

The leap to carrier-grade Wi-Fi and its monetization potential



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Executive summary

The public Wi-Fi market is poised for a transformation as service providers prepare to move from best-effort to fully carrier-grade networks. This shift is being driven by technology enhancements and new end-user expectations of both capacity and quality from Wi-Fi. But the biggest driver is carriers' need to deliver a new level of customer experience on Wi-Fi, which they can monetize through new services.

Whatever their business models, service providers are starting to see Wi-Fi as a strategically important offering, that can enhance or damage their reputations and which needs to support a user experience, comparable to that of cellular networks. Several of the enablers of this change are in place, such as the Hotspot 2.0/Passpoint standard, but there are others which are still immature, especially in the area of the tools to ensure the essential quality of experience (QoE) required.

Best-effort Wi-Fi networks are not controlled from the carrier's core network or OSS tools and the Wi-Fi access points (APs) often do not support any form of traffic management or prioritization. As a result, the operators are unable to monitor or address performance issues such as congestion, as it would in the wireless or wireline access network. This means the provider cannot guarantee QoS (quality of service) such as e.g. speed, low latency, unbroken connection and prioritization. These features are vital to time sensitive and high bandwidth services such as video and other QoS-dependent uses such as enterprise voice, media streaming or critical monitoring (e.g. heart monitors, VoIP, video, online gaming). These kind of capabilities underpin many of the emerging monetization options for Wi-Fi such as TV everywhere. Therefore, until Wi-Fi becomes carrier-grade by implementation of carrier-class tools, end-to-end traffic management and carrier-grade Wi-Fi APS, many operators may delay making the leap to new Wi-Fi services, because QoE will be essential to their new monetization strategies. Future Wi-Fi networks can only be monetized successfully if they are upgraded to carrier-grade infrastructure and managed properly.

This was one of the findings of a global survey of Wi-Fi operators, in developed and large emerging markets in North America, Europe and Asia-Pacific, conducted by Real Wireless for Amdocs. This included MSOs, MNOs and Pure-Play Wi-Fi providers. The survey revealed that for most of these players, best-effort Wi-Fi is becoming less profitable but that new revenue streams can be built once they achieve higher QoE and tighter integration of Wi-Fi with cellular and wireline networks, and the carrier's BSS/OSS.

In the case of cable operators (MSOs), those new monetization strategies will have a radical impact on their business models. Many, especially in the US and parts of Europe, are harnessing Wi-Fi to add new services to their portfolios, such as 'everywhere' content, and even to develop full quad plays.

For MNOs, the aim is to offer a seamless pool of wireless capacity across cellular and Wi-Fi with common QoE. This will enable them to support far higher data usage, since users will move between Wi-Fi and cellular without noticing the difference, and that capacity can improve customer experience and support data-intensive applications.

These changes also open up new opportunities for Pure-Play Wi-Fi providers, particularly to extend their revenue model via wholesale activities. In 2016, 61% of MSOs' Wi-Fi hotspots, and 70% of MNOs', will be sourced from third parties, though some will be managed within the primary operators' BSS/OSS. That will help Wi-Fi players to enhance a business case which has been squeezed in terms of revenue and profit by simple paid or free access services.

The move to carrier-grade Wi-Fi

These trends will drive a wave of rapid investment in deploying or upgrading carrier-grade Wi-Fi, whether directly by MNOs and MSOs, or by Pure-Play Wi-Fi operators, in the period to 2017. Across the operator categories, 85% plan to start upgrading at least part of their Wi-Fi networks to carrier-grade by the end of 2016. By 2018, these build-outs and upgrades will result in a base of almost 12 million hotspots accessible to MNOs and MSOs and their customers, over 70% of them carrier-grade.

MSOs are leading this trend. Over one-quarter (27%) already support carrier-grade Wi-Fi in at least part of their network, twice the number seen among MNOs. By 2018, 72% of an MSOs network, on average, will be carrier-grade, up from 17% in 2014, while for MNOs the figure will be 66% (up from 14%) and for Pure-Plays 63% (up from 12%).

The improvements to the Wi-Fi standards, such as the gigabit 802.11ac upgrade and HotSpot 2.0 [1], are important to deliver the new levels of speed, security and reliability, but not enough on their own to fulfil the potential of Wi-Fi to support cellular-grade QoE, and the new monetization opportunities which go with that.

Carrier-grade tools are essential

Among the barriers is the shortage of tools for planning, managing and optimizing Wi-Fi networks, in the way that operators are accustomed to doing in cellular or wireline. Strategy, good planning and tools are very important for monetizing Wi-Fi, because they can deliver the QoE to support high margin services such as enterprise and streamed video.

Without these tools, operators believe they will not secure the optimal performance and ROI from investing in high quality Wi-Fi, and some may hold back on roll-out. Almost two-thirds (65%) of the operators surveyed placed the lack of strong network planning and management tools in their top three risk factors for investing in carrier-grade Wi-Fi. This is not just about good Wi-Fi management, but the ability to manage Wi-Fi, cellular and wireline in the same way and from the same BSS/OSS. By 2017, 80% of MNOs will include Wi-Fi hotspots in their networks, and almost half will be managing at least some of those from their main network systems. And almost 90% of MSOs, according to the Real Wireless study, will have Wi-Fi in their networks, with 56% managing these from their primary platforms.

The new breed of management systems will also need to accommodate wide-scale roaming and the use of third party hotspots in many cases. The converged operators will rely on the Wi-Fi specialists' installed base to improve coverage and capacity, while the Wi-Fi hotspot owners will secure a share of the revenues from mixed-network services. Also, MNOs will start to roll out combined Wi-Fi/cellular small cells; by 2017, 30% of their small cells will be dual-mode.

All these complexities will just add to the need for robust tools, such as network planning and analytics, which can manage the network and carrier-grade Wi-Fi APs as one element of a broader carrier-grade system – controlled by the same tools and subject to the same performance metrics as cellular or cable. Since this converged network will appear as a single pool of capacity to users, it will be capable of supporting a wide range of new monetization opportunities that depend on a strong level of QoS from end to end.

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1. Introduction

This paper describes the opinions of these senior executives in 40 leading global Wi-Fi operators. The questionnaire and interview breakdown between the 3 Wi-Fi operator categories is the following:

- **MNO:** 15 questionnaire, 5 interviews (tier 1, e.g. O2 Wi-Fi)
- **MSO:** 15 questionnaire, 5 interviews (tier 1, e.g. BT, Virgin)
- **Pure-Play:** 10 questionnaire, 5 interviews (split of tiers, e.g. The Cloud)

In this paper, we explain the various types of Wi-Fi operators and the strategic role Wi-Fi plays in their operation. We explain the challenges they face in deploying Wi-Fi and their opinions and requirements, but also their perceived issues, challenges and technology use cases in Wi-Fi deployments.

More details of the scope and respondents to the report can be found in the Appendix.

2. Wi-Fi background and challenges

2.1 Wi-Fi background and evolution

Wi-Fi (also called WLAN or Wireless LAN) is a wireless local area technology, used to connect devices wirelessly to broadband and internet service.

Wi-Fi is based on the IEEE 802.11 standards and uses electromagnetic waves that run at a specific frequency. There are two main frequencies used for Wi-Fi today; these are 2.4 GHz (initially 802.11 and 802.11b) and 5 GHz (initially 802.11a). Today's 802.11n and 802.11ac Wi-Fi standards and devices support both the 2.4 and 5 GHz bands.

Wi-Fi is developing fast and getting faster. The next generation of Wi-Fi technology will be able to transmit over 7 Gbps and by 2018, worldwide Wi-Fi traffic is set to overtake wired traffic for the first time ever [1]. Today, Wi-Fi is in 25% of homes around the world, and about two billion Wi-Fi devices were sold in 2013 [2].

Mobile data demand is projected to grow vigorously in the coming years, e.g. Cisco [3] anticipate global mobile traffic to grow by a factor of 11 between 2013 and 2018 equivalent to an annual growth rate of 61%. Subscribers in South Korea, averaged over 12 GB of mobile data consumed per month when accounting for both cellular and Wi-Fi usage followed by subscribers in Japan and Russia averaged slightly less than 10 GB of data consumption per subscriber [4].

Offloading some of this traffic to Wi-Fi networks has been a key strategy of some mobile operators in recent years. Wi-Fi accounted for an enormous 75%-90% of all mobile data consumed in 'leading LTE markets' [4]. But for this to be successful, carrier-grade Wi-Fi becomes an increasingly important requirement. A critical enabler of the trends towards mobile data offload, and carrier-grade Wi-Fi, is the emergence of the Hotspot 2.0/Passpoint and Next Generation Hotspot (NGH) specifications, from the Wi-Fi Alliance and Wireless Broadband Alliance respectively.

