Towards 2020: Emerging Opportunities for Wi-Fi Services

Source: Maravedis-Rethink
Author: Caroline Gabriel
Issue date: 20 May 2015
Version: 1.0
Document status: Final

Wireless Broadband Alliance

Driving next generation Wi-Fi experience

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Founded in 2003, the aim of the Wireless Broadband Alliance (WBA) is to secure an outstanding user experience through the global deployment of next generation Wi-Fi. In order to make this a reality, the WBA is currently championing various initiatives in the Wi-Fi ecosystem including Next Generation Hotspot (NGH) trials, Wi-Fi Roaming and its Interoperability Compliance Program (ICP). Today, membership includes major fixed operators such as BT, Comcast and Time Warner Cable; seven of the top 10 mobile operator groups (by revenue); and leading technology companies such as Cisco, Microsoft, Huawei Technologies and Intel. WBA member operators collectively serve more than 1 billion subscribers and operate more than 10 million hotspots globally. The WBA Board includes Arqiva, AT&T, Boingo Wireless, BT, Cisco Systems, Comcast, iPass, KT Corporation, NTT DOCOMO, Orange and Ruckus Wireless.

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Executive Summary

Behind the scenes of the massive expansion of public Wi-Fi around the world in recent years, there has been another development going on. The Wi-Fi platform has been evolving rapidly and is now emerging as a fully carrier-grade network, poised to revolutionize the services and business models which Wi-Fi can support.

Recent years have mainly been a story of expansion, making broadband access available to millions of users in every corner of the world. This has seen a significant build-out of Wi-Fi hotspots – and more recently, community hotspots (residential gateways with a second SSID left open for public access) – by many kinds of venues and operators (see Figure 2-4).

However, the service models for these networks have been largely limited to best-effort web access, while monetization has relied on a few well-established options like pay-as-you-go access fees, advertising or indirect benefits like churn reduction. The move to fully carrier-grade Wi-Fi networks will spark an explosion in the range of services which consumers can use on hotspots, and in the monetization options for operators.

New capabilities include faster data rates (802.11ac hotspots), seamless authentication and hand-off to cellular (NGH and Passpoint), wider roaming, carrier-grade network and subscriber management, and improved QoS and security. All these add up to a network which can support many services which were difficult or impossible with previous public Wi-Fi generations. The most important fall into four categories, all of which are enabled by improved levels of performance and reliability:

- Services which require high levels of security and QoS, such as enterprise communications (especially voice) and public sector applications like safety
- Services which rely on integration with other networks, such as cellular or cable – part of a broader trend towards converged quad play offerings
- Services which focus on ultra-reliable machine-to-machine communications rather than human use, such as smart city and smart healthcare applications
- Services such as ‘TV everywhere’, which are driven by high quality video, which is dependent on good bandwidth and QoS

The ability to implement services in these emerging categories will not only create new revenue streams for Wi-Fi networks, they will create a new class of service providers. As the types of services expands, there will be a major proliferation of companies supporting consumer, enterprise or IoT (internet of things) services on Wi-Fi. Many of these will not build their own hotspots, but will harness improved roaming and authentication schemes to rely on third party networks.

Venues, retailers, smart city providers, over-the-top content providers, multimedia applications developers and many others will offer their services and brands to the growing base of users by riding on carrier-grade Wi-Fi.

Many of these new service providers, as well as new revenue streams for conventional operators, will rely on Wi-Fi integrating with other technologies. In the smart home, it will work alongside WPAN (wireless personal area network) technologies like Bluetooth LE and ZigBee; for consumer services, there will be increasing integration – at access and management levels – with cellular. These are complementary technologies, but there will also be new networks appearing in licence-exempt bands – LTE-Unlicensed, for instance, or specialized low power wide area (LPWA) technologies for smart cities.

Cooperation with these other technologies will drive yet more service models, and will point towards a ‘5G’ era where it is likely that many networks will work together in a highly integrated manner. Wi-Fi is well positioned for this heterogeneous world. It has flourished by having a broad ecosystem at equipment and device levels, and a

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high degree of global harmonization, both of which make it well-suited to be the basis of new devices and services. It is inherently a 'good neighbor' standard, which can coexist with other technologies, and its capabilities are being enhanced by carrier-grade functionality and expanded spectrum options.

All those developments will underpin the next phase of public Wi-Fi history, characterized by a huge expansion of services and revenue streams, and of the variety of service providers. 2015 will be a landmark year, with key technical and market developments which will enable new business models for existing and new service providers. As well as driving new hotspot build-outs and service launches in the 1-3 year timeframe, it will also lay the foundations for Wi-Fi's prominent role in the wireless world of 2020, which will see an even bigger explosion of consumer, enterprise and IoT services and providers.

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Introduction: The Transition to Carrier-Grade Wi-Fi

The past few years have seen public Wi-Fi platforms evolving from supporting affordable broadband coverage and capacity for best effort access, to becoming truly carrier-grade. That process is still ongoing, but 2015 is seeing rising uptake of some of the technologies that are making Wi-Fi carrier-grade, such as Passpoint and Next Generation Hotspot (NGH), the 802.11ac upgrade, and closer integration with other operator networks such as cable or cellular.

These trends will drive investment in deploying or upgrading carrier-grade Wi-Fi, by MNOs, MSOs, pureplay Wi-Fi operators and venues. Between 2015 and 2017, according to Rethink calculations, 82% of operators plan to start upgrading at least part of their Wi-Fi networks to carrier-grade, and this will result in two-thirds of public hotspots being carrier-grade by the end of 2018.

A carrier-grade Wi-Fi network has several key characteristics including:

- High performance (more than 1Gbps for 11ac)
- Handoff and seamless authentication across multiple Wi-Fi networks and to cellular
- Roaming capabilities
- High levels of security and QoS
- Ability to be managed by a carrier's OSS/BSS

What is Carrier-grade Wi-Fi?

The rising importance of carrier-grade Wi-Fi to enable new business models prompted the WBA to release a comprehensive definition of Carrier Wi-Fi, which can be rather a vague and overused term, in 2014.

This aimed to help drive all providers towards common approaches to user experience and end-to-end management. The WBA brought together nearly 20 large operators and vendors to participate in creating its definition.

The WBA Guidelines state that the following standardized Carrier Wi-Fi capabilities are needed to ensure networks can scale to meet the requirements of the industry:

- Consistent User Experience
- Network Discovery and Access
- Authentication and Security
- Service Experience
- Fully Integrated End-to-End Network
- Network Architecture
- End-to-End Service Provisioning
- Network Management
- Network Quality
- Network Security
- Network Manageability

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1. New Business Opportunities

These new opportunities will expand the business case for existing Wi-Fi operators, and will also enable a huge variety of new companies to deliver services over Wi-Fi. As the range of services expands, there will be a major proliferation of companies supporting consumer, enterprise or IoT (internet of things) services on Wi-Fi. Many of these will not build their own hotspots, but will harness improved roaming and authentication schemes to rely on third party networks.

Venues, retailers, smart city providers, over-the-top content providers, multimedia applications developers and many others will offer their services and brands to the growing base of users by riding on carrier-grade Wi-Fi (see Section 2 for more detail). Some providers may offer just one specialized application, such as a smart parking service for a city; others may bundle Wi-Fi connectivity with a device or consumer app to drive usage and add value; others will be adding Wi-Fi's wide availability and ease of use to enhance a primary service such as cable TV or enterprise unified communications.

In turn, the proliferation of service provider types will drive further innovation in services, and new applications will emerge which take advantage of public Wi-Fi, creating a virtuous circle of usage and investment.

In research, conducted among MNOs, MSOs and a wide range of Wi-Fi service providers by Maravedis-Rethink in spring 2015, seven of the key business opportunities were singled out by the providers as the most promising for the period from 2015 to 2018. Each is enabled by the shift to carrier-grade Wi-Fi, and in many cases, by specific technology enhancements in the Wi-Fi arena. In this section, we outline those key enablers and the new business cases they will drive.

Different service providers will choose to support different combinations of these services, in order to maximise the returns on their investment in Wi-Fi and to offset the squeeze in ARPU for simple 'access everywhere' models.

1.1 Voice

1.1.1 Key enablers: IMS-based Wi-Fi Calling

Voice is the wireless 'killer app' which refuses to die. Despite the rising use of other methods of communication, from instant messaging to email to social media, voice remains an important service. It is assumed to be a hard to generate profits from voice – cellular and wireline voice revenues are in decline and there are many over-the-top offerings, like Skype, which generate little for the network provider.

However, there are several business cases emerging around enhanced voice services, which go beyond what Skype and WhatsApp can promise. The most promising ones, according to our research, are in enterprise communications and carrier VoWi-Fi.

In an IP environment like Wi-Fi, the business case is often enhanced by making it part of a unified communications offering, integrated with messaging of various kinds, including multimedia. This allows carriers to support enhanced voice offerings, especially for business users, which can compete well with OTT alternatives.

This, in turn, can create opportunities for new types of service providers, sometimes quite disruptive ones. In the US, several companies, including Republic Wireless and Scratch Wireless, have launched Wi-Fi-first services. These offer very low cost subscriptions, with the device defaulting to Wi-Fi and only moving to a cellular connection when there is no WLAN in range.

The ongoing trend for greater integration between cellular and Wi-Fi wireless networks is helping create new opportunities for these Wi-Fi-first models and for Wi-Fi-based voice. VoWi-Fi or Wi-Fi Calling saw two important breakthroughs last year – support in the latest release of the iPhone's iOS software, and the first commercial launches. T-Mobile USA, three UK operators, Dutch cable company Ziggo, and others have launched these

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services, which are supported by the carrier's IMS (IP Multimedia Subsystem) in the same way as other carrier-controlled IP voice services such as VoLTE or cable VoIP.

