

# Home Infotainment Networking

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# Agenda

Home Infotainment Networking Overview

Home Infotainment Networking Requirements

Home Infotainment Networking Wireless Solutions

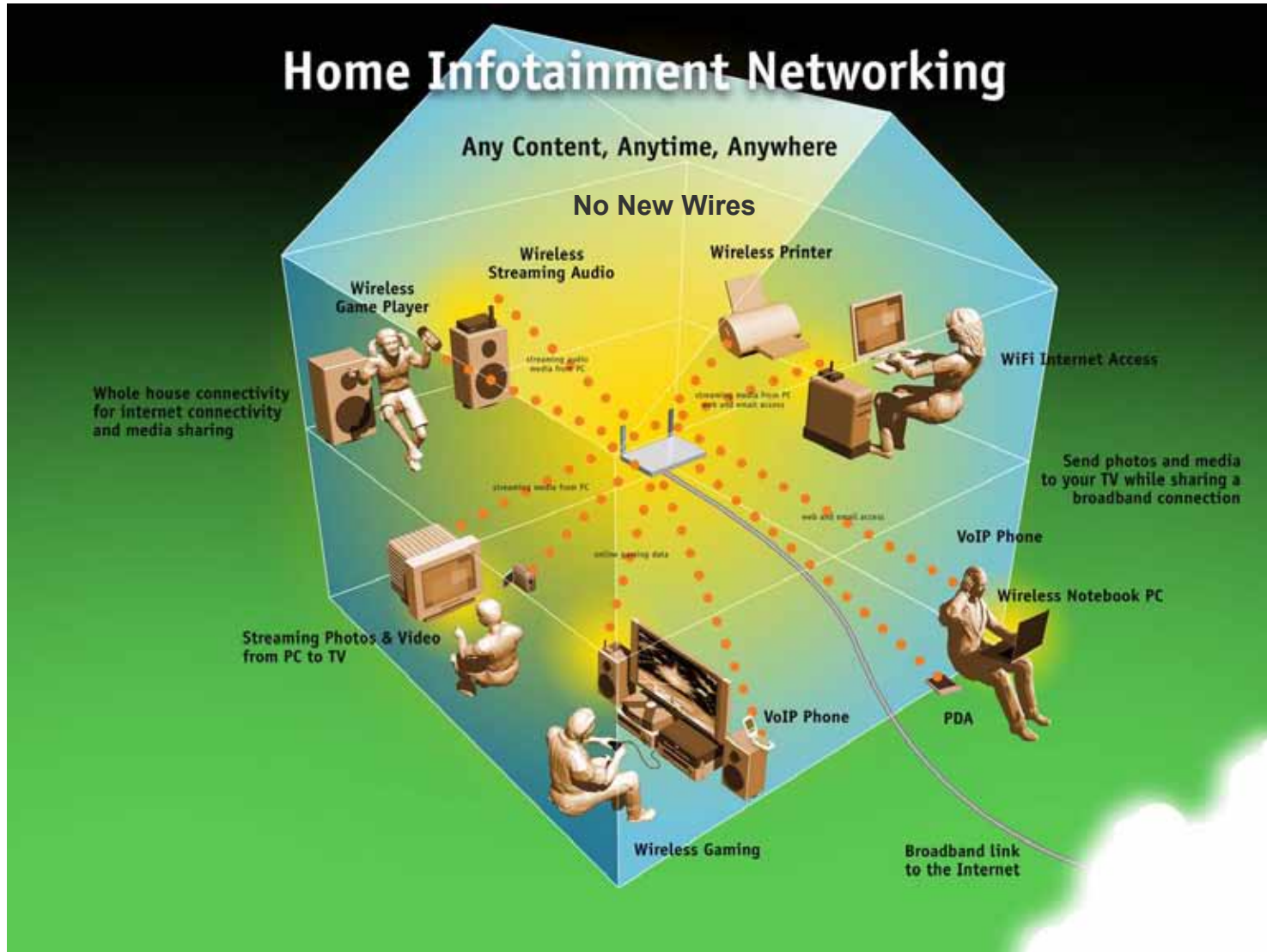
Summary

Q&A

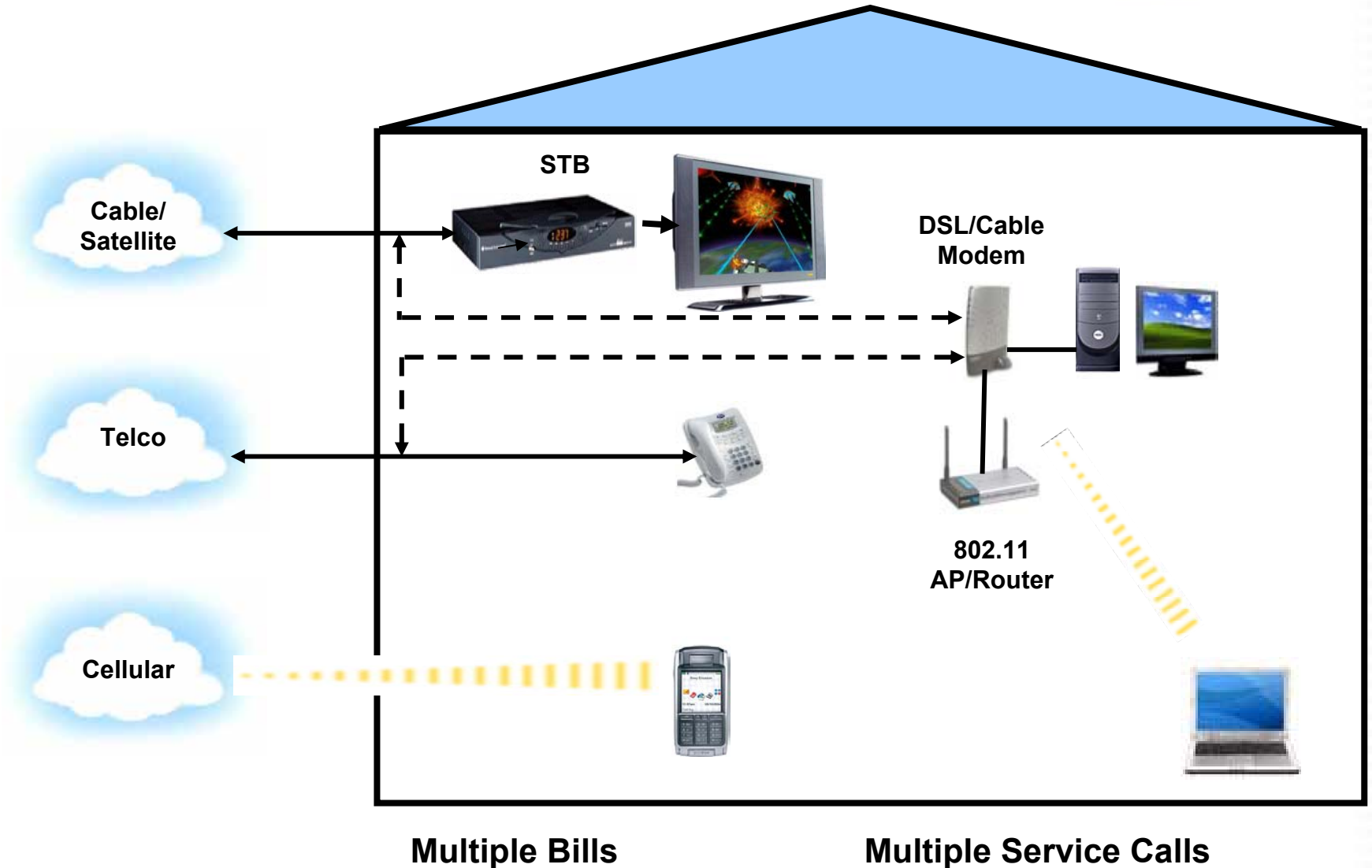
# Home Infotainment Networking Overview



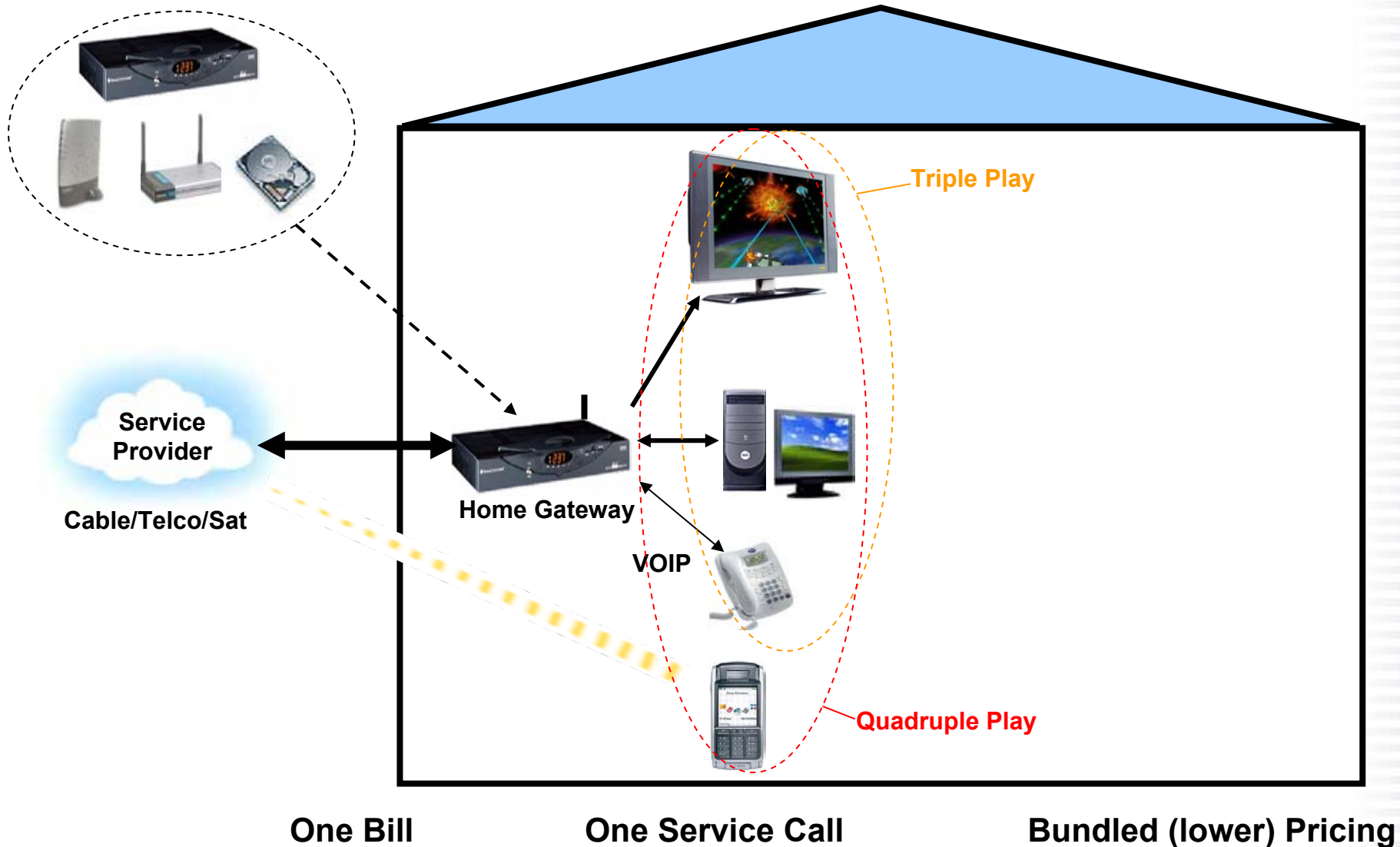
# Home Infotainment Networking Ideal



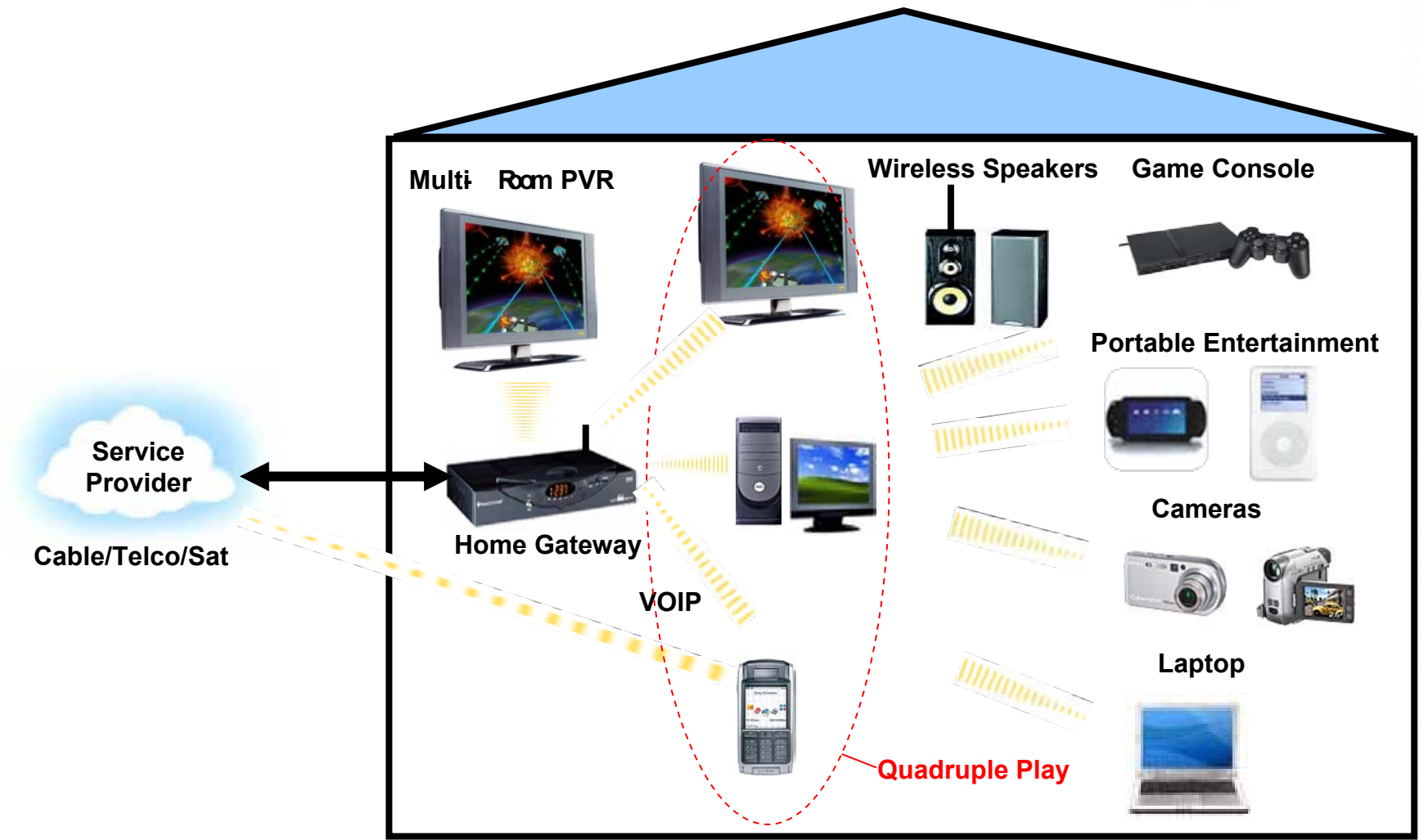
# Consumer Home Services Today



# Consumer Home Services Tomorrow



# Quadruple Play+ (“Killer Apps”)



# Market Trends & Drivers

## Service Providers (PUSH)

- New services, higher ARPU, reduce churn (switching barriers)
- Quadruple Play + Home Network (install & lease to consumer)
- Infrastructure investments for Triple/Quad Play
- SP statements of intent (press, financial reports)

## Consumer Demand (PULL)

- VOIP demand