2.2 Recent Wi-Fi developments and trends

Recent developments and trends based on the Wi-Fi standards include:

- **VoWi-Fi (Voice-over Wi-Fi):** VoWi-Fi is being discussed and tested by many global and smaller operators. VoWi-Fi is also considered as a stop-gap measure till VoLTE and the LTE coverage (e.g. indoors) is adequate. This approach has been in the press recently with operators Three (3) and Everything Everywhere (EE) in the UK discussing VoWi-Fi strategies [5]. The challenge with VoWi-Fi is providing a 'Carrier-Grade' user experience [6].
- **Wi-Fi multicast:** Wi-Fi multicast (alongside LTE multicast) is getting lots of attention from vendors and mobile operators for its ability to deliver live multimedia to smartphones and tablets being used by concentrated groups of people, such as those attending a sporting event or concert. Wi-Fi multicast has already been deployed by venue owners in e.g. stadia [7].
- **LTE in Unlicensed Spectrum:** This describes the emerging ability to use LTE wireless technology in the same unlicensed spectrum as currently used by Wi-Fi, although this is currently restricted to operate only in conjunction with existing licensed spectrum. The technology is therefore known as Licensed Assisted Access (LAA-LTE). But the technical concern with LAA-LTE is that unmodified LTE does not include 'listen before talk' functionality which is standard in Wi-Fi, so some extension is needed to avoid significant degradation of neighbouring Wi-Fi systems and is under development in 3GPP [8]. The long-term commercial impact of License Assisted Access (LAA)-LTE is not yet clear, with very mixed views amongst MNOs and others.
- **IoT (Internet of Things):** Wi-Fi will connect new types of devices to each other and the internet, with IoT emerging as the next major wave of connected innovation, which will often operate in the same frequencies as Wi-Fi (especially as Wi-Fi moves to sub-1GHz bands). Applications will include connected cars, 'body area networks' based on wearables and even sensors embedded in the body, smart home monitoring and metering; industrial internet systems which build on traditional machine-to-machine, with additional internet access and big data capabilities.

2.3 Market size and forecast

Figure 1 and Figure 2 indicate the scale of expansion of Wi-Fi at the time of writing this white paper, and provide a general context for the more detailed surveys of operators conducted here. The key patterns are huge growth in coverage and capacity; accelerating increase in speed; and a rising emphasis on quality of service as well as data rates.

In terms of build-out, a peak in 2015 is driven by pent-up demand to support carrier-grade standards such as HotSpot 2.0/Passpoint and NGH. Although these deployments started in late 2013, they are expected to really drive a wide-scale round of network upgrade from 2015. Another peak will be seen in 2017, largely because truly integrated architectures such as MNO HetNets will be more achievable by then, and because of an expected major uptick in India and other growth markets in Asia.

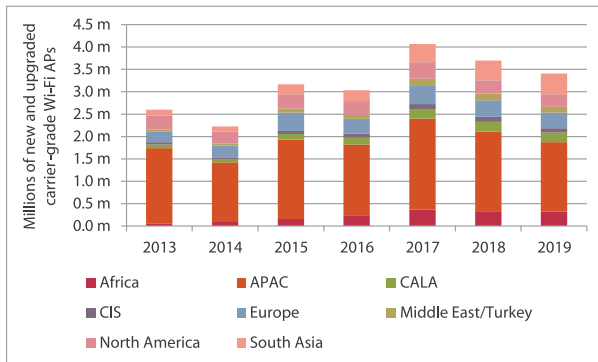


Figure 1: New and upgraded public Wi-Fi access points deployed by region (Source: Rethink Research)

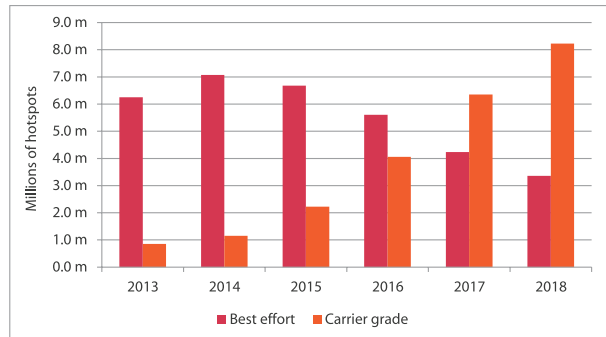


Figure 2: Installed base of Wi-Fi hotspots accessible to MNOs and MSOs, with split between best-effort and carrier-grade (Source: Rethink Research)

These build-outs and upgrades will result in a base of almost 12 million hotspots accessible to MNOs and MSOs and their customers in 2018 (see figure above). By 2018, we estimate that 72% of this base will be carrier-grade. The figure below shows how ownership will break down between the different operator types, with a significant shift towards direct deployment by MSOs and, to a lesser extent, MNOs, though both categories will still also rely heavily on wholesale and roaming deals with one another and with Pure-Play operators, to extend coverage outside their core territories.

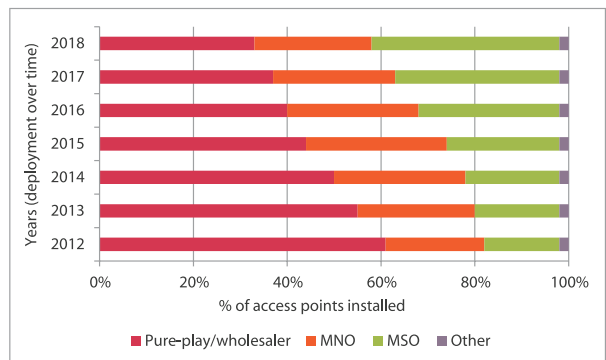


Figure 3: Deployment and upgrade of public Wi-Fi hotspots by operator type over time

2.4 Monetization of public Wi-Fi

Public Wi-Fi is often referred to as having reached its ‘third generation’, and to be evolving rapidly into its fourth. The generations are not defined by big architectural shifts as in cellular, but by changes of usage and therefore of monetization opportunities. More to the generations can be found in Appendix 2.

The last generation of Wi-Fi is just beginning and sees Wi-Fi integrated with other networks. In MNOs’ case this can offer a seamless pool of wireless capacity and as tools for dynamic capacity management evolve, they will be able to harness that capacity in an efficient and targeted way. For MSOs and other wireline carriers, Wi-Fi is increasingly capable of enabling them to add a carrier-grade wireless option to their service bundles, to encourage on-load and roaming access, and so reduce churn. They can also derive revenues from MNO off-load deals, and use these as a bargaining counter to reduce their own fees for cellular access via MVNOs. Critical to these carrier Wi-Fi strategies are the latest standards updates, such as 802.11ac (gigabit Wi-Fi), as well as improved quality of experience and service assurance standards, so that the user experience on Wi-Fi is the same as on other networks.

As the figure below indicates, these generations are creating changes in usage which are also impacting on monetization for Wi-Fi network owners, whether they are Pure-Play or MNOs/MSOs. It is also notable that the generations are shortening as technology advances more quickly, and as Wi-Fi becomes more critical to the business models of many players, driving further evolution.

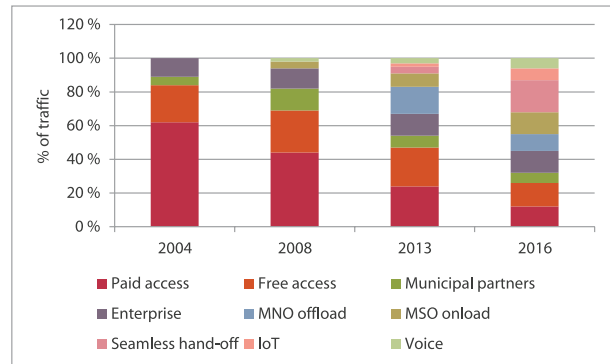


Figure 4: Percentage of data over public Wi-Fi hotspots (excluding homespots), by source. Source: Rethink calculations, industry sources e.g. WBA, operator estimates.

The figure shows how the monetization of Wi-Fi becomes far more diverse as the technology grows in sophistication and is harnessed by a widening variety of service providers. In the early days of public hotspots, the vast majority of the traffic was accounted for by users paying for access, while by 2008, when metro-zones had been built out in regions such as North America and eastern Asia and Wi-Fi’s robustness was improving, there was already a shift towards enterprise and city contracts, important to provide a more predictable business for a Wi-Fi network than consumer usage – especially as that was shifting towards free access in many areas.

In 2013, although the largest amounts of data carried over public Wi-Fi were still monetized by access fees (individual or enterprise) and advertising, the fastest growing source of data was offload from mobile networks. By 2016, we can see more traffic being processed as part of an integrated activity spanning mobile or MSO networks, as well as greater quantities of voice traffic, and the start of significant volumes generated by the IoT.

It is increasingly important to achieve monetization that operators of all kinds support applications and services enabled by the Wi-Fi network, such as premium video, rather than just access fees. Although access, whether consumer or wholesale, will still account for 40% of Wi-Fi network revenues by 2019, according to Rethink calculations based on operator predictions, applications and services will be more important, especially contracts to support enterprise and vertical/IoT usage.

2.4 Monetization of public Wi-Fi (continued)

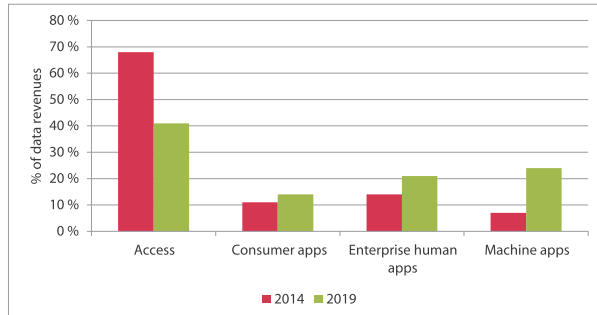


Figure 5: Predicted split in revenues from Wi-Fi networks, between wholesale and retail access, and various classes of apps and services. Source: Rethink Research calculations based on operator predictions.

