Point-to-Point Protocol
Routing Algorithms
Internet Addressing

ETSF05
Internet Protocols
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(Jens Andersson)

Previously on ETS05

- Introduction
- Network topologies §1.1-2
- Network models §2.1-5
- Frames and data link control §11.1-5
- Local area networks and Ethernet §13.1-3

Student Representative Election Day!

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Today's lecture

- **Point-to-point protocol, PPP** §11.7
- Circuit-switched and datagram networks §8.1-2
- **Routing algorithms** §22.3
- IPv4 and **IPv6 addresses, NAT** §19.1-2
- Internetworking §20.1
- Address mapping, ARP §21.1

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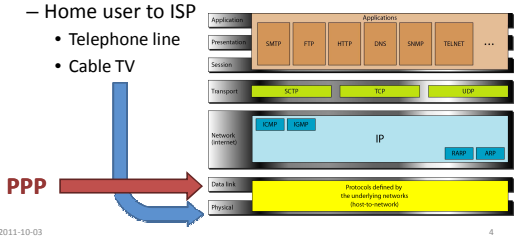
Point-to-point protocol (PPP)

- Direct connection between two nodes
  - Internet access
  - Home user to ISP
    - Telephone line
    - Cable TV



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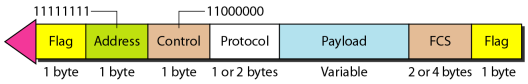
PPP frame format

- Support for several (sub)protocols
- Address & control not used
- Maximum payload 1500 bytes



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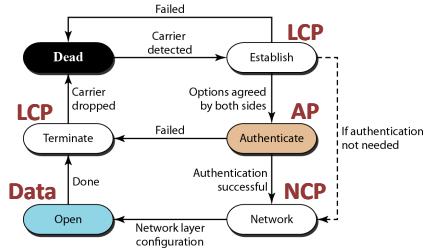
State transitions in PPP

- That's why we need (sub)protocols



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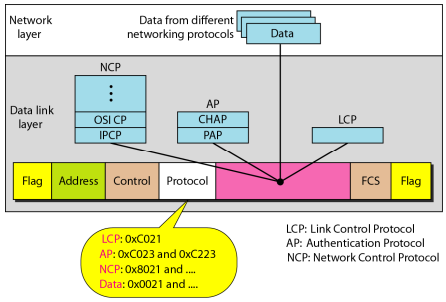
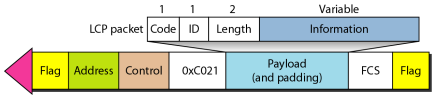
(Sub)protocols in PPP



Link control protocol (LCP)

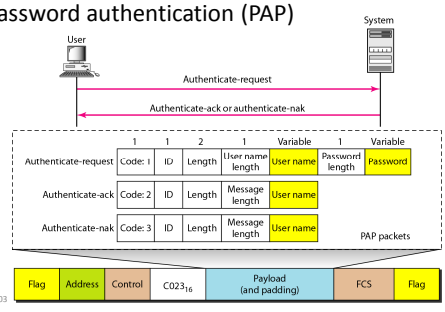
- Establish
- Configure
- Terminate

Code	Packet Type	Description
0x01	Configure-request	Contains the list of proposed options and their values
0x02	Configure-ack	Accepts all options proposed
0x03	Configure-nak	Announces that some options are not acceptable
0x04	Configure-reject	Announces that some options are not recognized
0x05	Terminate-request	Request to shut down the line
0x06	Terminate-ack	Accept the shutdown request
0x07	Code-reject	Announces an unknown code
0x08	Protocol-reject	Announces an unknown protocol
0x09	Echo-request	A type of hello message to check if the other end is alive
0x0A	Echo-reply	The response to the echo-request message
0x0B	Discard-request	A request to discard the packet



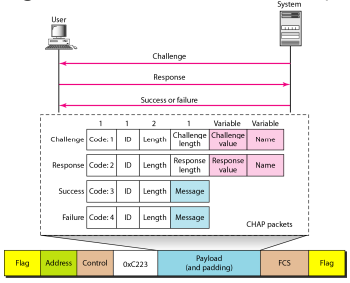
Authentication protocols (AP)

- Password authentication (PAP)



Authentication protocols (AP)

