15.561
Information Technology Essentials

Session 4
Networks II

Outline

- **Network protocols**
  - Enterprise networking

- **Example: Looking at a web page**

- **Wireless networks**
  - Wireless telephony
  - Wireless data communication

What does it mean to be on the Internet?

- **Run TCP/IP protocol**

- **Have an IP address**

- **Have ability to send IP packets to other machines on the Internet**

Network Protocols

- ## Rules of behavior
  - What, when, and how should A send messages to B and vice versa?

- ## Protocol layers
  - Each layer uses the layers below it and can be used by the layers above it
  - Often, multiple alternatives can be substituted at one layer without affecting the other layers

Example: TCP/IP protocol architecture

Application layer

Provides communication between applications on separate machines (e.g., email, file transfer, web browsing)

Transport layer

Provides end-to-end reliable data transfer across multiple networks (e.g., TCP - Transmission Control Protocol)

Internet layer

Routes data from source to destination through one or more networks (IP - Internet Protocol)

Network access layer

Manages logical interface between a machine and its local network (e.g., Ethernet, X.25)

Physical Layer

Converts bits to signals and back (e.g., wires, radio, etc.)

Different types of connection protocols

X.25 -- A packet switching protocol for connecting devices on a WAN

Frame relay -- Another packet switching protocol for connecting devices on a WAN (faster but less error checking than X.25. Up to about 45 Mbps)

Asynchronous Transfer Mode (ATM) -- A "cell switching" protocol that establishes "virtual circuits" from fixed size packets (faster than X.25, e.g., suitable for real-time video. Up to about 622 Mbps)

Different types of connection "boxes"

Hub - Connects parts of a network, typically different parts of the same LAN (network access level)

Bridge -- Connects two LANs using software (network access level)

Switch -- Connects different LANs, typically using hardware only (network access level)

Router -- Connects two networks that may or may not be similar and routes packets appropriately (Internet level)

Gateway -- Connects networks that use different protocols (transport level or above)

Example: The World Wide Web

- **A collection of *interlinked documents* stored on computer *servers* all over the world and accessible to user *clients* via the Internet.**
  - Documents communicated in HTML (HyperText Markup Language)
  - Rules for requesting and providing documents (and other interactions between clients and servers) are defined by HTTP (HyperText Transfer Protocol)

- **Documents may contain easily "clickable" links to other documents.**
  - Documents are identified by "web addresses" called URLs (Uniform Resource Locators)

- **"Hypertext" means text documents that contain embedded links to other documents.**

Looking at a Web page

- **Connect your PC to the Internet**
  - Dialup an Internet service provider (via modem)
  - Establish a point-to-point link with the provider's machine
    - » Using PPP (Point to Point Protocol)
    - » Your PC receives a "temporary" IP address
      - Using DHCP (Dynamic Host Configuration Protocol)
    - » Your PC receives the address of a Domain Name Server (DNS)

