Networks

COMP2410/COMP6340 Networked Information Systems

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Module Outline

Network Classification

Connecting networks

Network metrics

A device connected to a network

Jason opened his tablet and checked his email

We have seen that this implies that the tablet is connected to the Internet. In fact, the tablet is connected to a *local* network, which is in turn connected to (typically) an ISPs network, which directly or indirectly is connected to the Internet.

We can classify networks based on communication media and scale, amongst other approaches.

Communication media

Based on communcation media, we can classify networks into two main categories:

1. **Wired technologies**, where a physical *wire* is used to connect devices in the network. Examples are: *twisted pair*, *coaxial cable* and *optical fiber*. Speeds range from a few Megabits per second to Petabits per second, while distances range from a few meters to several hundred kilometers.
2. **Wireless technologies**, where the devices are connected via wireless. Examples are: microwave, satellite, cellular, radio and infrared. Speeds range from a few Megabits per second to Gigabits per second, while distances range from a few meters to thousands of kilometers.

Scale

Based on scale, we can classify networks into the following broad categories:

- PANs (Personal Area Networks)
- LANs (Local Area Networks)
- CANs (Campus Area Networks)
- MANs (Metropolitan Area Networks)
- WANs (Wide Area Networks) and
- Internetworks

Scale (contd)

Personal Area Networks

Lets devices communicate that are close to a person. Examples are computers, printers, PDAs, telephones and scanners. May include wired and wireless devices. The wireless technologies include Bluetooth and Infrared. Range is typically 10 meters.

Local Area Networks

A network that connects devices in a limited area such as home, school, lab, office or factory. Privately owned. Wired LANs typically use Ethernet technology. WiFi is generally used for wireless connections, using Access Points. Devices on the Ethernet are connected using **switches**. The LAN is connected to the Internet via a **router**, **cable modem** or **adsl modem**.

Scale (contd)

Campus Area Networks
A network made of interconnected LANs within a small geographical network, such as a university campus. Example: the ANU network. All of the related hardware are almost entirely owned by the campus tenant/owner.

Metropolitan Area Networks
A network that covers a city or a large campus. Interconnects a number of LANs using a high-capacity **backbone**. Can use microwave (WiMAX), radio or infra-red laser for this purpose. Could be owned by many individuals and organizations. They provide up-link services to WANs or the Internet.

Scale (contd)

Wide Area Networks

Such networks cover large areas and may cross national and/or continental boundaries, using a combination of phone lines, cables and wireless. Often uses telecommunication infrastructure provide by common carriers, such as telephone companies. Could be owned by one or more organizations.

Internetworks

A network that is the collection of interconnected networks is called an **internetwork** or **internet**. This normally involves connecting two distinct networks such as two LANs or a LAN and a WAN. The networks forming an internet may use different technologies. Networks are connected to each other using routers. The **Internet** is the largest internet on Earth.

A comparison table

Category	Local Area Network	Metropolitan Area Network	Wide Area Network
Abbreviation	LAN	MAN	WAN
Service Area	*On customer premises* (home, apartment, office, building, campus, etc.)	*Between sites* in a metropolitan area (city and its suburbs) A Type of WAN	*Between sites* in a region, a country, or around the world.
Implementation	Self	Carrier	Carrier
Ability to Choose Technology	High	Low	Low
Who manages the network?	Self	Carrier	Carrier
Price	Highly related to cost	Based on strategy. Highly unpredictable.	Based on strategy. Highly unpredictable.
Cost per Bit Transmitted	Low	Medium	High
Therefore Typical Transmission Speed	100 Mbps to 1 Gbps or more	10 to 100 Mbps	1 to 50 Mbps
Can Use Switched Technology?	Yes	Yes	Yes
Can Use Routed Technology?	Yes	Yes	Yes

