

# DE050 Computer Network and Security

H. Anthony Chan

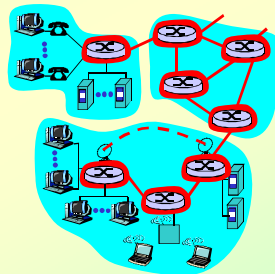
<https://cis.cihe.edu.hk/Anthony-Chan/index.html>

## Communication Networks Overview

- ♦ What is the Internet?
- ♦ What's a protocol?
- ♦ Network structure, network edge
- ♦ Network core
- ♦ Access network
- ♦ LAN topology
- ♦ Physical media
- ♦ Internet structure and ISPs
- ♦ Performance: loss, delay
- ♦ Protocol layers, service models
- ♦ History

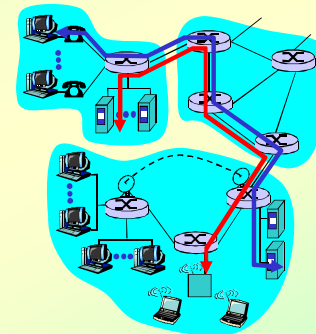
## The Network Core

- ♦ mesh of interconnected routers
- ♦ *the fundamental question*: how is data transferred through net?
  - **circuit switching**: dedicated circuit per call: telephone net
  - **packet-switching**: data sent thru net in discrete "chunks"



## Network Core: Circuit Switching

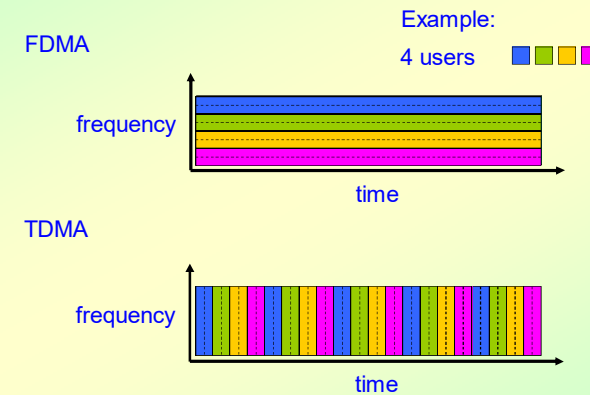
- ♦ **End-end resources reserved for "call"**
- ♦ link bandwidth, switch capacity
- ♦ dedicated resources: no sharing
- ♦ circuit-like (guaranteed) performance
- ♦ call setup required



## Network Core: Circuit Switching

- ◆ network resources (e.g., bandwidth) **divided into “pieces”**
- ◆ pieces allocated to calls
- ◆ resource piece **idle** if not used by owning call (*no sharing*)
- ◆ dividing link bandwidth into “pieces”
  - frequency division
  - time division

## Circuit Switching: FDMA and TDMA



## Numerical example

- ◆ How long does it take to send a file of 640,000 bits from host A to host B over a circuit-switched network?
  - All links are 1.536 Mbps
  - Each link uses TDM with 24 slots
  - 500 msec to establish end-to-end circuit

**Work it out!**

## Network Core: Packet Switching

each end-end data stream divided into **packets**

- ◆ user A, B packets **share** network resources
- ◆ each packet uses full link bandwidth
- ◆ resources used **as needed**

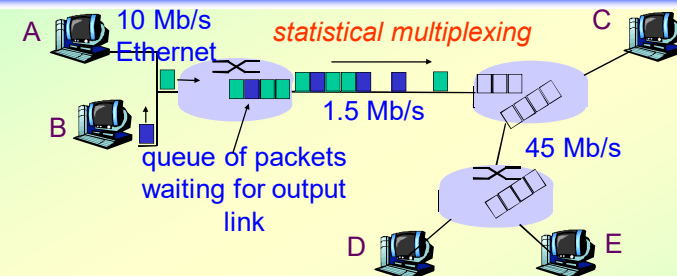
~~Bandwidth division into “pieces”  
Dedicated allocation  
Resource reservation~~

## Network Core: Packet Switching

### resource contention:

- ◆ aggregate resource demand can exceed amount available
- ◆ congestion: packets queue, wait for link use
- ◆ store and forward: packets move one hop at a time
  - Node receives complete packet before forwarding
  - transmit over link, wait turn at next link