- **Start your browser program (e.g. Internet Explorer)**

- **Type in a URL (Uniform Resource Locator)**
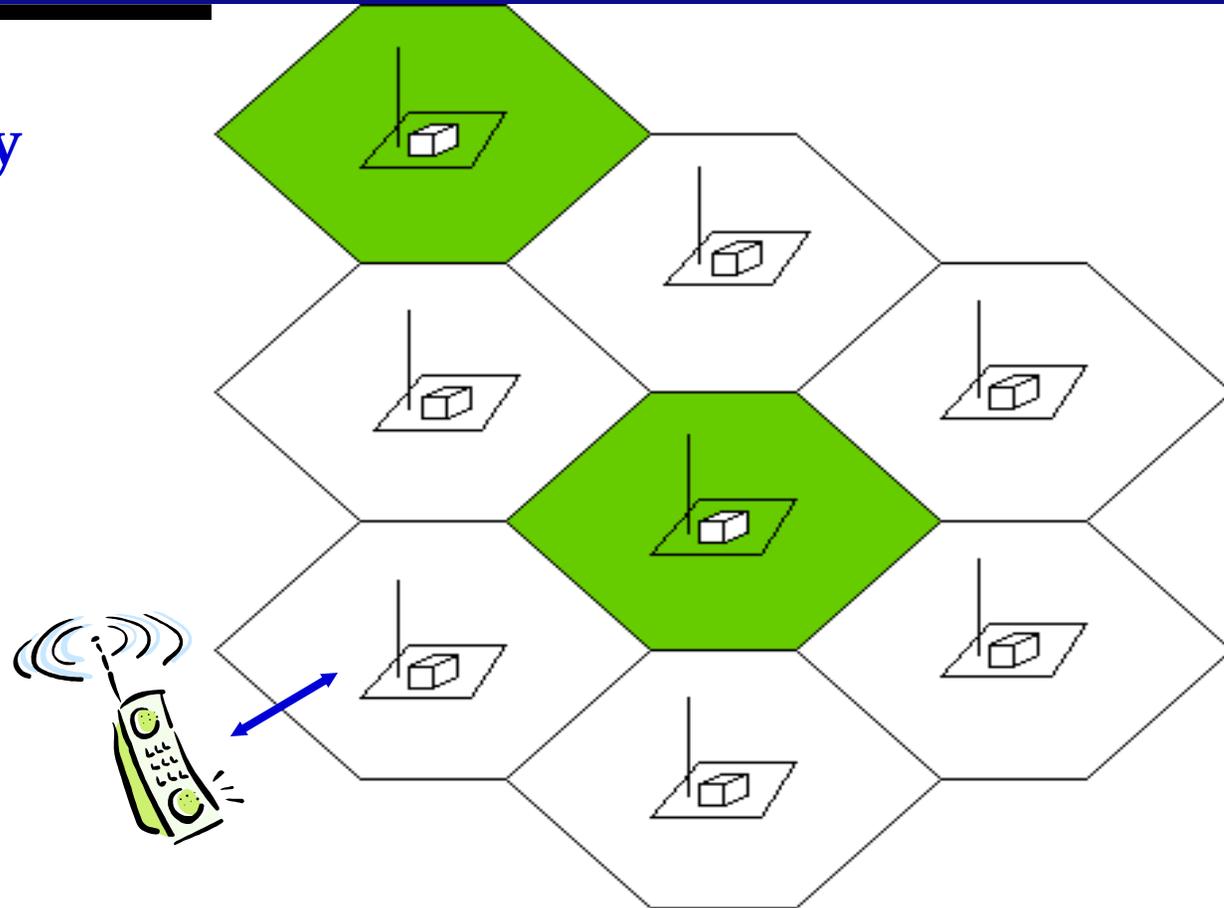
Looking at a Web page (cont.)

