WHITE PAPER

WI-FI FIRST

HEWLETT PACKARD ENTERPRISE'S VISION FOR MOBILE CONNECTIVITY AND LTE IN UNLICENSED SPECTRUM

aruba
a Hewlett Packard Enterprise company

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A Wi-Fi connection is the last network most of us use before going to bed, and the first network we connect to in the morning. Our days consist of roaming from one Wi-Fi network to another, with occasional breaks that are covered by a cellular data plan. Our personal mobile devices stay connected during the day to a corporate Wi-Fi network, while our business devices stay connected after work hours on personal Wi-Fi routers and hotspots. The common refrain "can you hear me now?" has been replaced by "what's the Wi-Fi password?" All over the world, people choose restaurants, airlines, cruise ships and even new cars based on Wi-Fi connectivity. At Hewlett-Packard Enterprise (HPE), we believe that the pervasiveness, performance and price of Wi-Fi has crossed the tipping point, and that we are now irrevocably in a "Wi-Fi First" world.

What's even more remarkable is how deeply Wi-Fi has become embedded in the most basic functioning of the world around us – and how fundamentally different our daily lives would be without it:

- Every major large e-commerce and brick-and-mortar retailer runs on Wi-Fi. Your e-commerce order does not ship without numerous Wi-Fi based transactions. Product pickers and forklift operators in warehouses and distribution centers depend on Wi-Fi to meet aggressive hourly productivity targets.
- Many products that transit through container ports and railyards on their way to our homes and businesses are loaded and unloaded by specialized cranes that are controlled exclusively over Wi-Fi networks in very harsh radio conditions.
- Wi-Fi is reducing healthcare costs and improving patient outcomes by reliably and securely carrying medical telemetry in the hospital. The average patient room has over 15 devices that are usually connected over the Wi-Fi network.
- Gate operations of major global airlines are heavily dependent on Wi-Fi; planes today literally cannot take off without ticket scanners, baggage scanners, maintenance inspections and flight plans being carried over Wi-Fi.
- Hundreds of billions of dollars of financial transactions are traded daily on Wi-Fi-enabled tablets at financial exchanges with millisecond response time.
- Over 10 terabytes of photos, videos, emails and messages were sent at Super Bowl 50 over Wi-Fi, while simultaneously supporting television broadcasters, ticket taking and retail point-of-sale transactions. This was more data than carried by all four cellular operators inside the stadium.

What is the reason that Wi-Fi has achieved such a mission-critical role in our homes and workplaces? Because Wi-Fi is the "open source" answer to proprietary licensed wireless networks. For the first time since the invention of the telephone, enterprises, consumers and governments have the freedom to purchase and operate low-cost, standardized and robust equipment to serve their communications needs – without being beholden to a small group of national or regional telecommunications providers. Thanks to foresighted allocation of unlicensed spectrum by governments around the world and decades of advocacy by the Institute of Electronic and Electrical Engineers (IEEE), Wi-Fi certified equipment is meeting a wide range of connectivity needs from life-safety and mission-critical to casual browsing and social media. It generates over $222 billion of annual economic activity[1]. Ironically, at least $300 million of this is spent every year by traditional telecommunications companies to build Wi-Fi networks that offload traffic from their congested licensed spectrum[2]. We are even seeing the creation of massive and entirely new operator-driven networks based on cable and fiber backbones that use exclusively Wi-Fi in the unlicensed spectrum to deliver residential and commercial service.

As in all markets, the presence of a disruptive and lower-cost solution has upset the traditional order. Licensed operators are aggressively looking to unlicensed spectrum for several important reasons. One is simply the insatiable demand of subscribers for more wireless data. According to some estimates, a 1000X increase in mobile data traffic is expected in the coming years[3]. Ultimately Shannon's Law tells us that more capacity requires more spectrum. Another is that LTE operators want to provide innovative new services in the unlicensed bands that are easier for them to manage and integrate with their existing RATs and EPCs. But the most important reason is that these operators want to capture and put a price on data that is otherwise being carried for free or at comparatively low cost.

Unlicensed bands by definition are available for anyone to use, subject to explicit or implicit requirements for fair play. But for this very reason, unlicensed radios are very hard to make work because no one controls the air. It took the IEEE and the Wi-Fi community over 20 years of engineering, innovation and problem solving to reach today's level of reliability and performance. Some of the current proposals for unlicensed LTE to operate in the same bands as Wi-Fi are thoughtful and attempt to build on this experience, while others appear to be catastrophic for nearby Wi-Fi equipment based on available simulations and test results.

