

# Dator- och telekommunikation

(EITG01)

Höstterminen 2024

***”Kort sammanfattning”***

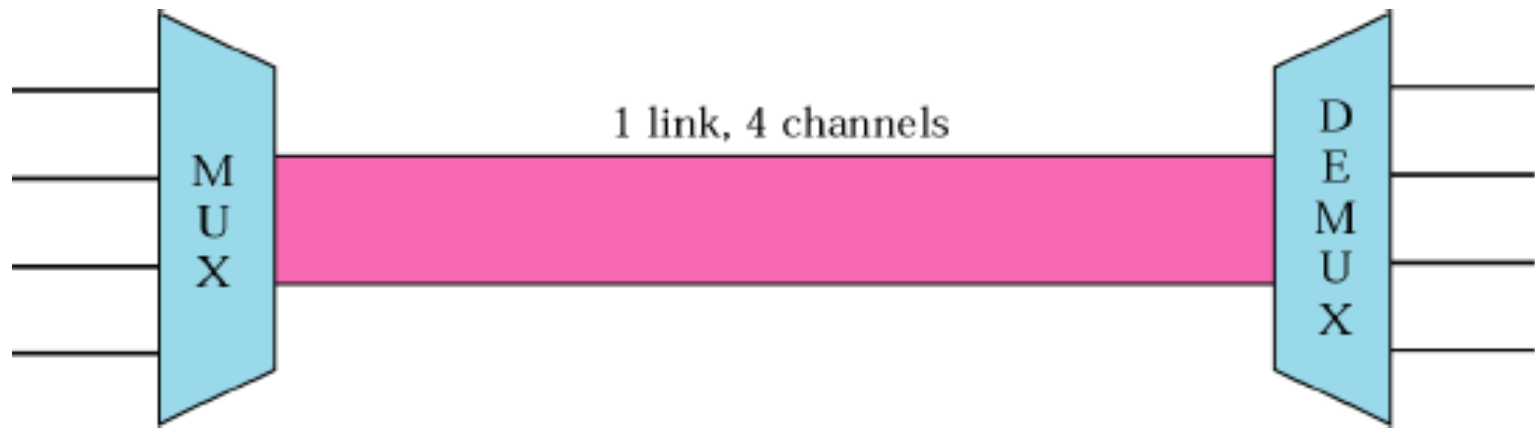
- Föreläsningar
- Övningar
- Laborationer

# OSI-modellen

<b>Applikation</b>	Program som interagera med användaren; epost, www
<b>Presentation</b>	Kryptering, komprimering, teckensnitt, färger
<b>Session</b>	Kommunikationssamordning Sessioner ~ uppkoppling
<b>Transport</b>	TCP, UDP Ankomstkontroll ( <i>segment</i> )
<b>Nätverk</b>	Vägval, virtuella vägar, IP ( <i>paket</i> )
<b>(Data)Länk</b>	Fel- och flödeskontroll på länknivå, MAC, LLC, PPP ( <i>ramar</i> )
<b>Fysisk</b>	Kodning, signalnivåer ( <i>bitar</i> )

# Multiplexering allmän princip

- Flera signaler sänds samtidigt över samma länk



# Multiplexering allmän princip

- En gemensam kanal delas på något av följande sätt
  - FDM (Frequency Division Multiplexing)
  - WDM (Wavelength Division Multiplexing)
  - TDM (Time Division Multiplexing)
  - CDM (Code Division Multiple Access)

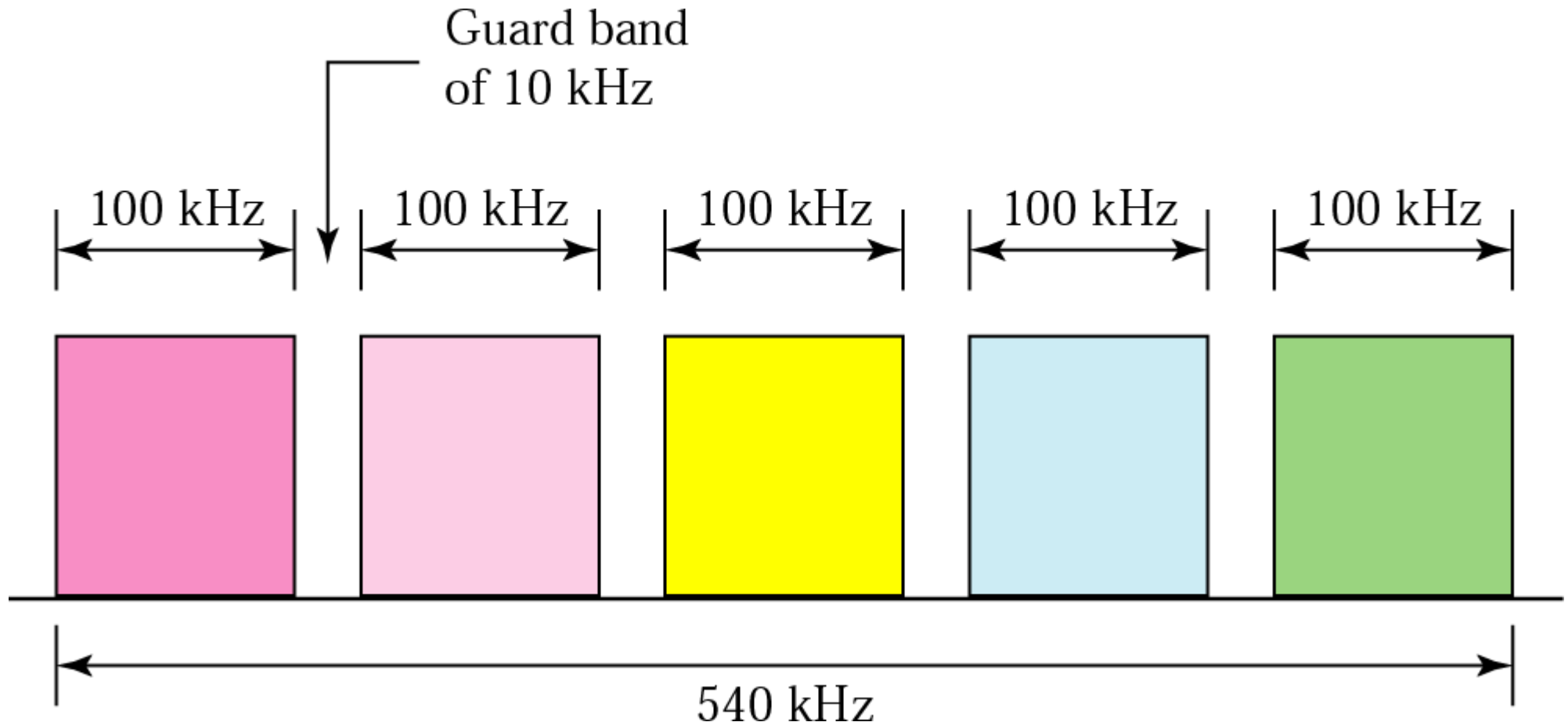
# Multiplexering FDM

- Kombination av signaler med olika frekvens



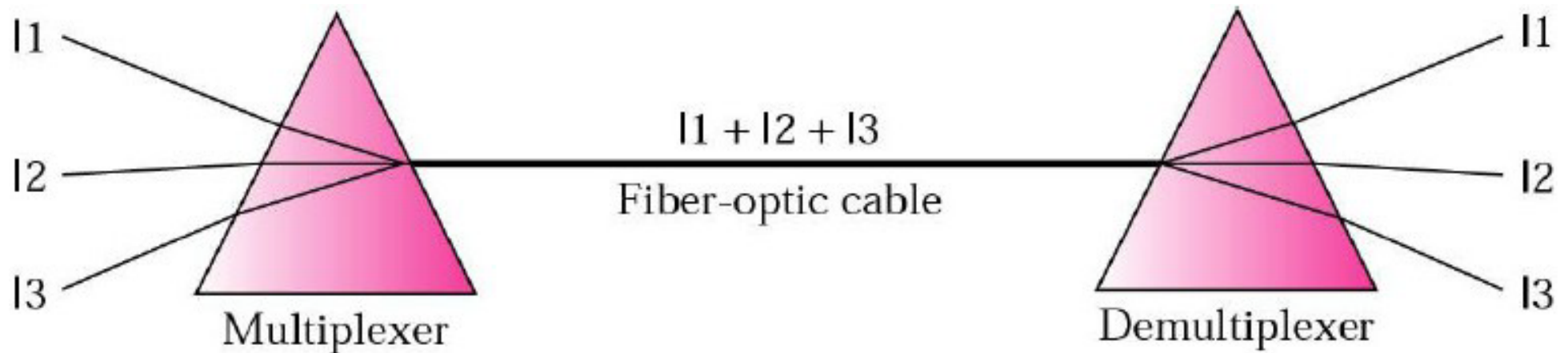
# Multiplexering, FDM

- Exempel: Multiplexering av 5 signaler (bandbredd 100 kHz) med "lucka" (guard band) på 10 kHz



