523353 – Computer Networks

Lecture 1: Introduction to Networking

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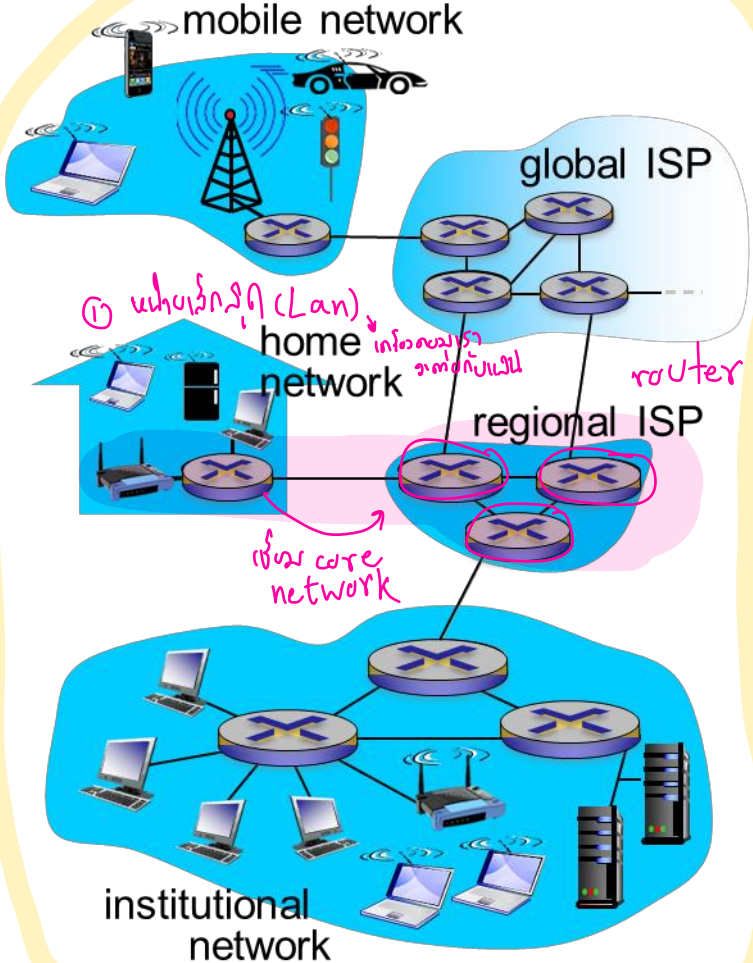
Outline

- What is the Internet?
- Network and Internet Connection

The Internet

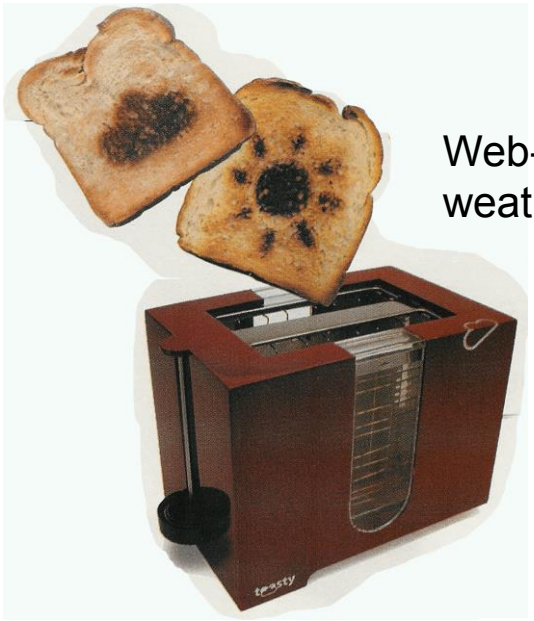
What is the Internet

- billions of connected computing devices:
  - hosts = end systems
  - running network apps
- communication links
  - fiber, copper, radio, satellite
  - transmission rate: bandwidth
- packet switches: forward packets (chunks of data)
  - routers and switches



Internet-connected devices

IP picture frame
http://www.ceiva.com/



Web-enabled toaster +
weather forecaster

Tweet-a-watt:
monitor energy use

Internet
refrigerator

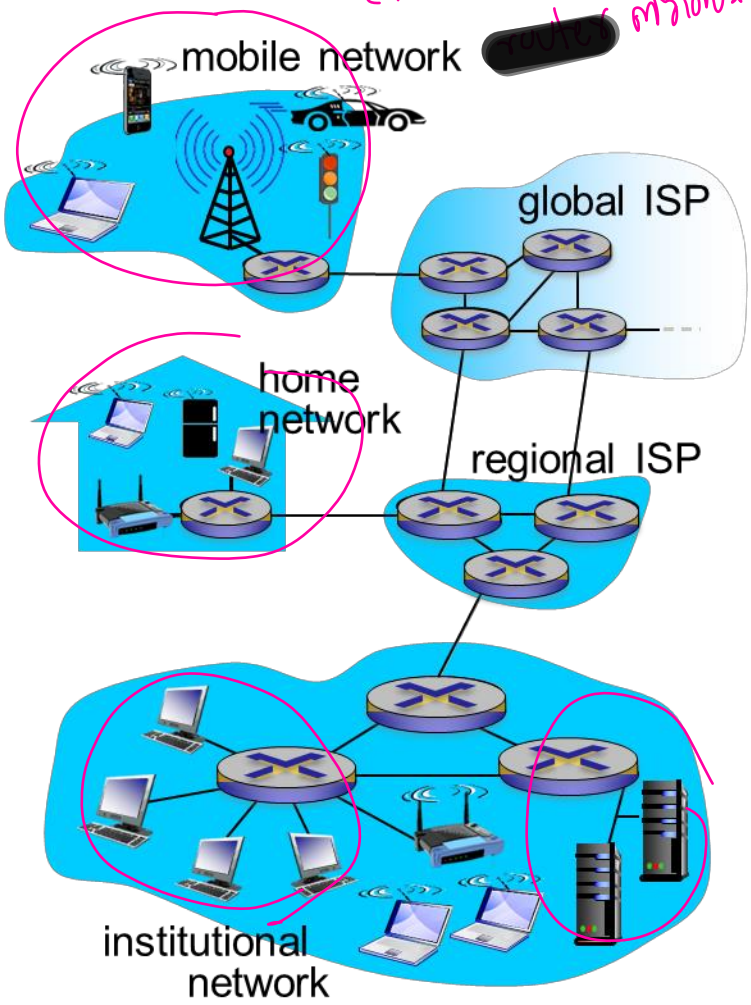
Slingbox: watch,
control cable TV remotely