Like mobile data offload, VoWi-Fi is a means for MNOs to extend their coverage and capacity affordably, but in this case for voice. As they migrate away from circuit-switched 2G and 3G services, they can roll out VoLTE at their own pace and deliver IMS-based Wi-Fi services even where they do not have LTE built-out, or where devices are scarce.

The IMS allows providers to provide added value communications services such as multimedia mailboxes and conferencing, which can differentiate them from OTT, especially in the business world. With Wi-Fi, these services can be supported everywhere, not just where there are LTE or cable deployments, and can help wireless and wireline carriers to protect at least the high value business portion of their voice business, where enhanced IP options and QoS will be important.

Such incentives will lead to a large percentage of MNOs and MSOs deploying IMS-based VoWi-Fi applications between 2015 and 2018, either alone or, more commonly, in tandem with other IP communications systems such as VoLTE. As Figure 1-1 shows, MSOs lead the way in most regions, since Wi-Fi Calling helps make their wireless offering more competitive with that of cellular, but MNOs are also keen to extend their voice coverage and capacity with Wi-Fi, as they start to move away from 2G/3G. In emerging markets, VoWi-Fi may also be an interim step towards future VoLTE deployments. By 2018, 80% of north American MSOs will offer Wi-Fi Calling, the group with the highest uptake, but even the lowest level, among European MNOs, will have reached 56%.

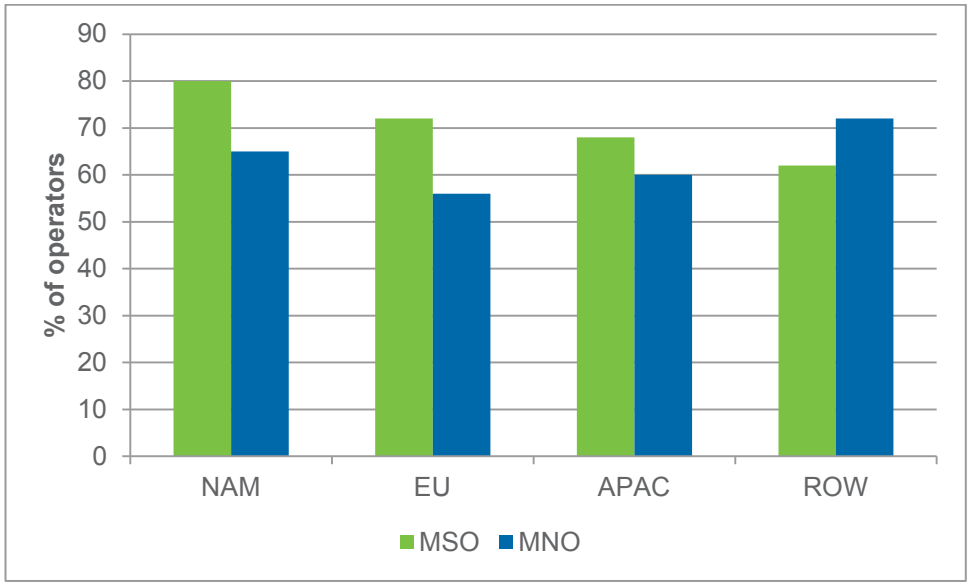

Figure 1-1 Percentage of MNOs and MSOs planning to deploy IMS-based VoWi-Fi by end of 2018. MaRe operator survey March 2015

1.2 Always best connected

1.2.1 Key enablers: Passpoint, NGH, ANDSF, vendor solutions

The launch of Google's US-based MVNO service, Fi, in April placed a strong spotlight on 'always best connected' services. These involve the service provider using clever access management algorithms, on the device or server side, to connect the customer to the 'best' wireless link available, according to various criteria, such as speed, price, QoS or application type. As the user moves across different connections, connectivity, security, authentication credentials and other settings are maintained seamlessly.

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This may sound like housekeeping, but it can drive significant new business cases. For network owners, it can reduce the cost of supporting data usage by spreading this across cellular and Wi-Fi, or by offloading lower value traffic.

It can also improve the overall quality of experience by automatically giving the customer the best available connection, and this can reduce churn. It can also make it more viable for operators to offer high value applications that rely on strong QoS, such as video streaming or enterprise conferencing, or SLA-based services. By shifting the revenue mix towards QoS-reliant offerings, an operator can increase ARPU.

Figure 1-2 indicates the primary business drivers behind the move to support always best connected policies. These are dominated by the desire to reduce churn by giving users more reliable connectivity, and to improve overall QoS in order to support new or enhanced revenue streams from applications like video.

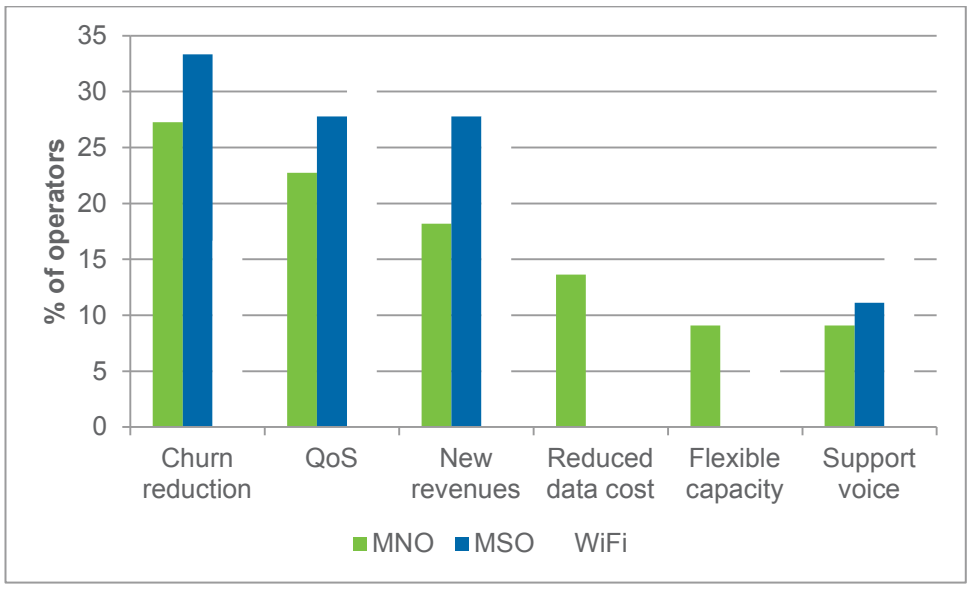

Figure 1-2 Primary business motivation to invest in 'always best connected' strategies by 2018.

Operator survey March 2015.

The uptake of Passpoint and NGH supports seamless authentication and handoff, while ANDSF, though active device support is happening more slowly, allows for selections driven by operators' policy engines. Some vendors in the Wi-Fi and cellular communities already offer their own solutions, with criteria which can be set either by the device owner or the operator.

Looking towards the future, always best connected is a stepping stone towards a far more dynamic allocation of bandwidth and capacity. Google Fi indicates some future trends. It allows users to move between Wi-Fi and cellular with just one number, and to use that number on many devices such as handsets and laptops. This sees an over-the-top provider taking control of the phone number and connection, and it is just another step towards full 'network as a service' ideas, in which a third party allocates capacity across many Wi-Fi and cellular networks to large numbers of applications providers, on an on-demand basis.

In such architectures, according to proponents such as Google, wireless technologies in licensed and unlicensed spectrum really become part of a single pool of capacity, increasing the economics for the providers and the QoS for the end users.

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1.3 Increasingly granular location and proximity services

1.3.1 Key enablers: Wi-Fi Aware, Wi-Fi Direct, advances in positioning technologies

Location awareness has been of interest to Wi-Fi service providers for years as a way to deliver customized adverts and applications tailored to a user's position. Now that idea is evolving rapidly towards full personalization, and the delivery of services shaped not just by location but the users' preferences and past habits.

This can enable more precisely targeted and relevant content or adverts, increasing satisfaction and response rate, and of course providers also gather a large amount of data about their customers' behavior, which can be fed into analytics engines for internal marketing use or (anonymised) to sell to partners.

The latest addition to this mix is proximity-based marketing and services. The ability for Wi-Fi devices to discover one another automatically when in range, and communicate directly, leads to a new range of service opportunities. Wi-Fi Direct supports this capability and has been joined this year by Wi-Fi Aware, which enables Wi-Fi to behave almost like Bluetooth beacons. It sends a continuous stream of very small messages, allowing Wi-Fi Aware devices to seek out others nearby that are interested in the same activities – content sharing, gaming, peer-to-peer messaging and so on – and to launch the relevant application. The proximity awareness can also support more precise versions of location-based services such as context-driven notifications and promotions.

As well as supporting services, such as gaming, which may carry subscription or usage fees, these platforms allow Wi-Fi providers to collect and analyse an even greater wealth of information about their customers. The more analytics they apply, the more they can understand each user and personalize services for them, to encourage them to spend more money. Big data is one of the biggest potential opportunities for service providers between now and 2020, as improved engines emerge to help them harness all this information. It is also an activity which is reliant on carrier-grade Wi-Fi, in which individual users can be identified and tracked, with integration to back office databases and applications such as customer experience management (CEM).

1.4 Smart city

1.4.1 Key enablers: Public hotspot upgrades to 11ac, emergence of 11ah and 11ax

Smart cities are one of the big discussion topics of 2015 among service providers of all kinds. The aim is to create a single platform for connectivity and data management, on which a variety of services can be launched in an integrated fashion, coordinated by the city authority and its partners. Applications such as smart lighting and traffic management are designed to make cities safer, more efficient and less power hungry, while these infrastructure services will also integrate with services offered directly to citizens, such as free broadband access, information alerts and directions, or online voting.