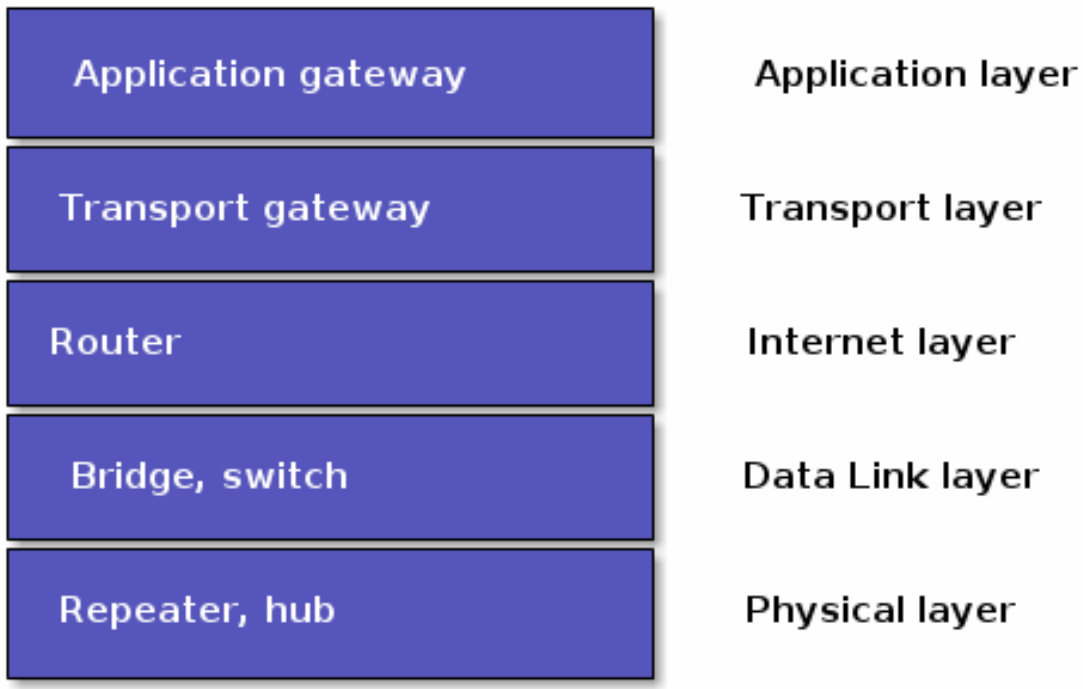
Other types of networks

Can you think of other kinds of network?

Network devices

If hosts on different networks are to communicate with each other, then the respective networks need to be interconnected. In a similar fashion, we may also think of extending a network by adding another network. A range of devices can be used for these purposes. They are best studied by looking at the layers in which they primarily act. For the sake of clarity, we will split the link layer into the data link layer and the physical layer, as in the OSI model. Devices are also specified as being layer 1 or layer 2 and so on. In such a case, the layers being referred to are those of the OSI model.

Network devices in layers



Repeaters and hubs

These operate in the physical layer or layer 1. They are analog devices that work with signals on the cables to which they are connected. A *repeater* takes the signal appearing on one cable, filters to remove noise and amplifies it, and put's it out on another cable.

A *hub* has a number of input lines or *ports*. Signals arriving on one port is sent out or *broadcast* on all other ports. There is usually no amplification involved. If two different signals arrive at the same time, they will collide.

Bridges and switches

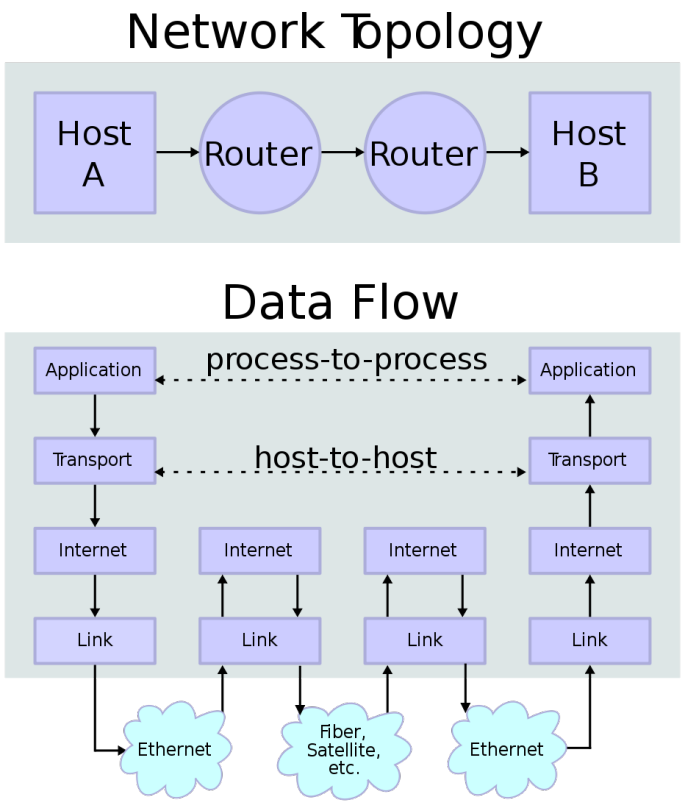
These operate in the data link layer or layer 2. Data in this layer is transmitted in small chunks called *frames*. A *bridge*, like a hub, has multiple ports. However, a bridge only outputs a frame on the port where it is needed, thus limiting any collisions to that port's domain. In effect, it creates a virtual path between two ports. Many such paths can exist at the same time. The input lines can run at different speeds. Bridges support buffering for this to happen. They are used to join networks of the same type and these will then operate as one aggregate network.

Switches are modern version of bridges. A switch normally has more ports than a bridge. Computers are generally connected directly to a switch.

Routers

A *router* operates in the Internet layer, or layer 3. Data in this layer is in the form of *packets*, so routers understand packets. On the Internet, routers operate on IP packets. They read the packet header to find the destination address and will pass on the packet to an appropriate output line, based on the information in its routing table. Routers are the glue that connect different networks to form the Internet. The networks connected by a router remain separate networks. There are layer 3 switches as well and these work in a similar manner to routers.

