

Client Reliability

A Technology Brief
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While pundits, the press and product purveyors long on hardware but short on installation experience argue about how many radios are required to provide capacity for metro-scale Wi-Fi networks, system vendors with extensive deployment experience have discovered a fundamental truth – while great mesh performance is important, it is meaningless unless subscribers can reliably connect to the network.

On the surface, connectivity seems like it should be easy. Clients comply with Wi-Fi standards. Mesh nodes comply with Wi-Fi standards. How hard can it be?

Very hard, it turns out.

Even traditional, standards-compliant Wi-Fi client devices, such as laptop computers and Wi-Fi bridges used to connect homes to metro-scale Wi-Fi networks, exhibit wide variability in their technical parameters. Power output can range from 10 mW to 200 mW or more. Some clients stick to access points that offer poor connection quality; others wander from access point to access point. Many clients connect to metro Wi-Fi networks at lower than optimal speeds, dramatically reducing client throughput. Mobility is another area of inconsistent performance on the part of Wi-Fi clients.

In conventional Wi-Fi venues – homes, offices and coffee shop hot spots – these variations are less apparent. Hot spots serve a handful of laptops located in close proximity to a single access point. In this bounded environment, client variations are easily tolerated.

Metro-scale Wi-Fi is a different story. Metro Wi-Fi offers ubiquitous coverage for thousands of widely varying fixed and mobile clients over tens, or even hundreds, of square miles. Clients can often “hear” five, ten or more Wi-Fi routers. They can be located very close to a router but still “hear” distant routers. Or, they can be hundreds of feet from the nearest Wi-Fi router. The environment is inevitably diverse – outdoors and in, hilly and flat, straight and crooked streets, verdant and barren.

Because of this environmental diversity, client variations that are tolerable in hot spots cause unreliable connectivity in metro-scale settings and result in an inconsistent and frustrating user experience. As metro-scale Wi-Fi networks have become more popular, users have connected a wider range of Wi-Fi clients, including PDAs, cellular telephones, gaming devices, meter reading devices and surveillance cameras, to them, further increasing device variability and lowering reliability.

Tropos® Networks employs a three-pronged strategy to provide reliable client connections in metro-scale Wi-Fi networks:

- o The Adaptive Mesh Connectivity Engine (AMCE™) compensates for the wide variations in technical parameters of “standard” Wi-Fi clients and creates more reliable and predictable network connections.
- o The Tropos Metro Compliant Extensions (TMCX™) specifies essentials for metro Wi-Fi wireless modems that improve their connection reliability.
- o Tropos Insight client-specific reports provide visibility required for network operator action to improve client connection reliability and predictability.

Adaptive Mesh Connectivity Engine

The Adaptive Mesh Connectivity Engine (AMCE) significantly improves a network operator's ability to consistently deliver reliable Wi-Fi connections to a broad range of client devices in a metro-scale mesh network. The AMCE software, which is embedded in the MetroMesh OS operating every Tropos MetroMesh router, provides adaptive tuning that dynamically compensates for the wide variations in Wi-Fi devices that use metro-scale mesh networks. This software creates more reliable client connections to metro-scale Wi-Fi networks.

For example, as noted above, some clients stick to access points that offer poor connection quality. They may, for instance, associate with the first access point they detect that broadcasts the SSID with which they want to connect and stay associated with it as long as they hear its transmissions, even if poorly.

In a hot spot setting, this characteristic does not create a problem because there is generally only one access point in range that belongs to the network to which the client wants to connect. The client associates with it. Period.

In a metro-scale network, the situation is very different. There can be several metro Wi-Fi routers broadcasting the SSID for the network to which the client wants to connect within range of the client. Moreover, because routers transmit at a much higher power than clients, the client can often clearly hear routers that can't hear it. A client that associates with the first router it detects broadcasting the desired SSID may be associating with a router that offers poor or no connectivity. If it sticks to this router, the client is stranded.

Tropos MetroMesh routers with AMCE use per-packet transmission power and timing control to compensate for low power client devices. By doing so, they create a more balanced link between clients and MetroMesh routers. A more balanced link enables clients to make better decisions about which MetroMesh router offers the best connection to the Wi-Fi network.