Cities which already have large-scale networks of public Wi-Fi hotspots will often use these as a starting point for a more integrated smart city project, so this is a significant opportunity for the technology and for service providers, whether specialized city service providers or regular MNOs and MSOs.

Smart city projects will spawn new providers, often with very specialized applications for a certain aspect of municipal usage, such as smart metering, traffic management or surveillance. The need for high reliability means that these providers will often look for close integration with the network, rather than delivering their services purely over-the-top, and that will create a proliferation of Wi-Fi-based specialist operators. In some cases these may cooperate with more established carriers, but in others they will be alternatives to them.

Smart cities also provide an example of how Wi-Fi, in the next generation of its business models, will often have to work with other technologies closely. This is already happening with cellular, thanks to Passpoint and NGH, and in the smart city, there will often also be applications running on specialized LPWA (low power wide access) technologies such as Sigfox or LoRa, plus many personal area network applications, perhaps enabled by Bluetooth beacons.

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Wi-Fi will evolve itself to support a wider variety of city applications too. The 802.11ah extension is going through the standards process and would allow Wi-Fi to run over long ranges in the sub-1GHz ISM bands, as Sigfox and other LPWA technologies do. Further down the track, 802.11ax will be optimized for dense deployments in areas such as stadiums. Both these will enable operators to extend their capabilities and services, building on their existing base of hotspots, which will themselves be upgraded to the high speed of 802.11ac and to other carrier-grade functions.

The end result will be greatly enhanced citywide Wi-Fi networks with the ability to support a large number of services, generating revenue for the operator either directly from the city authorities or utilities; from citizens paying for premium options such as multicasts during sports events; and from advertisers.

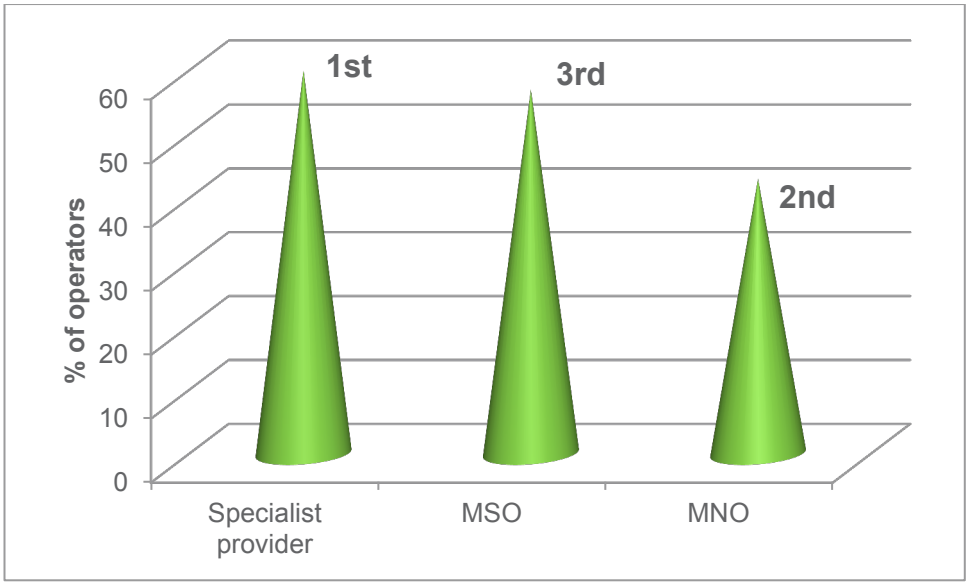

Figure 1-3 Percentage of operators planning to deploy smart city services on carrier-grade Wi-Fi and/or 802.11ah by 2018, and the priority smart cities take in their business case for 2018.

Source: Operator survey February 2015

Figure 1-3 indicates just how important smart city opportunities are to Wi-Fi providers. In a study of about 45 providers in 2015, it was found that Wi-Fi specialists are particularly enthusiastic about the prospect of hosting city services on their current and future networks, with 60% planning to offer these by 2018, and half of them aiming to add 802.11ah to their platform. For this group, smart cities are the number one priority in terms of driving new revenues and the business case for carrier-grade Wi-Fi.

For MSOs, 57% plan to support smart city services by 2018 and 26% are interested in 11ah. This is a higher percentage than for MNOs (47%, with only 15% interested in 11ah, presumably because of potential conflicts with LTE's low power variants). However, among MNOs, smart cities take second place among the drivers for investing in public Wi-Fi (after data offload) while for MSOs they come third after quad play and video offerings.

1.5 (Consumer) internet of things

1.5.1 Key enablers: Wi-Fi support in Android Wear, very compact chip modules, wireless charging, WiGig, Wi-Fi Aware

The Internet of Things is a huge umbrella term which spans all kinds of services from industrial M2M (machine-to-machine) to smart cities (enterprise and city use cases are addressed separately). One branch of the IoT where Wi-Fi providers will see strong opportunities will be in consumer applications, largely centered on wearables,

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personal health and fitness, connected car and smart home applications. Here the providers will have a range of business cases, usually supported by a multi-technology network in which Wi-Fi provides the hub while shorter-range connections are supported by other technologies like Bluetooth LE. Business models will range from added-value home or personal applications like health monitoring, to big data.

As with the smart city, Wi-Fi has an advantage as the IoT emerges because it provides readymade infrastructure in areas like the home. A common scenario will be to have a home hub, connecting a large number of devices – appliances, media players, home security systems, meters and so on – by Wi-Fi. Where the devices are very low power, or there are large numbers of them, they may be clustered together with Bluetooth, ZigBee or Thread too.

So as in other areas of the IoT, consumer applications will drive convergence between several technologies living in licence-exempt bands. The IoT will support such a huge variety of devices, services and network requirements that it will rely on a range of connectivity options, each optimized for a different function. Wi-Fi was always designed as a 'good neighbor' technology and so it is in a strong position to coexist with other, complementary platforms like the ultra-low power, short range standards (eg Bluetooth LE). It is well placed to take the leadership role in a converged consumer IoT platform operating mainly in licence-exempt spectrum, and so able to harness a broad ecosystem and strong economics.

So far, wearables like smart watches and spectacles, these have mainly been merely companions for a smartphone, tethered to it by Bluetooth. However, in April Google added Wi-Fi support to Android Wear, which could enable future wearables, from smart clothing to virtual reality headsets, to be directly connected to the internet over WLANs.

There are many forecasts for wearables, and they all involve huge numbers like 250m by 2018 (CCS Insight), or 60m fitness devices alone by that date (Juniper).

It is not clear what percentage of those will be Wi-Fi-connected, rather than tethered to a handset, but Wi-Fi Direct will play an important role in that pattern. It will allow smart accessories or clothing items to discover and communicate with one another securely and automatically, without the need for the smartphone or access point, which will support different use cases and greater flexibility.

But the consumer IoT goes far beyond wearables, and embraces many other devices and screens. Google noted, when launching its cellular/Wi-Fi connectivity service Fi, that in future some of the 'customers' would be M2M devices like its own Nest thermostats, rather than just human-controlled handsets. That indicated how important the smart home will be in terms of future connections and revenues, and the connected car is also a significant growth opportunity, as seen in platforms such as Android Auto and Apple CarPlay. The consumer of 2020 really will be connected at all times and in all places, but not just via a smartphone – much of that connectivity will be via other routes such as in-car systems, sensors embedded in clothing, health monitors and so on.

Such changes will open up new business models based on connecting huge numbers of consumer gadgets, which were previously 'dumb', to the internet and to one another. The actual connectivity fees attached to such devices are likely to be extremely low or zero, but if a wider variety of 'things' are connecting to the public Wi-Fi network, there will be new opportunities to deliver adverts and applications, and to gather customer data, related to a larger range of activities. An example is AT&T with its Digital Life program, which embraces many kinds of consumer IoT devices and provides the device management, provisioning, security and services delivery – all essential to make sense of the billions of IoT sensor connections, and also to drive meaningful revenues from them.

Looking further ahead, there are initiatives to develop ultra-low power Wi-Fi-based technologies to support wearables and sensors, including one at the UCLA (University of California at LA), which claims to use 10,000 times less power than conventional Wi-Fi. Another nearer term development is the emergence of 802.11ad or WiGig – the multi-gigabit Wi-Fi-like technology in the 60 GHz band – which will be well suited to supporting high bandwidth home media networks or high end home hubs.

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1.6 Cable Wi-Fi and the road to quad play

1.6.1 Key enablers: high speed connections (802.11ac), seamless access for QoS (Passpoint, NGH, ANDSF, vendor solutions), community hotspots, video over Wi-Fi, Wi-Fi Multicast

Cable operators, especially in North America and Western Europe, have been highly active in deploying carrier-grade Wi-Fi in order to add high quality wireless services to their bundles, a first step towards a fully-fledged multiplay.

In addition, by carrying more traffic over Wi-Fi, they can reduce the fees they pay for cellular access under their MVNO deals – hence the rise of Wi-Fi-first services from companies like Cablevision in the US or UPC in The Netherlands, which default to the WLAN and only move to cellular when there is no Wi-Fi in range.

The cable MSOs and other fixed broadband providers have also started to augment the public hotspots they build or source through partners, with large networks of community hotspots. These are home Wi-Fi gateways, backhauled by their own broadband lines, but with a second SSID which is left open for public access by passers-by (usually the MSO's customers). This is a very low cost way of expanding Wi-Fi coverage, especially in suburban areas where it may be hard to justify dense hotspot deployment, and the community hotspots are fully managed by the operator's back office systems, allowing it to monitor and monetize usage (see below for homespot forecast).

Initially, the drivers for cable Wi-Fi are to provide broadband access on the move without paying cellular fees, but many MSOs have more ambitious plans for their networks too, particularly to support video services such as TV everywhere and quad play. These allow subscribers to watch the same content on any device and from any location, with the same security settings, preferences and stored items as on their home TV.

