NETWORKING INFRASTRUCTURE
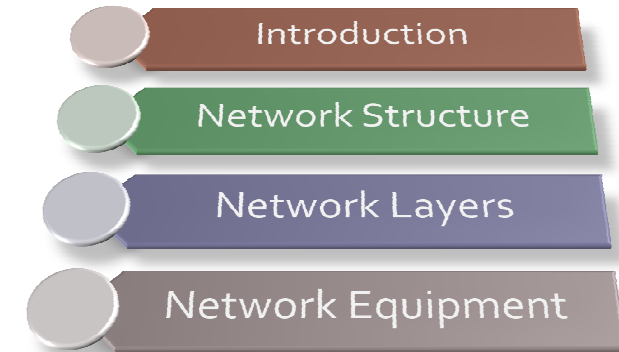
2110684 Information System Architecture

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Agenda

- Introduction
- Network Structure
- Network Layers
- Network Equipment

INTRODUCTION

Internet – Global Connectivity

- Internet architecture is very scalable
  - Connecting people and contents from all over the world
  - 1,600 M users (24% of human race)
  - Contents
    - > 100 M web sites
    - > 45,000 M web pages
- Thailand Statistics
  - Internet Penetration: 8.5M in 2007 (13%)
    - Norway = 88% (1), South Korea = 71% (11)
  - Broadband: 1M in 2007 (1.5%) and 10M in 2009
    - Bermuda = 36.5% (1), South Korea = 27.4% (9)

Internet Components

- Internet clients
  - Can be computer, mobile phones, etc.
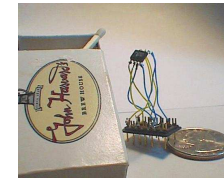 - Web browser, email client, etc.
- Internet servers
  - Web servers

"Cool" internet appliances

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

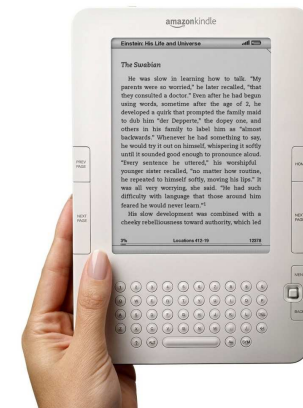World's smallest web server
http://www-ccs.cs.umass.edu/~shri/iPic.html

Web-enabled toaster+weather forecaster

Mobile Internet Device

SMARTQ 7
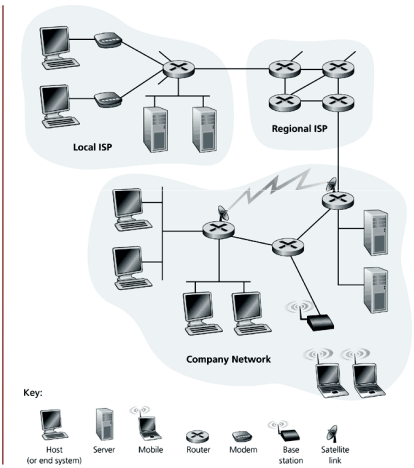WWW.ELETROWORLD.CN

Other Internet Devices

Other Internet Device

Internet Architecture

- Internet is "network of networks"
  - Millions of connected devices (*hosts = end systems*)
  - Running network apps
  - communication links
    - fiber, copper, radio, satellite
    - transmission rate = *bandwidth*
  - routers: forward packets (chunks of data)

Message Transmission

- Source host creates the message to send
- Message is transmitted via the local network to the local router (gateway)
- Message travels from router to router until the destination's gateway is reached
- Message is transmitted across the destination's LAN to the destination host.
- Destination host receives and acts upon the message
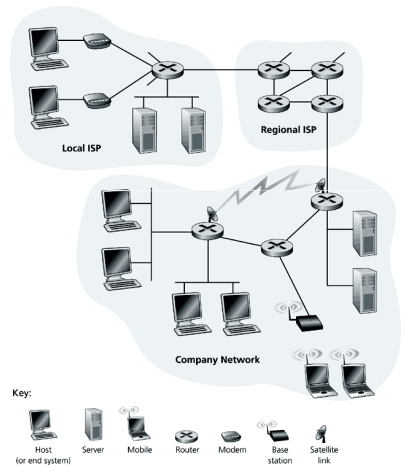
NETWORK STRUCTURE