Routers and data flow



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The netstat command

```
Kernel IP routing table
Destination     Gateway         Genmask         Iface
150.203.24.0    0.0.0.0         255.255.255.192 eth1
0.0.0.0         150.203.24.1    0.0.0.0         eth1
```

Gateways

A *transport gateway* operates at the Transport layer or layer 4. These connect two computers that use different connection-oriented transport protocols. It can reformat the data if required, while copying it from one connection to the other.

An *application gateway* operates at the Application layer, or layer 7. It understands the format and contents of the data and can translate from one format to another. An email gateway could, for example, translate Internet messages to SMS messages for mobile phones.

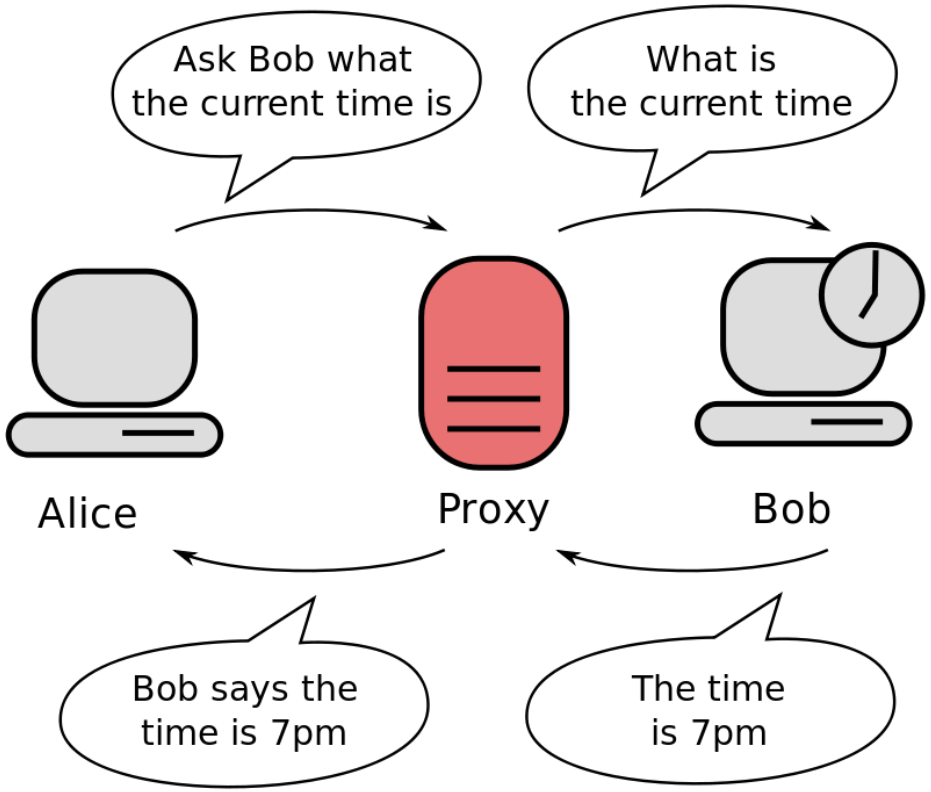
Proxy servers

A *proxy server* acts as an intermediary for clients seeking resources from other servers. A client connects to the proxy requesting some service from another server (such as a web page). The proxy then contacts the server on behalf of the client. A proxy can provide a number of functions:

- Caching (eg, web proxies, dns proxy)
- Security (client, content, access control)

A proxy can be *transparent* (invisible to the client) or *non-transparent* (requires client configuration).