In some cases, Wi-Fi is no longer just an add-on to the core cable TV or fixed broadband business but the centerpiece. For instance, in early 2015, Cablevision said it planned to

prioritize Wi-Fi over the TV business it had better costs and margins. Its Freewheel Wi-Fi Calling and data service, launched early this year, has seen uptake outside the operator's regional cable footprint in the New York area, an important incentive to deploy Wi-Fi.

Video-oriented technologies such as Wi-Fi Multicast will help MSOs to offer video services over Wi-Fi which are comparable to those their customers receive at home, or which are supported by LTE Multicast. Wi-Fi Multicast is just evolving and has been deployed by a few venue owners, mainly in stadiums, already. It can deliver live multimedia to smartphones and tablets being used by concentrated groups of people, such as those attending a sporting event or concert.

Such trends will make the cable providers even more determined to invest in a wireless network they can control, tipping the balance of their quad play bundles towards the higher profits of wireless data, and stealing some of those profits from the mobile carriers along the way.

In the US, Comcast is the biggest deployer of hotspots and community hotspots, and together with Cablevision, Time Warner Cable, Cox and BrightHouse is also part of the huge CableWi-Fi hotspot roaming alliance, helping the MSOs extend their national reach to almost cellular scale in some areas. Comcast said recently that 70% of in-home mobile traffic in its broadband households now travels over the company's Wi-Fi connections.

New developments like faster Wi-Fi, as well as improved QoS from seamless hand-off, will make it increasingly practical to deliver high quality video, the MSOs' core business, over hotspots and community hotspots.

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1.7 HetNet

1.7.1 Key enablers: VoWi-Fi, seamless access (Passpoint, NGH, ANDSF), Wi-Fi/cellular combined core and BSS/OSS, Wi-Fi SON (self-optimizing network), multimode small cells

The mirror image of the MSOs' Wi-Fi-driven quad play business models are the heterogeneous networks planned by many MNOs between now and 2020. These aim to create a pool of seamless capacity, combining cellular and Wi-Fi and directing users' connections intelligently to the most appropriate link.

That will represent a step on from mobile data offload, which has been the MNOs' primary use of Wi-Fi until now. That has been important to the economics of mobile data because it has allowed MNOs to harness lower cost, licence-exempt spectrum as well as expensive 3G and 4G licences, but the decision of which traffic to offload has often been rather unsubtle, usually based on packet size or subscriber type.

In the HetNet, there is far more handover between cellular and Wi-Fi, with users moving between the two seamlessly, retaining their call or video stream, and all their security and identify settings, as they go. That places a large amount of capacity at the MNO's disposal, combined with new levels of QoS across all links, so they can start to support their own quad plays by delivering video and TV over their wireless networks.

We have already seen how MNOs are using VoWi-Fi to extend coverage and capacity for IMS-based voice, and the same can apply to IP video services. Some MNOs, such as T-Mobile USA, have launched Wi-Fi-first services in order to encourage consumers not to overuse the constrained cellular resource, which can then be retained for premium services for which licensed spectrum QoS is essential.

Mobile operators will also use Wi-Fi to expand their availability and coverage rapidly to support other emerging opportunities, such as some in the smart home and smart city sectors, even when they do not yet have LTE built out. Here, if they do not have suitable cellular connections in all locations, they can move into the new application space anyway and establish a position based on Wi-Fi.

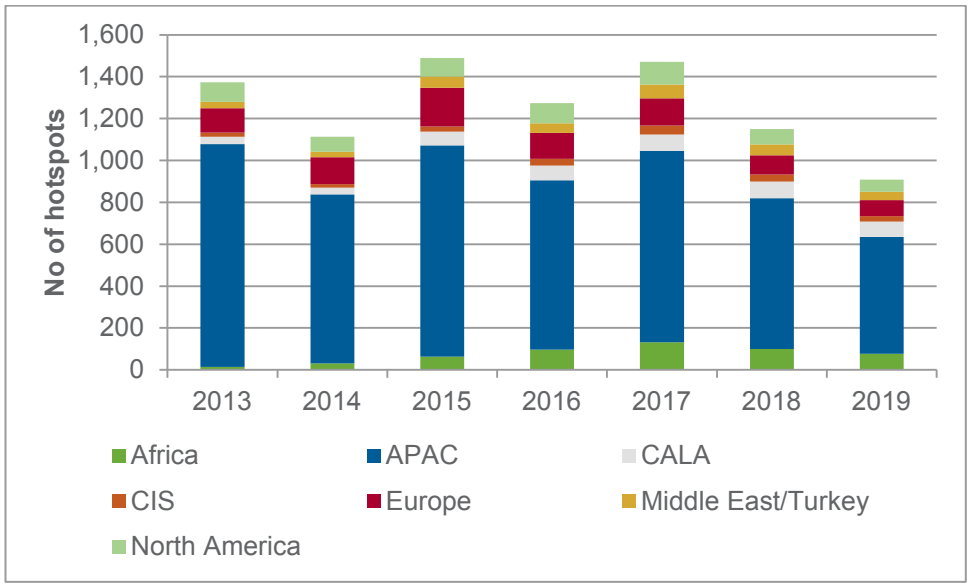

Figure 1-4 Deployment of new Wi-Fi hotspots by MNOs (directly or via partner deals and roaming) between 2013 and 2019, by region.

Source RAN survey of 76 MNO groups, January 2015

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The result, for some operators, especially in Japan, China, Korea and parts of the US, will be dense HetNets of small cells, working in different spectrum bands and combining Wi-Fi and cellular (and perhaps others in future, especially for the IoT). This will be enabled by the availability of BSS/OSS and mobile core platforms that can plan and manage Wi-Fi and cellular access points in the same way; and by the emergence of SON tools which optimize these mixed-mode networks, not just 3G and 4G. All that will enhance the MNO's ability to build up huge pools of capacity in which connectivity can be intelligently handled to improve QoS, and in which resources can be targeted most efficiently where they are required.

And like MSOs, they will look to create 'inside out' coverage by encouraging subscribers to install dual-mode Wi-Fi/cellular access points indoors, with both connections allowing for some measure of public access.

Mobile and wireline operators will increasingly converge in order to support quad play services – in mature markets, where consumer ARPUs are stagnant and there are high levels of competition, operators will seek to boost their share of a household's total media and communications spend, even if rates for individual elements are falling. For these converged carriers, building a huge pool of wireless capacity will be essential to winning those quad play customers, as they spend an increasingly percentage of their time consuming broadband and video services while on the move, not in the living room.

1.8 The value of the new service opportunities:

The proliferation of carrier-grade Wi-Fi, together with all the other technology advances outlined above, will create a large number of new opportunities for service providers. The seven examples detailed here are the ones which operators currently see as being the most important for future business models, but others are sure to emerge, especially in the fledgling market of the IoT.

Together, they will drive a significant increase in service revenues directly attributable to public Wi-Fi. This is because the ability to charge directly for best effort access is limited in most countries, and deployment of Wi-Fi has typically been justified in other ways – by reduced total cost of ownership for a mixed broadband network (cellular/Wi-Fi or cable/Wi-Fi); by advertising or enterprise services; or by wholesale fees.

With carrier-grade infrastructure enabling new services and higher QoS, there will be new revenue streams directly attributable to Wi-Fi. For instance, a report by Senza Fili for the WBA estimated that Wi-Fi service revenues driven by the deployment of NGH, an important element of the transition to carrier-grade hotspots, will grow to over $150bn by 2018, which would represent 9% of total global carrier service revenues.

Figure 1-5 shows how these revenues will be driven by the growing variety of services which Wi-Fi can enable as the platform evolves. Total service revenues will be split between a far larger number of offerings by 2020, with simple internet access fees sinking from 17% to 9% of the total, while higher value services such as location-aware promotions, premium content and smart city applications will take a larger share of the pie, partly because they will maintain their ARPUs far more robustly than access plans. Access and advertising will remain bedrocks of Wi-Fi service revenue, but will account for a far smaller portion of a larger total as their falling prices lead operators to seek new revenue streams, and as service innovators enter the space with new propositions.

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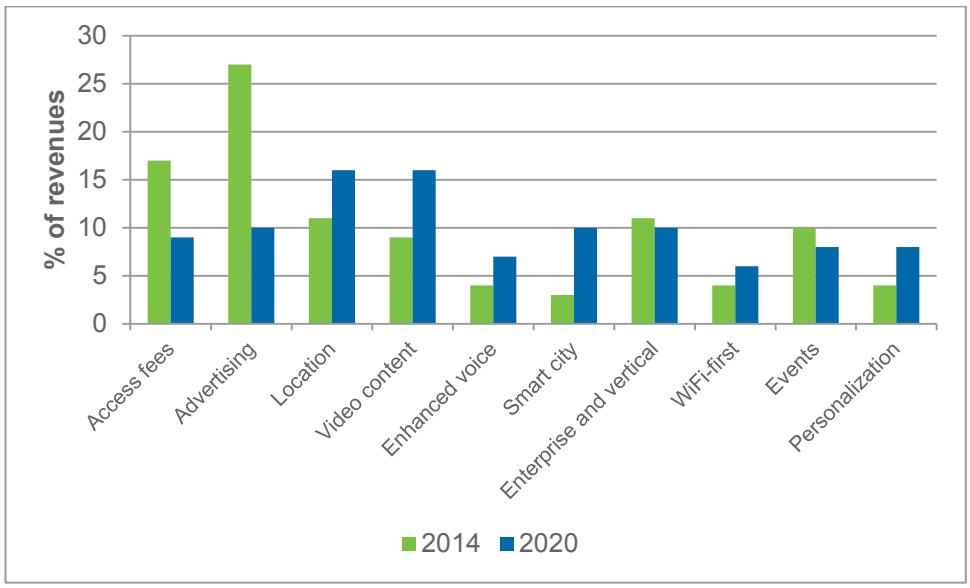

Figure 1-5 Breakdown of Wi-Fi revenues by service type (excluding wholesale and offload). Broad base of service providers asked to identify the services and then rate the top 10 which emerged.

