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Strategic Use of Wi-Fi in Mobile Broadband Networks

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Introduction

The mobile-broadband market has reached critical mass thanks to fast networks, innovative applications, powerful platforms, and widespread user adoption. Operators are experiencing increasing data revenues even as voice revenues are declining. The business opportunity for mobile broadband is huge but also challenging. Users are clearly willing to pay for broadband service, but data usage is growing so quickly that it threatens to swamp the capacity of today's networks. Operators are increasingly employing Wi-Fi as a means to offload user traffic. This can be done defensively to purely address capacity needs or as an offensive opportunity to leverage these Wi-Fi networks for new revenue flows.

This paper, sponsored by Ruckus Wireless, examines the market trends with respect to data consumption, explains the use of Wi-Fi for offload, and then presents new ways that Wi-Fi networks can be strategically employed to quickly gain capacity and coverage, in order to address raw bandwidth demand as well as to create a platform for new service capabilities. It concludes with a discussion of Wi-Fi technical challenges and how only appropriate carrier-class Wi-Fi equipment with appropriate technical features can fully meet operator requirements.

Impact of the Mobile Internet on the Service Provider Market

There are a number of challenges in providing mobile broadband services. One is that wireless connections have inherently limited capacity compared to wireline approaches. One fiber connection has much greater capacity than all the RF spectrum to 100 GHz. This is a problem as bandwidth-intensive applications, such as video streaming, become widely used on wireline networks and set user expectations that similar operations should be possible on their mobile connections. But it only takes a small number of such users to consume the capacity of an entire cell sector.

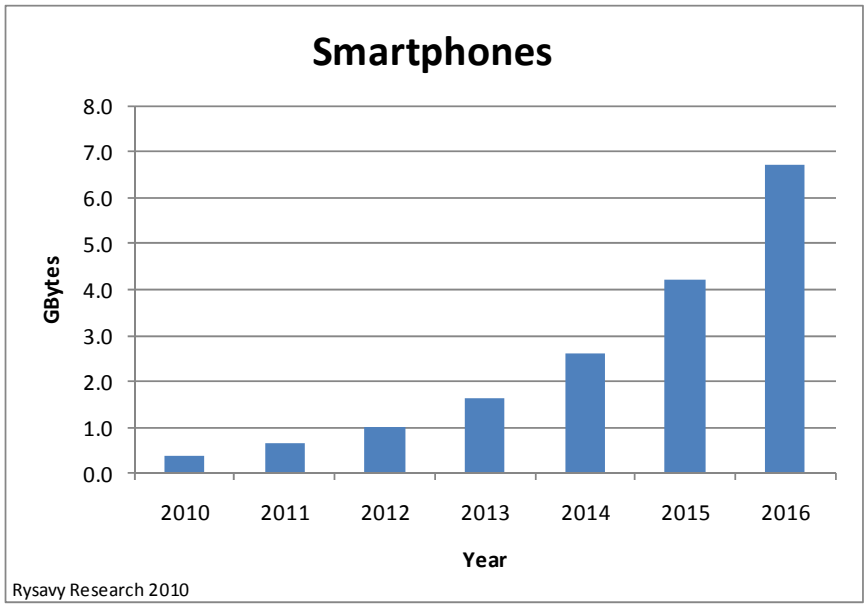
Another challenge is the shared nature of wireless connections. Although new technologies such as LTE can deliver more bandwidth than any previous wide-area wireless network, dozens of users may be simultaneously using that bandwidth. A more recent challenge is the rapid adoption of new platform such as tablets. These devices will arguably consume even more bandwidth than smartphones due to their larger screens and the likelihood of users spending longer periods interacting with them. For instance, a smartphone user may watch a short sports segment on their phone but a tablet user is more likely to watch an entire movie.

Figures from the Allot MobileTrends report for the first half of 2010, based on data passing through operators around the world with a total of 190 million subscribers, show that video streaming in the first

half of 2010 was almost double compared to the previous six months, and is now the largest consumer of mobile bandwidth.[1]

So even as more users enjoy e-mail, Web browsing, social networking, and video streaming on their smartphones and tablets, the impact on the network is significant. The trend is for users to keep consuming more bandwidth. Cisco, for example, anticipates that mobile traffic will grow at a 108% compound annual rate through 2014.[2] Rysavy Research projects that smartphone data usage is likely to increase at the rate shown in Figure 1 and data used by other devices such as tablets and notebooks will grow even faster, as shown in Figure 2.[3]