Proxy concept



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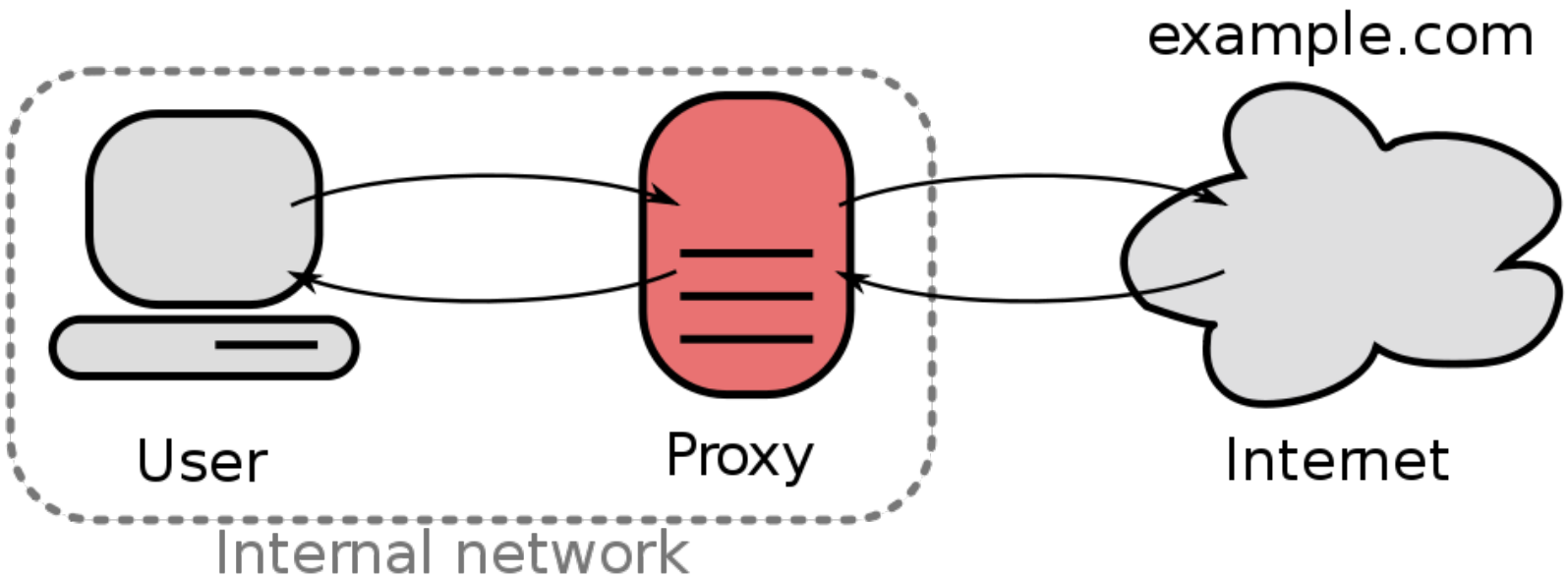
Types of proxies

There are several types of proxies. Some of them are:

- **Forward proxy**, which forwards client requests and accepts responses from the server. Generally takes requests from clients on an internal network.
- **Open proxy**, which is a forwarding proxy that takes requests from anyone on the Internet. Can be used to hide the clients IP address while they browse the Web.
- **Reverse proxy**, which acts as a proxy to a number of servers. Appears to the client to be an ordinary server. Used for several reasons such as security, load balancing, caching, spoon feeding (slow clients) and compression.

Forward proxy



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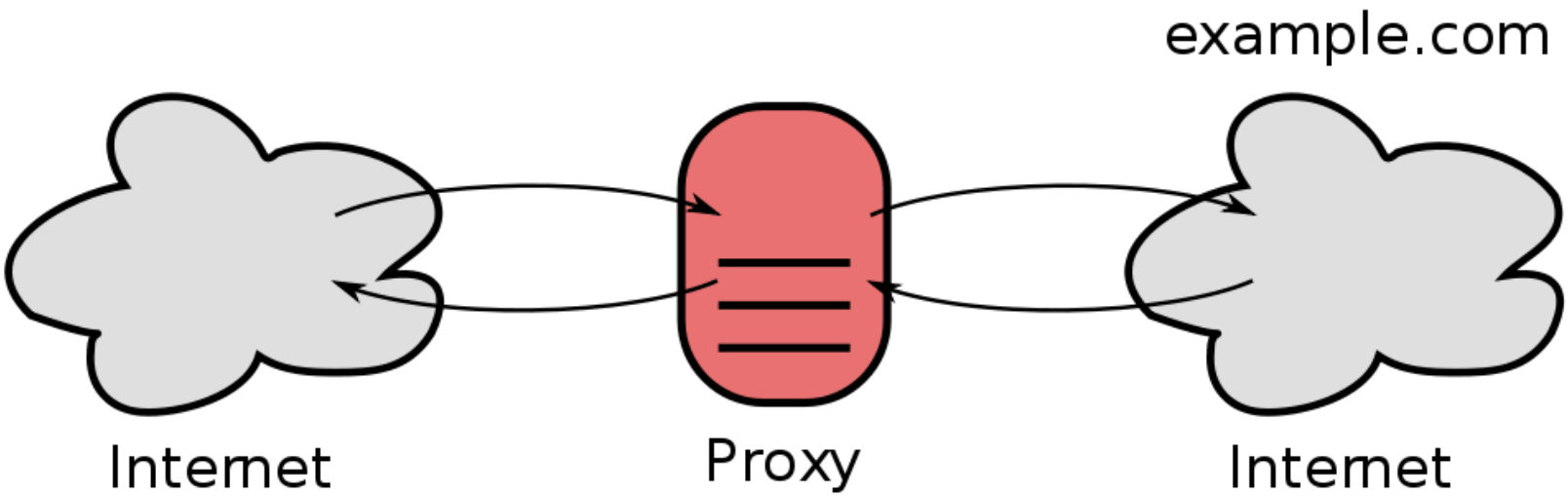
Open proxy



