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

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# The Networked Home: Competitive Landscape

- **Competition between service providers is intense**
  - MSOs have leveraged new technologies to add <u>voice</u> to existing video/data packages
  - Telcos have leveraged new technologies to add <u>video</u> 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 <u>new</u> 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**
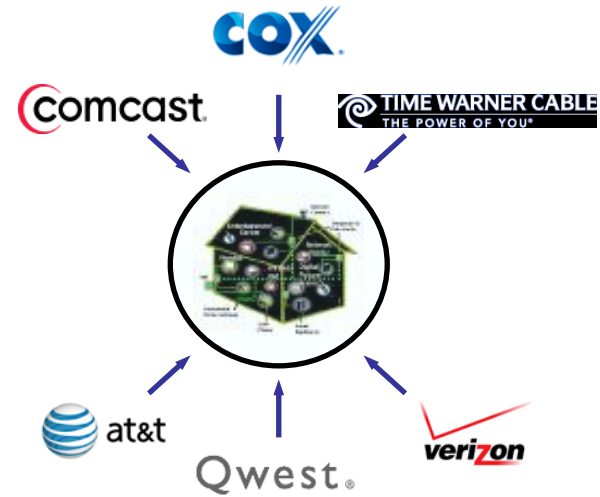
	High-Speed Internet	Voice	Digital Video
AT&T	10.8%	-8.08%	**46.60%**
Verizon	14.88%	-8.32%	**95.15%**
Comcast	16.64%	**84.05%**	16.80%
TWC	12.90%	**47.19%**	9.70%

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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
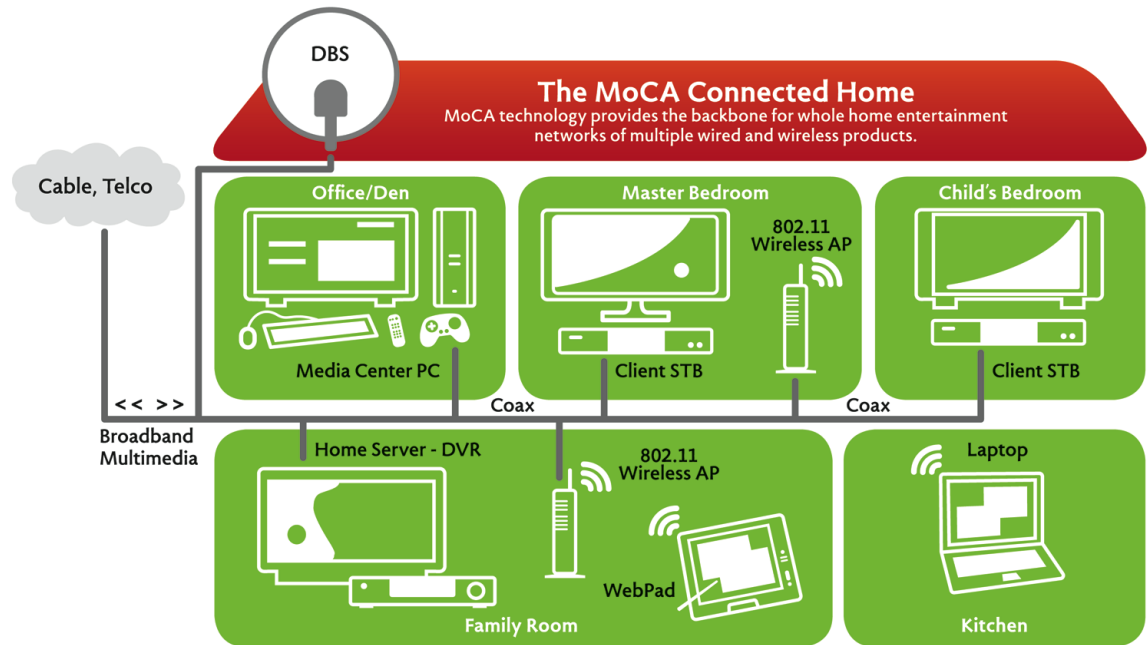
Source: "MoCA: The Standard for Home Entertainment Over Coax™" Brochure
http://www.mocalliance.org

New home networking technologies will be needed to support the new applications...

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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

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The Networked Home: Network Technology Choices

	Ethernet	802.11b/g	HPNA	HomePlug AV	802.11n	MoCA
Physical Media	Twisted Pair	Air	Twisted Pair / Coax	Electrical Wiring	Air	Coax
Maximum PHY Rate	1000 Mb/s	54 Mb/s	160 Mb/s (Twisted Pair) 320 Mb/s (Coax)	200 Mb/s	600 Mb/s	270 Mb/s
Spectrum		2.4 GHz	4 MHz – 28 MHz (Twisted Pair) 4 MHz – 52 MHz (Coax)	2MHz – 28MHz	2.4 GHz / 5.0 GHz	850 MHz – 1525 MHz
Range	300 ft	~150 ft	~4000 ft (Coax)	~500 ft	~200 ft	300 ft

What would be the most optimal choice for your organization?