AMCE's per-packet transmission power and timing control also help stabilize clients that wander from router to router and optimize the data rate that a client uses to connect to the MetroMesh network.

Additional AMCE features and benefits are summarized in the following table.

Feature	Benefit
Intelligent local interference mitigation	Improves packet reception, delivers high throughput in dense metro-area deployments
Network-level optimizations	Improves client connections in high user-density settings
Dynamic Wi-Fi transmission parameter adjustment	Improves client connection reliability and throughput

With AMCE, clients get connected, stay connected, get data faster and fuss with the network less. The result is an outstanding user experience with fewer support headaches and lower operating costs for network operators.

The benefits of AMCE are delivered via software embedded in every Tropos MetroMesh router. They are available to all clients connected to a Tropos MetroMesh network. No special client hardware, software or configuration is required.

Tropos Metro Compliant Extensions

The Tropos Metro Compliant Extensions (TMCX), provide a specification for Wi-Fi devices used for residential and business access to metro Wi-Fi networks. TMCX-compliant devices provide the highest performance and reliability when connected to a metro-scale Wi-Fi mesh network. They also support an exceptional level of integrated management, optimization and provisioning through Tropos MetroMesh operation and optimization tools such as Tropos Control and Tropos Insight.

Wi-Fi clients often lack sufficient transmit power and radio control software to send data reliably to metro-scale wireless mesh networks. They also generally lack the management intelligence to be monitored, optimized and maintained remotely by service providers. The requirements of the TMCX specification provide a blueprint to client device manufacturers allowing them to optimize their products for use in a carrier-grade, metro-scale Wi-Fi environment. These enhancements to the device’s software intelligence, connectivity and manageability add significantly to the optimal operation and economics of a carrier-class broadband wireless network.

The TMCX specification details two levels of requirements: a base level that improves connectivity and performance when the client attaches to any metro Wi-Fi network and

an advanced level that further enhances operation when the client connects to a Tropo MetroMesh network. Examples of the former include requirements for transmit data rate selection, minimum transmit power levels, access point selection algorithm, security mechanisms and IP networking for remote manageability of a large number of devices. Examples of the latter include requirements for client throughput tests that can be initiated by MetroMesh routers and storage of statistics that can be retrieved by MetroMesh operation and optimization tools.

The TMCX specification does not use proprietary mechanisms to improve connectivity. Rather, it provides implementation guidance to improve connections to metro-scale mesh networks within the framework of the IEEE standards and Wi-Fi Alliance certification.

The TMCX specification is available to qualified manufacturers interested in developing client devices optimized for metro-scale Wi-Fi deployments or those wishing to enhance their current product offerings. The TMCX spec is available to qualified Wi-Fi client and chip manufacturers at http://www.tropos.com/tmcx_application.html.

AMCE/TMCX Relationship

AMCE and TMCX attack the problem of reliable metro-scale Wi-Fi client connectivity from different angles. TMCX provides a specification that narrows the variations of Wi-Fi clients in a way that improves their reliability and performance in metro Wi-Fi networks. AMCE recognizes that only a subset of Wi-Fi clients will conform to the TMCX specification and improves the connection reliability of all Wi-Fi clients used in metro Wi-Fi networks, especially those that don't conform to the TMCX specification.

Tropo Insight Client Reports

In addition to AMCE and TMCX, Tropo has incorporated new client reporting capability into Tropo Insight. The Tropo Insight client reports provide network operators with the visibility into client operation and performance that they need to cost-effectively manage their networks.

For example, Tropo Insight's client reports tell network managers, on an hourly basis, how many subscribers were active on the network, what type of client they were using, how much data clients uploaded and downloaded, if clients were stationary or mobile, where they went if they were mobile, and clients' signal-to-noise ratios (SNR) and packet error rates.

Tropos Insight also aggregates and analyzes data across the network. It pinpoints, for example, who were the top uploaders and downloaders, which clients had the poorest SNRs and which clients had the highest packet error rates, again on an hourly basis. This allows trending of data by time of day, day of week and over time, and improves the management decision-making ability of network operators.



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