HPE has a unique vantage point. We are the second largest provider of Wi-Fi infrastructure outside the consumer market[2], with over $4 billion dollars of lifetime installed base. We provide affordable and reliable wireless solutions that are powering massive economic activity in over 150 countries and in nearly every industry you can imagine. Our customers expect us to protect their interests and the significant investments they have made in the mission-critical Wi-Fi infrastructure that is powering their businesses, hospitals, school districts, universities, military bases, warehouses, stadiums, airports and municipalities.

This white paper summarizes the state of unlicensed wireless technologies. It introduces our vision of how our customers – both network operators and enterprises alike – should be leveraging current and future Wi-Fi equipment as the basis for carrier-grade and mission-critical networks, respectively. The document explains the serious concerns that HPE has with respect to certain proposed LTE-based technologies operating in the unlicensed bands, the threat they pose to our global customer base, and our expectations for minimum coexistence performance. It sets forth our strong disagreement with the proposition advanced by some parties that Wi-Fi is neither reliable nor spectrally efficient. And it explains our belief that licensed operators will ultimately be far more successful by embracing Wi-Fi, just as HPE has by pivoting around open source, open switching and other "bottom-up" innovations.

WI-FI TODAY

Wi-Fi, the technology already in use to provide access using the 2.4GHz and the 5GHz unlicensed spectrum bands, is ubiquitous today. Private homes, offices, businesses as well as public places like cafes, restaurants, retail stores, shopping malls, stadiums, convention centers, hospitals, airplanes, trains, buses, ships, transportation hubs, hotels, education centers, city centers, and municipalities all deploy Wi-Fi to offer access to the internet. Wi-Fi connects users in more than 450 million households worldwide and at over 47 million global public hotspots[1]. Free Wi-Fi availability is increasingly considered by consumers as a key requirement when choosing a service. In fact, Wi-Fi is considered as one of the basic amenities by millennials[4].

All consumer access devices including smartphones, tablets, e-readers, and laptops come equipped with Wi-Fi as the primary, and sometimes the only, connectivity method. An average home has more than eight devices on the Wi-Fi network and there are an estimated total of 6.8 billion Wi-Fi products in use[1]. These figures are expected to grow exponentially with the proliferation of the Internet of things (IoT).

The ever growing popularity of Wi-Fi has also fueled tremendous innovation in the technology. In the last 16 years, Wi-Fi data rates have progressed from 11 Mbps with IEEE 802.11b to 3 Gbps with 802.11ac Wave 2. The ubiquity of Wi-Fi access points and clients coupled with the technological advancements have already made Wi-Fi the primary means of access. Not surprisingly, Wi-Fi has been the key driving force behind the rise of the mobile Internet. Wi-Fi today carries ten times the IP data traffic as compared to cellular networks[5].

While Wi-Fi has established itself as the chief technology to meet the global demand for data today, it is expected to maintain that lead in the foreseeable future with the continued innovation by the Wi-Fi industry to stay ahead of the growth in data traffic demand. Incorporation of OFDM, MU-MIMO, enhanced modulation and coding, and other advanced techniques into Wi-Fi makes it as spectrally efficient as any other technology. Further use of carrier sense multiple access with collision avoidance (CSMA/CA) method in Wi-Fi enables fair sharing of the unlicensed spectrum with other technologies. Moreover, the rich suite of features built over years for Wireless Local Area Networks (WLAN) make it the technology of choice for businesses and enterprises alike. In fact, public and private entities are fast getting rid of their dependence on wired connections for data and voice in favor of Wi-Fi as the only mode of access within their establishments.

With the long lead that Wi-Fi enjoys over other contending technologies in terms of technological and feature enhancements, penetration, proliferation and economics, the question remains if there really is a need for a new access technology in the unlicensed band that will solve a user pain-point not addressed by Wi-Fi. With the continued innovation by the Wi-Fi community, Wi-Fi seems all set to be able to meet the growing capacity demands of the future. Will a new technology be able to meet the economics delivered by Wi-Fi to justify the business case and meet mass acceptance? Unless the new technology is able to solve a yet unknown end-user problem that cannot be addressed by Wi-Fi, its success in replacing Wi-Fi as the preferred access technology in the unlicensed band remains questionable. Meanwhile, the risk posed to the 6.8 billion installed Wi-Fi devices in the hands of citizen voters worldwide[1] by unproven new radio access technologies suggests that regulators and policymakers should set a high bar before moving forward with large scale deployments.

