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WHITE PAPER

Wi-Fi Offload—
Is your gateway ready?

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Network equipment manufacturers (NEM) are building and testing gear such as Wi-Fi offload gateways. Carriers are integrating their networks with Wi-Fi access points. However, before Wi-Fi Offload services becomes widely available, all parties need to perform rigorous testing of functionality, reliability, security, and scale, to ensure their offload implementation will meet the demands of real-world customers. Once services are deployed carriers will also perform on-going tests to verify target service levels and identify where more capacity is needed. Carrier partners will also perform tests to validate individual components of the end-to-end Wi-Fi offload solution.

In order succeed with Wi-Fi offloading, carriers and their partners must:

- Gain familiarity with the technology and business concerns related to Wi-Fi offloading
- Ensure that all critical success factors are known and addressed
- Verify functionality and performance of control, data and security plane simultaneously by testing with millions of WLAN subscribers simultaneously accessing the mobile packet core that roam between LTE and Wi-Fi networks

Proper testing solutions—including equipment, expertise, and procedures—should be established around three key factors:

1. Test methodologies with detailed procedures and test cases
2. Test equipment that supports the latest networking specifications
3. Automated tools designed for Wi-Fi offload testing

A proper testing solution, based on these factors, can be used to help design, build, and validate Wi-Fi offload systems that meet the performance, availability, security, and scalability requirements of carriers, partners and customers. This is essential to the viability of Wi-Fi offload and, in turn, essential to the ability of carriers to sustain growth.

Executive Summary

As consumers and business users increase their use of mobile broadband and IP services, carrier mobile networks can't always keep up. The bandwidth-intense nature of applications like hi-def video streaming, and the sheer growth in number of user mobile devices, continue to stress available mobile spectrum.

One solution is Wi-Fi offload which uses the 802.11 network protocol rather than using mobile wireless connections from the carrier such as 3G or LTE. Wi-Fi offload transparently connects devices to fixed hot-spots or Wi-Fi access points (AP) when they are available. By using a Wi-Fi connection to the Internet, the carrier's mobile network is bypassed, thereby significantly reducing the demand on available spectrum. While the products and specifications for Wi-Fi offloading are still maturing, industry activity is increasing rapidly.

Running Out of Wireless Spectrum for Voice and Broadband: the Problems that Come with Success

The use of mobile wireless spectrum for voice and for broadband data is a continuing demonstration of the "problem of success." As early iPhone adopters can attest, too many users in a service area can lead to data saturation or signaling saturation, resulting in service degradation or even loss of service. The number and range of cellular voice and broadband-enabled devices in use grows hourly. In addition to person-centric devices like smartphones, tablets, notebooks, and gaming devices, mobile broadband devices are also being added to vehicles, including cars, buses, trains, and more.

In addition to the growing number of users and applications, bandwidth demands continue to grow for a number of other reasons:

- **More hours of use:** Many device owners are working via their mobile broadband connection while at home or office as well as when mobile.
- **Larger content:** A movie streamed or downloaded on Apple's new HD iPad model, for example, can consume four times the bandwidth of a version intended for the iPad 2 or other lower-pixel-count displays.
- **Increasing access:** Expanding mobile networks provide more opportunities to use high bandwidth applications such as video, from any location. Voice over LTE (VoLTE) is another emerging application that will only add to the problems.

For carriers, increased customer demand for spectrum increases the number of unsatisfied customers who may switch to another provider. Additionally, lack of available spectrum limits how aggressively carriers can pursue additional customers and new markets. It also accelerates the need for carriers to build more towers—an action which is both very costly and time consuming. In many cases carriers must rely on cell towers that use another carrier's fiber backbone to connect back to the Internet. Here they may incur disproportionate costs to support the data requirements of customers.

This increasing load on mobile networks isn't just a concern for carriers. It also quickly creates user concerns including higher bills and/or poor service. For example, a two-hour HD movie viewed on Apple's new HD iPad will require about 2GB of bandwidth. Since many users only subscribe to a few GB per month, this quickly leads to overages and higher bills. New behaviors, such as accessing the Internet from smartphones while at home—rather than booting a PC—also increase consumption. Even users with unlimited data plans may experience throttling as they are downgraded to significantly slower speeds for the duration of the billing period.