sensorized,
bed
mattress

Internet phones

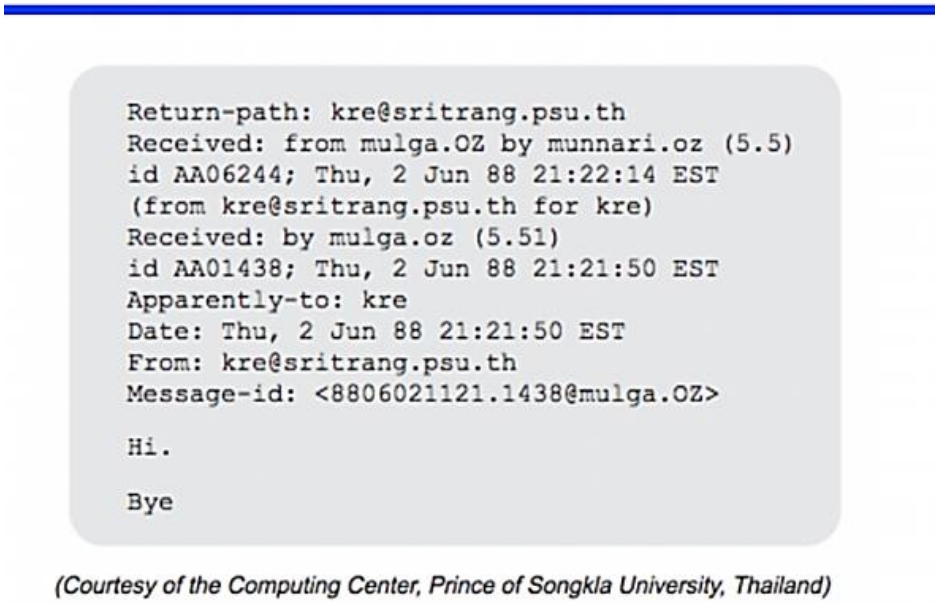
What is the Internet (cont.)

- *Internet:* "Network of networks"
  - Interconnected ISPs
- *protocols* control sending, receiving of messages
  - e.g., TCP, IP, HTTP, Skype, 802.11
- *Internet standards*
  - RFC: Request for comments
  - IETF: Internet Engineering Task Force



Internet in Thailand

- In 1988, Kevin Robert Elz – kre from Prince of Songkla University (PSU) started electronic mail connection with University of Melbourne.

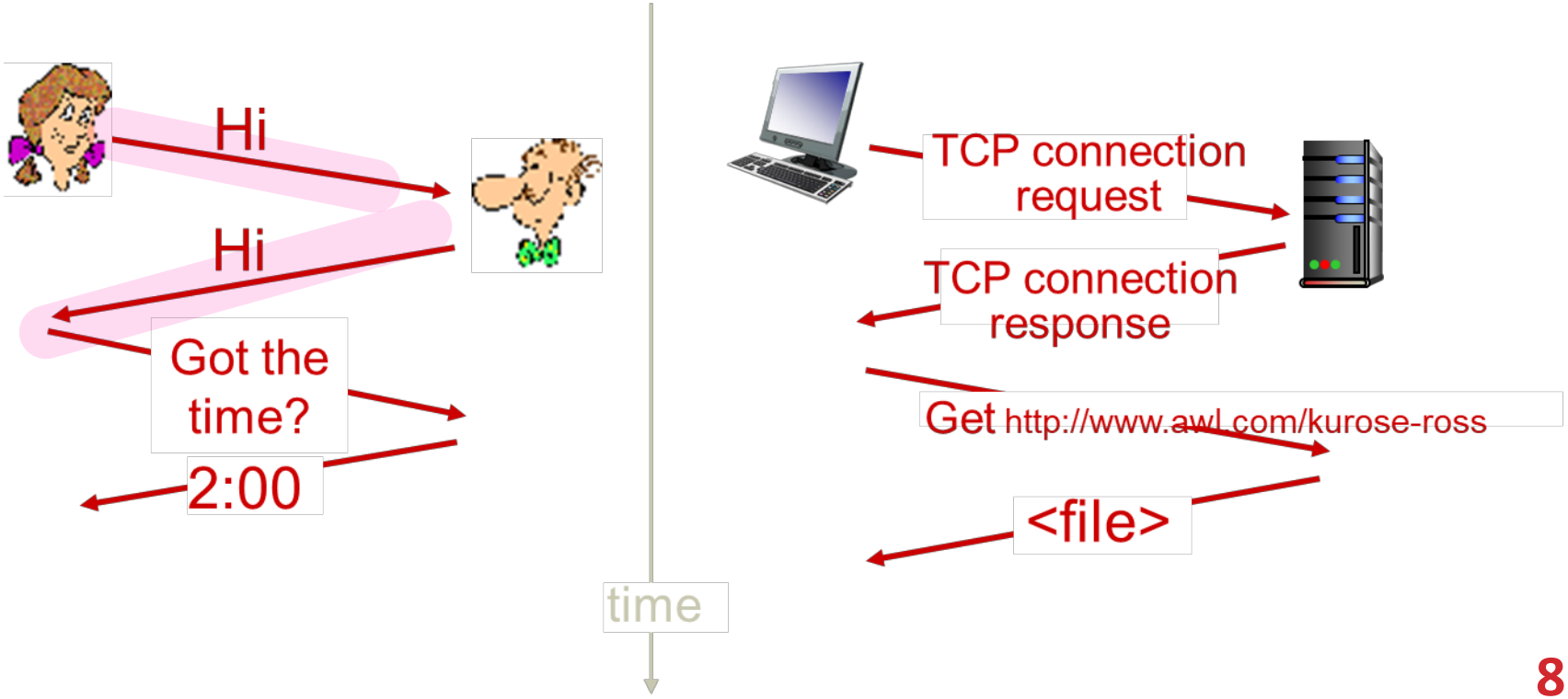


```
Return-path: kre@sritrang.psu.th
Received: from mulga.OZ by munnari.oz (5.5)
id AA06244; Thu, 2 Jun 88 21:22:14 EST
(from kre@sritrang.psu.th for kre)
Received: by mulga.oz (5.51)
id AA01438; Thu, 2 Jun 88 21:21:50 EST
Apparently-to: kre
Date: Thu, 2 Jun 88 21:21:50 EST
From: kre@sritrang.psu.th
Message-id: <8806021121.1438@mulga.OZ>

Hi.

Bye
```

(Courtesy of the Computing Center, Prince of Songkla University, Thailand)

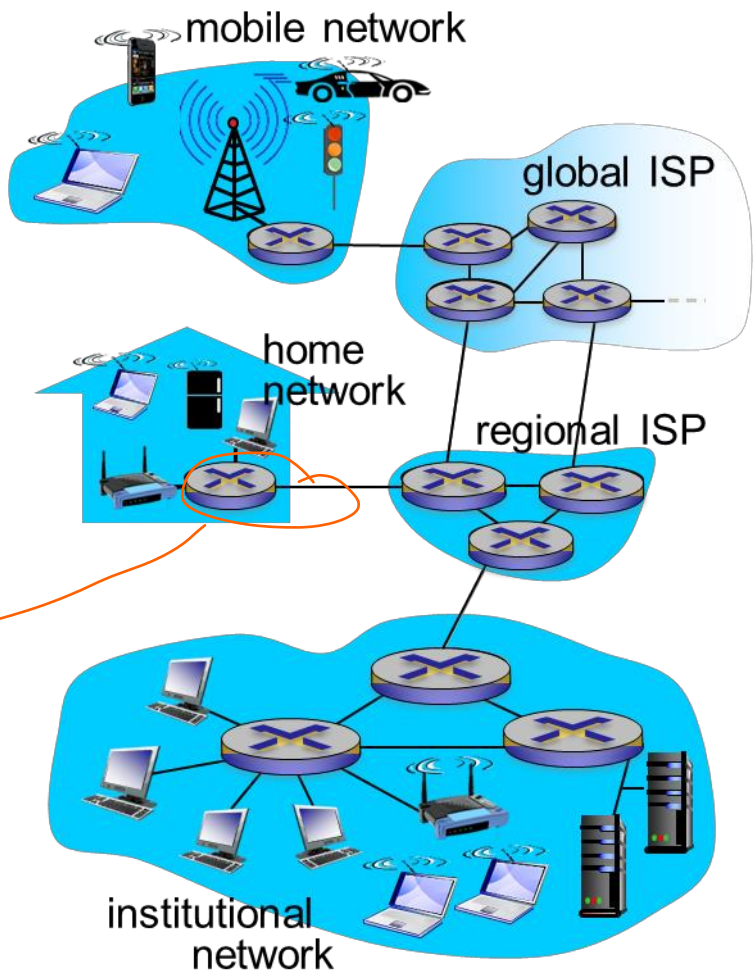
What's a protocol?

