Presentation on MoCA

Agenda

- IP Connections
- MoCA® – The Alliance
- MoCA® – The Technology Standard
- MoCA® in retrofit environments
- How and when to install MoCA technology

IP Connections

- What IP systems are you installing right now?
- What streaming video applications are your customers using right now?
- How are you installing these systems for your customers?

IP Challenge in Typical Home Entertainment Installs

The television is the center of entertainment for most homes.

Televisions are disconnected from consumers’ computers and stored digital content.

The Ideal Networked Home

- Uses existing home wiring (plant)
- Coexists with cable, telco/IPTV, satellite
- Provides high capacity (100 Mb/s - 1 Gb/s)
- Offers low latency, jitter and loss; supports real-time applications
- Delivers Reliable, Secure, Ubiquitous services...available throughout the entire home
- Allows communication between all connected home devices

Typical Applications of the Ideal Networked Home
Coax is the best delivery medium for home networking

Ever see an Ethernet or WiFi connection behind a TV?
- Coax is next to every TV entertainment center
- Coax is next to every Cable Modem
- Coax is used by nearly every major operator to deploy triple play services
- Your customers want multiple glitch-free streams of HD video. This requires a robust and high net-throughput network.
- Coaxial cabling already exists in 90% North American homes.
- Coax is shielded from noise and interference (especially compared to wireless).

This is where MoCA comes in...

- MoCA technology occupies unused frequency spectrum...adjacent to cable television carriers.
- MoCA technology offers performance suited for transporting multimedia content
  - Net Throughput = 175 Mb/s
  - Low Packet Loss Rate (< 1e-5)
  - Low Latency (< 10 ms)
  - Low Jitter (< 1 ms)

“For those who can’t string Gigabit Ethernet, MoCA is clearly the only choice when high performance is needed. ” Tom’s Hardware, 11/30/09

The MoCA Advantage Retrofit Environments

- MoCA leverages existing coax
  - Ubiquitous in the home
  - Wide Base (90% of US homes)
  - Low Cost
  - Not tied to a specific service provider
- No need to pull multiple wires
- Saves you time/money
- Allows for more installs with less home destruction or reconstruction

Who is MoCA The Organization
A non profit technology alliance
Established January 2004 by some of the most respected service providers and OEMs in the world
Promotes distribution of multiple streams of HD content throughout the home using existing coax
Only alliance with appeal to all three pay TV segments (telco, cable, DBS)
Deployed: Comcast, Cox, DirecTV, Verizon’s FiOS TV
In Trial: TWC, Mediacom, Sunflower, Buckeye
Committed: Cincinnati Bell
More than 70 certified products (STBs, ONTs, BHRs, ECBs)
Recently established liaison agreement with HomePlug
Incorporated into DLNA’s Interoperability Guidelines
Member of OPASTCO (US tier 2 telcos and cable) and CEDIA (installers and integrators)

What is MoCA The Technology Standard

- A universal global industry standard protocol which defines transmission of HD video quality content from outlet-to-outlet over existing home coaxial wiring
- MoCA coax technology standard is designed to guarantee ubiquity, reliability, security, high throughput
  - 175 Mbps Throughput (270 Mbps Phy Rate for MoCA 1.1)
  - Minimal signal degradation through long distances in the home

More than 80 Certified Products...

...MoCA IC Solutions

![Entropic EN2510](image1)

![Broadcom BCM7019 & BCM7025](image2)

...Set Top Boxes, NAS
...Ethernet Bridges, Gateways

ADB ADB-6880CX
Motorola DCX-3400M
Motorola QIP6416
Motorola DCX-3200M
Pace DC900X HD DVR
Network Attached Storage Device
Cisco Explorer 8652HDC
DVR with M-Card Interface

Actiontec ECB2200
MoCA Network Adapter
Westell UltraLine
Series3 MoCA Gateway
Actiontec MI424WR
Broadband Home Router
NetGear MCAB1001
Ethernet to Coax Bridge
D-Link DXN-221
Coax Ethernet Adapter Kit

