Cisco and Intel: Collaborating to Enhance 802.11n in the Enterprise

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Few enterprise IT managers would question the assertion that Wi-Fi is the most significant emerging enterprise network access technology of this decade. The vast majority of these managers enjoy the benefits of Wi-Fi at home and on the road, and while the convenience of wireless in those venues is undeniable, benefits in the enterprise are even more significant. Wireless access is both powerful and inevitable and the emergence of the 802.11n standard raises the ante to a new level.

Over a 10-year period, Wi-Fi has overcome technical obstacles to emerge as a mainstream network solution, a notable element of this new era of mobility. However, its more subtle shortcomings have made it difficult for many enterprise IT professionals to view it as strategic. Performance was limited, reliability was unproven, security was inadequate, and both deployment and operational costs were high. The emergence of new standards and product offerings --- most notably the IEEE's 802.11n standard --- now have Wi-Fi positioned for ubiquity, not just in the home and select vertical markets, but in the carpeted enterprise as well.

For enterprise network veterans eager to meet demands of their co-workers, it's been a long time coming. The emergence of a robust security architecture, manageable infrastructure and high-speed 802.11n removes many legacy obstacles, but many key design and operational issues remain. Of these, robust interoperability, secure roaming, and scalable performance are all critical yet are also complex to characterize and measure. Pilot projects provide some insight, as do internal product bakeoffs and third-party tests, but evaluating the toughest problems facing enterprise Wi-Fi has been a challenge that has so far eluded the industry.

Intel and Cisco, market leaders in enterprise Wi-Fi, understand this challenge, and their collaborative evaluation of 802.11n performance in Intel's Over-the-Air (OTA) test facility in Portland, Oregon represent perhaps the most ambitious vendor-sponsored effort to systematically document and resolve enterprise Wi-Fi challenges. The two companies have both made major investments in this facility, in their collective efforts to assure compatibility and high performance, reduce customer problems, and systematically evaluate best practices for design and deployment.

In a September, 2008 visit to the OTA lab, I engaged Cisco and Intel engineers in a discussion of Wi-Fi testing, reflecting on my own experiences over the past decade designing and conducting enterprise Wi-Fi tests. I came away both impressed with current test results and intrigued about future opportunities.

A Brief History of Wi-Fi Testing

Owing largely to their technical roots in key vertical markets, enterprise-oriented 802.11 product offerings have been around since the initial IEEE standard. I conducted my first comparative evaluation of such products in late 1998 with results published in the March 22, 1999 issue of Network Computing Magazine (http://www.networkcomputing.com/1006/1006r22.html). At the time, the technology was limited as an enterprise network solution. At 2 Mbps, performance was very limited, the security architecture lacked enterprise capabilities, and interoperability was hit or miss. As a solution for retail, distribution, education, and health care verticals, 802.11 had some legs, but the broader enterprise market showed little interest.

While 802.11n commands our attention today, ratification of the 802.11b standard and the emergence of the Wi-Fi Alliance in 1998 marked the first important maturation point for the emerging broadband wireless industry. The fundamental interoperability issues we discovered in our early lab tests would now be addressed through an independent product certification program. It was a valuable first step that advanced the industry but, over the years, it became increasingly clear that Wi-Fi certification addressed only a small proportion of enterprise IT issues. As a test of basic interoperability, Wi-Fi certification had significant value, especially for the consumer market. However, it was never designed to tackle the most challenging issues

related to enterprise Wi-Fi. In short, products certified by the Wi-Fi Alliance were tested for basic interoperability, but lacked assurance of performance and rich interoperability as part of a larger enterprise network.

To fill the void, many enterprise network professionals turned to third parties, including independent labs and technology-oriented publications like Network Computing and Network World, to move beyond the bias of whitepapers and vendor-commissioned tests. Enterprise network managers working in larger IT shops often devised and conducted their own internal tests, sometimes comparing notes with their peers. Vendors also participated in customer bakeoffs, which included a series of tests designed to evaluate the system attributes thought to be most important to that organization. To meet demands of an expanding market, a number of wireless test tools also emerged, promising to provide reliable and repeatable measures of system performance.