# Multiplexing, WDM

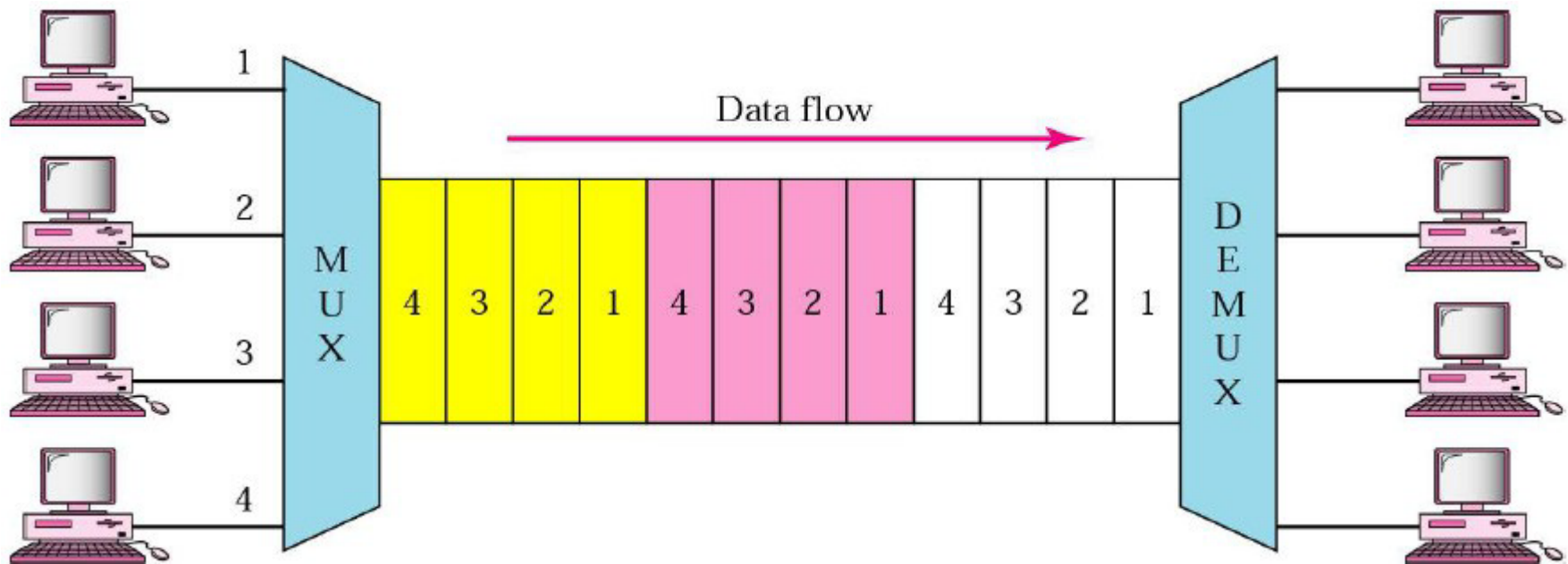
- Användning av prismor för WDM





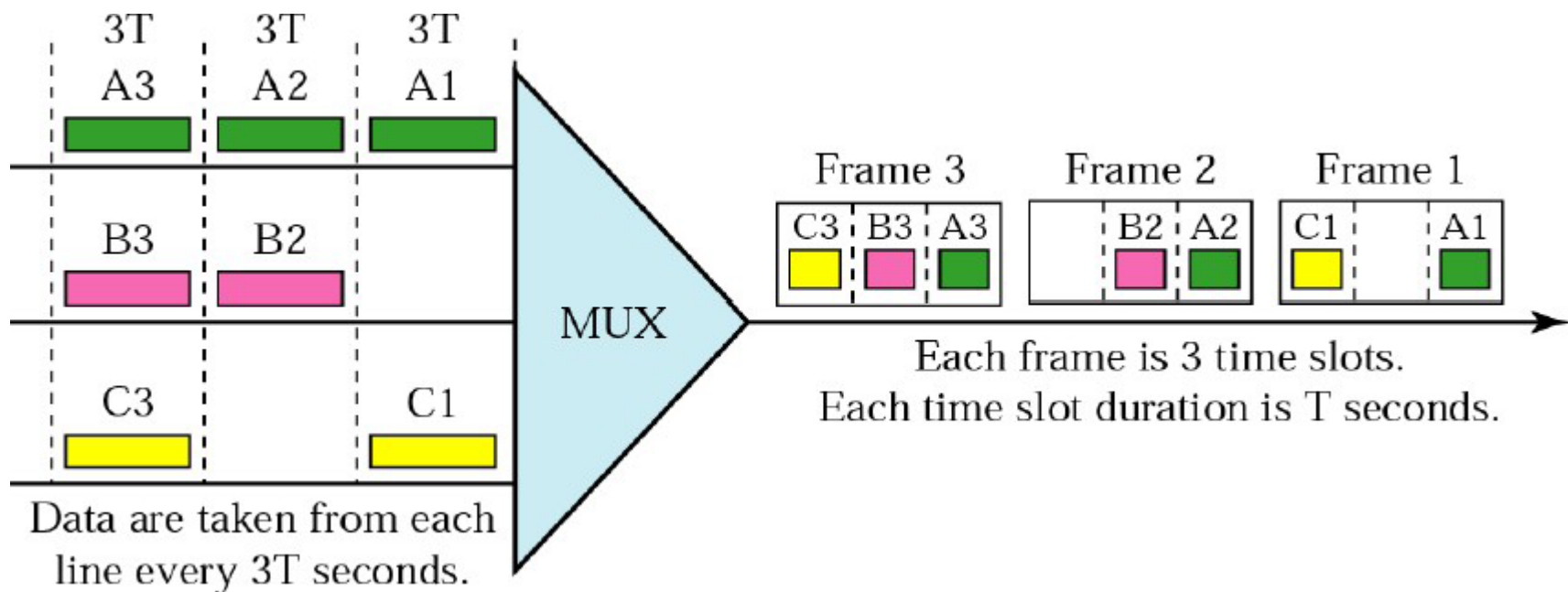
# Multiplexing, TDM

- Time-Division Multiplexing (TDM) kombinerar flera digitala signaler så att de skickas tillsammans i snabb takt



# Multiplexing, TDM

- Varje "tvärsnitt" skickas som en ram över länken fast  $N$  ggr så snabbt



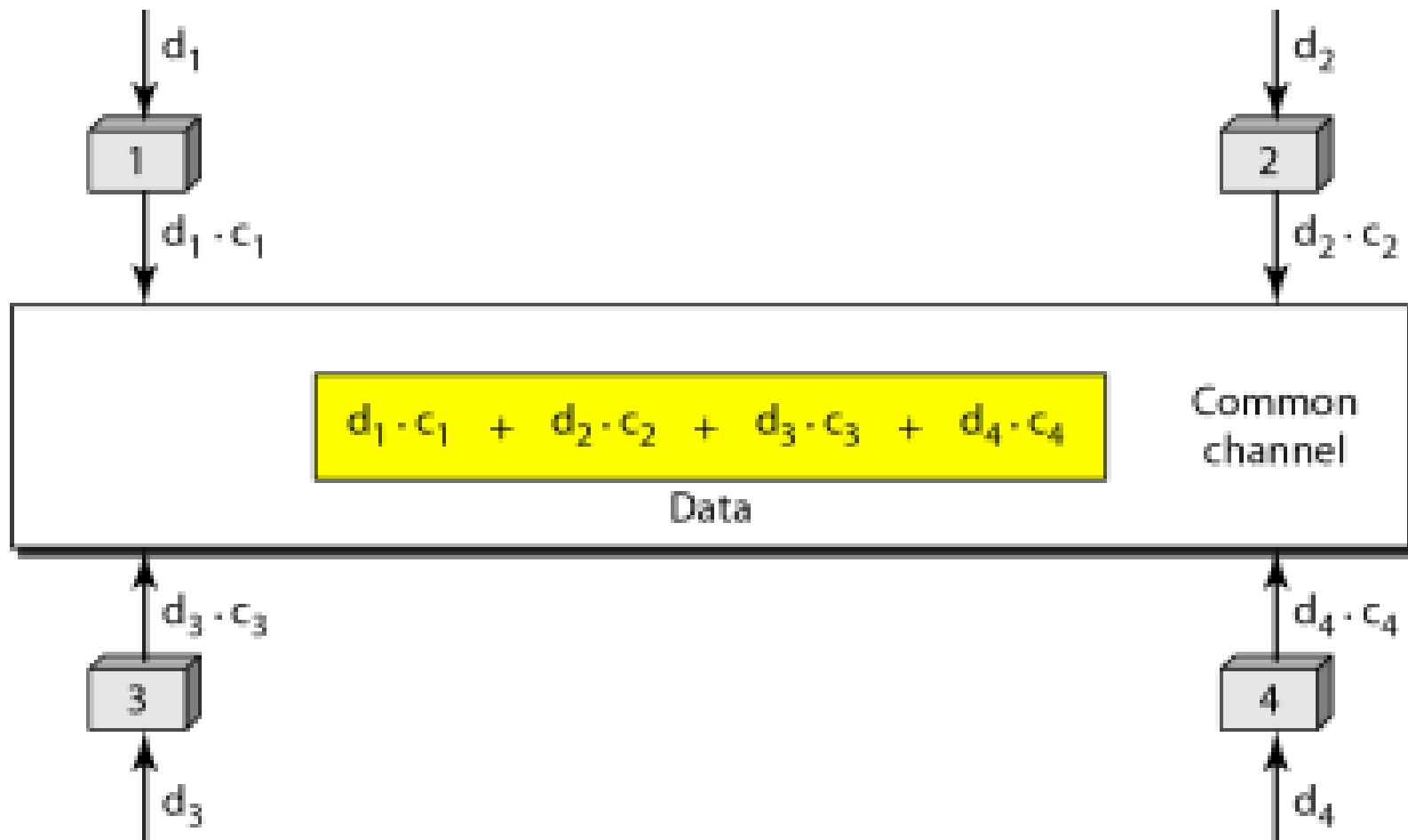
# Multiplexering, CDM

- Varje sändare har en vektor  $\alpha_i$  som är ortogonal mot alla andra sändares vektorer:

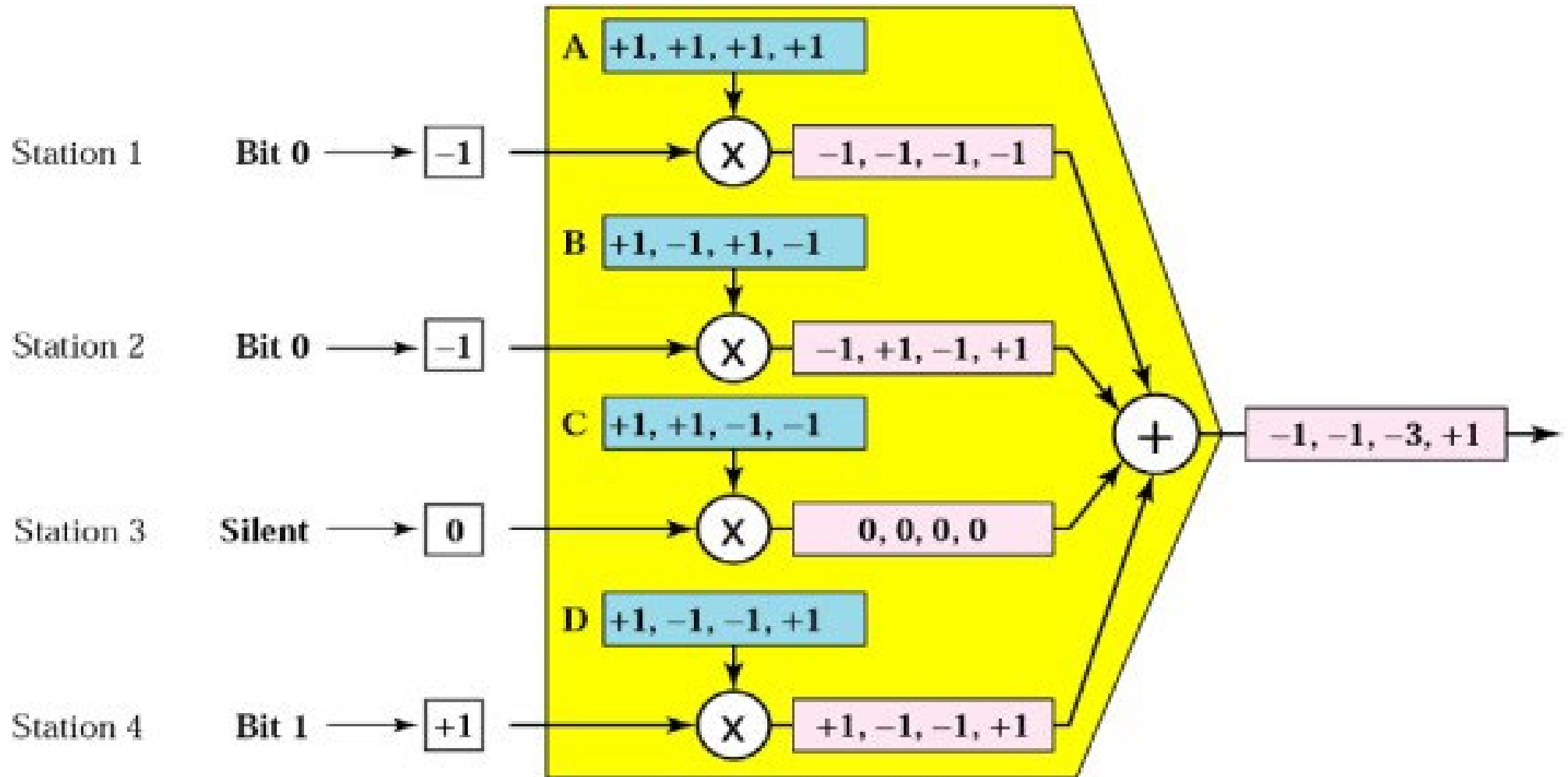
Om  $i \neq j$  så är  $\alpha_i \cdot \alpha_j = 0$