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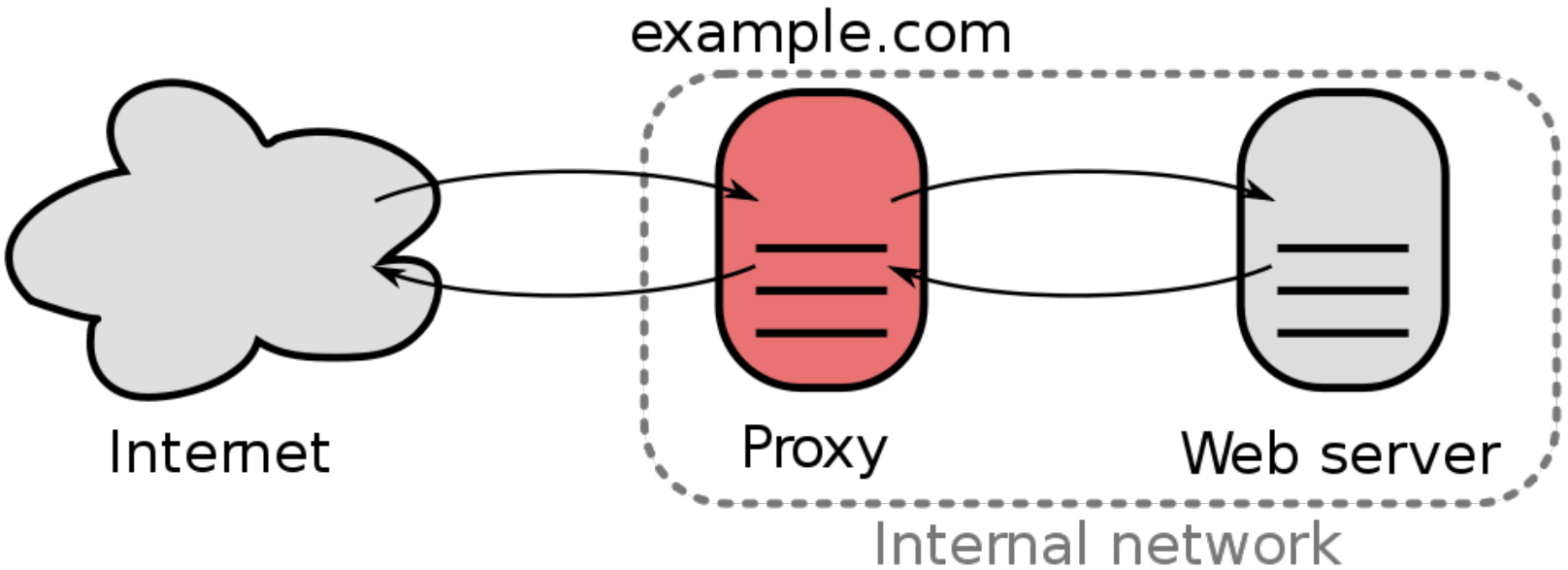
Reverse proxy