Internet Service Providers (ISPs)

- Tier 1 ("backbone")
  - AT&T, Sprint, UUNet, etc.
  - National & international connections
- Tier 2
  - Provide regional connections, e.g. Uninet, CAT
  - Purchase services from Tier 1 providers
- Tier 3 and local
  - "Last mile" connections e.g. ChulaNet, True
  - Purchase services from Tier 2
  - Sell services directly to individual & small business customers

Message Path through Internet
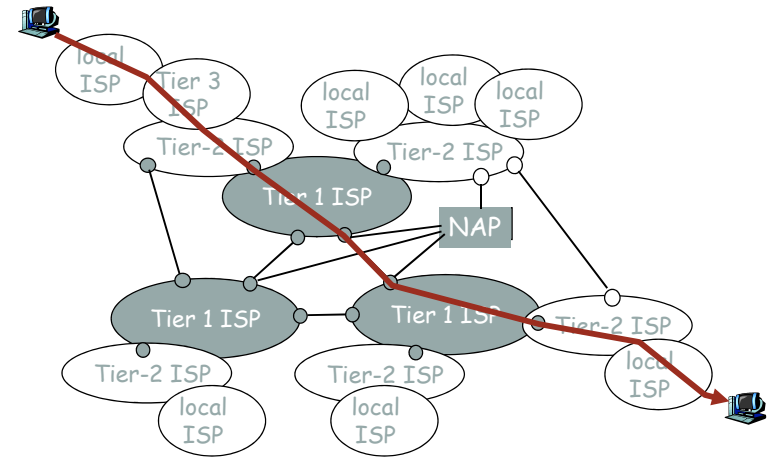
Residential "gateway" connections

- Dialup modem
  - Standard analog telephone line
  - <= 56Kbps
- Digital subscriber line (DSL)
  - Standard phone lines, restricted distance to modem
  - 3 Frequency channels (downstream, upstream, voice)
  - 384K–1.5Mbps downstream, 128K-256Kbps upstream
- ADSL: asymmetric digital subscriber line
  - up to 1 Mbps upstream (today typically < 256 kbps)
  - up to 8 Mbps downstream (today typically < 1 Mbps)
  - FDM: 50 kHz - 1 MHz for downstream
    - 4 kHz - 50 kHz for upstream
    - 0 kHz - 4 kHz for ordinary telephone

Local Area Networks

- Ethernet (most common wired technology)
  - 10 Mbps , 100 Mbps, 1Gbps even now 10Gps
  - Twisted pair copper wire or coax cable
- Wireless LAN
  - Base station (access point) connected to wired LAN
  - IEEE 802.11b is 11Mbps (802.11g is faster)
  - Typically good for 10s of meters
- WAP (Europe, US) and I-mode (Japan)
  - Extend cell-phone network to Internet
  - Eg. GPRS / EDGE
- Upcoming 3G
  - HSDPA

Building Links: Guided Media

- Twisted pair copper wire (phone, CAT-5)
  - 2 wires twisted around each other to help limit interference
  - CAT-5 cable has more twists, better insulation

- Coaxial Cable
  - Cable wrapped by insulation surrounded by another conductor

- Fiber optics
  - Thin flexible "glass pipe"
  - Require optical rather than electrical transmitters, receivers, switches, amplifiers, etc.

Wi-Fi : Internet without wire

- High-Speed "wireless" internet
  - AKA. Hot-Spot
- Allow users with wireless-enabled device to access internet
  - Notebook, PDA, media boxes, game console
  - No setup needed
  - Available in many places (shopping centers, hotels, coffee shops, campus, home)

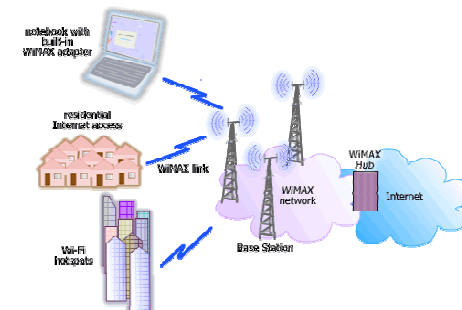
Wireless access networks

- Wireless access network connects end system to router
  - via base station aka "access point"
- Wireless LANs:
  - 802.11b (WiFi): 11 Mbps
- Wider-area wireless access
  - provided by telco operator
  - 3G ~ 384 kbps
  - WAP/GPRS in Europe