Dessutom gäller  $\alpha_i \cdot \alpha_i = 1$

- Data som ska skickas av sändare  $i$  kallas  $d_i$



# Multiplexing, CDM



# Multiplexing, CDM

- Raderna i en Walsh-matris är ortogonala mot varandra

$$W_1 = \begin{bmatrix} +1 \end{bmatrix} \qquad W_{2N} = \begin{bmatrix} W_N & W_N \\ W_N & \overline{W_N} \end{bmatrix}$$

a. Two basic rules

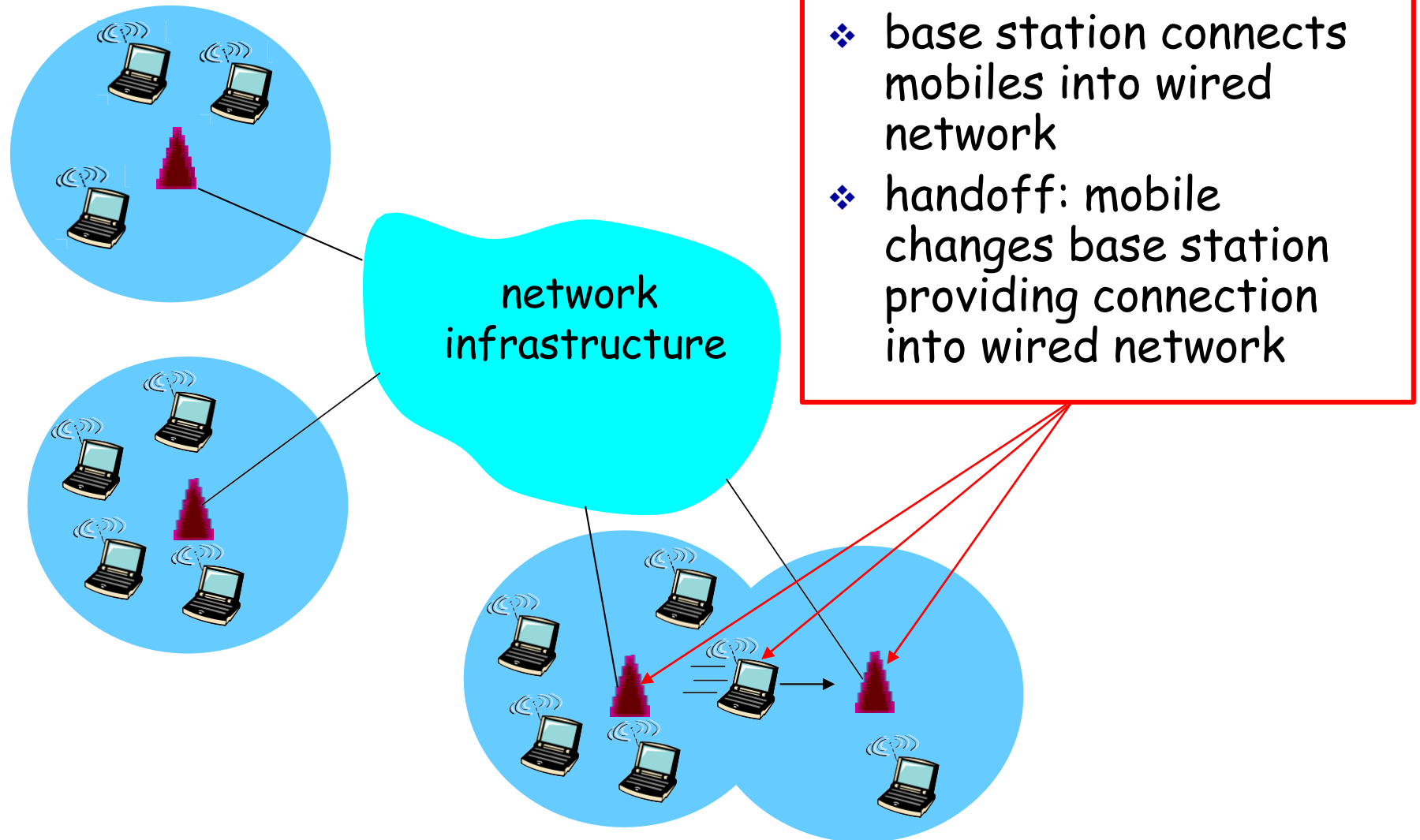
$$W_1 = \begin{bmatrix} +1 \end{bmatrix}$$

$$W_2 = \begin{bmatrix} +1 & +1 \\ +1 & -1 \end{bmatrix}$$

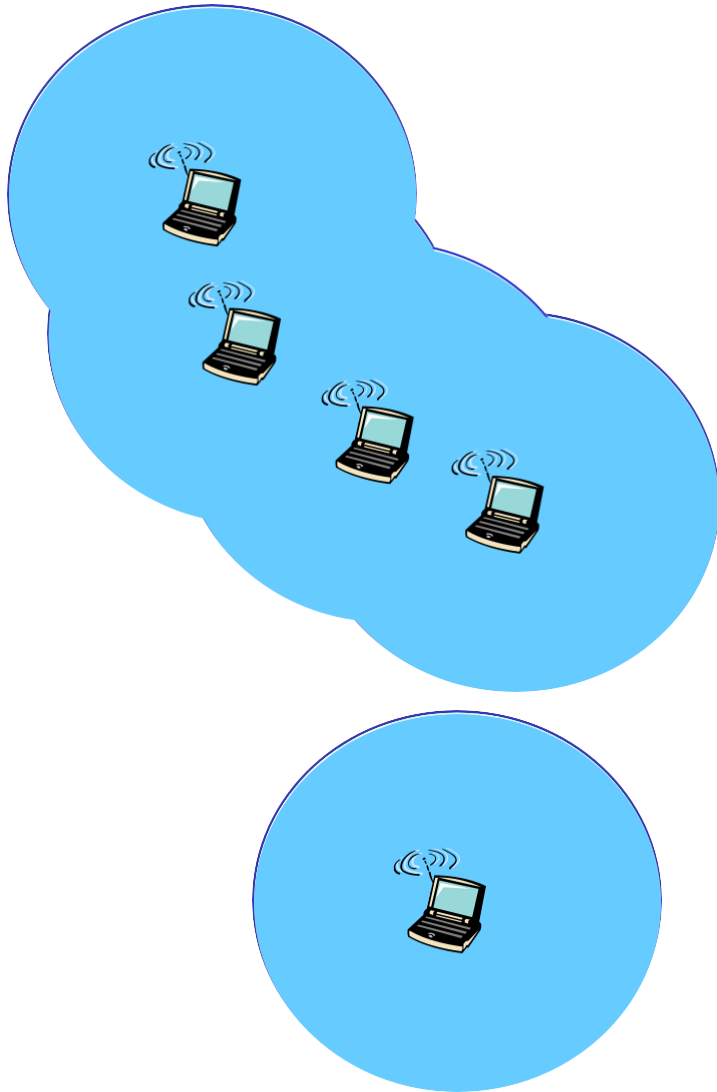
$$W_4 = \begin{bmatrix} \begin{bmatrix} +1 & +1 \\ +1 & -1 \end{bmatrix} & \begin{bmatrix} +1 & +1 \\ +1 & -1 \end{bmatrix} \\ \begin{bmatrix} +1 & +1 \\ +1 & -1 \end{bmatrix} & \begin{bmatrix} -1 & -1 \\ -1 & +1 \end{bmatrix} \end{bmatrix}$$

b. Generation of  $W_1$ ,  $W_2$ , and  $W_4$

# Elements of a wireless network



# Elements of a wireless network



## ad hoc mode

- ❖ no base stations
- ❖ nodes can only transmit to other nodes within link coverage
- ❖ nodes organize themselves into a network: route among themselves

# Wireless Link Characteristics

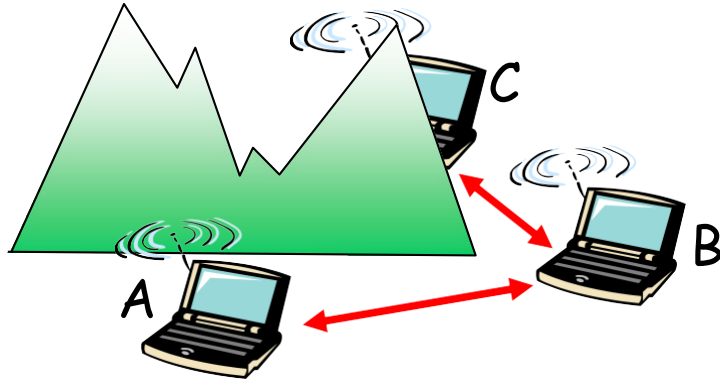
Differences from wired link ....

- **decreased signal strength:** radio signal attenuates fast
- **interference from other sources:** wireless network frequencies (e.g., 2.4 GHz) shared by other devices (e.g., phone); devices (motors) interfere as well
- **multipath propagation:** radio signal reflects off objects ground, arriving to a destination at slightly different times



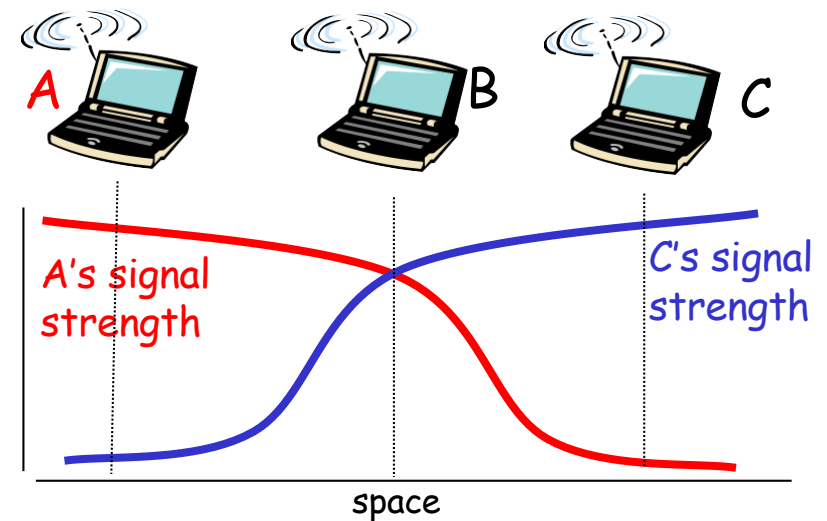
# Wireless network characteristics

Additional problems:



Hidden terminal problem

- ❖ B, A hear each other
  - ❖ B, C hear each other
  - ❖ A, C can not hear each other
- means A, C unaware of their interference at B



Signal attenuation:

- ❖ B, A hear each other
- ❖ B, C hear each other
- ❖ A, C can not hear each other interfering at B

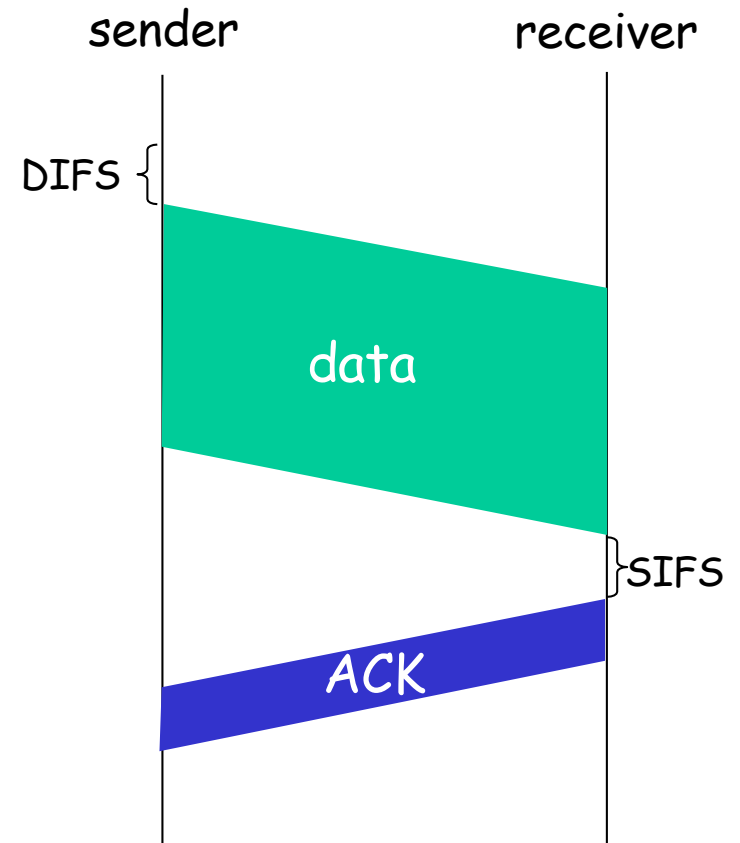
# IEEE 802.11 MAC Protocol: CSMA/CA

## 802.11 sender

- 1 if sense channel idle for **DIFS** then  
transmit entire frame (no CD)
- 2 if sense channel busy then  
start random backoff time  
timer counts down while channel idle  
transmit when timer expires  
if no ACK, increase random backoff  
interval, repeat 2