Source: Rethink Wi-Fi survey March 2015

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2. Wi-Fi Ecosystem Update

The preceding section provided examples of how the transition to carrier-grade Wi-Fi, as well as other emerging trends in Wi-Fi technology and business models, will drive new revenues for service providers.

It will also change the landscape of those service providers – as indicated in the preceding chapter, there will be a far wider variety of providers delivering services over Wi-Fi, some of them highly specialized in areas like the smart city. As well as pure-play hotspot deployers and aggregators, MNOs and MSOs, there will be Wi-Fi-based services being delivered by venues, web services companies, single-application providers (e.g. some city apps), over-the-top content providers, vertical enterprise specialists, automotive firms, device makers and many others.

Figure 2-1 shows how the Wi-Fi service provider landscape will become far more mixed by the end of the decade, indicating the breakdown of companies monetizing WLANs – and within each of these broad categories, there will be many different types of provider, large and small. From a map dominated, in 2014, by MNOs, MSOs and wireless ISPs, by 2020, over-the-top brands will be responsible for the largest number of connections, monetizing 17% of the total, according to consensus estimates from providers and Rethink modelling. MSOs will still be a very important force because of their quad play and Wi-Fi-first activities, while other newly important categories will include specialist city service providers, vertical market or enterprise companies and retailers.

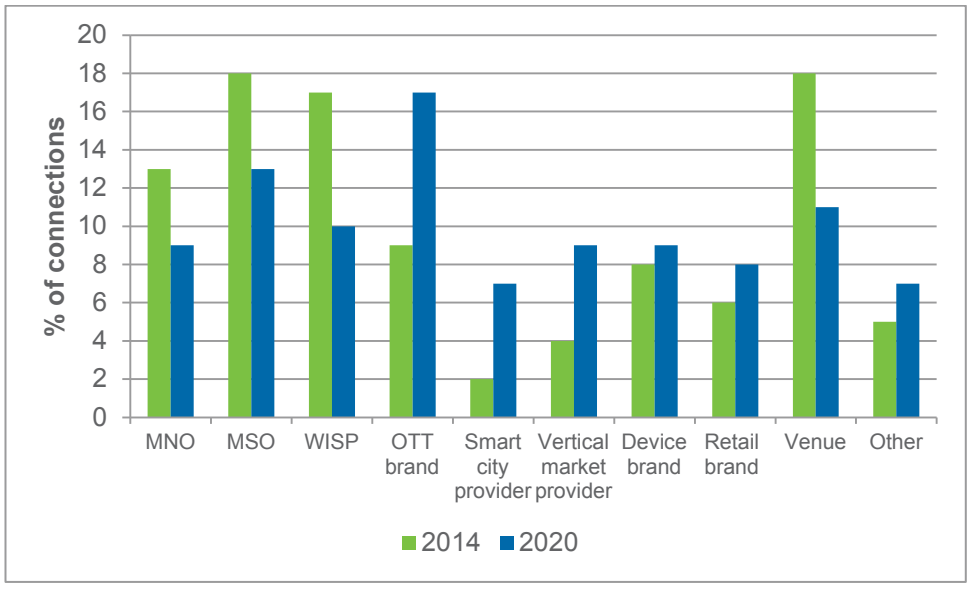

Figure 2-1 Breakdown of Wi-Fi connections by type of service provider. The figures refer to the provider monetizing the connection, not the hotspot owner.

Source: consensus of service provider estimates across broad base of companies delivering services over Wi-Fi – Rethink study March 2015

These new roll-outs and upgrades will also provide growth opportunities for the Wi-Fi ecosystem of course - suppliers of Wi-Fi infrastructure, components, management tools and software.

Some of these revenues will come from expansion or updating of existing product lines – 802.11ac access points and smartphones, for instance. Others will be driven by new product categories from Wi-Fi wearables to WLAN SON tools to new big data analytics platforms for operators.

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2.1 Hotspot deployment patterns

The trends towards denser networks, a wider variety of user cases and carrier-grade hotspots will all help drive a sharp increase in public Wi-Fi deployments in the next five years. Figure 2-1 and Figure 2-2 illustrate these patterns.

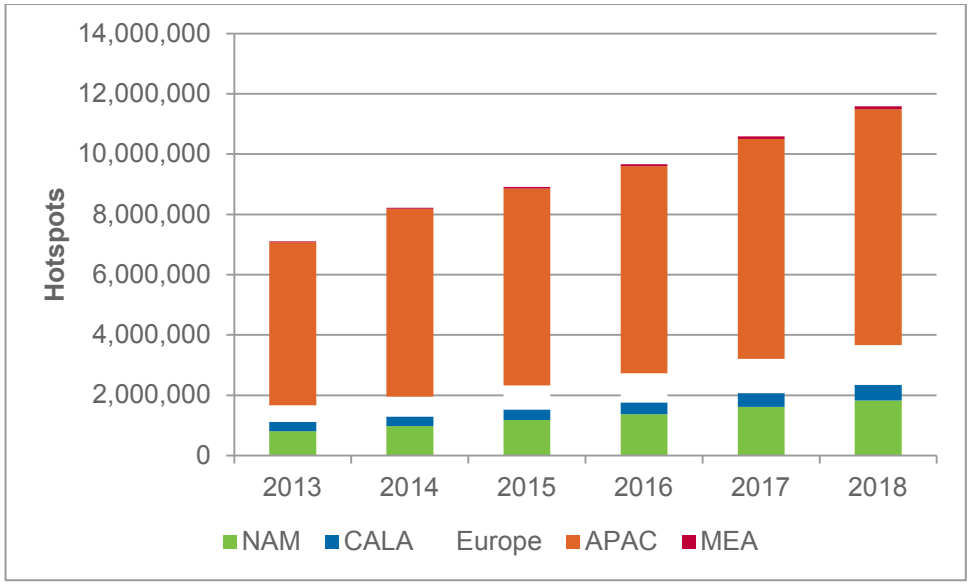

Figure 2-2 Deployment of carrier-grade Wi-Fi hotspots (excluding community hotspots) to 2018.

Source: Maravedis-Rethink estimates November 2014

The installed base of carrier-grade hotspots will rise at a CAGR of 11% a year even from the large existing base of 2013, to reach almost 12m by 2018. The fastest growth in the installed base is in the emerging markets of Middle East and Africa, but both North America and Europe will outpace the global growth rate during the period, often driven by extensive carrier roll-outs. However, Asia-Pacific will still account for two-thirds of the total world base in 2018, despite the expansion in other regions.

There will also be significant deployment of community hotspots by providers which control residential (and in some cases, enterprise) broadband lines. These will add significantly to Wi-Fi coverage, especially outside dense urban centers, and will support new services for the broadband providers and their partners, although in most cases they will not, in the early stages, be classified as fully carrier-grade. In some cases, providers will succeed in connecting a community hotspot – with a second SSID left open for public access – to the majority of their installed lines within a few years, creating an extensive installed base topping 300m by 2019 (Figure 2-3)

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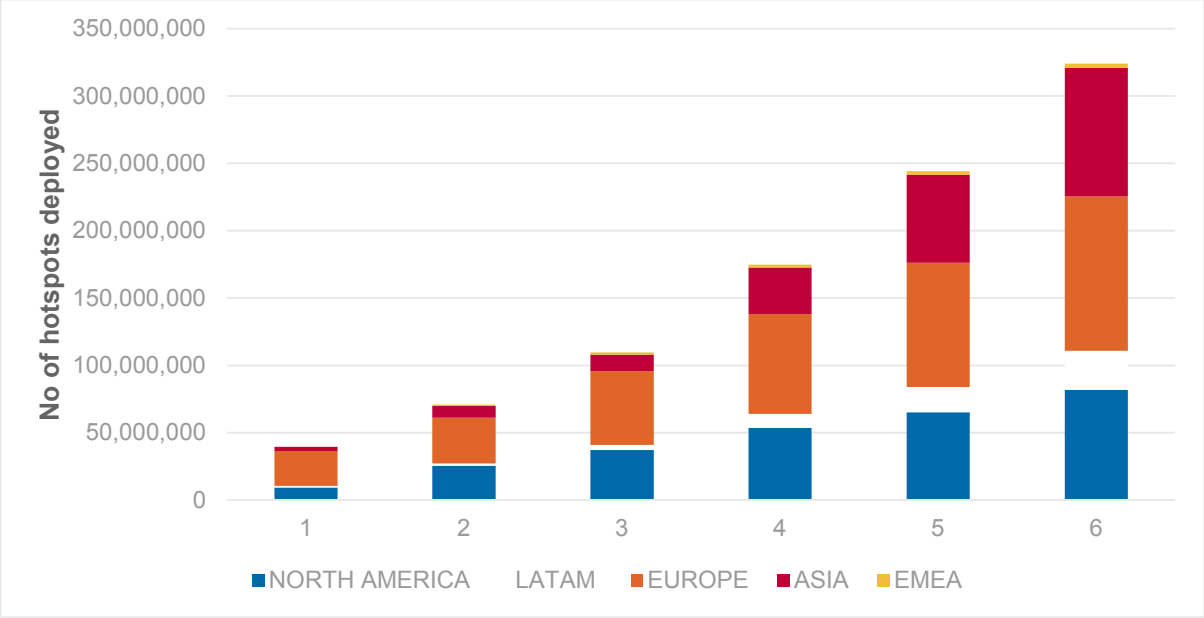

Figure 2-3 Installed base of community hotspots, by region, to 2019.