Some of these new revenue streams will be enabled directly by the move to carrier-grade networks, especially those which create clouds of coverage rather than standalone hotspots.

These include:

- Enterprise services, which are growing in importance as companies move to mobile-first strategies and expect employees to be able to communicate and join meetings from any location
- VoWi-Fi, for carriers and independents
- Service bundles and, eventually, a quad play, as Wi-Fi supports similar QoS to a carriers' licensed networks, even for applications such as video

Other new revenue strategies will be driven by the need to generate revenues at different parts of the value chain, not from the consumer. As the consumer's willingness to pay reduces, operators have compensated for low access fees by charging advertisers or content providers to put their brands in front of users. When the WLAN is integrated with a carrier's core network and content platform, there will be greater opportunities in this area. The options open to service providers are clearly divided into those available to Wi-Fi-only providers, and those which rely on interworking with other networks. The greater variety of strategies available to converged players

will accelerate the trend for partnerships between Pure-Play providers and MNOs or MSOs – the converged operators relying on the Wi-Fi specialists' existing installed base of hotspots to improve coverage and capacity, the Wi-Fi hotspot owners securing a share of the revenues from mixed-network services, via infrastructure fees and, in some cases, extending their own models via MVNOs.

Level of maturity	Business model
Well established	<ul style="list-style-type: none"> • Pay-as-you-go access • Free access driving other services (Retail free Wi-Fi) • Wholesale access • Aggregation • Managed services (venues and outdoor) • Cellular offload (user driven) • Added value for broadband subscription • Advertising and sponsorship
Growing rapidly	<ul style="list-style-type: none"> • Cellular offload (carrier driven) • Community Wi-Fi/hotspots • Neutral host services • Wi-Fi roaming services • Location-aware services • Onload • TV everywhere • Large events • Big data analytics • Public transportation Wi-Fi (Car and bus)
Emerging	<ul style="list-style-type: none"> • Wi-Fi capacity marketplace/trading • Transaction platform • Internet of things • Personalized promotions and service bundles • Context awareness • Wi-Fi-first mobile services • Carrier-grade voice over Wi-Fi • Quad play with Wi-Fi supporting wireless element • Full Wi-Fi/mobile integration (HetNet) • Connected car (in-car Wi-Fi)

Table 1: Established and emerging key public Wi-Fi business models in 2014

3. Wi-Fi deployment overview

3.1 Respondents to this survey

This Amdocs / Real Wireless survey aimed to drill more deeply into the business and technical drivers and barriers, underlying the growth in carrier deployment of Wi-Fi. It conducted an in-depth survey of 40 players with an active interest in Wi-Fi. The scale of their deployment plans were very varied. For instance, among MNOs, one respondent planned to have over four million hotspots managed within its network by the end of 2016, while four MSOs planned to have over one million. By contrast, three MNOs and two MSO will have fewer than 5,000 hotspots deployed or integrated by the end of 2016. This indicates the range of scale which Wi-Fi plans involve.

Pure-Play respondents tended to be more localized and number locations in five figures (100,000 > 1,000,000) rather than six. Although they will frequently extend their services in other areas via roaming, they are less likely to integrate third party hotspots into a common core system, as they lack the tools to do this.

Another important trend in carrier-grade Wi-Fi is the deployment of ‘homespots’. These are home access points with a second SSID, which the user agrees to leave open for use by passers-by. This is primarily a tool for MSOs, since they provide the home gateway and the fixed line to backhaul the Wi-Fi connection. It enables them to extend their Wi-Fi coverage for subscribers on the move, at low cost because they are harnessing existing cable infrastructure and provisioning tools. As Figure 6 shows, some operators are planning large scale roll-outs over the next 2-3 years, converting large sections of their residential user bases into public access homespots. By the end of 2016, the survey indicated that 77% of MSOs would have some homespots in their networks and 20% would have over one million. Although these emerging platforms are outside the scope of this paper, they will raise their own issues in terms of network management, security, privacy and quality as they become widespread.

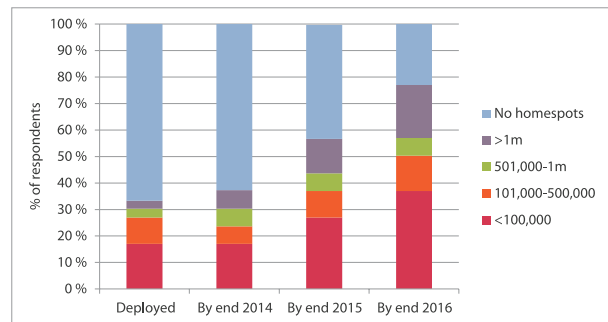


Figure 6: Percentage of respondents deploying hotspots, by scale of deployment

3.2 Key trends observable

It was observed that carriers are investing more heavily in Wi-Fi, directly or indirectly, to:

- Increase total capacity as data usage rises
- Reduce the cost per megabyte and Mbps of that capacity
- Support additional services and revenue streams
- Improve coverage, both locally and via wide-scale roaming

In most cases, Pure-Play Wi-Fi network owners see this as a business opportunity, to partner with MNOs and MSOs, rather than a threat to their existing business. That business is driven heavily by simple access services (paid or free) which are being squeezed in terms of revenue and profit. There is a need to enhance that model and in most cases, the future business case is only viable, for any type of operator, if the Wi-Fi networks are fully carrier-grade, and able to support a wider range of services, and a similar customer experience to the cable and mobile systems.

That will drive a wave of investment in deploying or upgrading carrier-grade Wi-Fi, whether directly by MNOs and MSOs, or by their Pure-Play partners. The primary opportunity for Pure-Plays to extend their revenue model is often via wholesale activities. In 2016, 61% of MSO's Wi-Fi hotspots, and 70% of MNOs', will be sourced from third parties, though some will be managed within the primary operator's BSS/OSS. The main reasons for this high level of outsourcing are to reduce cost and accelerate deployment, but another factor, especially in urban areas, is that pure-plays and aggregators have often acquired the best sites and done the work of negotiating lease and backhaul rights. This projection does not allow for the likelihood that some of these independent networks may be acquired by an MNO or MSO, as happened to The Cloud in the UK, for instance (acquired by BSKyB).

Some of the enablers of a carrier-grade Wi-Fi network are already in place, such as the emergence of HotSpot 2.0 [9] and of faster standards, but there are still significant barriers to deploying carrier-grade Wi-Fi in such a way as to support profitable services and new revenues. Among these barriers is the shortage of tools for planning, managing and optimizing Wi-Fi networks, in the way that operators are accustomed to doing in cellular or wireline. There is a significant opportunity to provide carrier-grade tools to enable operators to deploy and manage Wi-Fi in the same way as cellular and cable.

4. Carrier-grade Wi-Fi aspects

4.1 Benefits of carrier-grade

It is clear from the above that operators of all kinds are increasingly incorporating Wi-Fi into their services. However, interviews with providers highlight that the business models for best-effort Wi-Fi are limited. Simple access, whether free (advertising supported) or paid-for, is competitive and carries falling 'average revenue per user' (ARPU) and margins. Many additional services will be enabled by the evolution of Wi-Fi platforms, and will improve the business case, but they will often rely on higher levels of QoS, security and user experience than is common with best-effort Wi-Fi. Until networks, and the systems managing them, are carrier-grade, MNOs and MSOs will be hesitant to make them too strategic, for fear of a negative impact on their main networks, or on their customer experience and brand perception.

For all these reasons, there will be a significant move to implement carrier-grade Wi-Fi in the period to 2016, driven by the availability of new technologies, and by the increasingly urgent need for carriers to increase their wireless data capacity to support new revenue streams. Indeed, across the operator categories, 85% plan to start upgrading at least part of their Wi-Fi networks by the end of 2016.

Figure 7 shows that MSOs are leading this development: 27% already support carrier-grade Wi-Fi in at least part of their network, twice the number seen among MNOs. This is because they have the most urgent motivations - to get the best MNO offload deals and to support consumer services which rely on consistent user experience and streaming, such as TV everywhere.

This is especially true for MSOs which see Wi-Fi as an alternative wireless network to reduce their reliance on cellular MVNO deals, and to reduce their competitive disadvantage against converged carriers, a trend which is increasingly common in North America. Regionally, North America and Asia-Pacific will lead the upgrade process, with European deployments being more heavily weighted to 2016.

Deployment of carrier-grade Wi-Fi will see a sharp uptick in 2015. While early movers have already begun the process in 2014, the majority of players, especially Pure-Play Wi-Fi providers, will wait until there are fully standardized and cost effective products supporting key enablers like HotSpot 2.0; and until there are readily available tools and management systems to get the optimal results from the upgraded infrastructure. This will happen during the course of next year.