## 802.11 receiver

- if frame received OK  
return ACK after **SIFS** (ACK needed due to  
hidden terminal problem)



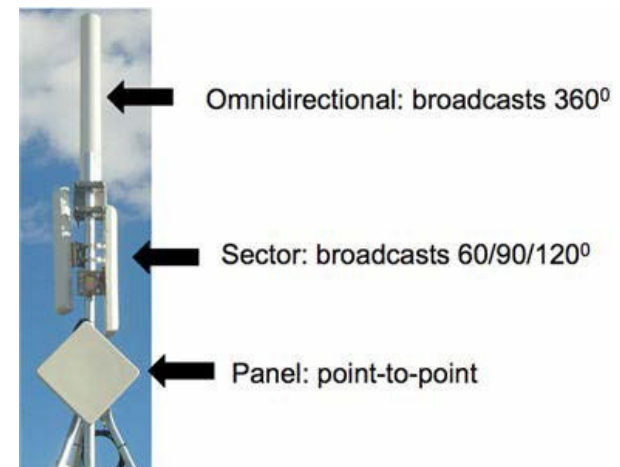
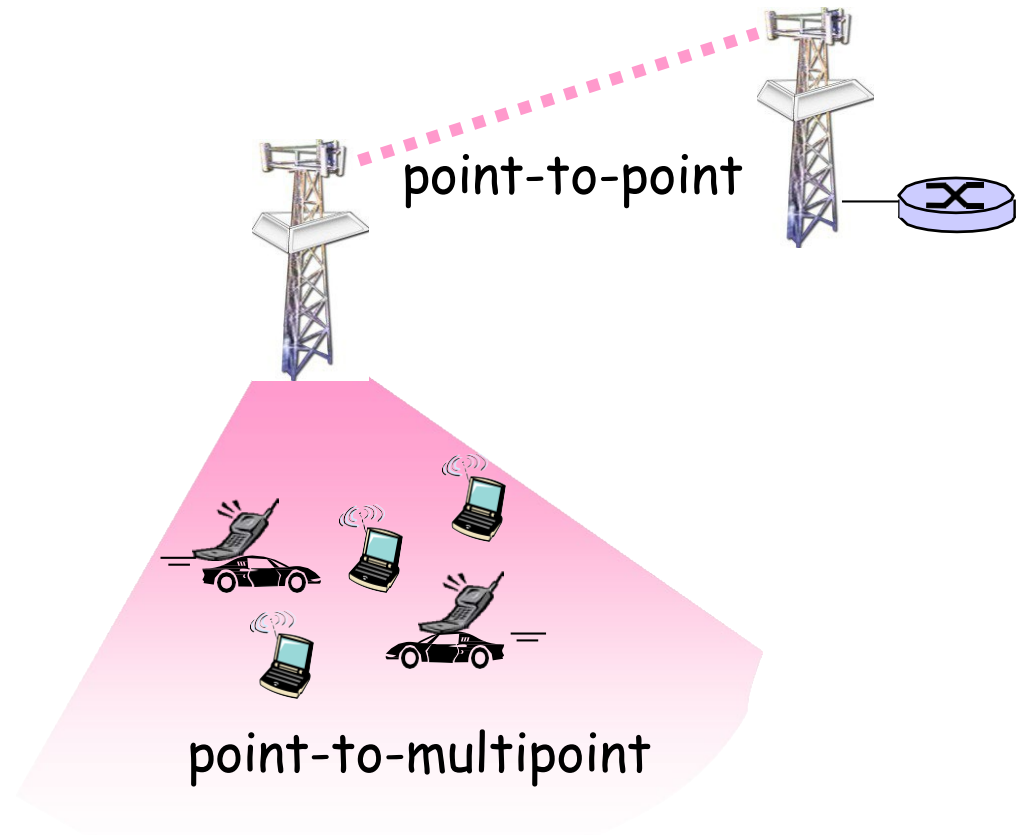
# 802.16: WiMAX

## ❖ like 802.11 & cellular: base station model

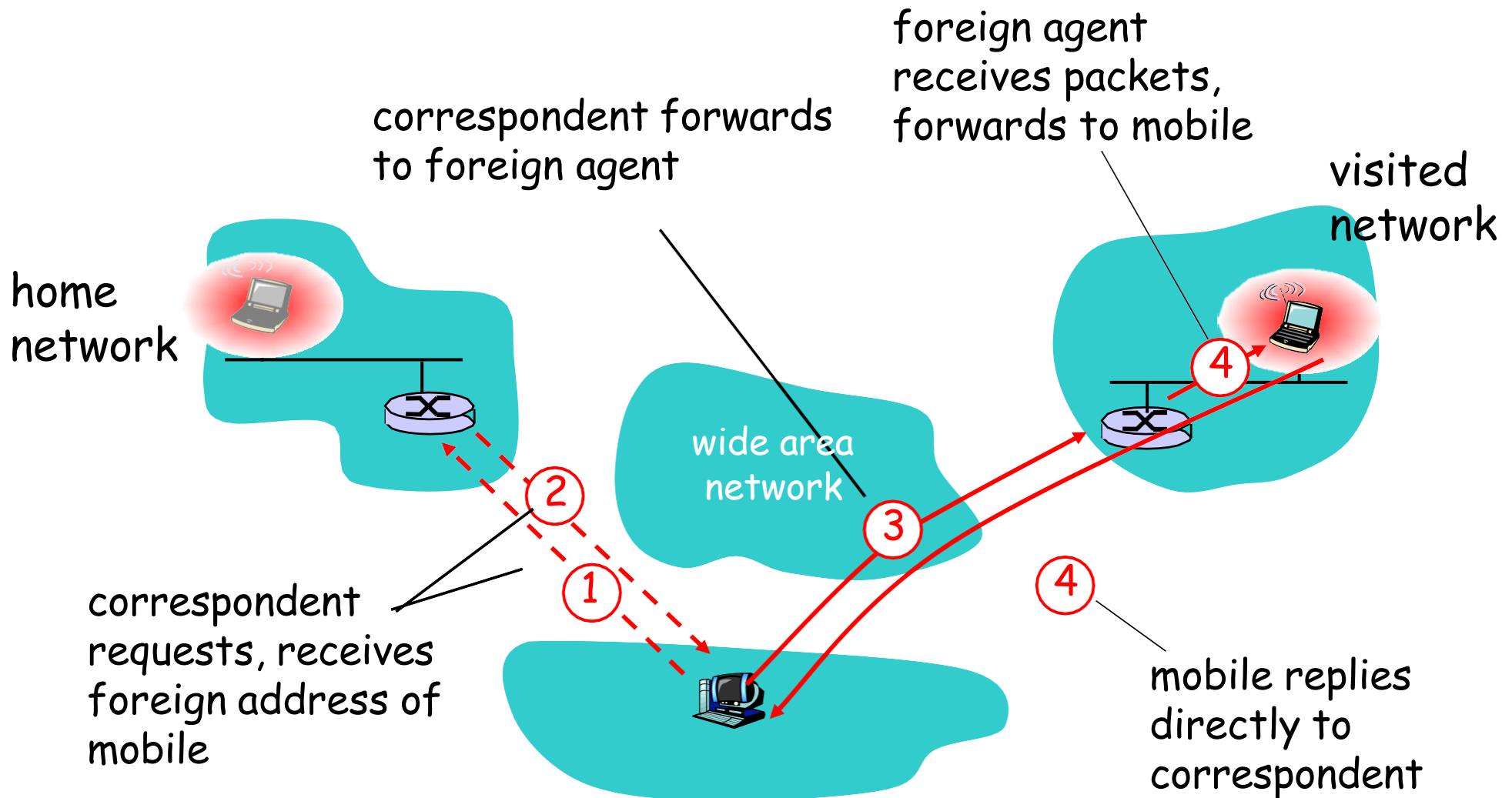
- transmissions to/from base station by hosts with omnidirectional antenna
- base station-to-base station backhaul with point-to-point antenna

## ❖ unlike 802.11:

- range ~ 6 miles ("city rather than coffee shop")
- ~14 Mbps



# Mobility via Direct Routing



# Mobile IP

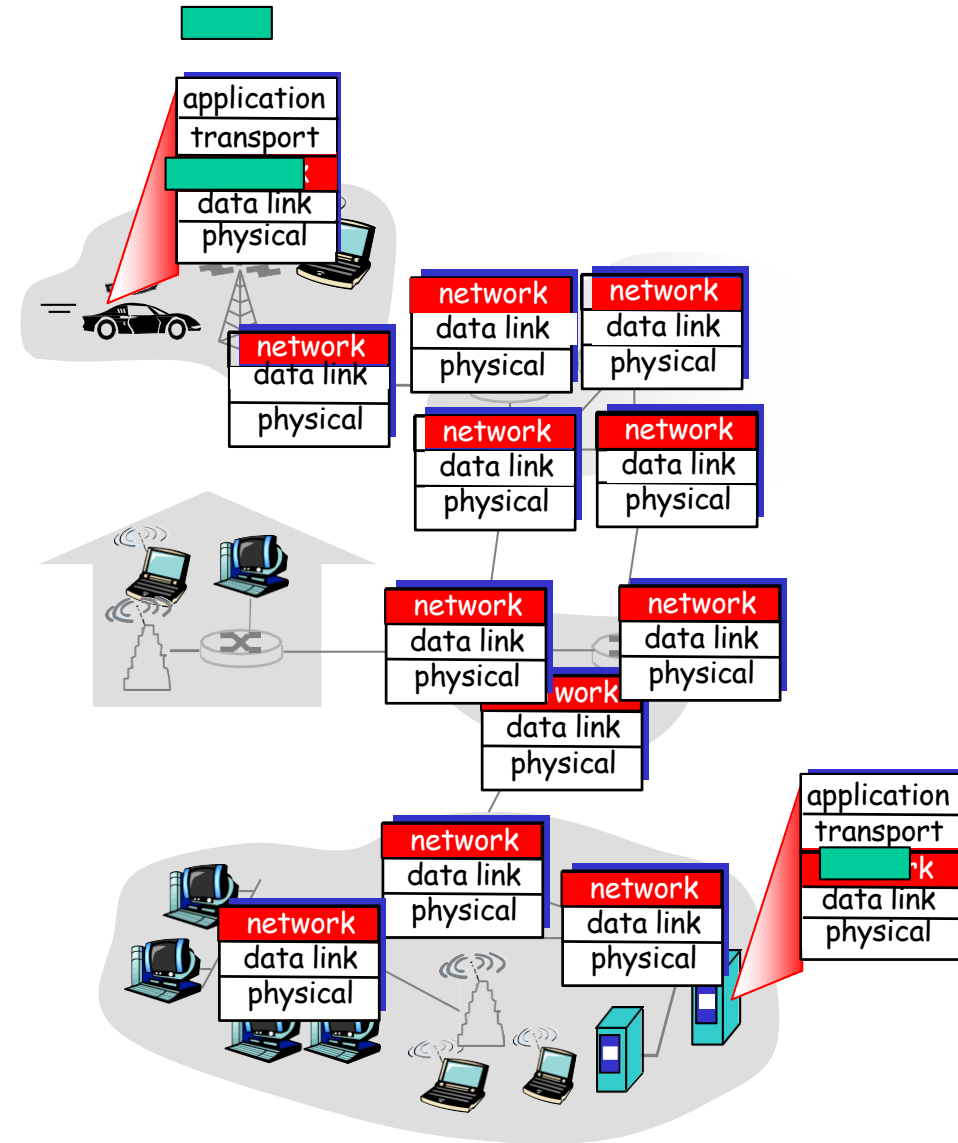
- ❖ RFC 3344
- ❖ has many features we've seen:
  - home agents, foreign agents, foreign-agent registration, care-of-addresses, encapsulation (packet-within-a-packet)
- ❖ three components to standard:
  - indirect routing of datagrams
  - agent discovery
  - registration with home agent