Source: Maravedis-Rethink forecast May 2015

In the near term, hotspot deployments will still be mainly driven by the expansion of existing business models – faster access, advertising and location services, venue services and so on. But by rolling out denser networks with higher QoS, and complementing those with community hotspots for coverage, the foundations are being laid to support the emerging business cases outlined above, during the coming five-year period.

This is illustrated in Table 2-1, which outlines the current and future business cases for public Wi-Fi, based on the expectations of the service providers surveyed. Some models are mature and well-established, notably those based around paid-for or advertising-supported access. These are increasingly hard to monetize through direct fees, but well-positioned hotspots can attract significant revenue from advertisers and promoters, and there is increasing effort to enhance those opportunities by supporting location and context awareness.

Level of maturity	Business model
Well established	Pay-as-you-go access Free access driving other services Wholesale access Aggregation Managed services (venues and outdoor) Cellular offload (user driven) Added value for broadband subscription Advertising and sponsorship
Growing rapidly	Cellular offload (carrier driven) Community Wi-Fi hotspots Neutral host services Hotspots managed by venues and brands Wi-Fi roaming services Location-aware services Onload TV everywhere Large events Big data analytics

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Level of maturity	Business model
	City broadband projects Carrier VoWi-Fi
Emerging	Wi-Fi multicast and broadcast Smart city platforms Wi-Fi capacity marketplace./trading Transaction platform Internet of Things Personalized promotions and service bundles Context awareness Wi-Fi-first mobile services Quad play with Wi-Fi supporting most or all of the wireless element Full Wi-Fi/mobile integration (HetNet) Connected car

Table 2-1 Levels of maturity of different business cases for public Wi-Fi, based on service provider expectations 2014-2019.

Wi-Fi access is often an added-value service to attract customers to another telecoms service, such as cable or mobile, or to an unrelated service, such as a retail outlet, café or transport method. In the mature business models, therefore, much of the build-out is driven by venues, or by aggregators focused on supporting access in a wide range of venues from airports to restaurants to hotels to malls.

However, some of the high-growth or emerging business cases are tied more tightly into the services of wireline or wireless carriers. This should drive a shift in new hotspot deployment towards those service providers, especially when it comes to the community hotspots, which are backhauled by the fixed-line operators' own lines. The MNOs and MSOs will, in many cases, deploy their own hotspots in their main regions of activity, and rely on partner deals, aggregators and roaming to achieve broader coverage.

Another group which will become a rising contributor to investment in new and upgraded hotspots will be city authorities and their business partners, as the smart city concept evolves from research projects and trials towards wide-scale integrated platform deployments.

These trends, and the proliferation of business cases, will see a changing mixture of organizations building public Wi-Fi, as Figure 2-4 illustrates.

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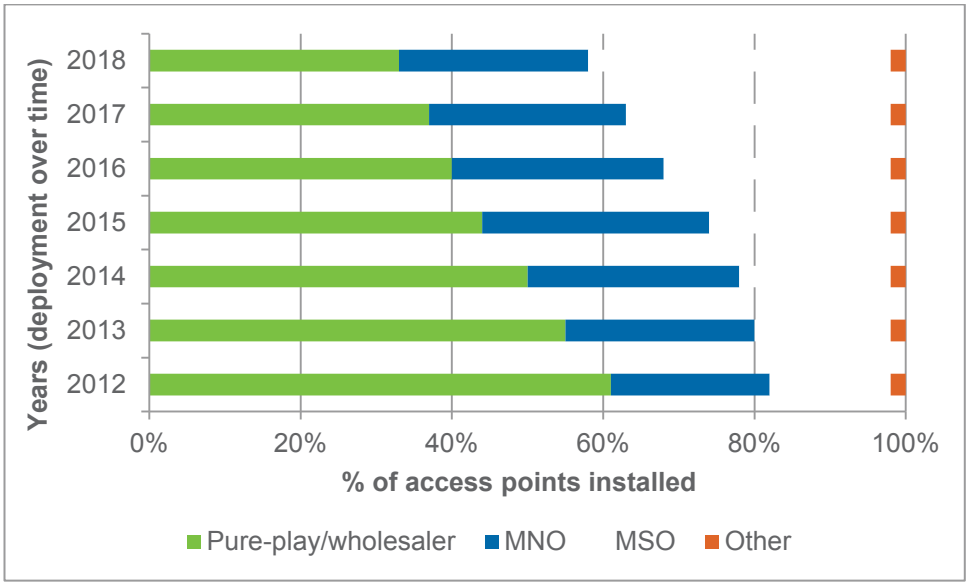

Figure 2-4 Percentage of new or upgraded carrier-grade hotspots deployed by each operator group.

They will also see increasingly complex roaming and sharing arrangements so that all these stakeholders have the coverage they need, putting a heavy focus on the ongoing work of the WBA in building a common platform for roaming.

Wider roaming; better integration with cellular and cable networks; new capabilities to monitor and monetize Wi-Fi users and to target them by context; a rising number of services delivered to 'things' and machines rather than humans – all these trends will create a very different public Wi-Fi landscape from that of the early years of this decade. The common trend underpinning all those changes will be the increased focus on carrier-grade performance and QoS, in order to support a larger variety of revenue streams.

The change in that landscape is illustrated in Figure 2-5, which refers to public hotspots (not community hotspots) directly accessible to the customers and OSS/BSS of fixed or mobile carriers. In 2014, only 14% of those hotspots could be classified as carrier-grade, the majority of those in the US or Japan. By 2018, 71% of the installed base will be carrier-grade, and over 85% of the new deployments of locations manageable by MSOs and MNOs. That shift will continue until the end of the decade, and the definitions of 'carrier-grade' will change over time too, as customer expectations of speed, QoS and available services rise.

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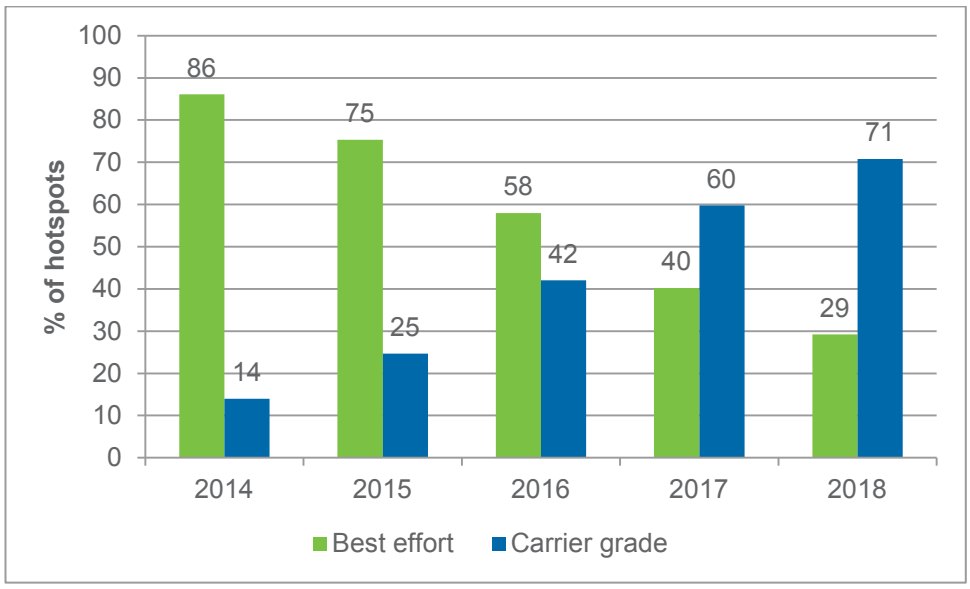

Figure 2-5 Installed base of Wi-Fi hotspots accessible to MNOs and MSOs, with split between best effort and carrier-grade

Source: Rethink Research January 2015

2.2 Challenges

Of course, there are many challenges to achieving the growth in service revenues and infrastructure build-out that were outlined in previous sections. The report's forecasts take a conservative middle ground approach, so the numbers of users, hotspots and service dollars could be almost 20% higher by 2019 if the key enablers, explained above, emerge more quickly than expected. However, the forecasts could be lower than expected by up to 15% if those enablers do not materialize or are delayed.

The fundamental challenge for wireless providers will remain unchanged – how to deliver the capacity to support rapidly rising demand and QoS expectations, while achieving return on that investment in infrastructure? More efficient network techniques such as Wi-Fi SON, together with greater reliance on roaming and neutral host/shared networks, can help reduce cost; while the new business cases enabled by carrier-grade Wi-Fi should generate incremental revenues, much of it non-consumer (and therefore higher margin and more loyal).

Figure 2-6 shows how a new service mix which includes more enterprise, IoT or wholesale customers can relieve the relentless pressure to reduce the total cost of ownership (TCO) of the network in order to maintain profitability when capacity and data usage is rising. In a survey of over 45 wireless operators (cellular and Wi-Fi), those mainly focused on consumer services believed, on average, that they must achieve improved TCO of over 20-fold on their networks by 2019, in order to break even on their investments, while for those with a primarily wholesale or neutral host model, the figure was sixfold because of the higher revenues and margins associated with their services, and a higher opportunity for growth.

