Cost savings and revenue benefits from Next Generation Hotspot (NGH) Wi-Fi

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Executive Summary

Seamless Wi-Fi access in public locations has heightened fixed and mobile operators' interest in Next Generation Hotspot (NGH) Wi-Fi – i.e., in deploying their own Wi-Fi networks or relying on their partners' networks to provide access to their subscribers. NGH Wi-Fi deployments have become an integral component of the operators' strategy to increase capacity in a cost-effective way, and to improve subscriber experience using the Wi-Fi wireless interface that is ubiquitous in mobile devices. Operators are drawn to NGH Wi-Fi's SIM-based authentication, automatic network detection and selection, and secure access. The appeal of Wi-Fi will grow even stronger with the upcoming addition of online signup and policy control.

With Wi-Fi's new functionality, its improved performance, and the converging efforts of organizations such as the Wireless Broadband Alliance, the Wi-Fi Alliance, the GSMA, the Small Cell Forum, IEEE and 3GPP, operators have started to treat Wi-Fi as one of their core radio-access technologies, alongside 3G and 4G, and to integrate it within their networks.

Our TCO and revenue analysis compares costs and profitability on a per-bit basis to show how Wi-Fi, 3G and 4G complement each other in meeting rapidly growing data traffic loads in public areas. Our results show that:

- **A higher proportion of data traffic carried by NGH Wi-Fi leads to lower per-bit costs. Mobile operators can reduce their per-bit RAN costs by 18% when they carry 20% of their traffic through NGH Wi-Fi.**
- **The combination of Wi-Fi and cellular small cells brings additional cost savings and higher profitability. The per-bit costs in a network with NGH Wi-Fi and 4G small cells may be 38% of those of a 3G macro network.**
- **NGH Wi-Fi's ability to drive more traffic than legacy Wi-Fi from the same infrastructure results in lower per-bit costs. If a legacy network attracts 25% of the traffic that an NGH Wi-Fi network would, we expect the overall per-bit costs in that mobile network to be 18% higher than in the network with NGH Wi-Fi.**
- **Based on the potential cost savings from Wi-Fi and on operator commitments, we forecast NGH Wi-Fi to account for 9% of global mobile traffic and reach $150 billion by 2018.**