OVERVIEW OF LTE TECHNOLOGIES FOR UNLICENSED BANDS

Mobile service providers, who have traditionally trusted licensed spectrum to offer reliable services to their subscribers, are increasingly under pressure by over-the-top applications nibbling away at their margins. Faced with explosive data traffic growth, service providers are exploring non-conventional ways to serve this impending demand in a cost-effective manner. The freely available unlicensed spectrum offers an attractive option for service providers to expand the capacity of their radio access networks without massive investments to acquire licenses to new spectrum.

Several new technologies are being investigated concurrently by the industry to tap into the capacity offered by unlicensed spectrum for mobile subscribers. These include:

1. LTE in Unlicensed spectrum (LTE-U),
2. Licensed Assisted Access (LAA),
3. LTE WLAN Aggregation (LWA and LWIP), and
4. MuLTEfire™.

The balance of this white paper discusses these new technologies to provide access using the unlicensed spectrum and explores some of the challenges and opportunities in front of the industry.

LTE-U

LTE in Unlicensed spectrum (LTE-U) enables simultaneous operation of LTE over both licensed and unlicensed bands. It is a proprietary technology developed by LTE-U Forum, a private industry consortium created in 2014 by Verizon along with Qualcomm, Ericsson, Nokia/Alcatel, and Samsung. LTE-U uses LTE's carrier aggregation technology (LTE-CA) to tie the licensed and unlicensed bands together at the eNodeB and the device. The licensed band acts as the anchor (Primary Cell or "PCell") for the connection and carries bidirectional data, including control and security information as well as any QoS sensitive data traffic. One or two 20MHz channels (Secondary Cells or "SCells") in the unlicensed band carry downlink data, primarily best effort, to boost the cellular capacity. Traffic can be dynamically moved between bands on per flow basis.

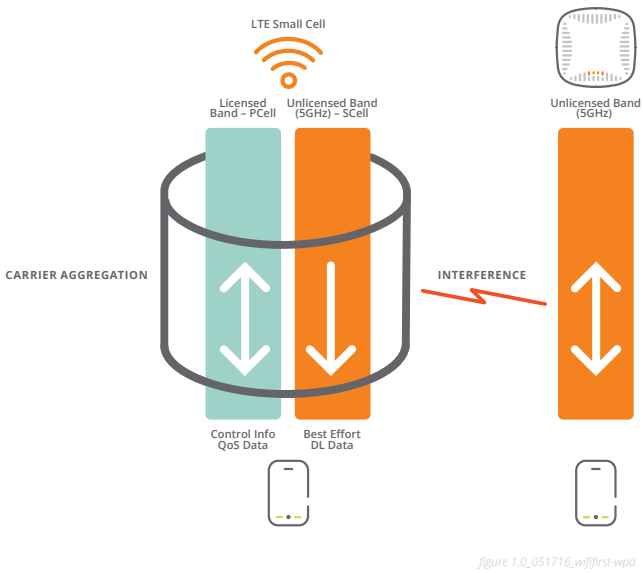

Figure 1: LTE-U operation in unlicensed band can impact Wi-Fi performance.

LTE-U offers the following rudimentary mechanisms for coexistence in the unlicensed band with other technologies:

- Channel Selection – chooses an unoccupied channel when one is available
- Duty Cycling – turns off transmission for a fraction of the period to share channel with others
- Opportunistic Switch off – turns off transmission when channel is not needed.

The above mechanisms are defined for use when interference is high (above -62dBm). No mechanisms have been defined for moderate interference (below -62dBm). Notably, LTE-U does not specify any listen-before-talk (LBT) requirements that are commonly utilized by technologies operating in the unlicensed band. Thus, LTE-U deployment is only possible in countries like the USA, China and India that do not have any specific LBT coexistence regulations defined for the unlicensed spectrum.

