Multimedia over Coax Alliance
Field Test Report Executive Summary

June 2005

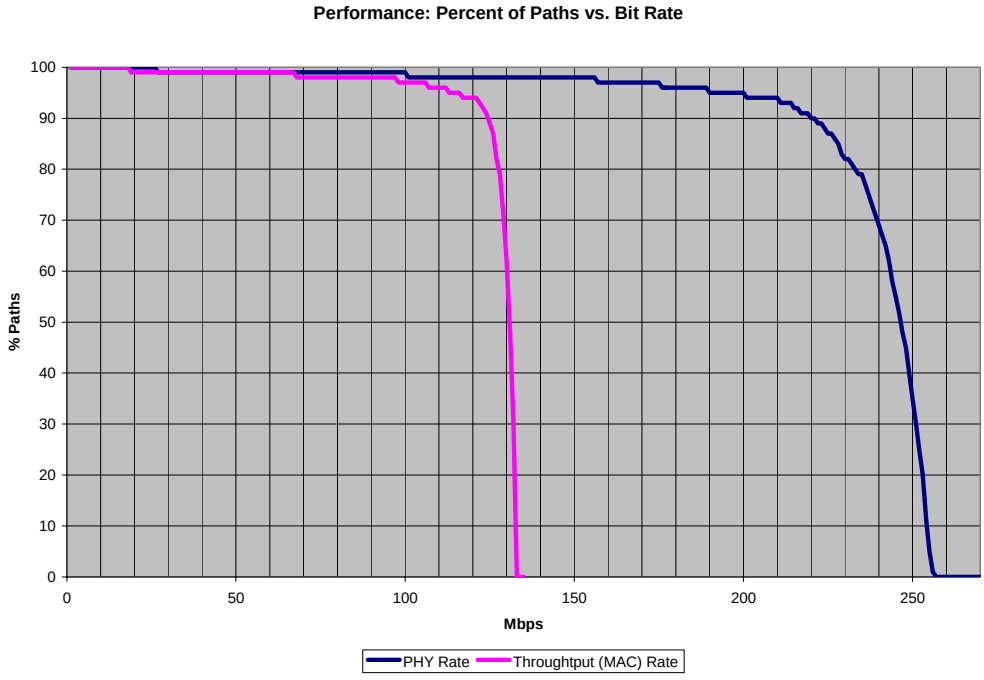
OVERVIEW

MoCA™ performed field trials in 246 homes across the USA and successfully validated that the technology for its initial specification meets and exceeds the MoCA requirements for multimedia home networking. Each of the 8 members of MoCA - Comcast, Echostar, Entropic Communications, Linksys, Motorola, Panasonic, Radio Shack, and Toshiba - performed testing in their respective areas resulting in tests of homes in more than 120 zip codes.

The key results measured and verified in the field tests were:

- Packet Error Rate less than $1E^{-6}$
- Latency less than 5ms
- Net usable (MAC) data rates, with no changes to the home coax system:
  - 97% of all paths in all homes achieved ≥ 100 Mbps
  - 100% of homes achieved > 120 Mbps on at least one path
  - 90% of homes achieved ≥ 80 Mbps on every path in the home
- Net usable (MAC) data rates, with simple remediation to the installed coax cable system:
  - 100% of homes achieved ≥ 95 Mbps on every path in the home

The results show that the MoCA technology supports the advanced multimedia requirements and coexists with existing services on the coax while operating in the 1000 MHz to 1400 MHz band. The test results cited in this document are averaged across the 1000 MHz to 1400 MHz band. The most important parameter for both the field testing and multimedia home networking deployment is Throughput, or net usable (MAC) data rate. The Throughput and PHY level bit rates measured in the field tests are shown in the following curves.