# Handling mobility in cellular networks

- ❖ *home network*: network of cellular provider you subscribe to (e.g., Telia, Telenor)
  - *home location register (HLR)*: database in home network containing permanent cell phone #, profile information (services, preferences, billing), information about current location (could be in another network)
- ❖ *visited network*: network in which mobile currently resides
  - *visitor location register (VLR)*: database with entry for each user currently in network
  - could be home network

# Network layer

- ❖ transport segment from sending to receiving host
- ❖ on sending side encapsulates segments into datagrams
- ❖ on receiving side, delivers segments to transport layer
- ❖ network layer protocols in every host, router
- ❖ router examines header fields in all IP datagrams



# Two Key Network-Layer Functions

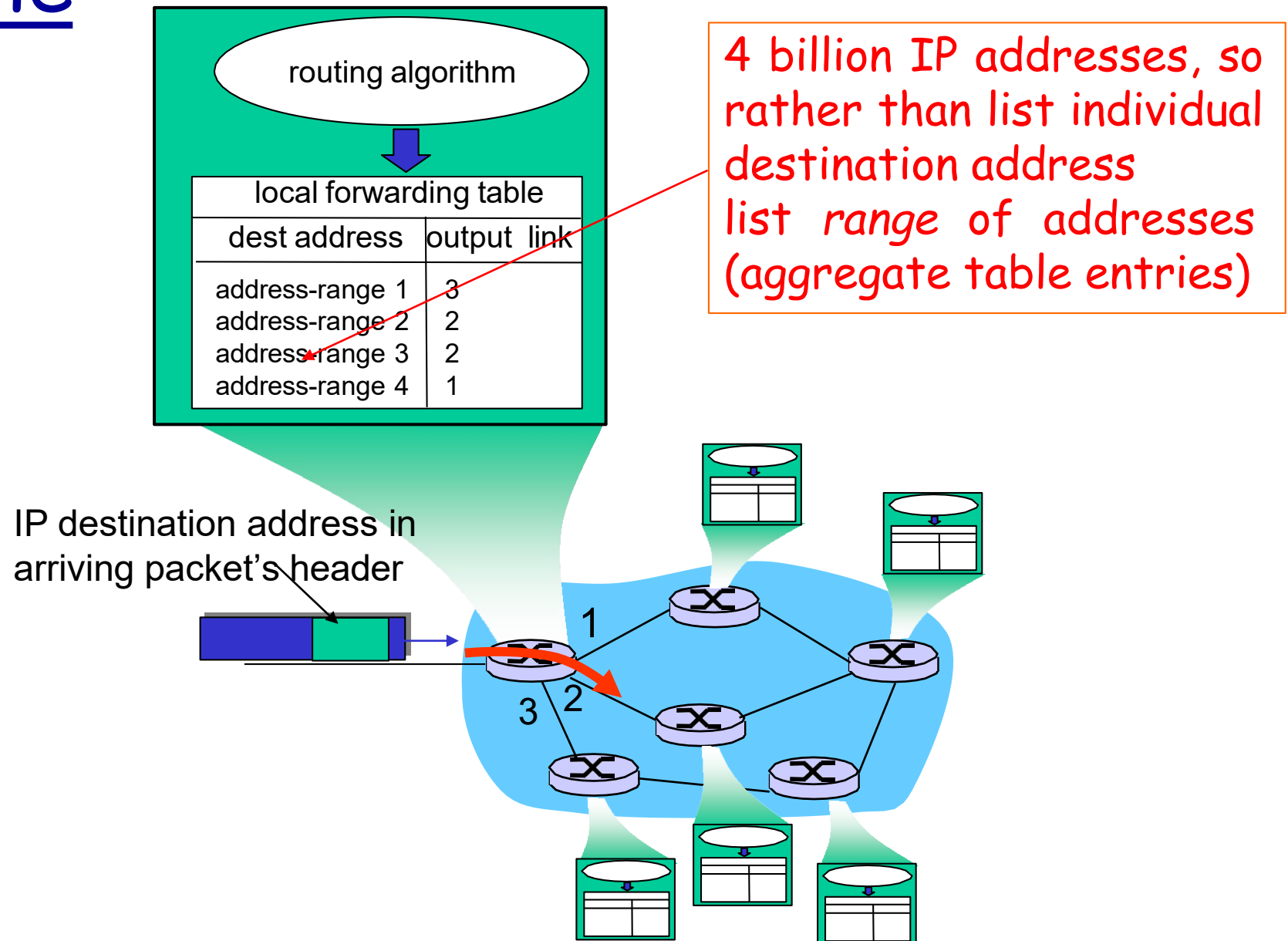
- ❖ *forwarding*: move packets from router's input to appropriate router output
- ❖ *routing*: determine route taken by packets from source to destination
  - *routing algorithms*

## Analogy (driving):

- ❖ *routing*: process of planning trip from source to destination
- ❖ *forwarding*: process of getting through single interchange



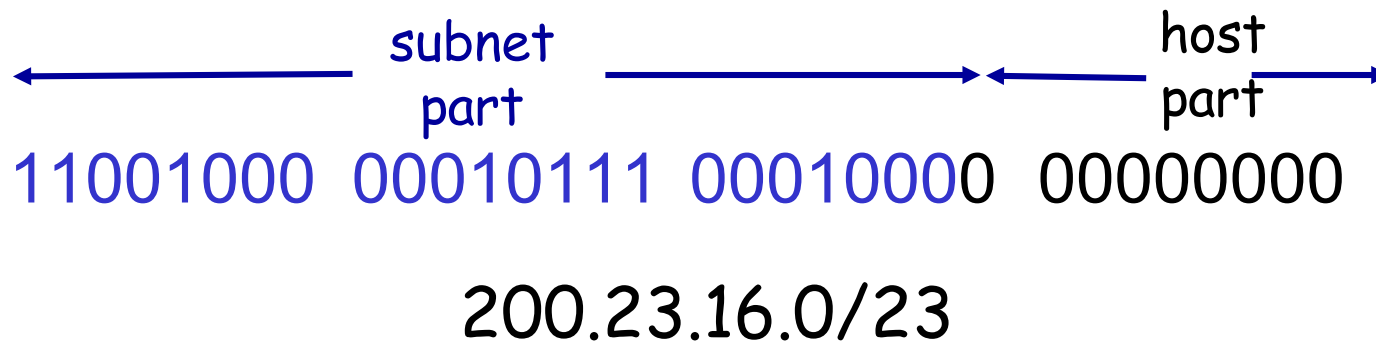
# Datagram Forwarding table



# IP addressing: CIDR

## CIDR: Classless InterDomain Routing

- subnet portion of address of arbitrary length
- address format: **a.b.c.d/x**, where x is # bits in subnet portion of address



# IPv6

- ❖ **Initial motivation:** 32-bit address space soon to be completely allocated.
- ❖ **Additional motivation:**
  - header format helps speed processing/forwarding
  - header changes to facilitate QoS

## **IPv6 datagram format:**

- fixed-length 40 byte header
- no fragmentation allowed

# Transition From IPv4 To IPv6

- ❖ Not all routers can be upgraded simultaneous
  - How will the network operate with mixed IPv4 and IPv6 routers?
- ❖ *Tunneling*: IPv6 carried as payload in IPv4 datagram among IPv4 routers
- ❖ *Dual stack*: Both IPv4 and IPv6 protocol implemented in the routers
- ❖ *Translation*: When transiting, translate between protocols (information lost)

# A Link-State Routing Algorithm

## Dijkstra's algorithm

- ❖ net topology, link costs known to all nodes
  - accomplished via "link state broadcast"
  - all nodes have same info
- ❖ computes least cost paths from one node ("source") to all other nodes
  - gives *forwarding table* for that node
- ❖ iterative: after  $k$  iterations, know least cost path to  $k$  destinations

## Notation:

- ❖  $c(x,y)$ : link cost from node  $x$  to  $y$ ;  $= \infty$  if not direct neighbors
- ❖  $D(v)$ : current value of cost of path from source to destination  $v$
- ❖  $p(v)$ : predecessor node along path from source to  $v$
- ❖  $N'$ : set of nodes whose least cost path definitively known

# Distance Vector Algorithm

## Bellman-Ford Equation (dynamic programming)

Define

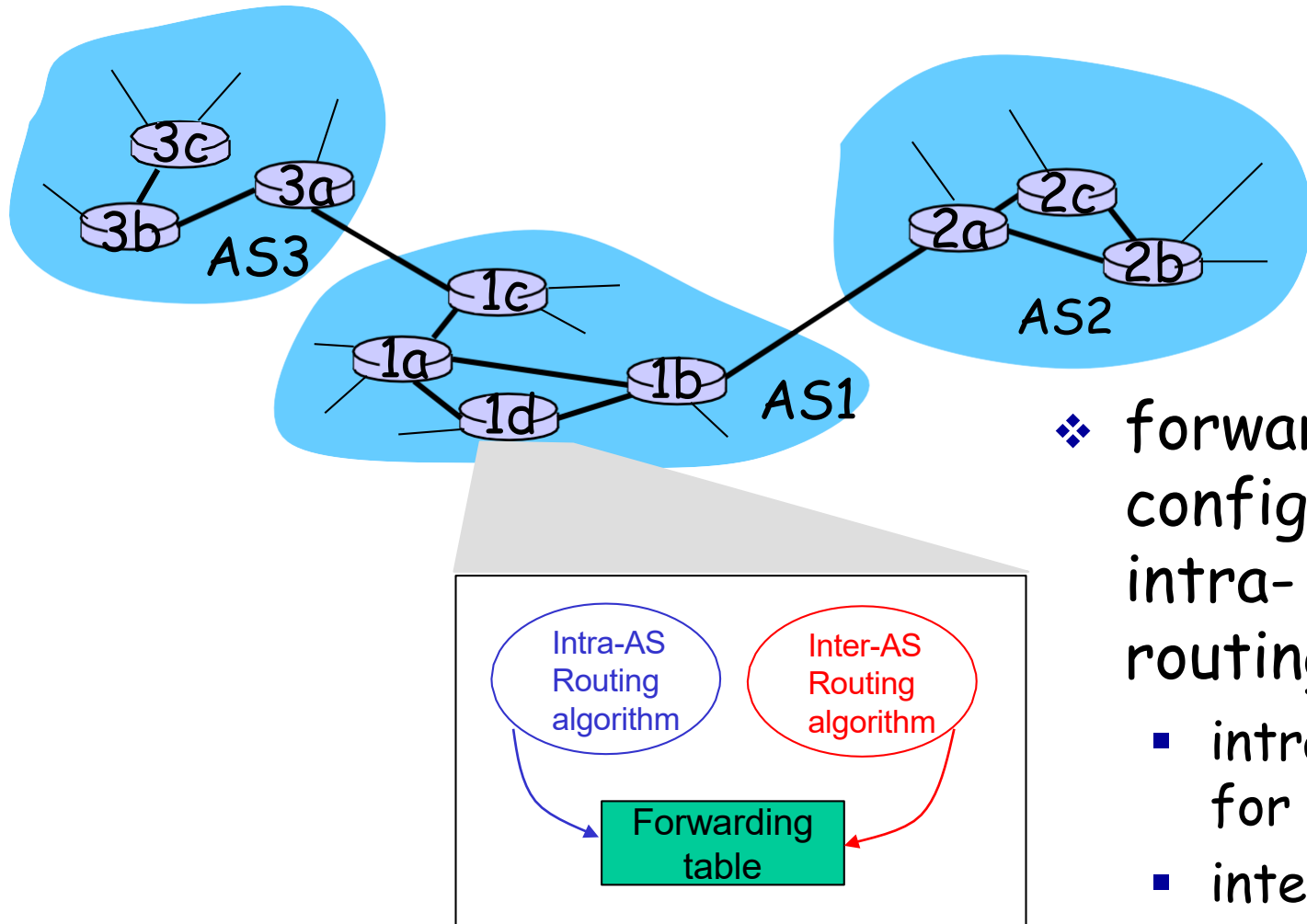
$d_x(y) :=$  cost of least-cost path from  $x$  to  $y$

