MoCA Basics

Presented to
San Diego Chapter SCTE

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MoCA Basics – San Diego Chapter SCTE

MoCA
Multimedia over Coax Alliance

What is MoCA?
- MoCA is an Ethernet over coaxial cable technology that is used to “network” audio/video electronics in the home
- MSOs are currently implementing MoCA for multi-room DVR applications
What is MoCA?

- Multimedia over Coax Alliance (MoCA) promotes and specifies delivery of digital entertainment and information content over the in-home coaxial cable
- Established in 2004
- Leverage large installed base of coaxial cable
- Large worldwide deployment base of MoCA enabled devices
• Applications
  - Distribution of video in the house for applications with multi-room DVR
  - High speed networking (sharing of pictures and home videos between PCs and media players, backbone network for Wi-Fi extenders)
  - High definition video streaming from the internet
  - Home security/remote monitoring

• Alternatives to MoCA
  - What alternatives exist to MoCA?
  - Why has the cable industry standardized on MoCA?
### Other In-Home Networking Methods

<table>
<thead>
<tr>
<th>Technology</th>
<th>Media</th>
<th>Max Phy Rate</th>
<th>Benefits</th>
<th>Drawbacks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wi-Fi</td>
<td>RF</td>
<td>54 ~ 600 Mbps</td>
<td>Mobility, no wires</td>
<td>Reliability, reduced throughput due to interference, unlicensed band</td>
</tr>
<tr>
<td>Ethernet</td>
<td>Twisted Pair</td>
<td>1000 Mbps</td>
<td>High speed</td>
<td>Lack of Cat 5 wiring in homes, dedicated network (media not shared)</td>
</tr>
<tr>
<td>HomePlug AV</td>
<td>Electrical Wiring</td>
<td>200 Mbps</td>
<td>Power outlets throughout the house</td>
<td>High interference issues, outlet use limited by house wiring, speed and reliability does not match MoCA</td>
</tr>
<tr>
<td>HomePNA</td>
<td>Twisted Pair/Coax</td>
<td>160 Mbps (twisted pair)</td>
<td>Phone jacks throughout the house</td>
<td>Doesn't work in a cable modem environment, niche market (Telco only), no extended standards development, performance doesn't match MoCA</td>
</tr>
<tr>
<td>MoCA</td>
<td>Coax</td>
<td>270 Mbps</td>
<td>Reliable, designed to work in a cable modem environment, fast network, well accepted by service providers (cable, telco, and satellite), continued standards development</td>
<td>Availability of coax outlets</td>
</tr>
</tbody>
</table>
Why MoCA?

- 90% of homes in North America already have coax installed to at least some of the TV sets in the home.
- The use of coaxial cable ensures a high level of shielding, providing immunity to interference and noise (especially when compared to Wi-Fi).
- MoCA is compatible with cable modem networks as it occupies bandwidth above the standard HFC frequency range.
- MoCA provides the necessary throughput for transporting multiple data streams carrying multimedia content.
MoCA 1.1 Attributes

RF Frequency Range

- RF Return: 5 to 42 MHz
- Forward RF: 54 to 860 MHz
- Future Digital Expansion: 860 to 1000 MHz

6 MoCA Channels: 850 to 1000 MHz
- A1
- B1
- C1
- C2
- C3
- C4

8 MoCA Channels: 1125 to 1525 MHz
- D1
- D2
- D3
- D4
- D5
- D6
- D7
- D8
MoCA 1.1 Attributes

• 8 ea. 50 MHz RF channels, 1125 to 1525 MHz

• Each channel has
  - 256 sub-bands, 224 occupied (OFDM) plus guard bands
  - Each sub-band goes from BPSK to 256 QAM in near real time
  - Channel 1 (1125-1175) is most likely choice, can be made a requirement via addressable set top controls