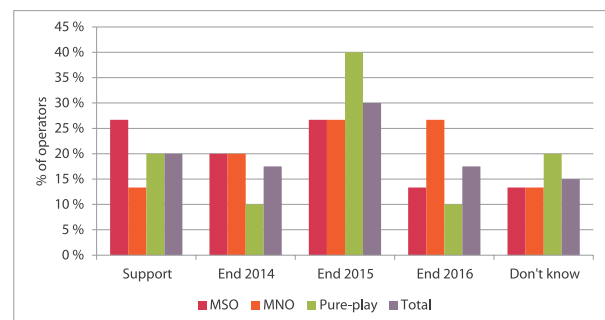


Figure 7: Operators planning to start deploying carrier-grade Wi-Fi in their networks (directly or indirectly) between 2014 and 2016, by operator type

By 2018, 72% of an MSO's network, on average, will be carrier-grade, up from 17% in 2014, while for MNOs the figure will be 66% (up from 14%) and for Pure-Plays 63% (up from 12%). This illustrates how operators of all kinds will be driven to upgrade their Wi-Fi networks, even if the Wi-Fi specialists move a little more slowly, because of resource constraints or less urgent business imperatives.

The patterns of Wi-Fi deployment, management and upgrade will to some extent be determined by the nature of the operator's networks. Among MNOs and MSOs, those with a high level of direct ownership of hotspots were generally in the forefront of carrier Wi-Fi upgrades. Their willingness to invest in their own infrastructure indicates that Wi-Fi is highly strategic and so they are more likely to place importance on network quality. For instance, of the four MNOs with the highest ownership of Wi-Fi hotspots, three will implement carrier-grade Wi-Fi by the end of this year, and the same is true of all four of the MSOs with the highest roll-out of their own hotspots.

4.1 Benefits of carrier-grade (continued)

MSOs are far more likely to build and own their own hotspots than MNOs, as Figure 8 indicates, and so have less reliance on third parties. This is because they generally see Wi-Fi as an integral part of their infrastructure, and an asset which can generate revenue, from their own customers, or from MNOs seeking offload.

Pure-Plays, predictably, build and manage the majority of their networks, since these provide their primary business, though they do supplement these networks with third party relationships to fill in gaps, especially when they are mainly consumer-facing rather than wholesale.

There is a decline in direct build-out by all parties, as better tools emerge to enable operators to integrate third party locations fully with their own back office systems, and as optimal new sites become harder to find. The emergence of tools which allow third party hotspots to be accessed and managed as a seamless part of the primary network is a critical aspect of carrier Wi-Fi, to the business cases of MNOs and MSOs.

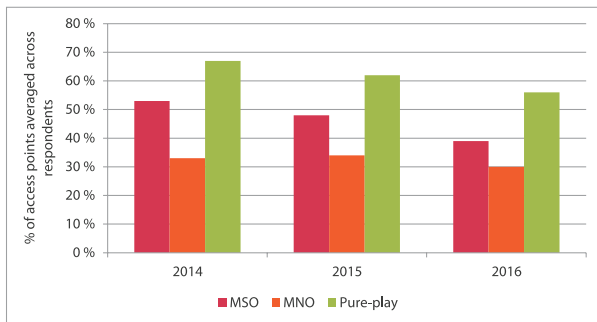


Figure 8: Percentage of access points built and managed in-house, by operator type

As shown in Figure 9, although these capabilities are rare in 2014 (and usually proprietary), within two years they will be powering significant integration of third party managed hotspots into carrier networks. About one-third of MSOs' locations, on average, will fall into this category by the end of 2016, and over one-quarter of MNOs.

Even a few Pure-Plays are starting to introduce full core/back office platforms to improve the quality of their own networks and to manage partner hotspots seamlessly, though these will still account for only 13% of Pure-Play hotspots by 2016 while home-managed locations will still be well over half.

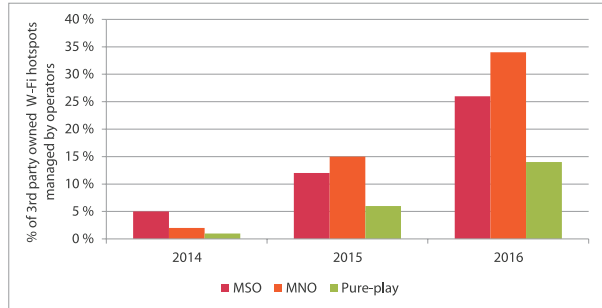


Figure 9: The percentage of Wi-Fi hotspots which are owned by third parties but managed from the operator's core and BSS/OSS

4.2 Carrier-grade business drivers

In general, the drivers for investing in carrier-grade Wi-Fi are to increase capacity and quality, in order to support new revenue streams; to improve customer experience, whether for consumers or partners such as off-loaders; and in the case of companies with other networks, to reduce the total cost of ownership of the whole system by harnessing unlicensed spectrum and a huge existing device ecosystem, and by offloading data from mobile networks.

More specifically, however, there is a wide variety of business drivers, and some variation among different types of operators. Figure 10 indicates the top five business case priorities for carrier-grade Wi-Fi, for each operator type.

Some of the drivers are specific to a certain type of operator, such as reducing offload costs, which is the most important commercial imperative for MNOs as a group (see Figure 10), with over 70% putting it in their top three priorities for a Wi-Fi business case (and 87% in the top five). The main reason for the intense interest in data offload is to improve quality of experience across their whole network. This not only helps retain cellular customers, but to relieve congestion on the 3G/4G systems in order to support new revenue streams which require high QoE, such as enterprise. These motivations are clearly seen in the MNO's top priorities.

The importance of offload to overall QoE is echoed by the significance of revenues from that offload, to MSOs (the second most important driver, placed in the top three by more than half the group) and to Pure-Plays (also the second most significant factor, selected by 60% for the top three).

The most important driver for MSOs is to help create quad play services (service bundles incorporating content, TV, connectivity and voice over both wireline and wireless). Variations of this model increasingly include wireless-dependent options such as TV everywhere (the same video content, preferences and user interface, delivered to mobile as well as home screens); and Wi-Fi-First (mobile voice and data services which default to a Wi-Fi connection, only moving to cellular when there is no good Wi-Fi signal. This model is being embraced by some MSOs to reduce MVNO fees to mobile carriers and ensure they have the primary billing relationship with customers for all services).

Smart city is the category which is most important across all provider types, being placed in premier position by Pure-Play providers (a top three choice for 60% and top five for 80%), in second ranking by MNOs and third by MSOs. The importance among Pure-Play providers is partly because they can build on existing municipal networks and partnerships with local authorities and other agencies which will be investing in broader smart city applications such as intelligent lighting or traffic management. This is seen as an important emerging opportunity in which Wi-Fi will be a suitable network for many deployments, enhancing the value of existing locations in city centres.

This is an example of a service which is prominent in the business case but still in the early commercial stages. Although 50% of Pure-Play providers claim some smart city locations already, only one-third of the other operator types are already offering such services, and all acknowledge that the biggest opportunities are in the 2016 and later timeframe.

4.2 Carrier-grade business drivers (continued)

These findings highlight that public Wi-Fi is a market at a significant point of change. In most cases, the services which have already been deployed are simple access (paid or best-effort) and municipal Wi-Fi, but these are not prominent in the business models.

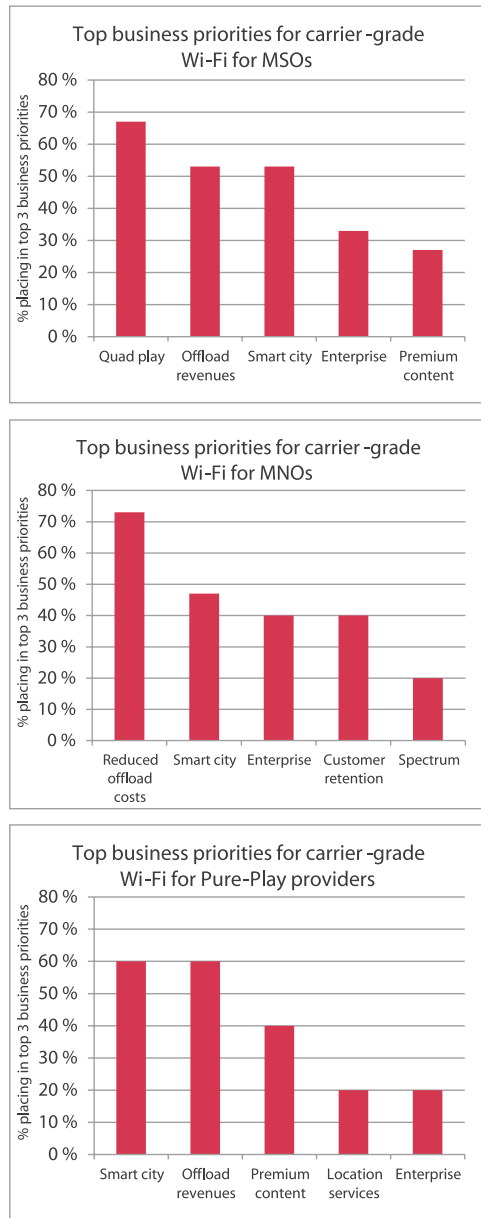


Figure 10: Top business priorities for carrier-grade Wi-Fi for MSOs (left), MNOs (right) and Pure-Play providers (below). Figures indicate the percentage of respondents of each operator type placing these factors in their top three in terms of importance to the business case for carrier Wi-Fi, as distinct from best-effort Wi-Fi

Figure 11, an MSO example, illustrates this contrast strongly. While every single MSO offers some best-effort, municipal and paid access services, directly or through partners, none places access in their top three business case priorities, and only 27% put municipal services there. The most significant business case elements, in their opinion, are yet to be deployed in most cases (MNO offload being the major exception).