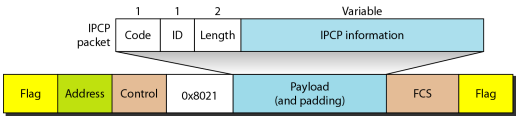
- Challenge handshake authentication (CHAP)



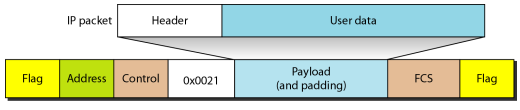
Network control protocols (NCP)

- Preparations for the network layer
  - IPCP for Internet

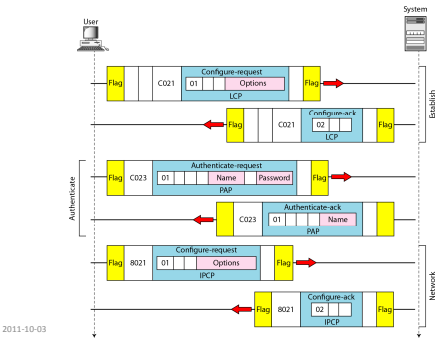
Code	IPCP Packet
0x01	Configure-request
0x02	Configure-ack
0x03	Configure-nak
0x04	Configure-reject
0x05	Terminate-request
0x06	Terminate-ack
0x07	Code-reject



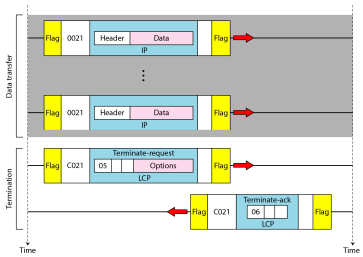
IP datagram encapsulation in PPP



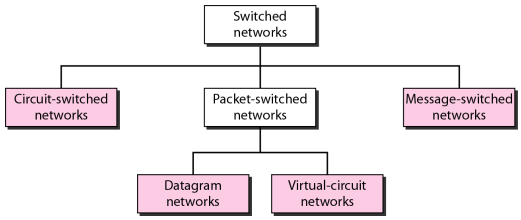
PPP session example



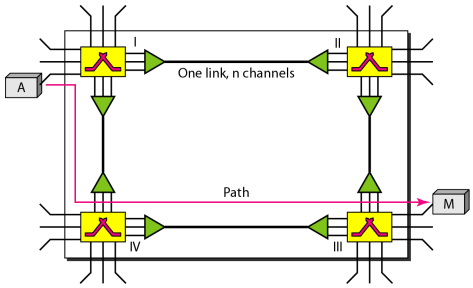
PPP session example (cont.)



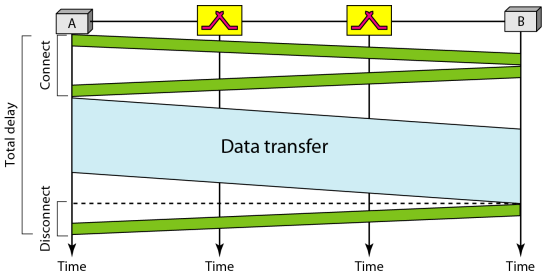
Switching



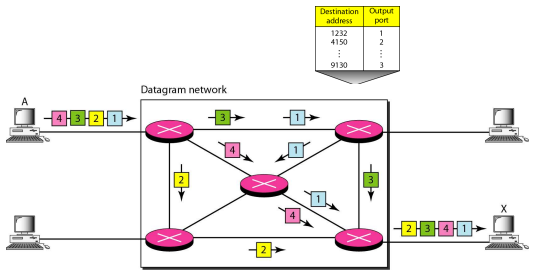
Circuit-switched networks



Phases of circuit switching

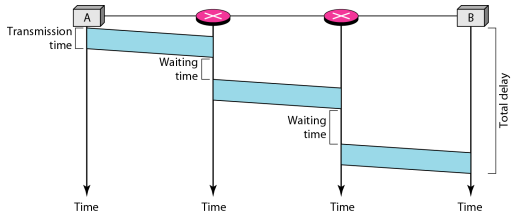


Datagram networks



Datagram transmission

- Higher delay
- Higher throughput



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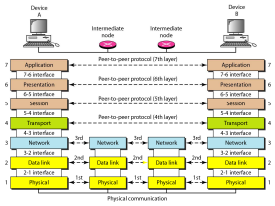
Routing

- Choosing the optimal path
  - Using a cost metric
- Algorithms
  - Rules and procedures
  - Updates
- Sharing information
  - Central
  - Distributed