Success in Search of a Solution

One of the more obvious approaches to resolving spectrum issues for mobile wireless networks is to upgrade the network. While network upgrades may provide additional spectrum and use it more efficiently, they are also time consuming and expensive. Even when a network has been upgraded to the best and latest technologies, the fact remains that mobile wireless spectrum is finite. Clearly, other solutions must be considered.

Other approaches for addressing spectrum issues include adjusting data plans and throttling high-usage customers. For example, carriers may eliminate unlimited data plans in hopes of reducing demands on the network. Unfortunately that approach can create dissatisfaction among customers and it may still leave large demands on the network. Throttling high-usage customers suffers from these same problems and also increases network complexity as it requires access control and policing.

What carriers really need is a solution that enhances their market position by improving—rather than limiting—their mobile broadband offerings. A quick look at two of the most basic objectives for carriers helps explain this.

1. **Keeping customers happy:** This is done, in part, by sustaining acceptable performance and avoiding excessive usage bills that would cause them to switch to another carrier.
2. **Adding new customers:** Reducing congestion not only improves customer satisfaction and retention, it lets carriers add new customers to their existing network.

One approach that would help with both of these core objectives would be to take advantage of other available networks. This would involve transparently offloading data traffic from mobile wireless networks such as 3G & LTE and using one or more alternative paths to the carrier's core network and/or to the Internet.

Wi-Fi: A Great Fit for Offloading Traffic from Mobile Networks

Thanks to work by the 3rd Generation Partnership Project (3GPP) and the Wireless Broadband Alliance (WBA), Wi-Fi offloading solutions are becoming real. Two related groups are currently working on technical proposals for Wi-Fi offloading which have some relatively minor technical differences. Many network equipment manufacturers (NEM) are already following these proposals and integrating Wi-Fi offload gateways with their 3G/4G mobile gateway network products. With this progress, Wi-Fi offloading is set to become more pervasive—even where mobile spectrum is currently limited. See Figure 1 for a closer look.

Rather than requiring new hardware, Wi-Fi offloading based on 3GPP can be enabled in mobile handsets with software updates. This creates a large base of potential users ready to gain the benefits of greater bandwidth. Better still, the 3GPP proposal makes the user experience seamless. Instead of entering credentials for each Wi-Fi network, as required in most handsets today, users can roam from one Wi-Fi partner's coverage to another without interrupting calls or reestablishing connections—provided they have a roaming agreement similar to that in today's mobile data services.

Large Wi-Fi networks are being introduced to serve locations where people do not move frequently. For instance, broadband Internet service with the ability to handle offloaded mobile traffic is available at a growing number of residential, private business, and public locations. For example, Wi-Fi is increasingly available in offices to authorized users—often including guest accounts that only provide Internet access and are walled off from other local users and devices.

Similarly, residential broadband providers routinely offer and install Wi-Fi routers, also known as access points (AP), for little to no additional cost.

Some providers are going even further to provide seamless Wi-Fi offload services to its mobile broadband customers. Partnerships with Wi-Fi providers will give mobile operators access to large Wi-Fi networks in both residential and business locations. This allows mobile operators to use Wi-Fi to offload traffic from its mobile network, reduce cost and improve user experience.

A growing number of hotels, airports, convention centers, libraries, schools, shopping centers, convention centers, health care providers and others are offering Wi-Fi hotspots. Some of these are free to the public at large, while others are only available to authorized paying users. Carriers are opening access to some of the pay-per-use APs through partnerships. Wi-Fi aggregator Boingo.com reports nearly 30,000 publicly-accessible Wi-Fi hotspots within the United States. For the worldwide perspective, JiWire.com estimates there are 500,000 free and paid Wi-Fi hotspots in over 144 countries.

The vast majority of mobile users are in range of one or more Wi-Fi APs at any given time. It only makes sense for mobile broadband users to be able to take advantage of local Wi-Fi services when they are available. Wi-Fi offloading is set to become the ideal alternative for data connectivity.