- protocols define format, order of messages sent and received among network entities, and actions taken on message transmission, receipt
- a human protocol and a computer network protocol:



Network structure

- *network edge:* (ส่วนของ network ชายขอบ)
  - hosts: clients and servers
  - servers often in data centers
- *access networks, physical media:* wired, wireless communication links
- *network core:*
  - interconnected routers
  - network of networks



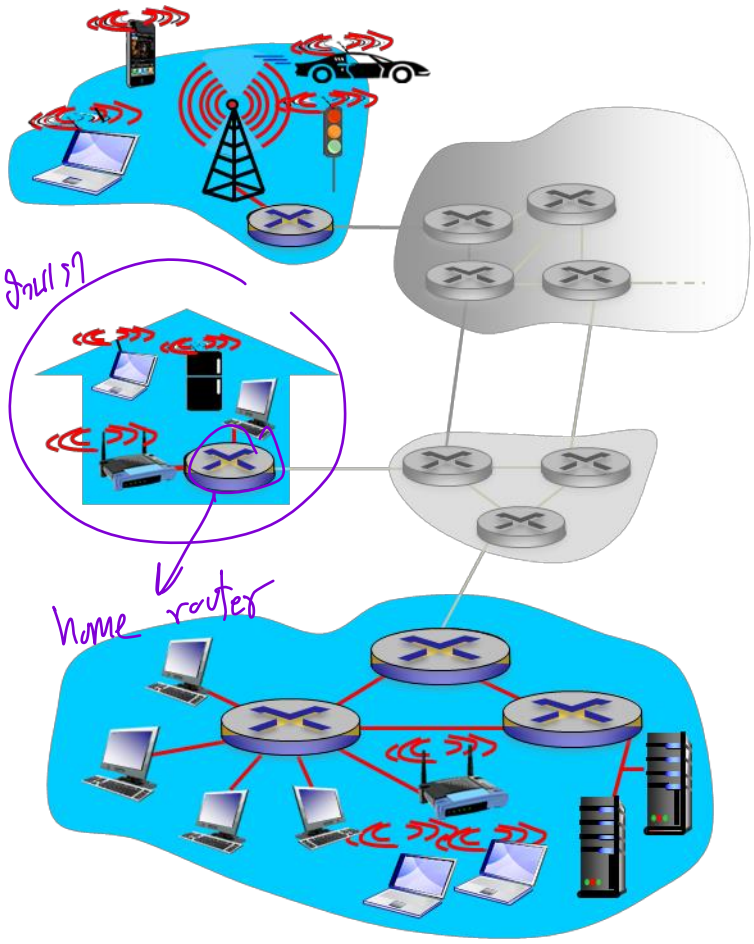
Access networks and physical media

How to connect end systems to edge router (the first router)?

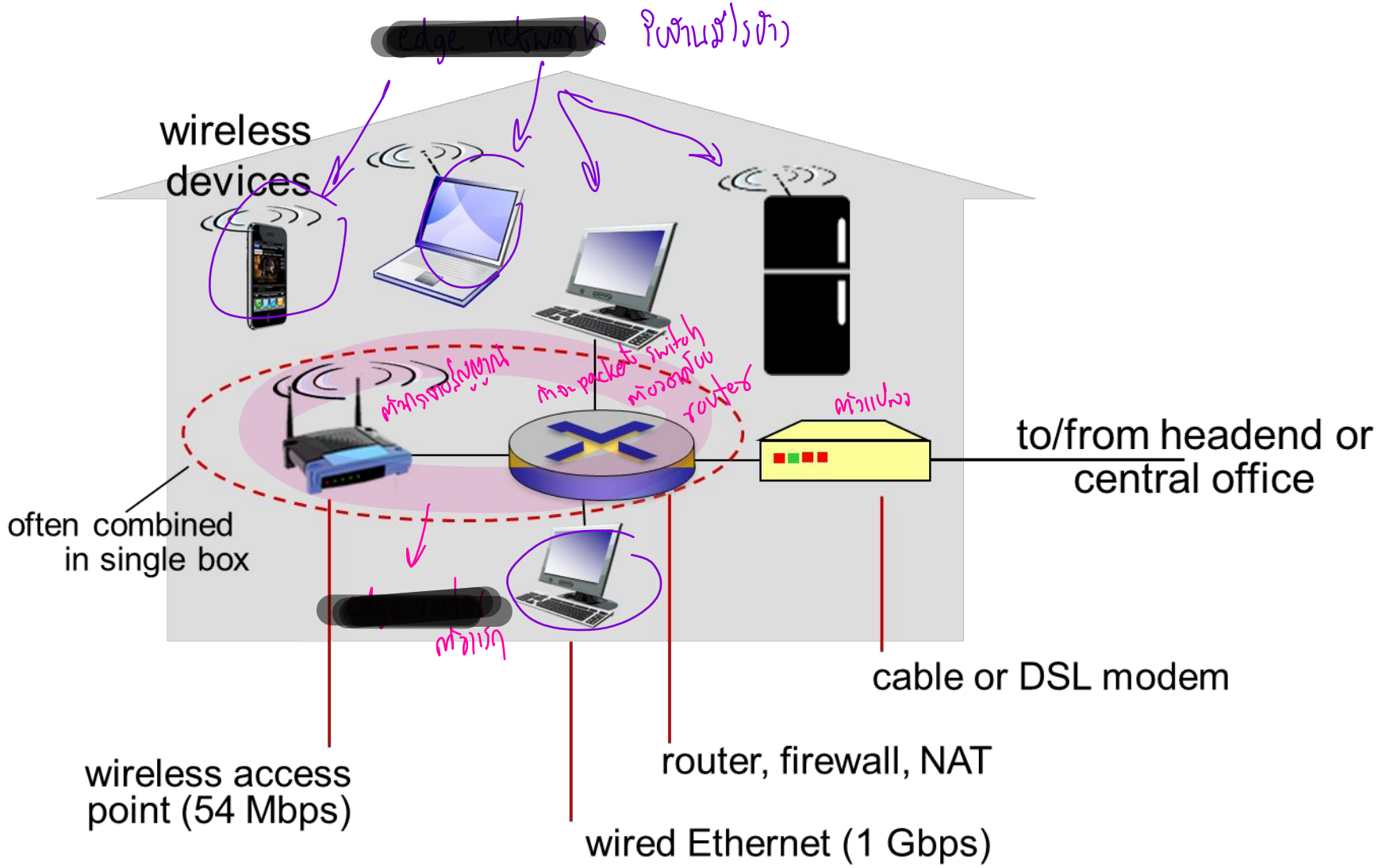
- residential access nets
- institutional access networks (school, company)
- mobile access networks

keep in mind:

- bandwidth (bits per second) of access network?

