CS 716: Introduction to communication networks

- 8th class; 17th Aug 2011

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Key points to consider for MAC

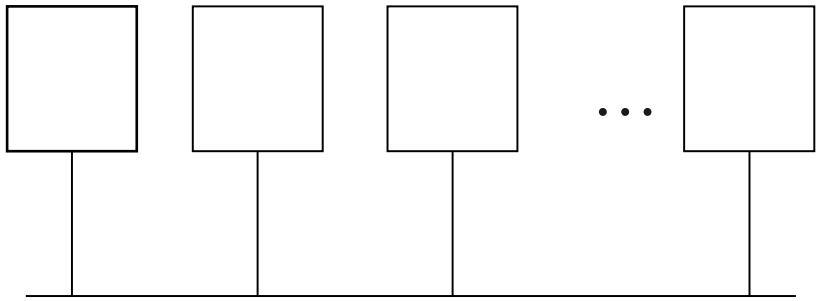
- Types/Modes of communication:
  - Although the medium is shared, who is talking to whom?
    - 1-to-1: Conversation between two students in a corner.
    - One-to-Many: Instructor lecturing.
    - Many-to-One: Students responding to instructor's question.
    - Many-to-Many: Your group discussion!

- Protocols for each modes of communication:
    - 1-to-1: Separate space; Separate channel (language/frequency).
    - 1-to-Many: Broadcast; Often associated with notion of Priority.
    - Many-to-One: Polling; Round-robin; Some notion of taking turns.
    - Many-to-Many: Speak at will; Listen before talk; Handle collisions!

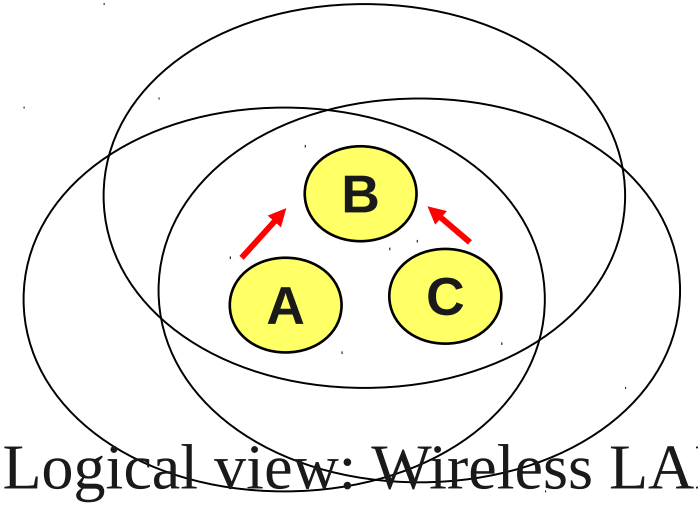
Multiplexing in MAC layer

Effective resource sharing

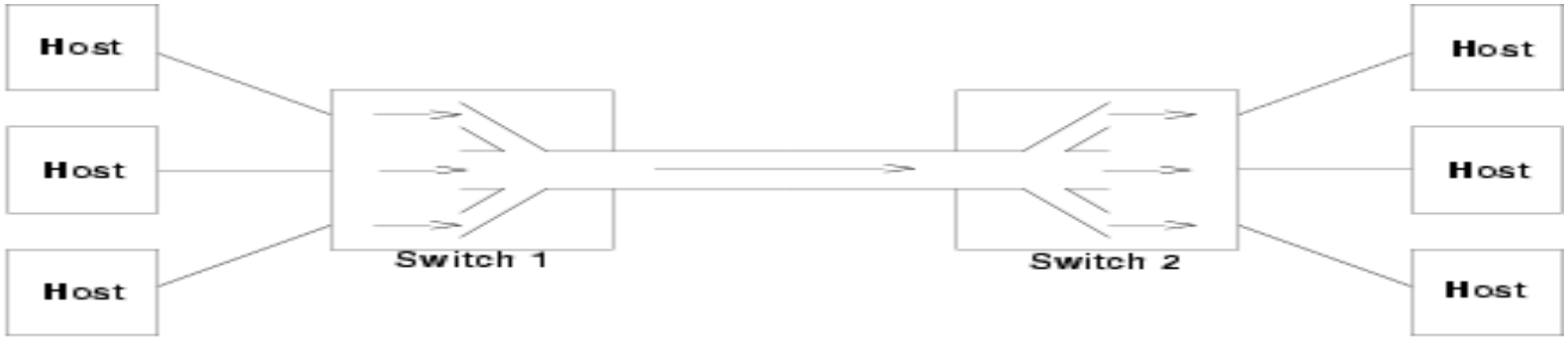
Need to share (*multiplex*) network resources (nodes and links) among multiple users.



