High Speed Mobility Testing Report
Test Date: 19 June 2007

Summary

Live field testing of MeshDynamics wireless mesh node performance was conducted using streaming video and TCP Chariot data generation. MeshDynamics MD4350 wireless mesh nodes were set up in a one-mile test course along a public road, simulating a railroad right-of-way. Another MD4355 (including a scanning radio) was mounted in an automobile along with a camera, simulating the installation in a railcar. The automobile was driven in repeated passes along the simulated railroad right-of-way at speeds of 88-96 kph (55-60 mph).

During repeated passes, simulating a rail line length of over 11 km (over 7 miles), performance of both streaming video and streaming test data generated from inside the moving vehicle were monitored at a fixed point.

New software functionality added to the MD4000 mesh nodes significantly improved the consistency of performance in this mobility test. Past tests had shown problems with "drop-outs" of throughput during mobility testing. These new tests showed very consistent performance for both video and streaming data in the simulated rail environment, with very smooth shifting from node-to-node as the vehicle traveled.

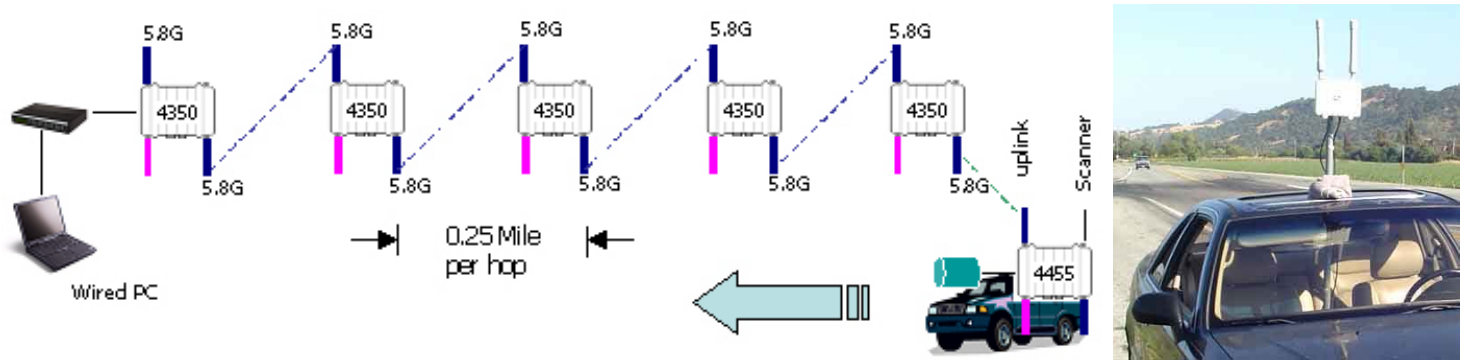
The primary enhancement to the MD4000 software was the capability of fragmenting large IP packets to minimize the impact of momentary errors. While this results in some small degradation of maximum data rate, overall performance for video will be much higher due to a more consistent rate.

Since the field test was conducted on a public highway, speeds were limited, but the performance of the software changes suggests that much higher vehicle speeds may be obtained with similar data and video performance.

Network Configuration

A network was created using 5 **MD4350** nodes along the shoulder of a highway (see graphic below). The backhaul connection between these nodes was formed using WiFi 802.11a. A wired Ethernet connection at the root node at one end of the network was the destination for video and data streams generated from the moving vehicle.

The moving automobile contained data generation equipment, a video camera, and an **MD4455** scanning wireless mesh node. The automobile made multiple passes through the test range in simulation of a rail vehicle moving down the railroad right-of-way. More details of the specifics of the test configuration are available from MeshDynamics.



Mobility Test Configuration with five Stationary 4350 nodes and one mobile 4455 node

The modulation scheme on the backhaul was confined to the 16-QAM (Quadrature Amplitude Modulation) option of WiFi 802.11a. While this limits the highest possible speed to 24Mbps, it provides a much more robust system due to a higher tolerance for errors and increased receive sensitivity. The video camera was also limited to 10 Frames per second though higher frame rates are possible.

MeshDynamics developed software to allow the fragmentation of longer packets (over 800 bytes). This is transparent to sending and receiving devices, but allows for shorter retransmissions in the case of short (e.g., single-baud) errors. The effect is to slightly decrease the highest possible throughput, but to allow much more consistent throughput for data and video streams. Most importantly, the minimum bandwidth is much higher than observed in previous tests, substantially improving video performance.