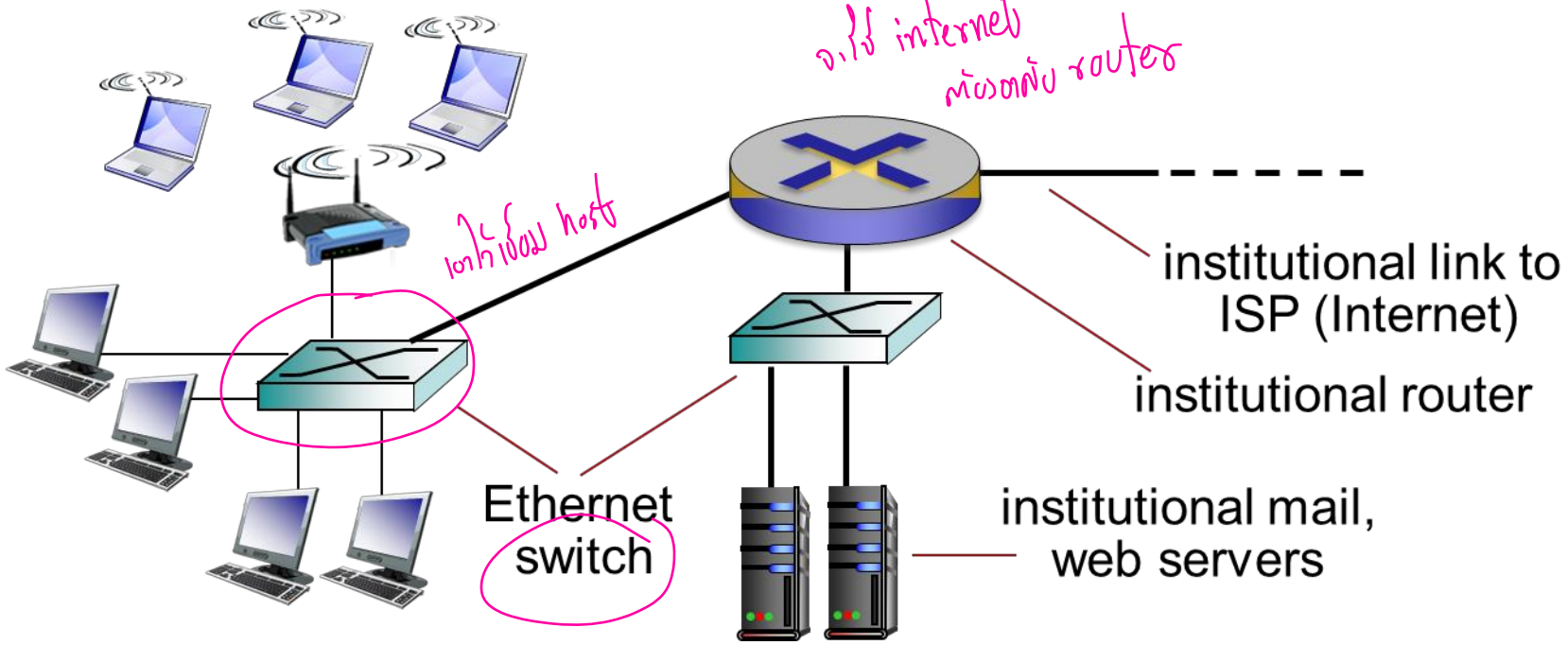


Access network: home network



Enterprise access networks (Ethernet)

- typically used in companies, universities, etc.
- 10 Mbps, 100Mbps, 1Gbps, 10Gbps transmission rates
- today, end systems typically connect into Ethernet switch



Network and Internet Connection

Personal Computer

host

IBM PC

Laptop Computer

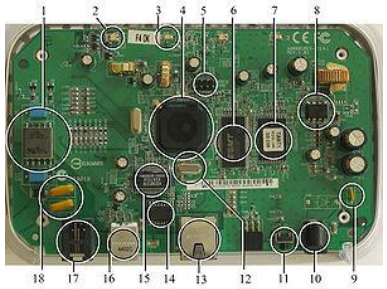
Desktop Computer

Tablet Computer

Source: http://en.wikipedia.org/wiki/Personal_computer

Embedded Computer

host



ADSL modem/router

Gumstix

eSOM270 &eSOM300
Computer on Modules

Electronic Voting Machine

Source: http://en.wikipedia.org/wiki/Embedded_system

Network Devices

จัดการทำ packet

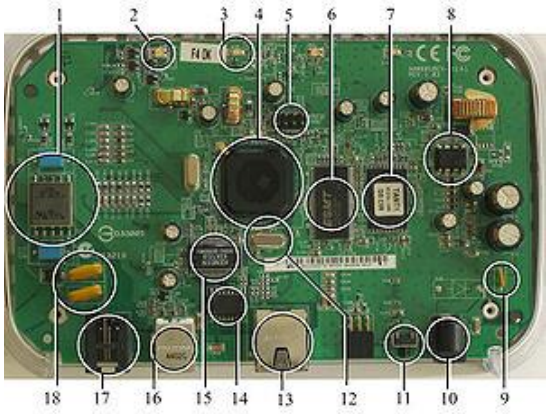
Router

Layer 3 Switch

Layer 3 Switch

ADSL modem/router

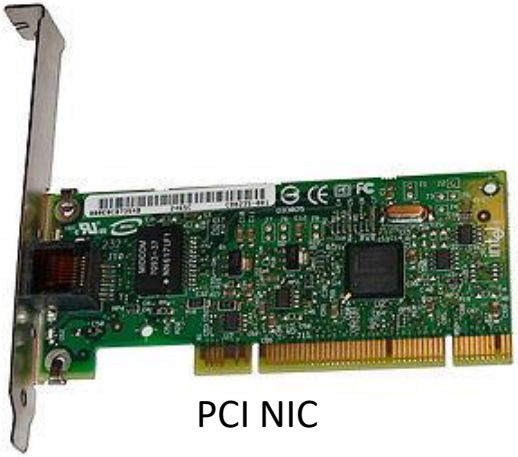
อุปกรณ์ในบ้าน



Direct Attached Network Devices

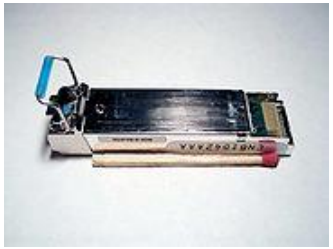
GBIC Module


GBIC Module


PCI NIC


PCMCIA/Cardbus NIC

Cardbus NIC


SFP Module

Indirect Attached Network Devices

ต่อกับสิ่งต่างๆ

Outdoor WiFi Access Point

PCI WiFi for PC

Bluetooth™

Wi Fi™

Cardbus WiFi Adapter

USB WiFi Adapter

wimax

Physical media

- bit: propagates between transmitter/receiver pairs
- physical link: what lines between transmitter & receiver
- guided media:
  - signals propagate in solid media: copper, fiber, coax
- unguided media:
  - signals propagate freely, e.g., radio