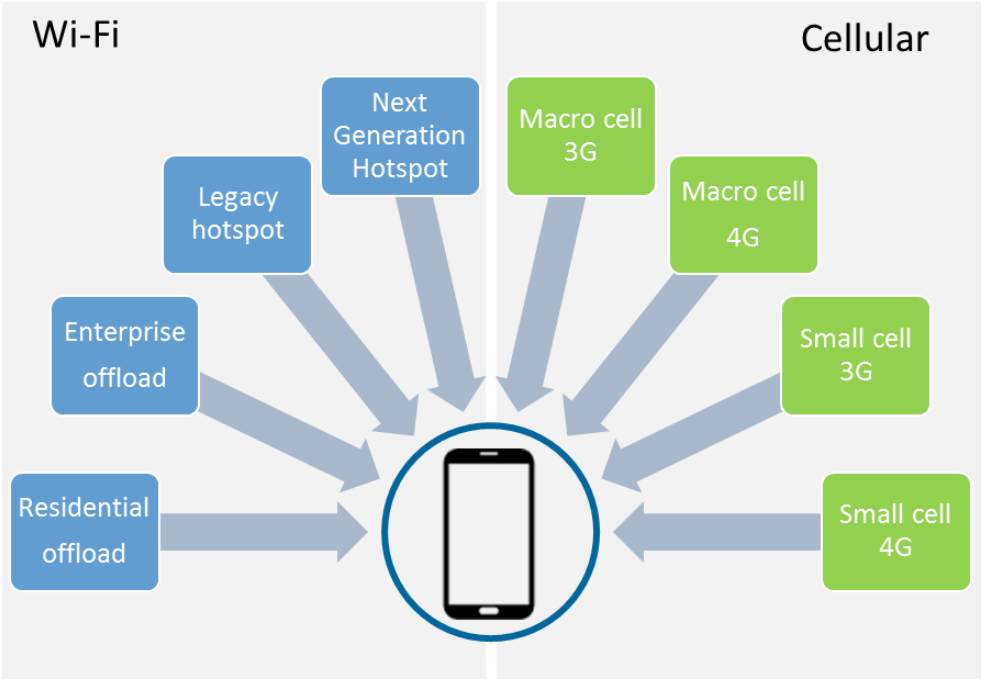
CONTENTS

1. Introduction.

Expanding Wi-Fi access from mobile devices

Mobile devices are changing the way we connect with others online, and how we access and share content. Over the last few years, wireline connectivity has been increasingly replaced by wireless connectivity, as we moved first from desktops to laptops, and then to smartphones and tablets. Today, for many of us wireless data access has become the primary way to be online, and to keep in touch with family, friends and colleagues.

The convergence of two wireless interfaces – cellular and Wi-Fi – has made possible this shift from wireline to wireless access. Cellular networks bring us reliable coverage and increasingly high data rates everywhere we live, work or travel. Wi-Fi complements cellular access with high data rates and lower costs in the places where we spend most of our time: home, work, and public spaces such as schools, stadiums and public transportation hubs. The coexistence of cellular and Wi-Fi has been crucial to the rapid adoption of mobile devices and our growing reliance on them.



As mobile devices become more powerful and usage models rapidly evolve, the technology and standards for Wi-Fi and cellular continue to develop as well, to keep up with rising traffic loads. With small cells, cellular networks are moving closer to the subscriber. At the same time, Wi-Fi is moving beyond private spaces (home and work), expanding its role in public spaces. Wi-Fi hotspots have provided public access in public places for a long time, but their impact will grow with the introduction of new features that will make access easier and more secure. Seamless access and security enables operators to treat Wi-Fi as another radio-access-network (RAN) interface that complements cellular networks, in turn allowing operators to roll out carrier Wi-Fi networks. We refer to this carrier-driven Wi-Fi as Next Generation Hotspot (NGH) Wi-Fi, to distinguish it from the Wi-Fi offload that takes place in homes and offices, and from legacy hotspots that do not support the new functionality.

In this paper, we examine the economic benefits NGH Wi-Fi brings to fixed and mobile operators that build their own Wi-Fi networks or use their partners' Wi -Fi infrastructure. Our total cost of ownership (TCO) and revenue model explores the impact of NGH Wi-Fi adoption on 3G and 4G networks. We define a range of scenarios in which traffic is transported by a combination of cellular and Wi-Fi networks, with operators relying in different proportions on Wi-Fi, small cells, and legacy (versus NGH) Wi-Fi. Finally, we present a forecast of global service revenues that are attributable to NGH Wi-Fi based on that analysis.

2. A new role for Wi-Fi in fixed and mobile public networks.

Why should operators care about NGH Wi-Fi?

More demanding capacity requirements. Our growing reliance on mobile devices results in heavier traffic loads on wireless networks. Improved performance of wireless networks further contributes to the growth in traffic, as subscribers use an increasing number of applications more extensively and more effectively. As the quality of video streaming improves, for instance, users are more likely to watch videos more frequently. As users move from 3G to 4G, the traffic they generate increases, because they can pack more activities – and traffic – into the same amount of time. As a result, traffic growth outstrips the increase in capacity afforded by improved spectrum efficiency from 4G, and new spectrum allocations.

A capacity boost from Wi-Fi. To meet demand, operators have to increase the density of their networks by installing new base stations. Because of cost, spectrum and interference management considerations, and the availability of real-estate locations, this approach often proves to be too expensive or insufficient. In outdoor areas with high-density demand and in difficult-to-reach indoor areas, Wi-Fi can give operators the capacity boost they need, either in a separate underlay network or alongside cellular small cells that include a Wi-Fi module within their enclosure.