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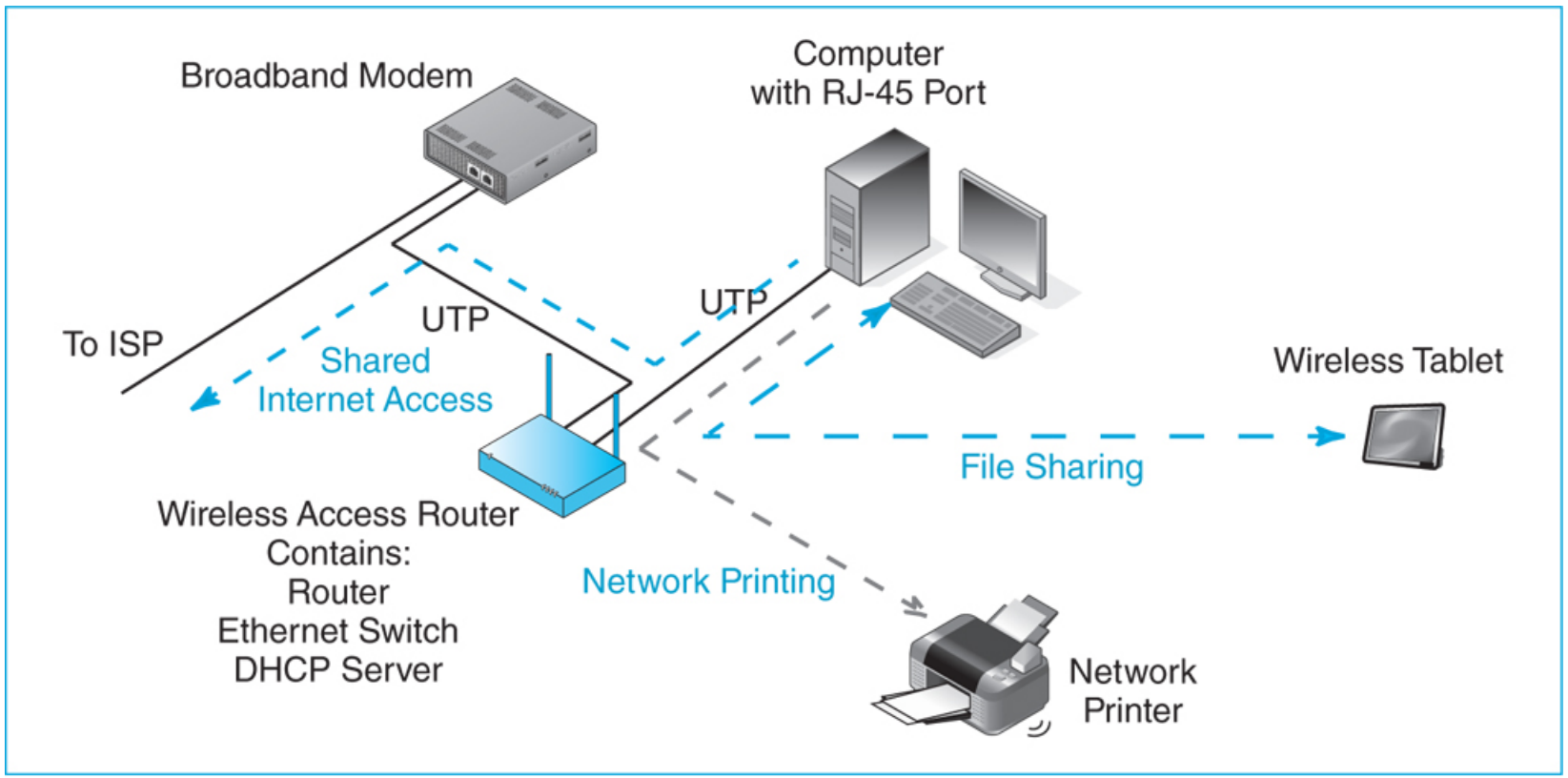