- Browser asks DNS for the IP address of the MIT Server

- DNS replies with 18.170.0.167

- Browser opens TCP connection to 18.170.0.167

- Browser sends the command `GET/class/syllabus.htm`

- The MIT Server sends file `syllabus.htm`

- TCP connection is released

- Browser displays the contents of `syllabus.htm`

How a cell phone works
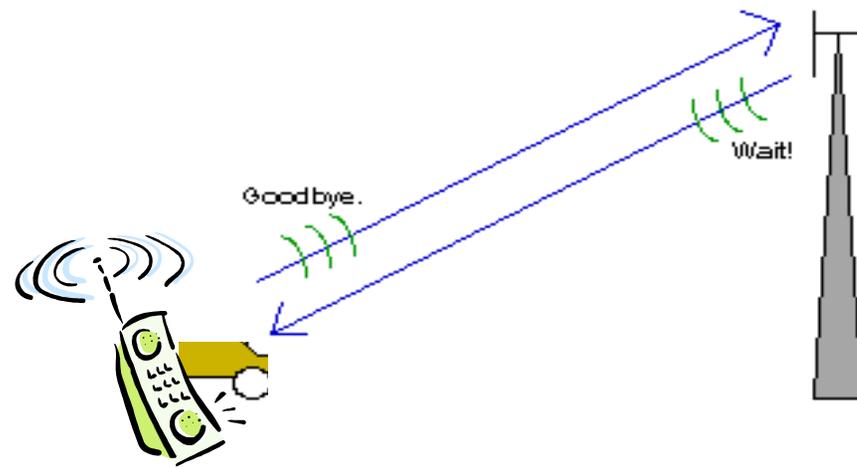
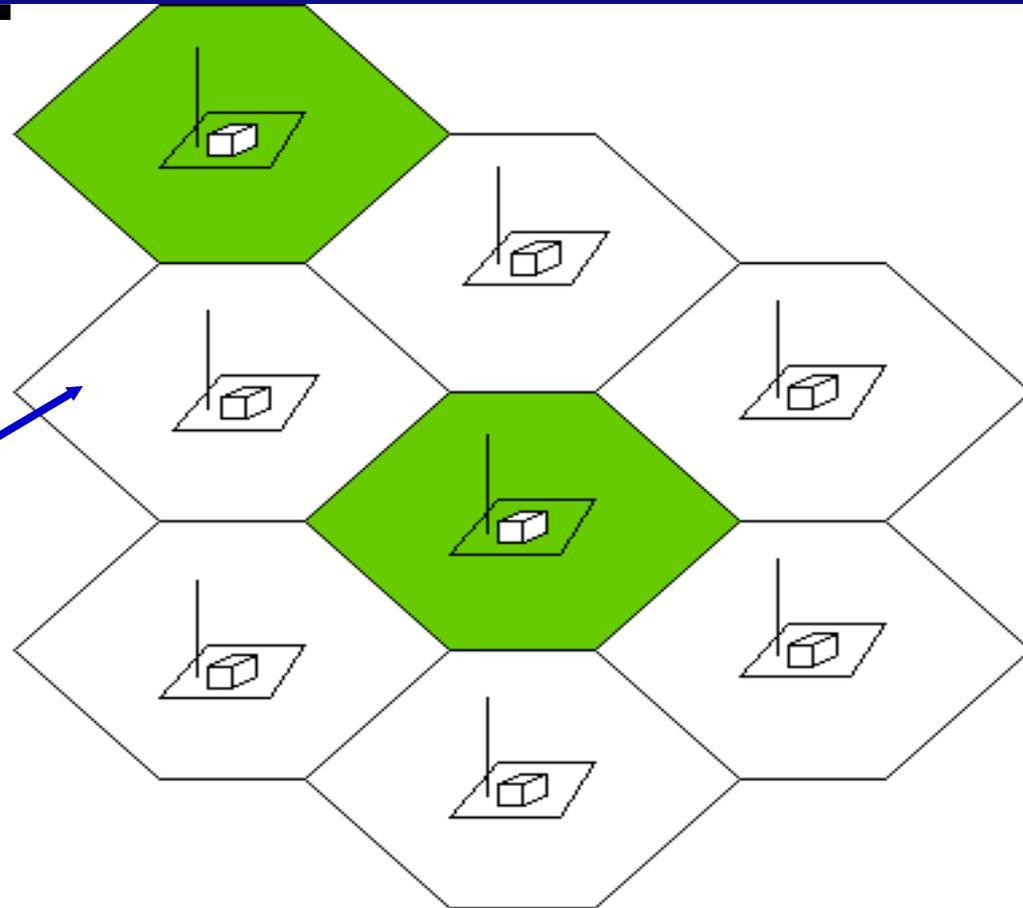Goodbye.

Wait!

