

# Capítulo 5

## A camada de Rede

(fim do capítulo)

### Provinha 5 11.03.2010

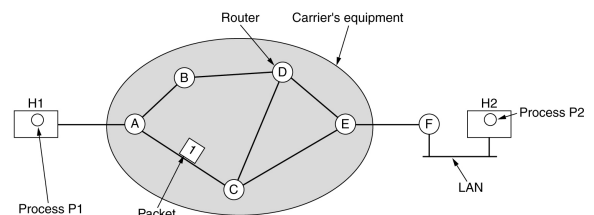
A rede da USP ocupa toda a faixa provida pelos endereços 143.107.X.X. Imagine um esquema de divisão de endereços em que a distribuição é feita por unidades (FEA, POLI, ICMC, Direito). Cada unidade, então divide sua porção entre os seus departamentos (SCC, SSC, SMA, SME).

- mostre os esquemas de netmasking e dê alguns exemplos
- como seria o processo do roteamento de pacote enviado do Computer Lab (Cambridge) para o SSC (ICMC) nos seguintes pontos:
  - um roteador intermediário em Miami;
  - o roteador de borda da USP (CCE - são paulo)
  - o roteador de borda do ICMC
- indique as possíveis vantagens e desvantagens do esquema de endereçamento da Internet.

## Network Layer Design Issues

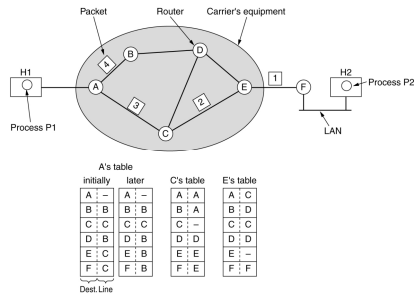
- Store-and-Forward Packet Switching
- Services Provided to the Transport Layer
- Implementation of Connectionless Service
- Implementation of Connection-Oriented Service
- Comparison of Virtual-Circuit and Datagram Subnets

## Store-and-Forward Packet Switching



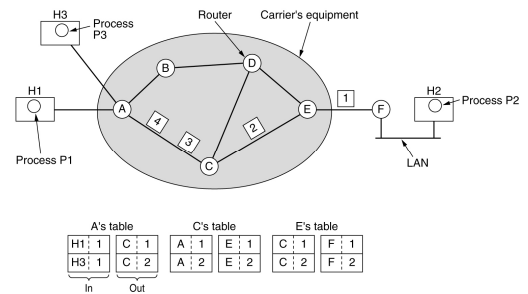
The environment of the network layer protocols.

## Implementation of Connectionless Service



Routing within a datagram subnet.

## Implementation of Connection-Oriented Service



Routing within a virtual-circuit subnet.

## Comparison of Virtual-Circuit and Datagram Subnets

Issue	Datagram subnet	Virtual-circuit subnet
Circuit setup	Not needed	Required
Addressing	Each packet contains the full source and destination address	Each packet contains a short VC number
State information	Routers do not hold state information about connections	Each VC requires router table space per connection
Routing	Each packet is routed independently	Route chosen when VC is set up; all packets follow it
Effect of router failures	None, except for packets lost during the crash	All VCs that passed through the failed router are terminated
Quality of service	Difficult	Easy if enough resources can be allocated in advance for each VC
Congestion control	Difficult	Easy if enough resources can be allocated in advance for each VC

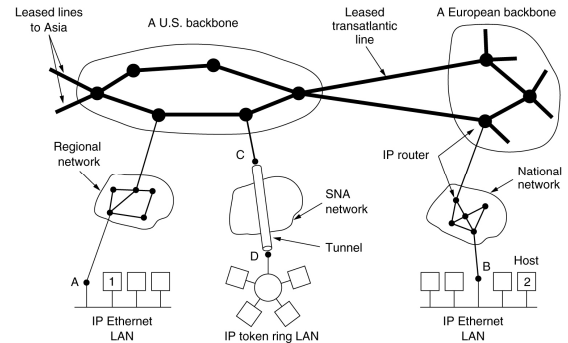
## The Network Layer in the Internet

- The IP Protocol
- IP Addresses
- Internet Control Protocols
- OSPF – The Interior Gateway Routing Protocol
- BGP – The Exterior Gateway Routing Protocol
- Internet Multicasting
- Mobile IP
- IPv6

## Design Principles for Internet

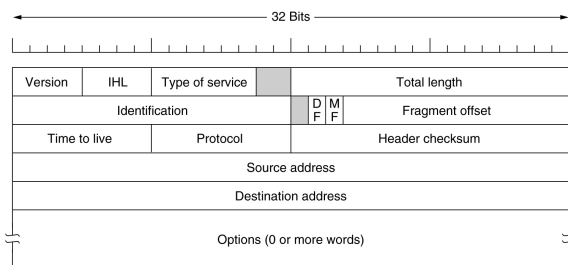
1. Make sure it works.
2. Keep it simple.
3. Make clear choices.
4. Exploit modularity.
5. Expect heterogeneity.
6. Avoid static options and parameters.
7. Look for a good design; it need not be perfect.
8. Be strict when sending and tolerant when receiving.
9. Think about scalability.
10. Consider performance and cost.