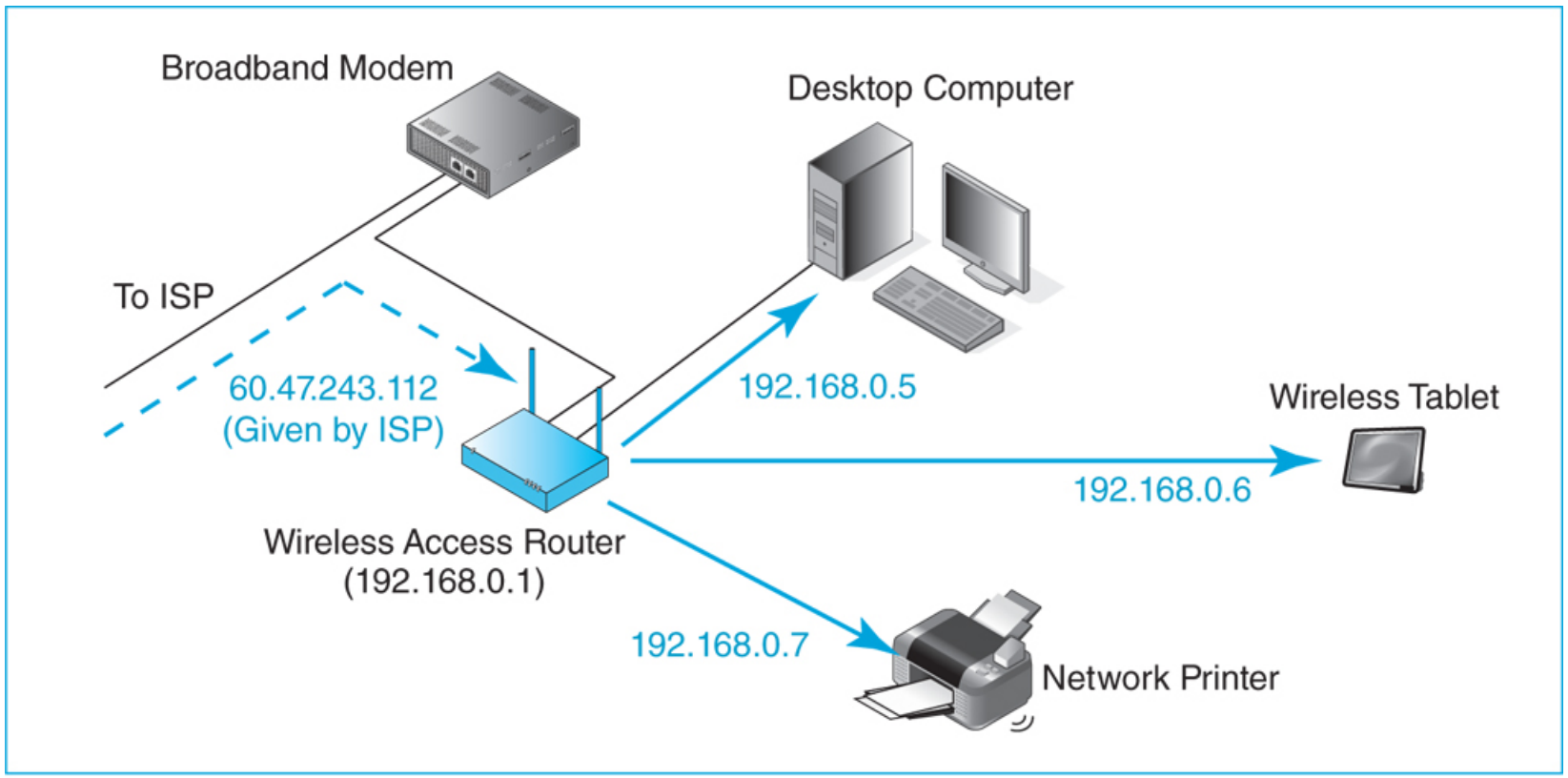
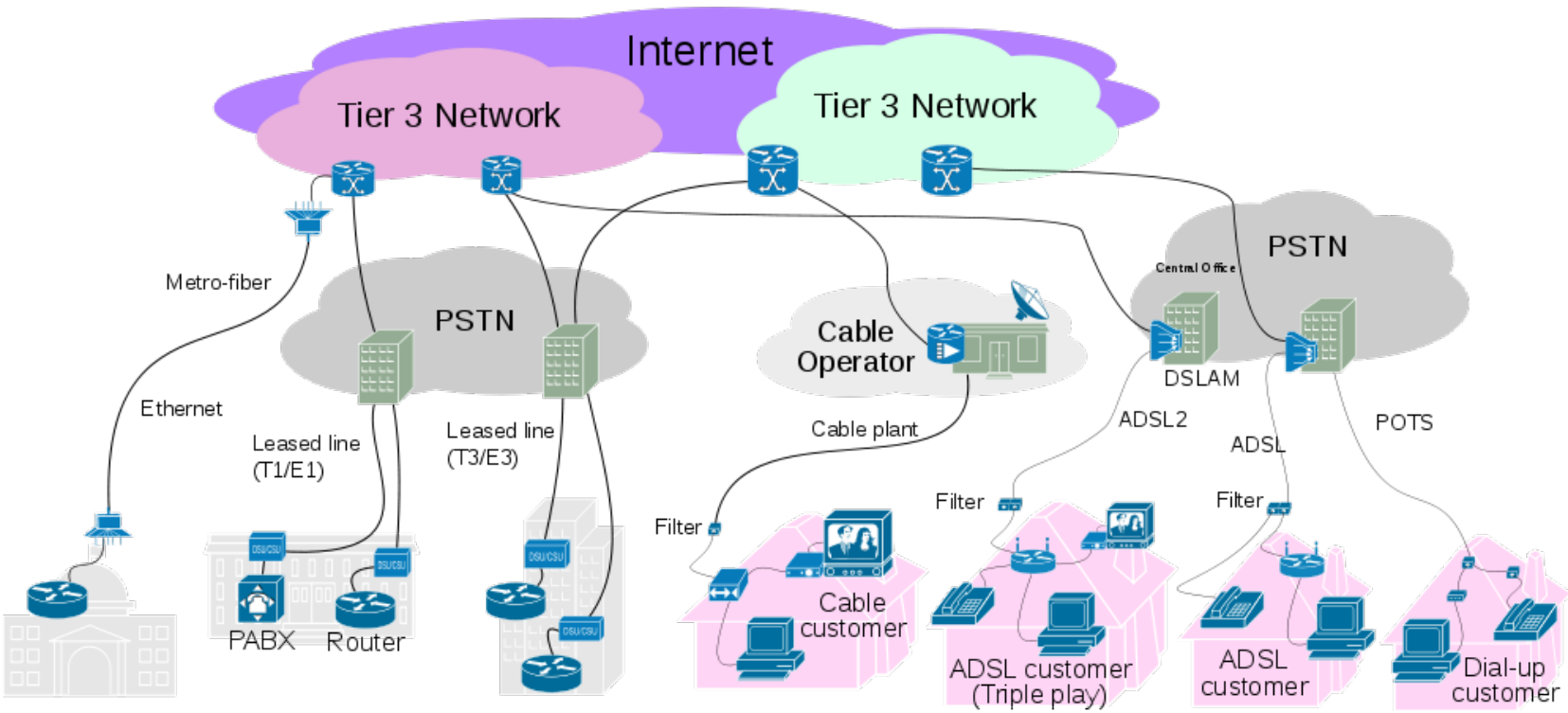
A home network