- Bundled services
- Multi-room DVR – 70% of PVR owners want capability on every TV in home (Parks/IDC/Gartner)

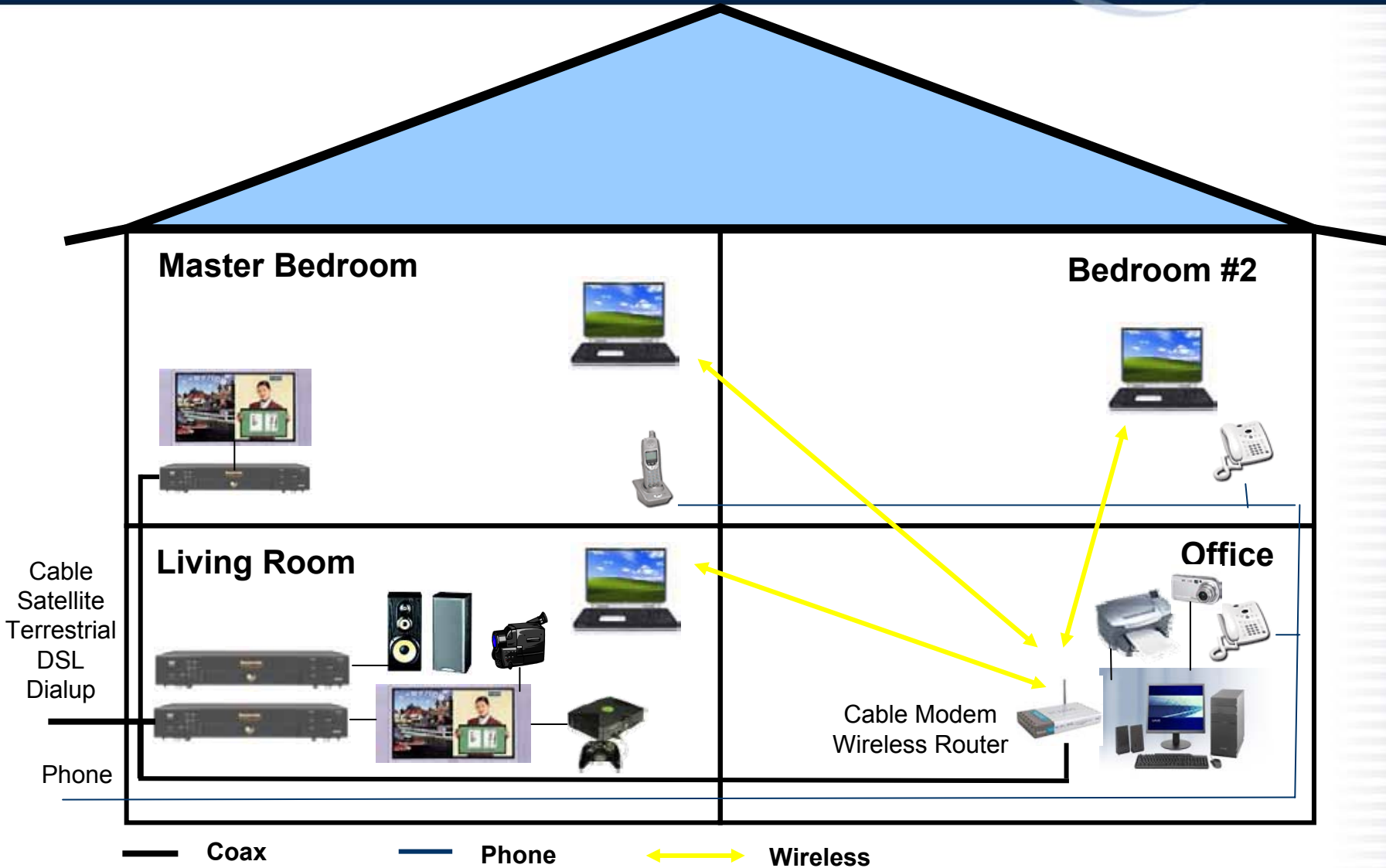


## Service Providers Will Push Home Networks

“... global home network adoption is expected to grow from 35 million in 2004 to more than 162 million in 2010. This growth will be fueled in large part by broadband service providers who are beginning to push combined modem/networking solutions known as residential gateways ...”

“...broadband service providers are now looking ‘beyond the modem’ for new sources of revenue, and home networks are a key part of their strategy to dominate emerging digital home control points and locking revenue and profits.”

# Home Network Configuration – Data



# Home Infotainment Network Configuration

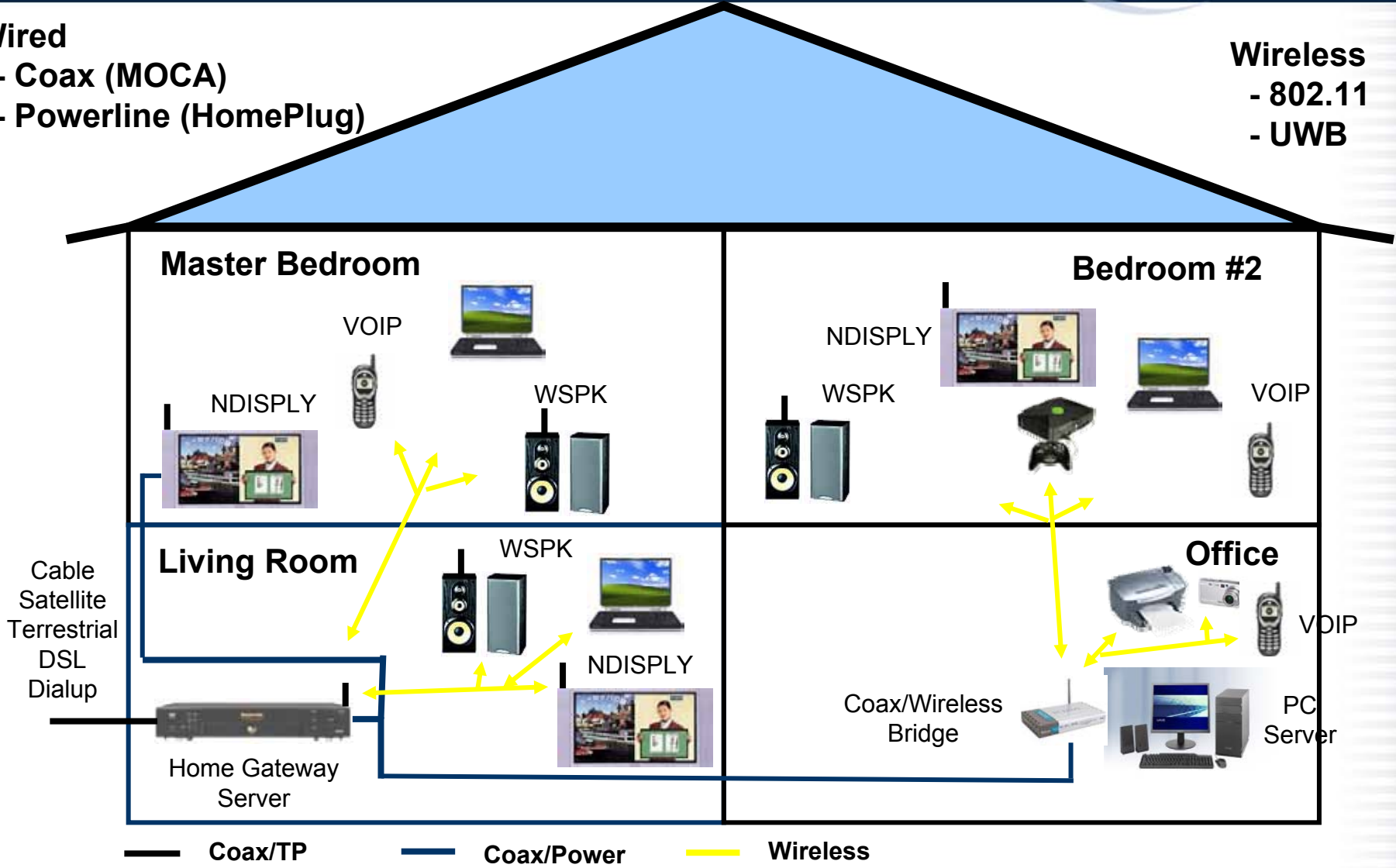
## – Hybrid, No New Wires

### Wired

- Coax (MOCA)
- Powerline (HomePlug)

