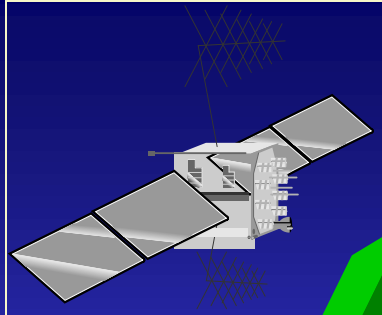
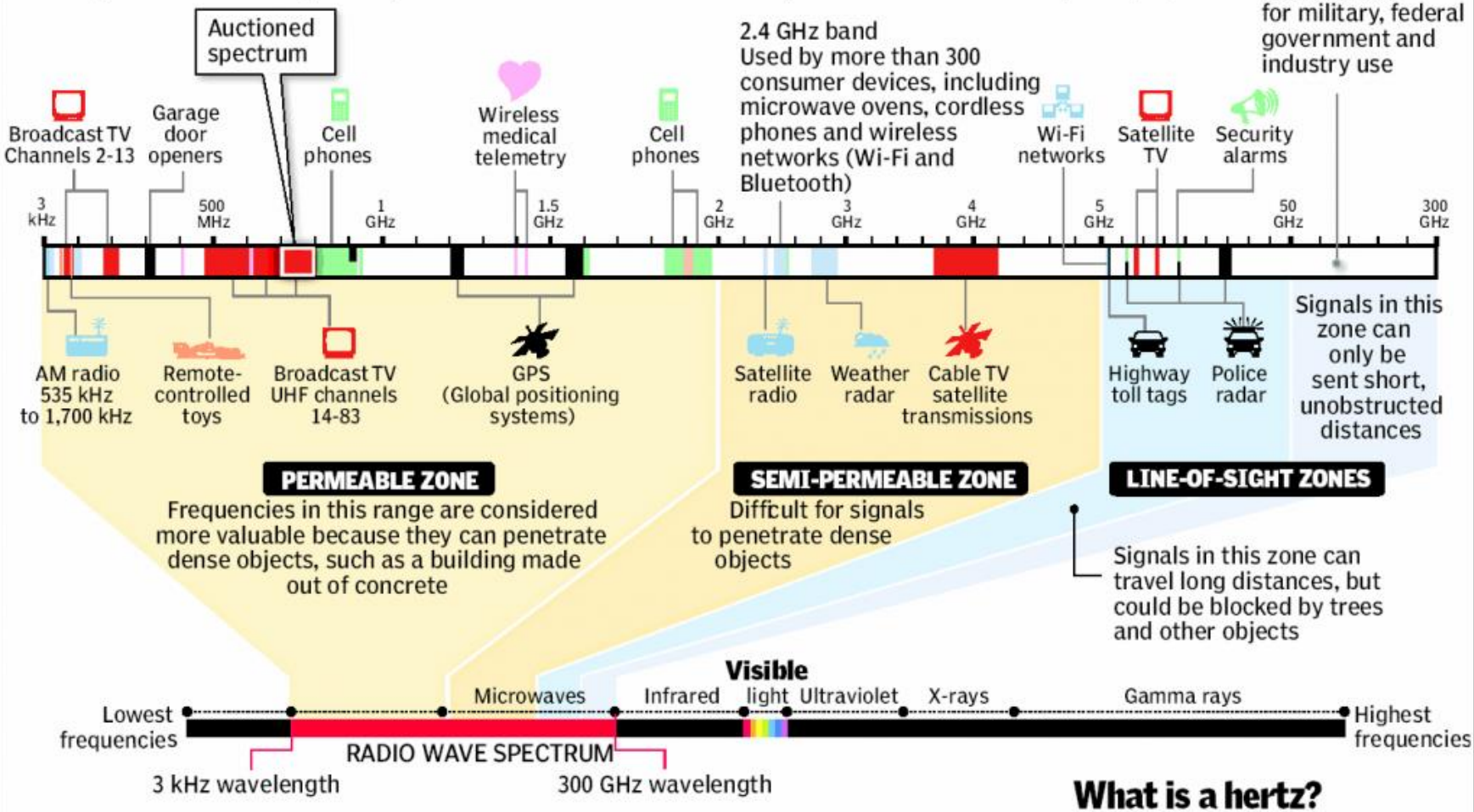


Wireless Networking

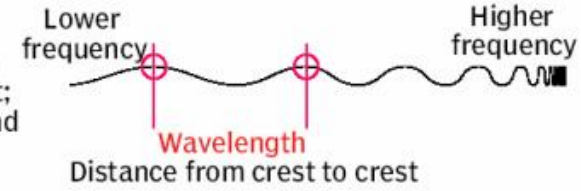
Inside the radio wave spectrum

Almost every wireless technology – from cell phones to garage door openers – uses radio waves to communicate. Some services, such as TV and radio broadcasts, have exclusive use of their frequency within a geographic area. But many devices share frequencies, which can cause interference. Examples of radio waves used by everyday devices:



The electromagnetic spectrum

Radio waves occupy part of the electromagnetic spectrum, a range of electric and magnetic waves of different lengths that travel at the speed of light; other parts of the spectrum include visible light and x-rays; the shortest wavelengths have the highest frequency, measured in hertz



What is a hertz?