router

base station

mobile hosts
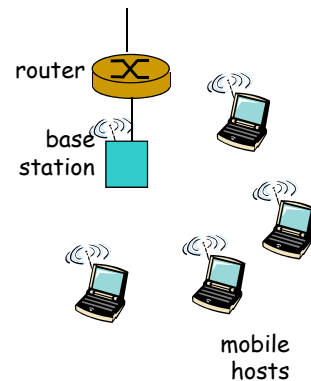
Wimax : Wi-Fi on Steroid

- Up-coming "very high-speed" wireless networks
- Long-range (10km or more)
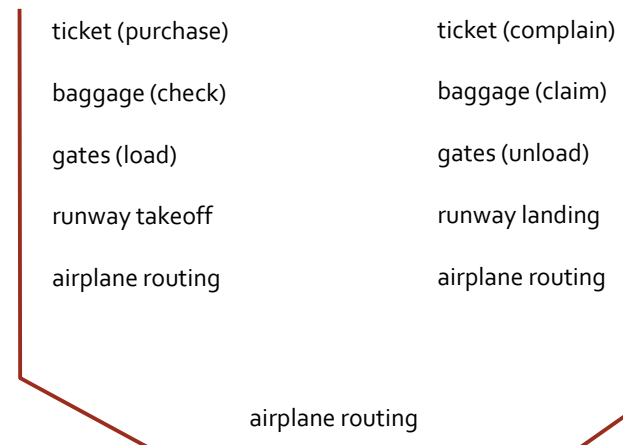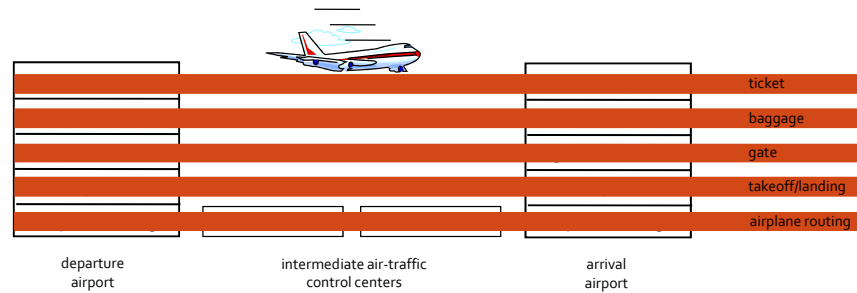
Wimax on Bike

NETWORK LAYERS

Dealing with Complexity

- The path a message takes is complex; dealing with hosts, switches, packets, media, etc.
- Therefore we use an *abstract* model to divide the transmission into *layers*
- The sender at each layer uses the lower layers (as a black box) to send information directly to the recipient at that layer.
- Each layer considers information from layers above to be "data bits"

Example: Airplane Routing

ticket (purchase)	ticket (complain)
baggage (check)	baggage (claim)
gates (load)	gates (unload)
runway takeoff	runway landing
airplane routing	airplane routing

airplane routing

Layering of airline functionality

	ticket
	baggage
	gate
	takeoff/landing
	airplane routing

departure airport — intermediate air-traffic control centers — arrival airport

Layers: each layer implements a service
- via its own internal-layer actions
- relying on services provided by layer below

Enveloping a Message

- Each layer takes data from the above layer
  - Breaks it apart if necessary (e.g. packetizing)
  - Adds an "envelope" = header and/or footer bits
  - Passes it to the next layer below, which will treat envelope as part of the data

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Internet protocol stack

- **application:** supporting network applications
  - HTTP, FTP, SMTP
- **transport:** host-host data transfer
  - TCP, UDP
- **network:** routing of datagrams from source to destination
  - IP, routing protocols
- **link:** data transfer between neighboring network elements
  - PPP, Ethernet
- **physical:** bits "on the wire"