### Wireless

- 802.11
- UWB





# Home Infotainment Networking Requirements



# Home Infotainment Networking Requirements

## Reliable throughput

- Up to 30Mbps now, 200Mbps+ in future
- QOS

## Range

- Whole-home coverage, through walls, floors

## Content protection

- Content owners must approve CP techniques
- Cost, consumer convenience

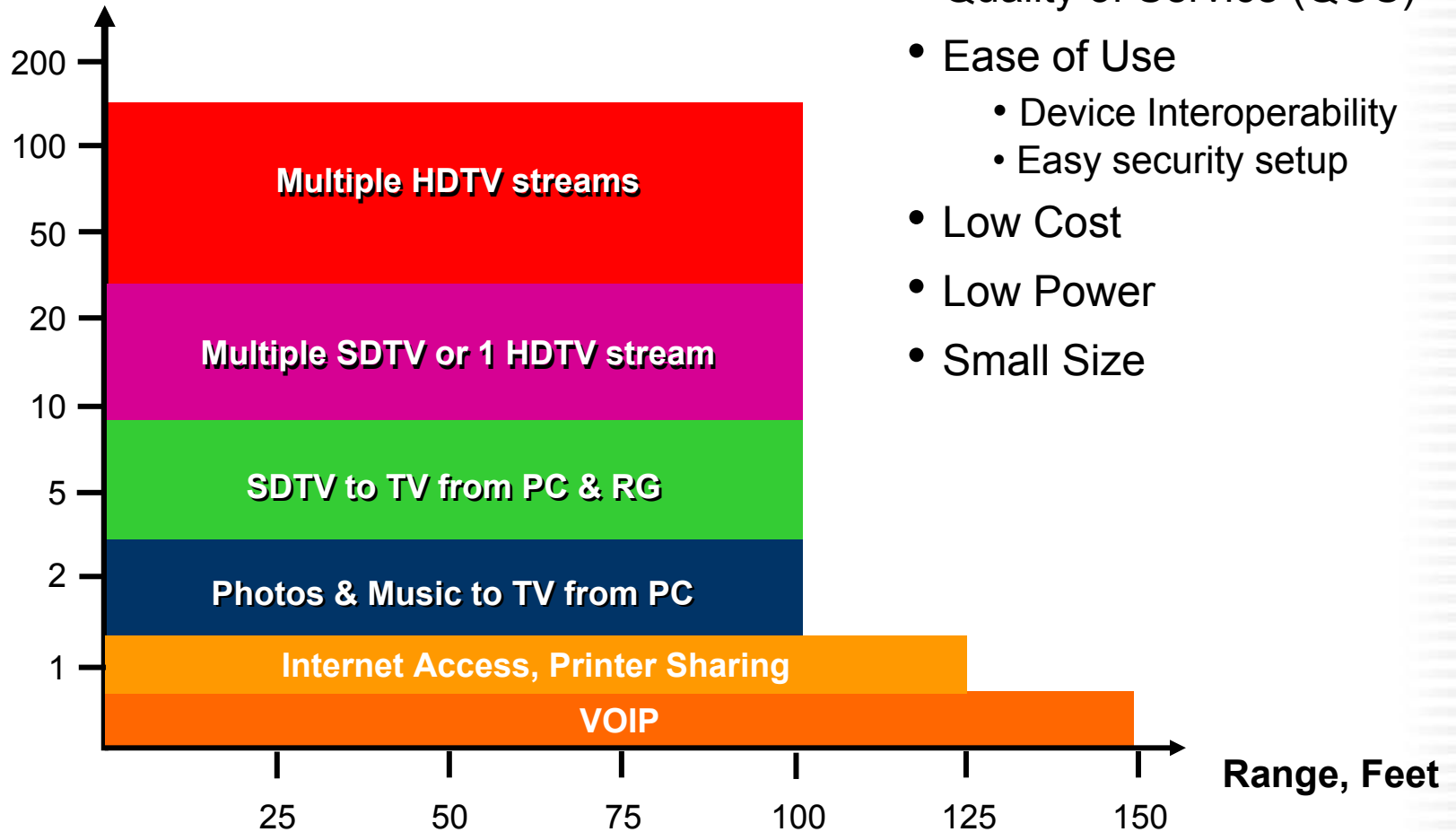
## Ease-of-Use

- Device interoperability standards, e.g. DLNA
- Easy security setup

## Affordable Cost

# 802.11 Home Infotainment Networking Requirements

Throughput, Mbps

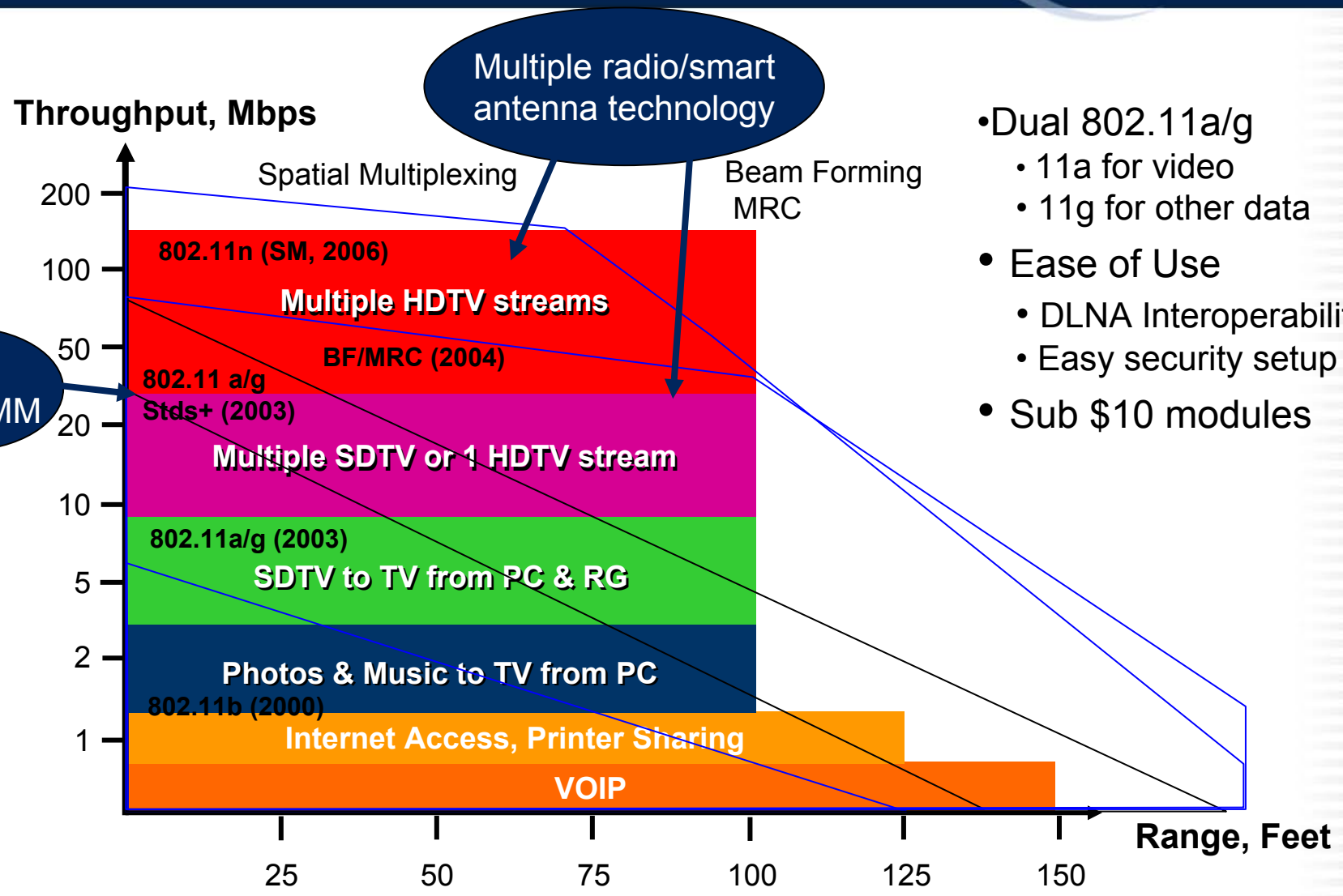


- Quality of Service (QOS)
- Ease of Use
  - Device Interoperability
  - Easy security setup
- Low Cost
- Low Power
- Small Size

# Home Infotainment Networking Wireless Solutions



# 802.11 Home Entertainment Networking Solutions



- Dual 802.11a/g
  - 11a for video
  - 11g for other data
- Ease of Use
  - DLNA Interoperability
  - Easy security setup
- Sub \$10 modules



# Dual-Band Advantage

Or 27?

