Home Infotainment Networking

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Home Infotainment Networking Overview

Home Infotainment Networking Requirements

Home Infotainment Networking Wireless Solutions

Summary

Q&A
Home Infotainment Networking Overview
Home Infotainment Networking Idea

Home Infotainment Networking

Any Content, Anytime, Anywhere

No New Wires

Whole house connectivity for internet connectivity and media sharing

Wireless Game Player

Wireless Streaming Audio

Wireless Printer

WiFi Internet Access

Send photos and media to your TV while sharing a broadband connection

Streaming Photos & Video from PC to TV

VoIP Phone

Wireless Notebook PC

Wireless Gaming

Broadband link to the Internet

PDA
Consumer Home Services Today

Multiple Bills

Multiple Service Calls

- Cable/Satellite
- Telco
- Cellular

STB
DSL/Cable Modem
802.11 AP/Router

Multiple Bills
Multiple Service Calls
Consumer Home Services Tomorrow

Service Provider

Cable/Telco/Sat

Home Gateway

VOIP

Triple Play

Quadruple Play

One Bill

One Service Call

Bundled (lower) Pricing
Quadruple Play+ ("Killer Apps")

Service Provider

Cable/Telco/Sat

Home Gateway

Multi Room PVR

Wireless Speakers

Game Console

Portable Entertainment

Cameras

Laptop

Quadruple Play
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)
“... 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.”

Source: The Diffusion Group, 2005
Home Network Configuration – Data

Master Bedroom
- Cable
- Satellite
- Terrestrial
- DSL
- Dialup
- Phone
- Coax

Living Room
- Cable Modem
- Wireless Router
- Phone
- Wireless

Bedroom #2
- Phone
- Wireless

Office
- Cable Modem
- Wireless Router
Home Infotainment Network Configuration
– Hybrid, No New Wires

Wired
- Coax (MOCA)
- Powerline (HomePlug)

Wireless
- 802.11
- UWB

Master Bedroom
- NDISPLY
- VOIP

Living Room
- NDISPLY
- WSPK

Bedroom #2
- NDISPLY
- WSPK

Office
- NDISPLY
- Coax/Wireless Bridge

Home Gateway Server

Cable
Satellite
Terrestrial
DSL
Dialup

Coax/TP Coax/Power Wireless
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

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

Throughput, Mbps

- Multiple HDTV streams
- Multiple SDTV or 1 HDTV stream
- SDTV to TV from PC & RG
- Photos & Music to TV from PC
- Internet Access, Printer Sharing
- VOIP

Range, Feet

Throughput (Mbps):
- VOIP: 1
- Internet Access, Printer Sharing: 1
- Photos & Music to TV from PC: 2
- SDTV to TV from PC & RG: 5
- Multiple SDTV or 1 HDTV stream: 10
- Multiple HDTV streams: 200

Range (Feet):
- 1Mbps: 25 feet
- 2Mbps: 50 feet
- 5Mbps: 75 feet
- 10Mbps: 100 feet
- 20Mbps: 125 feet
- 50Mbps: 150 feet
Home Infotainment Networking
Wireless Solutions
802.11 Home Entertainment Networking Solutions

- Multiple HDTV streams
- Multiple SDTV or 1 HDTV stream
- SDTV to TV from PC & RG
- Photos & Music to TV from PC
- Internet Access, Printer Sharing
- VOIP

Throughput, Mbps

- 802.11a/g (2003)
- 802.11n (SM, 2006)

Range, Feet

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

QoS 11e/WMM

Multiple radio.smart antenna technology

Spatial Multiplexing

Beam Forming MRC

- 802.11a/g (2003)

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

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

\[
\begin{align*}
2.4 \text{ GHz} & = 3 \text{ usable channels only} \\
\text{from 2.400-2.483 GHz}
\end{align*}
\]