• System operation
  - 175 Mbps throughput (target PHY rate of 270 Mbps)
  - Demonstrated operation to 57 dB dynamic range
  - Transmitter lowers power when link exceeds target rate
  - Beacon always at maximum output power (56 dBmV)
    • Some MSOs are considering lowering the beacon to 40 dBmV, which also reduces the link budget to 41 dB, due to concerns with overdriving the input to non-MoCA enabled devices with the high beacon carrier level
  - Up to 16 devices on the in-home network TDMA Tx-Rx
MoCA 2.0 Changes

• **Baseline Mode**
  - 400+ Mbps MAC throughput (500+ Mbps in turbo mode)
  - 700 Mbps PHY rate
  - Single 100 MHz channel

• **Enhanced Mode**
  - 800+ Mbps MAC throughput (1+ Gbps in turbo mode)
  - 1.4 Gbps PHY rate
  - Dual bonded 100 MHz channels (channel bonding)

• **Expanded Operating Frequency Range**
  - 500 through 1650 MHz

• **Additional Changes**
  - Energy saving modes
  - Reliability improvements (latency, improved PER, re-transmission)
  - Backward Interoperability
MoCA Signal Flow

WAN Point Of Entry

NORMAL 2-WAY CATV PATH

3:1 Splitter

Node Device

3:1 Splitter

Node Device

2:1 Splitter

Node Device

Node Device

Node Device

Node Device

Node Device
MoCA Logical Topology

- Logically, MoCA operates as a fully meshed point-to-point network, where each node is interconnected bi-directionally to every other node in the MoCA network.
- The data rates for each link are scalable, up to the aggregate network throughput of 175 Mbps.
- The speed of each link is determined by the quality of the communications path between those two nodes.
**Multi-Room DVR Data Rate Usage Example**

- Assuming 1 DVR connected to 3 MoCA enabled STBs
- Each link is bi-directional and contains both control information and the video information
  - Video is MPEG2 HD @ 20 Mbps per stream
  - Control is < 1 Mbps
  - Each link is 21 Mbps
- Total bandwidth consumed is 3 x 21, or 63 Mbps
- Data rate remaining for other MoCA services is 175 Mbps minus 63 Mbps, or 112 Mbps
Drop Network Considerations

- **Low-pass filter (5 to 1002 MHz) must be installed at each residence to protect against adjacent home interference**
  - Ideal location is at the first splitter or in the drop amp to maximize benefit

- **57 dB maximum loss between MoCA nodes**

- **Low splitter insertion loss at MoCA frequencies**
  - Too high splitter insertion loss may limit the number of MoCA devices that can be on the same network

- **Low port to port isolation at MoCA frequencies**
  - Port to port isolation is the loss between output ports on a splitter
  - For operation in the return path (5 to 42 MHz), this needs to be ≥ 35 dB
  - For MoCA frequencies, it should be lower (≤ 20 dB is targeted, but will work with current products with higher port to port isolation)
The MoCA transmitter adjusts its bit rate automatically, depending on channel quality, to maintain a low bit error rate (BER) at the MoCA receiver.

As a result, the PHY rate is a measure of link quality.

PHY rate vs. path loss is plotted in the diagram to the right.
MoCA Loss Budget

- **Loss Calculations @ 1125 MHz**
  - Total cable length: 50 ft
  - Loss / 100 ft of Series 6 coax: 6.95 dB
  - Cable loss: 3.48 dB
  - Port-to-Port isolation of typical 3-way splitter: 29 dB
  - Total loss @ 1125 MHz: 32.48 dB

- **Loss Calculations @ 1525 MHz**
  - Total cable length: 50 ft
  - Loss / 100 ft of Series 6 coax: 8.09 dB
  - Cable loss: 4.05 dB
  - Port-to-Port isolation of typical 3-way splitter: 22 dB
  - Total loss @ 1525 MHz: 26.05 dB
• **Loss Calculations @ 1125 MHz**
  - Total cable length 100 ft
  - Loss / 100 ft of Series 6 coax 6.95 dB
  - Cable loss 6.95 dB
  - Port-to-Port isolation of typical 3-way splitter 29 dB
  - Insertion loss of 2-way splitter 4.1 dB, 3-way splitter 8.0 dB
  - Total loss @ 1125 MHz 48.05 dB