Then

$$d_x(y) = \min_v \{c(x,v) + d_v(y)\}$$

where  $\min$  is taken over all neighbors  $v$  of  $x$

# Interconnected ASes



- ❖ forwarding table configured by both intra- and inter-AS routing algorithm
  - intra-AS sets entries for internal dests
  - inter-AS & intra-AS sets entries for external dests

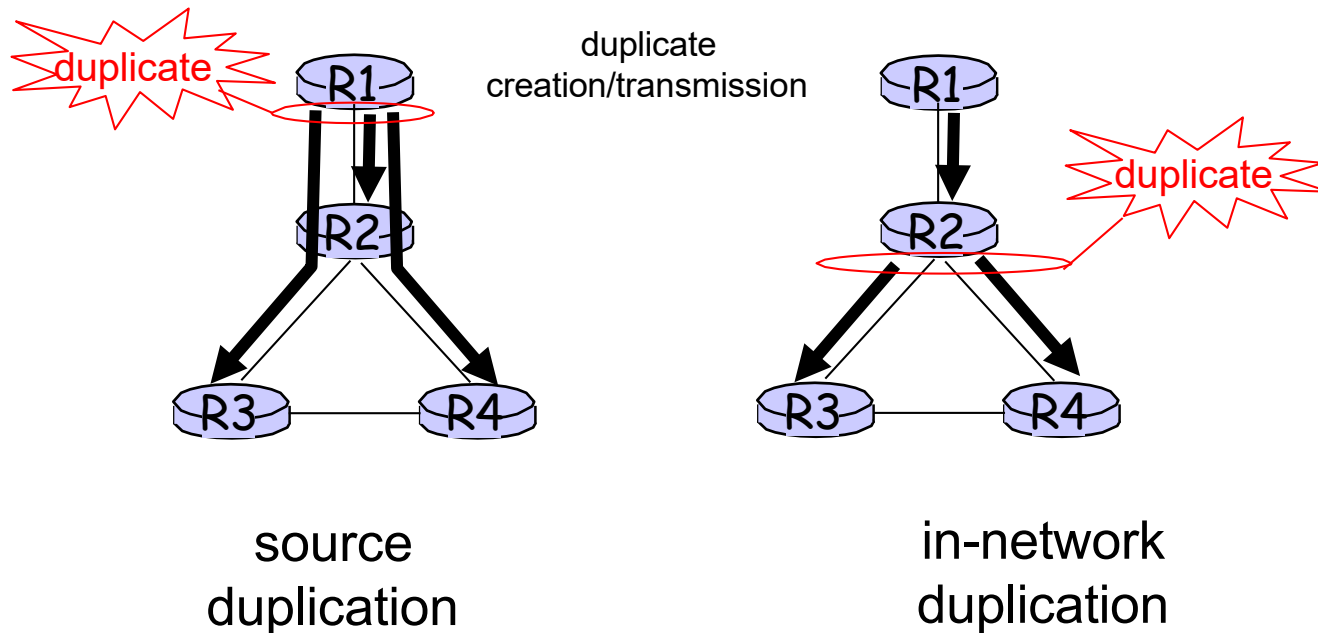
# Intra-AS Routing

- ❖ also known as **Interior Gateway Protocols (IGP)**
- ❖ most common Intra-AS routing protocols:
  - RIP: Routing Information Protocol
  - OSPF: Open Shortest Path First
  - IGRP: Interior Gateway Routing Protocol (Cisco proprietary)



# Broadcast Routing

- ❖ deliver packets from source to all other nodes
- ❖ source duplication is inefficient:



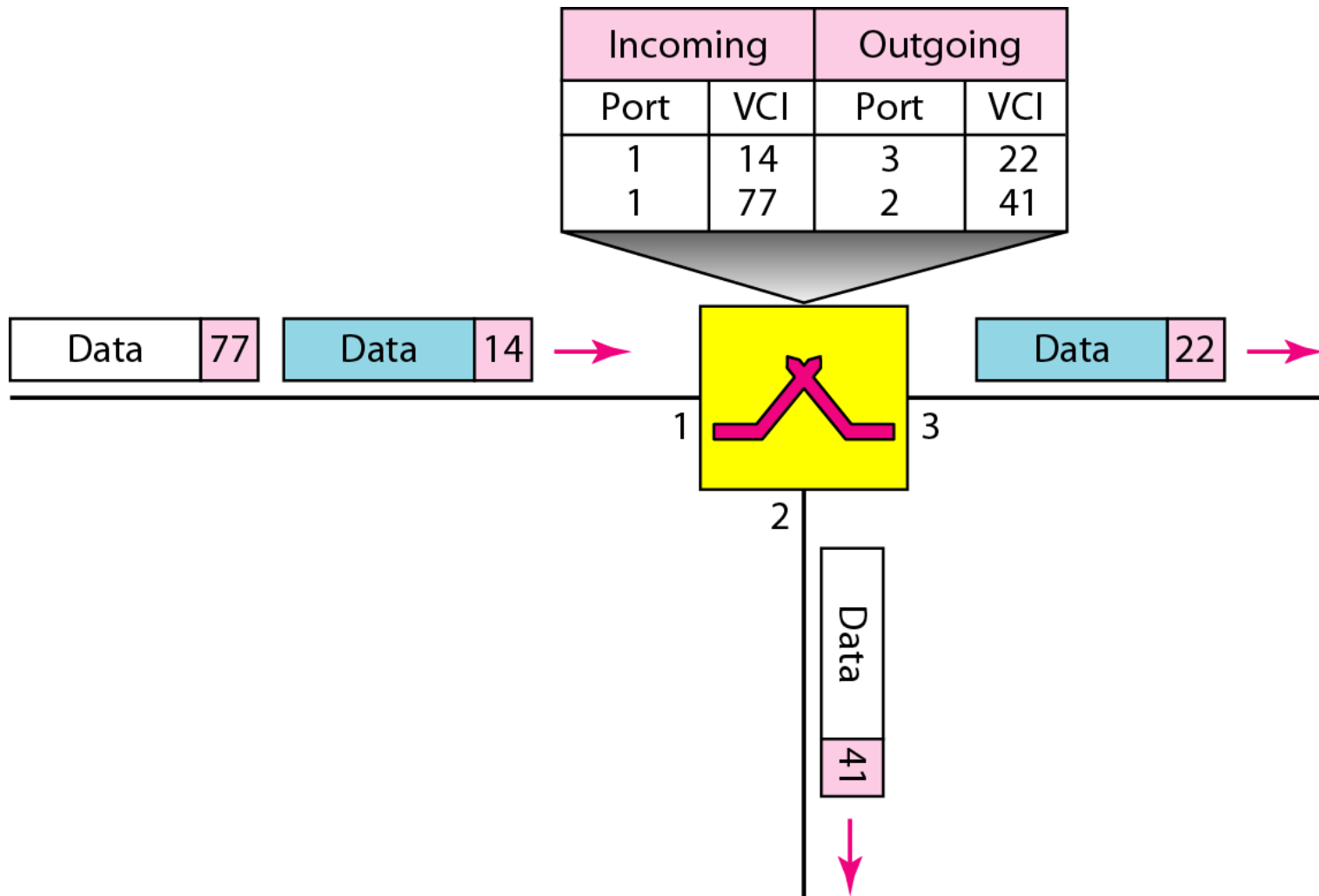
# Virtuella kretskopplade nät

## virtual circuit networks

- Blandning mellan kretskoppling och datagram
- Förbindelser har tre faser:
  - Initiering
  - Dataöverföring
  - Nerkoppling
- Data skickas i paket med adress
- Alla paket i en förbindelse går samma väg

# Virtuella kretskopplade nät

- En växel, observera att VCI byts vid passagen



# What is simulation?

- Simple synonym: imitation
- We are interested in studying a system
- Instead of experimenting with the system itself we experiment with a model of the system

# Two approaches to simulation

- Event-scheduling method
- Process-interaction method

# Event scheduling approach

What is needed:

- A state description
- Events
- Rules telling what will happen when an event occurs
- Parameters

# Processes in simulation

- In simulation a *process* is something that does something
- A process has some *internal state*
- Processes communicate by sending *signals* to each other
- Signals have a name and can carry information
- When a signal arrives to a process some *activity* is triggered
- During an activity the state of the receiving process might be changed and signals may be sent
- When a signal is sent the sender assigns it an *arrival time*

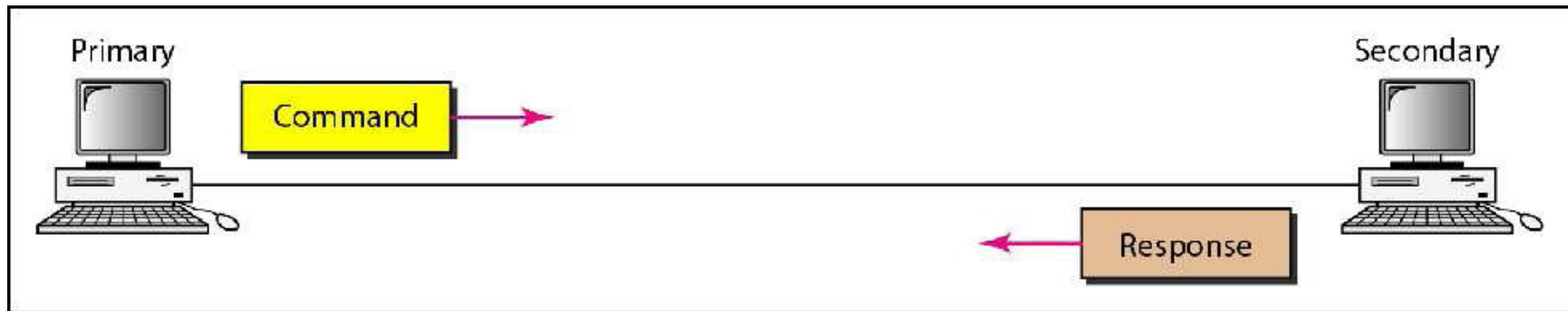
# Punkt-till-punkt-access

- HDLC  
(High-level Data Link Control)
- PPP  
(Point-to-Point Protocol)