One hertz is one cycle per second. For radio waves, a cycle is the distance from wave crest to crest

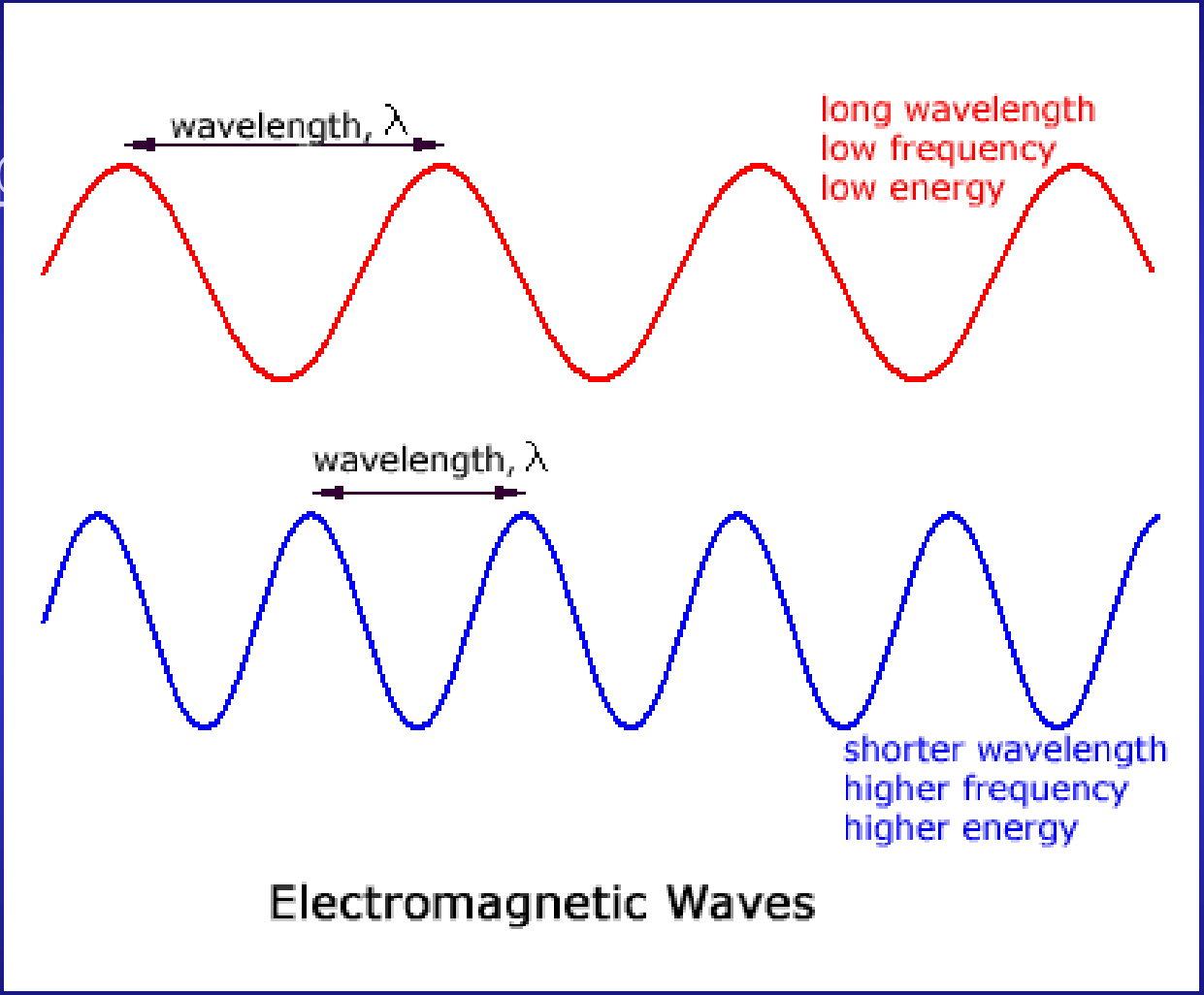
1 kilohertz (kHz) = 1,000 hertz

1 megahertz (MHz) = 1 million hertz

1 gigahertz (GHz) = 1 billion hertz

Source: New America Foundation, MCT, Howstuffworks.com
Graphic: Nathaniel Levine, Sacramento Bee

Comp


wavelength, λ
long wavelength
low frequency
low energy
wavelength, λ
shorter wavelength
higher frequency
higher energy
Electromagnetic Waves

Why Use Wireless?