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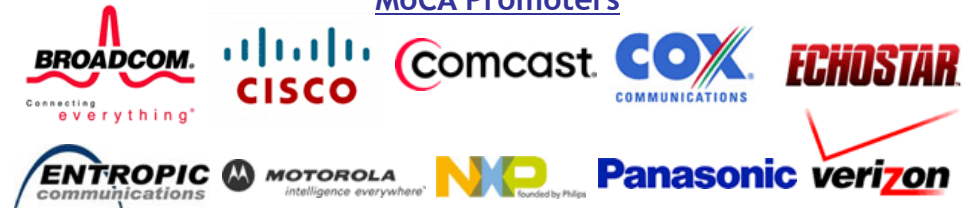# The Networked Home: Why MoCA?

- 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)

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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

MoCA Promoters

BROADCOM · CISCO · Comcast · COX COMMUNICATIONS · ECHOSTAR · ENTROPIC communications · MOTOROLA · NXP · Panasonic · verizon

MoCA Contributors

ARRIS · DIRECTV · intel · Silicon Image · ST · TEXAS INSTRUMENTS · TIME WARNER CABLE

MoCA Associates and Affiliates

Actiontec · ADB · Alcatel·Lucent · AMBIT · bel · caiw · Calix · CommScope · D-Link · FUNAI · HITACHI · HUMAX · Infineon · JDSU · LG · MACOM · mototech · NETGEAR · Pace · PPC · Pulse · SAMSUNG · Soontai · SPIRENT · SUNRISE TELECOM · THOMSON · TRILITHIC · WESTELL · WNC · ZiNWELL

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

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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

Multi-Room DVR

STB 1

"Root" Splitter

STB 2

Drop

POE Filter (1 GHz LPF)

STB 3

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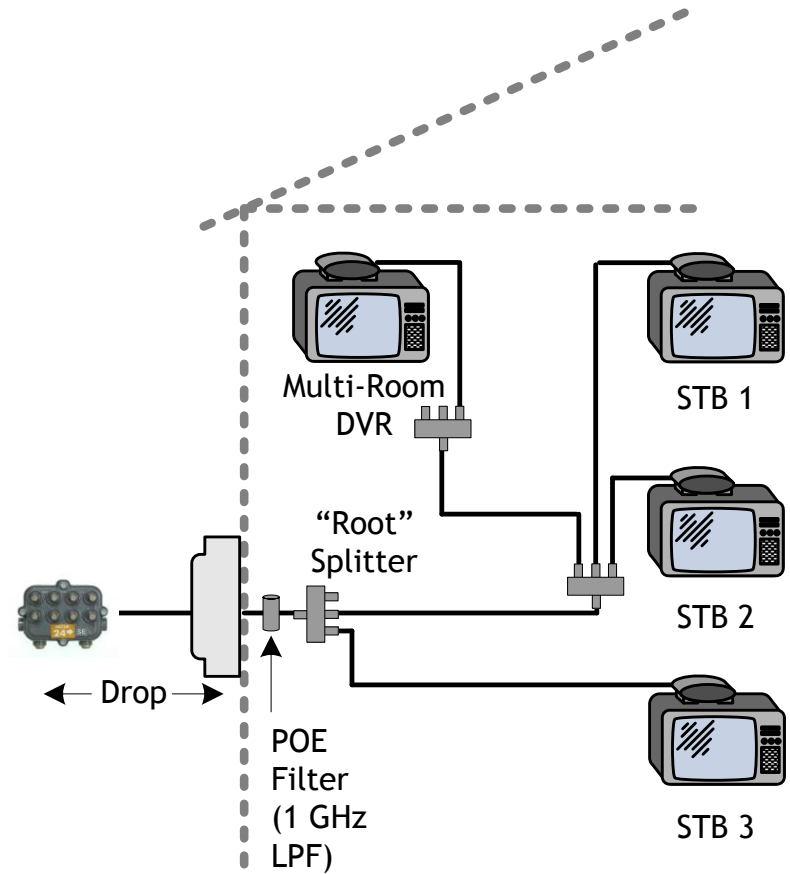
MoCA Logical Topology

- 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

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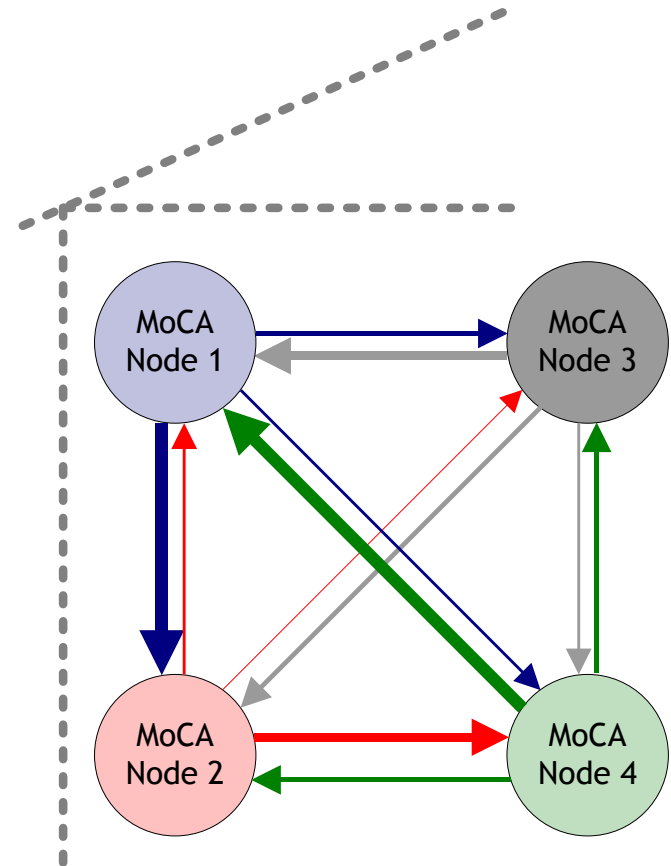
MoCA Frequency Plan