• **Loss Calculations @ 1525 MHz**
  - Total cable length 100 ft
  - Loss / 100 ft of Series 6 coax 8.09 dB
  - Cable loss 8.09 dB
  - Port-to-Port isolation of typical 3-way splitter 22 dB
  - Insertion loss of 2-way splitter 7.1 dB, 3-way splitter 12.0 dB
  - Total loss @ 1525 MHz 49.19 dB
MoCA Filters

• Are:
  - Low-pass filters that pass 5 to 1002 MHz and block signals above 1002 MHz, and are optimized to block signals within the MoCA frequency range used by cable operators, which is 1125 to 1650 MHz
  - Installed at each residence to protect against adjacent home interference and to keep the MoCA signals within the home network

• Can also:
  - Help improve performance of the in-home MoCA network

• Ideal locations:
  - At the ground block
  - At the input to the first splitter in the home
  - In the drop amp to maximize the benefit
MoCA Filter Performance

Ideally, a MoCA filter should:

- **Pass 100% of the energy between 5 and 1002 MHz**
  - Insertion loss is a measure of the signal lost passing through a device
  - If 100% of the signal passes through, the insertion loss would be 0 dB
  - In practice, close to 1.5 dB of signal is lost passing through a MoCA filter within the 5 to 1002 MHz range

- **Reflect 100% of the energy in the MoCA frequency range of 1125 to 1650 MHz**
  - Return loss is a measure of the reflected energy, and is the difference, in dB, between the forward signal and the reflected signal
  - If 100% of the signal is reflected, the difference will be 0 dB, so the return loss would be 0 dB
  - In practice, this is usually about 1.5 dB within the 1125 to 1650 MHz range
MoCA Filters

- Used to stop MoCA signals from interfering with adjacent homes
  - Passes signals below 1002 MHz
  - Reflects signals above 1002 MHz
MoCA Filter Benefit

- Use of the MoCA filter can improve the loss budget of the MoCA network.
- The reflected energy helps overcome port-to-port isolation of the splitter and lower the loss.

Port-to-Port Isolation
= 26 dB Loss @ 1125 MHz

Insertion Loss x 2 + Return Loss
= 4.1 dB + 4.1 dB + 1.5 dB
= 9.7 dB total Loss @ 1125 MHz
MoCA Filters

- Improve measured port to port isolation due to reflecting signals
  - Use of a MoCA filter reduces 2-way splitter isolation to <7.5 dB @ 1125 MHz, <10 dB @ 1525 MHz
MoCA Loss Budget with MoCA Filter

- **Loss Calculations @ 1125 MHz**
  - Total cable length 100 ft
  - Loss / 100 ft of Series 6 coax 6.95 dB
  - Cable loss 6.95 dB
  - Port-to-Port isolation of typical 3-way splitter w/MoCA filter installed 12 dB
  - Insertion loss
    - 2-way splitter 4.1 dB
    - 3-way splitter 8.0 dB
  - Total loss @ 1125 MHz 31.05 dB

- **Loss Calculations @ 1525 MHz**
  - Total cable length 100 ft
  - Loss / 100 ft of Series 6 coax 8.09 dB
  - Cable loss 8.09 dB
  - Port-to-Port isolation of typical 3-way splitter w/MoCA filter installed 19 dB
  - Insertion loss
    - 2-way splitter 7.1 dB
    - 3-way splitter 12.0 dB
  - Total loss @ 1525 MHz 46.19 dB
Loss Budget with MoCA Filter at the Tap

• Loss calculations @ 1125 MHz to the MoCA filter at the tap
  - Total cable length 400 ft
  - Loss / 100 ft of Series 6 coax 6.95 dB
  - Cable loss 27.8 dB
  - Insertion loss
    - 3-way splitter 8.0 dB
    - 2-way splitter 4.1 dB
  - Insertion loss of 3-way splitter 8.0 dB
  - Total loss @ 1125 MHz 47.9 dB