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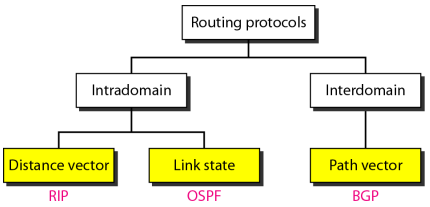
Routing protocol classification



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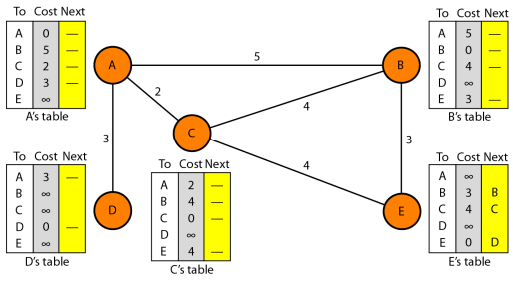
Distance vector routing

- Best path info shared locally
  - Periodically
  - Upon any change
- Routing tables updated for
  - New entries
  - Cost changes

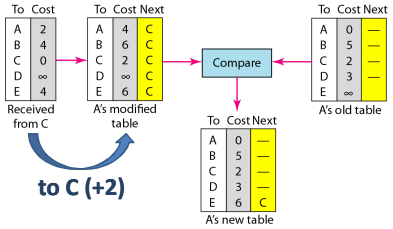
Initialisation of routing tables



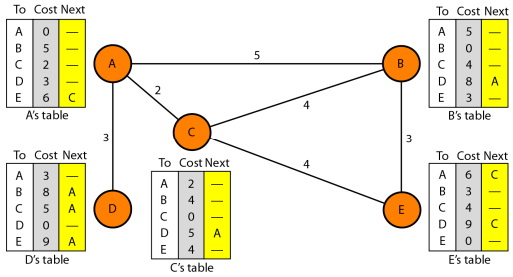
Updating algorithm

```
if (advertised destination not in table)
   {
   add new entry // rule #1
   }
else if (adv. next hop = next hop in table)
   {
   update cost // rule #2
   }
else if (adv. hop count < hop count in table)
   {
   replace old entry // rule #3
   }
```

Updating a routing table



Distance vector concept



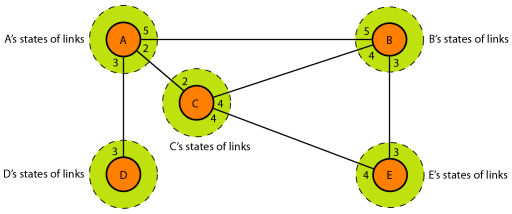
See you in 15' :)

- **Now: Student Representative Election**
- After the break
  - IPv4/IPv6 addresses
  - Internetworking
  - Address mapping

Link state routing

- Local topology info **flooded** globally
  - Periodically
  - Upon any change
- Routing tables updated for
  - New entries
  - Cost changes

Initial link state knowledge

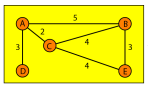


Updating algorithm (Dijkstra)

```
put yourself to tentative list
while tentative list not empty
   {
   pick node with least cumulative cost
   put it to permanent list
   add its least cost link to tree
   put its neighbours to tentative list
      (if not already there)
   }
```

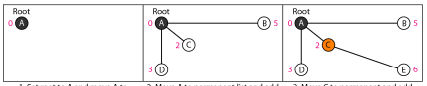
Shortest path tree generation

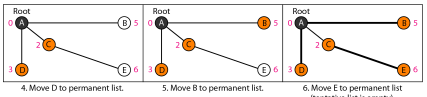
- **A**



Topology

Node	Cost	Next Router
A	0	—
B	5	—
C	2	—
D	3	—
E	6	C





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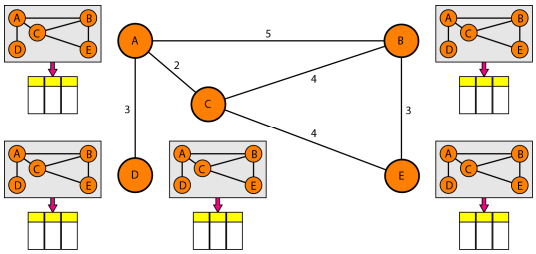
Link state concept