- MoCA operates using 50 MHz channels between 850 – 1525 MHz

- Analog and digital television uses spectrum between 5 – 1000 MHz

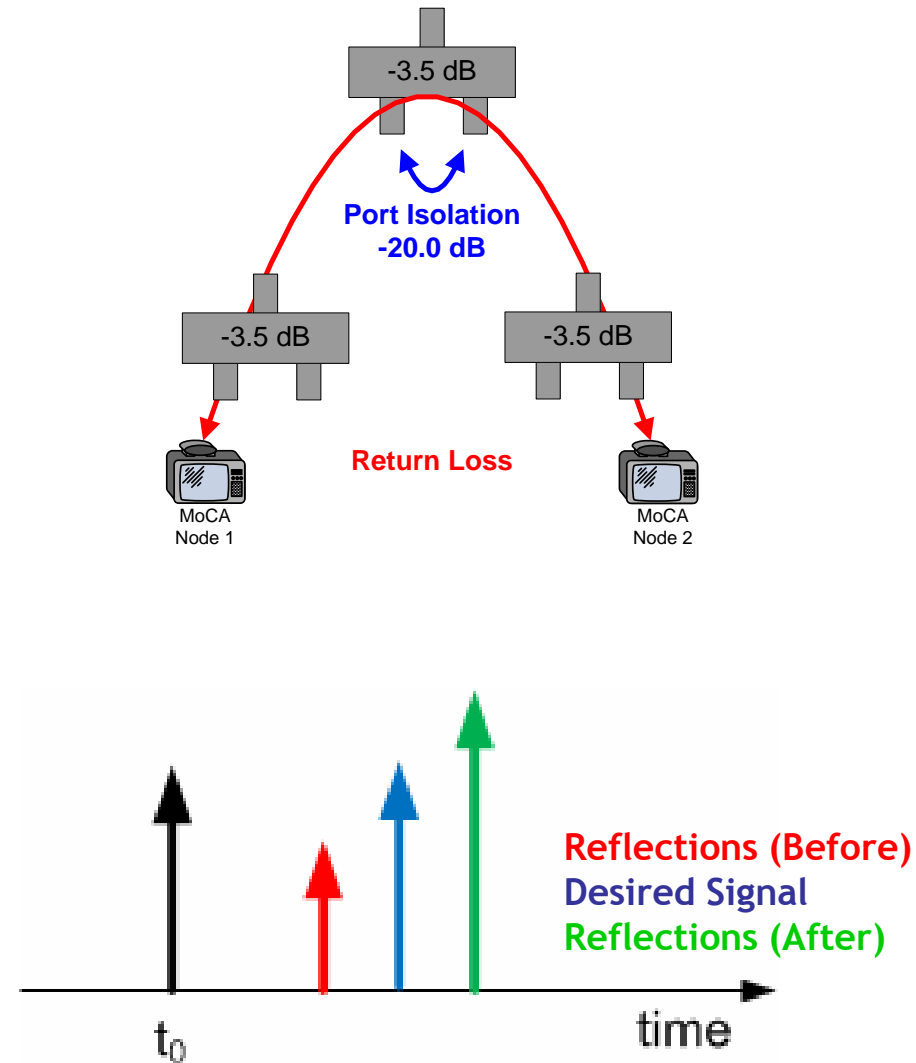- MoCA "Frequency Plan D" operating between 1150 – 1525 MHz is commonly selected by cable system operators
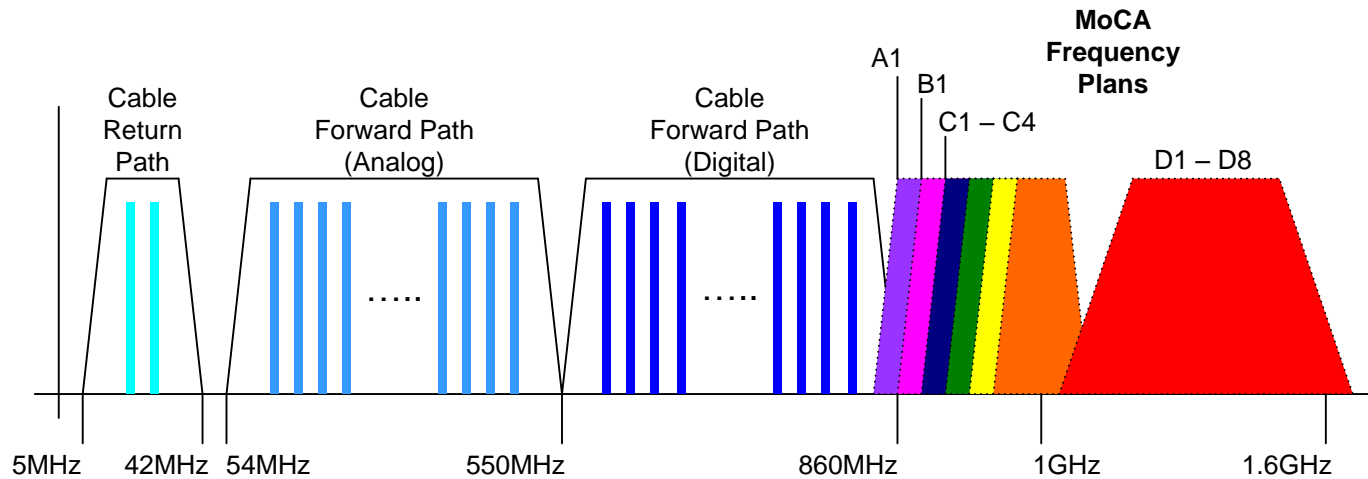
Source: "MoCA: It's in the House™" Presentation
http://www.mocalliance.org