**Data**

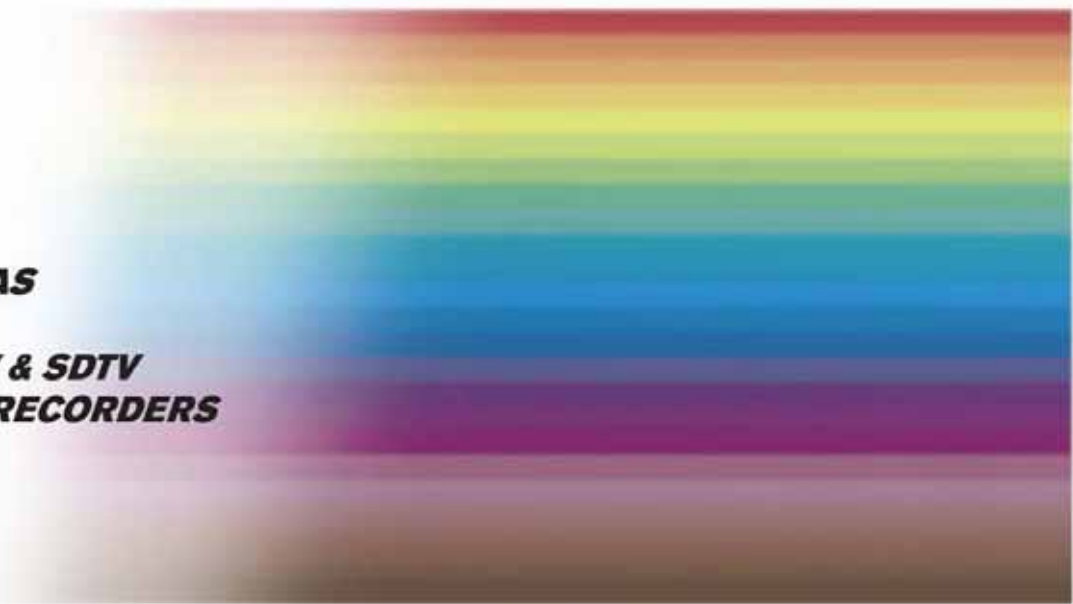
**PCs  
ROUTERS  
NICs  
PRINTERS**

**CE**

**DIGITAL CAMERAS  
DIGITAL VIDEO  
STREAMING HDTV & SDTV  
PERSONAL VIDEO RECORDERS**

**VoIP**

**VoIP/ LANDLINE  
VoIP/ CELLULAR**



# 802.11 Use of Spectrum

## 100s of Millions Interfering Sources

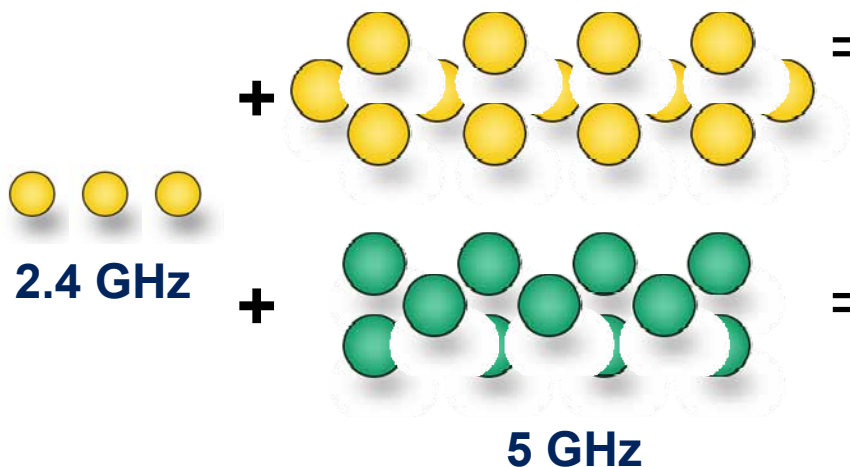
microwaves, cordless phones,  
baby monitors, Bluetooth, GPS

**802.11b/g products – 11 to 54mb+ throughput**



**= 3 usable channels only**  
from 2.400-2.483 GHz

**802.11a/b/g products – 54mb+ throughput**



**= 16 usable channels in 2002**  
add 5.150-5.350, 5.725-5.850 GHz

**= 27 channels**  
**with new FCC rules in Nov 2003**  
add 5.470-5.725 GHz

**<10 million interferers**

# WLAN Congestion at 2.4 GHZ

Huge success of 802.11 leads to congestion in the 2.4 GHz band

MAC	SSID	Name	Chan	Type	Vendor	Type	Enc.	SNR	Signal	Noise	SNR+	IP Addr	Subnet	Latitude	Longitude
000F3D41FD8F	Apple/Wireless		3												
0004E21872ED	CLUBQUARTERS		11	11 Mbps	SMC	AP	WEP	15	60	100	12				
A24E802AE079	Wireless Network		10	11 Mbps	Elm-e-l	Peer		17	43	100	17				
0040965740B7			2	11 Mbps	Cisco	AP	WEP	35	65	100	35				
0002F028941	software		1	11 Mbps	Senao Int	AP		23	77	100	23				
0002F028941	Public_WiFi_Headset		1	11 Mbps	Senao Int	AP		30	70	100	30				
0002F028941	software		8	11 Mbps	Senao Int	AP		15	65	100	15				
0040965740B7			2	11 Mbps	Cisco	AP	WEP	23	77	100	23				
00036A0297CA	Comcast/Internet		7	11 Mbps	Delta [N]	AP		11	69	100	11				
000E362896D	inoble		8	11 Mbps	Cisco	AP		12	69	100	12				
000C950A3F9	incoln		6	11 Mbps	Cisco	AP	WEP	14	66	100	14				
000C4184ACE4	linksys		6	11 Mbps	Linksys	AP		13	61	100	13				
020CF1AE09D	linksys		10	11 Mbps	Elm-e-l	Peer		13	67	100	13				
000E2556262	ararat		11	11 Mbps	Linksys	AP	WEP	18	62	100	18				
000E2548F15	ararat		6	11 Mbps	Linksys	AP	WEP	7	93	100	7				
000F50A4566	arabep		6	11 Mbps	Linksys	AP	WEP	12	88	100	12				
0040F898F5A	1D1		6	11 Mbps	Symbol	AP		13	67	100	13				
000C418A645E	linksys2eth		6	11 Mbps	Linksys	AP		13	67	100	13				
020CF100FE25	empowerless		10	11 Mbps	Elm-e-l	Peer		12	68	100	12				
000294E4D07	Wapnet_Access		2	11 Mbps	Artek	AP		10	90	100	10				
000BACE700B	15h Floor BLDG WIF		11	11 Mbps	3Com E..	AP		15	95	100	15				
0000E03205A3			11	11 Mbps	Cisco	AP	WEP	8	91	100	8				
020423D486D1	NETGEAR		11	11 Mbps	Intel	AP		7	93	100	7				
0002F028941	software		1	11 Mbps	Senao Int	AP		24	52	100	24				
0000E018BF0E	inoble		1	11 Mbps	Cisco	AP		18	61	100	18				
0002208D17AC	Verizon Wi-Fi		4	11 Mbps	Proxim [..	AP		11	64	100	11				
0002F028941	software		1	11 Mbps	Senao Int	AP		13	61	100	13				
00095B3A375	WBN/WF01		11	11 Mbps	Netgear	AP	WEP	63	100	100	63				
004096482988			6	11 Mbps	Cisco	AP	WEP	43	100	100	43				
000E2567973	EPS		6	11 Mbps	Linksys	AP	WEP	18	78	100	18				
020423FC175D	Touchcom INC		6	11 Mbps	Intel	Peer		65	100	100	65				
004096055237			6	11 Mbps	Cisco	AP		77	100	100	77				
000E29445F18			1	11 Mbps	Cisco	AP	WEP	65	100	100	65				
0040965806EA			1	11 Mbps	Cisco	AP	WEP	66	100	100	66				
000082C753F	cc917		6	11 Mbps	D-Link	AP	WEP	61	100	100	61				
00030E3142D	Romann		1	11 Mbps	Apple	AP	WEP	62	100	100	62				
0002F028941	software		1	11 Mbps	Senao Int	AP		62	100	100	62				
0002208D5C8C	Verizon Wi-Fi		2	11 Mbps	Proxim [..	AP		15	77	100	15				
004096599A99			6	11 Mbps	Cisco	AP	WEP	94	100	100	94				
000E25A48192	ibeyond		6	11 Mbps	Linksys	AP		61	100	100	61				
0011332A3250			2	11 Mbps	Intel	AP		62	100	100	62				
0000B3C33765	Guest Internet Access		1	11 Mbps	Z-Cor	AP		63	100	100	63				
00409630008C	mytelnet		6	11 Mbps	Cisco	AP	WEP	65	100	100	65				
8E3105A3A6A	G		11	11 Mbps	Elm-e-l	Peer	WEP	64	100	100	64				
0004E2187ED3	WLAN		11	11 Mbps	SMC	AP		68	100	100	68				
AEF5C5A6078	DTVector		11	11 Mbps	Elm-e-l	Peer		66	100	100	66				
0004E2187E85	TCHD/WLAN		11	11 Mbps	SMC	AP		66	100	100	66				
000E25A48192	Emboly Hotel		6	11 Mbps	Z-Cor	AP		60	100	100	60				
020CF100E04B	cc		11	11 Mbps	Elm-e-l	Peer		61	100	100	61				
00022075296A	Any		2	11 Mbps	Proxim [..	AP		64	100	100	64				
00006572C252	WiFi		6	11 Mbps	Cisco	AP	WEP	66	100	100	66				

Real World Example:  
45<sup>th</sup> and Avenue of the  
Americas – NYC

50 APs sharing 3 channels = low performance!

# QOS – 802.11e/WMM MAC Enhancements

Wireless networking technologies with high throughput and range are not enough to deliver good consumer AV products.

Consumer expectations need QoS:

- Ability to prioritize traffic
- Deliver voice calls without delay
- Clear and continuous video streaming

IEEE 802.11e/WMM QoS standards help deliver these requirements

# 802.11e QoS

Enhancements to MAC layer which extend the legacy CSMA/CA-based “equal priority, best effort” DCF mechanism with new channel access mechanisms

- Enhanced Distributed Channel Access (EDCA)  
<prioritized channel access>
- HCF Controlled Channel Access (HCCA)  
<parameterized, slot reservation channel access>  
<also called Scheduled Access>

Protocol efficiency improvements

802.11e is a toolkit allowing many optional capabilities, which may not be implemented in all products

# WMM

WMM is **Wi-Fi MultiMedia**, the WiFi Alliance's version of 11e, based on a subset (profile) of the IEEE 802.11e WLAN QoS draft standard.

Features that improve the user experience for audio, video and voice applications over a Wi-Fi® network.

## Wi-Fi CERTIFIED™ for WMM™

- Optional for Wi-Fi products, but products that offer QoS are required to be Wi-Fi CERTIFIED™ for WMM™
- Available Sep 2004

WMM uses EDCA to prioritize traffic demands from different applications into four access categories – voice, video, best effort, background

# Confusion Over QoS

## Wi Fi Alliance Terminology

- **Wireless Multimedia Enhancements (WME)**
  - Pre-11e spec, EDCA + protocol efficiency, defunct
- **Wi Fi Scheduled Media (WSM)**
  - WME + HCCA, defunct
- **Wi Fi Multimedia Extensions (WMX)**
  - Terminology replaced WME, WSM temporarily until WMM
  - EDCA is baseline, everything else is optional
- **Wi Fi MultiMedia (WMM)**
  - Current terminology

## There is no more WME or WSM

- Until 11e ratification, there is only one QoS standard today – WMM (Wi-Fi MultiMedia)
- 11e Scheduled Access(SA) option is the closest thing to WSM
- All WMM-SA products must fall back to and support WMM

# Enhanced Distributed Channel Access (EDCA)

Prioritized QoS, contention-based channel access mechanism

Differentiated service traffic classes - 802.1D Traffic Classes (8) mapped to 4 Access Categories (voice, video, best effort, background)