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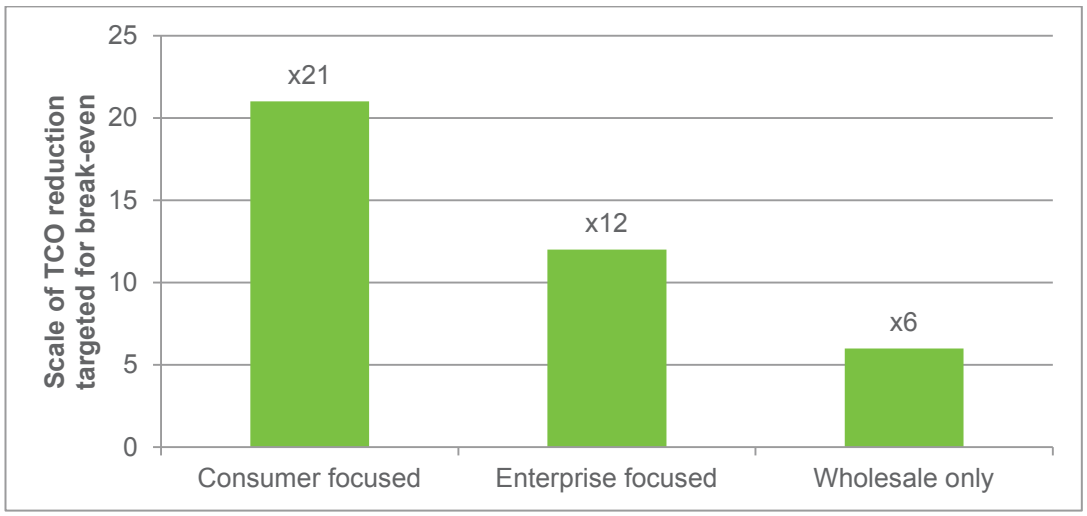

Figure 2-6 Average targeted TCO reductions in order to achieve network break-even by 2019, by primary operator business model.

Source: Survey of 46 wireless operators, December 2014

In addition to the eternal challenge of balancing capacity investment with revenues and profits, there are some other challenges to achieving the expected service revenues and deployment growth in public Wi-Fi.

The key risks include:

- A higher percentage of the new service revenues are enabled by cellular or wireline networks than expected, squeezing the need for further Wi-Fi investment. In particular, some MNOs which relied heavily on Wi-Fi capacity to augment 3G now believe LTE will be sufficient for most of their needs. However, we expect this to be a temporary strategy as capacity needs continue to rise.
- With community hotspots an important element of MSOs' wireless strategies, poor consumer acceptance (or a backlash, as seen in customer complaints against Comcast last year) could mitigate their effect
- Key spectrum bands become congested, affecting customer experience and churn. Operators such as BSkyB say 2.4 GHz is already too congested, in some urban areas, to support an acceptable service, and they may even disable it rather than face dissatisfied users. However, 5 GHz could itself become overcrowded, especially if other technologies such as LTE-LAA are also using it (see below).
- Other technologies and service providers take a greater share of new business opportunities than expected eg LPWA networks in the smart city.
- Sites become increasingly hard to locate and power, and increasingly expensive, as network deployments become denser.
- Critical enablers for dense Wi-Fi and multimode HetNet platforms are delayed or unsatisfactory – new standards, SON platforms etc.
- Backhaul becomes more challenging because of the proliferation of hotspot sites close to the ground, and because rising expectations of data rates and QoS will make some lower cost options, such as VDSL, impractical in many scenarios.
- Roaming and sharing arrangements take longer to work out than expected, delaying the achievement of broad coverage because of bureaucracy or logistics (hence the importance of initiatives like the WBA's roaming work).
- Security and privacy issues limit the uptake or viability of some important consumer and IoT business models based on location or big data.

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2.3 Spectrum

All these challenges are important and run the risk of delaying large-scale public Wi-Fi expansion and profitability in some areas. However, there are also significant ongoing efforts, by industry alliances like the WBA, by regulators, vendors and service providers, to mitigate those risks through changes in technology, best practice guidelines and consumer perception.

One of the most important aspects, of course, is spectrum. Additional, desirable spectrum is vital to support ever-rising capacity and coverage demands; while congestion can create interference, poor user experience and churn or low uptake of new services.

Wi-Fi currently operates mainly in the 2.4 GHz and 5 GHz bands. The former is becoming increasingly congested in many areas, especially as it is shared with many other technologies such as Bluetooth.

2.3.1 The vital 5 GHz band:

The need to harness the more plentiful and less overcrowded 5 GHz frequencies has driven uptake of dual-band devices. The installed base of dual-band 2.4 GHz/5 GHz devices overtook single-mode for the first time at the end of 2014, according to ABI Research and the Wi-Fi Alliance, and dual-band will account for 68% of shipments this year[1].

The next step is to shift users towards 5 GHz-only and particularly to the higher performance of the 802.11ac standard, which operates in this band. It achieves gigabit data rates (up to 500Mbps to the end user) by using wide channels (80 MHz mandated, and these can be extended or aggregated to 160 MHz), as well as a larger number of MIMO antenna streams than in 802.11n (up to 8x8, though 4x4 is the current peak). A second wave of the 11ac standards recently added further capabilities to boost data rates, including Multiuse MIMO on the downlink, supporting up to four clients at once; and denser modulation of up to 256QAM.

Such advances put the focus of Wi-Fi business growth firmly on the 5 GHz band. Regulators round the world are looking at ways to increase the amount of spectrum available for licence-exempt, or lightly licensed, usage in this band, and it should be an important topic at this year's World Radio Conference, WRC-15.

The European Commission, and national European regulatory bodies, are investigating ways to open up more 5 GHz spectrum without interfering with incumbents like satellite and radar, and also at ways to share with such users.

In the US, in April 2014, the FCC signed a ruling which increases the radiated power that can be applied in parts of the 5 GHz spectrum, removed the indoor-only requirements in the 100 MHz from 5150-5250 MHz and extending the 5.8 GHz band by an extra 25 MHz ,from a prior 5825 MHz upper limit to 5850 MHz. Now Congress is seeking to pass legislation to open the higher end of the 5 GHz band (5850-5925MHz) for unlicensed broadband technologies like Wi-Fi, although this is being opposed by the auto industry as intelligent transportation systems live in 5.9 GHz.

2.3.2 Spectrum sharing

Overall, however, we can expect to see additional frequencies added for the use of licence-exempt wireless broadband, as regulators recognize the rate at which data usage is increasing. But in increasing number of cases, this will involve sharing with incumbents, as the amount of untouched spectrum, at least below 6 GHz, becomes scarce.

[1] https://www.wi-fi.org/news-events/newsroom/5-ghz-wi-fi-is-now-mainstream

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That will see intensifying development of techniques to allow multiple technologies to share a band without interfering with one another. A trail has been blazed with the TV white spaces spectrum, which can be used for wireless broadband in the US subject to geolocation databases, which allow users to check for available channels before signalling in order to steer clear of TV transmissions. Similar methods are being examined for other potential shared bands, while more advanced technologies such as cognitive radios and cloud-based dynamic bandwidth allocation systems are also under development.

2.3.3 The LTE-LAA debate

Wi-Fi is well used to sharing with other technologies in the 2.4 GHz band, and was specifically developed to be a 'polite' protocol, like many standards created for use in licence-exempt spectrum, and that good neighborliness is further reinforced by regulators, many of which (though not the US and China) mandate 'listen before talk' in 5 GHz. Now, one of the technologies which is looking to coexist with Wi-Fi in its core 5 GHz band is LTE, which of course usually lives in exclusive licensed spectrum.

Companies such as Qualcomm and Ericsson have developed a technology called LTE-LAA (Licensed Assisted Access), which allows LTE to run in 5 GHz and provide a supplemental downlink carrier for a licensed-band 4G network. This will be standardized in 3GPP Release 13 next year, but is already being demonstrated in pre-standard form, partly to test how well it can be a good neighbour to Wi-Fi.

This is the important issue. While different parties may argue about whether 5 GHz should be used by a technology which is only available to a licensed spectrum owner, it is unlikely to be seriously challenged as long as it does not degrade the Wi-Fi experience. There are varying views on this.

Some cellular players – Qualcomm, the major OEMs and a group of operators including T-Mobile USA, Verizon and SK Telecom – have carried out lab tests and are starting field trials, initially targeting in-building small cells (because of the limited range and power limitations of 5 GHz, small cells are the only architectural choice, and the main initial target application is to provide additional downlink capacity when an LTE network is overstretched by a busy indoor urban environment). One lab test, for instance, aggregated 20 MHz of licensed spectrum with 40 MHz in the 5 GHz band and achieved peak speeds of 450Mbps and improved coverage - with no unacceptable interference with Wi-Fi, according to the participants.

Critics say that claims of greater spectral efficiency and performance are based on comparisons with the ageing 802.11n technology, not the upcoming 802.11ac, which has a higher level modulation scheme (up to 256QAM) than LTE-LAA. The Wi-Fi Alliance, and other Wi-Fi stakeholders, have generally given LAA a guarded welcome to the 5 GHz band, as long as it behaves itself. "There is a risk that LAA, and especially pre-standard systems deployed ahead of coexistence work being done in the industry, will negatively impact billions of Wi-Fi users who rely on 5 GHz today for networking and device connectivity," said the WFA in a statement in February 2015. "It is generally agreed in principle that fair sharing is required, but there needs to be further work from all parties to address this risk in practice."

Another way for LTE and Wi-Fi to be integrated more closely to create additional capacity for the MNO is with LTE-LWA (LTE Wi-Fi Access), which supports Wi-Fi link aggregation. An LTE data session is augmented by extra traffic sent over standard Wi-Fi, which can be aggregated in the core. Like LAA, this should be included in the 2016 3GPP Release.

Similar cellular/Wi-Fi aggregation approaches could look ahead to 5G by using higher bands and the WiGig technology in 60GHz. This was discussed by SK Telecom of Korea, for instance, which has trialled a system to augment an LTE data session with another wireless technology running in a wide band at frequencies up to 100GHz.

