MoCA HOME NETWORK
INSTALLATION AND MAINTENANCE

SCTE Greater Chicago Chapter Meeting
December 2, 2010
Agenda

- The Networked Home
- MoCA Technical Overview
- MoCA Installation and Maintenance
- Q & A
The Networked Home: Competitive Landscape

- Competition between service providers is intense
  - MSOs have leveraged new technologies to add *voice* to existing video/data packages
  - Telcos have leveraged new technologies to add *video* to existing voice/data packages
  - MSO and Telco triple play services bundles are comparable

- MSOs and Telcos are seeking ways to increase competitiveness and drive additional revenues through **new** service offerings

- Quad-play, enhanced access architectures and advanced home entertainment networks will be the service provider’s next significant opportunity to gain competitive advantage

<table>
<thead>
<tr>
<th></th>
<th>High-Speed Internet</th>
<th>Voice</th>
<th>Digital Video</th>
</tr>
</thead>
<tbody>
<tr>
<td>AT&amp;T</td>
<td>10.8%</td>
<td>-8.08%</td>
<td>46.60%</td>
</tr>
<tr>
<td>Verizon</td>
<td>14.88%</td>
<td>-8.32%</td>
<td>95.15%</td>
</tr>
<tr>
<td>Comcast</td>
<td>16.64%</td>
<td>84.05%</td>
<td>16.80%</td>
</tr>
<tr>
<td>TWC</td>
<td>12.90%</td>
<td>47.19%</td>
<td>9.70%</td>
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</tbody>
</table>
The Networked Home: Applications

- Video-On-Demand
- Multi-Room DVR Sharing
- Multi-Player Gaming
- Music, Photo and Home Video Sharing
- 3G/4G Cellular Wireless Integration - “3 Screens”
- Home Security and Automation
- Smart Grid Applications

New home networking technologies will be needed to support the new applications...
The Networked Home: Network Requirements

- Use existing home wiring plant
- Coexist with cable, telco and satellite services
- High capacity (100 Mb/s - 1 Gb/s)
- Low latency, jitter and loss to support real-time applications
- Reliable
- Secure
- Ubiquitous...available throughout the entire home
- Allows communication between all connected home devices
# The Networked Home: Network Technology Choices

<table>
<thead>
<tr>
<th>Physical Media</th>
<th>Ethernet</th>
<th>802.11b/g</th>
<th>HPNA</th>
<th>HomePlug AV</th>
<th>802.11n</th>
<th>MoCA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Twisted Pair</td>
<td>1000 Mb/s</td>
<td>54 Mb/s</td>
<td>160 Mb/s (Twisted Pair)</td>
<td>200 Mb/s</td>
<td>600 Mb/s</td>
<td>270 Mb/s</td>
</tr>
<tr>
<td>Air</td>
<td>Air</td>
<td>Air</td>
<td>Electrical Wiring</td>
<td>Air</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coax</td>
<td>Coax</td>
<td>Coax</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum PHY Rate</td>
<td>2.4 GHz</td>
<td>2.4 GHz - 28 MHz (Twisted Pair)</td>
<td>2MHz - 28MHz</td>
<td>2.4 GHz / 5.0 GHz</td>
<td>850 MHz - 1525 MHz</td>
<td></td>
</tr>
<tr>
<td>Spectrum</td>
<td>300 ft</td>
<td>~150 ft</td>
<td>~4000 ft (Coax)</td>
<td>~500 ft</td>
<td>~200 ft</td>
<td>300 ft</td>
</tr>
</tbody>
</table>

**Range**

- Ethernet: 300 ft
- 802.11b/g: ~150 ft
- HPNA: ~4000 ft (Coax)
- HomePlug AV: ~500 ft
- 802.11n: ~200 ft
- MoCA: 300 ft

**What would be the most optimal choice for your organization?**
The Networked Home: Why MoCA?

- Coaxial cabling is installed in the home network already
  - 90% North American homes
  - Outlets located near entertainment centers
- The coaxial network currently connects all of the video-enabled devices in the home
- MoCA occupies unused spectrum...adjacent to cable television system carriers
- Coaxial cabling is shielded with greater immunity to noise and interference (especially compared to wireless)
- MoCA offers performance suited for transporting multimedia content
  - Net Throughput = 135 Mb/s or 175 Mb/s
  - Low Packet Loss Rate (< 1e-5)
  - Low Latency (< 10 ms)
  - Low Jitter (< 1 ms)
MoCA: Multimedia over Coax Alliance