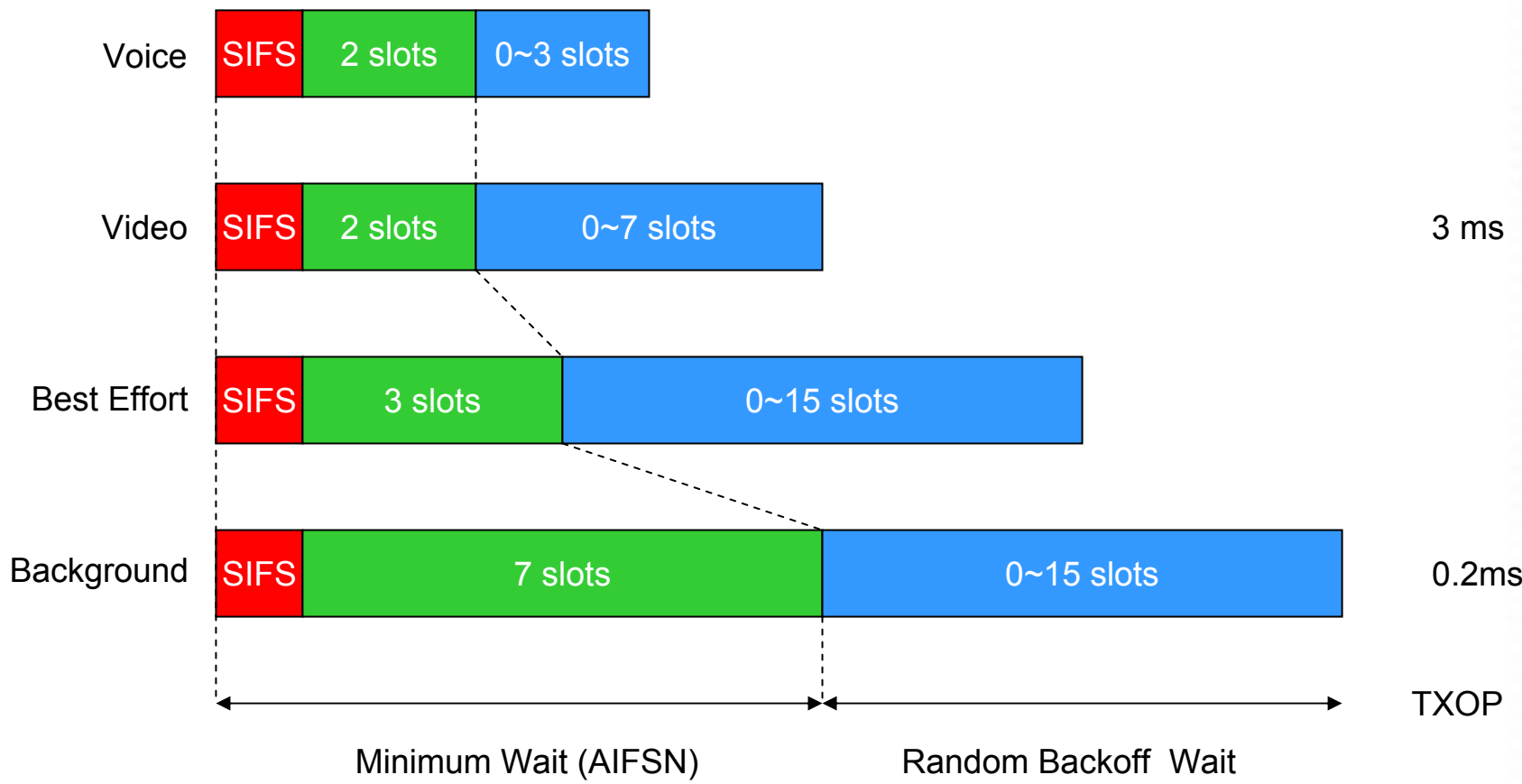
Traffic classes assigned to different data queues, with each queue assigned a priority based on:

- Arbitration Inter Frame Spacing (AIFS) - queues with shorter AIFS times get access before those with longer AIFS
- Contention Window (CWmin, CWmax)
- Transmission Opportunity (TXOP) length

Admission control protects high-priority traffic from low-priority traffic via TSPEC



# EDCA (WMM) Details



# HCF Controlled Channel Access (HCCA)

Parameterized QoS, controlled channel access mechanism

Centralized coordinator schedules & manages bandwidth by polling stations for TXOP requests & reserving TXOPs based on all station requests

Admission control based on Transmission Specification (TSPEC) & available bandwidth

# Protocol Efficiency Improvements

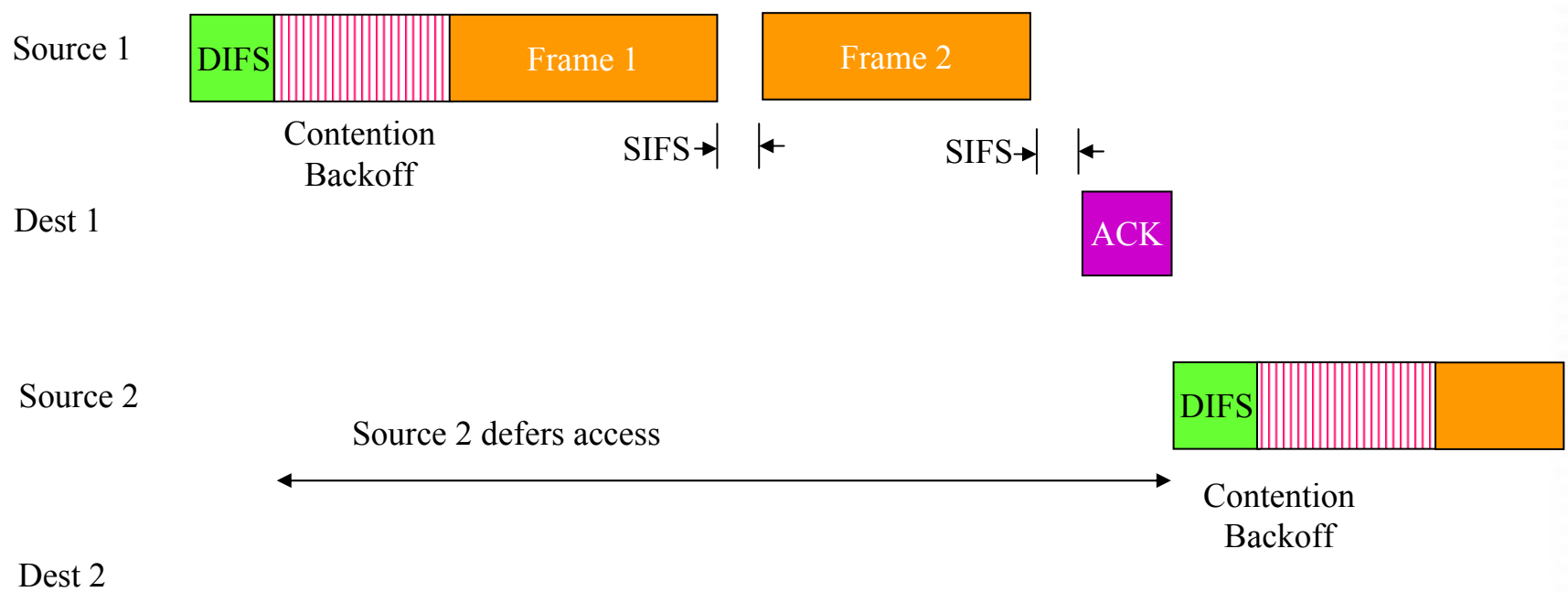
Block Acknowledge

Frame Bursting

Fast Frames

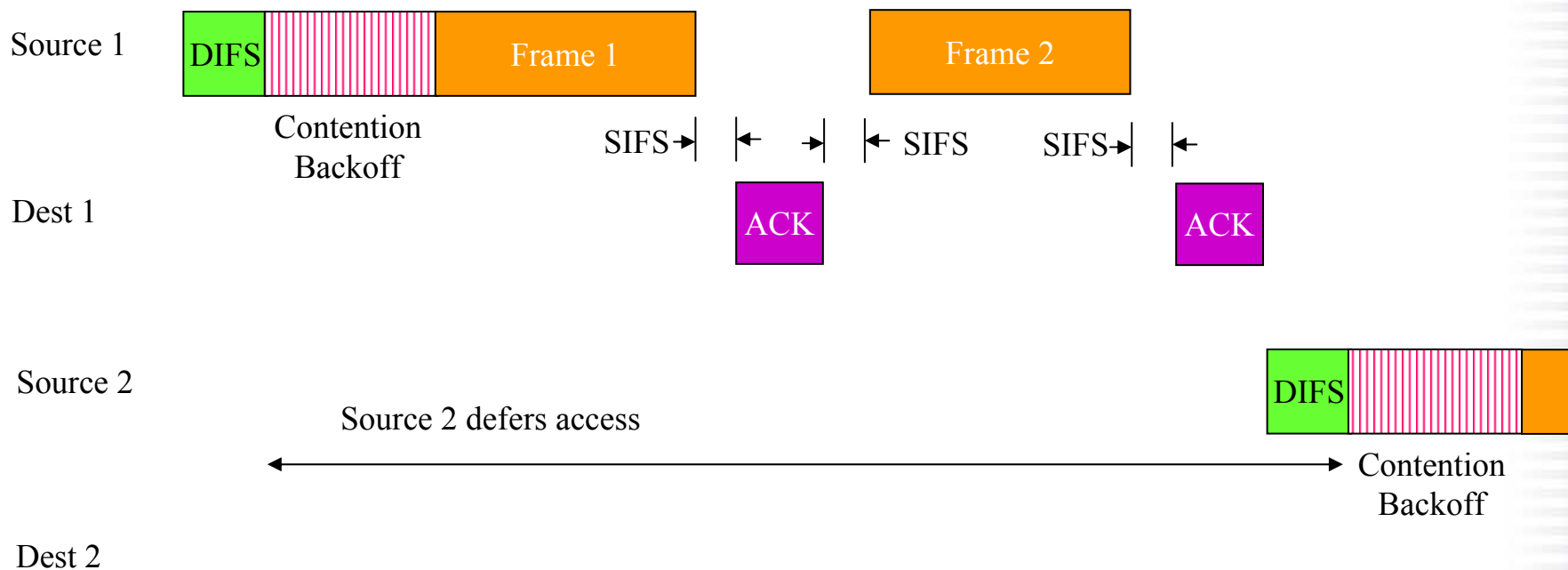
# Block Acknowledge

- Source 1 sends multiple frames separated by SIFS, followed by 1 ACK
- Source 2 waits the normal DIFS interval, and is pre-empted by Source 1