Based on industry studies, the mechanisms defined for LTE-U are not sufficient to enable fair coexistence with other technologies in the unlicensed spectrum. According to[6 and 7], Wi-Fi performance can be severely impacted by LTE-U. In high interference scenarios, when Wi-Fi is detected at above -62dBm, Wi-Fi throughput can be unfairly reduced. Latency on Wi-Fi can also be significantly increased, which can impede QoS sensitive applications like VoIP and multimedia gaming. Further, battery life of Wi-Fi devices is reduced due to impact on Wi-Fi power-save functions. More importantly, in moderate interference scenarios when LTE-U and/or Wi-Fi can hear the other at power levels below -62dBm, Wi-Fi

service can be completely crippled. Given that LTE-U always has fallback available on the licensed band, an LTE-U operator does not have sufficient incentive to ensure implementation of effective coexistence mechanisms to enable fair access on the unlicensed band.

Of equal concern is the fact that the LTE-U Forum specifications do not mandate critical operating parameters such as duty cycle, on time duration and off-time duration. These are at the discretion of each network operator, meaning that there could be wide variation in the nature and intensity of coexistence issues. Because there is no requirement to sense or otherwise be aware of Wi-Fi transmissions at all, some implementations have a "hard" cutoff that will begin sending in the middle of Wi-Fi transmission – which has been shown to negatively impact both systems.

Because it is a duty-cycle based solution, an LTE-U base station effectively takes control over its channel by force under control of a licensed operator, leaving it up to Wi-Fi to sense when the duty cycle is off. This simple reality in effect subordinates Wi-Fi, and converts the unlicensed bands into de-facto licensed band.

LAA

Licensed Assisted Access (LAA) may be thought of as the industry standardized version of unlicensed LTE. It is quite different from LTE-U. LAA is being standardized by 3GPP as part of Release 13 and is expected to be finalized in the first half of 2016. LAA has been designed to meet the European Telecommunications Standards Institute's (ETSI) listen-before-talk (LBT) requirements, so it can be deployed anywhere in the world. Like LTE-U, LAA introduces an LTE waveform in the 5-GHz band. And like LTE-U, LAA uses carrier aggregation (LTE-CA) to tie the licensed and unlicensed bands together. The licensed band acts as the anchor (PCell) and carries bidirectional data, including control and security information as well as any QoS sensitive data. Channels in unlicensed band (SCells) also carry bidirectional data, although primarily best effort, to boost cellular capacity. Traffic can be dynamically moved between bands on per flow basis. 3GPP's initial standardization work in Release 13 is focused on LAA downlink operation. Uplink operation is expected shortly thereafter as part of Release 14. At the time of this writing it has been proposed that LAA eNBs may be able to aggregate up to four 20-MHz channels in a similar manner to Wi-Fi.

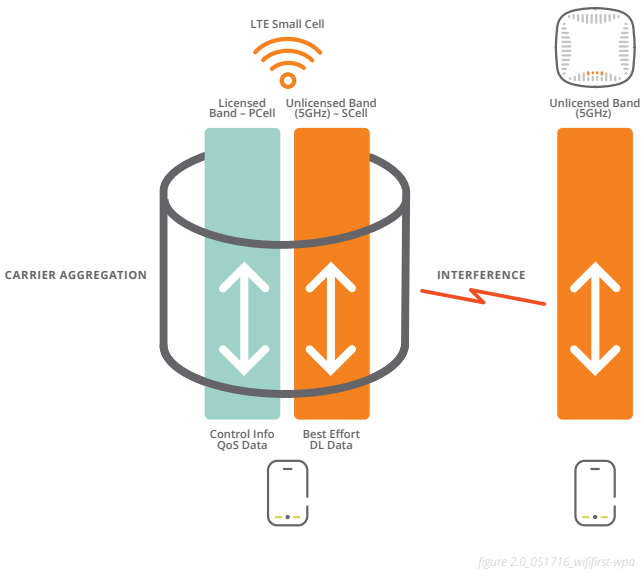

Figure 2: LAA operation in unlicensed band can impact Wi-Fi performance.

In order to meet ETSI's proposed LBT requirements in the 5-GHz band, LAA defers transmission on the unlicensed band until interference falls below -72dBm. No coexistence mechanisms have been defined for moderate interference (below -72dBm for 20MHz operation). Note that in contrast, Wi-Fi defers access to the channel if any preamble can be detected down to the receive sensitivity of the hardware (typically down to at least -92dBm).