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

\[
\begin{align*}
2.4 \text{ GHz} & + 5 \text{ GHz} = 16 \text{ usable channels in 2002} \\
& \quad \text{add 5.150-5.350, 5.725-5.850 GHz}
\end{align*}
\]

\[
\begin{align*}
2.4 \text{ GHz} & + 5 \text{ GHz} = 27 \text{ channels} \\
& \quad \text{with new FCC rules in Nov 2003} \\
& \quad \text{add 5.470-5.725 GHz}
\end{align*}
\]

<10 million interferers
Huge success of 802.11 leads to congestion in the 2.4 GHz band

Real World Example: 45th and Avenue of the Americas – NYC

50 APs sharing 3 channels = low performance!
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
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 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

Voice
- SIFS: 2 slots
- 0~3 slots

Video
- SIFS: 2 slots
- 0~7 slots

Best Effort
- SIFS: 3 slots
- 0~15 slots

Background
- SIFS: 7 slots
- 0~15 slots

Minimum Wait (AIFSN)

Random Backoff Wait

TXOP

3 ms

0.2 ms
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
• 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.
• 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

>60Mbps*

~40Mbps

~22Mbps

Dynamic Turbo Mode:
- Utilizes dual channels to double rates
- Dynamically adjusts for need / environment
- For critical high bandwidth needs

Super G Mode:
Packet Bursting
- More data packets per given time period
- Benefits realized regardless of AP type

Fast Frames and Compression
- Packet aggregation & timing modifications
- Standards-based Lempel Ziv compression
- AP supports on link-by-link basis

Base Mode: Standard 802.11a/g with enhanced Tx power and Rx sensitivity

*Standards based
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

Wireless PVR
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

Test Environment: Home

- Kitchen
- Breakfast
- Family
- Living
- Bath
- Dining
- Entry
- Garage
- Downstairs
- Upstairs
- BR 1
- BR 2
- BR 3
- Office
- Bath
- Closet
- Test locations

36
BF/MRC *Measured* Performance

AV10/CB63 Dual vs. Single, FF Bursting

![Graph showing throughput comparison](Image)

- **AV10/CB63 Dual MRC Best FF Bursting TCP Uplink**
- **AV10/CB63 Dual MRC Best FF Bursting TCP Downlink**
- **AV10/CB63 Chain0 MRCoff Best FF Bursting TCP Uplink**
- **AV10/CB63 Chain0 MRCoff Best FF Bursting TCP Downlink**
BF/MRC Measured Performance (Turbo)

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

Location

Throughput (Mbps)

AV10/CB63 Dual MRC Best FF Bursting Turbo TCP Uplink
AV10/CB63 Dual MRC Best FF Bursting Turbo TCP Downlink
AV10/CB63 Chain0 MRCoff Best FF Bursting Turbo TCP Uplink
AV10/CB63 Chain0 MRCoff Best FF Bursting Turbo TCP Downlink
Ease-of-Use: Simple Security Setup

Encryption tunnel established

Button press on headless client creates wireless encryption tunnel

User visually authenticates device

User observes LED blinking light pattern on handset and AP to confirm pairing

User confirms authentication

User confirms pairing by pressing AP button

SSID PMK AP provides SSID and PMK to handset

Secure connection of handset to WLAN is established!
Ease-of-Use

<table>
<thead>
<tr>
<th>Media Formats</th>
<th>DRM/CP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Image, Audio and AV</td>
</tr>
</tbody>
</table>

**Device Discovery, Control and Media Management**

<table>
<thead>
<tr>
<th>Media Formats</th>
<th>UPnP AV 1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>UPnP Device Architecture 1.0/1.0.1</td>
</tr>
</tbody>
</table>

**Media Transport**

<table>
<thead>
<tr>
<th>Media Formats</th>
<th>HTTP 1.0/1.1 RTP Optional</th>
</tr>
</thead>
</table>

**Network Stack**

<table>
<thead>
<tr>
<th>Media Formats</th>
<th>IPv4 Protocol Suite</th>
</tr>
</thead>
</table>

**Network Connectivity**

<table>
<thead>
<tr>
<th>Media Formats</th>
<th>Wired: 802.3i, 802.3u Wireless: 802.11a/b/g</th>
</tr>
</thead>
</table>

*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