DHCP on a home network



Internet Connectivity



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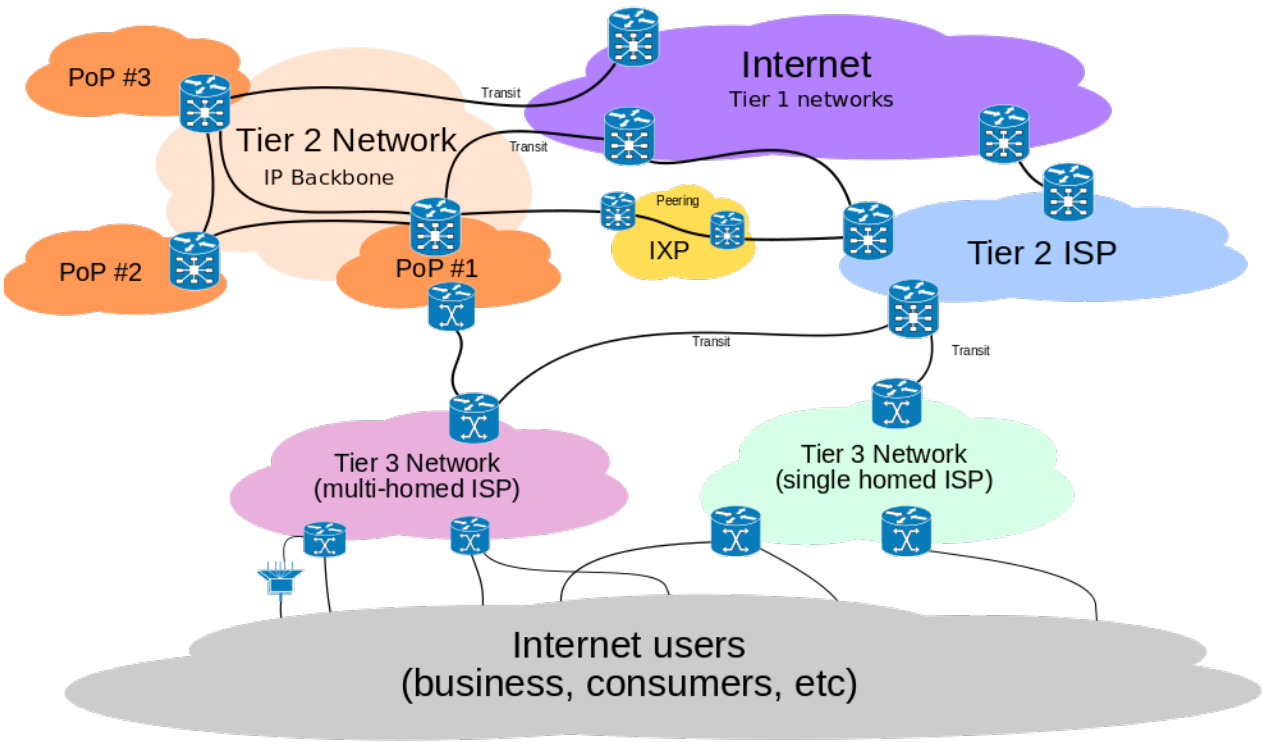
Internet Architecture



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Speed

Network transmission speed is usually measured in **bits per second (bps)**. Metric prefixes are used for specifying large bit rates.

Transmission Speed Measurements		
Bits per second (bps)		
Usually not bytes per second (Bps)		
Metric Suffixes		
Kilobits per second	kbps (lowercase k)	1,000 bits per second (not 1,024)
Megabits per second	Mbps	1,000 kbps
Gigabits per second	Gbps	1,000 Mbps
Terabits per second	Tbps	1,000 Gbps

Sample download times

Applications	10 kbps	100 kbps	1 Mbps	5 Mbps	10 Mbps	100 Mbps	1 Gbps
File Transfers							
Text e-mail message (250 words)	1.5 s	0.15 s	0 s	0 s	0 s	0 s	0 s
Photograph (5 MB), E-Mail with 5 MB attachment, or media-rich webpage	83 m	8 m	1 m	10 s	5 s	1 s	0.1 s
Download 1 Hr. HDTV Video (10 Mbps)	42 d	4 d	10 h	2 h	1 h	6 m	36 s
Backup/File Synchronization (10 GB)	116 d	12 d	28 h	6 h	3 h	17 m	2 m
Live or streaming media							
MP3 Song (10 kbps)	OK	OK	OK	OK	OK	OK	OK
Standard-quality TV (2 Mbps)				OK	OK	OK	OK
HDTV (10 Mbps)					OK	OK	OK

Throughput, channel efficiency and other measurements

Throughput is the amount of actual data successfully delivered per unit time over a communcation channel. It is usually measured in bps. Communication overheads are not included in the calculation. Network latency may affect throughput. If, of 1538 bytes transmitted, 1500 bytes are actual data in a 100 Mbps Ethernet link, then the throughput is 1500/1538 * 100 = 97.52 Mbps.

Channel efficiency is the achieved throughput related to the maximum bitrate of a communication channel. If the throughput is 80 Mbps in a 100 Mbps Ethernet connection, then the channel efficiency is 80%.