- Bridge a distance
- Convenience
- Flexibility
- Temporary Deployments
- Bandwidth Backup
- Mobility

Types of Wireless

- Packet Radio (CB radio)
- Microwave
- Satellite
- GSM
- BlueTooth
- 802.11x (Wi-Fi)
- WiMax

Bits vs. Bytes

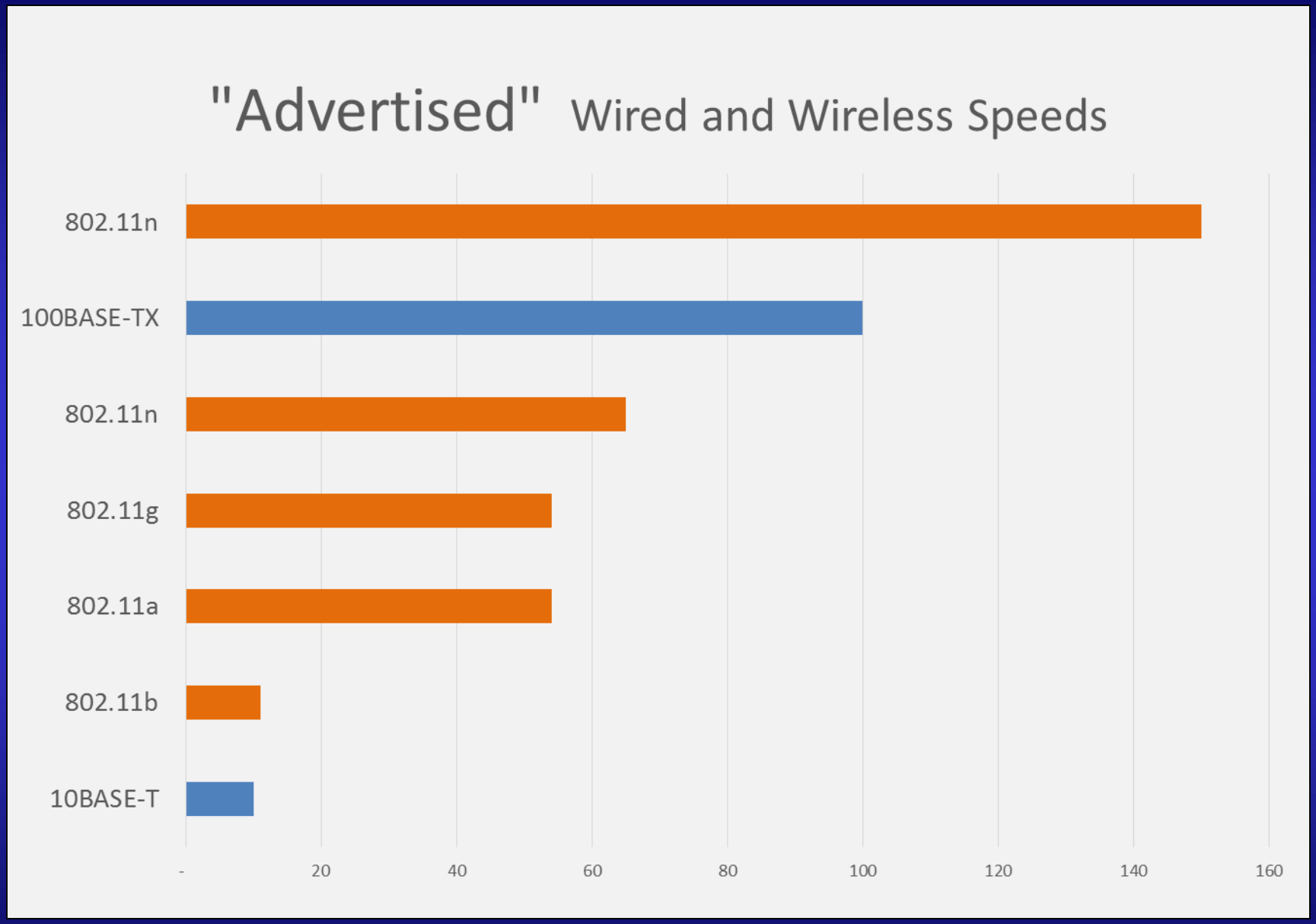
- Bits are the zeros and ones we pump from one device to another.
- We measure a pipe's bandwidth in bits.
- Bytes are a package of eight bits that are used to describe a symbol (number or letter) or a "chunk" of data.
- We store files in bytes.
- Bits / 8 = bytes
- Bytes x 8 = bits

Asymmetry

- More bit consumption versus bit spewing
- Web activity: tiny request → big response
- Satellites: uplink… downlink
- Networks: upload… download
- Why waste valuable spectrum / bandwidth?
- No need to pay to “reserve” capacity that may not be used.