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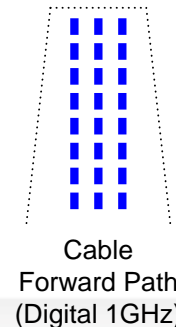
MoCA Channel Characteristics

- 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

-3.5 dB

Port Isolation -20.0 dB

-3.5 dB

-3.5 dB

Return Loss

MoCA Node 1

MoCA Node 2

t_0

time

Reflections (Before)
Desired Signal
Reflections (After)

Source: "MoCA Protocols"
http://www.mocalliance.org

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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
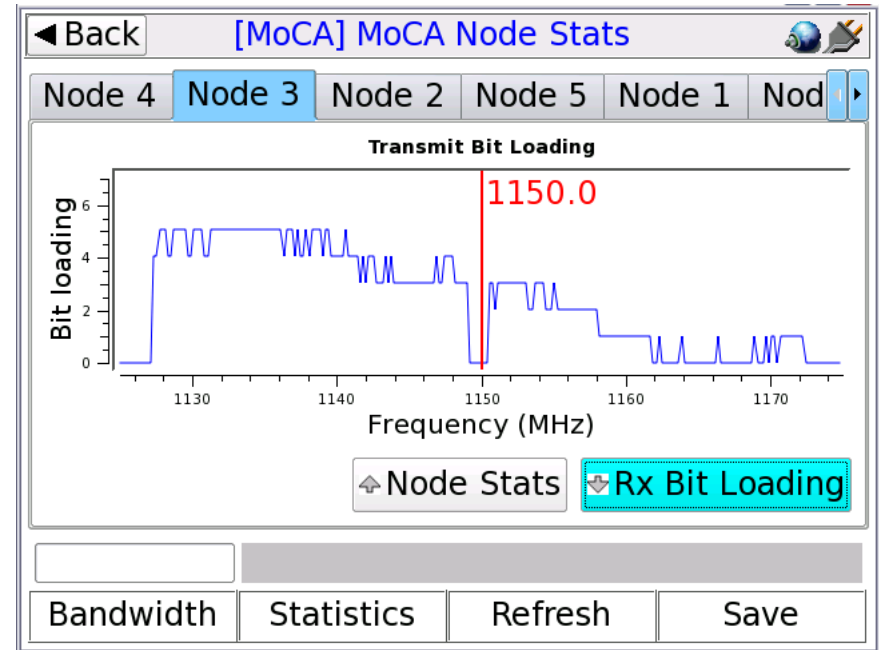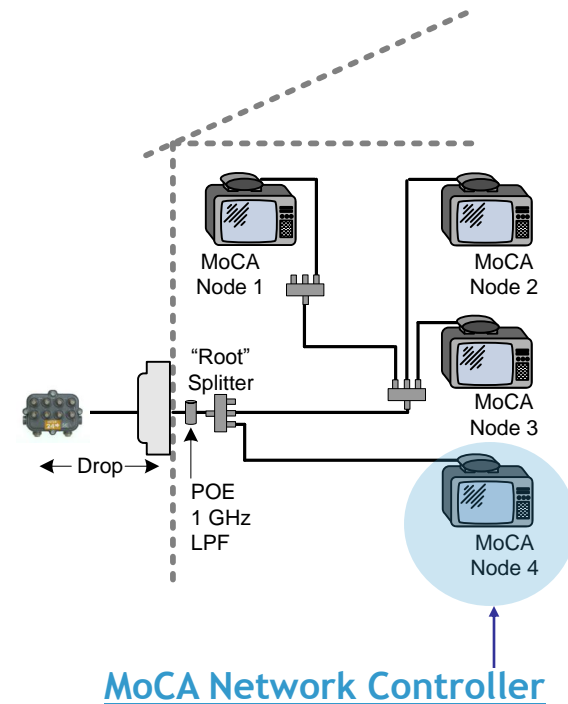
MoCA Rates and Attenuation