Logical view: Wired LAN



Logical view: Wireless LAN



Common Multiplexing Strategies

- Space-Division Multiplexing (SDM):
  - Different user groups are separated physically.
- Time-Division Multiplexing (TDM):
  - Each user periodically gets the entire bandwidth for a small burst of time.
- Frequency-Division Multiplexing (FDM):
  - Frequency spectrum divided into logical channels.; Each user has exclusive access to his channel.
- Code-Division Multiplexing (CDM):
  - Each user has access to the entire spectrum but uses a different code sequence.
- Variants and combinations of above are used in practical networks.

Frequency multiplex

Separation of the whole spectrum into smaller frequency bands

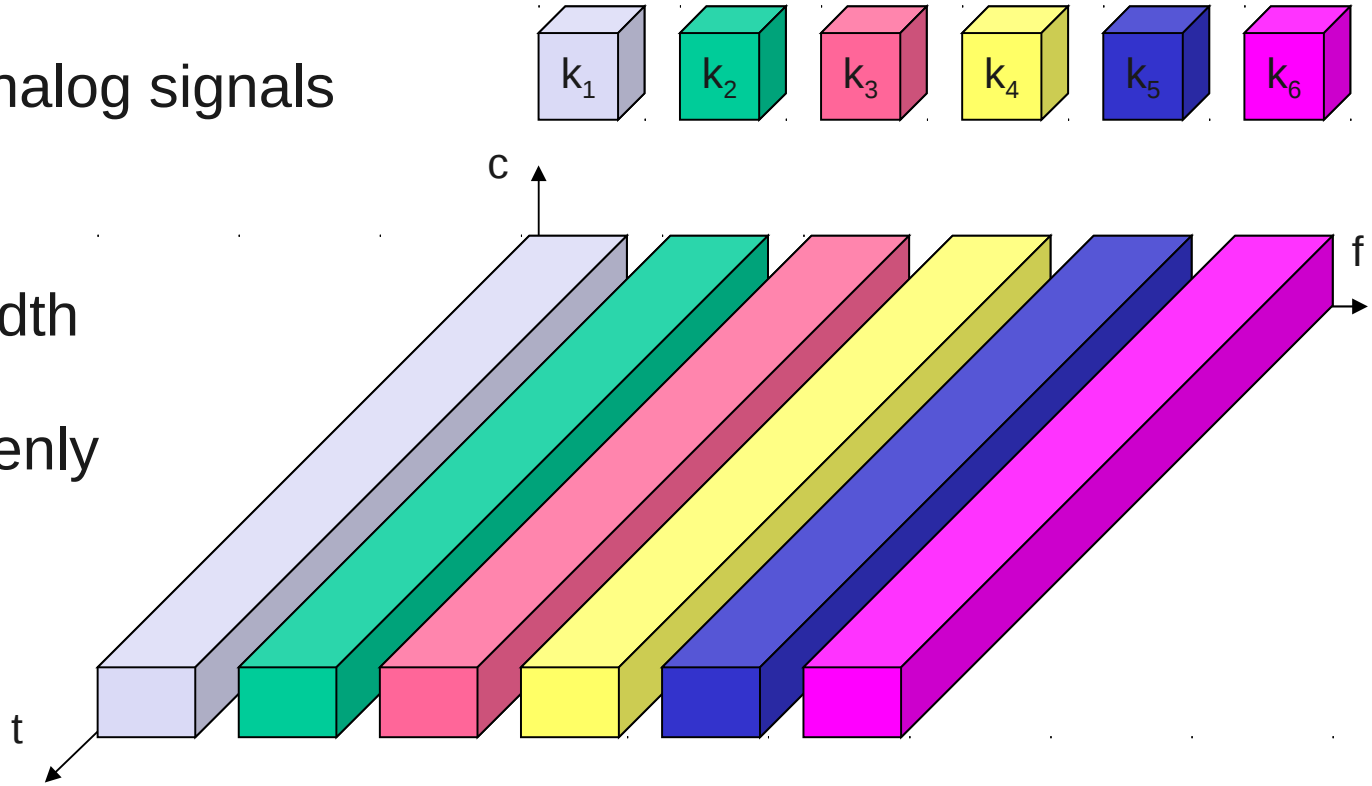
A channel gets a certain band of the spectrum for the whole time