Legacy and NGH Wi-Fi. Wi-Fi offers operators more than raw capacity: new functionality is available to improve the integration of Wi-Fi with fixed and mobile networks. The converging efforts of organizations such as the Wireless Broadband Alliance (WBA) and the Wi-Fi Alliance, as well as the 3GPP, the GSMA, IEEE and the Small Cell Forum, are transforming Wi-Fi into a full-fledged RAN technology that meets mobile operators' need to offer additional capacity within their footprint, and fixed operators' need to extend connectivity beyond wireline. As a result, many operators have decided to move beyond legacy hotspot Wi-Fi, which has been greatly successful but does

Next Generation Hotspot Wi-Fi: Features
Seamless SIM-based (cellular devices) and EAP-TTLS (devices without a SIM card) authentication.
Automatic network discovery and selection, with the ability to steer subscribers toward preferential Wi-Fi use.
Secure access to trusted networks.
Policy support for defining connection preferences – e.g., to decide which Wi-Fi network a device should associate with, when multiple ones are available.
NGH Wi-Fi: Benefits to operators
Increased traffic on Wi-Fi networks.
More visibility into subscriber experience.
Policy management and enforcement extended to Wi-Fi and, if desired, integrated with cellular policy control, enabling operators to leverage Wi-Fi access more extensively to relieve traffic load in cellular networks.
Wi-Fi as a radio-access technology that can be tightly integrated with the cellular RAN and core network, and jointly deployed in cellular small-cell networks.
Support for location-based services, such as navigation, mobile advertising, geofencing and B2B applications, especially at indoor locations where the GPS signal is not available or is less accurate than outdoors.

not maximize the potential of Wi-Fi. With features such as secure SIM-based authentication, and automatic network discovery and selection, as well as with the anticipated addition of online signup and policy control, operators can drive an increasing portion of their subscribers' traffic to Wi-Fi, thus increasing return on their investment.

Definitions of terms used in this paper	
NGH Wi-Fi	Wi-Fi networks using Wi-Fi CERTIFIED Passpoint equipment that provides support for authentication, security, automatic network access and selection, and policy. NGH functionality was designed to meet the specific requirements of network operators, so we consider it as a core component of carrier Wi-Fi. Operators may decide to integrate their Wi-Fi infrastructure more or less tightly into their existing fixed or mobile networks, but they can rely on multiple tools to do so.
Legacy hotspot Wi-Fi	The Wi-Fi technology that is prevalent today in public hotspots and that we expect to continue to be used in independent small hotspots (e.g., in coffee shops), and that typically uses a username-and-password authentication. In operator-managed networks, however, we expect a transition to NGH Wi-Fi in line with commitments expressed by many operators that already own or plan to deploy their own Wi-Fi infrastructure.
Wi-Fi offload	Wi-Fi traffic in mobile devices with cellular connectivity over networks that the operator does not directly operate. More specifically, we do not consider NGH Wi-Fi traffic to be offload, because we treat it as an integral part of network traffic.
Small cells	Compact base stations that create a RAN underlay to the macrocellular network for public access. We include both cellular transceivers and Wi-Fi APs in the definition of small cells, but exclude residential/enterprise femtocells and APs from it.
3G, 4G, Wi-Fi	In our TCO and revenue model, our cost and data-rate assumptions refer to 3GPP cellular technologies – i.e., UMTS/HSPA for 3G, and LTE for 4G. For Wi-Fi, we assume adoption of Wi-Fi n APs as a conservative assumption. Operators will move to LTE Advanced and Wi-Fi ac over the coming years, but we expect the relative improvement in performance to be comparable, hence our TCO results will continue to hold as networks are upgraded.
ARPU	In our analysis, we look at the overall average revenues per user (ARPU), without distinguishing between data and voice components. As data services become more prominent and VoLTE transforms voice in data applications, defining voice and data ARPU becomes increasingly difficult and, as it is currently done in the industry, it underestimates the revenue contribution of data services.