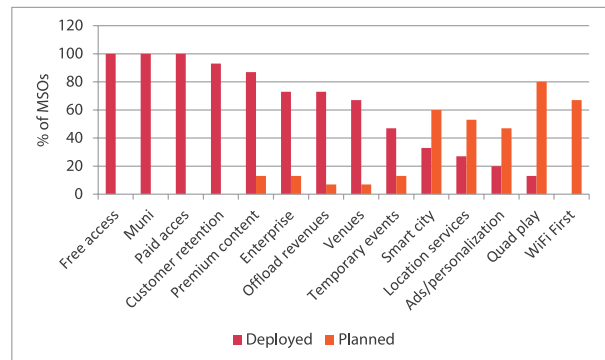


Figure 11: Percentage of MSOs which have deployed each service already, and percentage planning to do so in 2015-2016

This illustrates how operators want to move beyond access and towards high value services, but these will require the kind of quality and tools which will make Wi-Fi perform almost like cellular. In MNOs' case that will allow for seamless user experience between 3G, LTE and Wi-Fi, and for the other operator types, it will enable them to create a comparable experience on Wi-Fi to that offered by MNOs on LTE. There will always be challenges in terms of ubiquitous coverage and full mobile hand-off, when Wi-Fi is compared to LTE, but the gap is narrowing with extensions to the 802.11 standards and the common IP base of both standards. Indeed, two-thirds of MSOs, and 50% of Pure-Plays, plan to support voice over Wi-Fi services, as better quality alternatives to over-the-top offerings, by the end of 2016, in order to increase their ability to be the primary service provider to many consumers and enterprises. An even higher percentage of MNOs (60%) have similar plans, mainly as an interim step towards the more fully featured VoLTE, and a weapon against Over The Top (OTT) services.

4.3 Carrier-grade enablers and barriers

Despite the strong indications that operators of all kinds plan to move towards carrier-grade Wi-Fi in the coming two years, there are still issues which may delay the timing of those upgrades if they are not addressed promptly by vendors, standards bodies and the operators themselves. There is a set of key technologies which the respondents believe are essential enablers, and need to be in place before they will embark on high volume deployments. There are also additional barriers to deployment which need to be addressed.

The most important of the technology enablers, according to this study, are better tools to manage Wi-Fi hotspots in the same way as other carrier networks, to improve efficiency and user experience; faster connectivity, largely via the move to the 802.11ac standard; and technologies to deliver more consistent and guaranteed quality of service. For the response base as a whole these emerge as the most important technology enablers, with tools being placed in the top three by half the sample (see Figure 12).

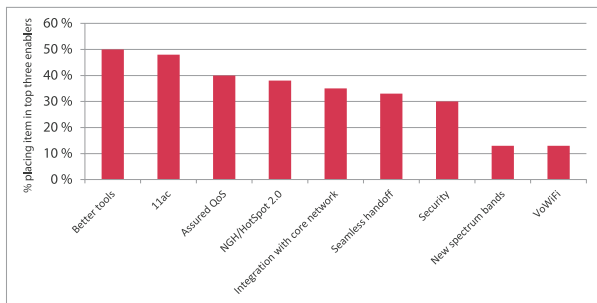


Figure 12: Technology enablers which need to be in place before providers will move to carrier-grade Wi-Fi. The graph indicates the percentage of respondents which placed each factor in the top three in terms of importance to deployment

Within different operator types, there are some variations. Improved carrier-grade tools are the most important enabler for MSOs, and in second place for MNOs, behind integration with the core network. Several of the most important enablers for these two groups relate to interworking with existing networks and systems, as seen in the priority placed on HotSpot 2.0 (which supports seamless authentication and roaming between cellular and Wi-Fi), and on seamless hand-off in general.

Pure-Play operators place the greatest significance on improving the QoS they can guarantee to customers, and on boosting the speed, especially with 11ac. Predictably, they are more focused on enhancing the Wi-Fi network itself, and less on interworking, though the latter will become an important issue for those which want to secure the best partnership deals with MNOs and MSOs.

The Hotspot 2.0 registration approach, based on the 'Extensible Authentication Protocol' (EAP)-SIM, will help ease deals between MNOs and external hotspot providers because it allows for seamless authentication and hand-off between Wi-Fi and cellular. Many respondents believe Hotspot 2.0 is a critical element of carrier-grade Wi-Fi and MNOs, in particular, regard it as an important step from simple offload to integrating Wi-Fi fully into their heterogeneous networks and services.

If improved tools are seen as a key technology enabler of carrier Wi-Fi, the shortage of these so far appears as a critical challenge to deployment too. Across the whole sample, the most significant challenges to deploying carrier-grade Wi-Fi, emerged as strong network planning and management tools (65% of respondents), integration with existing back office systems (58% of respondents) and cost/return on investment issues (35% of respondents).

Among the operators surveyed, the top three challenges to deploying carrier-grade Wi-Fi emerged as a lack of strong network planning and management tools (65% of respondents), integration with existing back office systems (58% of respondents) and cost/return on investment issues (35% of respondents).

4.3 Carrier-grade enablers and barriers (continued)

There were different priorities among different operator groups. For MSOs, network tools were placed in the top three by a full 80%, compared to just over 50% for MNOs (for whom BSS/OSS integration was the primary challenge, with over 70% giving it a top three position). Quality of service and ROI were also important to these two groups. For Pure-Play, QoS is the dominant challenge, placed in the top three by 70%, followed by security and planning tools.

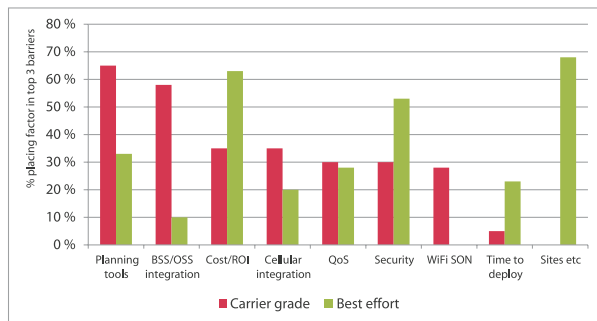


Figure 13: Key challenges to deploying Wi-Fi networks, in carrier-grade or best-effort mode. The graph shows the percentage of respondents placing each factor in their top three most important challenges

As shown in Figure 13, there is a significant change of emphasis when carriers turn from best-effort to carrier-grade deployments, which will alter their pattern of technology investment. For best-effort, across all groups, logistical issues such as site acquisition, plus cost and security considerations, are pre-eminent. Those three factors are the most important for all operator groups when considering best-effort, but all are expected to be addressed, to some extent at least, by the move to carrier Wi-Fi, at which point new challenges come to the fore, relating more to quality of experience and optimization, and less to logistics and cost. Among those quality of experience issues, carriers indicated that unbroken, high quality video and voice sessions; simple or automated sign-up processes; and (where relevant) precisely targeted adverts, information or promotions, were the most critical areas. Actual speed of connection was less prominent as that is almost taken for granted now, even on best-effort networks.

5. Investment in new tools for carrier Wi-Fi networks

It is clear from the findings in section 4.3 that there is a perceived need, once operators start to transition from best-effort to carrier-grade Wi-Fi, for the same type of network, and back office tools that are used on cellular and wireline systems. However, there is also a perceived shortage of such tools currently available. As Figure 14 illustrates, fewer than 20% of providers have deployed any tools specifically for carrier-grade Wi-Fi, even though two-thirds of the response base intends to do so. This gap highlights a factor which could delay the deployment or upgrade of new Wi-Fi networks – many of those interviewed indicated that they had not yet invested because the existing solutions are unavailable or insufficiently proven.

The perceived shortage is most acute among MSOs, which have the most urgent business case to deploy fully carrier-grade networks, especially where they see Wi-Fi as their primary wireless platform. MNOs are the most cautious about deploying these tools, even though they are the least likely to stick to a best-effort model – although best-effort networks are adequate where the MNO has a very simple offload strategy and is mainly disposing of low value traffic, carrier-grade networks are essential once high value customers are moving seamlessly between cellular and Wi-Fi. This movement may be controlled by the operator but may also be actively chosen by the user via his or her device settings – yet MNOs are concerned that, even in these cases, users blame the mobile carrier when they reach a poor Wi-Fi experience.

For these reasons, MNOs are generally waiting for tools which can span cellular and Wi-Fi networks, and until then will stick to fairly basic offload strategies. Respondents indicate that these tools are scarcely available yet – and that extending existing cellular tools to Wi-Fi without also adding new capabilities entails too many trade-offs (only 7% of MNOs believe they can simply extend their current products to Wi-Fi).