Advantages:

- no dynamic coordination necessary
- works also for analog signals

Disadvantages:

- waste of bandwidth if the traffic is distributed unevenly
- inflexible
- guard spaces



Source: Schiller - Mobile Communincations

Time multiplex

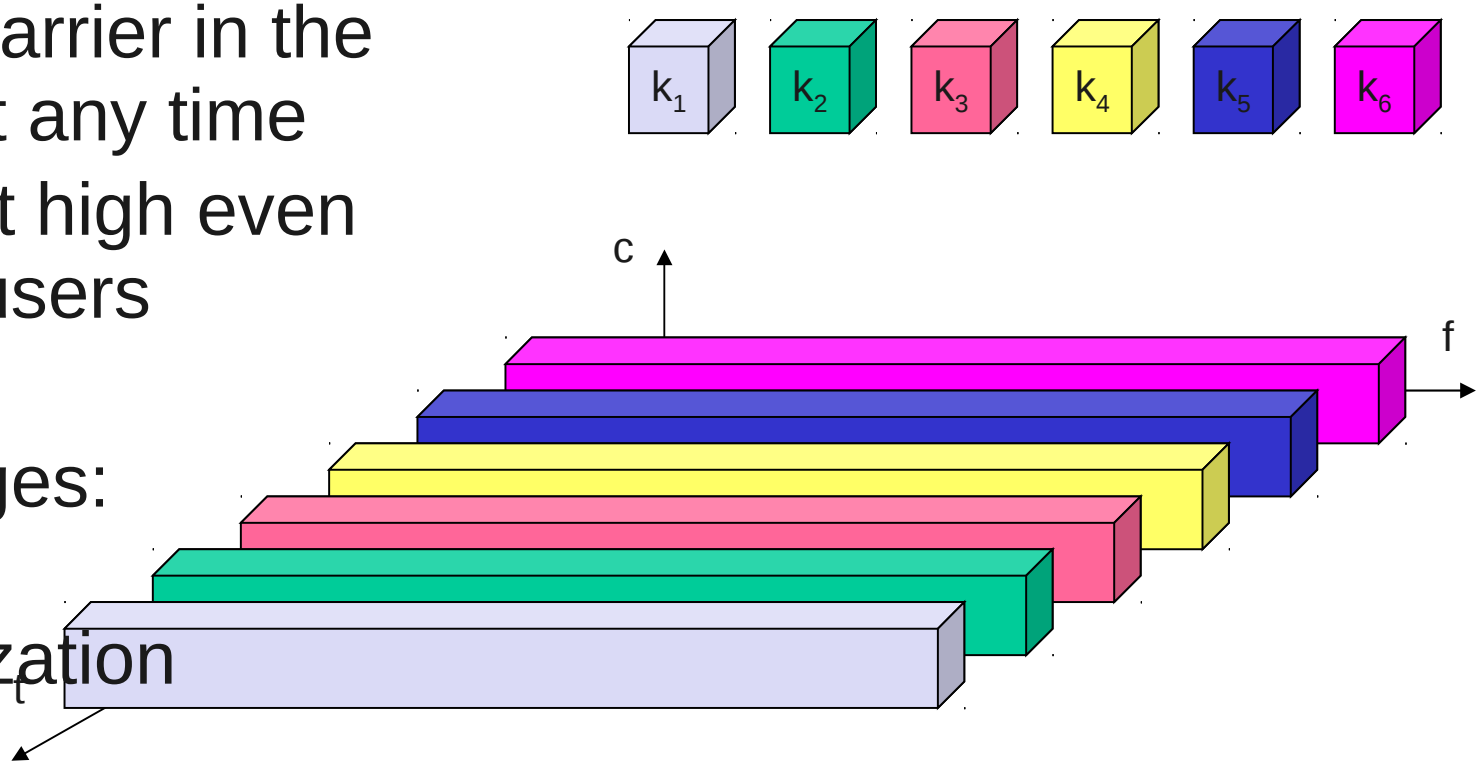
A channel gets the whole spectrum for a certain amount of time