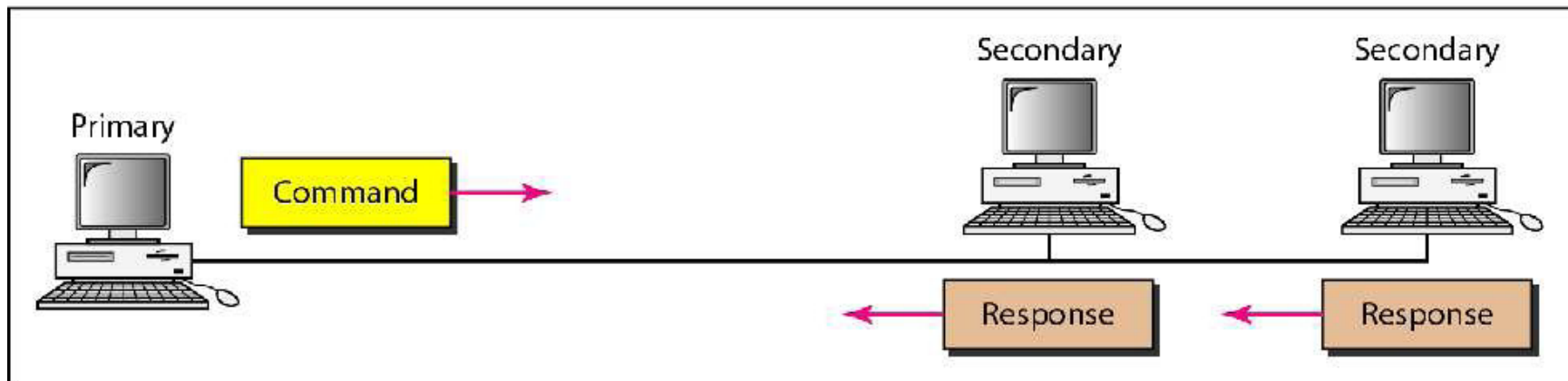


# HDLC

- NRM (Normal Response Mode)



a. Point-to-point



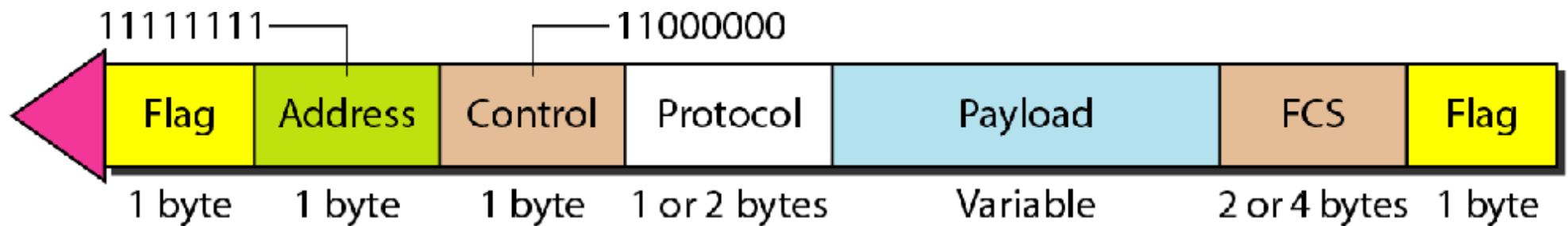
b. Multipoint

# PPP

- PPP (Point-to-Point Protocol)
  - Vanligaste protokollet för punkt-till-punkt-förbindelser
  - Används för kontakt mellan användare och internetleverantör
  - Använder en variant av HDLC