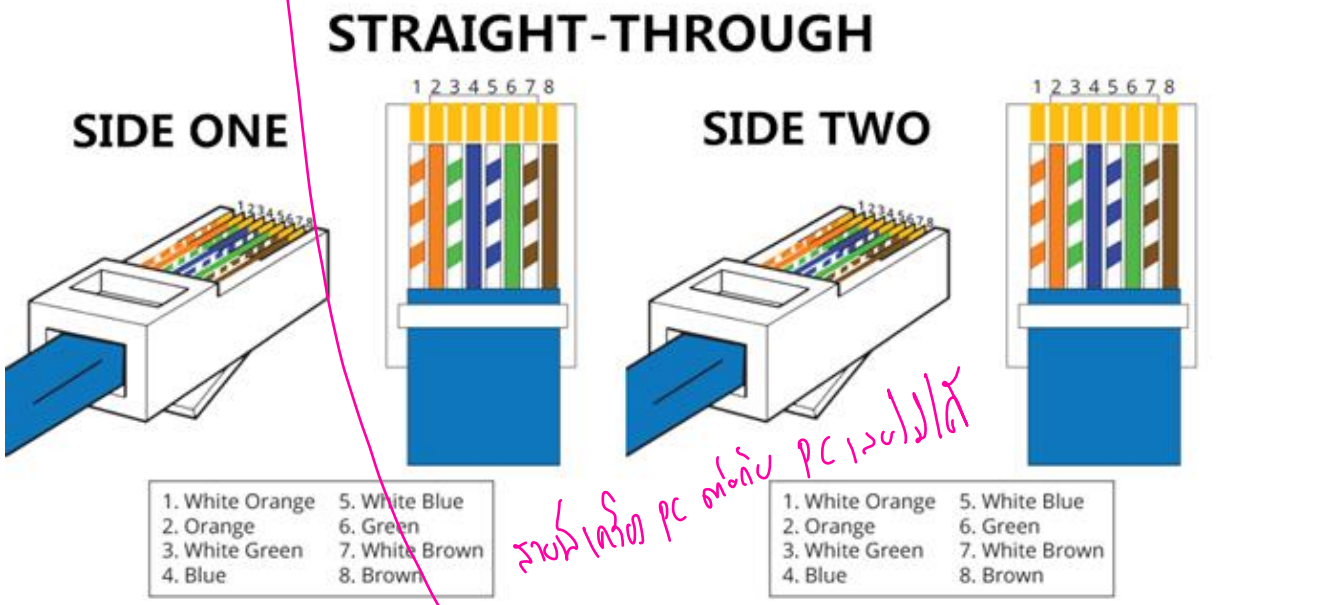
twisted pair (TP)

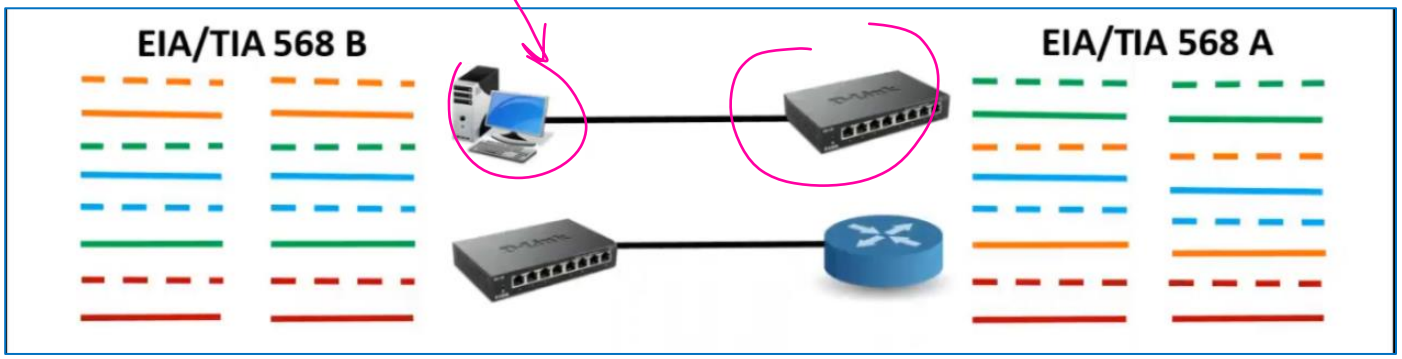
- **Standard types of twisted pair**
  - Category 5: 100 Mbps, 1 Gbps Ethernet
  - Category 6: 10 Gbps
  - Category 8: 25/40 Gbps

UTP (Unshielded Twisted Pair)

Ethernet Cable (RJ45)

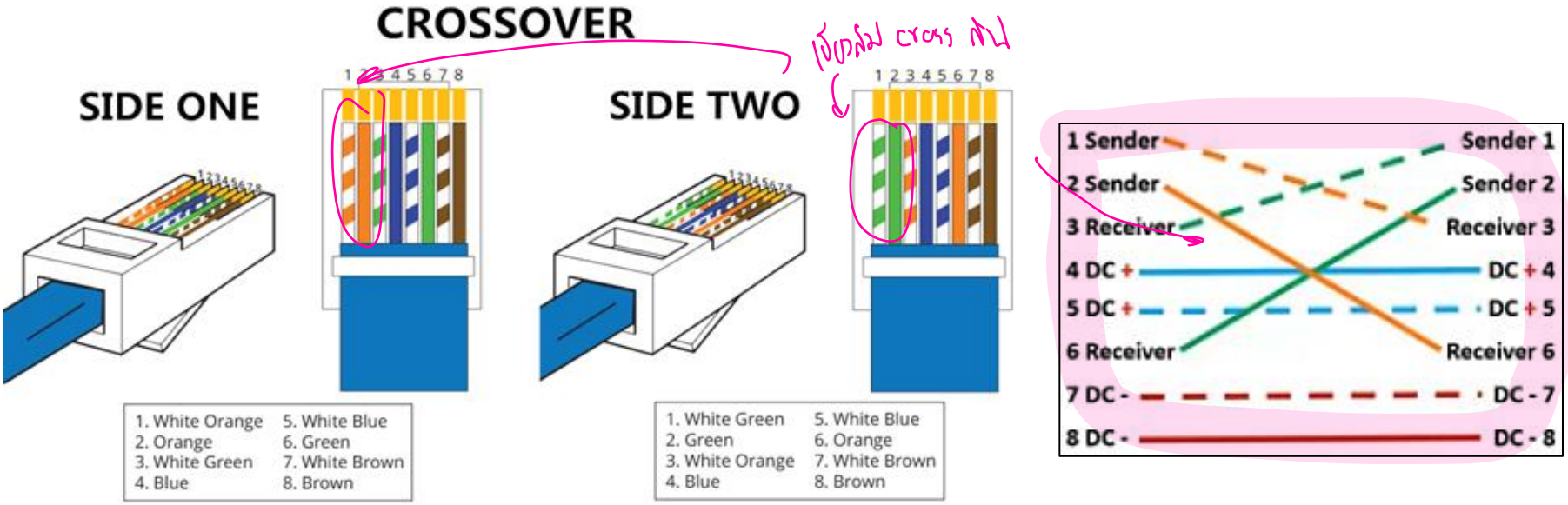
- [redacted]
  - PC to Switch, Switch to Router, etc