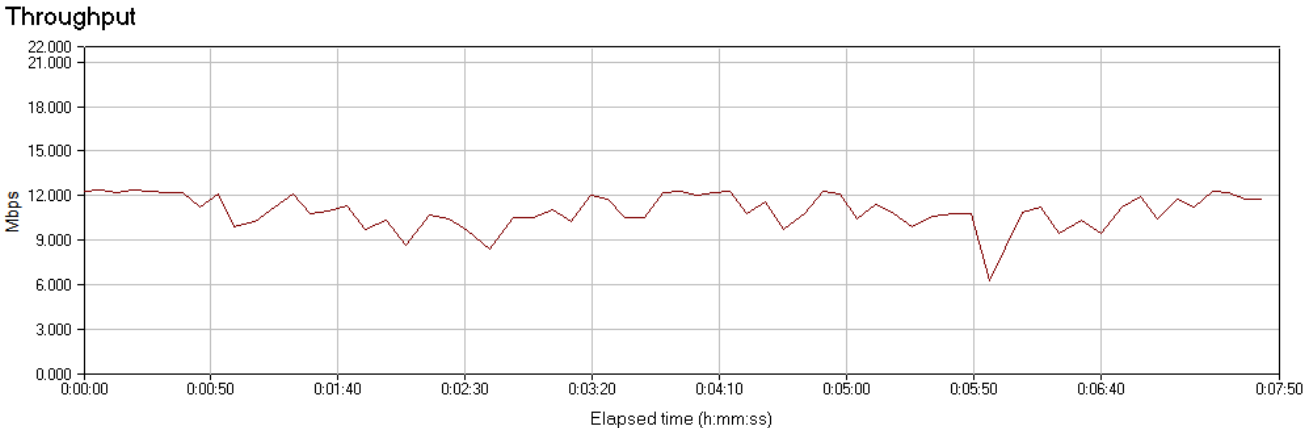
The MeshDynamics EffiStream™ features allowed the performance of the nodes to be tuned specifically for the video application.

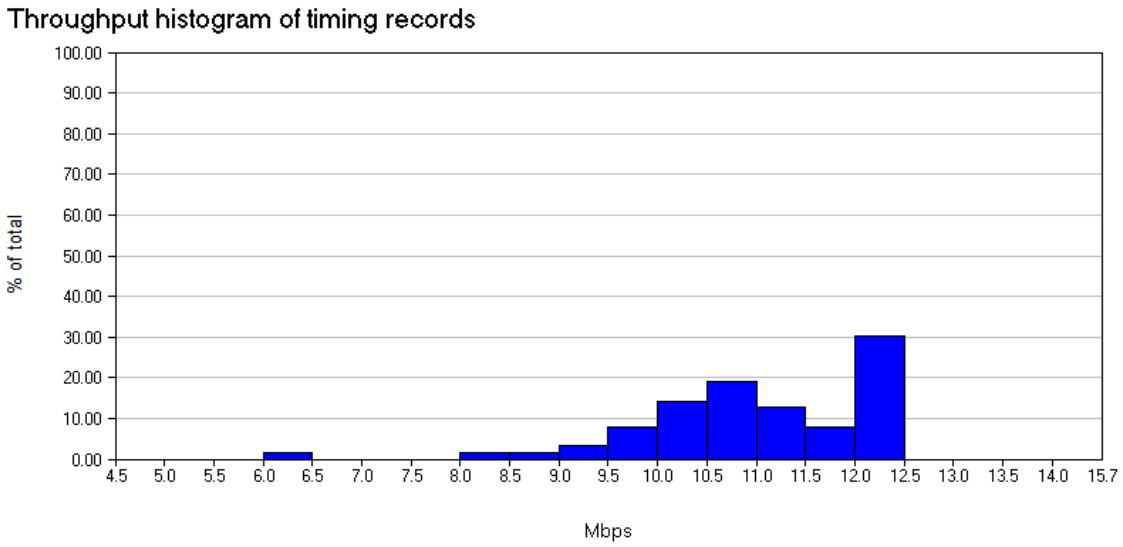
Test Results

Results are shown, below, with additional detailed results available from MeshDynamics. Both TCP Chariot and video streams were measured during test runs. Video streams exhibited few transient artifacts (errors) and the average throughput in TCP Chariot tests was over 10Mbps. Significantly, the minimum momentary throughput observed was over 6 Mbps, significantly higher than in past tests. The switching between nodes as the vehicle travels is transparent and consistent, not appreciably affecting the data or video streams.

TCP Chariot test results between the WIRED PC and the VEHICLE PC

Bytes transferred	630 Mbytes
Max throughput	12.395 Mb/s
Avg throughput	10.868 Mb/s
Minimum throughput	6.248 Mb/s
Chariot script	Benchmarks\High_Performance_Throughput.scr
10-12.3 Mbps Percentage	86%
09-10.0 Mbps Percentage	11%
0- 09.0 Mbps Percentage	3%





Test Video

The Live MPEG-4 stream from the vehicle camera was recorded at the WIRED PC using Axis Camera Station software. A low-resolution copy of the recorded stream is available for viewing at: http://video.google.com/videoplay?docid=8355845277500091788 Please allow the player to load the entire video before viewing.

The screen of the WIRED PC running MeshDynamics Network Viewer and Chariot was continuously captured into video. A low-resolution copy of the capture is available for viewing at: http://video.google.com/videoplay?docid=-9054716494385101065

Summary

These new test results demonstrate the effectiveness of MeshDynamics' recent software developments in delivering higher and more consistent performance in mobile environments such as rail. Although the current suite of tests were not at the highest speeds typical of modern rail lines, MeshDynamics expects that similar results will be obtained at much higher speeds than those tested to date. Analysis of the test data suggests that speeds of up to 240 mph (400 kph) may be obtained with the current software release.