CD

Cellular Phone Networks

- **Frequency reuse**

- **Handoff**

Cellular Phone Networks

- **Frequency reuse**

- **Handoff**

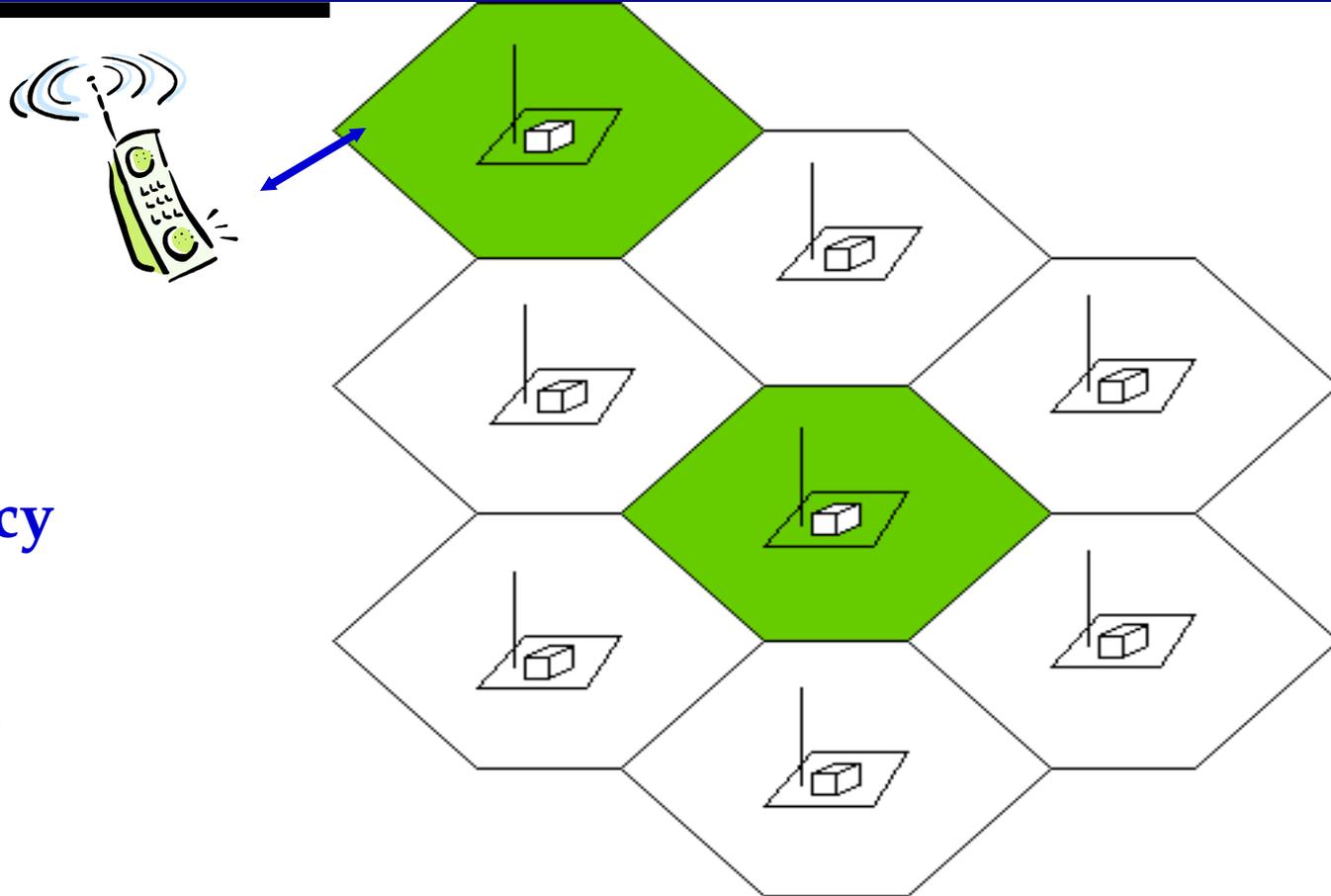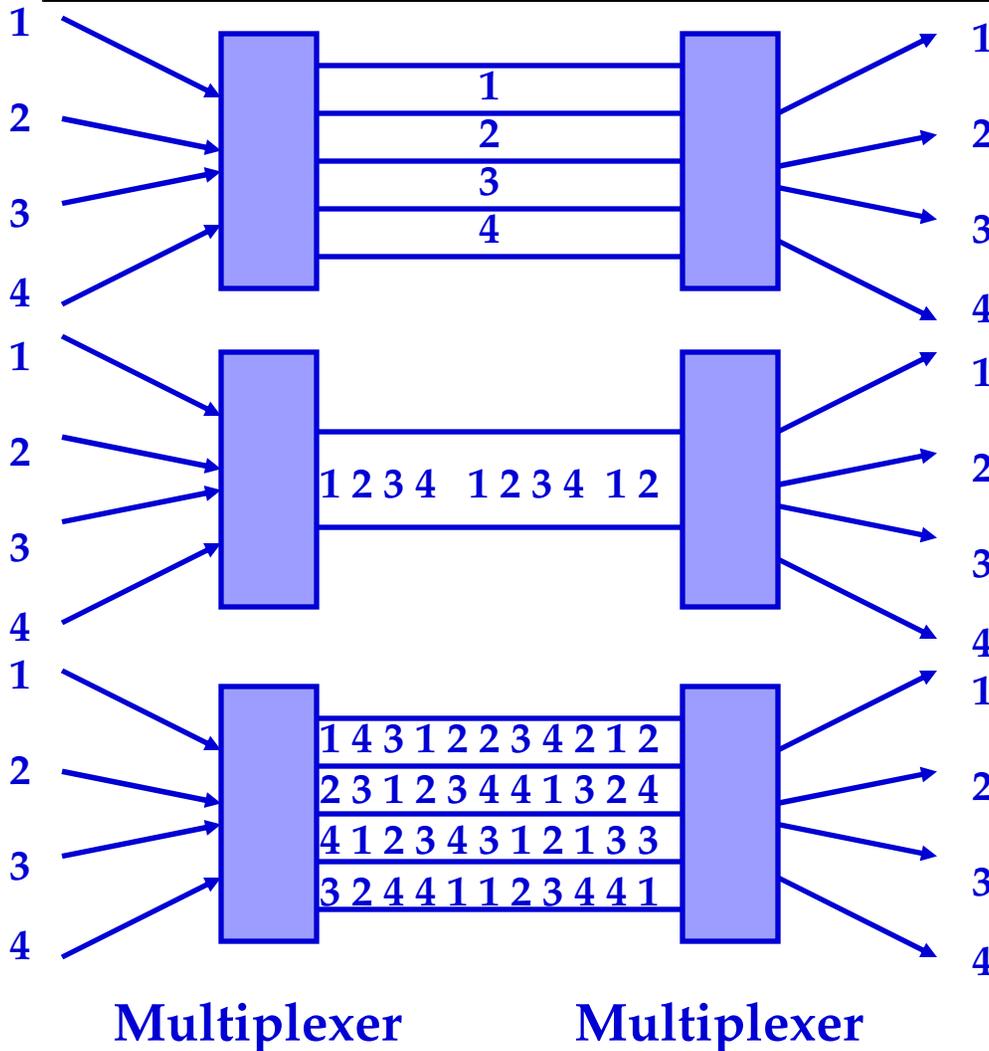# Cellular Phone Networks