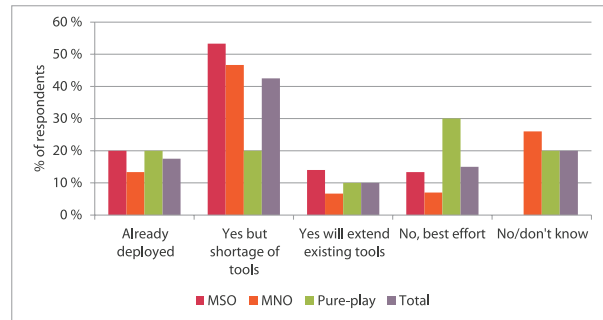


Figure 14: Percentage of operators in each group which intend to invest in carrier-grade Wi-Fi network tools in 2014-2016

The types of tools in which the largest numbers of operators would invest are those for network planning, and for network performance and usage analytics (see Figure 15). This is because these are areas which are critical to the business case – to ensure optimal and cost-efficient roll-outs, and to provide detailed analysis of network behaviour and customer usage, which can feed into improved quality of experience, and can be used for big data purposes. These are also areas where operators say their existing tools will not extend well to Wi-Fi without additional investment. MNOs, in particular, contrast the richness of user analytics data which is available from their cellular network tools, with that typically available with Wi-Fi. Near-parity between the two will be critical to seamless HetNet strategies.

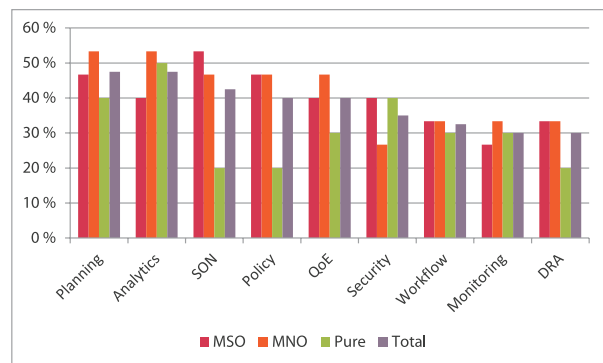


Figure 15: Percentage of operators which would invest in particular categories of carrier-grade network tools by 2017, by operator type

By contrast, some types of tools, such as security, score lower, not because they are not critical, but because operators are more confident about using existing products.

The availability of these products is very important to the operators' business case for investing in carrier-grade Wi-Fi, and so will affect the timelines for these deployments. Providers have a dual set of motivations to include carrier Wi-Fi in their plans - improved QoE at reduced cost, in order to drive both increased service revenues and better margins.

Figure 15 shows that improved customer experience is the most important ROI factor across the respondent group as a whole, followed by lower opex costs and improved QoS. There are, however, variations in the priorities of different operator types, reflecting their different business case focuses. For instance, overall QoS is the most critical factor for Pure-Play Wi-Fi providers, since this will underpin wholesale business as well as consumer services. Opex is a major factor for MNOs and MSOs, which are under intense pressure to reduce their overall operating costs across all their platforms, and see Wi-Fi as a way to do this. That also explains the importance MNOs attach to targeted capacity, so that they can avoid the cost of over-provisioning their networks with scattergun access points, and can improve their overall cost mix by introducing Wi-Fi alongside cellular.

Wi-Fi Self-Optimizing Networks (Wi-Fi SON)

Some types of tool are only just emerging, including SON. This is an area of significant growth in cellular networks, and both MNOs and MSOs would like to have SON-like capabilities for Wi-Fi too, for automatic organization, provisioning and optimization. In MNOs' case, they want to see cellular SON products extended to Wi-Fi, treating all cells in the same way, but 47% believe they will need to invest in new SON tools for Wi-Fi as well. Indeed, 60% believe SON will be critical or very important to the success of a carrier Wi-Fi program, and 40% of MSOs believe the same. Indeed, 53% of MSOs would invest in SON tools for Wi-Fi if these were available (note, this relates to broad definitions of SON, not the specific 3GPP standards which do not cover Wi-Fi). These capabilities are of less interest to Pure-Play Wi-Fi providers, and only 10% see SON as critical or very important to their model.

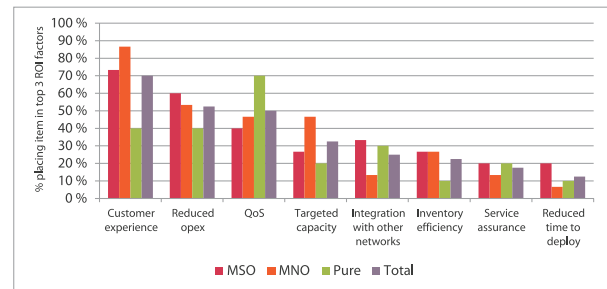


Figure 16: Key return on investment drivers for investing in carrier-grade tools for Wi-Fi networks. The graph shows the percentage of operators in each category placing each ROI factor in the top three, in terms of significance to the Wi-Fi business model

6. Summary and conclusions

The operator study has highlighted the increasingly strategic importance of Wi-Fi to the business models of MNOs and MSOs, a trend which will also drive new business for Pure-Play Wi-Fi network owners, through increased wholesale demand. All three categories of Wi-Fi operators will be investing in new ways to monetize their access points, as well as new ways to use their capacity more cost-effectively and in a more targeted way. All those patterns will drive a rapid cycle of network upgrade and build-out, focused on carrier-grade capabilities which will support an enhanced quality of experience, and therefore higher customer satisfaction and usage, as well as new services such as high quality voice and smart city apps, where full reliability and consistency is essential.

The shift away from best-effort and towards more diverse business models will create new complexities, as the Wi-Fi platform expands along with the carriers' service models. For instance, as well as introducing new Wi-Fi-based offerings, operators will also deploy new types of equipment, which will need to be incorporated in management systems too. As an example, MNOs will start to roll out combined Wi-Fi/Cellular small cells – by 2017, 30% of their small cells will be dual-mode.

Bringing the same quality of planning and optimization tools to Wi-Fi as operators currently have for their mobile and wireline networks will be an important enabler of these carrier-grade services. Without these tools, operators believe they will not secure the optimal performance and ROI from investing in high quality Wi-Fi, and some may hold back on roll-out.

Any service provider, such as an MSO, with a broadband connection in the home, is interested in 'homespots' (home Wi-Fi routers with a second SSID (service set identification = network name) left open for public access by passing subscribers). Because these are backhauled by the existing broadband line, they provide a low cost method for the operator to broaden its Wi-Fi availability, especially in residential areas where there may be fewer public locations such as cafes. In the first instance, these will be provisioned by the same tools used for the MSOs' in-home equipment, but they will start to become a capacity resource to be managed and optimized in the same way as other locations.

Looking ahead, many operators are starting to evaluate plans for integrating and managing new Wi-Fi-enabled devices in future, such as connected cars, home appliances and industrial objects like traffic lights or meters; and at building out Wi-Fi at new levels of density, for instance in stadiums. The new IoT services will often not involve high data rates or volumes, but availability and reliability will be critical; while ultra-dense deployments will require QoS and interference mitigation as much as higher data rates.

Appendix 1 – Scope and respondents of the report

Scope, report description and market respondents

This Wi-Fi study has been requested as a direct follow-up ('Phase2') to Real Wireless' previous research on behalf of Amdocs on the survey of global MSOs to understand the impact of Small Cells on backhaul [10]. The study aims to understand the opinions and requirements of Wi-Fi operators with regard to their range and variety of deployment.

In this independent study conducted by Real Wireless on behalf of Amdocs in August 2014, we held 15 telephone interviews and made a survey of 40 national and large regional MNOs (mobile network operators), MSOs (multiple system operators, mainly cablecos) and Pure-Play Wi-Fi network operators. The focus was on developed and large emerging markets in North America, Europe and Asia-Pacific (see split of operators contacted in Figure 17). All respondents had been pre-selected as having an active deployment, trial or evaluation of public Wi-Fi services for the period 2013-2017.

The views of the industry have been considered to allow Real Wireless to form an independent view on the challenges and opportunities for Wi-Fi deployments.

This report is organized as follows:

- In chapter 2 we look at the Wi-Fi market and its challenges. We review the Wi-Fi evolution, its future, recent trends, Wi-Fi outliers, market size, forecasts and monetization
- In chapter 3, we review the wireless deployments based on the respondents of the survey and outline the observed key trends
- In chapters 4, we analyse the raising importance of 'carrier-grade' performance and discuss in chapter 5 the associated need for investment into Wi-Fi tools to support this requirement
- In chapter 6, we draw out the key findings and summarise it into our conclusion

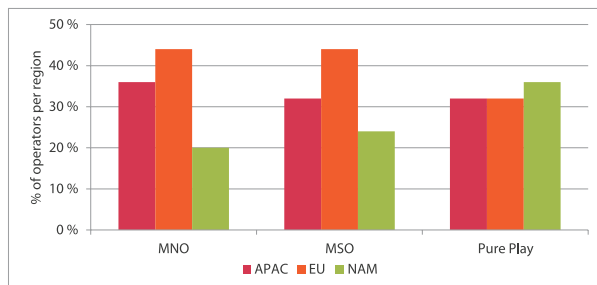


Figure 17: Regional mix of Wi-Fi operators contacted (MNO, MSO and Pure-Play)

Key characteristics of the respondents to this survey

A survey was conducted in August 2014 of 40 national and large regional MNOs (mobile network operators), MSOs (multiple system operators, mainly cablecos) and Pure-Play Wi-Fi network operators. The focus was on developed and large emerging markets in North America, Europe and Asia-Pacific.