3. A TCO and revenue model for NGH Wi-Fi in mobile networks.

Quantifying the financial benefits of Wi-Fi

A cost-effective alternative? Wi-Fi can add capacity to congested mobile networks, but is it cost effective? If Wi-Fi access is cheaper than cellular access in the macro network, is it also cheaper when deployed alongside small cells? And does NGH Wi-Fi provide a cost benefit over legacy hotspot Wi-Fi?

A per-bit TCO and revenue model. The TCO and revenue models address these questions by looking at multiple scenarios, defined as variations over a base case, for a network that includes 3G, 4G and NGH Wi-Fi. The TCO model includes capex and opex over a period of five years.

Because our focus is on network capacity and the evaluation of different topologies, we computed both costs and revenues in per-bit terms. This approach gives us a common scale with which to compare the contribution of network interfaces that have different costs and performance features. For the same reason, our TCO includes only RAN costs, while marketing, customer support, management and core network costs are left out, because they are shared among different wireless interfaces. Our model also estimates the increase in revenues over the next five years, using as benchmarks the projected traffic growth calculated by Ericsson and Cisco, and revenue estimates from the GSMA.

Model goals. We designed the TCO and revenue model to show the impact of incremental NGH Wi-Fi adoption on network traffic, RAN costs, service revenues and profitability (defined as a ratio of revenue to RAN costs). NGH Wi-Fi benefits can be framed both as lowering the per-bit cost to accommodate the same traffic load, and as enabling operators to increase capacity (and hence the number of subscribers supported, or the traffic volume per subscriber). In the first case, the operator reduces its costs, while keeping revenues constant. In the second case, the operator sees no reduction in cost, but should expect increasing revenue.

Model assumptions

Mobile network components:

- 2G macro cell (2GM)
- 3G macro cell (3GM)
- 4G macro cell (4GM)
- 3G small cell (3GS)
- 4G small cell (4GS)
- NGH Wi-Fi

Base case:

ARPU: $22 per subscriber, per month

Subscribers: 10 million

Traffic per subscriber, per month: from 0.5 GB (3G only) to 1.25 GB (3G, 4G, Wi-Fi)

Wi-Fi traffic: ranges from 0% (3G only) to 20% (3G, 4G, Wi-Fi)

Sources: Senza Fili, Cisco, GSMA, Ericsson and mobile operators.

4. Costs and profitability by technology.
A comparison among 3G, 4G and NGH Wi-Fi

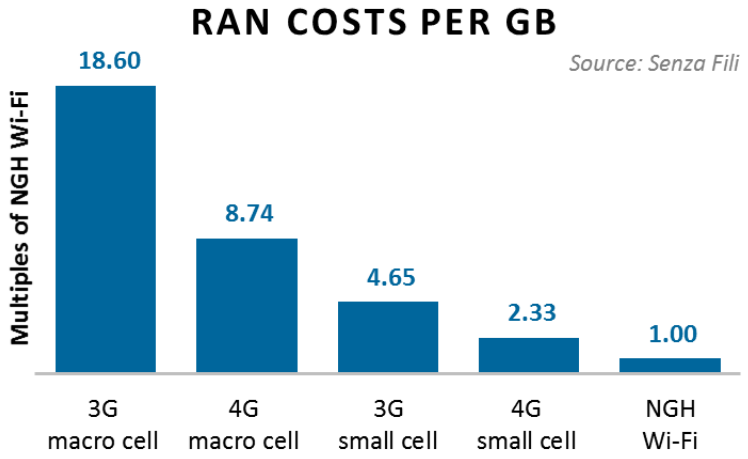
Analysis by technology. Before we looked at costs and revenues at the network level, we compared them for each technology separately. We computed the per-bit costs based on the cost of operating a single macro cell (assuming three sectors), small cell (one sector) or AP, and of the traffic transported.

Although we expect operators to combine Wi-Fi and cellular modules in their small cells, we assume that operators deploy Wi-Fi and cellular small-cell networks separately to allow a straightforward comparison across technologies. At the network level, the combination of Wi-Fi and cellular in small cells will generate additional cost savings over a topology with separate cellular and Wi-Fi small cells.