U.S. Home Connections

	DSL Internet	Cable Internet	Fiber Optics
Download (Min)	768 Kbps	4 Mbps	10 Mbps
Download (Max)	7.1 Mbps	20 Mbps	50 Mbps
Upload (Min)	128 Kbps	384 Kbps	2 Mbps
Upload (Max)	768 Kbps	1.5 Mbps	20 Mbps
Connection	Copper	Copper	Fiber Optic
Monthly Price	$20 to $45	$40 to $55	$45 to $145

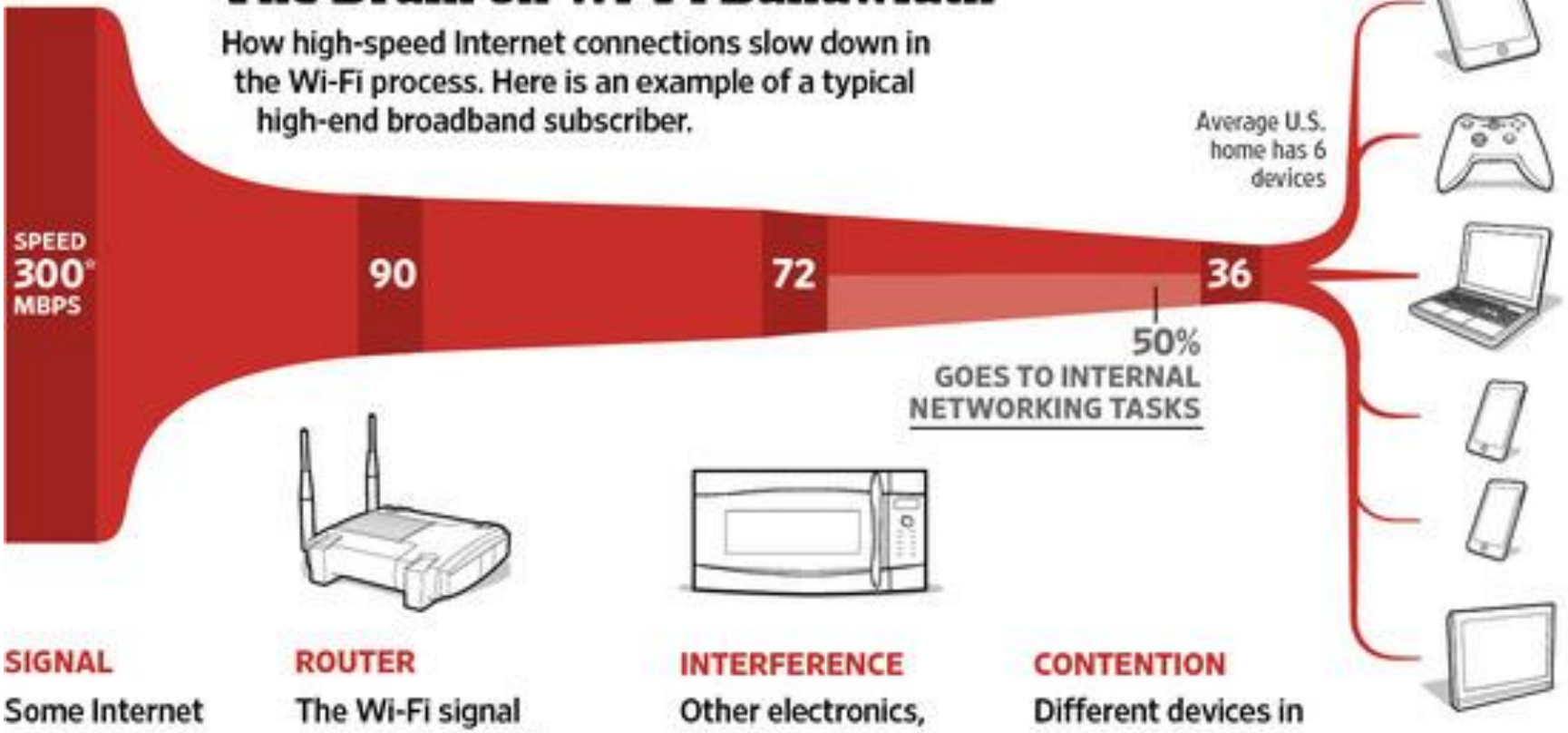


Note: gigabit wired networking is not represented here.