Figure 1: Monthly Smartphone Data Consumption per Subscriber over Time

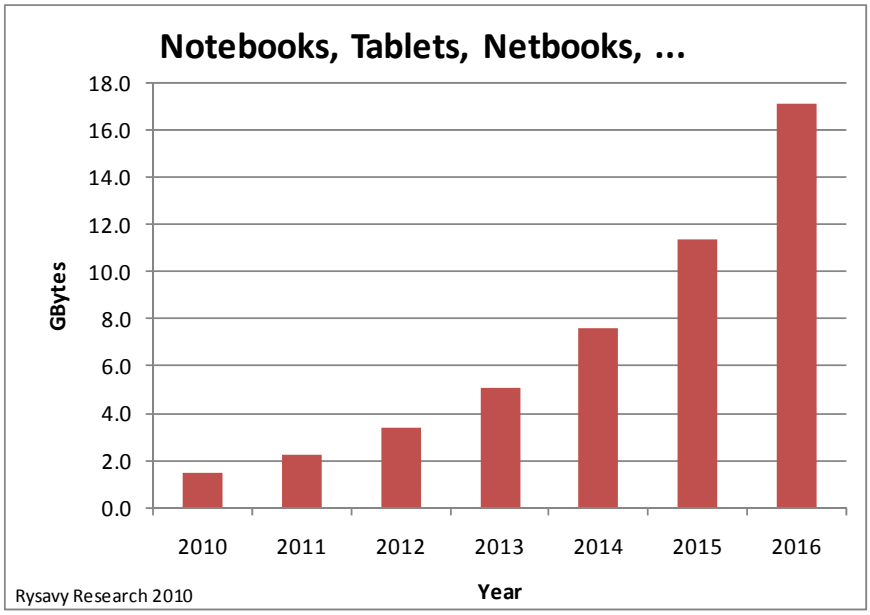


[1] Source: Allot MobileTrends Report H1, 2010. http://www.allot.com/MobileTrends_Report_H1_2010.html

[2] Source: Cisco, "Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update," February 10, 2010.

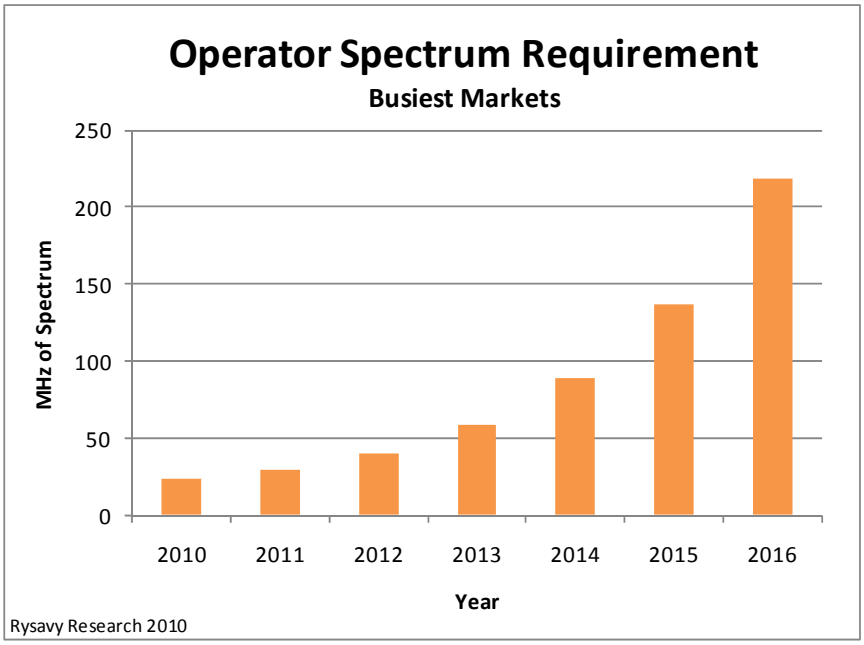
[3] For more details, refer to "Mobile Broadband Capacity Constraints And the Need for Optimization," Rysavy Research, February 24, 2010, http://www.rysavy.com/Articles/2010_02_Rysavy_Mobile_Broadband_Capacity_Constraints.pdf

Figure 2: Monthly Data Consumption per Subscriber over Time by Other Mobile Platforms



The amount that operators can charge for this bandwidth, however, will not continue to rise. Deploying more efficient technologies such as LTE will help, but is not enough. New spectrum will also eventually become available and will also help, but also will not be sufficient. Rysavy Research projects in the same report as the previous figures that many operators are likely to face severe pressure on their spectral resources within three to five years as shown in Figure 3. Even before then, however, congestion will occur on a regular basis in coverage areas with active mobile broadband usage, especially if only a small number of radio channels for data have been deployed.