- 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)

Coax Network Data Rate vs. Attenuation
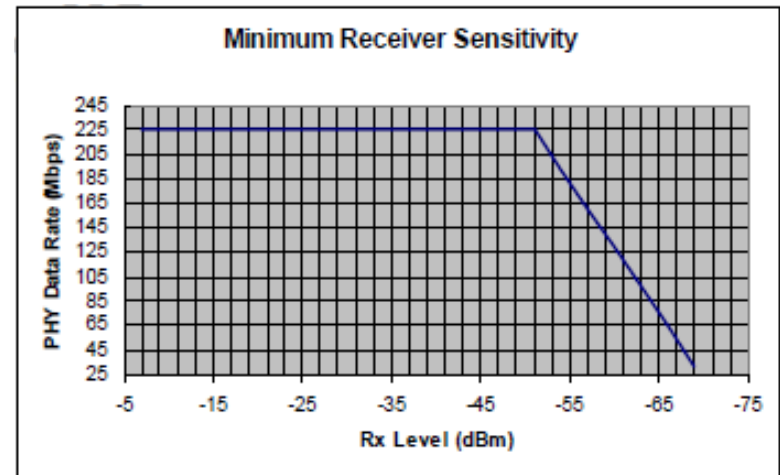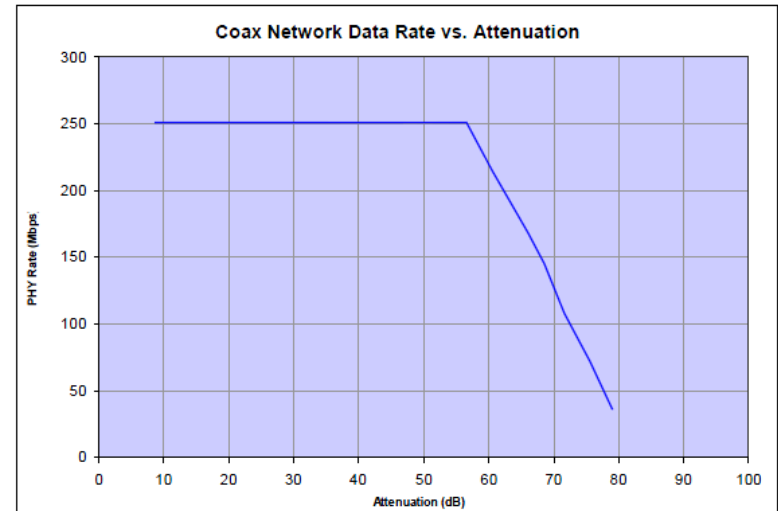
MoCA PHY Rate (Mb/s)	Receive Power (dBmV)
225.0	41.75 – -2.25
192.9	-5.25
160.7	-8.25
128.6	-11.24
96.4	-14.25
64.3	-17.25
57.0	-17.95

Minimum Receiver Sensitivity

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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 Node 1

MoCA Node 2

MoCA Node 3

MoCA Node 4

"Root" Splitter

← Drop →

POE 1 GHz LPF

MoCA Network Controller

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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

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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

◀ Back	[MoCA]	

Frequency(MHz): 1150-LAN ▾
Security Enabled: true ▾
Password: p@33w0Rd ▾

Start Cancel

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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 uni-directional 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**

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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?

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# 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

Validate the equipment's MoCA interfaces

↓

Measure the data rates between MoCA nodes

↓

Confirm the integrity of the coaxial cable plant

↓

Identify noise/interference using bit loading analysis

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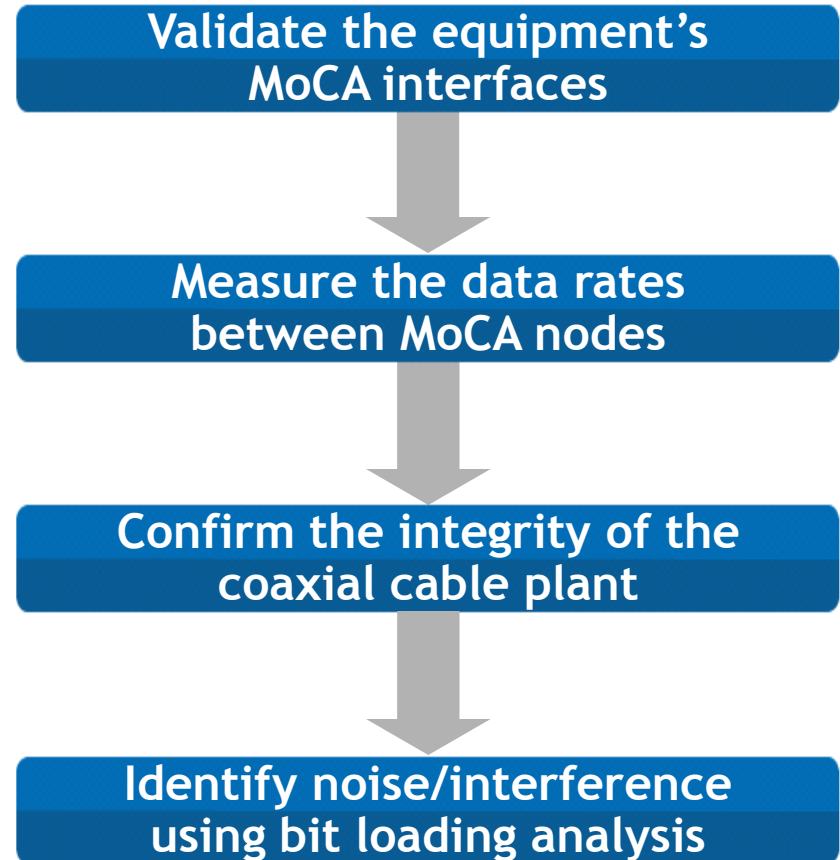
MoCA Interface Testing
## *Does the equipment's MoCA interface function properly?*