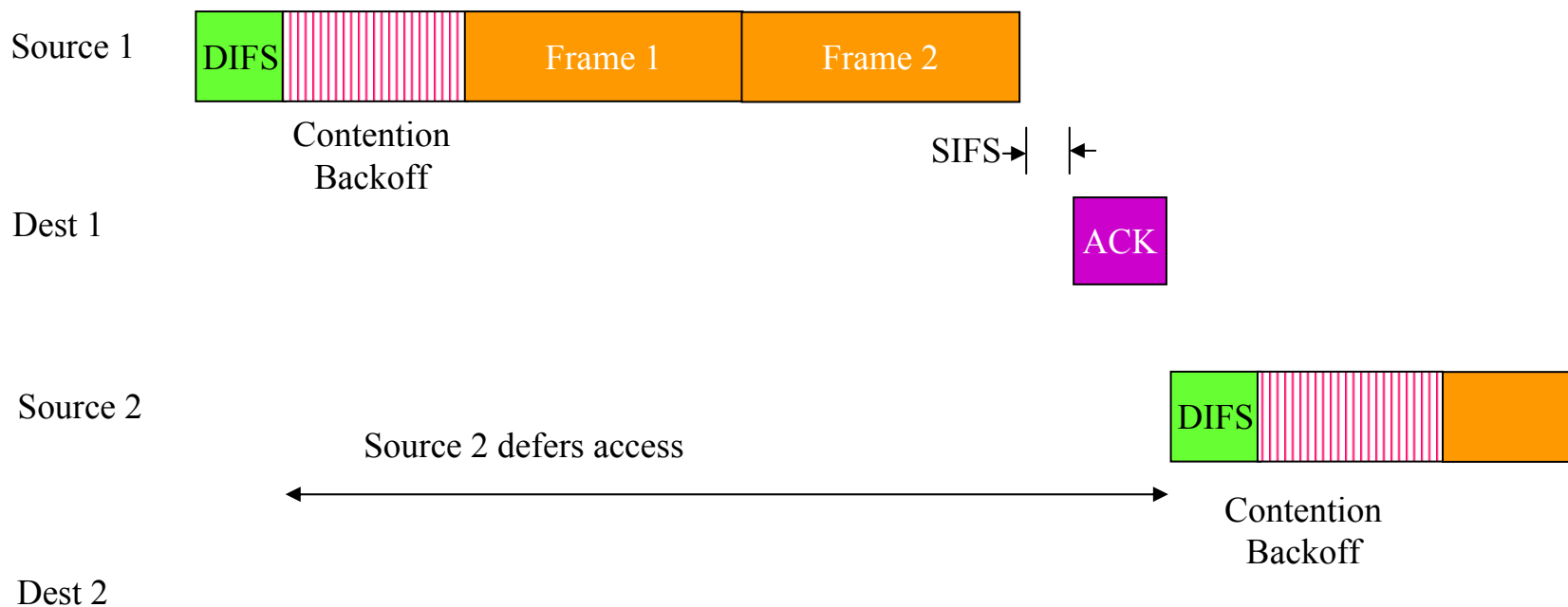
# Frame Bursting

- Source 1 waits a shorter SIFS interval before sending successive frames
- Source 2 waits the normal DIFS interval, and is pre-empted by Source 1



# Fast Frames

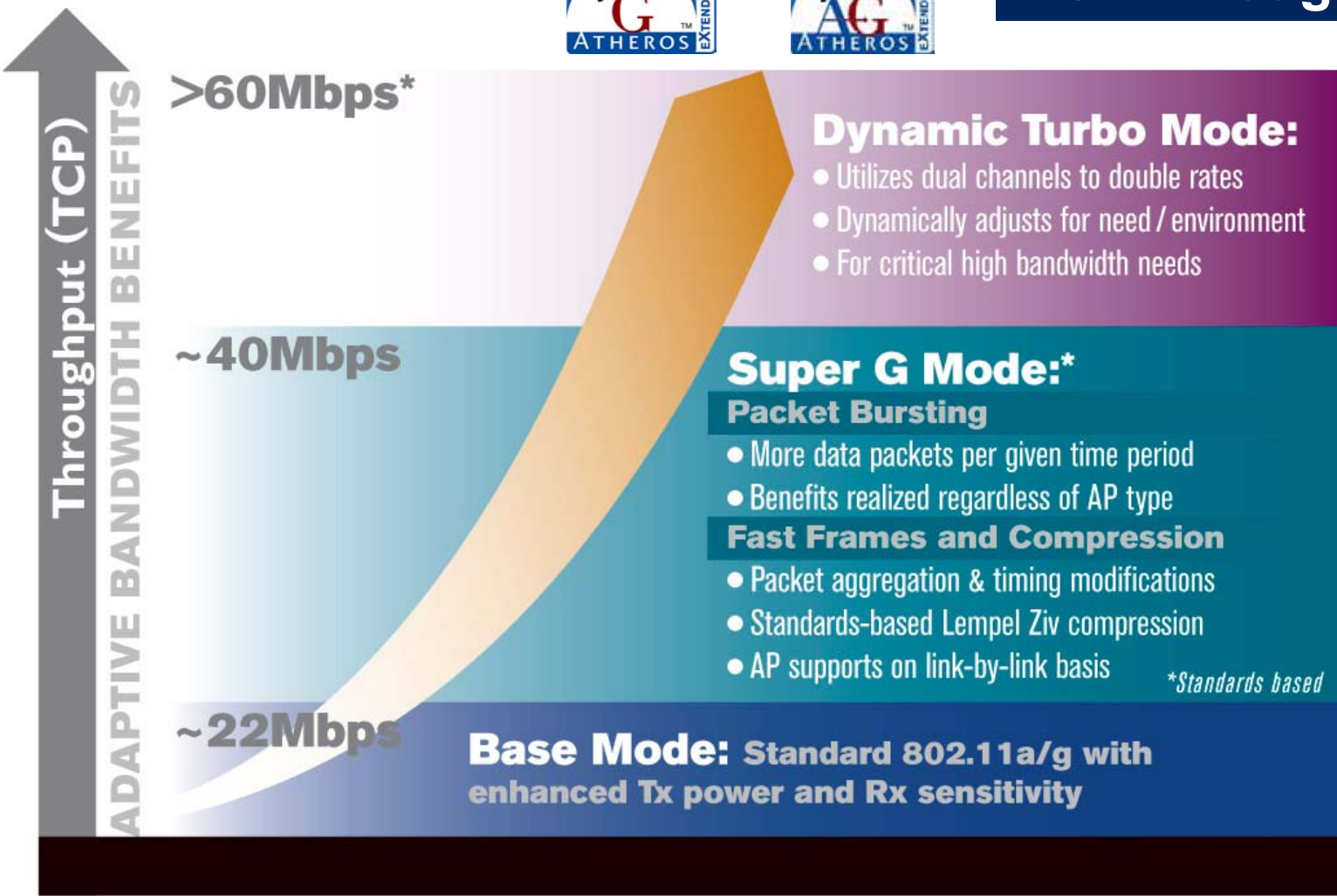
- Source 1 sends multiple frames (or 1 larger frame), followed by 1 ACK
- Source 2 waits the normal DIFS interval, and is pre-empted by Source 1



# Performance: Super G / Super AG



**2-3x Throughput**



# Multiple Radio/Smart Antenna Technologies

## Beamforming (BF) & Maximal Ratio Combining (MRC)

- Increases distance at a link rate (whole-house HDTV coverage)
- Available now at low cost

## Spatial Multiplexing (SM)

- Increases throughput (many HDTV streams)
- Multiple HDTV streams

## 802.11n

- Includes BF, MRC, SM & other technologies
- 300Mbps+ throughput
- Standard expected 2007



# Multiple Radio Technologies

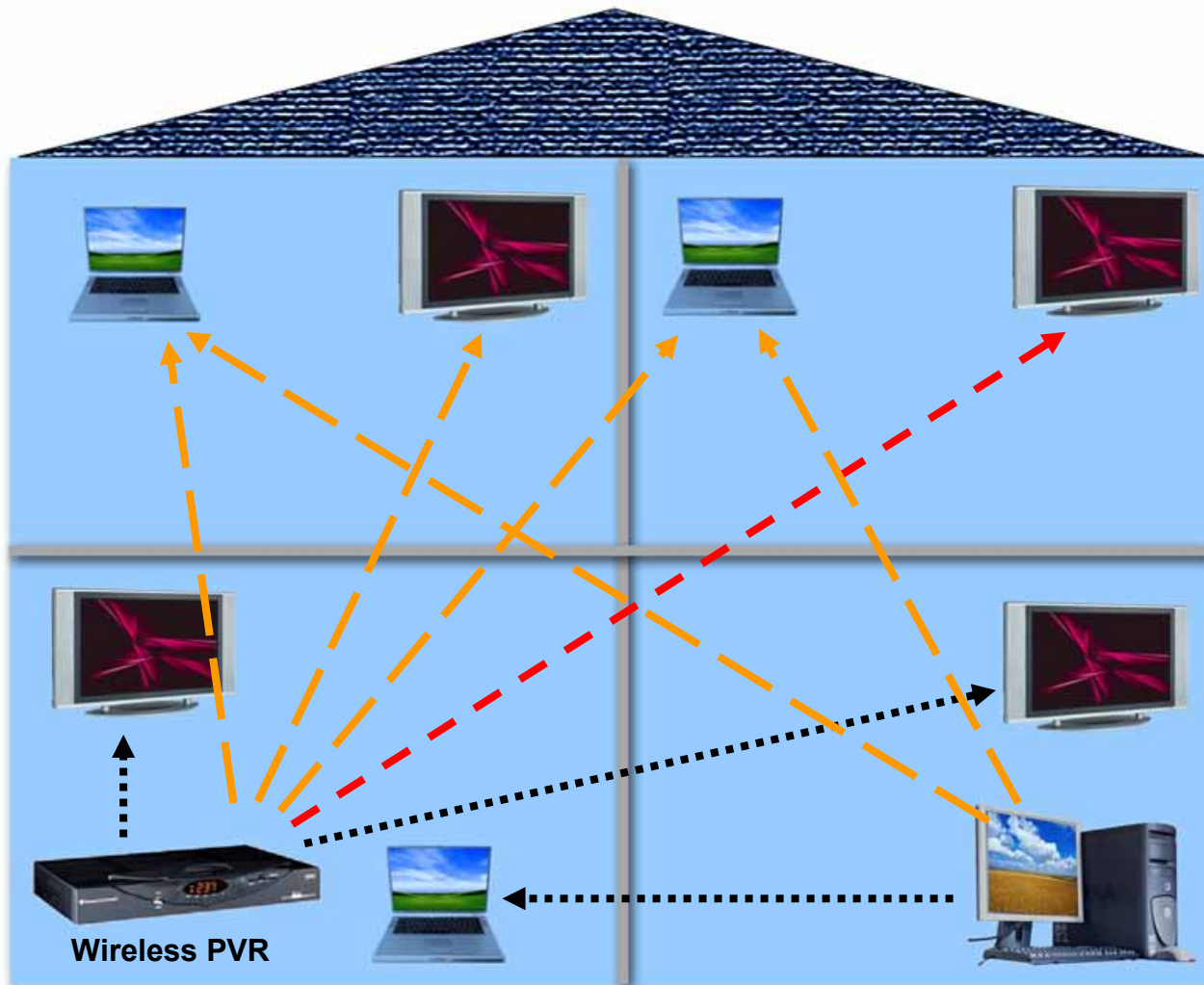
802.11n  
(Throughput)



BF/MRC  
(Distance)



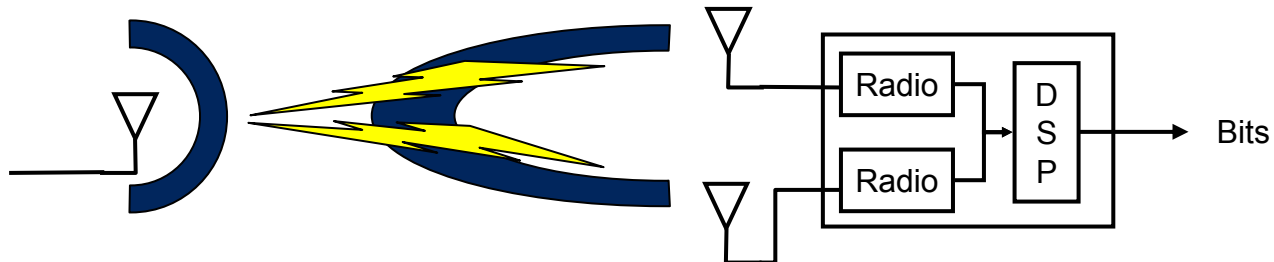
802.11



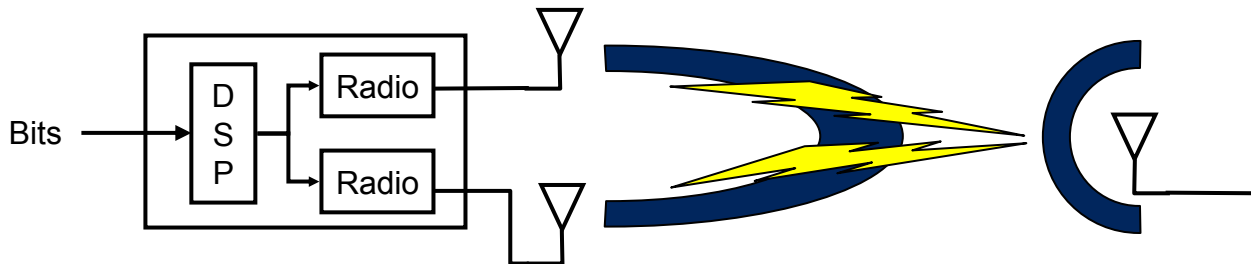
# Beamforming & Receive Combining

Beamforming and Receive combining are designed to improve signal robustness:

- Higher data rate at range
- Benefit even when one end is legacy 802.11 device
- Receive combining focuses energy arriving from the AP/STA direction



- Transmit beamforming focuses energy towards the AP/STA direction



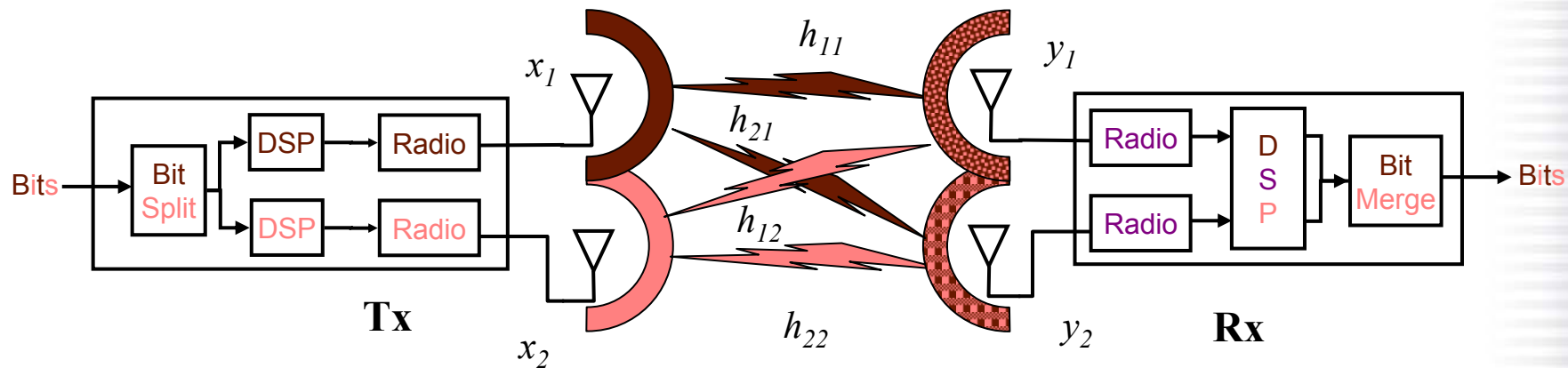
**6-10 dB System Link Gain**

# Spatial Multiplexing - MIMO

Form multiple independent links on same channel between Tx and Rx to communicate at higher effective data rates

In reality there are cross-paths between the antennas

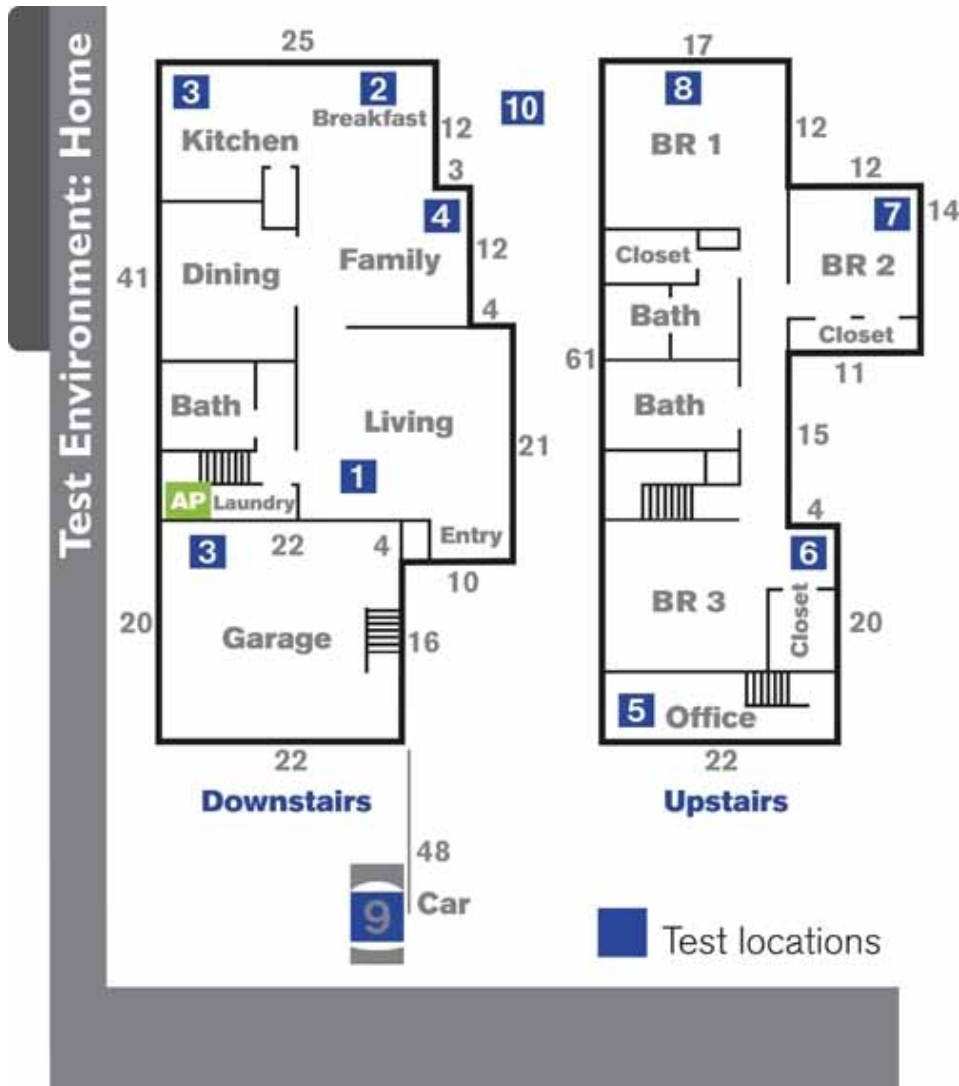
The correlation must be decoupled by digital signal processing algorithms – channel estimation, equation solving