Advantages:

- only one carrier in the medium at any time
- throughput high even for many users

Disadvantages:

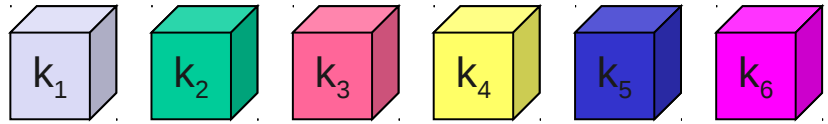
- precise synchronization necessary



Source: Schiller - Mobile Communincations

Code multiplex

Each channel has a unique code



All channels use the same spectrum at the same time

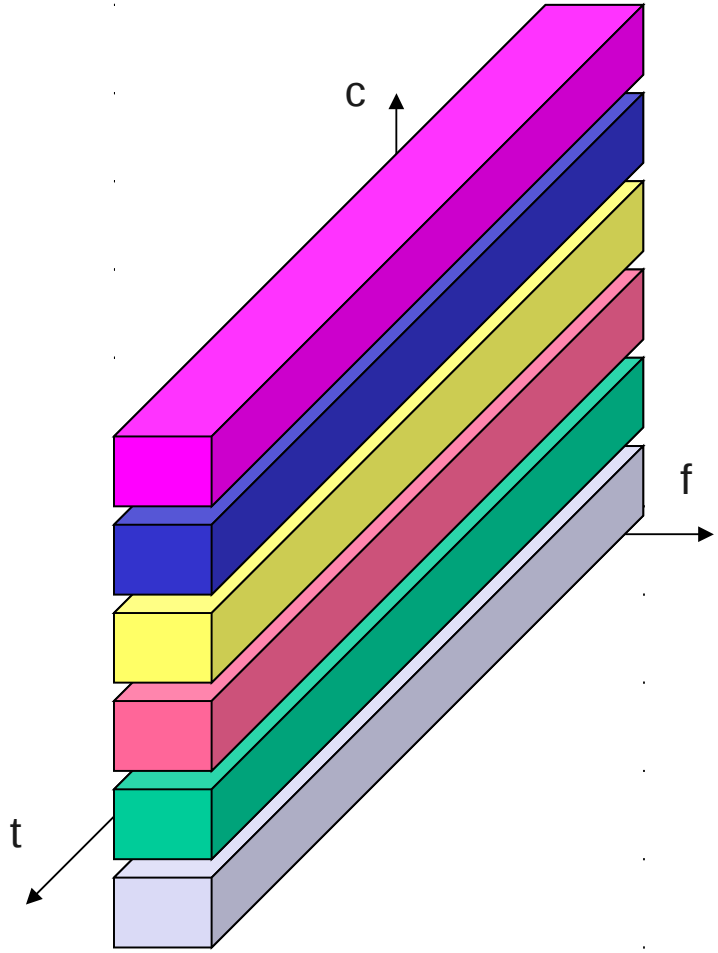
Advantages:

- bandwidth efficient
- no coordination and synchronization necessary
- good protection against interference and tapping

Disadvantages:

- lower user data rates
- more complex signal regeneration

Implemented using spread spectrum technology



Source: Schiller - Mobile Communincations

Activity: Pair-Solo

Consider a channel having Time Division Multiplexing.