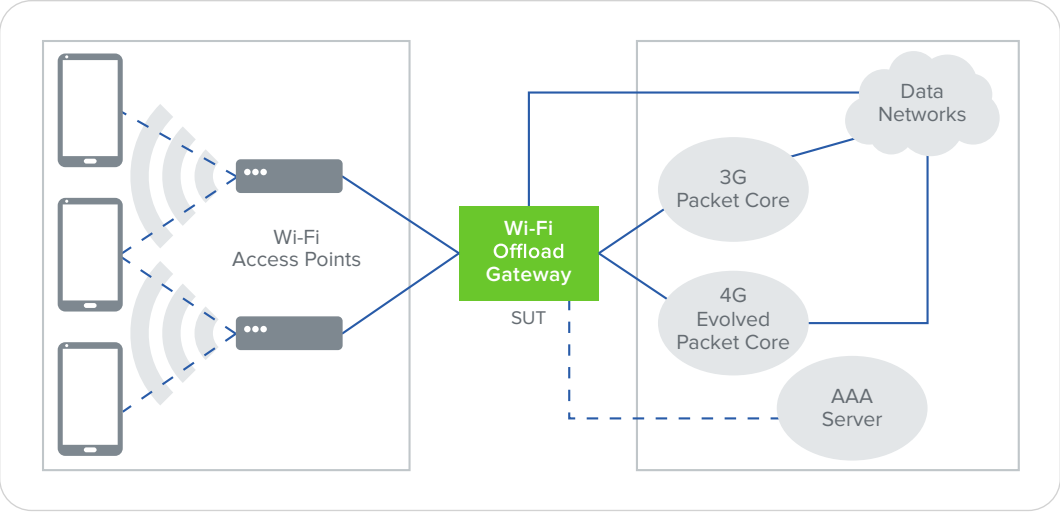

Figure 1. Wi-Fi Offloading with 3GPP.

Carrier Challenges

Offloading device traffic from mobile networks to Wi-Fi requires a Wi-Fi gateway to be added at the edge of the mobile core. These can be deployed as functionality added to other installed network devices such as routers. Wi-Fi gateways provide the capability to bridge secure/insecure domains and transfer sessions and traffic between the carrier's network and the local hotspot and back again. They also provide access to carrier and hotspot authorization and billing databases, ultimately enabling devices to roam from mobile to Wi-Fi networks and between Wi-Fi APs.

Wi-Fi gateways are a core component of the overall solution which carriers must deploy in order to deliver Wi-Fi offload to their customers. The complete solution must:

- Work with existing user devices that have or can add Wi-Fi capability
- Integrate easily to existing Wi-Fi hotspots and APs
- Work automatically with a given device, including:
  - Automatically selecting and transferring to Wi-Fi if available
  - Roaming seamlessly among Wi-Fi hotspots and APs
  - Transferring back to the mobile network when out of Wi-Fi range
- Provide consistently good performance to users, including invisible roaming transfer between mobile and Wi-Fi as well as between individual Wi-Fi APs
- Include access and authentication for user equipment across both carrier and partner Wi-Fi networks, and ensure security by using acceptable encryption
- Integration with 3G and 4G packet core gateways to provide similar user experience and features as a user on the cellular network
- Integrate with billing databases, both carrier and for potential revenue split with partners
- Support better pricing than that of bandwidth cap/overages to encourage the use of offload
- Scale in terms of connection performance as well as access/authentication management

It is worth repeating that Wi-Fi offload must be seamless to customers. Carriers and their Wi-Fi partners must provide a solution that works consistently, automatically, and reliably.

Testing is a Key to Success for Wi-Fi Offloading

To ensure that Wi-Fi offload solutions succeed—from both technical and business perspectives—testing must be treated as an integral component of the development, sales, deployment, and support processes. Testing of Wi-Fi offload is not only needed to identify and resolve pain points. It must be performed before and during the design and deployment of Wi-Fi offload services. Ongoing testing should also be performed to monitor installations and troubleshoot unexpected degradations and failures.

Performance

- Data throughput and latency, with identification of bottlenecks
- Latency versus 3G/4G connections
- AP and UE Activation rates
- Rapid handover time, in the 50-100ms range

Availability

- Clean transfers without disconnections, testing UE inter- and intra-AP mobility
- Application prioritization and DPI (e.g., voice and live video as higher priority than YouTube)
- Clean hand-offs in both directions for voice and data sessions while moving between SSIDs and APs with various UEs
- Interoperability with 3G and 4G Gateways

Security

- Authentication, addressing and bearer provisioning
- Full support for mobile USIM-based authorization (e.g., EAP-SIM and EAP-AKA)
- IPsec tunnels as required
- SSID discovery identification (e.g., Hot Spot 2.0, 3GPP ANDSF)
- Resist attacks while minimizing impact to authentic user traffic

Scalability

- Tens of thousands of APs and UEs per gateway
- Maximum number of users
- Maximum number of streams or sessions
- Maximum data throughput

Since testing is such a critical yet complex undertaking, it is helpful to have a guiding test methodology in place. Spirent has developed a methodology called PASS testing which can be used by carriers, NEMs, and Wi-Fi service partners to verify performance, availability, security and scalability. Example tests for each element of PASS are listed below.