Some argue that LTE-LAA would do better to leave 5 GHz to Wi-Fi and concentrate its efforts on the 3.5 GHz band (LAA was designed to be band-neutral and could be deployed itself in 3.5GHz, allowing the small cells to provide supplemental capacity for a parent macro network). In 3.5 GHz, the US may be setting an important precedent for

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other bands, by opening it up on a tiered basis, with different levels of access priority for federal incumbents, licensed non-federal users, and licence-exempt general access users, respectively.

Many countries are likely to follow the lead of the US in allowing the plentiful capacity at 3.5GHz to be shared among multiple operators, a move which could make this spectrum a valuable proving ground for ideas of dynamic spectrum access and flexible sharing schemes – and a new target for Wi-Fi.

In a world where LTE and Wi-Fi stay in their separate bands, convergence at network, device or chip level becomes important, as seen in, for instance, Alcatel-Lucent's new Wireless Unified Network (WUN). In this approach, LTE and Wi-Fi radios are both operational at once, with data signals from the two types of access points being blended to leverage the upload and download capabilities of each, simultaneously. The first step is to launch 'Wi-Fi Boost', which combines the downlink of Wi-Fi with the uplink of cellular, and 'Wi-Fi Boost Plus' which also combines cellular downlink. In future iterations, LTE-LAA will be included in the mix. The goal is to boost speeds by harnessing Wi-Fi capacity, and ALU has demonstrated data rates up to 600Mbps, with some of the data travelling over 4G and some over Wi-Fi. In typical homes Alcatel says this Wi-Fi boost can increase download speeds up to 70% and increase upload speeds by an order of magnitude or more, compared to standalone Wi-Fi at the cell edge.

2.3.4 60 GHz and WiGig:

In addition, the 802.11ad standard, branded WiGig, runs a Wi-Fi-like technology in the licence-exempt 60 GHz band. This spectrum is plentiful and, although there are some other 60 GHz wireless technologies, such as WirelessHD, WiGig is the most widely deployed. There is little risk of congestion here in the foreseeable future, and since high frequencies are a critical study area in 5G R&D projects, the Wi-Fi community is gaining valuable experience of how radio behaves in these bands.

While 60 GHz offers very high capacity and data rates, its range and penetration through walls is severely limited, so it will usually be deployed as a complement to, not a replacement for, 11ac.

WiGig is commercialized in some devices, mainly laptops, in which its short range, multi-gigabit speeds support fast connections to peripherals. Its primary application in future is likely to be very fast content transfer between devices in a single room; and it is also likely to be used for hotspots in dense indoor networks (though another future standard, 11ax, will be even better suited to this); and for sensor hubs in home IoT systems. It may also have a role in low cost hotspot backhaul over short hops. The standard will start appearing in smartphones and tablets in 2015 and the Wi-Fi Alliance expects it to be mainstream in 2016, with key applications being "cable replacement for I/O and display extensions, wireless docking between devices like laptops and tablets, instant sync and backup, and simultaneous streaming of multiple UHD and 4K videos."

2.3.5 Other potential spectrum bands for Wi-Fi:

The IEEE 802.11 groups are working on the 802.11ah variant for the ISM band (868 MHz in Europe and elsewhere, 915 MHz in the Americas) and the 802.11af extension for the TV white spaces spectrum, which has been opened up for licence-exempt wireless broadband in the US and UK, and is the subject of vendor trials in parts of Africa and Asia. These extensions will support multi-kilometer range at very low power and duty cycle, making Wi-Fi better suited to smart city applications such as smart lighting and metering, which typically run in the ISM spectrum. They are expected to be finalized in 2016.

In the US, as well as the unlicensed portion proposed in the 3.5 GHz band, there are also plans to open up further licence-exempt frequencies in the 600 MHz broadcast spectrum.

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2.3.6 The potential for dynamic spectrum sharing

There are clearly blurring lines between licensed and licence-exempt spectrum and technologies, and whatever the precise combinations, the trend is toward using a mixture of both to maximize capacity and achieve cost efficiencies.

In that situation, the controlling position is not necessarily held by the licensed spectrum owner, as it was in the past. Google Fi taps into both a cellular MVNO and Wi-Fi, but the search giant clearly keeps control of the consumer – their phone number, SIM and customer relationship. It does not even deliver a major MVNO deal to just one MNO, but flexibly uses the networks of two (Sprint and T-Mobile USA), and probably others in future if it goes global.

In future, Google's vision would be that all MVNOs, even those without its market weight, will tap into any available bandwidth when they require it, paying for the time and amount they use on a marketplace basis, rather than having to sign rigid and expensive deals with a single provider.

That world of huge numbers of MVNOs, some very specialised or only delivering services occasionally, will be enabled by important emerging technologies – virtualization, which allows a wholesale network owner, whether cellular or Wi-Fi, to call up (and kill) a virtual machine to support each MVNO as it requires bandwidth; and dynamic bandwidth allocation technologies which manage the actual frequencies.

In the nearer term, some of those dynamic spectrum sharing technologies are starting to evolve, as seen in the TV white spaces. And other real world developments point forward to a distant horizon where almost any service, application or retail provider can become an MVNO for a day, a year or on an ongoing basis, according to need. For instance, BandwidthX has pioneered a marketplace system for Wi-Fi, which matches hotspot owners to those needing capacity and calculates a market fee.

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3. Towards the 5G Future

Emerging trends such as fully dynamic spectrum and network sharing will pave the way for the next generation of wireless and broadband platforms and business models, which go under the umbrella term '5G'. There are no official standards yet – or even any consensus on whether 5G will, like previous generations, revolve around a brand new air interface (or several of them, for different purposes).

However, with 2020 likely to be the year in which standards are formalized and the first operators roll out pre-standard networks, there is significant R&D activity under way among vendors, carriers and academic institutions, and most key players are starting to form views on the elements they believe will be critical to 5G. For instance, the NGMN Alliance recently published a detailed white paper setting out end-to-end mobile operator requirements for 5G, which seeks to tie R&D efforts to real world business cases. Its core requirements mirror those outlined by many other wireless bodies:

- A network with far greater throughput, lower latency and higher connection density.
- To cope with a wide range of use cases and business models, a high degree of flexibility and scalability by design.
- Foundational shifts in cost and energy efficiency.
- On the end user side, a consistent customer experience achieved across time and service footprint.
- A 5G ecosystem that is truly global, free of fragmentation and open for innovations.

There are different schools of thought about whether 5G will have to include an entirely new platform, or will be an evolution and convergence of current trends in the IEEE, 3GPP, TV and other standards. Whatever the exact technologies, it is clear that operators of all kinds will need new platforms to address the huge increase in data traffic, signalling traffic, and numbers of devices in the 2020s, created by many emerging trends from 8K mobile video to the Internet of Things' billions of sensors.

There are several important elements which many believe will be part of 5G, whatever its exact technologies, and which are already emerging now, and being applied in Wi-Fi, 4G and other markets. Most of these will start to impact the way 802.11 and Wi-Fi evolve at the technical level, and how they are deployed and monetized, even before 2020.

They include:

- Densification - extremely small cells will create zones of high capacity for applications like delivering 8K video in a stadium; but will also provide dense but ultra-low power networks to support vast numbers of connected sensors. These cells are likely to be a mixture of Wi-Fi, cellular and WPAN technologies, all working in an increasingly tightly integrated, heterogeneous fashion.
- New generations of network tools will enable that HetNet to be increasingly flexible, dynamically responding to shifting capacity and signalling needs across its coverage area. Important developments will include next generation dynamic SON.
- Significant advances in battery and other technologies to create ultra-low levels of power consumption in order to enable new IoT services based around millions of sensors.
- Virtualization is already being adopted in some parts of the wireless networks such as mobile packet cores and Wi-Fi/cellular small cell management systems. It is early days for virtualizing the access network itself, but that is likely to be a feature of '5G', with most of the baseband processing functions centralized in the cloud, supporting large numbers of small antenna/radio units left at the cell sites.
- Extremely low latency for the IoT and the rise of real time applications like wireless financial trading, which will require latency of under 10ms, while efficient virtualized RAN architectures may need 1ms.
- Massive expansions of MIMO smart antenna designs from the current real-world maximum of 8x8 in Wi-Fi and cellular to numbers in the hundreds (128 antennas in a 3D array in a ZTE demonstration, for instance).

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- Very high frequency bands, with companies achieving high data rates by running ‘pre-5G’ technologies in millimeter and centimeter wave bands (3.5GHz to 70GHz), combining this with new frame structures to support latency down to single-digit milliseconds, and with phased array antennas and even new channel models to boost throughput and spectral efficiency.

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4. Conclusion

The developments outlined in this report – technical and commercial, near term and looking towards 2020 – show that 2015 is a year when there will be solid growth in public Wi-Fi deployment and services, as operators of all kinds start to harness the advances of recent years, such as faster networks, new management systems, and the adoption of Passpoint and NGH.

Those building blocks will help enhance Wi-Fi's capabilities and therefore assure it a critical role in broader trends such as the HetNet, the growth of quad play and multiplay services, and smart cities. Licence-exempt technologies are no longer the 'poor relations' of cellular and wireline networks, as their performance and QoS improves, and as they integrate tightly with other platforms.

That, in turn, means Wi-Fi will support a far wider range of business cases, beyond those based on simple broadband access and advertising. A large number of new technology developments, some Wi-Fi-specific and some with general application, are entering the commercial mainstream in 2015, enabling many new options for service providers. These include IMS-based Wi-Fi voice and video, new proximity and personalization systems, and virtualization.

Therefore, as well as consolidating some of the developments of the first half of the decade, 2015 is also a year which will lay some of the foundation stones for further expansion of Wi-Fi's role and its ability to support new revenue models. Those will see Wi-Fi networks and service providers starting to evolve towards a meaningful position in the Internet of Things, in smart cities, and eventually in '5G'.

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