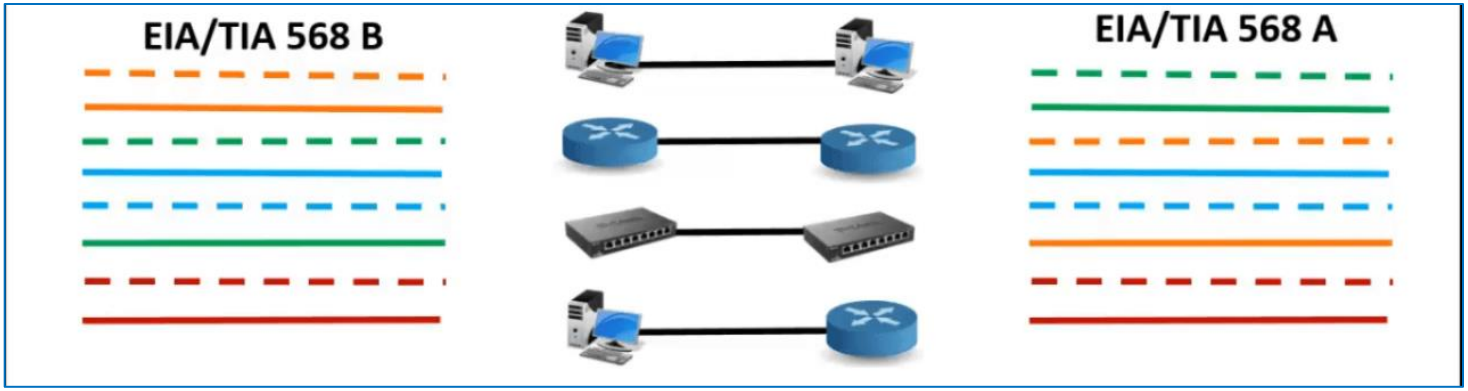




Ethernet Cable (RJ45) - cont.

- Crossover Cable
  - Two [redacted] devices: PC to PC, SW to SW, Router to Router

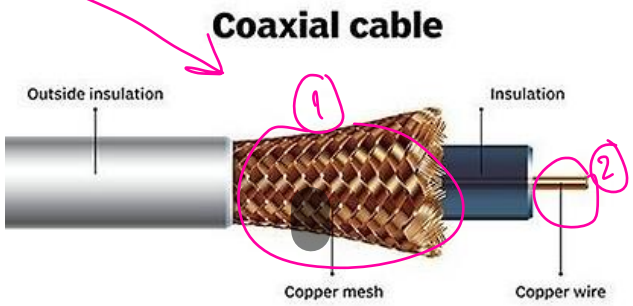




Physical media: coax, fiber

coaxial cable:

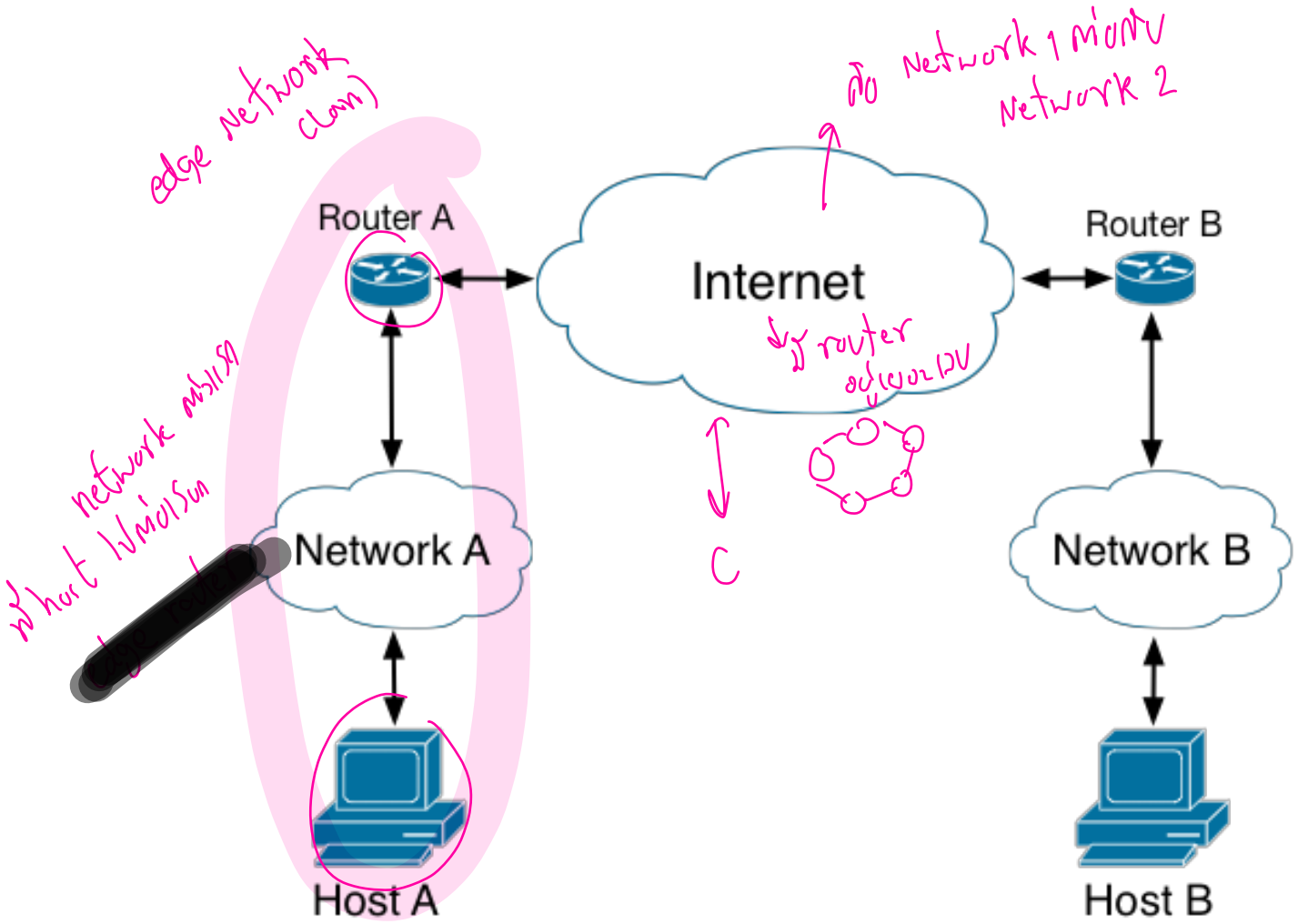
- two concentric copper conductors
- bidirectional
- broadband:
  - multiple channels on cable
  - HFC (Hybrid fiber-coaxial)



fiber optic cable:

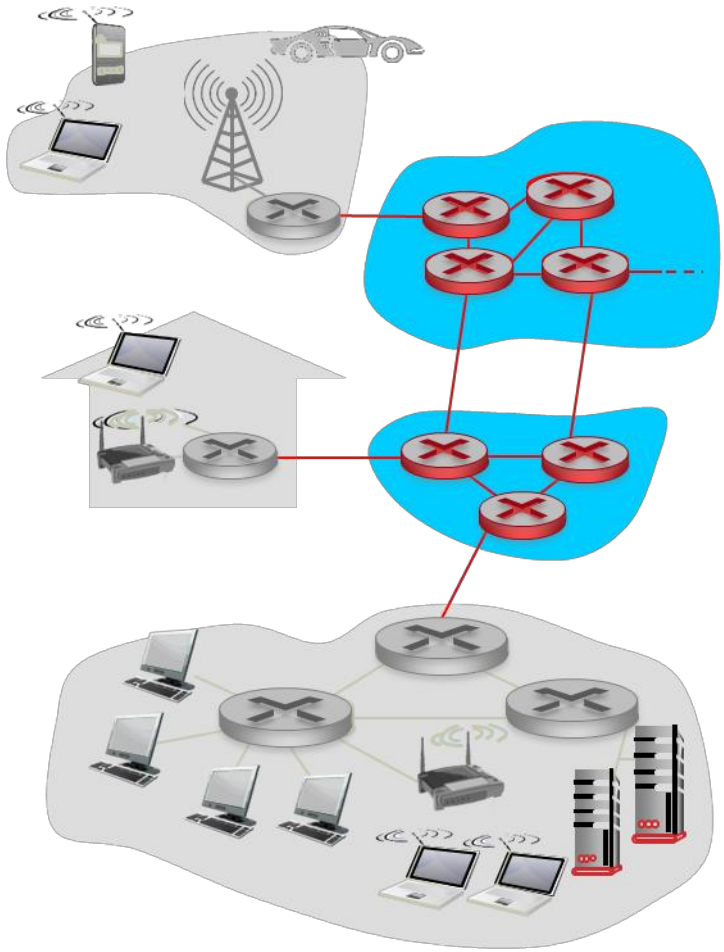
- glass fiber carrying light pulses, each pulse a bit
- high-speed operation:
  - high-speed point-to-point transmission (e.g., 10's-100's Gbps transmission rate)
- low error rate:
  - repeaters spaced far apart
  - immune to electromagnetic noise

Network and Internet Connection



The network core

- Mesh of interconnected Routers
- packet-switching: hosts break application-layer messages into *packets*
  - forward packets from one router to the next, across links on path from source to destination
  - each packet transmitted at full link capacity

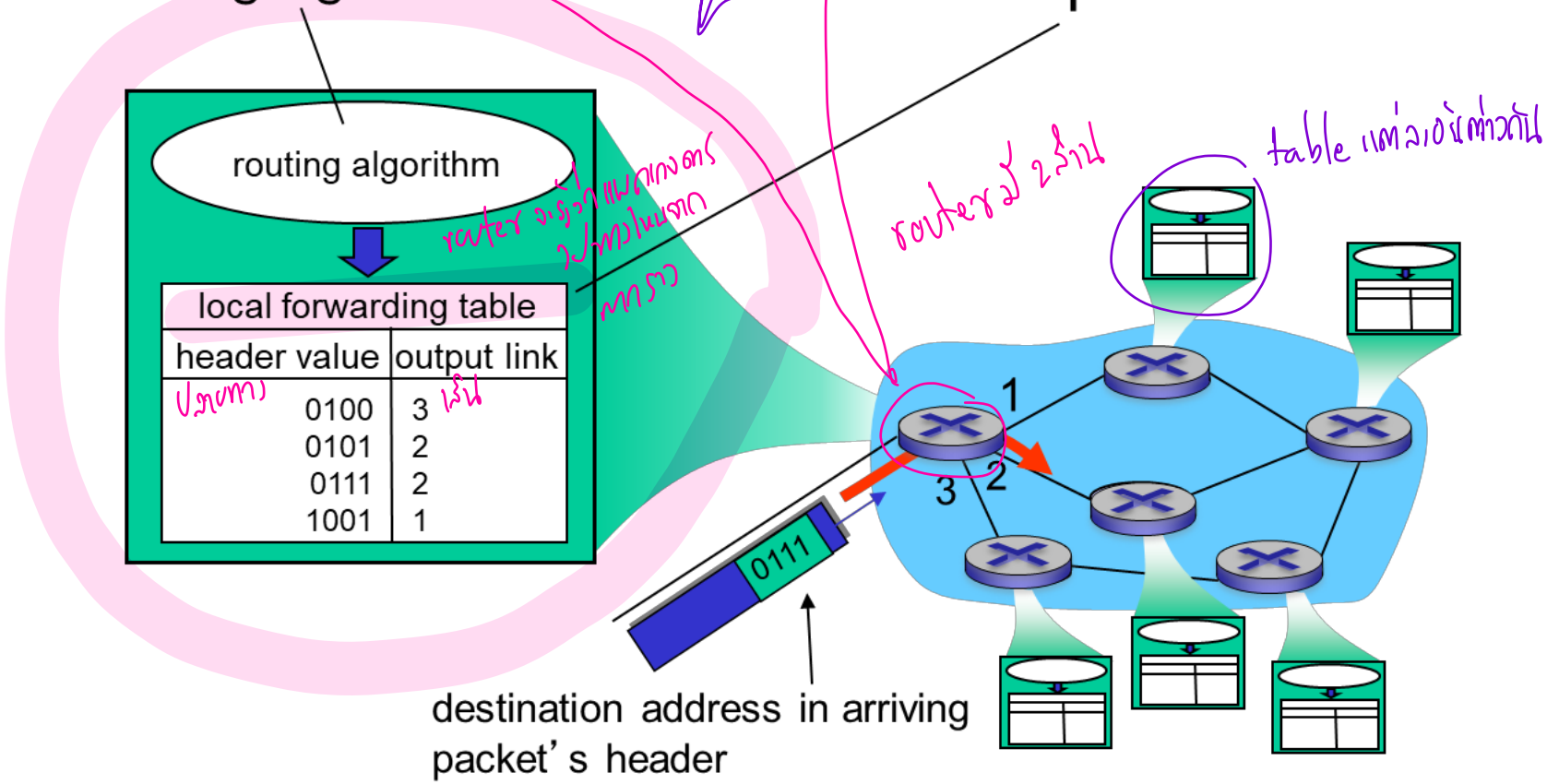


Two key network-core functions

routing: determines source-destination route taken by packets

- *routing algorithms*

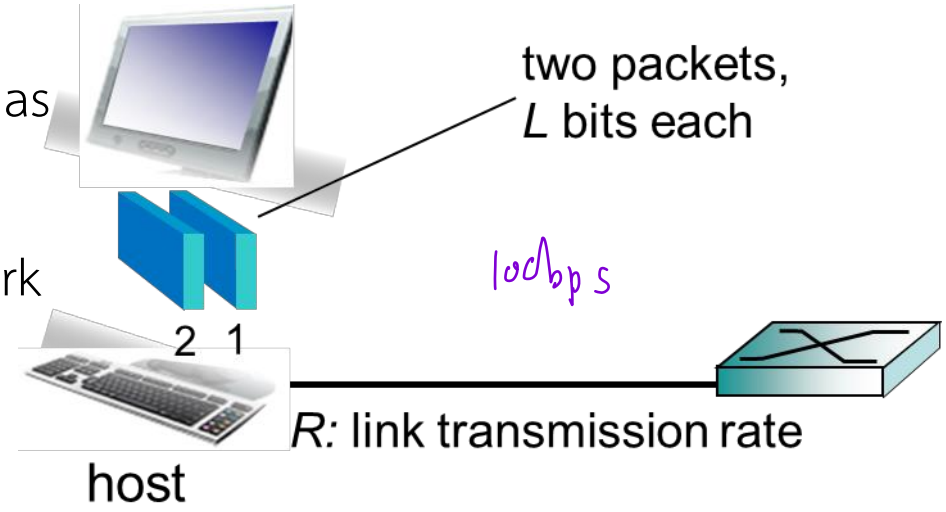
forwarding: move packets from router's input to appropriate router output