- Each time slot is of 100 millisec duration. The total bandwidth available on the channel is 64 Mbps.
- There are 10 users. Slots are alloted to users in a round-robin fashion. Users always have data to send.
- How much data would each user have transmitted at end of 5 seconds? What is the throughput per user?

- Pair - Discuss the solution approach with your neighbour.
- Solo - Work out the answer by yourself.

Designing multiple access protocols

Problem: control access so that

- Throughput (the number of frames, packets, or segments, exchanged per second) is maximized.
- Access delay (time spent waiting for a chance to transmit) is minimized.

Control methods options- Where?

- Centralized

  A controller grants access to the network.

- Distributed

  The stations collectively determine the order of transmission.

Control methods options - How?

- Unrestricted v/s Scheduled
  - Transmit freely v/s only during reserved intervals.

- Synchronous v/s Asynchronous
  - Specific capacity dedicated to a connection versus capacity made available in response to dynamic needs.

Multiple access protocols

Fall into two categories

- Deterministic access:
  - Stations talk only when they are authorized by access protocol
    - Time Division Multiple Access (TDMA): telephony, GSM.

- Non-deterministic access:
  - Contention based schemes. Collisions are avoided if possible, else resolved.
    - ALOHA: pure and slotted
    - CSMA/CD (Ethernet); CSMA/CA (WiFi)

Activity: Think-Pair-Share

Questions:

- What factors need to be considered for MAC protocol design?
- How does each factor influence the MAC protocol?

Example:

Factors	How they affect
Mode of communication	Duration of access to the medium; If all have equal priority, round-robin time-slots could be used.
Cost of medium	Licensed v/s unlicensed spectrum in wireless.

- Think – Individually
  - Add as many entries as you can to the above table.
- Pair - Discuss with your neighbour.
  - Copy answers from your neighbour's list that you have missed out!
- Share - Discuss with entire class.

Key: Choice of strategy depends on

- Do stations send steady streams or bursts of packets?
  - with streams, doesn’t make sense to contend for medium access on a per-packet basis.
  - with bursts, makes sense to contend for medium access, per-packet, to avoid wasting bandwidth.
- Do applications need guaranteed delay bounds?
  - with delay-guarantees, need to have a scheduled access and admission control.
  - with no-guarantees, simple contention-based schemes could be sufficient.
- What is the licensing cost for using the medium?
  - with licensed medium, need to make efficient use of the spectrum (resulting in complex protocols and expensive hardware).
  - with 'free' medium, often need to keep the hardware costs low (resulting in simple protocols but lower efficiency).

Concept-level summary

- MAC implementations in most technologies are some variations or combinations of:
  - Multiplexing strategies: FDM, TDM, CDM..
  - Control strategies: Centralized, Distributed, Priority..
  - Sharing strategies: Round robin, Polling, Carrier Sensing..
- Next class - details of design decisions for some specific technologies.

At the end of this topic

You should be able to do:

- State the pros and cons of sharing a PHY link.
- Describe the functions and services of the MAC layer in a network.
- Identify the multiplexing, control and sharing strategies being used in a given scenario.

- Describe three multiplexing strategies used to share a medium.
- Describe three control strategies to regulate access to a medium.
- Describe three sharing strategies to access a medium.
- Evaluate tradeoff between deterministic and non-deterministic access.
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Reflection

- What did I learn in today's class?
- Each student to mention one point.

- Take-home questions:
  - On what basis do we select a scheme or variations, while designing a MAC for our network?
  - How do we evaluate our solution?