Unless LAA coexistence mechanisms are carefully designed and tuned for fair medium access, performance of Wi-Fi and other unlicensed spectrum technologies can be severely impacted. Note that Wi-FI's CSMA/CA based medium access with truncated random exponential back-off provides a distributed mechanism for fair access. If LAA doesn't employ similar coexistence mechanisms, it can gain unfair advantage to dominate the unlicensed band. It must be said that the Wi-Fi and 3GPP communities have truly rolled up their sleeves and worked hard together to produce an improved LBT mechanism that closely resembles the operation of the Enhanced Distributed Channel Access (EDCA) method used by Wi-Fi. This is known as "Category 4" LBT and is expected to be the primary mode in which LAA will be deployed. Cat 4 LBT represents a dramatic departure from the brute-force approach of LTE-U, and of all the unlicensed LTE proposals it appears to have the best prospects of coexisting. Hewlett Packard Enterprise wishes to acknowledge the efforts of all those members of 3GPP and the IEEE who have worked behind the scenes to improve the LAA specification. Also, because the work of 3GPP is to a large extent done in public by many different industry stakeholders just like the IEEE, it can be thought of as more of an "open" standard than the closed and proprietary LTE-U Forum.

LWA AND LWIP

LTE WLAN Aggregation (LWA) and LTE WLAN Radio Level Integration with IPsec Tunnel (LWIP) are 3GPP technologies for interworking between LTE and WLAN. LWA and LWIP offer two different architectures for the common goal of using both LTE and Wi-Fi air interfaces simultaneously to augment LTE system capacity. However, unlike LTE-U or LAA, the LTE waveforms stay on licensed spectrum only. In the unlicensed band, standard Wi-Fi is used so there is zero concern about coexistence. LWA and LWIP enable utilization of unlicensed spectrum by leveraging existing (or new) Wi-Fi deployments to boost performance while still keeping subscribers connected on LTE. LWA and LWIP have been standardized by 3GPP as part of Release 13. Further enhancements are also expected to be brought in Release 14.

With LWA, the LTE data payload is tunneled to the Wi-Fi infrastructure over a new interface (Xw). Data is sent over the air using an 802.11 air link. LWA can be enabled via a software upgrade to LTE and Wi-Fi deployments. LWA can utilize Wi-Fi operating in both the 2.4 GHz as well as the 5 GHz bands. Configurations where eNodeB/small cell and the Wi-Fi AP are collocated and where the two are non-collocated are both supported by LWA. Signaling exchange between LTE and Wi-Fi infrastructure allows for fast adaptation to changes in RF and load conditions on the two networks.

While LWA requires an upgrade of Wi-Fi infrastructure, LWIP is a solution that is agnostic to the Wi-Fi infrastructure. It is designed to work over legacy Wi-Fi infrastructure without requiring any specific changes. Also no hardware related changes are expected for a terminal to support LWIP. With LWIP, the handset sets up an IPsec tunnel over Wi-Fi that is terminated on the LTE eNodeB or small cell. There are no standardized interfaces between LTE and WLAN with LWIP, and the IPsec tunnel is transparent to WLAN. Once the IPsec tunnel is set up, the LTE eNodeB and handset can send and receive bidirectional data on a per flow basis over Wi-Fi. LWIP is controlled by eNodeB based on measurement reporting by the handset.

Note that the Wi-Fi AP can provide both LTE aggregation as well as regular enterprise Wi-Fi services on the same hardware. LWA offers segregation and independent management of the traffic load between the enterprise and operator portions. Moreover, multi-operator support for LWA is possible on the same WLAN infrastructure with support for multiple RAN connections.

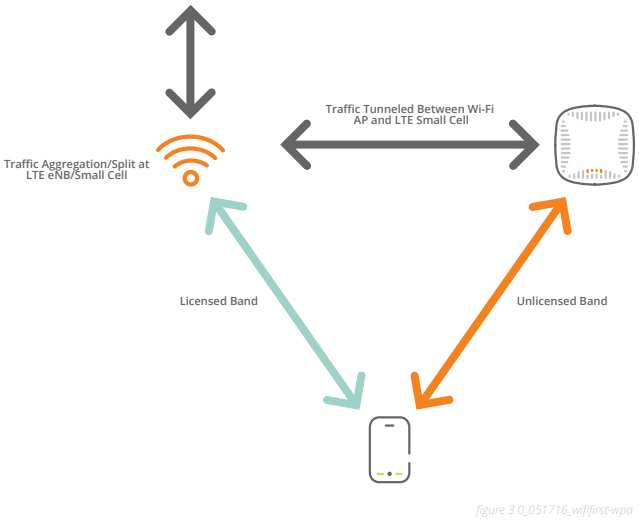

Figure 3: LWA and LWIP leverage Wi-Fi air interface to boost user experience.