MoCA and Alternatives
<table>
<thead>
<tr>
<th>Technologies</th>
<th>Value Proposition</th>
<th>Drawbacks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wireless (WiFi)</td>
<td>Mobility</td>
<td>Reliability is a challenge</td>
</tr>
<tr>
<td></td>
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<td>Prone to interference</td>
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<tr>
<td></td>
<td></td>
<td>Unlicensed band</td>
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<tr>
<td>Powerline (HomePlug, HDPLC, UPA)</td>
<td>Ubiquity of outlets</td>
<td>Performance not on par with MoCA</td>
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<tr>
<td></td>
<td></td>
<td>Prone to high interference</td>
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<tr>
<td></td>
<td></td>
<td>Low outlet coverage performance</td>
</tr>
<tr>
<td>Phoneline (HomePNA)</td>
<td>Ubiquity of phone jacks</td>
<td>Performance can not match MoCA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Does not work in cable modem environment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No endorsement by US satellite providers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Niche market (telco only)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Technology deadends. No HPNA 4.0.</td>
</tr>
<tr>
<td>Coax (MoCA)</td>
<td>Proven performance and Reliability</td>
<td>Reliant on coaxial outlet penetration</td>
</tr>
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<td>In use by all three pay TV segments.</td>
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<tr>
<td></td>
<td>MoCA 2.0 ratified</td>
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</table>

**Horizontal Communications**

Traditional services use a “Vertical” communications path: Multi-Tap Outlet

- MoCA enables simultaneous “Horizontal” communications:
  - Outlet <-- Outlet
  - “Splitter Jumping”
- MoCA enables new content sharing services such as Multi-Room DVR or PC-to-TV

**Physical Operating Conditions**
MoCA Plant Assumptions

- 300 feet max cable from multi-tap to first splitter
- 25 dB max attenuation (@ 750 MHz) between first splitter and outlet
- 300 feet max cable between first splitter and outlet (+other splitters)
- No amplifiers in the path between desired outlets
- CATV analog and digital signal levels at outlets are within system specifications

MoCA Network Topology

MoCA Devices Form Full-Mesh/Peer-to-Peer Network
- MoCA 1.1 : 16 devices max

Example of MoCA Network w/ 4 Devices
- Each DVR or STB connected to coax outlet
- 6 unique coax links (1/2, 1/3, 1/4, 2/3, 2/4, 3/4)
- 12 unique MoCA connections must be managed – bi-directional links established

MoCA Network Overview Usable Data Rate

MoCA allows Scalable Data Rate per Link
- MoCA 1.1 : < 175 Mbps Aggregate Network Date Rate

Typical Multi-Room DVR Data Rate Usage
- Assume a single DVR connected to 3 client STBs
- Each DVR/STB link is bi-directional = control + data (video)
  - Video is MPEG2 HD @ 20 Mbps per stream
  - Control is <1 Mbps
- Total MoCA BW consumed is 3 x (20+1) = 63 Mbps
- MoCA data rate remaining for other services: 175 Mbps – 63 Mbps = 112 Mbps
MoCA Physical Layer (PHY) Data Rate

MoCA PHY Rate provides indication of connection quality

- ~250 Mbps max PHY Data Rate (equivalent to 11g 54Mbps)
- Max PHY Rate for <55 dB Path Loss
- 55% - 70% of PHY Rate is Usable Data Rate (WiFi is typically 20%)

MoCA Frequency Planning

- MoCA network communications occur in a single 50 MHz BW channel
- Same 50 MHz BW channel for all Tx/Rx (TDD/TDMA)
- Broadband noise-like signal (similar to QAM)
- One MoCA device becomes Network Controller (NC) and manages all network communications in the 50 MHz channel
- Guaranteed Low Packet Error Rate (~1e-5) allows broadcast video quality user experience
- MoCA channel coexistent w/ all operator primary services bands
  - Optional band plans defined by MoCA from 500–1500 MHz
  - Special MoCA products for DBS services