MoCA REQUIREMENTS

The MoCA marketing requirements document (MRD) sets forth technical and general requirements for in-home networking of high-definition multimedia, audio, voice, and broadband data. Each MoCA member contributed to the development of the MRD and the result was approved by MoCA's board of directors. The MRD includes comprehensive performance, quality of service (QoS), and general requirements. A summary of the major requirements includes:

Performance

- >100 Mbps net usable (MAC) throughput in > 95% of homes
- >80Mpbs net usable (MAC) throughput in 100% of serviceable coax outlets with reasonable remediation such as replacing low bandwidth splitters; installing in-line filters, diplexers, or amplifier bypasses; or point of entry (POE) filters onto the in-house coax. (note – a serviceable coax outlet is one that supports analog or digital TV service and/or DOCSIS)

Quality of Service

- Must support eight 802.1p priorities
- Latency: <10 ms for highest priority asynchronous traffic up to the maximum aggregate throughput.
- Packet Error Rate: $1E^{-5}$ at any throughput

General Requirements

- Support tree-branch, loop (or daisy-chain), and home run in-house coax topologies
- Self-adaptive to time and location varying characteristics of coaxial networks
- Plug and play at the majority of serviceable coax outlets in homes with no need to access or change splitters, or run new cables. For serviceable coax outlets that are not plug and play, there shall be a reasonable remediation/corrective method, such as replacing low bandwidth splitters; installing in-line filters, diplexers, or amplifier bypasses; or POE filters onto the in-house coax.
- Compatible with existing devices on the coax with no interference
- Compatible with existing services on the coax with no interference

TESTING METHODS

Testing was conducted in accordance with a Field Test Plan developed by the MoCA Field Test Working Group (FTWG) and approved by the MoCA Board of Directors in advance of the testing. The test plan included basic and advanced testing procedures for field tests and a comprehensive battery of lab tests for requirements inappropriate for field measurement. Basic testing in homes was done in a plug-and-play manner, without any changes to the home, and often with non-technical homeowners doing the testing. Additionally, advanced testing was conducted in a limited number of homes by technical personnel. The advanced tests included the basic testing procedure followed by detailed measurements and modifications to the in-home coax.

In-home testing was coordinated by Field Test Coordinator(s) (FTC) from each MoCA member. The FTCs were responsible for recruiting, training, and scheduling testers, maintaining the test system, and

uploading test results following each test. Testing was performed independently by technical and non-technical volunteers employed by MoCA member companies. Test homes included single family homes, apartments, and condos and were required to have at least 3 coax outlets.

All tests were performed using a field test kit developed by the FTWG. The kit allowed each tester to install MoCA devices in their home at up to four (4) coax outlet locations, continue operation of their cable or over-the-air services to their installed STBs, TVs, VCRs, PCs, etc. and simultaneously run data transmission tests over the MoCA network. During each test, the MoCA signal was automatically varied in transmission power and frequency of operation to characterize performance on each path being tested in the home. Test data were uploaded at the conclusion of each test to an independently maintained site. Data files were then validated prior to inclusion in the database of test results. In cases where the test results seemed anomalous, the site was revisited and retested by either the volunteer, the FTC, or trained personnel. During the revisits, the tester tried to ascertain and document the reason for the original anomalous results.

The data was collected from all tests, analyzed and plotted to yield statistics. Since the field test kit consisted of prototype hardware and test software some defects were found that resulted in updates to hardware and software to eliminate bugs or inconsistent operation. Each change to the hardware or software was analyzed against the test data to determine if a home required retesting. If so, the home was retested and the new data for the home was substituted into the database of collected data. Additionally there were errors introduced from some volunteer testers such as connecting the test unit to a coax output connector on a VCR or the like, neglecting to power on one or more of the test units, or neglecting to connect the coaxial cable at all. In these cases the tests showed invalid results which were corrected with a simple retest of the home using the correct procedures. The invalid data for the home was replaced with the valid data in the results database.