• Loss calculations @ 1125 MHz by splitter jumping
  - Total cable length 100 ft
  - Cable loss 6.95 dB
  - Port-to-Port isolation of 3-way splitter 29 dB
  - Insertion loss
    - 2-way splitter 4.1 dB
    - 3-way splitter 8.0 dB
  - Total loss @ 1125 MHz 48.05 dB
Loss Budget with MoCA Filter at the Tap

• Concerns
  - Loss on the path thru the drop to the filter and back thru the drop has almost identical loss as the path that includes the port-to-port isolation thru the splitter (-47.9 dB vs. -48.05 dB)
  - The propagation delay in the longer path = 0.372 µsec
  - The signals from both paths, virtually identical in strength, will appear at the MoCA node with a short delay between the two
  - This may result in potentially degraded performance, including:
    - Inter-symbol interference
    - Degraded MER (modulation error ratio)
    - Packet loss
    - Reduced data throughput

• MoCA is designed to work in an environment that has a great deal of reflections, so the extent of the potential interference is hard to quantify. The scenario described above is the worst case scenario, and will result in some amount of degraded performance.
Drop Amplifiers with Integrated MoCA Filters

- LPF ensures MoCA signals (1125 to 1525 MHz) are constrained to the home network.
- LPF reduces output port to port isolation to minimize loss for MoCA networking signals.
### Drop Amplifiers, 4-Port with MoCA Filter

- **Output Port to Port Isolation**
  - Typical 30 dB port to port isolation without the MoCA filter
  - MoCA filter provides better than 10 dB improvement over standard drop amps
  - Ensures link loss between devices is within 57 dB for a PHY data rate of 230 Mbps
Drop Amplifiers with Integrated Modem Port and MoCA Filter

- LPF ensures
  - MoCA signals (1125 to 1525 MHz) are constrained to the home network
  - Low output port to port isolation to minimize loss for MoCA networking signals
- MoCA bypass connection enables in-home networking between eMTA, set top boxes, and in-home networking devices (game consoles, PCs, etc.)
- Passive RF path to eMTA ensures connection to MSO network even in the event of power or amplifier failures
MoCA Drop Amplifiers with 2-Way Splitter Connected

- Use of an inline MoCA filter or a drop amplifier with integrated MoCA filter can reduce MoCA link loss by up to 15 dB
  - Splitter connected to MoCA drop amplifier = -10 dB port to port isolation
  - Splitter connected to MoCA filter = -10 dB port to port isolation
  - Splitter connected to typical cable drop = -25 dB port to port isolation
- For best performance, the splitter and MoCA filter should be as close together as possible
  - 1 dB of distance between them will increase the link loss by 2 dB
Troubleshooting MoCA

- Standard signal level meters don’t cover MoCA frequencies above 1 GHz
- Drop qualification for MoCA requires a different process than qualification for other services
- Node to Node testing for link budget and throughput are both required
- Based on cable age, loss at MoCA frequencies may be a concern
- Drop passives will vary in performance at MoCA frequencies
- Signal leakage and signal ingress are both concerns in MoCA
- Drop passive placement in the design is critical to maintaining the 57 dB MoCA Link Budget

SCTE, through Membership Services, has published an Implication Paper written by Spirent titled: “Deploying Enhanced Media Services with MoCA” that includes a detailed section on MoCA testing considerations. This document is available for free to SCTE members at [http://www.scte.org/content/index.cfm?pID=1728](http://www.scte.org/content/index.cfm?pID=1728)
MoCA Recap

- MoCA can work with existing installation materials
- Filtering is needed to isolate homes and add security
- Filtering can improve the link budget for MoCA
- Drop amps with MoCA filtering incorporated can improve MoCA performance
- Troubleshooting will require new tools and techniques
Questions?