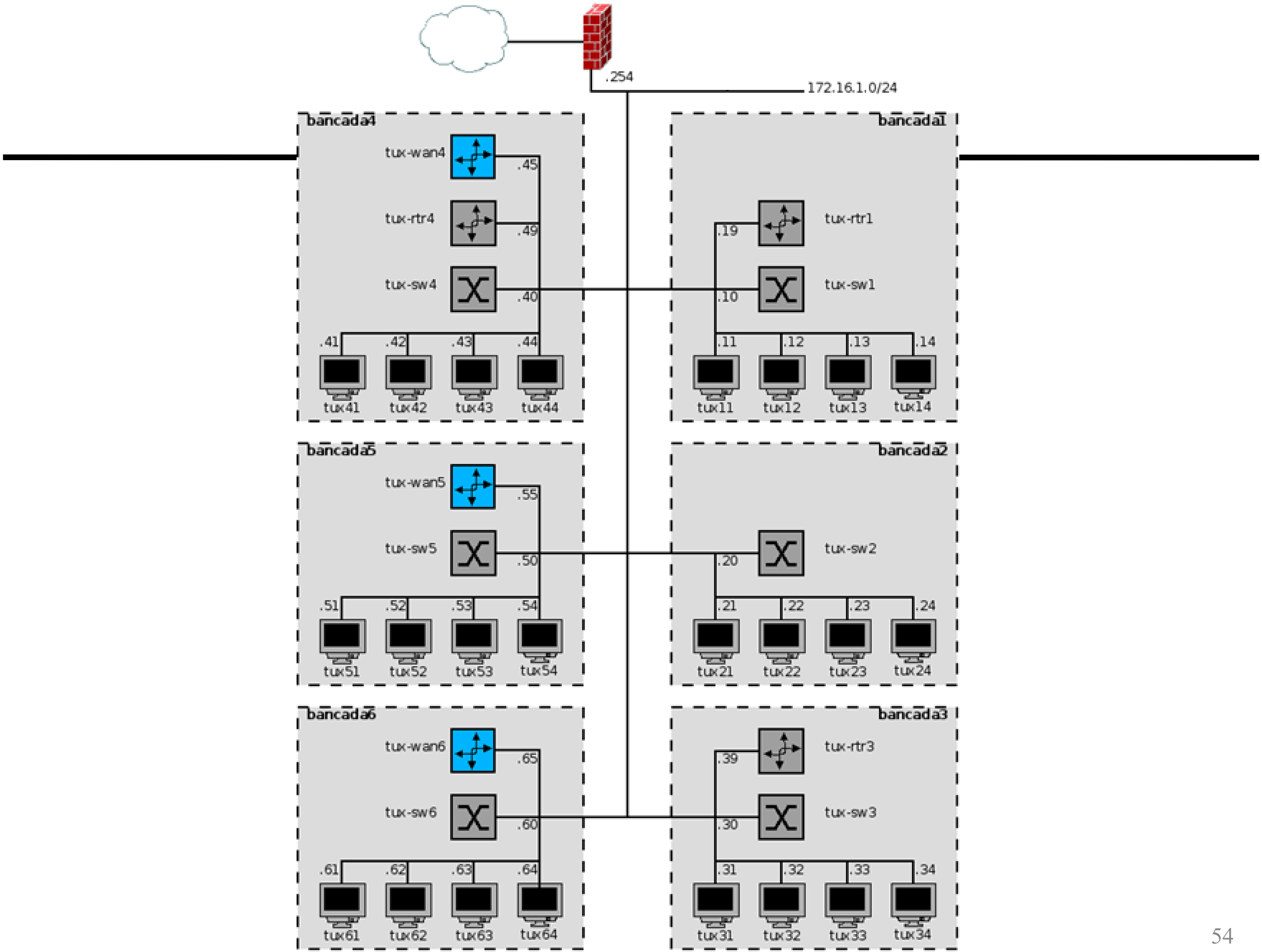
Configuring the Mikrotik router

- Network Interfaces
  - » /ip address add address=172.16.1.Y9/24 interface=ether1
  - » /ip address print
- Routes
  - » Default gateway
    - – /ip route add dst-address=0.0.0.0/0 gateway=172.16.1.254
  - » Static Routes
    - – /ip route add dst-address=172.16.10.0/24 gateway=172.16.11.253
  - » Show routes
    - – /ip route print
- NAT
  - » Disable default nat
    - – /ip firewall nat disable 0
  - » Add NAT rules
    - – /ip firewall nat add chain=srcnat action=masquerade out-interface=ether1

Connections in Bancada 1



IP Table	
	IP
tux11	172.16.1.11
tux12	172.16.1.12
tux13	172.16.1.13
tux14	172.16.1.14
tux-sw1	172.16.1.10
tux-rtr1	172.16.1.19


.254
172.16.1.0/24
bancada4
tux-wan4
.45
tux-rtr4
.49
tux-sw4
.40
.41
.42
.43
.44
tux41
tux42
tux43
tux44
bancada1
tux-rtr1
.19
tux-sw1
.10
.11
.12
.13
.14
tux11
tux12
tux13
tux14
bancada5
tux-wan5
.55
tux-sw5
.50
.51
.52
.53
.54
tux51
tux52
tux53
tux54
bancada2
tux-sw2
.20
.21
.22
.23
.24
tux21
tux22
tux23
tux24
bancada6
tux-wan6
.65
tux-sw6
.60
.61
.62
.63
.64
tux61
tux62
tux63
tux64
bancada3
tux-rtr3
.39
tux-sw3
.30
.31
.32
.33
.34
tux31
tux32
tux33
tux34