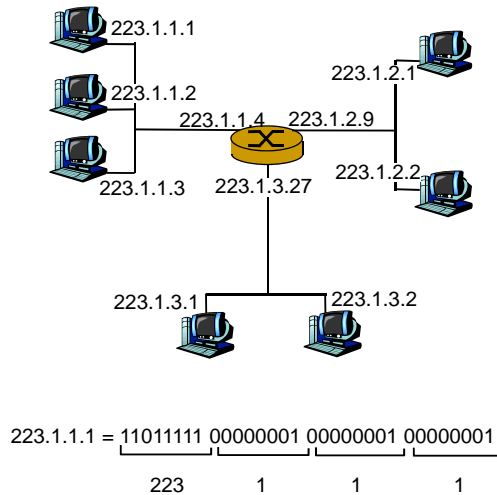| Application |
| Transport |
| Network |
| Link |
| Physical |
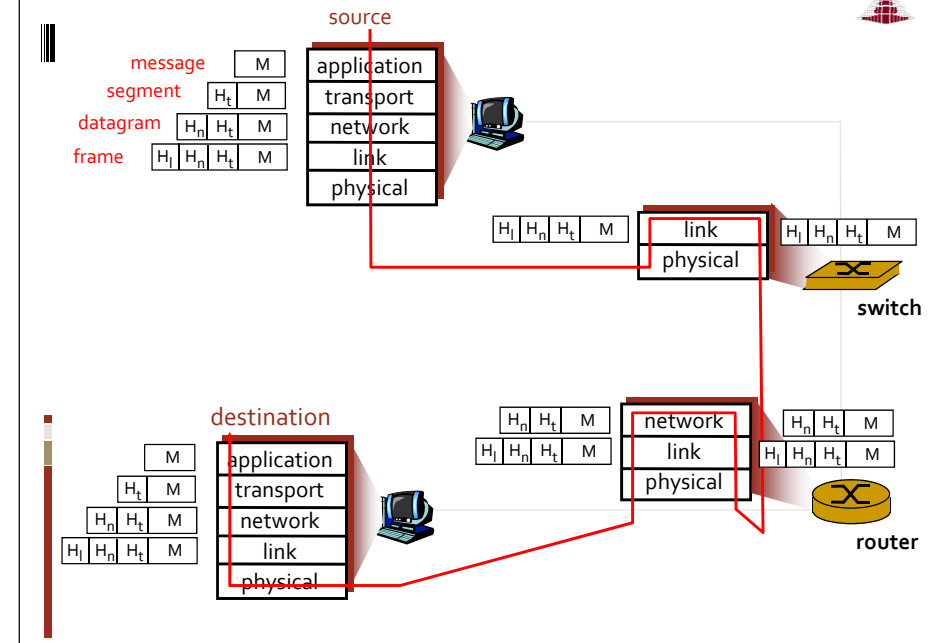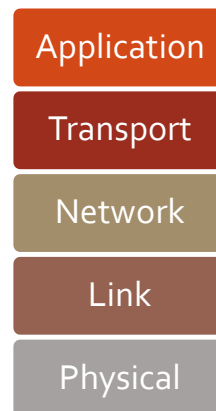
IP Addressing: introduction

IP address: 32-bit identifier for host, router *interface*

interface: connection between host/router and physical link

- router's typically have multiple interfaces
- host may have multiple interfaces
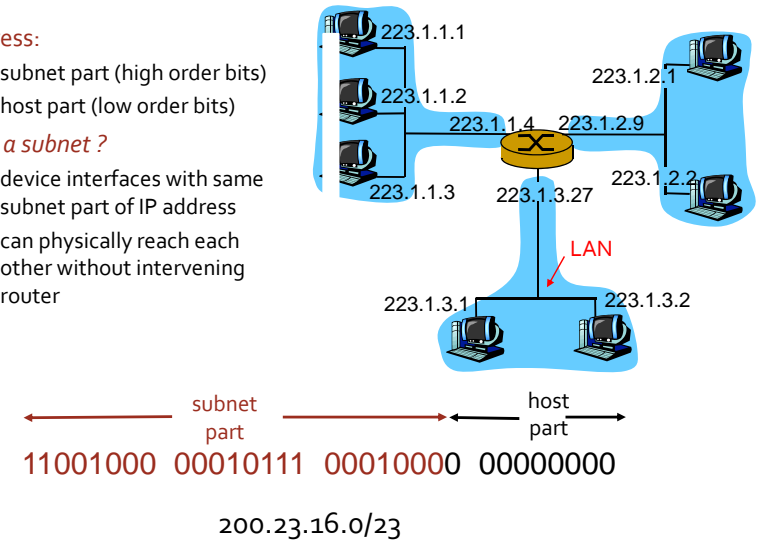- IP addresses associated with each interface