While these activities played a positive role in advancing the Wi-Fi industry, all were lacking. Most significantly, these tests failed to adequately characterize operational issues with wireless in real world enterprise environments. IT professionals found themselves hoping that the results of limited-scale tests could provide an indicator of expected performance as the technology was deployed across the enterprise. Unfortunately, this assumption often proved to be invalid. Instead, they were often confronted with ambiguous design guidelines, unexpected performance problems, and disruptive compatibility issues.

Intel's OTA Testing Facility

In my first test of 802.11 products, I evaluated client network cards from InTalk, Samsung, Lucent and MaxTech, amongst others, but none from Intel. As a relative latecomer to Wi-Fi, Intel initially played catch-up to other leading chipset vendors and some of their early offerings didn't stack up too well in our testing. However, once Intel made the decision that Centrino would be a central element of their mobile computing strategy, the company leveraged its vast resources on creating one of the most advanced 802.11 development and testing facilities in the world. This has evolved to include an impressive array of RF isolation chambers, conductive testing facilities, and automated test suites at its Jones Farm campus as well as an Over-the-Air (OTA) testing facility in suburban Portland, a facility intentionally isolated from the RF pollution that typifies most urban environments.

The OTA facility is a 27,000 square foot office building with a typical blend of cubicles, walled offices, and conference rooms. Desks arranged in cubes emulate a typical open-office environment while sheet-rocked walls provide obstructions that impair the free flow of RF signals, introducing reflections that often cause performance and reliability issues for wireless LANs. Purists might argue that the notable lack of people – sometimes referred to as bags of RF-absorbing water to RF engineers – diminishes the real-world accuracy, but that's only a minor deficiency.

One of the more interesting elements of Intel's OTA facility is the robotic instrumentation that allows certain tests, including performance, roaming, and X-Y coordinate positioning, to be automated under computer control. This enhances the productivity of the testing staff, but more importantly, it also allows for reproducible test results. For example, enhancements to a client roaming algorithm can be systematically evaluated and directly compared to previous results conducted under identical conditions.

In ten years of testing enterprise wireless LAN products in our real-world labs at Syracuse University, we applied many of the same principles in efforts to generate objective test results, but Intel's facility takes systematic testing to a new level. In addition to the robotic instrumentation, Intel has developed custom software that correlates physical testing with results gathered through wireless protocol analysis tools and displays aggregate results in a manner that makes

performance variations and problems readily apparent. Their collaboration with Cisco provides the Wi-Fi infrastructure most commonly encountered by Intel customers and also the field experience of Cisco's wireless engineering team.

In my day-long visit to Intel's facility, I had the opportunity to fully engage the Cisco and Intel teams working in the OTA lab, as well as technical managers from their conductive wireless testing facility. Conductive testing is used for quality assurance, protocol conformance, and Wi-Fi certification. These two facilities and their respective approaches are highly complementary.

The Cisco – Intel Partnership

Intel's market position as the leading supplier of Wi-Fi client radio subsystems (over 15 million 802.11n wireless NICs already shipped) is akin to Cisco's dominance in the enterprise Wi-Fi market (63% market share for enterprise 802.11 offerings according to Q208 results compiled by Dell'Oro Group). The two companies share a common customer base and also a common need to address customer needs and problems without resorting to the finger-pointing that is common to many multi-vendor computing environments, particularly when dealing with emerging technologies like 802.11n.

Finger-pointing has a long history in the enterprise network market, even in the Ethernet market, where interoperability is seldom a significant issue. But in the early days of 10BaseT, I personally experienced the disruption of client and infrastructure interoperability problems that only appeared under real-world conditions of high utilization. In fact, early problems were serious enough that single-vendor Ethernet solutions had significant appeal.

Given today's market realities, single-vendor Wi-Fi implementations are not practical. Instead, enterprise IT professionals must have confidence that the respective infrastructure and client vendors are cooperating on product development and field engineering support. Unfortunately, this is frequently not the case in an industry where business and product strategies, and even engineering egos, sometimes discourage rather than encourage cooperation.