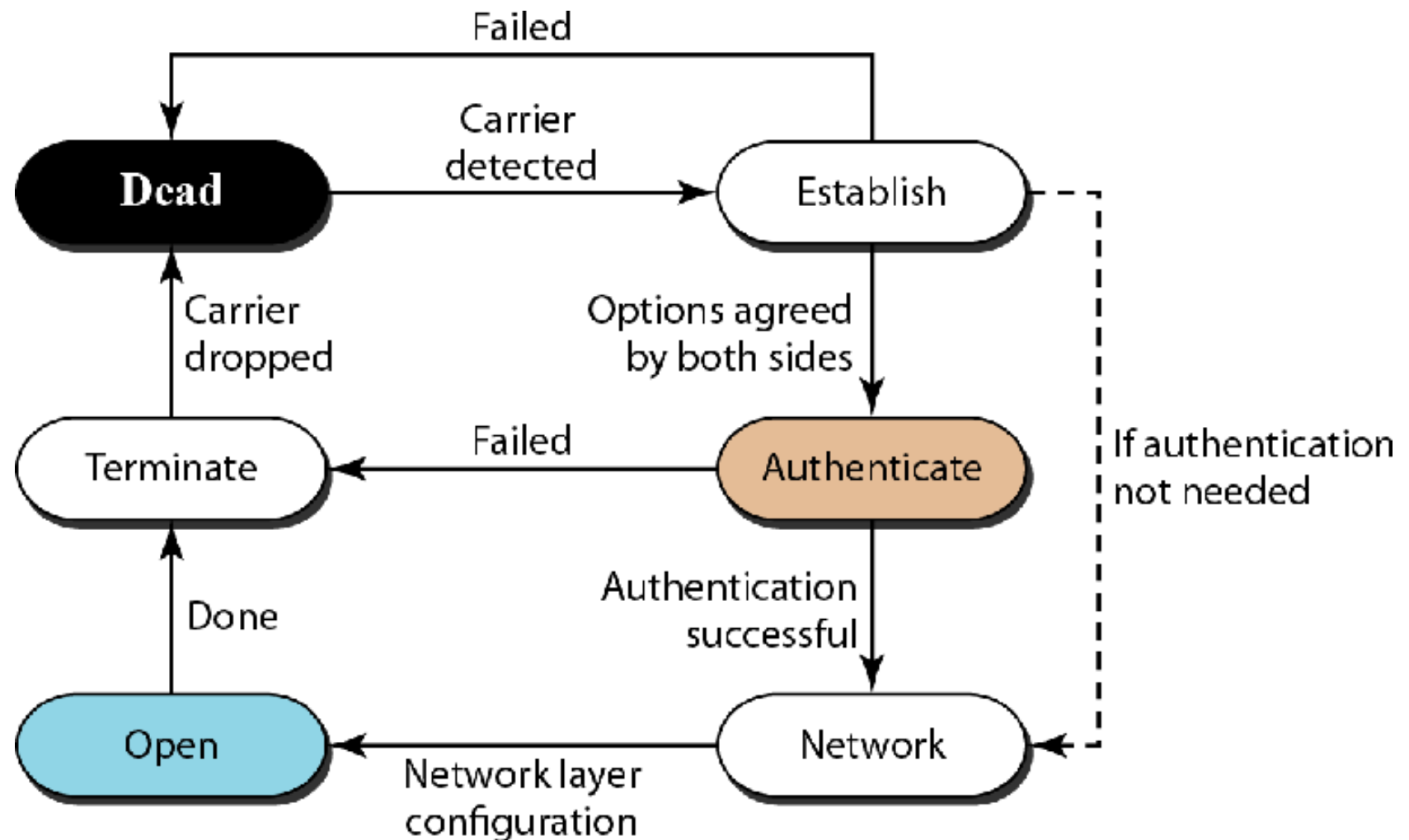
# PPP

- Formatet på en PPP-ram

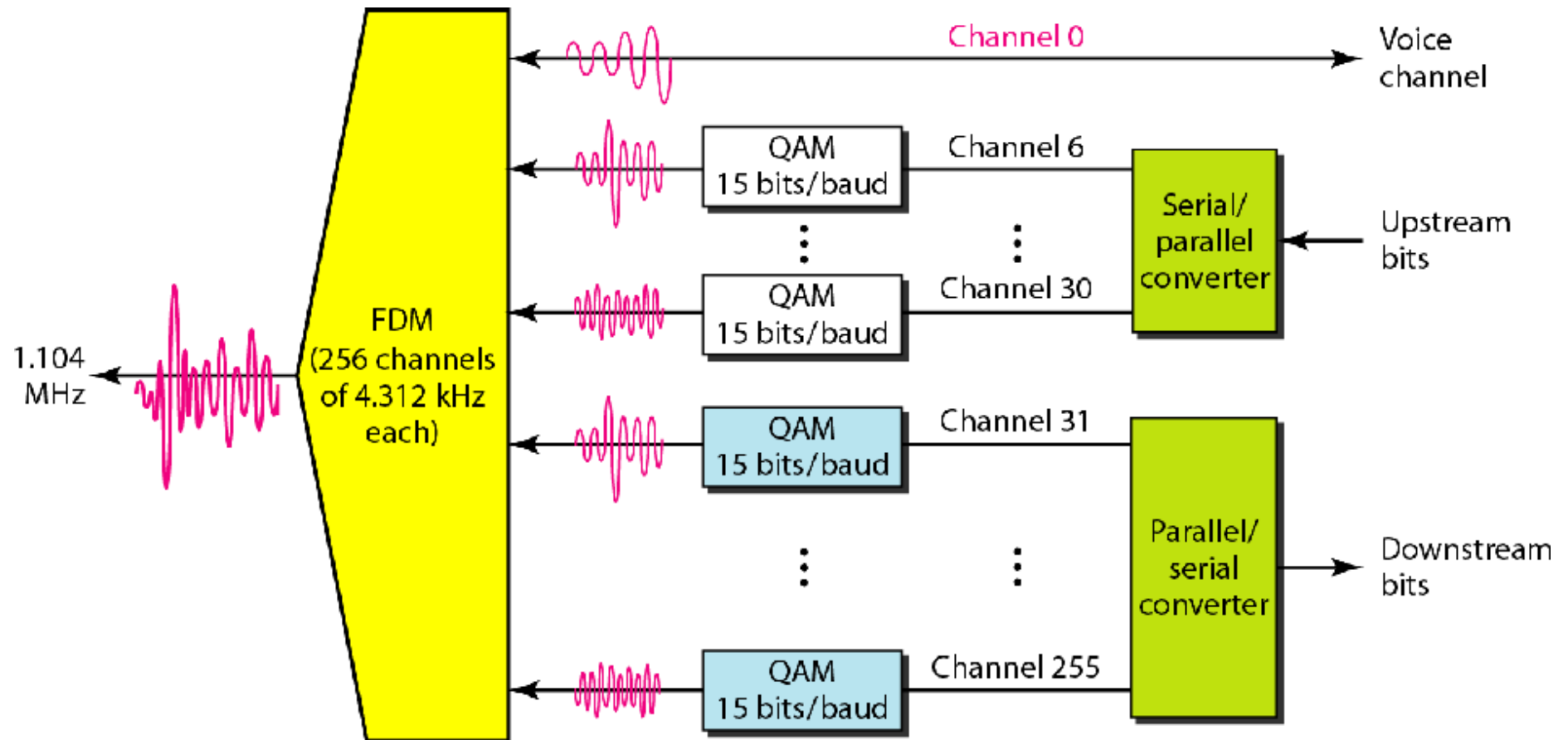


# PPP

- Tillståndsgraf för PPP

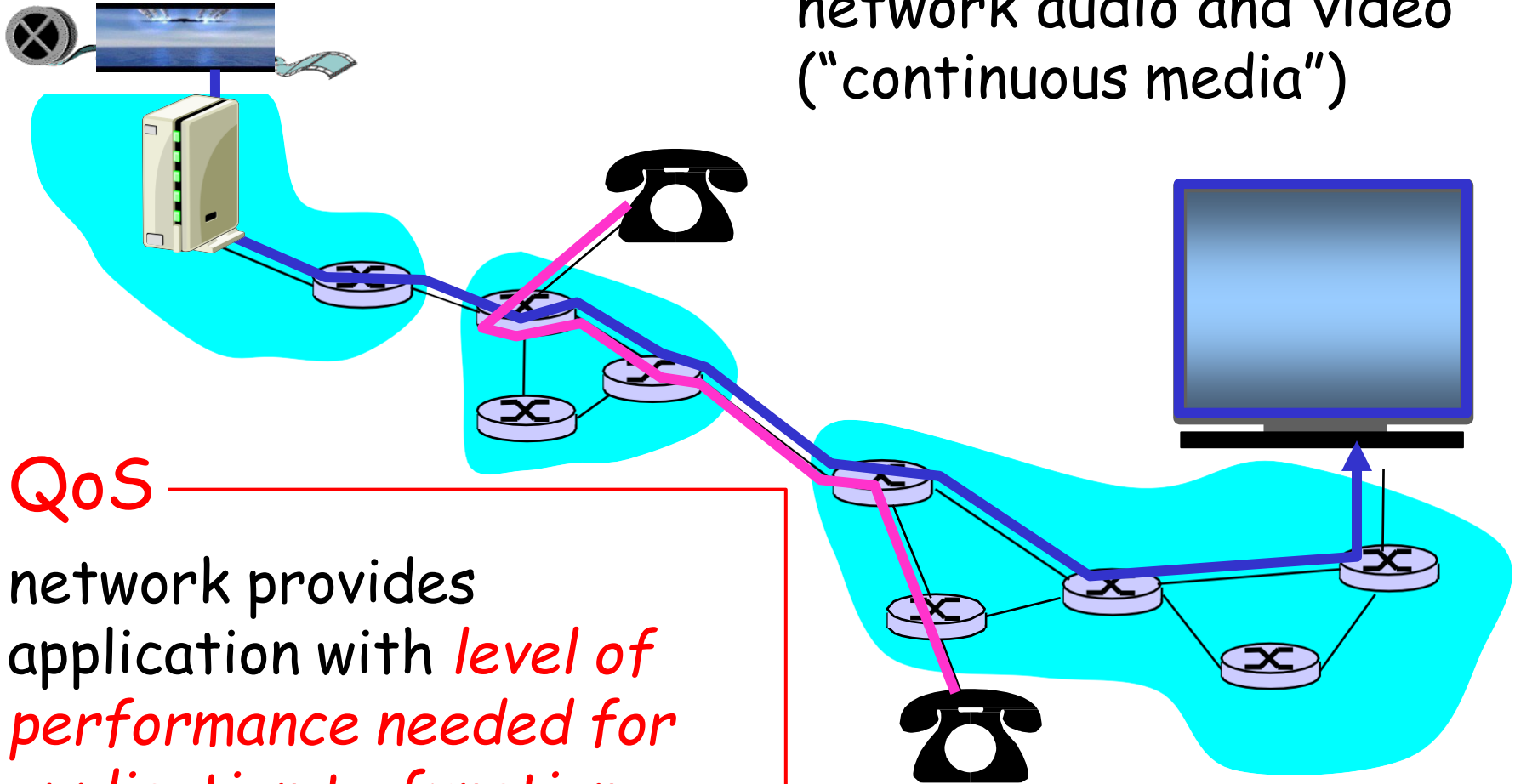


# ADSL



# Multimedia and Quality of Service: What is it?

multimedia applications:  
network audio and video  
("continuous media")



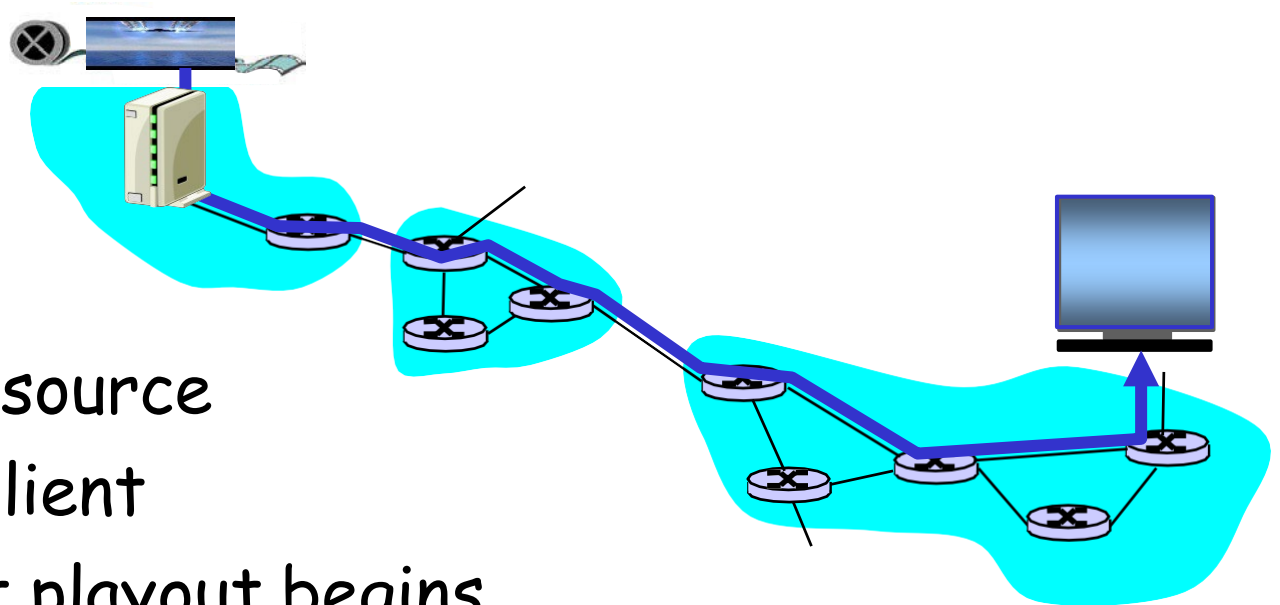
## QoS

network provides  
application with *level of  
performance needed for  
application to function.*

# Streaming Stored Multimedia

## Stored streaming:

- ❖ media stored at source
- ❖ transmitted to client
- ❖ streaming: client playout begins before all data has arrived
  - ❖ timing constraint for still-to-be transmitted data: in time for playout



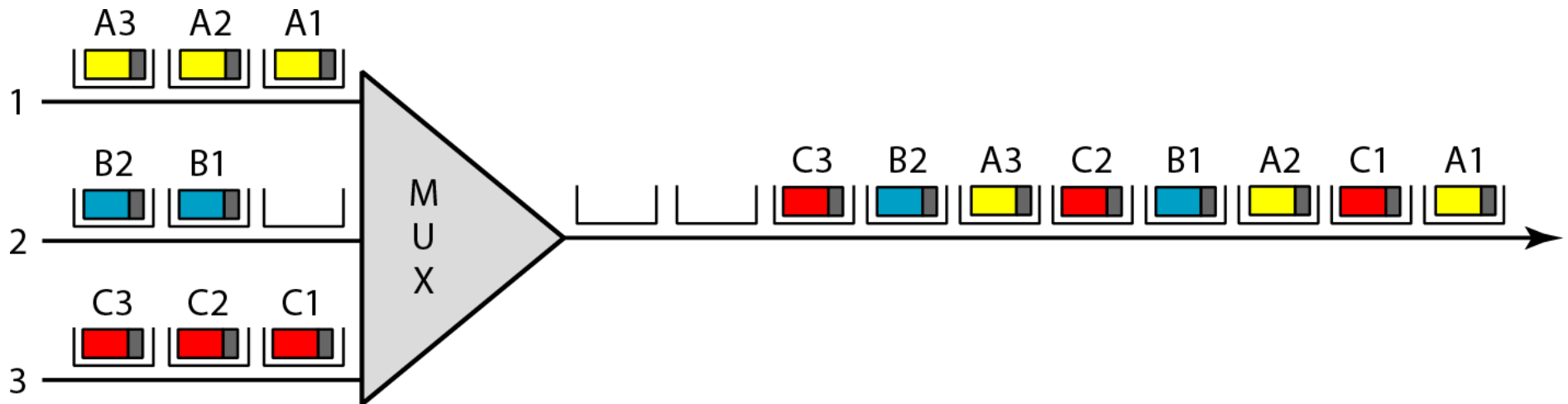
# ATM

- Asynchronous Transfer Mode (ATM)
  - Kan fungera som "informationsmotorväg"
  - I stället för ramar har man små paket (s.k. celler) med fix längd



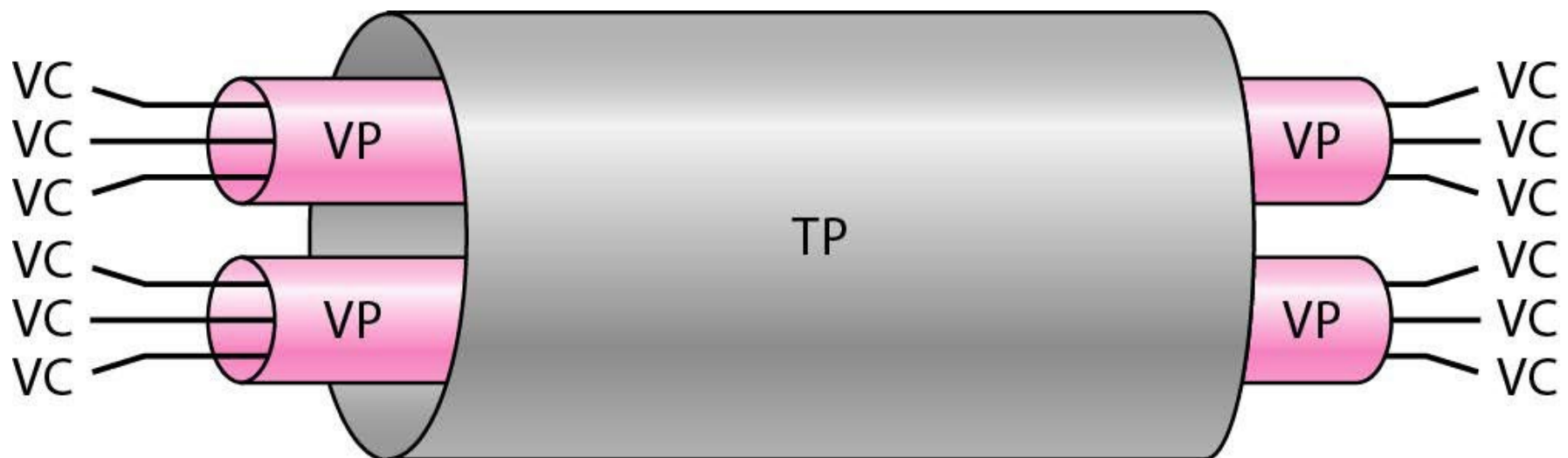
# ATM

- Multiplexering med ATM
  - Cellerna har fix storlek
  - Varje lucka (slot) behöver inte fyllas

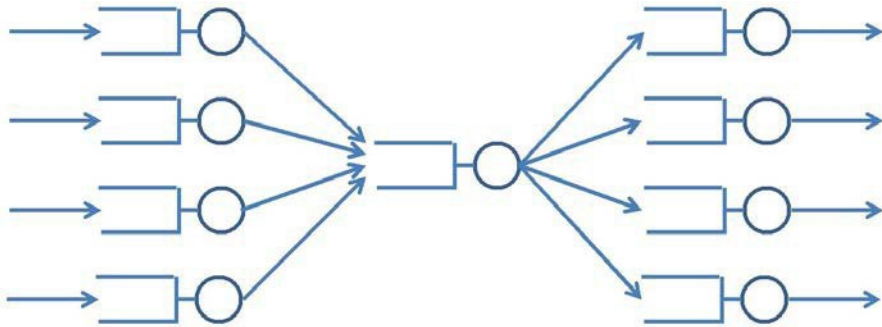


# ATM

- Indelning av förbindelser
  - TP (Transmission Path): Fysisk förbindelse
  - VP (Virtual Path): Logisk förbindelse mellan två växlar, vilken ingår som en del av en TP
  - VC (Virtual Circuit): Delar av en VP där varje VC utgör en väg mellan de två växlarna



# Köteori



- Ankomstintensitet
- Genomströmning
- Betjäningstid
- ....

$P(\text{spärr})=?$

Little's sats

$$E(N) = E(T) \cdot \lambda_{eff}$$