- **Frequency reuse**

- **Handoff**

CD

Multiplexing: Squeezing many channels into one

```
1                                        1
    1
2                                        2   Frequency Division Multiple Access
    2                                        (FDMA)
    3
3   4                                    3

4                                        4
```

```
1                                        1
                                             Time Division Multiple Access
2   1 2 3 4   1 2 3 4 1 2                2   (TDMA)

3                                        3

4                                        4
```

```
1                                        1
    1 4 3 1 2 2 3 4 2 1 2
2   2 3 1 2 3 4 4 1 3 2 4                2   Code Division Multiple Access
    4 1 2 3 4 3 1 2 1 3 3                     (CDMA)
3   3 2 4 4 1 1 2 3 4 4 1                3

4                                        4
```

Multiplexer   Multiplexer

Generations of cellular technology

- **First Generation ("1G", 1980's and 90's)**
  - Analog, primarily used for voice, low bandwidth (eg., 9.6Kbps)
  - Ex: AMPS (USA)

- **Second Generation ("2G", 1990's and early 2000's)**
  - Digital, cheaper, somewhat higher bandwidth (e.g., 14.4 Kbps), more data services (e.g., short messages, caller ID)
  - Ex: GSM, TDMA, CDMA, PCS

- **Third Generation ("3G", started 2002)**
  - Digital, much higher bandwidth (e.g., 2Mbps), many more services (e.g., video)
  - Ex: WCDMA, CDMA2000