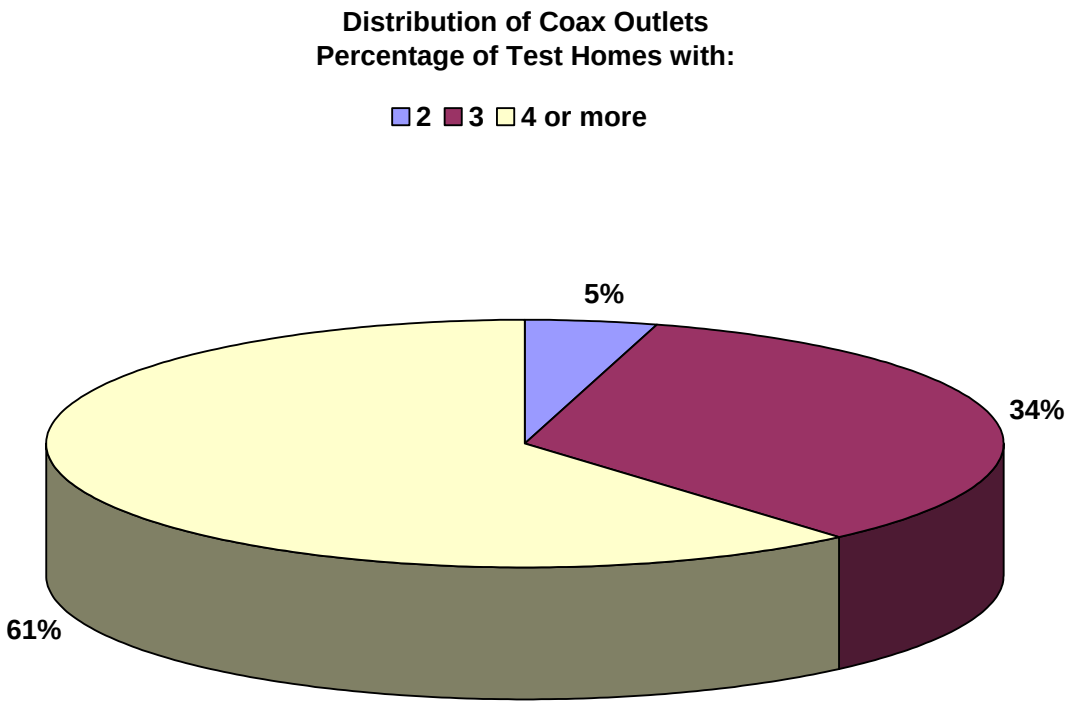
When an advanced test was performed in a home with multiple cable drops, the multiple drops were connected with a standard 4:1 splitter as specified by the test plan prior to testing. During basic testing, some multiple drop homes may have been tested by volunteers unaware of the multiple drops. In such instances the results were included in the statistics.

Test Home Statistics

Tests homes were located in and around areas where MoCA members have facilities. A summary of the general areas or counties of the test homes is provided below (A list of the covered zip codes is included in the appendix). Note the wide geographic dispersion of the test locations.

Santa Clara, CA	15
Orange County, CA	42
San Mateo, CA	1
Philadelphia, PA	57
Various, New Jersey	23
Atlanta, GA	21
Denver, CO	7
San Diego, CA	45
Fort Worth, TX	33
Riverside, CA	1
Simi Valley, CA	1
Total Homes	246

Along with the locations of the homes, the volunteers and FTC's were asked to collect specific data on the coaxial cables in the home, the equipment installed in the home, and the services provided on the coax. As noted earlier, homes were generally qualified by having three or more coax outlets. However, in a small number of homes, only two of the outlets were connected. The chart below shows the distribution of coax outlets found in the test homes. It is worthy to note that over half of the homes tested had four or more coax outlets in the home.



Conclusions

The primary goal of the MoCA Field Test was to validate that the proposed technology would meet or exceed the requirements established by MoCA for home networking of digital entertainment in a real world environment. The tests conclusively show the technology consistently exceeds the requirements in real world homes and coax configurations as represented by the wide range of locations and homes tested.