We also assume that network utilization is the same across technologies, although it may vary across operators depending on their deployment strategies, policy and incentives for subscribers to use one technology instead of another.

RAN costs. 3G macro cells are the most expensive way to transport traffic, because of their lower throughput, which is mostly ascribable to their narrow channel widths compared to 4G and Wi-Fi. On a per-bit basis, a 3G macro cell costs almost 19 times as much as a Wi-Fi AP. The cost of a 3G small cell is almost nine times that of Wi-Fi, and almost twice that of 4G macro cells.

4G is cheaper than 3G, but still more expensive than Wi-Fi. 4G macro cells cost 4.65 times what Wi-Fi APs cost to install and operate; 4G small cells cost 2.33 times Wi-Fi. The cost decrease as we move from 4G macro cells to NGH Wi-Fi is due to the overall lower costs of small cells when compared to macro cells, the higher throughput of NGH Wi-Fi (this lowers the per-bit costs), and the lower cost to install and operate Wi-Fi equipment compared to cellular.



Legend	
3GM	3G macro cell
3GS	3G small cell
4GM	4G macro cell
4GS	4G small cell
NGH Wi-Fi	Carrier Wi-Fi, excludes Wi-Fi offload to networks not controlled by operator

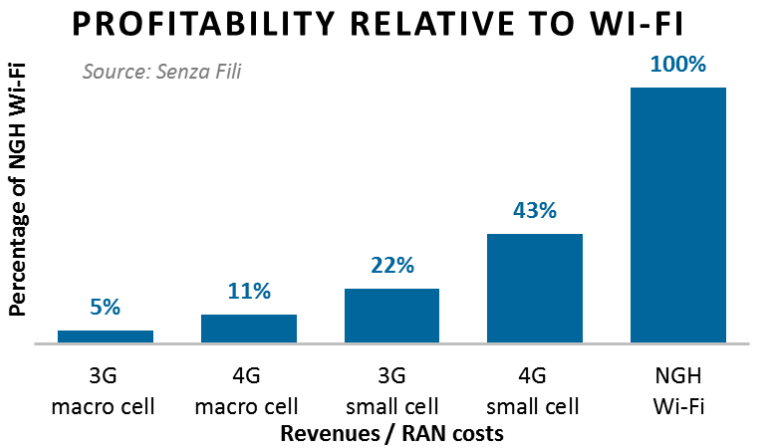
Revenues. Throughout the model, we allocate revenues according to the traffic split across technologies, treating all technologies equally. The monthly per-GB revenues are computed as ARPU divided by the GB of traffic for the average subscriber. As a result, we assume that one GB generates the same revenues for the operator whether carried by 3G, 4G or Wi-Fi. Allocating revenues independently of technology is based on the premise that operators charge the same amount regardless of the interface that subscribers use – subscribers value service availability and reliability, regardless of the technology used by their devices. In this perspective, we assume that operators will charge for NGH Wi-Fi traffic as they do for cellular traffic – or count NGH traffic toward subscribers' monthly quotas, as it provides the same value to subscribers. Even if an operator decides to offer Wi-Fi for free to encourage subscribers to use Wi-Fi to reduce the traffic load on the cellular network, revenues still have to be allocated to Wi-Fi, because Wi-Fi traffic frees resources in cellular networks that can be used to support new subscribers or provide a better service to existing subscribers.

Profitability. As a measure of profitability, we used the ratio of per-bit revenues over per-bit RAN costs for each technology and show the results as a percentage NGH Wi-Fi's profitability. The results mirror the RAN cost results: 4G small cells are 43% as profitable as NGH Wi-Fi; 4G macro cells 22%; 3G small cells 11%; 3G macro cells 5%. The profitability estimates shown in the graph assume equal revenue allocation across technologies.