MoCA Frequency Band

4 Band Channel Plan: 500 - 1500 MHz

- Operator/Service Provider exclusive bands
- D-Band allows Retail products
- Only 1 MoCA network allowed per band
<table>
<thead>
<tr>
<th>Band</th>
<th>Center Frequency</th>
<th>Channel Step</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>875 MHz</td>
<td>-</td>
<td>Operator Only (DBS)</td>
</tr>
<tr>
<td>B</td>
<td>900 MHz</td>
<td>-</td>
<td>Operator Only (DBS)</td>
</tr>
<tr>
<td>C</td>
<td>925 – 1000 MHz</td>
<td>25 MHz</td>
<td>Operator Only (MSO, Telco)</td>
</tr>
<tr>
<td>D</td>
<td>1150 – 1500 MHz</td>
<td>50 MHz</td>
<td>Operator + Retail</td>
</tr>
<tr>
<td>L &amp; PSK</td>
<td>500 – 2500 MHz</td>
<td>50 MHz</td>
<td>Operator Only</td>
</tr>
</tbody>
</table>

MoCA Frequency Coexistence

- Coax and splitters support reliable communications above 860 MHz
- Coexistence with existing services
  - UHF/VHF video to 806 or 860 MHz
  - Satellite DBS services from 950 MHz
  - MoCA channels are 50MHz wide

MoCA Network Additional Features

- Network Latency
  - 8 nodes (MoCA 1.0): <3.5 ms avg w/ 80% loading
  - 16 nodes (MoCA 1.1): <4.5 ms avg w/ 80% loading
- Quality of Service Support
  - MoCA 1.1 : UPnP 3.0 based Parameterized QoS (PQoS)
- Network Privacy
  - Single DES 56-bit encryption
  - Device Security Password for Network Admission

MoCA Service Provider Installs

MoCA in a CATV Environment

MoCA is designed to operate in a digital cable ready home

- 0 dBmV min Analog Carrier Levels @ outlets
- -15 dBmV min Digital Carrier Levels @ outlets
- <25 dB TAP to outlet loss in CATV band
MoCA Point-of-Entry (POE) Filter in a CATV Environment

- Simple Passive Device does not affect DS/US CATV services
  - 1002 MHz passive low-pass filter with <1 dB loss in CATV band
  - >35 dB rejection in MoCA D-band
- Provides Physical Isolation of homes connected to common Multi-Tap
  - Improved MoCA Outlet Coverage
    - Reduces root-splitter isolation (POE is a reflector @ MoCA freqs)
    - Reduces average installation time
  - Plant Leakage Mitigation
    - Prevents MoCA signal energy from affecting homes on common TAP
    - Prevents out of band ingress energy from affecting operation of MoCA home
- Privacy
  - Snooping & Service Theft Prevention
- Common Frequency Plan
  - All MSO homes can operate on the same channel
  - Network predictability and fast recovery

...POE Filters
MoCA in a Telco Environment

- All products with integrated MoCA interfaces
- Multi-Band MoCA networks
  - C & D bands
- Optical Network Terminal (ONT)
  - MoCA network with BHR in C-band
- Broadband Home Router (BHR)
  - MoCA network with ONT in C-band
  - MoCA network with DVR & STBs in D-band
- DVR & STBs
  - MoCA network with BHR in D-band

MoCA in a DBS Environment
MoCA Home Wiring Overview

Trunk and Branch Wiring

Typical All-Passive *Digi-Ready Home – No Changes Required for MoCA

* TAP-to-Outlet Loss
<20dB from 54-550 MHz
<25dB from 550 – 1002 MHz
Trunk and Branch w/ Drop Amp

Typical Drop-Amp *Digi-Ready Home – No Changes Required for MoCA

- Optional MoCA POE Filter
  - Improve Outlet Coverage
  - Isolation
  - Security