Figure 3: Projected Spectrum Requirements for a Large Operator

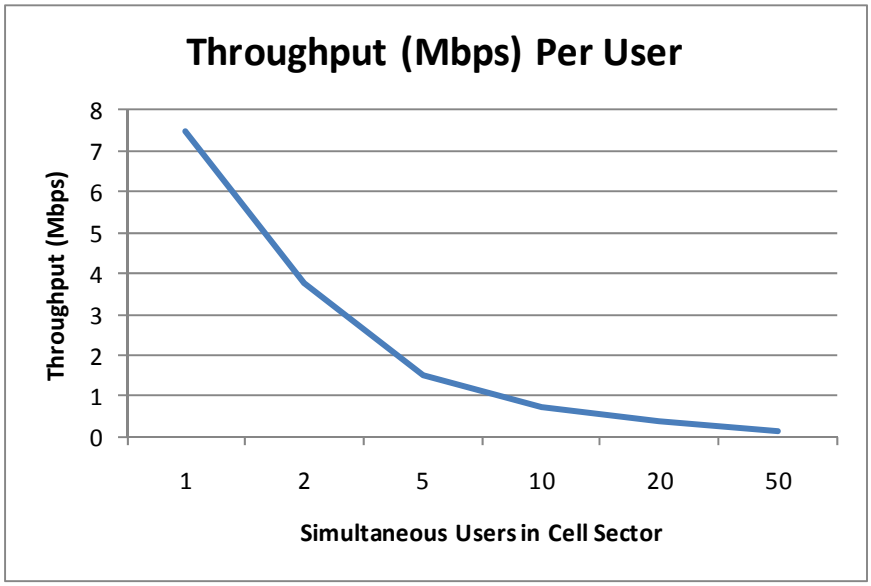


Allowing network capacity to saturate is something operators must aggressively avoid. AT&T experienced significant damage to its reputation when widespread use of the iPhone resulted in unreliable user experiences. Even after fixing the problem and boosting performance above its competitors[4], negative perceptions linger. Users demand not only ubiquitous coverage, but reliable connectivity. Congested networks are anything but reliable.

Consider a scenario of 20 MHz of spectrum allocated to HSPA, as shown in Figure 4. The effective throughput per active user depends on the number of simultaneous users in the cell sector. When going from 5 to 10 users, throughputs fall below 1 Mbps, and thus no longer deliver a true broadband experience. Considering that in the U.S. there are on average 1,000 wireless subscribers per cell site, and considerably more in busy markets, the number of subscribers per cell sector can range from between about 300 and 1000. Ten active users only constitute 1% to 3% of total subscribers. Thus, just a small percentage of subscribers can consume available capacity.

[4] PC Magazine, "The Fastest Mobile Networks 2010," June 3, 2010.
http://www.pcmag.com/article2/0,2817,2364263,00.asp

Figure 4: Throughput Per User Relative to Number of Users in Cell Sector



Operators must continue to augment capacity aggressively, and have to do so in the most cost effective manner. In this context, Wi-Fi will play an increasingly important role.

Wi-Fi as a Strategic Tool for Operators

Strategic opportunities for operators include using Wi-Fi for 3G/4G offload and also new applications such as managed wireless LAN services, using Wi-Fi for broadband service across high-density user areas in parts of the world where there aren't good wireline alternatives, and offering rich content and communications.

3G/4G Offload

Operators are already using Wi-Fi for effective data offload on their 3G networks. This is an excellent application of Wi-Fi because the technology can deliver much higher throughput in small coverage areas to more people than is possible with cellular technologies. Not only is there more unlicensed Wi-Fi spectrum available than the amount of spectrum licensed to any individual cellular operator, but since coverage areas are much smaller, frequency reuse is much higher, and thus there is more bandwidth available to each subscriber.