The OTA facility has proven to be a fertile venue for enhancing the cooperation between the Intel and Cisco. Some of that has been driven by pressure to resolve problems from high-profile customers, some of it by a mutual desire by both companies to provide value-added services not available from their competitors. Whatever the motivation, for customers deploying Cisco infrastructure and using Intel wireless clients, the resource commitments made by these two companies provide a very valuable service to their customers.

OTA Testing Overview

During my visit to the OTA facility, Intel and Cisco staff provided an overview of testing methods and I was able to assess the results of recent tests. I also spent considerable time discussing wireless industry technical challenges with product managers, technical marketing specialists, and wireless engineers. As an individual who has encountered a long list of performance and interoperability problems over 10 years of conductive and over the air product testing, I was fascinated by what I saw but also determined to provide the critical assessment they were no-doubt expecting.

Intel and Cisco have cooperated on several important tests, including the following:

- Line of sight (LoS) and non line of sight (NLoS) performance testing
- High client density testing
- 802.11n and 802.11abg interoperability and capacity testing
- Enterprise roaming testing

It should be noted that the above tests do not represent an exhaustive set of Wi-Fi tests. For example, the automated XY coordinate testing designed to reveal the enhanced reliability of 802.11n by systematically measuring performance of notebook computers in an array of different physical orientations is not unique to Cisco and Intel and was therefore not a focus of my evaluation. Likewise, tests of protocol conformance and security implementation, which are more efficiently evaluated through conductive testing, were also not an area of focus. I was mainly interested in tests that contributed to the vendors' ability to optimize their interoperability and address specific problems encountered by their customers.

The LoS and NLoS tests were designed to measure the performance of Cisco infrastructure and Intel clients in a real-world scenario that includes the cumulative impact of both the wireless radio subsystem as well as the antenna system. The latter is particularly important for 802.11n systems, which rely on more complex antenna implementations to support spatial multiplexing. A laptop computer is mounted on a robot equipped with a rotating turntable that positions the laptop in a continuously variable orientation, rotating the laptop 360 degrees every minute (i.e., 1 RPM). Using fixed AP's mounted on ceiling tiles as per Cisco's recommendation, the robot follows a predefined path through the facility. Along the path, throughput scripts are run while other metrics, including signal level, are gathered. Results from multiple test runs are averaged and correlated with other data gathered during the test runs.

The high client density test suite evaluates performance and scalability of 802.11n infrastructure and clients. A large number of laptops are installed in a room (in the future, this will be extended to the entire facility) and a scripted set of performance tests are run measuring bidirectional performance while incrementing the number of concurrent sessions. The goal is to achieve consistent aggregate performance as the number of laptops increases.

The 802.11n and 802.11abg interoperability and capacity tests tackle the backwards compatibility element of 802.11n implementation and management. It is well known that concurrently supporting 802.11abg and 802.11n clients on the same AP will yield performance that is lower than a pure 802.11n environment. However, the popular perception that the presence of an 802.11abg client will slow the entire network down to the maximum provided by that client is clearly refuted. Even with a mix of 7 11a clients and 1 11n clients, aggregate performance exceeds that of 8 11a clients. And with a single 11a client and 7 11n clients, aggregate performance exceeded 140 Mbps, almost 6 times what you would achieve with 11a clients.

Finally, the enterprise roaming tests address one of the most problematic aspects of enterprise Wi-Fi design. Fast secure roaming is becoming an increasingly critical component of enterprise wireless systems, one that will become even more critical on tomorrows converged wireless networks offering real-time voice and data services. Since 802.11 relies on clients to make roaming decisions, client vendors are on their own to devise appropriate algorithms. In past testing, we have witnessed numerous clients (including early Intel clients) that perform poorly in such scenarios, either holding on to an AP when an alternative AP would provide much better performance (sticky clients) or by frequently moving back and forth between AP's in an unpredictable manner. The OTA facility allows Cisco and Intel to systematically characterize and graphically depict the roaming behavior. The vendors claim that results of these tests have allowed them to tweak their algorithms to significantly improve roaming behavior.