$$y_1 = h_{11}x_1 + h_{12}x_2$$

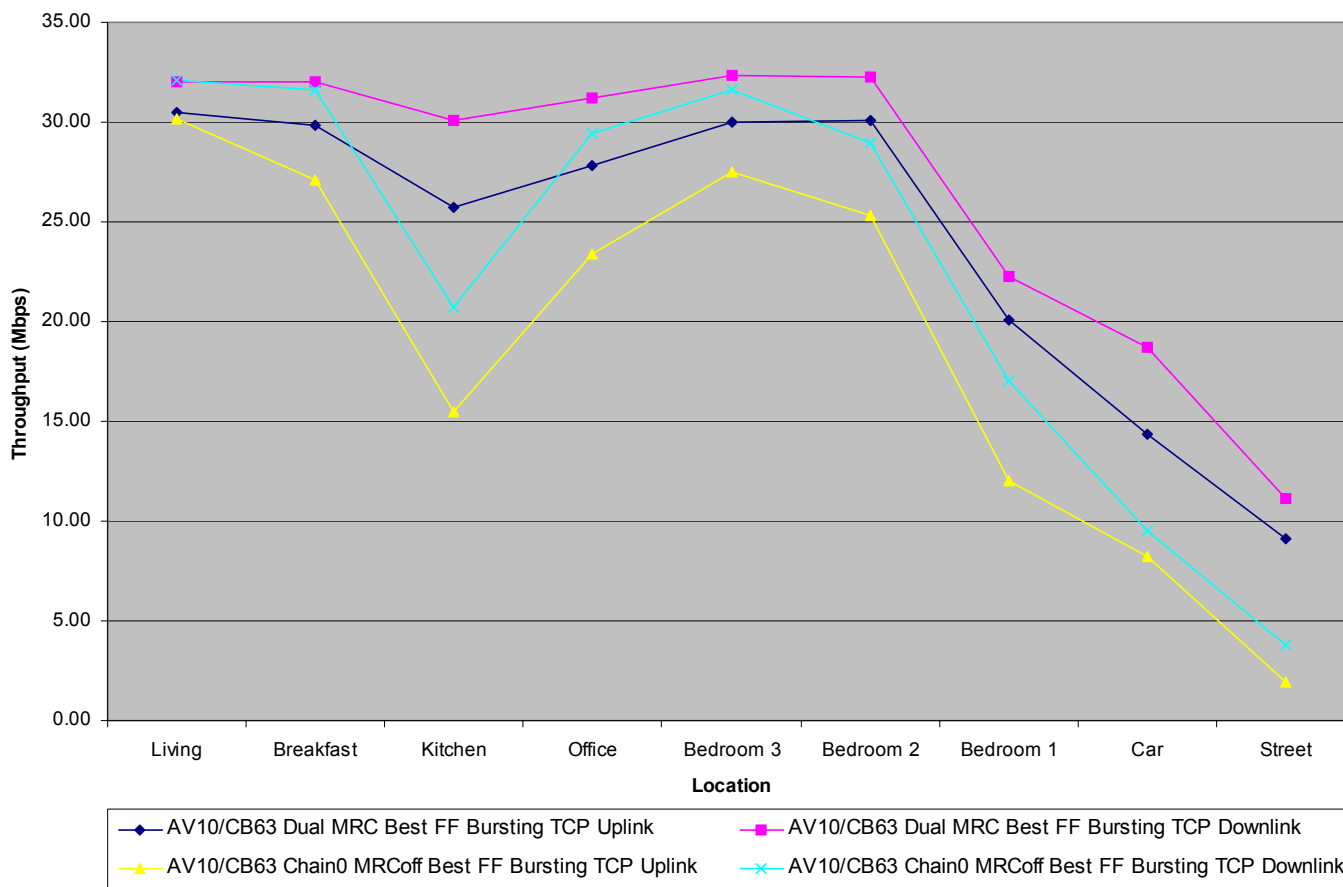
$$y_2 = h_{21}x_1 + h_{22}x_2$$

# Performance Test House Floor Plan



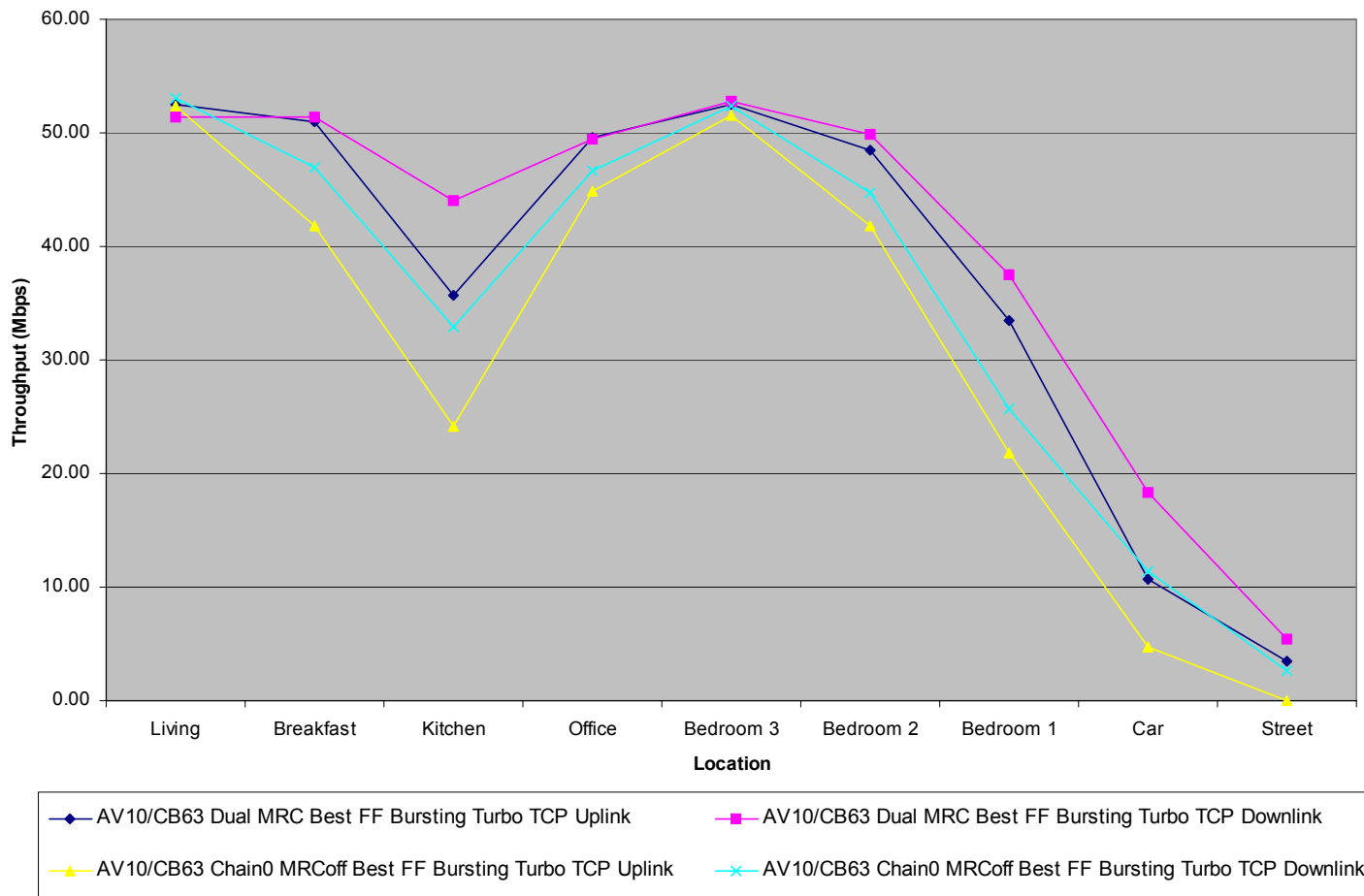
# BF/MRC Measured Performance

AV10/CB63 Dual vs. Single, FF Bursting

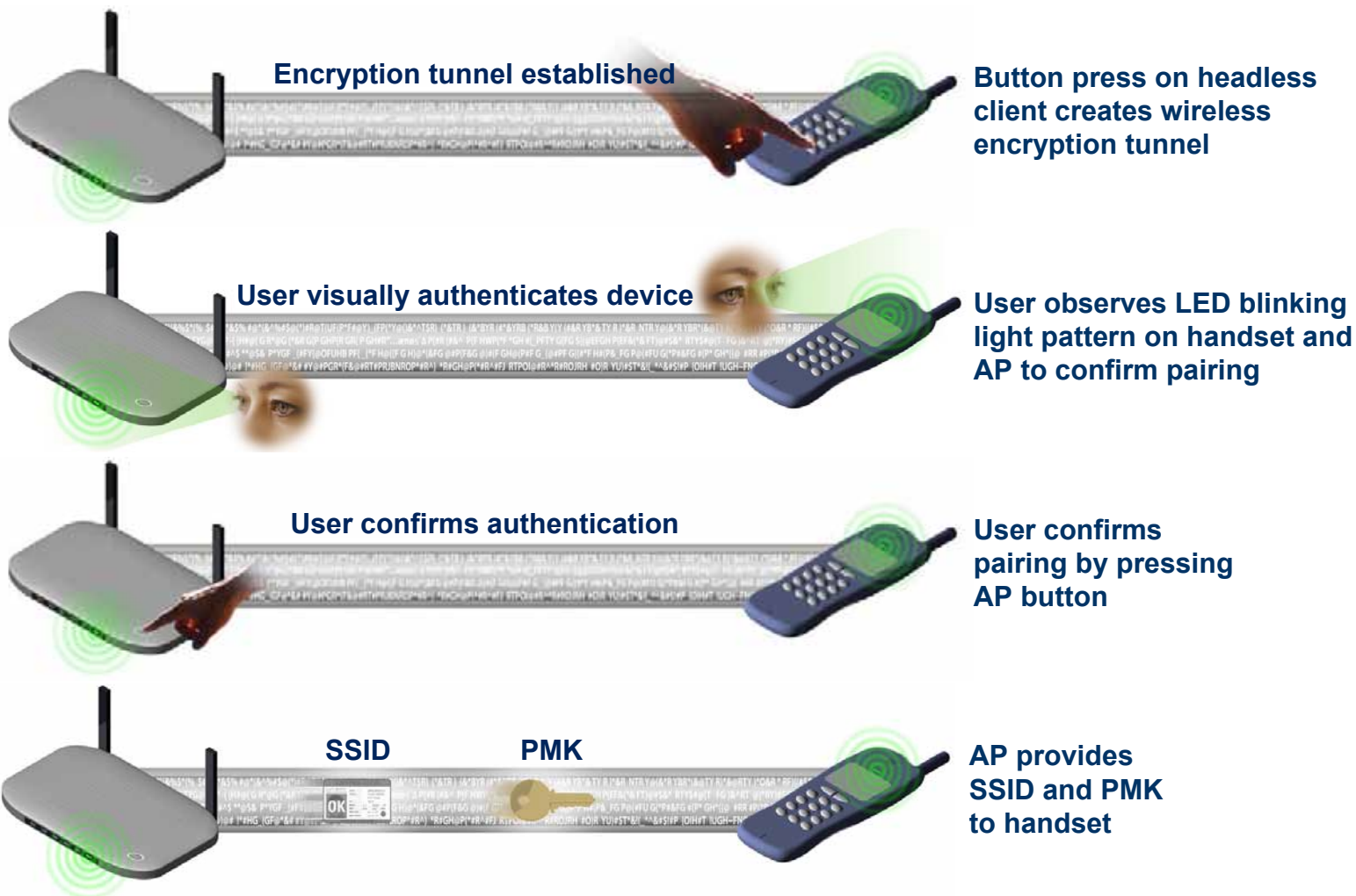


# BF/MRC Measured Performance (Turbo)

AV10/CB63 Dual vs. Single, FF Bursting Static Turbo

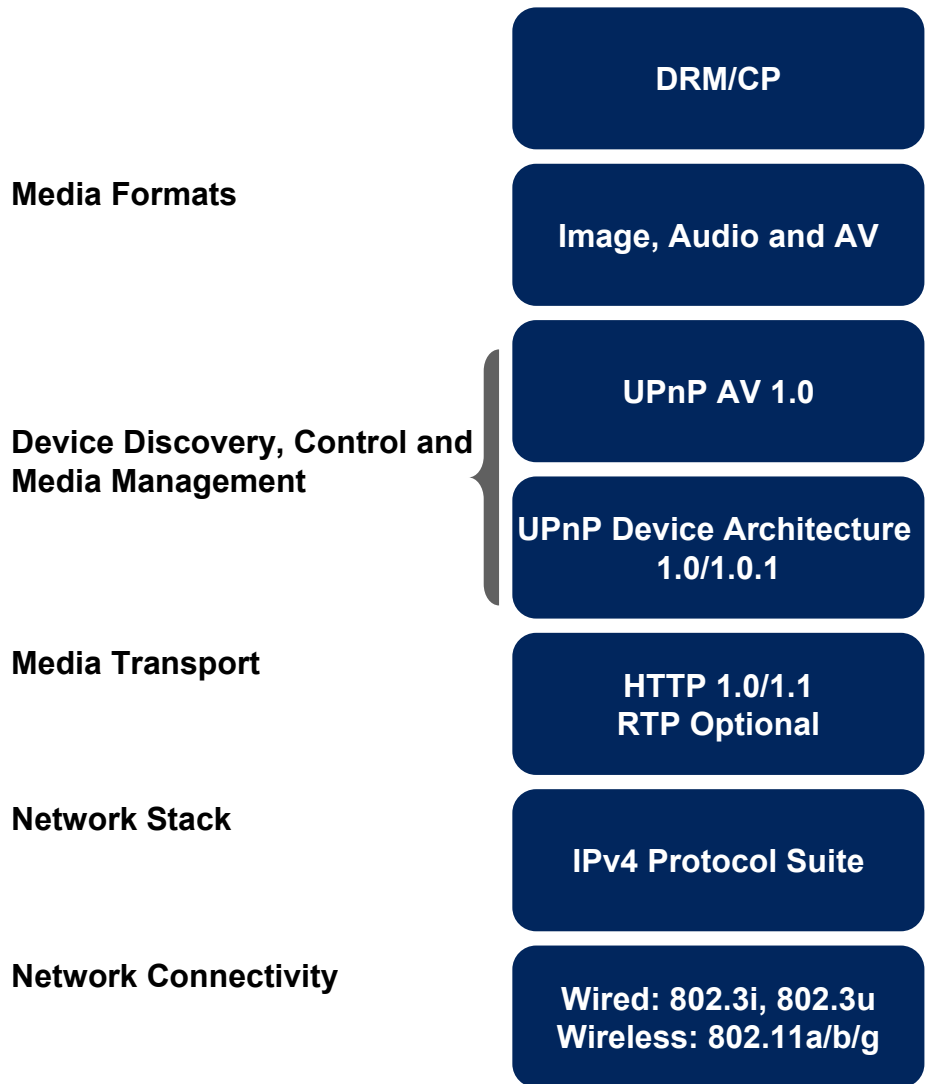


# Ease-of-Use: Simple Security Setup



**Secure connection of handset to WLAN is established!**

# Ease-of-Use



***DLNA Provides  
Plug & Play  
Interoperability***



# Summary

- Goal is Any Content, Anytime, Anywhere with “No New Wires”  
⇒ Consumers want it, service providers will push it
- 802.11 technology supports multiple SDTV/single HDTV today
- 802.11n technologies will enable a comprehensive wireless infotainment networking platform
- Hybrid infotainment networks are likely practical solutions
- Ease-of-Use being addressed through industry organizations (e.g. DLNA) & individual companies
- 802.11 technology continues on a steep cost reduction slope
- Content protection issues may stall the market

# Q & A