The beauty of LWA and LWIP solutions is that they allow an LTE service provider to leverage the capacity offered by unlicensed spectrum for its subscribers without impacting fairness on the unlicensed band. LWA and LWIP enable peaceful coexistence while leveraging existing carrier and enterprise assets — LTE continues to operate in licensed band and Wi-Fi continues to operate in unlicensed band. The user device is able to utilize both links simultaneously with no mutual interference since LTE and Wi-Fi continue to operate in separate bands.

LWA/LWIP may be thought of as a form of “Hotspot 3.0”. Hotspot 2.0 (or “HS2.0”) refers to a Wi-Fi Alliance program that leverages the 802.11u standard to simplify the process of paid Wi-Fi subscribers connecting to hotspot networks even while roaming. HS2.0 has been slow to take off for a number of reasons. From a licensed network operator perspective, it poses integration challenges because HS2.0 systems do not communicate with the LTE RAN, and do not understand standard 3GPP interfaces. And from a user equipment perspective, the connection process may not always be seamless. LWA/LWIP elegantly solve these problems by wrapping the LTE control plane around a Wi-Fi radio access layer. It has the potential to meet operator needs for uniformity in network operations and subscriber needs for transparent connectivity.

MULTEFIRE™

Qualcomm and Nokia recently announced their efforts to bring standalone LTE, dubbed MuLTEfire™, to the unlicensed band[8]. MuLTEfire, the latest among the technologies aimed to leverage unlicensed spectrum, proposes LTE small cells that operate exclusively in the unlicensed spectrum without any anchor in the licensed spectrum. The MuLTEfire technology is being promoted by another industry body, the MuLTEfire Alliance, with Qualcomm and Nokia as the founding members and Ericsson, Intel and a few others as members.

MuLTEfire is planned to be based on the LAA physical and medium access control layers, including the unlicensed band coexistence requirements. All of the same concerns raised with respect to LAA therefore apply to this proprietary technology. In addition, because there is no licensed component, MuLTEfire must also support its control plane and uplink transmissions in the 5-GHz band.

Ultimately, MuLTEfire aims to bring the LTE technology for wireless access to enterprises and indoor establishments. Proponents claim that MuLTEfire will offer the robust radio link, mobility and self-organizing/self-optimizing capabilities of LTE and its 3GPP standard evolution to local area network deployments.

Clearly, fair sharing of the available spectrum with other technologies in the unlicensed band needs to be a fundamental requirement for MuLTEfire. With potential options for no traditional service provider involvement, MuLTEfire would also need to have solutions around a number of areas including device onboarding and provisioning, zero touch deployment and guest services in an enterprise setting.

Any company considering MuLTEfire deployment could equally well deploy Wi-Fi at the same location. Whether MuLTEfire would offer sufficient differentiators and a justifiable business case to tilt an entity's decision away from a well-established and enterprise feature-rich technology like Wi-Fi remains an open question. And as with all wireless technologies, client support ultimately will determine marketplace success. The MuLTEfire Alliance has yet to explain why major manufacturers of smartphones, tablets and laptops would place a second 5-GHz baseband in their devices that would increase cost, power consumption and in-device interference. Or alternately why consumers would accept a degraded Wi-Fi experience on a device that cycles between MuLTEfire and Wi-Fi to mitigate in-device interference.

WI-FI ROBUSTNESS AND SPECTRAL EFFICIENCY

Proponents of unlicensed LTE technologies have increasingly been asserting two arguments against Wi-Fi. One is that Wi-Fi is essentially unreliable and cannot be depended upon for truly mission critical communications. The other is that it is much less spectrally efficient than LTE. HPE simply cannot allow these statements to go unchallenged. Not only is no proof offered for the first argument, but in fact it is demonstrably false as shown by some of the examples at the beginning of this paper. The spectral efficiency case is also taken for granted without any analysis. It too can be easily disproven on several levels.