Wi-Fi Does Not Play Well With Others

The Drain on Wi-Fi Bandwidth

How high-speed Internet connections slow down in the Wi-Fi process. Here is an example of a typical high-end broadband subscriber.



SIGNAL

Some Internet service providers offer high-speed services of up to about 300 megabits per second, or mbps.

ROUTER

The Wi-Fi signal emanates from the router, but most routers in U.S. households can only handle between 54 and 90 mbps, cutting down the speed.

INTERFERENCE

Other electronics, like microwaves or neighbors' routers, interfere with Wi-Fi signal. Also, the greater the distance from the router, the weaker the signal gets.

CONTENTION

Different devices in the house fight for the Wi-Fi signal. The make of each device also factors into how much each ends up getting.

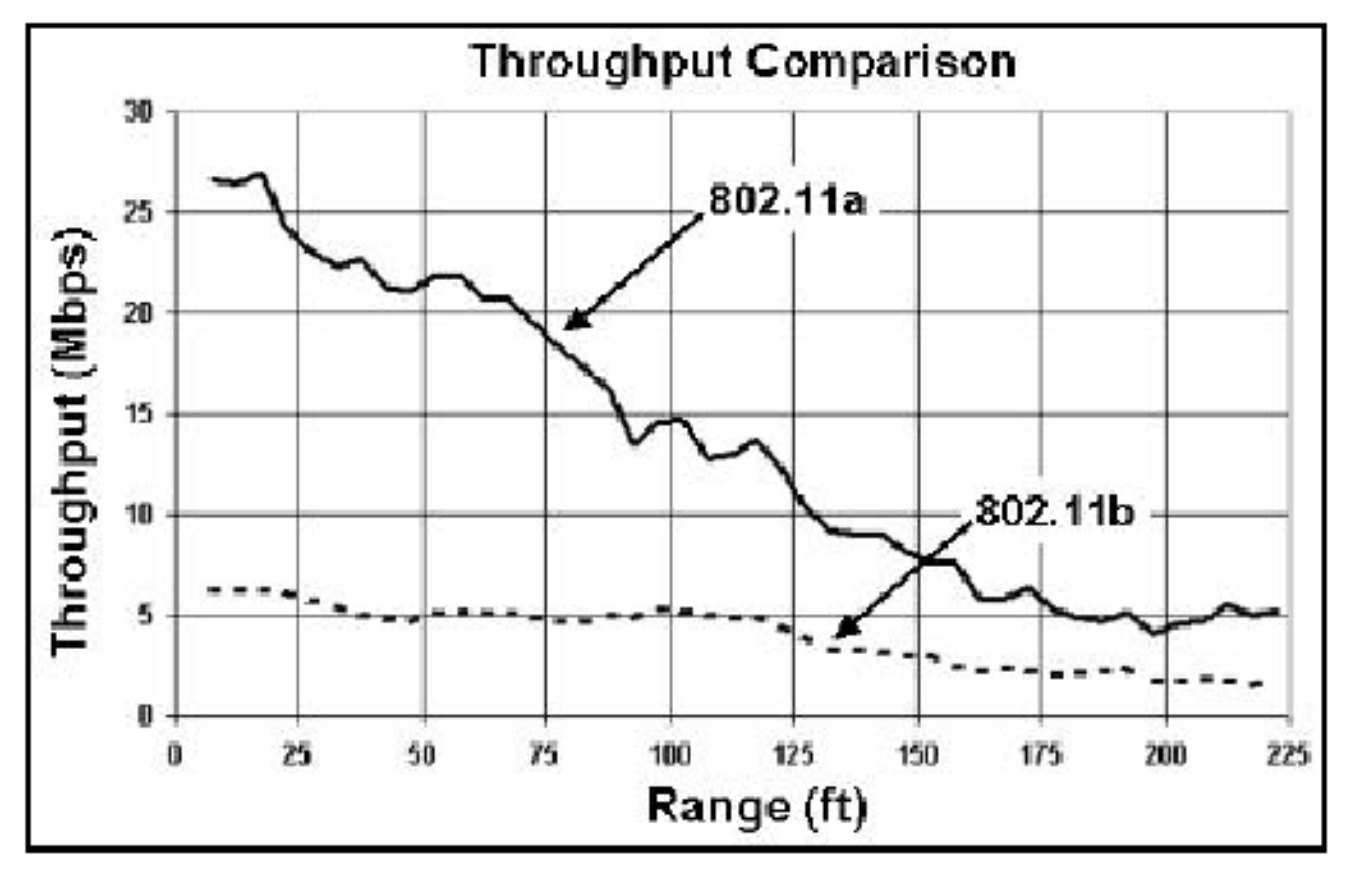
Source: WSJ research

*Maximum wired speed offered by Verizon FiOS

Graphic by Alberto Cervantes/ The Wall Street Journal

Trading Distance for Speed

803.11b 30m = 11mbit 100m = 5.5mbit



Optimizing Speed

- Line of sight provides the best throughput
- Obstacles (like walls and trees)
- Interference from other radio sources
- The shape of the environment
- Location of the antennas
- Need to experiment