Conclusions

Design, implementation and management of enterprise Wi-Fi networks continues to offer significant challenges for enterprise IT professionals. The emergence of 802.11n raises the bar once again, offering new opportunities but also raising important issues related to performance, scalability, backwards compatibility, and roaming. Dealing with these issues requires a multi-faceted approach, both for companies developing enterprise Wi-Fi solutions as well as for the customers implementing those services. Systematic over the air testing is one important element in that equation.

The emergence of the Wi-Fi Alliance in 1999 marked a significant event in the evolution of Wi-Fi. Consumers purchasing Wi-Fi products benefited from the alliance's interoperability certification, helping to grow the market. For enterprise customers, however, Wi-Fi certification also had value but was insufficient, largely because the design and operational challenges associated with enterprise Wi-Fi go well beyond basic protocol conformance and interoperability. Enterprise Wi-Fi systems have rapidly matured from tactical hot-spot implementations to pervasive mission-critical infrastructure. That trend will undoubtedly continue in the future.

Intel's investment in a highly automated OTA testing facility, and their cooperation with Cisco in the evaluation of some of the most challenging issues in enterprise Wi-Fi, fills an important industry void. Independent testing labs, including the Real World lab I co-founded at Syracuse University, lack the resources necessary to tackle the biggest problems and issues. There is still an important role for independent testing, but as the wireless market continues to mature, wireless hardware manufacturers must play an increasingly pivotal role.

While Cisco and Intel deserve credit for forging such a close partnership, both companies must recognize that future enterprise Wi-Fi implementations are unlikely to be based solely on technology from these two companies. Many of Intel's customers use non-Cisco infrastructure and likewise, Cisco shops have to contend with client devices that are not built around Intel chipsets. Navigating this multi-vendor world will not be easy for either company.

Beyond these competitive market dynamics, many technical challenges also exist. While the current test suite is impressive, it is clear that much more work remains to be done. For example, the client density tests could be enhanced by significantly increasing the number of client devices and also by physically distributing them throughout the facility. Work is already under way towards that end. In addition, this facility provides an ideal environment for examining the effects of co-channel interference when AP's are deployed in a micro-cellular architecture and also in evaluating the benefits of migrating enterprise Wi-Fi services from 2.4 GHz to 5 GHz. Finally, instrumenting tests that systematically evaluate high-density real-time services like wireless voice and video could go a long ways towards addressing issues and concerns of enterprise IT managers contemplating the delivery of converged services over Wi-Fi.

In the enterprise wireless business, Intel and Cisco are market leaders. Their close partnership in the OTA testing facility is clearly beneficial to both companies, but more importantly, it is beneficial to their customers. Further, the benefits come at every stage of the product cycle, from design to quality assurance to network deployments to customer problem resolution.

In my visit to the OTA testing facility, I was impressed by the work of Intel's engineering team and also by the spirit of cooperation between the two companies. The current test suite, which includes performance, coexistence, density, and roaming tests, provides valuable insights into 802.11n that can be directly applied to enterprise wireless network design. Equally important, the testbed provides a living lab for resolving the most difficult issues facing enterprises positioning themselves at the leading edge of wireless mobility services.

Author Bio: Dave Molta began his IT career in the early 1980's implementing first-generation personal computer networks and Internet services. He went on to hold IT management positions in academic computing, network services, systems and operations at two major universities. In 1993, he co-founded the Real World Labs at Syracuse University in cooperation with CMP Media. As an Editor with Network Computing Magazine, he was instrumental in defining the publication's coverage of enterprise networking issues, including wireless and mobility services. His first comparative review of 802.11 products appeared in 1999. Later wireless reviews included comprehensive evaluations of enterprise Wi-Fi infrastructure, Wi-Fi clients, wireless VoIP, and many other topics.

In 1998, Molta left his full-time IT management position to accept a faculty position at Syracuse University's School of Information Studies while continuing on with Network Computing until mid 2008. He currently works as Associate Professor, Assistant Dean for Technology, and Director of the Bachelor of Science program in Information Management and Technology and also the Center for Emerging Network Technologies.