## Collection of Subnetworks



The Internet is an interconnected collection of many networks.

## The IP Protocol



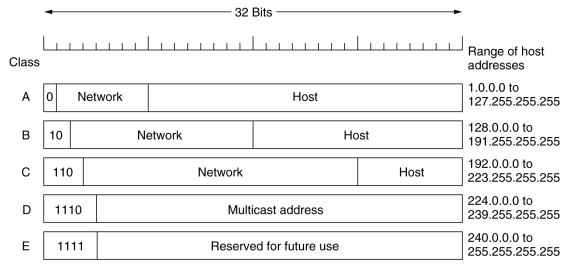
The IPv4 (Internet Protocol) header.

## The IP Protocol (2)

Option	Description
Security	Specifies how secret the datagram is
Strict source routing	Gives the complete path to be followed
Loose source routing	Gives a list of routers not to be missed
Record route	Makes each router append its IP address
Timestamp	Makes each router append its address and timestamp

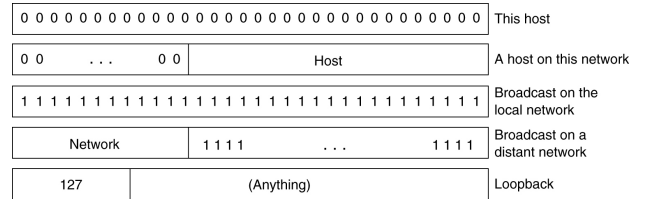
Some of the IP options.

## IP Addresses



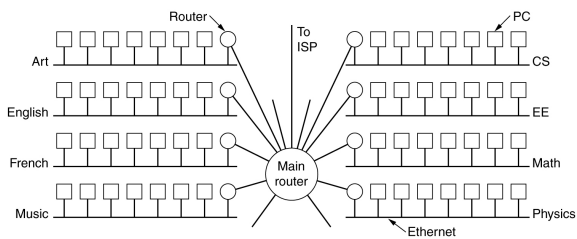
IP address formats.

## IP Addresses (2)



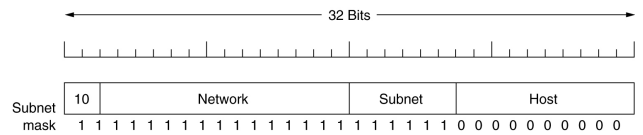
Special IP addresses.

## Subnets



A campus network consisting of LANs for various departments.

## Subnets (2)



A class B network subnetted into 64 subnets.

## CDR – Classless InterDomain Routing

University	First address	Last address	How many	Written as
Cambridge	194.24.0.0	194.24.7.255	2048	194.24.0.0/21
Edinburgh	194.24.8.0	194.24.11.255	1024	194.24.8.0/22
(Available)	194.24.12.0	194.24.15.255	1024	194.24.12/22
Oxford	194.24.16.0	194.24.31.255	4096	194.24.16.0/20

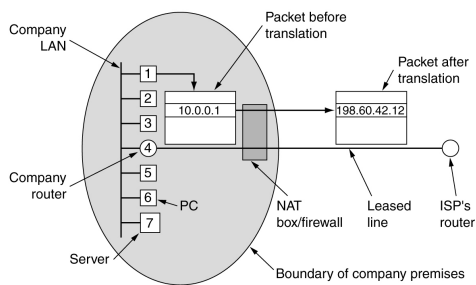
A set of IP address assignments.

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## NAT – Network Address Translation



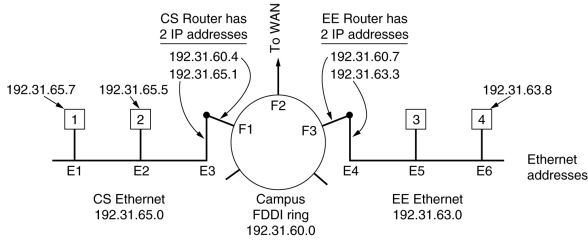
Placement and operation of a NAT box.