- Association developing and promoting a new standard for transporting multimedia content throughout the home using coaxial cabling
- Consumer Electronics and Chipsets
- Network Equipment Manufacturers
- Communications Services Providers - MSO, Telco and Satellite
- Test and Measurement Equipment

A complete overview of MoCA may be found here...
http://www.mocalliance.org
MoCA Physical Topology

- "Branching tree" using coaxial cable and passive filters and splitters
- Equipment connected to the MoCA network called "nodes"
- 1 GHz low pass filter at point of entry
- Designed to support max 300 ft / 25 dB loss (@ 750 MHz) between "root" and nodes
- Amplifiers must bypass MoCA frequencies
MoCA Logical Topology

- Fully-meshed logical point-to-point links established between all MoCA nodes
- Different modulation profiles (or, data rates) between nodes based on physical characteristics
- Maximum 8 nodes (MoCA 1.0) and 16 nodes (MoCA 1.1) connected to same network
- Supports point-to-point, multicast and broadcast transmissions
MoCA Frequency Plan

- MoCA operates using 50 MHz channels between 850 - 1525 MHz
- Analog and digital television uses spectrum between 5 - 1000 MHz
- MoCA “Frequency Plan D” operating between 1150 - 1525 MHz is commonly selected by cable system operators

Source: “MoCA: It’s in the House” Presentation
http://www.mocalliance.org
MoCA Channel Characteristics

- Port isolation and return loss (reflections) associated with home coaxial networks affect the MoCA channel’s quality
- Reflections create multipath interference
- Reflected signals arrive before, after or at the same time as the desired signals
- MoCA design has been optimized to address channel characteristics

Source: “MoCA Protocols”
http://www.mocalliance.org
MoCA Physical (PHY) Layer

- MoCA uses adaptive constellation multi-tone (ACMT) modulation—modeled after OFDM
- ACMT symbols mapped onto 224 discrete orthogonal sub-carriers—each modulated using BPSK - 256 QAM (1 - 8 bits per symbol)
- MoCA transmits using sub-carriers that can support the minimum bit error ratio only
- MoCA nodes use a number of “probe” messages to characterize channel conditions and develop optimized bit loading profiles
- Maximum PHY rate = 270 Mb/s
- Reed-Solomon FEC
MoCA Rates and Attenuation

- MoCA nodes maximum transmit power is -4 dBm - +8 dBm (+44 dBmV - +56 dBmV)
- MoCA PHY rates start to decline following about 50 dB loss (or, after power at receiver is less than about -50 dBm or -1 dBmV)

<table>
<thead>
<tr>
<th>MoCA PHY Rate (Mb/s)</th>
<th>Receive Power (dBmV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>225.0</td>
<td>41.75 - -2.25</td>
</tr>
<tr>
<td>192.9</td>
<td>-5.25</td>
</tr>
<tr>
<td>160.7</td>
<td>-8.25</td>
</tr>
<tr>
<td>128.6</td>
<td>-11.24</td>
</tr>
<tr>
<td>96.4</td>
<td>-14.25</td>
</tr>
<tr>
<td>64.3</td>
<td>-17.25</td>
</tr>
<tr>
<td>57.0</td>
<td>-17.95</td>
</tr>
</tbody>
</table>

Coax Network Data Rate vs. Attenuation

Minimum Receiver Sensitivity
MoCA Media Access Control (MAC) Layer

- MoCA controls access to the shared channel using TDMA
- Network Controller (NC) assumes responsibility for managing access to the network
  - Maintains and distributes the network’s clock reference
  - Advertises the network and handles node admissions
  - Schedules network transmissions and broadcasts media access plans
MoCA Quality of Service

- **MoCA 1.0: Prioritized QoS**
  - Supports priority-based queuing
  - Three traffic classes - high (voice), medium (streaming media) and low (interactive and best effort)
  - Uses Ethernet 802.1p field