POE Drop Amp

POE Filter

Demark

150 ft

- +15 dBmV Ana
- +19 dBmV Dig

CATV Feed in street

Multi-Tap

To Next Multi-tap

Rm 1

Rm 2

Rm 3

Rm 4

All room-to-room MoCA communications on output side of drop amp

*Tap-to-Outlet Loss
<20dB from 54-550 MHz
<25dB from 550 – 1002 MHz

Trunk and Branch w/ Line Amplifier

Typical Line-Amp *Digi-Ready Home – Changes Required for MoCA Operation

- Option 1: Replace Line Amp with MoCA Type A or B Line Amp
- Option 2: If eMTA in Rm 1, replace Line Amp with MoCA Type D or E Drop Amp

CATV Feed in street

Multi-Tap

To Next Multi-tap

Rm 1

Rm 2

Rm 3

Rm 4

Line Amp prevents MoCA communication between rooms on its output side and rest of house
Testing the MoCA Environment

As presented by Spirent Communications

- Prequalification of all outlets – MoCA ready
- Ensure qualification testing
- Measure specific Phy rates
- Multiple use of gateways for MoCA network

MoCA Testing

Audio/Video Quality Testing Over MoCA

As presented by Spirent Communications

<table>
<thead>
<tr>
<th>Audio/Video Quality Testing</th>
<th>- Measures multi-room DVR audio/video streams transported using MPEG-2 / IP encapsulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality Scores</td>
<td>- Reports audio/video quality using mean opinion score – 5 (best) – 1 (worst) quality</td>
</tr>
<tr>
<td>Expert Analysis</td>
<td>- Differentiate packet loss and packet delay variation</td>
</tr>
<tr>
<td></td>
<td>- Lead's technicians to root cause</td>
</tr>
<tr>
<td>Passive Mode Measurement</td>
<td>- Measure audio/video quality “in-line”</td>
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<tr>
<td></td>
<td>- Use STB to control audio/video stream</td>
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</tbody>
</table>

MoCA Network Qualification Testing

Quick tests to ensure network is functioning properly

As presented by Spirent Communications

- Combines coaxial cable, data rate and bit loading tests.
- Uses thresholds and analyzes measurement results to determine whether or not the MoCA network is operating properly.
- Pass/fail metrics provide quick problem identification.
- Measurements may be stored to create “birth certificate” for the customer's MoCA network.
- Verifies bi-directional data rates, number/type of nodes, and IP/MoCA packet loss.
MoCA Data Rate Testing

\textit{Does a bi-directional issue exist between nodes?}

\textit{As presented by Spirent Communications}

- Connect test set to the coaxial network and determine the data rate between each node
- Verify transmit and receive data rates
- Compare data rates to acceptable minimums needed to support multimedia services

\begin{center}
\begin{tabular}{|c|c|c|c|}
\hline
\textbf{Rx} & \textbf{Tx} & 0* & 1 & 2 & 3 \\
\hline
0* & 104 & 22 & 248 & 255 & \\
1 & 222 & 248 & 255 & \\
2 & 248 & 245 & 255 & \\
3 & 250 & 225 & 255 & \\
\hline
\end{tabular}
\end{center}

MoCA Transport Testing

\textit{Does the equipment’s MoCA interface function properly?}

\textit{As presented by Spirent Communications}

- Connect test set directly to customer equipment using verified coaxial cable
- Determine the transmit/receive data rates attained between the test set and the customer equipment
- Verify that data rates exceed the minimum acceptable values
- Replace customer equipment should data rates fall below benchmark

MoCA Coaxial Cable Testing

\textit{Between Nodes}

\textit{As presented by Spirent Communications}
Connect test set to outlets and splitters to check each coaxial cable segment

Determine the data rates attained at each segment to isolate physical issues

- Splitters or filters
- Un-terminated cables
- Cable faults
- Damaged cables or connectors
- Attenuation due to cable length
- Amplifiers without MoCA bypass

Locate areas of the spectrum with reduced bit loading which are affected by noise or interference

Identify the suspected source—multipath interference, L-band carriers (satellite)...

...Certified Test Equipment

Spirent Tech-X Flex
MoCA/DOCSIS 3.0/WiFi/1GHz CATV