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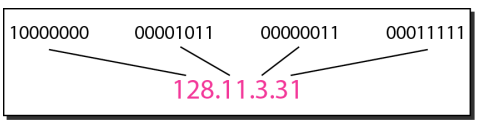
IPv4 addresses

- 32 bits = 4 bytes
- $2^{32} = (2^8)^4 = 256^4 = 4\ 294\ 967\ 296$
- Notations



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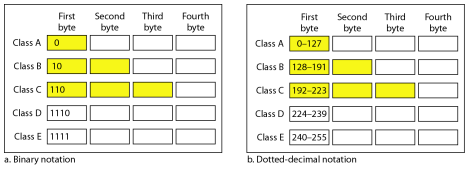
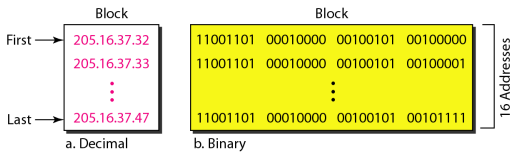
Classful addressing

- 3 main classes for all organisation types
  - Problem: not flexible
- Netid, hostid



Classless addressing

- Addresses in blocks
  - Count a power of 2
  - First address divisible by address count



Classless addressing example

- 205.16.37.39/28

Address:	11001101 00010000 00100101 00100111
Mask:	**11111111 11111111 11111111 11110000**
First address:	11001101 00010000 00100101 00100000

Address:	11001101 00010000 00100101 00100111
Mask complement:	**00000000 00000000 00000000 00001111**
Last address:	11001101 00010000 00100101 00101111

Network address translation (NAT)

- Private Internet usage increasing
  - Address needs becoming permanent
- Not enough addresses!
  - Solution: Separate internal from external
  - Let private networks do address translation

Range			Total
10.0.0.0	to	10.255.255.255	2^{24}
172.16.0.0	to	172.31.255.255	2^{20}
192.168.0.0	to	192.168.255.255	2^{16}

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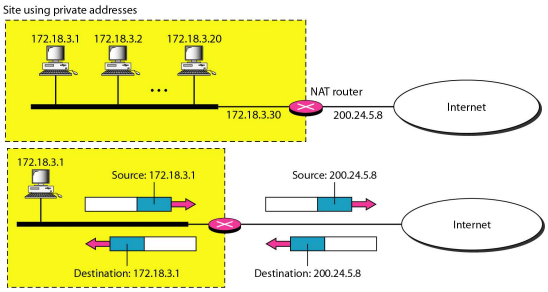
NAT implementation



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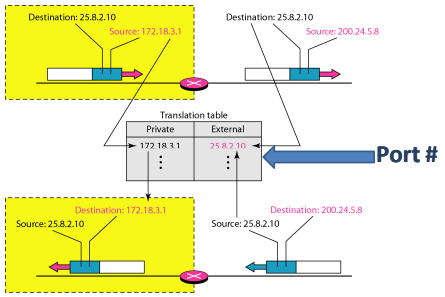
NAT address translation



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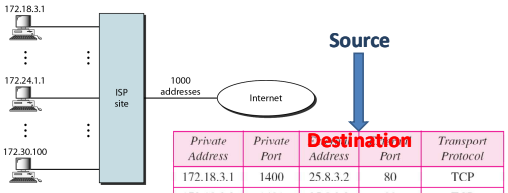
NAT improvements

- Using multiple external addresses
- Using port numbers



Private Address	Private Port	Destination Address	Destination Port	Transport Protocol
172.18.3.1	1400	25.8.3.2	80	TCP
172.18.3.2	1401	25.8.3.2	80	TCP
. . .	. . .	. . .	. . .	. . .

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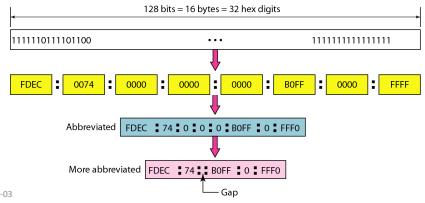
IPv6 addresses

- 128 bits = 16 bytes
- $2^{128} = (2^{16})^8 = 65\,536^8 > 3 \cdot 10^{38}$
- Notations