## Internet Control Message Protocol

Message type	Description
Destination unreachable	Packet could not be delivered
Time exceeded	Time to live field hit 0
Parameter problem	Invalid header field
Source quench	Choke packet
Redirect	Teach a router about geography
Echo request	Ask a machine if it is alive
Echo reply	Yes, I am alive
Timestamp request	Same as Echo request, but with timestamp
Timestamp reply	Same as Echo reply, but with timestamp

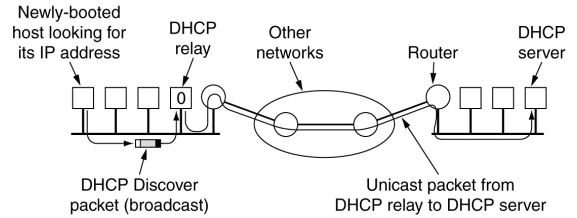
The principal ICMP message types.

## ARP– The Address Resolution Protocol



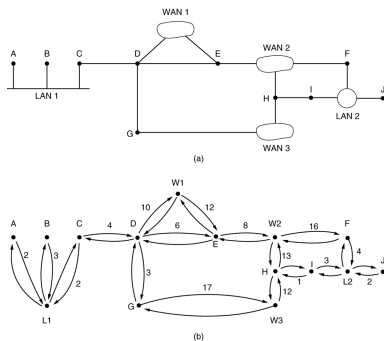
Three interconnected /24 networks: two Ethernets and an FDDI ring.

## Dynamic Host Configuration Protocol



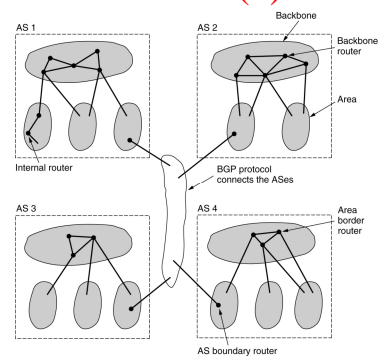
Operation of DHCP.

## OSPF – The Interior Gateway Routing Protocol



(a) An autonomous system. (b) A graph representation of (a).

## OSPF (2)



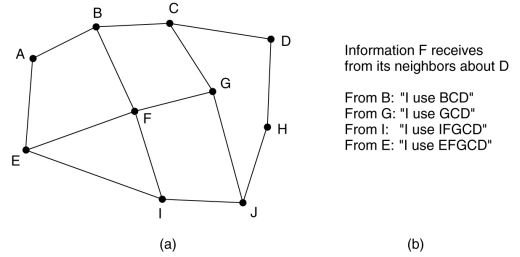
The relation between ASes, backbones, and areas in OSPF.

## OSPF (3)

Message type	Description
Hello	Used to discover who the neighbors are
Link state update	Provides the sender's costs to its neighbors
Link state ack	Acknowledges link state update
Database description	Announces which updates the sender has
Link state request	Requests information from the partner

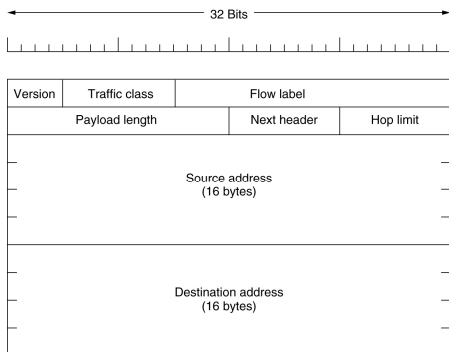
The five types of OSPF messages.

## BGP – The Exterior Gateway Routing Protocol



(a) A set of BGP routers. (b) Information sent to F.

## The Main IPv6 Header



The IPv6 fixed header (required).

## Extension Headers

Extension header	Description
Hop-by-hop options	Miscellaneous information for routers
Destination options	Additional information for the destination
Routing	Loose list of routers to visit
Fragmentation	Management of datagram fragments
Authentication	Verification of the sender's identity
Encrypted security payload	Information about the encrypted contents

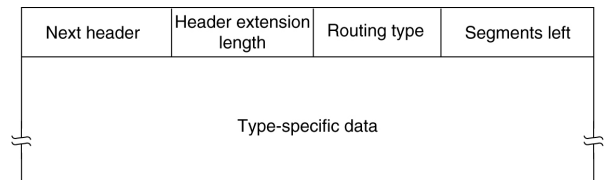
IPv6 extension headers.

## Extension Headers (2)

Next header	0	194	4
Jumbo payload length			

The hop-by-hop extension header for large datagrams (jumbograms).

## Extension Headers (3)



The extension header for routing.