- 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

Multi-Room DVR

Attenuator

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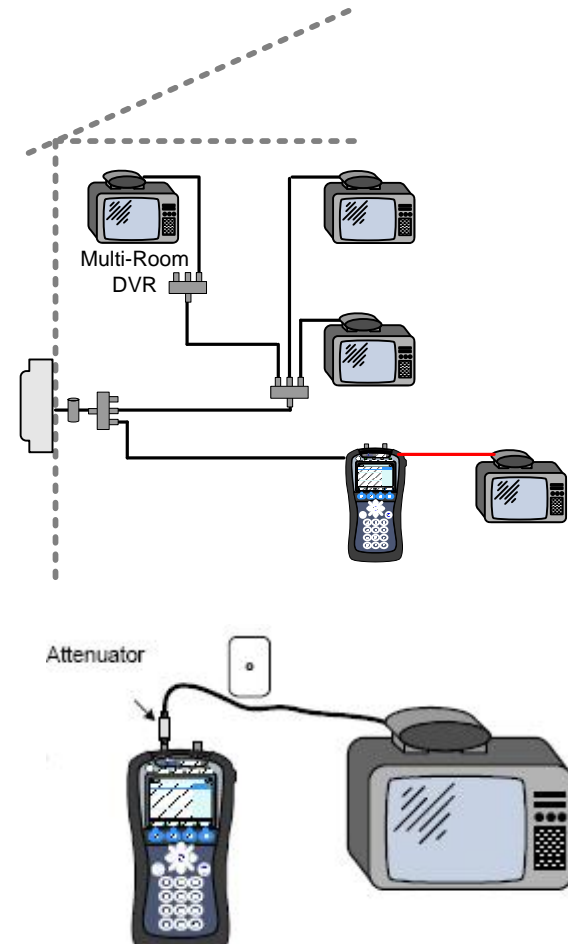
MoCA Data Rate Testing
Does a bi-directional issue exist between nodes?

- 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

Multi-Room DVR
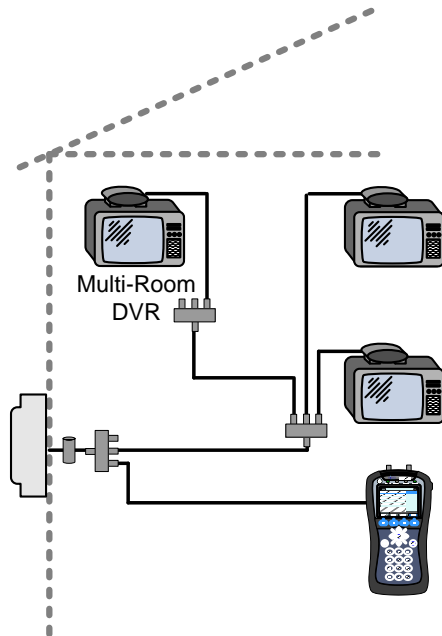
[MoCA] MoCA Bandwidth

◄ Back

Channel Freq.(MHz):	1150.0	Privacy:	Disabled

Network MoCA Ver.:	1.0	Flex Node: 3	* = NC

Rx / Tx	1	3	2	0*
3	85		231	251
1		70		
2		233		
0*		239		

Statistics	Node Stats		Save Start

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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