There are indeed many complex test cases are required for proper Wi-Fi offload testing. Of course test teams must also select equipment that has the capability to perform those tests as well as support the related protocols and technologies. Test equipment for Wi-Fi offload testing should support the following:

- Very high count UE and AP emulation
- 802.1X and Radius-based UE Authentication, AAA emulation
- Tunneled Data from APs or UEs to Gateway (CAPWAP, GRE, IPSEC etc.)
- PGW and GGSN emulation
- UE and AP DHCP support
- IP or Ethernet-based tunneling including MPLS and VLAN support
- Inter and Intra-AP mobility
- 3G/4G to Wi-Fi mobility

Initially, carriers and NEMs may want to do their own testing in order to guide design and development processes. However, testing should be done using procedures, easily-understood metrics, and equipment that third parties can replicate independently to validate carrier and vendor assertions.

Getting Started with 3GPP Rel. 11 Wi-Fi Offload Testing

Testing a proposed network service like Wi-Fi offloading which is expected to serve potentially millions of concurrent consumer and business users, and hundreds of types of devices, across one or more nations, requires extensive planning, procedures, people, products, project management and support.

Homegrown tools and scripts are insufficient for testing and validating complex, high-volume environments like Wi-Fi offloading. In fact, testing in general typically requires automated test tools that are just as complex and powerful as the system under test. The selection of commercial testing products must be done carefully. Mobile data networks continue to add the newest equipment, built with the latest network specifications. Be sure to select testing products that are continually updated to support leading-edge mobile network services and protocols.

Test cases and procedures must also be properly developed in order to accomplish the desired results. Products and services from Spirent have a proven track record of helping carriers, NEMs and others create and perform comprehensive stress-tests of new network technologies and products. Spirent Landslide provides an end-to-end platform that emulates millions of mobile data subscribers, accessing the wireless network using various access models, and transmitting and receiving real-world application data for comprehensive performance and scalability testing. Landslide includes a Wi-Fi offload gateway test case, emulating thousands of mobile users and thousands of emulated Wi-Fi access points.

Landslide's competitively unique solution enables comprehensive nodal and end-to-end system testing by emulating millionsof mobile and Wi-Fi subscribers, simultaneously accessing the mobile packet core network. Real-world user experience emulation allows Landslide users to simultaneously test control-, data- and security-plane capacities, performance and scalability while providing complete user control of the test scenario. Extensive mobility testing between 3GPP and non-3GPP mobile access technologies is supported.

About Spirent

Spirent Communications (LSE: SPT) is a global leader with deep expertise and decades of experience in testing, assurance, analytics and security, serving developers, service providers, and enterprise networks. We help bring clarity to increasingly complex technological and business challenges. Spirent's customers have made a promise to their customers to deliver superior performance. Spirent assures that those promises are fulfilled.

For more information visit: www.spirent.com

Conclusion

Wi-Fi offloading provides a number of benefits for users, carriers, and their Wi-Fi network partners. At the same time,
Wi-Fi offloading is complex and demands that carriers thoroughly test it to ensure a transparent, high-quality experience for customers. This includes providing a transparent, high-quality experience for users that is sustained even as user and application demands grow. These solutions must also be easy for service providers to deploy, including integrating with existing customer billing systems and with administration systems for ongoing management and monitoring.

Proving that a Wi-Fi offloading solution works as intended requires test teams to test with realism. This means testing in a way that simulates anticipated real-world user scenarios. To do this, carriers need test equipment with the right capabilities that can test end-to-end performance by emulating millions of subscribers using various access technologies to simultaneously access the packet core network and perform inter and intra-technology mobility with user plane data to ensure the best user experience possible. Test equipment must also support the latest networking technologies and provide automation for efficiency as well as repeatability.

In order to improve the odds of success in deploying Wi-Fi offload solutions, leaders of mobile carriers, NEMs, and Wi-Fi partners must be familiar with the unique challenges of Wi-Fi offload. They must confirm that the right technical and business questions are asked. They must also make certain that these questions are properly answered, based on hard data derived from testing and validation.

By demonstrating Wi-Fi offloading works as intended, carriers can reduce congestion in their networks and offer customers the desired performance in a cost-effective manner.

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