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IPv6 address categories

Type Prefix	Type	Fraction
0000 0000	Reserved	1/256
0000 0001	Unassigned	1/256
0000 001	ISO network addresses	1/128
0000 010	IPX (Novell) network addresses	1/128
0000 011	Unassigned	1/128
0000 1	Unassigned	1/32
0001	Reserved	1/16
001	Reserved	1/8
010	**Provider-based unicast addresses**	**1/8**

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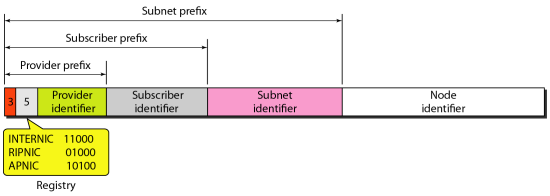
IPv6 unicast addresses

- Individual computer
  - Address type, area, ISP, organisation, subnet, user



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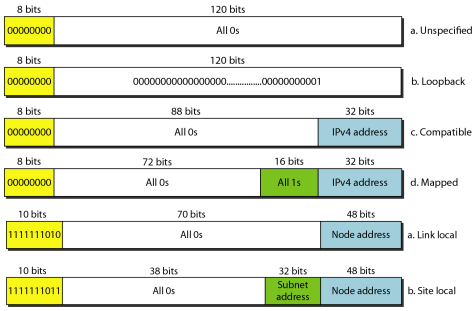
A few special IPv6 addresses



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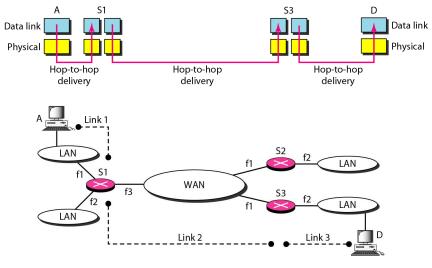
Internetworking

- L2 is host-to-host



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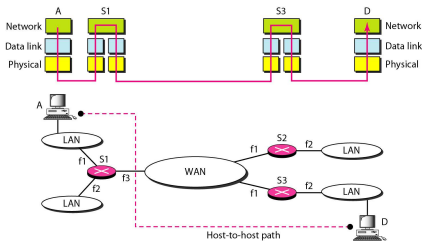
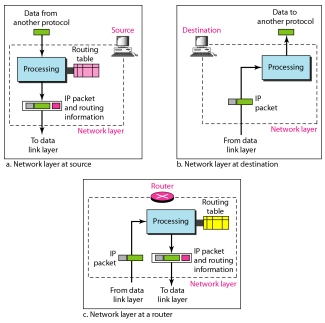
Network layer

- L3 is end-to-end

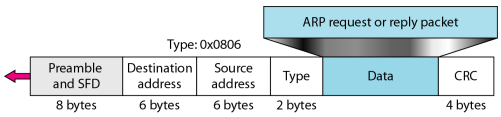


Routing at network layer

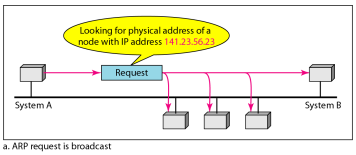


Address mapping

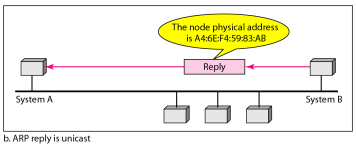
- Internetworking
  - Network of networks (Internet)
  - Connected by routers
- Routers need information
  - Logical (IP) ←→ physical (MAC)



Address resolution protocol (ARP)

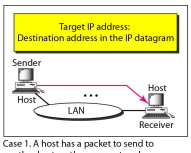


a. ARP request is broadcast

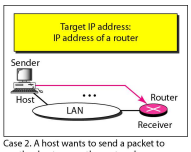


b. ARP reply is unicast

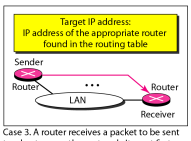
Four use cases for ARP



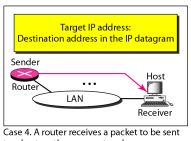
Case 1. A host has a packet to send to another host on the same network.



Case 2. A host wants to send a packet to another host on another network. It must first be delivered to a router.



Case 3. A router receives a packet to be sent to a host on another network. It must first be delivered to the appropriate router.



Case 4. A router receives a packet to be sent to a host on the same network.

Coming up next week

- Transmission modes §4.3
- Multiplexing §6.1
- SONET/SDH §17
- Asynchronous Transfer Mode, ATM §18.2-3