Multi-Room DVR

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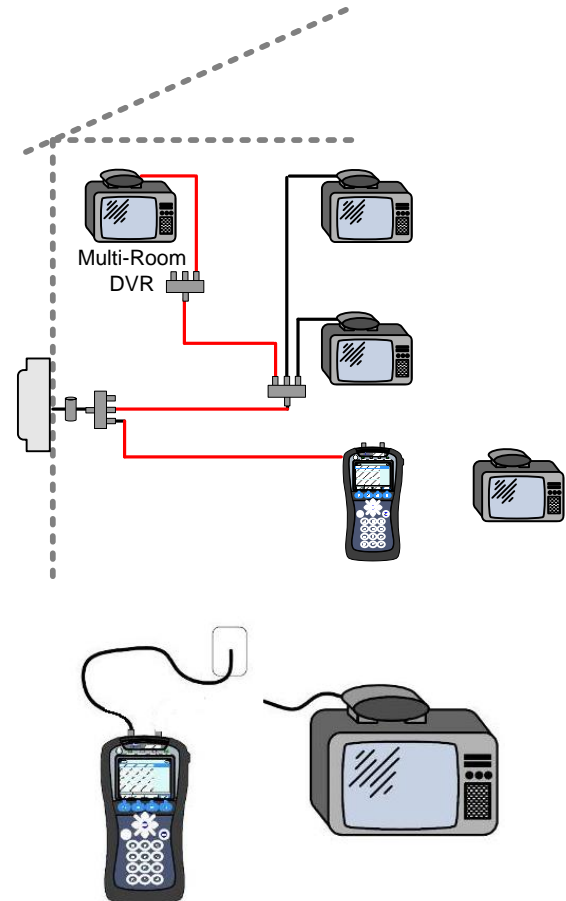
MoCA Bit Loading Analysis
Does noise or interference affect the MoCA carriers?

- 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
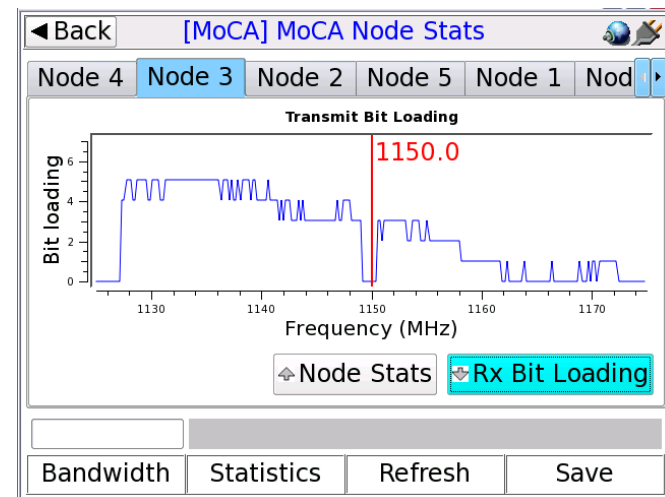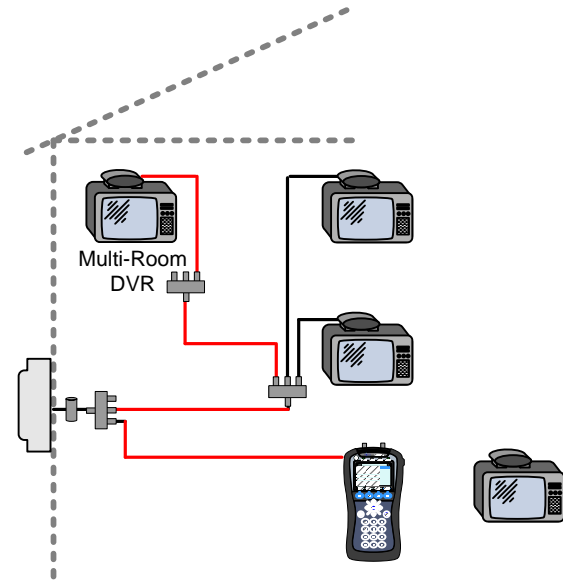
MoCA Quick Tests

- 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
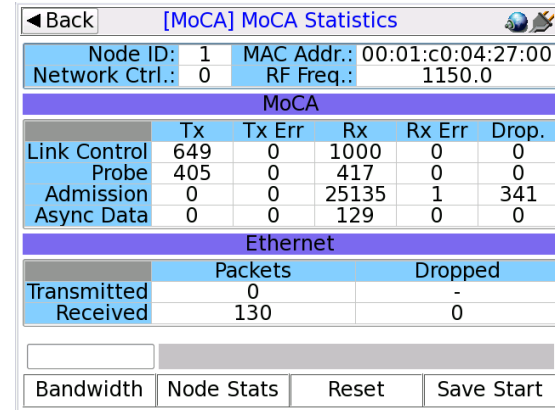
- ## Ethernet
  - Identify dropped / errored frames

- ## Ping / Traceroute
  - Verify MoCA nodes are reachable
  - Determine latency between nodes
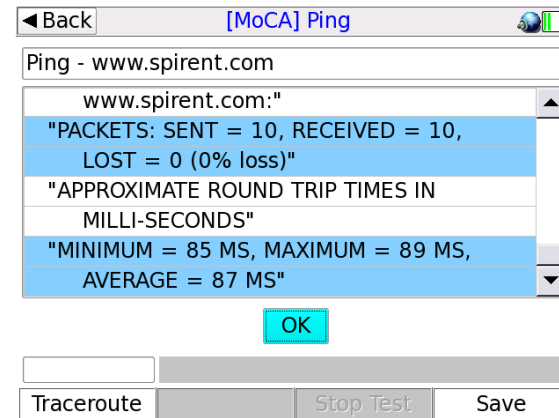
- ## Web Browsing
  - Manage customer equipment