Host: sends packets of data

Host sending function:

- takes application message
- breaks into smaller chunks, known as *packets*, of length *L* bits
- transmits packet into access network at *transmission rate - R*
  - link transmission rate, aka link *capacity, aka link* ***bandwidth***



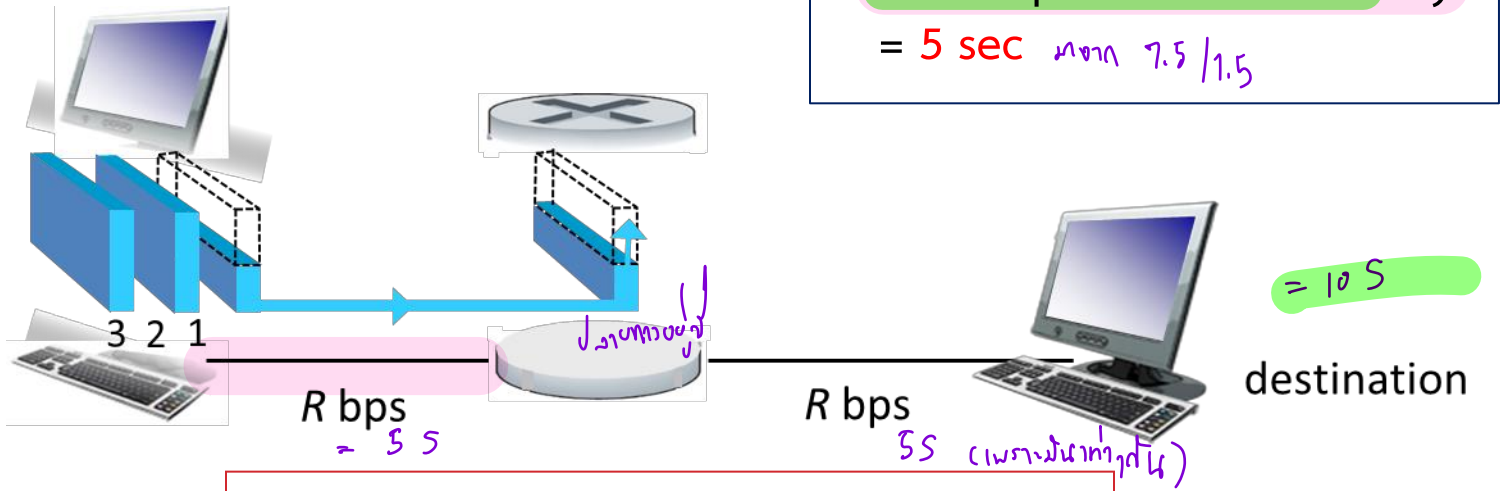
$$\text{packet transmission delay} = \text{time needed to transmit } L\text{-bit packet into link} = \frac{L \text{ (bits)}}{R \text{ (bits/sec)}}$$

Packet-switching: store-and-forward

- takes *L*/*R* seconds to transmit (push out) *L*-bit packet into link at *R* bps
- *store and forward:* entire packet must arrive at router before it can be transmitted on next link

One-hop numerical example:

- *L* = 7.5 bits
- *R* = 1.5 Mbps
- One-hop transmission delay = 5 sec



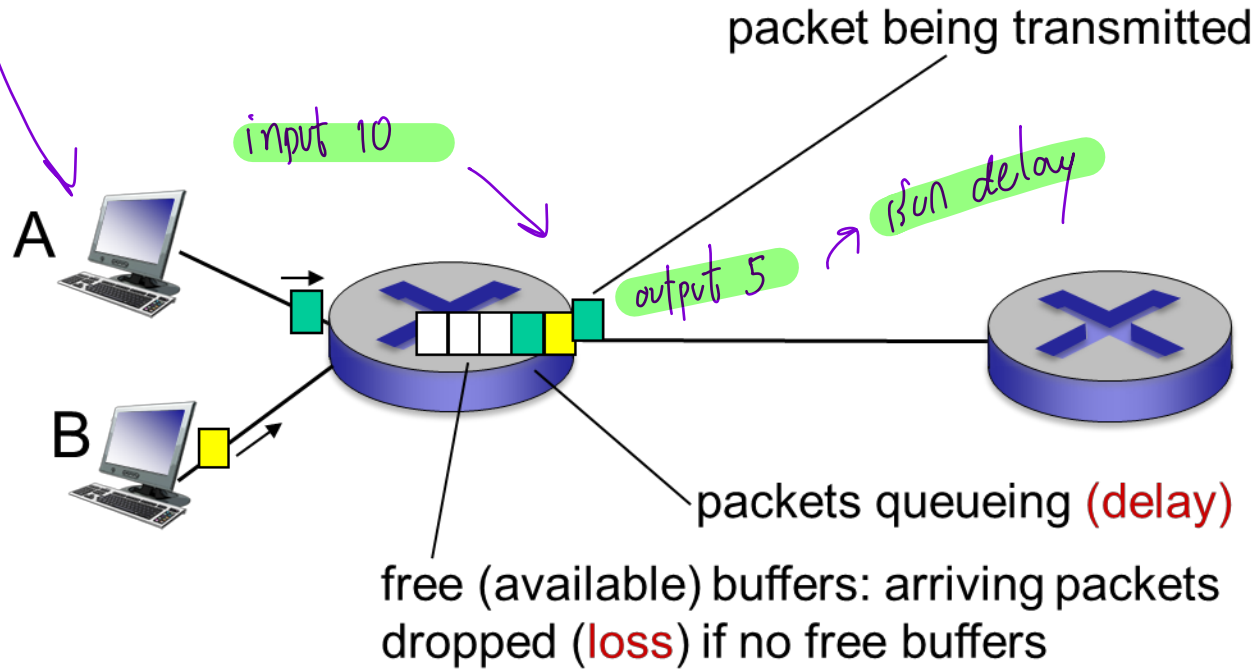
End-end delay = 2*L*/*R*

(assuming zero propagation delay)

How do loss and delay occur?

packets *queue* in router buffers

- packet arrival rate to link (temporarily) exceeds output link capacity
- packets queue, wait for turn



Logical Connection

- **Node or Host Addresses**
  - IPv4 and IPv6 Address
- **Communication Protocols**
  - Application Layer Protocols
  - Transport Layer Protocols
  - Network Layer Protocols
  - Network Access Layer Protocols

Reference

- CCNA 200-301 Official Cert Guide, Volume 1 (2019)
  - By Wendell Odom
- Computer Networking: A Top-Down Approach, Global Edition (2016)
  - By Keith Ross James Kurose