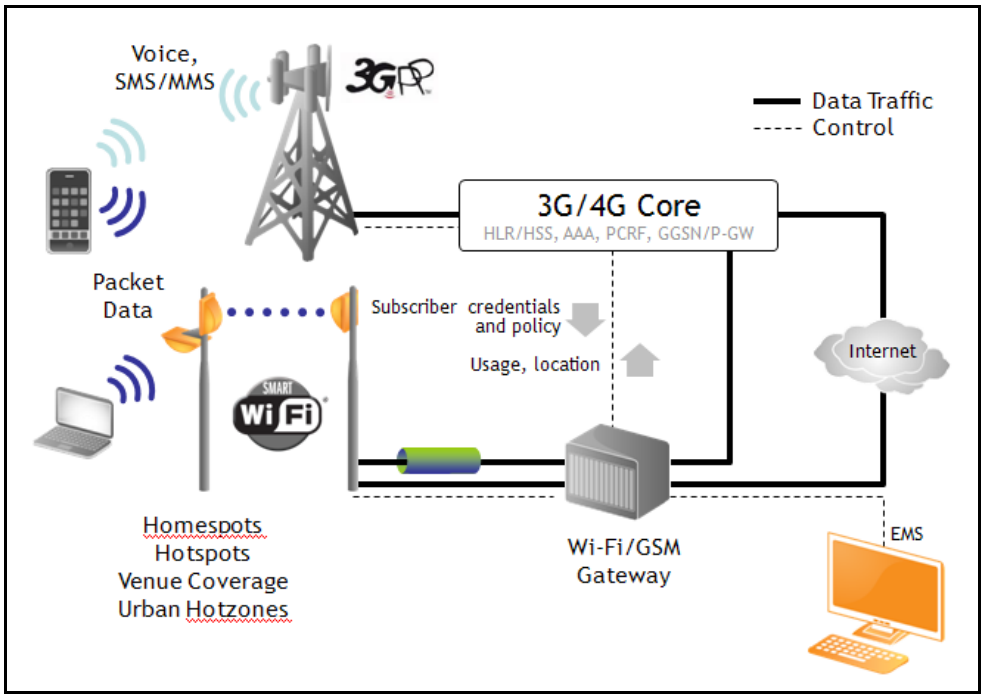
One germane example is PCCW, the principal supplier of telecommunications services in Hong Kong. In efforts to ease the congestion on their 3G infrastructure at peak times when users rush to the 3G network to view events or popular programs, PCCW has built a high-speed Wi-Fi network in points of presence around the city, such as unused phone booths, local retail shops, universities and other locations in and around Hong Kong. They have now deployed some ten thousand smart Wi-Fi access

points and estimate that nearly 20% of their peak mobile data traffic is offloaded in these high-demand locations. Like other broadband providers, PCCW is making their IPTV video content available to subscribers on their mobile handsets and now need the higher-bandwidth, highly-reliable Wi-Fi connections to satisfy users.

And it is not enough to just provide high-speed access to Wi-Fi. The user experience must be seamless, meaning easy and automatic. From an infrastructure standpoint, this requires features like being able to push authentication parameters and network identifiers to devices.

With Wi-Fi access, operators have the choice of loosely- or tightly-coupled integration with their cellular networks. Loosely coupled means that Wi-Fi network operates largely independently of the cellular network whereas tightly coupled means the Wi-Fi is more of a seamless extension of the cellular network and shares some functions, such as user authentication. In a tightly-coupled network, user data can also selectively flow through the cellular core network. For tightly-coupled operation, 3GPP has defined a standard called Integrated WLAN (I-WLAN), as shown in Figure 5, that enables Wi-Fi access networks to smoothly interconnect with cellular networks.

Figure 5: Example of a Tightly-Coupled Wi-Fi Configuration.



Offloading cellular traffic onto Wi-Fi may be done by the operator, but such service could also be offered on a wholesale basis through third-party organizations. Second- or third-tier operators in particular may prefer to partner with a wholesale provider.

New York-based Towerstream is building an extensive smart Wi-Fi network in Manhattan that will allow carriers to offload data traffic from their cellular network but still maintain control and quality of service through service-level agreements. To enable this wholesale, 3G offload model, Towerstream has deployed hundreds of smart 802.11n Wi-Fi nodes on rooftops throughout the city and has seen traffic loads skyrocket since doing so.

Managed Hotspot/Enterprise Services

As operators develop expertise in managing Wi-Fi networks using commercial-grade infrastructure for their own offload networks, they are then in an ideal position to deploy reliable and scalable Wi-Fi networks through other business models.

One is for managed hotspot services. Examples include providing Wi-Fi service in hotels or on university campuses. The operator can provide the service under their brand or as purely a managed service.