◀ Back [MoCA] MoCA Statistics

| Node ID: | 1 | MAC Addr.: | 00:01:c0:04:27:00 |
| Network Ctrl.: | 0 | RF Freq.: | 1150.0 |

MoCA

	Tx	Tx Err	Rx	Rx Err	Drop.
Link Control	649	0	1000	0	0
Probe	405	0	417	0	0
Admission	0	0	25135	1	341
Async Data	0	0	129	0	0

Ethernet

	Packets	Dropped
Transmitted	0	-
Received	130	0

| Bandwidth | Node Stats | Reset | Save Start |

◀ Back [MoCA] Ping

Ping - www.spirent.com

www.spirent.com:"
"PACKETS: SENT = 10, RECEIVED = 10, LOST = 0 (0% loss)"
"APPROXIMATE ROUND TRIP TIMES IN MILLI-SECONDS"
"MINIMUM = 85 MS, MAXIMUM = 89 MS, AVERAGE = 87 MS"

OK

| Traceroute | | Stop Test | Save |

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Audio/Video Quality Testing Over MoCA

Audio/Video Quality Testing
- Measures multi-room DVR audio/video streams transported using MPEG-2 / IP encapsulation
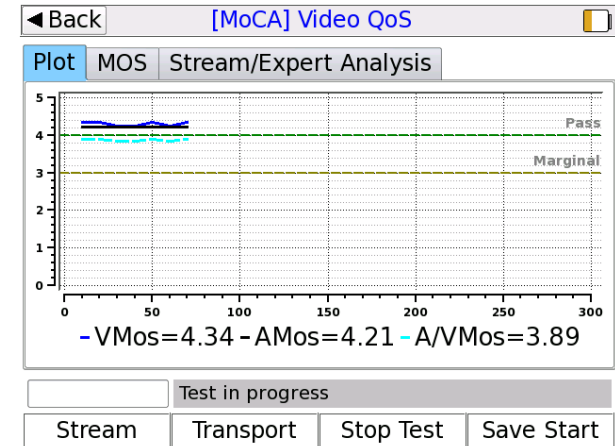
Quality Scores
- Reports audio/video quality using mean opinion score – 5 (best) – 1 (worst) quality

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

◄Back   [MoCA] Video QoS

| Plot | MOS | Stream/Expert Analysis |

Pass
Marginal

– VMos=4.34 – AMos=4.21 – A/VMos=3.89

Test in progress

| Stream | Transport | Stop Test | Save Start |

◄Back   [MoCA] Video QoS

| Plot | MOS | Stream/Expert Analysis |

| Codec Type | MPEG-2 Video |
Image Size	544X480
Image Type	SDTV
Degradation from Loss	0.00%
Degradation from Jitter	0.00%
Degradation from Codec Type	19.45%
Degradation from Delay	0.00%

Test in progress

| Stream | Transport | Stop Test | Save Start |

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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

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SCTE Implication Paper:
Deploying Advanced Media Services with MoCA

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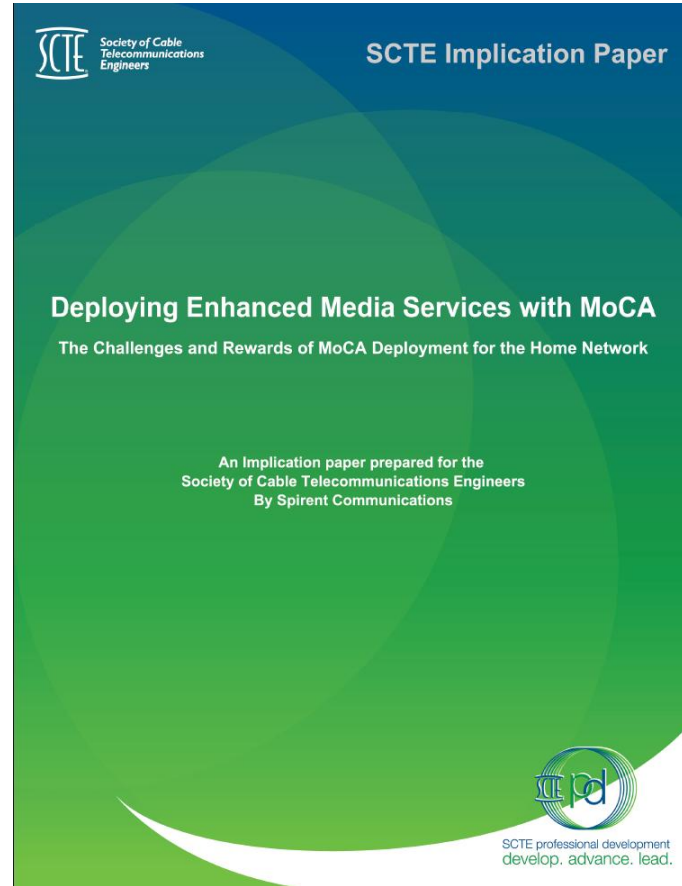
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