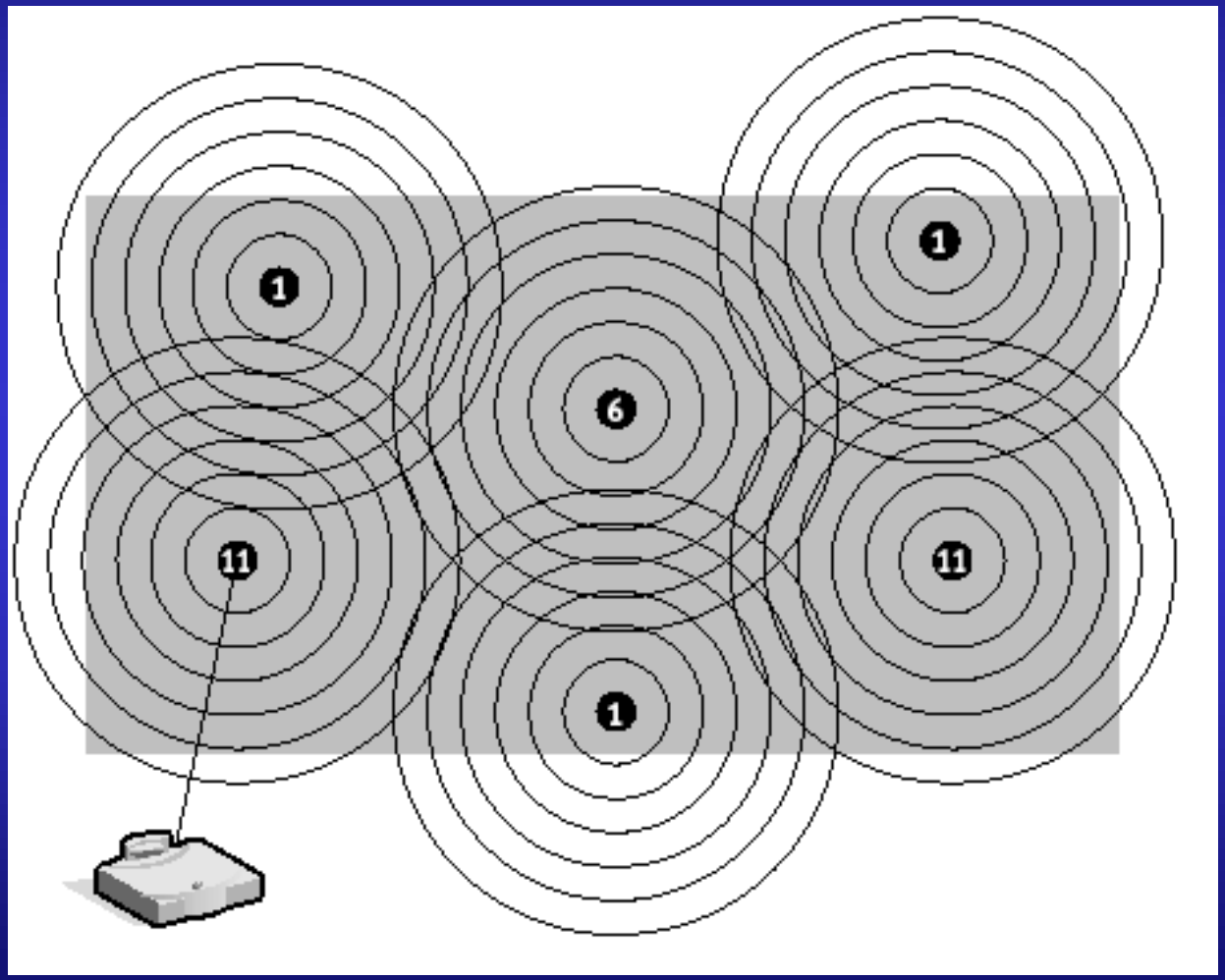
Security Concerns

- Broadcasting to the world
- Bandwidth bandits
- MAC level security has serious limitations
- Wired Equivalent Privacy (WEP) hackable
- VPNs and other encryption schemes reduce bandwidth
- Legitimate users need add'l support & training
- How much security can you afford?