In Germany, Deutsche Telekom is demonstrating the value of Wi-Fi to provide managed WLAN services in public venues. It recently outfitted Imtech Arena (formerly Hamburg Stadium) with an 802.11n Wi-Fi system from Ruckus Wireless. Indoor and outdoor APs are providing visitors and journalists with Wi-Fi access to their T-Mobile hotspot service, offloading this data traffic from their 3G network. Public venues will be among the first to see the infiltration of managed WLAN services by operators.

Another is Wi-Fi service for business environments. Deploying Wi-Fi over large coverage areas with many access points is a formidable challenge requiring careful attention to operating frequencies, radio-channel selection, interference management, determination of coverage areas, where and how to use directional beams, and centralized authentication and security administration. Larger businesses may have the skills to manage this complexity, but increasingly businesses will seek to outsource these deployments.

In addition to providing Wi-Fi coverage to enterprises, operators can also offer voice operation through fixed-mobile convergence solutions in which the operator's voice service integrates with the company's PBX. This type of solution enables a wide range of features. One is simultaneously ringing both desktop and mobile phones for an incoming call. Another is four-digit dialing with which a call can reach a mobile phone using a Wi-Fi connection when the device is on premises and via the cellular network when the device is off premises.

Wireless Broadband Access

Today, there are only about half a billion broadband subscribers.[5] Expanding broadband beyond this number represents a huge business opportunity, but must be done using increasingly cost-effective approaches because income levels of many possible markets are quite low. Wi-Fi is becoming increasingly more effective as a broadband access solution for the following reasons:

- The IEEE 802.11n provides for extremely high throughputs (maximum 600 Mbps theoretical rate), high spectral efficiency, extended range, multi-band support, and operating flexibility in trading off between distance and throughput.

- Wi-Fi can be deployed at lower cost than most alternative technologies, especially in environments where little wireline infrastructure exists. Time to market is also much faster.

- Maturing operator-class Wi-Fi equipment has the sophisticated functionality needed to work in these challenging RF environments, as described further below.

- New equipment enables flexible deployment. Example include mesh operation and Wi-Fi based point-to-point communication for backhaul.

In India, Tikona Digital Networks has quietly built what is considered to be the world's largest outdoor Wi-Fi mesh deployment in commercial operation. The Wi-Fi network was designed for providing wireless broadband access to residents and small businesses. A new generation of broadband operator, Tikona's initial goal was to cost-effectively deliver 2 to 5 Mbps of broadband connectivity to hundreds of subscribers throughout India. But in a highly competitive market, time was the enemy. After evaluating conventional wireless WAN technologies including 3G, WiMAX, and others, Tikona determined that Wi-Fi technology had advanced to the stage where it could support a carrier-class broadband service. In under 18 months, Tikona installed over 35,000 Wi-Fi mesh nodes in dozens of cities throughout India. Broadband capacity from local fiber links is backhauled over point-to-point connections to different Wi-Fi zones. Wi-Fi meshing from these "root" nodes fans out the broadband capacity. With this smart Wi-Fi model, Tikona is now providing commercial services to hundreds of thousands of subscribers – something that many thought impossible just five years ago.

The self-organizing mesh network is comprised of equipment from Ruckus Wireless that includes 802.11g access points and customer premise wireless repeaters. According to Tikona, data from thousands of samples show that 80% of Tikona subscribers enjoy throughput of more than 5 Mbps.

[5] Source: Gigaom, "By the Numbers: Nearly Half a Billion Broadband Subscribers Worldwide," http://gigaom.com/2010/07/09/worldwide-broadband-subscribers/

Rich Content and Communications

Through careful integration of high-capacity Wi-Fi networks, operators can aggressively pursue opportunities of making rich content like video entertainment available to subscribers. Operators can further differentiate themselves by providing tools to automatically facilitate such content. Users today are often reluctant to stream movies because they know this can result in a high bill at the end of a month. After all, one or two movies can consume more data than some of today's data plans. But users would likely feel much more comfortable if movies were automatically blocked when on the wide-area network but enabled when on Wi-Fi. Working with content providers, operators can make video streaming intuitive and glitch-free for users. This is just one example of the rich content that Wi-Fi enables. For instance, PCCW, an early IPTV pioneer, is using additional Wi-Fi capacity to enable subscribers to view IPTV content on handheld devices. AT&T has also stated that it will follow suit.[6]

As another example, through policy-based management and quality-of-service parameters, operators can offer high-resolution video conferencing over Wi-Fi, a service that could be too bandwidth intensive for their wide-area networks.