## Packet Switching: Statistical Multiplexing



- ◆ Sequence of A and B packets does not have fixed pattern → *statistical multiplexing*
- ◆ In TDM each host gets same slot in revolving TDM frame

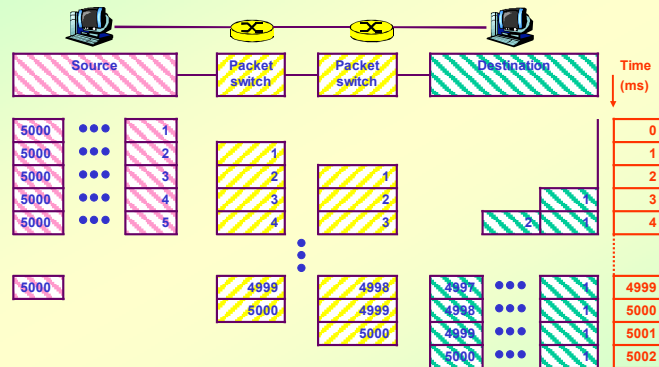
## Packet Switching

- ◆ Packet-switching versus circuit switching: human restaurant analogy
- ◆ other human analogies?

## Packet Switching

- ◆ Packet-switching: store and forward behavior
- ◆ break message into smaller chunks: "packets"
- ◆ Store-and-forward: switch waits until chunk has completely arrived, then forwards/routes
- ◆ Q: what if message was sent as single unit?

## Packet Switching



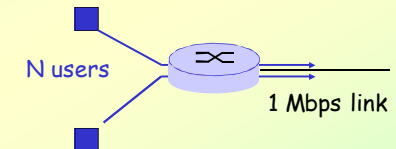
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Modern Society will find no solution to the ecological problem unless it takes a serious look at its lifestyles. (Pope John Paul II)

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## Packet switching versus circuit switching

- ♦ Packet switching allows more users to use network!
- ♦ 1 Mbit link
- ♦ each user:
  - 100Kbps when "active"
  - active 10% of time



- ♦ circuit-switching:
  - 10 users
- ♦ packet switching:
  - with 35 users, probability > 10 active less than .0004

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## Packet switching versus circuit switching

### Is packet switching a "slam dunk winner?"

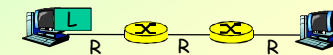
- ♦ Great for bursty data
  - resource sharing
  - no call setup
- ♦ Excessive congestion: packet delay and loss
  - protocols needed for reliable data transfer, congestion control
- ♦ Q: How to provide circuit-like behavior?
  - bandwidth guarantees needed for audio/video apps
  - still an unsolved problem (chapter 6)

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## Packet-switching: store-and-forward



- ♦ Takes  $L/R$  seconds to transmit (push out) packet of L bits on to link or R bps
- ♦ Entire packet must arrive at router before it can be transmitted on next link: *store and forward*
- ♦ delay =  $3L/R$

### Example:

- ♦  $L = 7.5$  Mbits
- ♦  $R = 1.5$  Mbps
- ♦ delay = 15 sec

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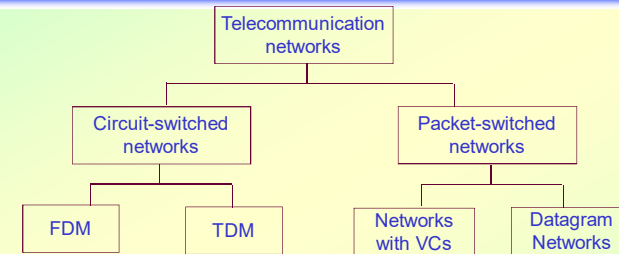
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## Packet-switched networks: routing

- ♦ **Goal:** move packets among routers from source to destination
  - we'll study several path selection (i.e. routing) algorithms (chapter 4)
- ♦ **datagram network:**
  - *destination address* determines next hop
  - routes may change during session
  - analogy: driving, asking directions
- ♦ **virtual circuit network:**
  - each packet carries tag (virtual circuit ID), tag determines next hop
  - fixed path determined at *call setup time*, remains fixed thru call
  - *routers maintain per-call state*

## Network Taxonomy



- ♦ Datagram network is not either connection-oriented or connectionless.
- ♦ Internet provides both connection-oriented (TCP) and connectionless services (UDP) to apps.

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