LAN Access Points

- Need to balance the number of AP for clients
- Most APs claim to support dozens if not hundreds of wireless connections
- Practical limit is 20-25 clients
- 2-4 users per AP maximizes the performance
- APs can overlap, but not on the same channel
- Lowering the signal strength of the AP reduces its coverage area, allowing more APs to fit in a specific space

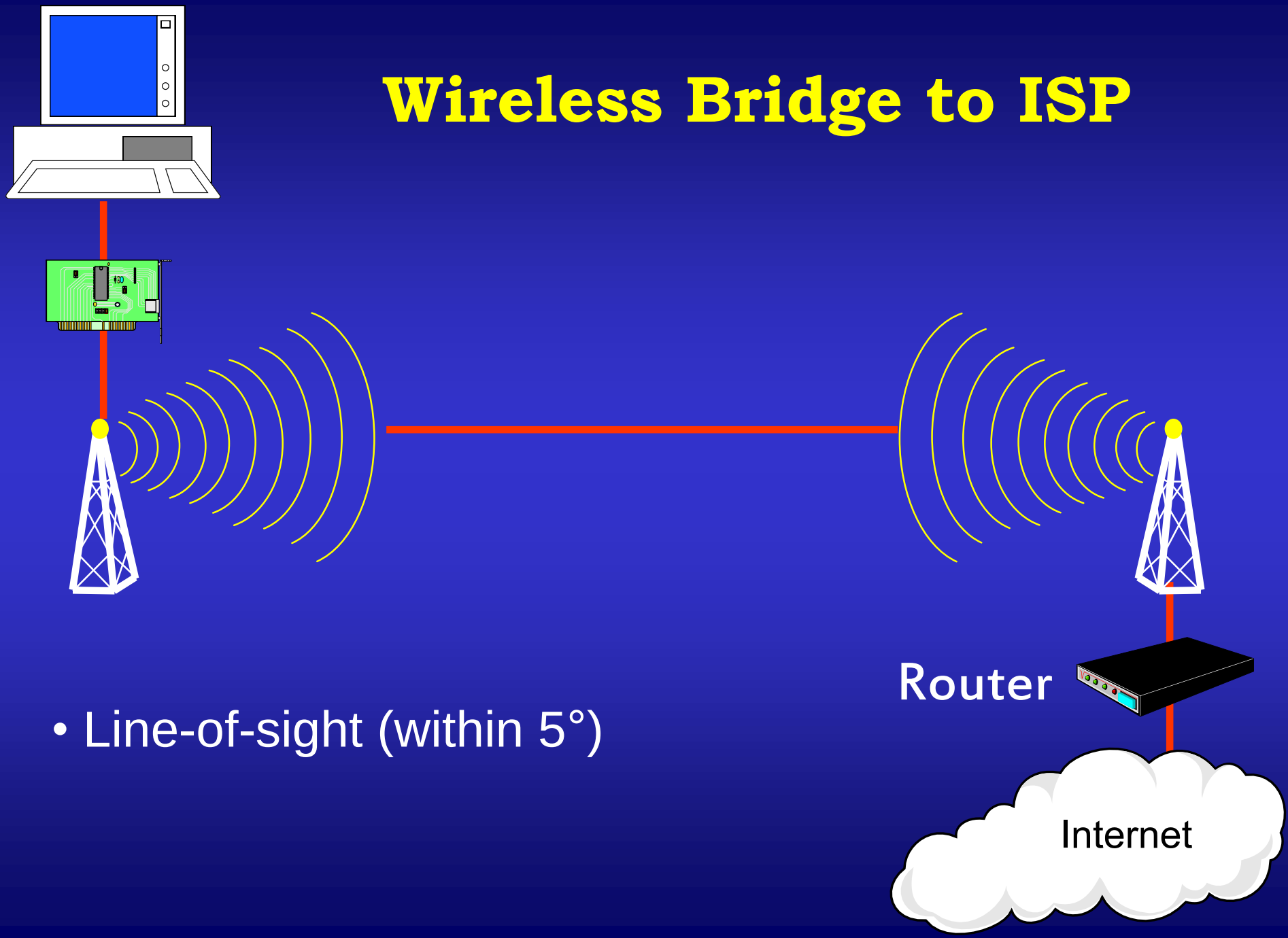
LAN Access Points



Wireless Wide Area Networks

- Fiber substitute / precursor
- Emergency or temporary installations
- Links that are difficult or too expensive to hardwire
- GSM (cell phone) data services
- More options than off-the-shelf Wi-Fi
- No comparison on bandwidth