All respondents had been pre-selected as having an active deployment, trial or evaluation of public Wi-Fi services for the period 2013-2017. Across the industry as a whole, Rethink Research estimates that the scale of adoption of carrier Wi-Fi is rising quickly among tier one and tier two MNOs and MSOs, as indicated in Figure 18.

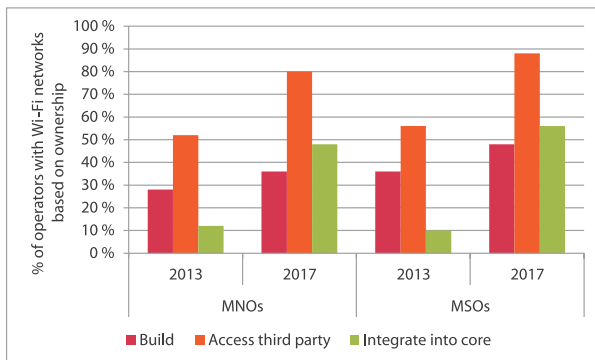


Figure 18: Percentage of tier one and two MNOs and MSOs including Wi-Fi hotspots in their networks

Figure 18 shows that, in 2013, 28% of MNOs and over one-third of MSOs are building some of their own hotspots, while over half in each category are accessing third party hotspots for offload or roaming (these figures overlap as many operators will assemble a network with a mixture of own-build and third party agreements). By 2017, the rate of building hotspots will have risen slightly, but the trend will be for operators to rely heavily on third party locations, once they have the capabilities to manage these from their own BSS/OSS and core systems.

By 2017, 80% of MNOs will include Wi-Fi hotspots in their networks, and almost half will be managing at least some of those from their main network systems. The trend is even more marked among MSOs, since for many Wi-Fi will be their primary wireless network and a key element of quad play bundles and 'everywhere' services. Almost 90% will have Wi-Fi in their networks by 2017 and 56% will be managing these from their primary systems.

Despite a high level of their own build-out, as indicated in Figure 18, MNOs and MSOs will be in need of many third party access and roaming agreements, which will provide an important business driver for Pure-Play Wi-Fi network operators. Many of these will turn to a primarily wholesale model rather than trying to compete with MNOs and MSOs for consumer services. Figure 19 shows that the absolute numbers of Wi-Fi Small Cells anticipated to be deployed varies regionally on a year to year basis, with highest relative growth anticipated in the less developed existing markets. Over 50% of the units deployed in the coming year will be in the APAC region with the remainder split between the remaining world markets.

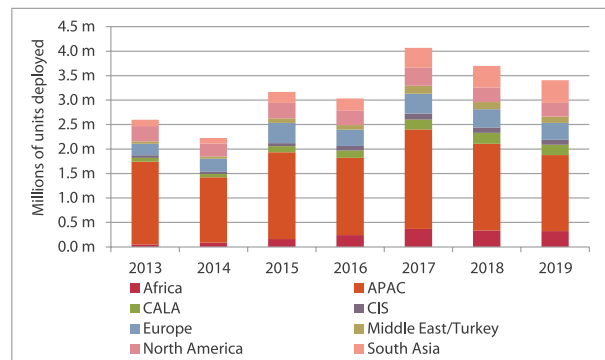


Figure 19: Deployment of carrier-grade Wi-Fi hotspots by MNOs and MSOs between 2013 and 2019 [by region in millions]

Appendix 2 – Wi-Fi development and challenges

Wi-Fi background and evolution

Wi-Fi (also called WLAN or Wireless LAN) is a wireless local area technology to transmit data to end devices and is based on the 802.11 standards. Typically Wi-Fi is used to connect devices wirelessly to broadband and internet service.

Wi-Fi uses electromagnetic waves that run at a specific frequency. There are two main frequencies used for Wi-Fi today; these are 2.4 GHz (initially 802.11 and 802.11b) and 5 GHz (initially 802.11a). Using 2.4 GHz worked with mainstream devices and was the one that most people used. 802.11b was the Wi-Fi of choice for some years, mainly due to the fact that 11a was more expensive. Today's 802.11n and 802.11ac Wi-Fi standards and devices support both the 2.4 and 5 GHz bands.

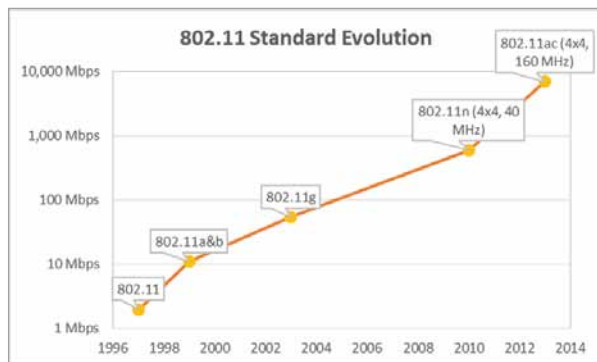


Figure 20: 802.11 evolution over time and associated data rates (11, 12)

Wi-Fi is developing fast and getting faster. The next generation of Wi-Fi technology will be able to transmit over 7 Gbps and by 2018, worldwide Wi-Fi traffic is set to overtake wired traffic for the first time ever [13].

Today, Wi-Fi is in 25% of homes around the world, and about two billion Wi-Fi devices were sold in 2013 [14]. This device availability has been probably the most critical factor behind public Wi-Fi's rapid growth. A decade ago, initiatives like Intel Centrino made Wi-Fi an increasingly common feature of laptops and other devices, and a far wider range of uses has been enabled by the development of low power Wi-Fi and multimode chips which are now almost a default in smartphones and other mobile products. Some devices, notably many tablets, are Wi-Fi only, with no cellular connection, an example which illustrates the 'virtuous circle' at work – a Wi-Fi only mobile device is only practical if there is very widespread network availability, while the build-out to provide that availability is heavily driven by the number of devices in use. The chipmakers have moved increasingly rapidly to support new Wi-Fi versions even before they are fully standardized and the Wi-Fi Alliance's certification program has been important for manufacturer and consumer confidence.

Conversely, when a feature is not embraced by the chip ecosystem, it is the main factor limiting adoption – as happened with 802.11a, which was 5GHz-only, a frequency which was rarely supported in mainstream devices.

The four generations of public Wi-Fi

Public Wi-Fi is often referred to as having reached its 'third generation', and to be evolving rapidly into its fourth. The generations are not defined by big architectural shifts as in cellular, but by changes of usage and therefore of monetization opportunities.

The first generation revolved around simple access, enabling users to get online when away from their tethered home and business connections. The rise in integrated Wi-Fi in devices drove massive uptake, but this was mainly focused on standalone hotspots in key areas of usage, such as railway stations and cafes. The key business model was simple paid-for access (pay-as-you-go or subscription) and the key standard was 802.11b.

The second generation involved broader coverage as well as higher speeds, and the idea that Wi-Fi access could be 'joined-up', supporting zones of access with relatively seamless hand-off. The infrastructure became more secure and faster thanks to extensions like 802.11g, WPA security and 802.11e QoS. The metro-zone development was driven heavily by web giants like Google and by municipalities. The main business models were free or low cost access subsidised by advertising, or by public authority efficiencies. However, in many cases the business case proved weak, partly because the technology for metro area Wi-Fi was immature.

The third generation saw the mobile operators embracing Wi-Fi as a way to offload data and relieve strain on their cellular networks. This sparked a new wave of investment in hotspots and hot-zones in areas of high mobile demand, either by MNOs themselves or by partners. The model for many Wi-Fi network owners shifted from consumer fees towards wholesale access and the trend was also a spur for aggregators. There was also a rising focus on performance, not just speed (the 802.11n upgrade) but improved QoS assisted by standard support for the less congested 5GHz, as well as 2.4GHz, and by QoS extensions such as 802.11e.

The fourth generation is just beginning and sees Wi-Fi integrated with other networks. In MNOs' case this can offer a seamless pool of wireless capacity and as tools for dynamic capacity management evolve, they will be able to harness that capacity in an efficient and targeted way. For MSOs and other wireline carriers, Wi-Fi is increasingly capable of enabling them to add a carrier-grade wireless option to their service bundles, to encourage on-load and roaming access, and so reduce churn. They can also derive revenues from MNO off-load deals, and use these as a bargaining counter to reduce their own fees for cellular access via MVNOs. Critical to these carrier Wi-Fi strategies are the latest standards updates, such as 802.11ac (gigabit Wi-Fi), as well as improved quality of experience and service assurance standards, so that the user experience on Wi-Fi is the same as on other networks.

Wi-Fi's future, and the move to IoT

Wi-Fi will connect new types of devices to each other and the internet. With the 'Internet of Things' (IoT) emerging as the next major wave of connected innovation, Wi-Fi's reach will extend into the smart home, connected cars, sensing and control networks, and much more.

The Wi-Fi Alliance roadmap features a number of additions and improvements of the Wi-Fi standards over the next few years. 802.11ac 'Wave 2' will be followed by 802.11ax in ~ 2019. New frequency bands will deliver just the right kind of connection, e.g. multiple-gigabit data rates for room-range connectivity in 60 GHz in 2016 based on 802.11ad. The Wi-Fi Alliance has also begun work to define certification programs based on 802.11af for operation below 1 GHz to support longer-range, very-low-power connectivity [15].