Appendix

Zip Code, City, State of MoCA Field Test Sites (partial listing)

07076	Scotch Plains	NJ
08003	Cherry Hill	NJ
08048	Lumberton	NJ
08053	Marlton	NJ
08054	Mount Laurel	NJ
08055	Medford	NJ
08083	Somerdale	NJ
08088	Vincentown	NJ
08096	Woodbury	NJ
08510	Clarksburg	NJ
08525	Hopewell	NJ
08534	Pennington	NJ
08803	Baptistown	NJ
18041	East Greenville	PA
18914	Brittany-Farms Highland	PA
18940	Newton	PA
18954	Richboro	PA
18966	Village Shires	PA
18974	Warminster Heights	PA
18976	Warrington	PA
19002	Ambler	PA
19020	Bensalem	PA
19027	Elkins Park	PA
19038	Glensdale	PA
19040	Hatboro	PA
19044	Ardmore	PA
19046	Jenkintown	PA
19047	Woodbourne	PA
19073	Newtown Square	PA
19086	Wallingford	PA
19090	Willow Grove	PA
19102	Philadelphia	PA
19104	Philadelphia	PA
19146	Philadelphia	PA
19403	West Norriton	PA
19440	Hatfield	PA
19446	Lansdale	PA
19454	North Wales	PA
19473	Schwenksville	PA
19720	New Castle	DE
30004	Alpharetta	GA
30008	Marietta	GA
30022	Alpharetta	GA
30024	Suwanee	GA
30032	Decatur	GA
30041	Cumming	GA
30043	Lawrenceville	GA
30047	Lilburn	GA
30078	Snellville	GA
30087	Stone Mountain	GA
30188	Woodstock	GA
30312	Atlanta	GA
30324	Atlanta	GA
30338	Atlanta	GA
30518	Buford	GA
75028	Flower Mound	TX
75104	Ceder Hill	TX
76008	Aledo	TX
76016	Arlington	TX
76020	Azle	TX
76022	Bedford	TX
76036	Crowley	TX
76039	Euless	TX
76087	Hudson Oaks	TX
76092	Southlake	TX
76109	Fort Worth	TX
76114	Westworth Village	TX
76116	Fort Worth	TX
76116	Forth Worth	TX
76131	Blue Mound	TX
76132	Fort Worth	TX
76137	Fort Worth	TX
76248	Keller	TX
80111	Englewood	CO
91746	La Puente	CA
91776	San Gabriel	CA
91913	Chula Vista	CA
91935	Jamul	CA
92007	Cardiff	CA
92008	Carlsbad	CA
92009	Carlsbad	CA
92019	El Cajon	CA
92024	Encinitas	CA
92029	Escondido	CA
92037	San Diego	CA
92056	Oceanside	CA
92064	Poway	CA
92078	San Marcos	CA
92109	San Diego	CA
92121	San Diego	CA
92122	San Diego	CA
92126	San Diego	CA
92127	San Diego	CA
92128	San Diego	CA
92129	San Diego	CA
92130	San Diego	CA
92543	Hemet	CA
92602	Irvine	CA
92603	Irvine	CA
92612	Irvine	CA
92618	Irvine	CA
92620	Irvine	CA
92630	Lake Forest	CA
92646	Huntington Beach	CA
92647	Huntington Beach	CA
92651	Laguna Beach	CA
92660	Newport Beach	CA
92677	Laguna Niguel	CA
92679	Portola Hills	CA
92683	Westminster	CA
92692	Mission Viejo	CA
92805	Anaheim	CA
92841	Garden Grove	CA
92867	Orange	CA
92868	Orange	CA
92869	Orange	CA
94018	El Granada	CA
94568	Dublin	CA
95014	Cupertino	CA
95070	Saratoga	CA
95124	San Jose	CA
95129	San Jose	CA
95138	San Jose	CA