- **MoCA 1.1: Parameterized QoS**
  - Allows guaranteed bandwidth reservations for specific unidirectional flows
  - Nodes make bandwidth requests using traffic specification that include information rate, burst size, packet size and duration
  - Network controller allocates bandwidth and coordinates with other nodes
MoCA Link Privacy

- Secures access to the network
- Protects the information exchanged between nodes
- Key based authentication and encryption
- All nodes share a common password
MoCA Standards

- **MoCA 1.0 standard ratified during February 2006**
  - PHY Rate = 270 Mb/s
  - Maximum Net Throughput Rate = 135 Mb/s
  - 8 nodes may be connected concurrently
  - Prioritized QoS - Bandwidth reservation based on the 802.1p field

- **MoCA 1.1 standardized during October 2007**
  - PHY Rate = 270 Mb/s
  - Packet aggregation (placing multiple Ethernet frames into a MoCA MAC frame) increases maximum MAC throughout rate to 175 Mb/s
  - 16 nodes may be connected simultaneously
  - Parameterized QoS - Admission control and reserved bandwidth for specific unidirectional traffic flows

- **MoCA 2.0 development occurring now...**
  - Target PHY Rates = 700 Mb/s and 1.4 Gb/s
  - Target Maximum Net Throughput Rates = 400 Mb/s and 800 Mb/s
MoCA Introduces Testing Challenges

- Coaxial Cable Plant Quality
  - Connectors, splitters, filters and amplifiers affecting MoCA carriers?
- Spectrum
  - Noise and interference impacting MoCA carriers?
- Network Capacity
  - Sufficient capacity to support customer’s applications?
- Customer Equipment Diagnostics
  - Customer equipment or coaxial cable plant?
- Quality of Experience
  - Verify the customer’s quality of experience?
**MoCA Installation and Maintenance Procedure Overview**

- Does the equipment’s MoCA interface function properly?
  - Connect directly to the equipment and determine data rates

- Does a bi-directional data rate issue exist between nodes?
  - Use test set to measure the data rates between MoCA nodes

- Does the coaxial plant between nodes have a problem?
  - Assess the coax segment-by-segment

- Does noise or interference affect the MoCA carriers?
  - Examine the bit loading analysis

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**Diagram:**

1. Validate the equipment’s MoCA interfaces
2. Measure the data rates between MoCA nodes
3. Confirm the integrity of the coaxial cable plant
4. Identify noise/interference using bit loading analysis
MoCA Interface Testing
Does the equipment’s MoCA interface function properly?

- 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 Data Rate Testing

*Does a bi-directional issue exist between nodes?*

- 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
MoCA Coaxial Cable Testing

Does the coaxial cable plant between nodes have a problem?

- 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
MoCA Bit Loading Analysis

**Does noise or interference affect the MoCA carriers?**

- Connect the test set to the affected outlet or splitter
- Establish the MoCA link and view the transmit and receive bit loading graphs
- 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)...
- Sectionalize the coaxial cable plant to locate the source
MoCA Quick Tests

- 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
MoCA Quality Testing

- **MoCA Statistics**
  - Link control, probe and admission messages transmitted and received

- **Ethernet**
  - Identify dropped / errored frames

- **Ping / Traceroute**
  - Verify MoCA nodes are reachable
  - Determine latency between nodes

- **Web Browsing**
  - Manage customer equipment
Audio/Video Quality Testing Over MoCA

Audio/Video Quality Testing
- Measures multi-room DVR audio/video streams transported using MPEG-2 / IP encapsulation

Quality Scores
- Reports audio/video quality using mean opinion score - 5 (best) - 1 (worst) quality

Expert Analysis
- Differentiate between packet loss and packet delay variation
- Lead's technicians to root cause

Passive Mode Measurement
- Measure audio/video quality “in-line”
- Use set top box to control audio/video stream
MoCA Network Testing Summary

- Measuring MoCA channel quality and data rates are critical for ensuring multimedia quality of experience.
- Validating customer equipment and pre-certifying coax will be an effective installation and maintenance strategy.
- Technicians need tools to overcome learning curve and efficiently identify a problem’s root cause and resolve issues.

Deploying MoCA networks and advanced multimedia applications creates new testing needs.
SCTE Implication Paper:
Deploying Advanced Media Services with MoCA

http://www.scte.org/content/index.cfm?pID=1729
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