Industry developments

Mobile data demand is projected to grow vigorously in the coming years, e.g. Cisco [16] anticipate global mobile traffic to grow by a factor of 11 between 2013 and 2018 equivalent to an annual growth rate of 61%. Subscribers in South Korea, averaged over 12GB of mobile data consumed per month when accounting for both cellular and Wi-Fi usage followed by subscribers in Japan and Russia averaged slightly less than 10GB of data consumption per subscriber [17].

Offloading some of this traffic to Wi-Fi networks has been a key strategy of some mobile operators in recent years. Wi-Fi accounted for an enormous 75% - 90% of all mobile data consumed in 'leading LTE markets' [4Error! Bookmark not defined].

A critical enabler of the trends towards mobile data offload, and carrier-grade Wi-Fi, is the emergence of the Hotspot 2.0/Passpoint and Next Generation Hotspot (NGH) specifications, from the Wi-Fi Alliance and Wireless Broadband Alliance respectively. 2014 has seen the start of deployment of networks supporting these technologies, which will be a fundamental aspect of carrier-grade Wi-Fi. They support authentication via EAP-SIM, which in turn allows for automatic sign-up and seamless roaming between cellular and Wi-Fi connections. These are important developments. Most carriers indicate that laborious sign-up routines are a significant barrier to user uptake, and Passpoint provides a standardized way of addressing this. However, while the SIM-based approach is a significant advantage to MNOs because of the cellular integration, it may be a double-edged sword for MSOs in cases where they are trying to present their services as an alternative to those of mobile operators.

MNOs, MSOs and Pure-Play operators are building Wi-Fi networks and start competing for locations, customers and coverage [18]. One of the key challenges is securing access to good locations for offloading Wi-Fi traffic and securing suitable backhaul. There are many different drivers for Wi-Fi rollout, but monetising Wi-Fi is a challenge [19] and this is where strategy, good planning and tools become very important for the success of Wi-Fi deployments. These tools help operators to control the quality of experience by planning the network efficiently and then monitoring each hotspot and its traffic patterns. Once quality of experience (QoE) can be assured, new revenue streams, which are QoS-dependent, can be added, such as premium video streaming services or business applications. As in cellular networks, planning and quality assurance are as important to QoE, and therefore to carrier competitiveness, as the speed and robustness of the access points themselves. Wi-Fi technology has developed significantly to increase throughput and quality. It is interesting to note that many "Wi-Fi performance" issues are related to backhaul limitations rather than air interface performance issues.

Wi-Fi outliers

This report focuses on the three most significant groups of companies which are deploying public Wi-Fi; there are the wireline operators (MSOs), MNOs and the major Pure-Play Wi-Fi network owners, which have extensive build-outs either regionally or nationally. However, because of its use of licence-free spectrum, Wi-Fi has always encouraged a diverse mixture of player and business models, and will always remain somewhat fragmented.

While an increasing percentage of roll-out will be done by the larger players, especially when it comes to carrier-grade deployment and upgrade, it is worth noting that about 15% of the world's Wi-Fi hotspots are run by other types of business. These include:

- Venues, such as hotels or coffee shops, which have their own hotspots specifically for their customers
- Municipal networks, owned or run by the local authority
- Neutral host networks operated by specialist providers in some airports or stadiums
- Vertical market WLANs owned or run by an enterprise or utility for its own purposes, such as smart metering
- Operators focused on a smaller locale such as a single city. These may support very high quality Wi-Fi if they are focused on enterprises, but on a smaller scale
- Community networks offering free shared access, often run by enthusiasts

The type of companies mentioned above were not targeted as part of this study and hence we had no questionnaire responses or interviews with them. But to give an idea, they would include the likes of Urban WiMax, Optimum or Metronet (UK), Jab (Colorado, USA), Linkem (Italy), G-Free (Japan), Zenbu (Australia) and Linx (Sweden).

We estimate that these smaller groups will account for a declining percentage of global hotspots (halving as a percentage by 2018) because they will lack the economies of scale to upgrade to new technologies, and they will not have the volume to attract major roaming/offload deals (high quality business-focused networks may be an exception, or firms which control valuable sites such as railway stations). However, they will still be an element of the overall service mix.

Definitions

Best-Effort:

Best-effort in Wi-Fi (also called 'Best Effort Wi-Fi') describes a network service in which the network does not guarantee quality of service or prioritization. All users obtain best-effort service, meaning that they obtain variable bit rate and delivery time, depending on the current traffic load.

Carrier-Grade:

Carrier-Grade and Carrier Class in the Wi-Fi industry (also called 'Carrier-Grade Wi-Fi') is not to be mistaken as Wi-Fi offload. This term applies to Wi-Fi deployments and APs that allow control; access (e.g. preferential access to specific users and security), quality (QoS) and service experience. The WBA defined Carrier Grade WLAN based on a set of guidelines and best-practices that distinguish carrier-operated public Wi-Fi networks from consumer and enterprise networks. Those attributes include:

- a. Features that must be supported by the infrastructure and the terminal devices built for carrier networks
- b. The network architectures and implementation methods that support operator-managed Wi-Fi services
- c. User experiences and operational best-practices typical of service provider networks

For MNOs this would mean that subscribers can access Wi-Fi automatically to stay on their service provider's network; or they can roam between a cellular network and residential, privately- and publicly-owned carrier Wi-Fi networks and hotspots with the complete peace of mind that these connections are secure.

HetNet:

With HetNet we mean Heterogeneous Network. But more specifically in our case, we focus on heterogeneous wireless networks (HWN) which are a special case of HetNets. A HWN is a wireless network which consists of multiple types of access nodes and devices using different underlying radio access technologies. A HetNet can connect macrocells, picocells, and/or femtocells in order to offer wireless coverage in an environment with a wide variety of wireless coverage zones, ranging from an open outdoor environment to office buildings, homes, and underground areas using and backhauling a variety of technologies.

Homespot:

Homespots fall into the 'Private Wi-Fi' category but it actually means home gateways (see Wi-Fi APs) that are used (upgraded) to offer both home and commercial / public Wi-Fi for other users in their area by means of a second SSID. This is widely implemented and can result in substantial network traffic offload.

Metro-zone:

Metro-zones are urban areas of high footfall (high concentration of users) and high capacity requirements where area-wide Wi-Fi is being deployed. Metro-zones are created to give the public access (e.g. free access commissioned by local council) but can also be a MNO's strategy to offload his network.

Private Wi-Fi:

Compared to public Wi-Fi, these APs are only accessible to dedicated and selected users (hence not 'open'). They are typically highly secure (protected) and for indoor usage, installed in e.g. businesses and homes.

Public Wi-Fi:

Under public Wi-Fi (loosely called hotspots) we understand low-cost, high-capacity access points (APs) that enable connections to the internet, cloud-based applications and storage that is accessible to everybody (i.e. the public). They might be found in e.g. coffee shops, hotels or lounges but can also be municipal wireless networks. They are often of lower security, might require additional billing and are operated typically as 'best-effort' networks.

SON:

SON stands for Self-Organising Network; with new and more complex network technologies, configuration and management becomes harder. The goal is to automate the functions to simplify the actions of configuration, organization, optimization of performance with the added feature of self-healing capabilities when faults occur. SON is based on the premise that networks themselves are able to monitor performance and hence can optimise themselves to be able to provide the optimum performance. Operators benefit from significant improvements in terms of performance, reaction time to faults, CAPEX and OPEX.

VoWi-Fi:

VoWi-Fi or Voice over WLAN is in essence the transmission of packet voice (VoIP) over a Wi-Fi network. For good service experience, this service requires QoS, hence it works best on a carrier Wi-Fi network.

Wi-Fi AP:

This stands for Wi-Fi (IEEE 802.11) Access Point (AP). The access point is the Wi-Fi equipment (Wi-Fi Router) that allows wireless devices (e.g. laptops, tablets and smart phones) to connect to a wired network using the Wi-Fi standard. The AP usually connects to a router as a standalone device, but it can also be an integral component of the router itself.

Abbreviations

AP	Access Point (Wireless / Wi-Fi Access Point)
IoT	Internet of Things
MNO	Mobile Network Operator
MSO	Multi/Multiple System Operator (e.g. cable or direct-broadcast operator)
NGH	Next Generation Hotspot
OTT	Over the Top (type of service delivery)
QoE	Quality of Experience
QoS	Quality of Service
VoWi-Fi	Voice of Wi-Fi (VoIP over Wi-Fi)

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About Real Wireless

Real Wireless is a leading independent wireless consultancy, based in the U.K. and working internationally for enterprises, vendors, operators and regulators – indeed any organization which is serious about getting the best from wireless to the benefit of their business.

We seek to demystify wireless and help our customers get the best from it, by understanding their business needs and using our deep knowledge of wireless to create an effective wireless strategy, implementation plan and management process.

We are experts in radio propagation, international spectrum regulation, wireless infrastructures, and much more besides. We have experience working at senior levels in vendors, operators, regulators and academia.

We have specific experience in LTE, UMTS, HSPA, Wi-Fi, WiMAX, DAB, DTT, GSM, TETRA – and many more.

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