Wireless Bridge to ISP

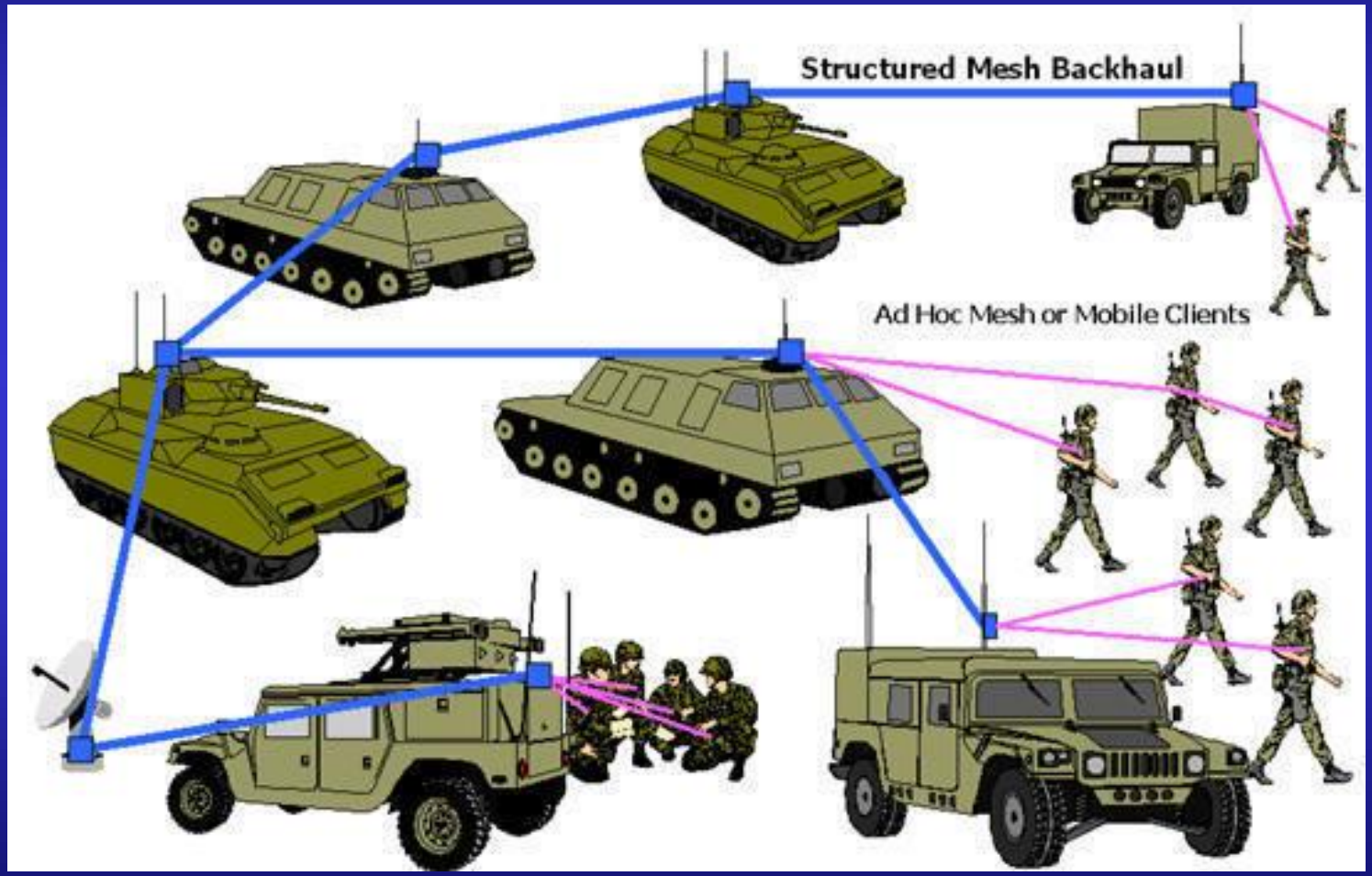


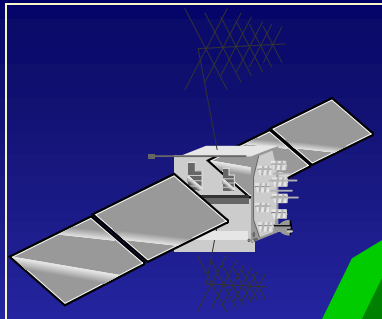
- Line-of-sight (within 5°)

Radio Antennas

- Extremely critical
- Omnidirectional
- Unidirectional
- Sectoral
- Tin can antennas

Mesh Networking





Wireless Networking