223.1.1.1
223.1.2.1
223.1.1.2
223.1.1.4   223.1.2.9
223.1.1.3   223.1.3.27
223.1.2.2
223.1.3.1   223.1.3.2

223.1.1.1 = 11011111 00000001 00000001 00000001

223　　1　　1　　1

Subnets

IP address:
- subnet part (high order bits)
- host part (low order bits)

What's a subnet ?
- device interfaces with same subnet part of IP address
- can physically reach each other without intervening router

223.1.1.1
223.1.2.1
223.1.1.2
223.1.1.4   223.1.2.9
223.1.1.3   223.1.3.27
223.1.2.2

LAN

223.1.3.1   223.1.3.2

← subnet part → ← host part →

11001000 00010111 00010000 00000000

200.23.16.0/23

IPv6

- "Next generation" internet addressing
- 128 bits (rather than 32 in IPv4)
  - Not as big a deal as originally thought (NAT, CIDR)
  - "Every grain of sand on the planet can be internet-addressable)
  - Multicast and anycast (pick-1) addressing now supported
- Simplified header (next slide)
- From IPv4 to IPv6 (until all IPv6)
  - Dual stack router
  - Tunneling

NETWORK EQUIPMENT

Equipment: Hub / Switch

Hub
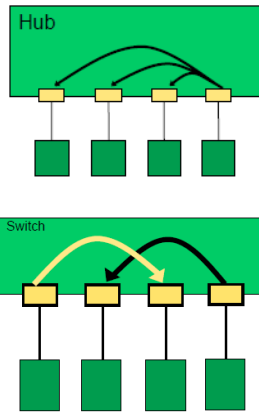
Switch

- Transmission of data of physical layer
- Connect several LANs of the same type
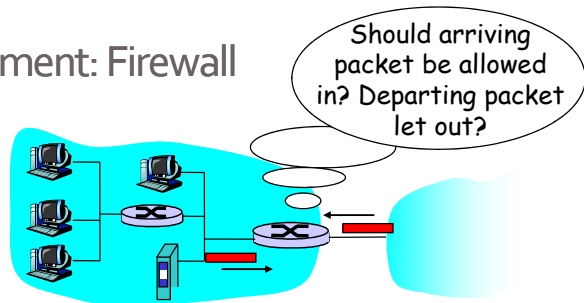- Switch is more intelligent than hub

Equipment: Router / Layer-3 Switch

- Connect 2 or more logical subnets
- Usually support multiple interface types (e.g. UTP, FC)
- Layer-3 Switch is router with less functions (e.g. only 1 interface type)

Equipment: Firewall

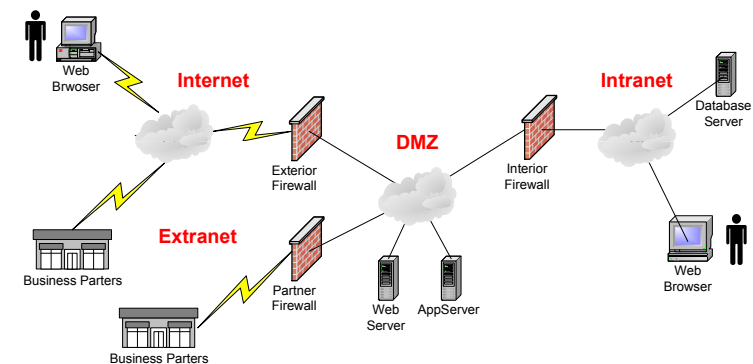Should arriving packet be allowed in? Departing packet let out?

- internal network connected to Internet via router firewall
- router filters packet-by-packet, decision to forward/drop packet based on:
  - source IP address, destination IP address
  - TCP/UDP source and destination port numbers
  - ICMP message type
  - TCP SYN and ACK bits

System Zones

Web Brwoser

Internet

Intranet

Database Server

DMZ

Exterior Firewall

Interior Firewall

Extranet

Business Parters

Partner Firewall

Web Server

AppServer

Web Browser

Business Parters

Real World: ChulaNet

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2110684 - Basic Infrastructure

Real World: ChulaNet

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Real World: EngNet