Spectral efficiency improvements have been a key part of the historical success of unlicensed band technologies, and in particular Wi-Fi. The desire for faster speeds has been realized through 3 major revisions of the IEEE 802.11 Wi-Fi standard (802.11a/b/g, 802.11n, 802.11ac). These revisions introduced new modulations and MIMO techniques, while maintaining backward compatibility to the very first generation devices. Throughout these revisions spectral efficiency has increased dramatically from 2.7 bits/s/Hz (using 802.11a, 64-QAM in a 20 MHz channel in 1999) to over 40 bits/s/Hz in the current generation 802.11ac standard. This increase was primarily achieved by higher modulation rates (256 QAM) and the introduction of MIMO, which supports multiple spatial streams (up to eight) in the same spectral bandwidth in the current revision of 802.11. Meanwhile, increases in speed and efficiency for Wi-Fi have all been maintained without sacrificing the underlying LBT spectrum sharing mechanism of CSMA/CA.

In contrast to the above figures for Wi-Fi's spectral efficiency, LTE offers a peak spectral efficiency of 16.3 bits/s/Hz for the downlink based on 64 QAM modulation and 4x4 MIMO system. LTE-Advanced, an enhancement to the original LTE standard, offers a peak spectral efficiency of 30 bits/s/Hz based on 128 QAM modulation and 8x8 MIMO system[9].

While it is certainly true that the quality of Wi-Fi networks can and does vary, it is equally certain that Wi-Fi would not enjoy the status it holds in the minds of citizen voters everywhere if most or all Wi-Fi was bad. However, in the event that unlicensed LTE technologies do not coexist very well with Wi-Fi it is entirely likely that the very scenario that the proponents describe will come to pass.

MINIMUM COEXISTENCE EXPECTATIONS & WI-FI ALLIANCE TESTING

HPE has a $4 billion installed base of Wi-Fi products in the market. The total installed base of enterprise Wi-Fi equipment is estimated at $30 billion (which is on top of the estimated $37 billion of installed consumer Wi-Fi products)[2]. Therefore, we have a responsibility to speak up on behalf of our customers.

It is to be noted that the unlicensed spectrum is already utilized by a multitude of applications ranging from simple consumer devices such as cordless telephones, remote control toys, garage door openers and baby monitors, to sophisticated business and commercial applications such as security systems, inventory control systems, manufacturing controls, and Wireless Local Area Networks (WLAN). Thus, any new technology deployed in the unlicensed spectrum needs to have effective coexistence mechanisms in place to ensure that the new technology accesses the medium fairly and does not unduly deteriorate the performance of incumbent applications.

HPE welcomes innovation in the unlicensed bands, and these are a resource for everyone by design. That said, we agree strongly with the definition of fairness first advanced by the unlicensed LTE community that an LTE-U or LAA radio co-located with Wi-Fi should not affect performance any more than another Wi-Fi network would.

The Wi-Fi Alliance and its membership have taken a leadership role in defining a coexistence test plan to evaluate this simple principle in real world equipment. The first public draft of an interim test plan was released on February 10, 2016. This test plan is not complete, but was published to show spectrum regulators and other stakeholders the progress that has been made. It is expected that real over-the-air testing will occur in the next few months. This test suite represents a consensus view of leading technical experts from across the Wi-Fi vendor community, including numerous companies that will be providing unlicensed LTE equipment.

It is of the utmost importance that the WFA test plan be widely adopted by the unlicensed LTE community and used as a baseline to evaluate the quality and market readiness of individual vendor implementations.

OPPORTUNITIES IN OTHER UNLICENSED & LIGHTLY-LICENSED BANDS

In April 2015, the Federal Communications Commission (FCC) of the US announced plans to make 150 MHz of spectrum in the 3.5 GHz band available for advanced spectrum sharing among federal and commercial operators[10]. This spectrum is located in the band spanning 3550 MHz to 3700 MHz and was previously allocated to the US Department of Defense (DoD).

2016 will also see the ratification of the new 802.11ah standard (also now known as Wi-Fi HaLow), which joins other long-range, low-power technologies in the 915/868-MHz bands such as SigFox™ and LoRa™. Recently ratified standards for TV white spaces (802.11af) and millimeter wave (802.11ad) in unlicensed bands are also beginning to see market traction. In addition, considerable additional spectrum at 5.4GHz, 5.9GHz and higher bands is currently the subject of rulemaking by regulators.