Wi-Fi Technology Considerations

Deploying Wi-Fi for commercial networks poses many challenges, but these are challenges that operators can address by making the right technology decisions. Challenges include interference mitigation, coverage and capacity in complex environments, scalable deployment, and backend integration.

Challenges

(1) Interference Mitigation

One of the biggest issues carrier have had with Wi-Fi is its instability and inconsistency. The culprit is uncontrollable radio interference that causes packet loss and retransmissions. Mobile network designers need Wi-Fi technology that is able to adapt to constant environmental changes through both dynamic signal path selection and proactive interference avoidance and rejection mechanisms.

(2) Coverage and Capacity in Complex Environments

Dealing with a myriad of different environments is another major challenge for operators. Here operators need to find suppliers with a broad and flexible portfolio of Wi-Fi access point designs that

[6] Source: VON Xchange, "AT&T Leverages Windows Phone 7 for U-verse IPTV," http://www.von.com/news/2010/10/at-t-leverages-windows-phone-7-for-u-verse-iptv.aspx

can be used to support a wide range of application and deployment scenarios – from dense urban locations and public venues where high-capacity and interference are essential, to rural environments where cost and coverage are king.

Another challenge is that Wi-Fi deployments are much more dynamic than cellular deployments. Interference conditions can change much more quickly since the spectrum is unlicensed and there are potentially many other users of the spectrum

(3) Scalable Deployment and Operation

Deploying a full-scale Wi-Fi network for 3G offload and last-mile access is much more complex than simply installing an access point in a hotspot. Many considerations, from customer-premise equipment to meshed-access nodes, point- to-point and point-to-multipoint backhaul links, along with comprehensive network management, must be taken into account. Obtaining a complete solution from a single supplier, however, has not been possible, relegating carriers to become systems integrators by cobbling together disparate products from different vendors.

Deployments are also dynamic because the operator may need to add access points rapidly to address coverage and capacity needs. Operators must be able to expand their networks quickly, flexibly, cost effectively, and in a scalable manner.

One way to achieve scalable and flexible deployment is with mesh operation in which access points operate as repeaters, forwarding packets to other nodes. This significantly simplifies the addition of access points because their location can be optimized for coverage and are not constrained by backhaul connections. Using Wi-Fi-based radio for backhaul can also simplify deployment. Most important in this scenario is a self-organizing mesh topology and a strong management system to provide complete visibility into, and control over, the entire Wi-Fi infrastructure.

(4) Seamless Backend Integration

Because Wi-Fi networks introduce many new nodes into the mobile operator's network, seamless integration with the existing cellular core and the services provided through that core must work flawlessly, without increasing the load on the 3G/4Ginfrastructure.

Carrier-class Wi-Fi systems for 3G offload must be able to seamlessly bridge between the Wi-Fi network and the existing cellular infrastructure – providing consistent user policy, provisioning, security, roaming and authentication. One-touch or no-touch signon – regardless of the network being accessed – is also a critical features for subscriber satisfaction.

Seamless client provisioning, authentication, and roaming services provided within a smart Wi-Fi architecture to achieve this "touchless" subscriber experience should include (but is not limited to) capabilities such as:

- Automatic configuration of smartphones with the requisite SSIDs and security protocols over the network
- Ensuring consistent IP addressing to end devices as they cross subnet boundaries, thereby eliminating the need for connection managers
- Support for SIM-based security and dynamic pre-shared key support for non-SIM clients.

Smarter Wi-Fi

For carriers and mobile operators, next-generation Wi-Fi equipment must not only address the technical challenges discussed above, but must do so in a cost-effective manner that enables emerging strategic applications of Wi-Fi such as alternative broadband access and enterprise deployments.

Some of the significant capabilities that are needed include dynamic beamforming that adapts signal direction instantaneously to extend range, and automatic RF interference rejection that decreases packet loss and increases throughput performance. Additional features include dynamic-channel management, band steering, and per-subscriber quality-of-service control. Moreover, mesh networking must be adaptive to enable the network to change how packets hop through nodes in the event of any disruptions. Capabilities like this are essential for carrier-grade resilient operation.

Conclusion

Many operators today are being forced to seriously consider the integration of Wi-Fi just to address capacity issues. A number of others, however, are moving beyond this basic entry point, incorporating Wi-Fi into their overall network strategy, with a focus on using the best available Wi-Fi technology in order to enable significant new business opportunities. Given the significant competitive advantage a coherent and well-executed Wi-Fi strategy can create — in a world of exponentially rising bandwidth demand — the technology merits serious consideration.