Different cellular standards

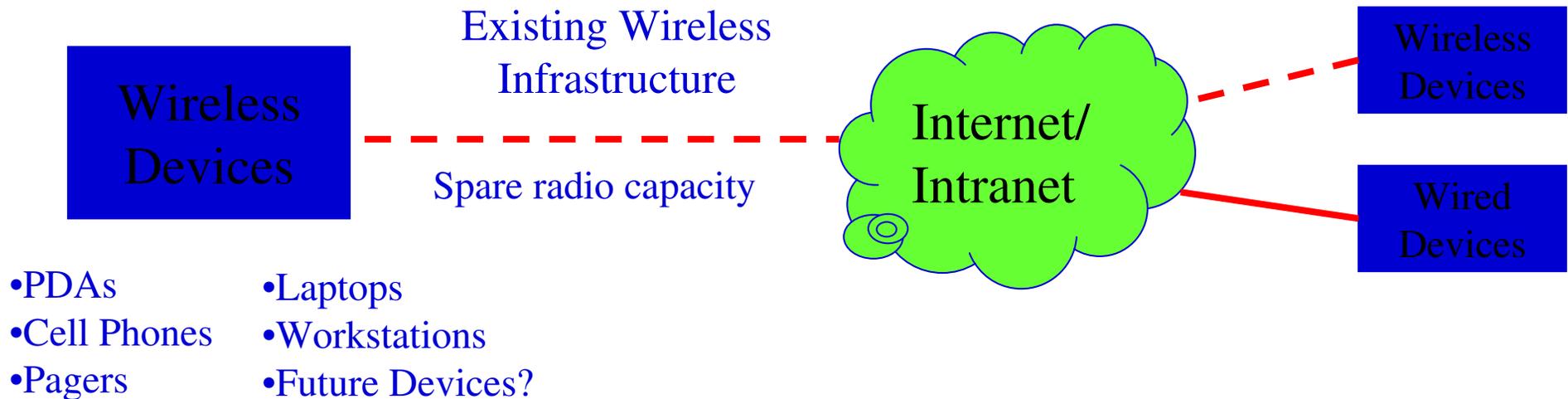| Standard	Appx. Freq. (MHz)	Mode	Multi-plexing method	Voice channels / radio channel	Comments
Analog (AMPS)	800 – 900	Analog	FDMA	1	Common in US, but becoming obsolete
GSM	900, 1800-2100	Digital	TDMA	8	Common in Europe & Asia, growing in US.
CDMA (IS-95)	800	Digital	CDMA	20-60	Qualcomm holds key patents
TDMA (IS-54 & IS-136)	800, 1800-2000	Digital	TDMA	3-6	Most common "digital" cellular in US
PCS	1800-2100	Digital	-	-	Generic term for 1800-2100 MHz svcs
WCDMA	Many	Digital	CDMA	Many	Migration path from GSM. Up to 2 Mbps.
CDMA2000	Any	Digital	CDMA	Many	Migration path from CDMA. Common in S. Korea. Up to 2 Mbps

Note: Acronyms defined on next slide

Cellular acronyms

- **AMPS – Advanced Mobile Phone System**

- **CDMA – Code Division Multiple Access**

- **FDMA – Frequency Division Multiple Access**

- **GSM - Global System for Mobile Communication**

- **IS – Interim Standard**

- **PCS – Personal Communications Services**

- **TDMA – Time Division Multiple Access**

- **WCDMA – Wideband CDMA**

What is Wireless IP?

- **A wireless connectivity solution employing IP that enables devices to access an Intranet or the Internet**

Wireless
Devices

Existing Wireless
Infrastructure

Spare radio capacity

Internet/
Intranet

Wireless
Devices

Wired
Devices

•PDAs
•Cell Phones
•Pagers

•Laptops
•Workstations
•Future Devices?

CD

Wi-Fi
(Wireless Fidelity)

- **Protocol for wireless LANs**

- **802.11b format – 11 Mbps**

- **802.11g format – 20+ Mbps**

- **Allows you to**
  - Connect to Internet in local "hot spots"
  - Connect many PC's to the Internet through one access point

Bluetooth

- **Wireless device connectivity**

- **Named after Scandinavian king who united several unruly kingdoms**

- **Short range (< 10m)**

- **Sample uses**
  - Wireless PDAs always connected to desktop via mobile phone
  - Wireless headphones connected to notebook
  - Office/Home device networks that automatically reconfigure by presence
  - ...

How will networks change business?