With the demand for data bandwidth increasing monthly for both enterprises and consumers alike, it is imperative that national policymakers continue to work to allocate additional spectrum for both licensed and unlicensed operation. Both types of spectrum play a critical and complementary role to meet the needs of the marketplace, and produce ongoing economic value.

WI-FI FIRST

At the end of the day, wireless subscribers will reject devices that do not feature Wi-Fi as a primary connectivity mode, and even more so if they experience higher monthly service bills for traffic carried over unlicensed LTE that was formerly at much lower cost on Wi-Fi. It may take a couple of years to work through, but ultimately such devices will simply fail in the market. In the meantime, both simulations and real lab tests show that the risk to the performance of installed Wi-Fi networks at home and at work is very real.

HPE further believes that the “small cell” is already on the ceiling in a huge number of businesses all over the world: a Wi-Fi access point. Major smartphone vendors have teamed with leading cellular operators around the world to enable Wi-Fi calling, which ultimately benefits the licensed networks by reducing congestion for limited spectrum.

Our point of view is that the answer to harnessing unlicensed spectrum is to better integrate Wi-Fi into the operator core networks such as is being done with LWA/LWIP. And that the most efficient and fair method of sharing the unlicensed bands is via a more operator-friendly version of Wi-Fi, which is currently under development in the IEEE as 802.11ax.

In other words, operators should embrace Wi-Fi, rather than fight it. The success of Wi-Fi is ultimately due to structural factors of cost, convenience, performance, critical mass and simplicity. Operators have legitimate and real concerns over how to deploy, manage and troubleshoot massive Wi-Fi networks. These can be addressed by working with the Wi-Fi community to extend its 20 year history of innovation and increased reliability.

As if to prove the point, the recent availability of "Wi-Fi First" calling plans such as Google's Project Fi, Republic Wireless and FreedomPop take the view that the primary radio in a smartphone is in fact the Wi-Fi radio. And that cellular connectivity is only necessary as "glue" when the user is outside of Wi-Fi coverage. This truly does invert the longstanding relationship between operator network and private network. It forces the traditional operators to alter their business models yet again to deliver new kinds of services and value to compete in the marketplace.

HPE is one of the largest providers of carrier-grade Wi-Fi equipment and management software in the world. We have a history of partnering with operators to enable them to roll out new business models and improve monetization of their customers. Our carrier Wi-Fi deployments support tens of terabytes of data traffic on a daily basis, delivering immense value to the operators. By deploying HPE's carrier-class Wi-Fi and value-add solutions, service providers can fulfill their goal of leveraging unlicensed spectrum to increase the overall capacity, performance and monetization without having to gamble on an unproven technology.

CONCLUSION

The unlicensed band works on a very different set of assumptions than a licensed band. With no central coordination or management authority, any access technology deployed in the unlicensed band needs to be acutely aware of other occupants of the channel in the vicinity and needs to back away gracefully to enable fairness. This kind of distributed fair access mechanism is necessary to enable peaceful coexistence of different technologies in the unlicensed spectrum.

Without effective coexistence mechanisms in place, LTE-U and LAA carry the risk of degrading the connectivity experience of billions of unlicensed spectrum users around the world. In a recent poll by Wi-Fi Alliance, three quarters of Americans said they would be concerned about a technology that could jeopardize their access to free Wi-Fi availability[11]. Industry bodies such as 3GPP, the Wi-Fi Alliance and the IEEE as well as other LTE and Wi-Fi communities must work together toward fair and effective coexistence mechanisms, testing and certifications to ensure there is no negative impact to the existing and future occupants of the unlicensed spectrum.

The availability of spectrum for unlicensed operations has not only provided an inexpensive communication medium, but it has spawned significant innovation and created new markets. The economic impact of the unlicensed spectrum has been estimated at more than $222 billion annually and growing[1]. It is incumbent upon the industry to ensure that unlicensed spectrum continues to be available freely and fairly to trigger innovations that usher mankind into a brighter tomorrow.

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1344 CROSSMAN AVE | SUNNYVALE, CA 94089
1.844.473.2782 | T: 1.408.227.4500 | FAX: 1.408.227.4550 | INFO@ARUBANETWORKS.COM

www.arubanetworks.com