Implications. Since NGH Wi-Fi provides substantial cost and profitability benefits, shouldn't operators move as much traffic as they can to Wi-Fi? The results of our analysis indicate that NGH Wi-Fi traffic costs the operator less, while providing subscribers the quality of experience they expect. As a result, adoption of NGH Wi-Fi and a push toward higher Wi-Fi usage in public networks can be financially advantageous to operators. The increased commitment from operators toward deploying their own Wi-Fi infrastructure in public areas reflects the expectation that Wi-Fi is more cost-effective than cellular for carrying traffic in high-density locations.

Beyond financials. However, financial considerations are only one element that operators weigh when deciding which technology to deploy where and when. Wi-Fi is not going to eliminate the need for cellular networks for coverage across footprint, nor will it provide most of the capacity needed, even in high-density locations. Although cellular networks are more expensive to install and operate, they will continue to have a central role. Across all scenarios in our model, we keep the percentage of overall network traffic carried by NGH Wi-Fi at or below 20%. In some markets, we might see higher percentages, but we expect Wi-Fi to capture an increasing percentage of data traffic only in high-density areas, where it makes financial sense.

Wi-Fi and cellular tradeoffs. In this perspective, the lower cost of Wi-Fi is made possible by the support of cellular networks, which provide fundamental connectivity. If Wi-Fi were deployed much more extensively, the cost savings would quickly dissipate, because network utilization would drop: Wi-Fi would provide more capacity than needed at the new locations covered, and hence the overall per-bit costs would go up. Operators' success in deploying NGH Wi-Fi crucially depends on finding the balance between cellular and Wi-Fi that works within their own footprint and subscriber base, and enables them to capitalize on Wi-Fi's cost efficiencies without diluting them.



5. How much Wi-Fi?

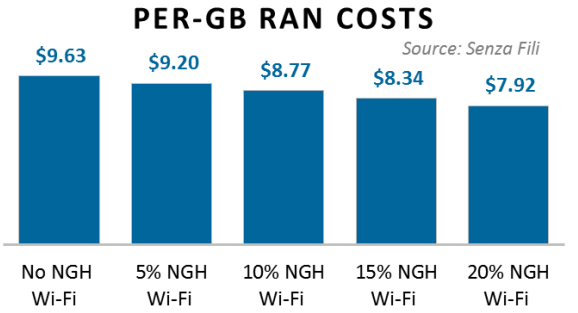
The network-wide impact of expanding the role of NGH Wi-Fi

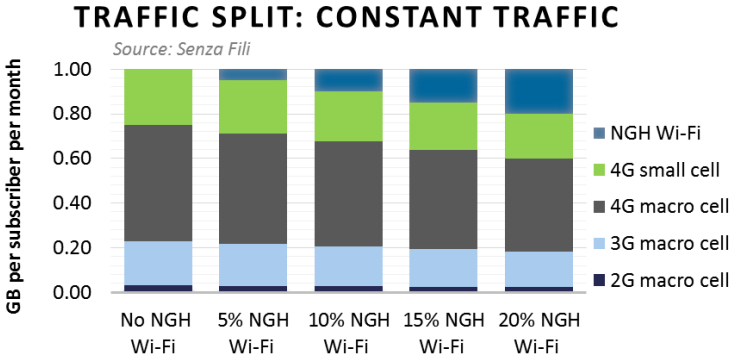
Network-wide Wi-Fi adoption. After looking at the cost and profitability analysis for each technology in the previous section, we now look at the financial impact of adding NGH Wi-Fi in our base-case network of 2G, 3G and 4G macro cells, and 4G small cells. We consider five scenarios defined by different percentages of overall traffic carried over NGH Wi-Fi, ranging from 0% to 20%. To accommodate those different Wi-Fi percentages, the traffic split across cellular technologies changes as well. Traffic over 4G (macro and small cells) ranges from 62% to 77%. Small-cell traffic ranges from 20% to 25%. We kept total traffic constant at 1 GB per subscriber per month for all scenarios (middle graph).

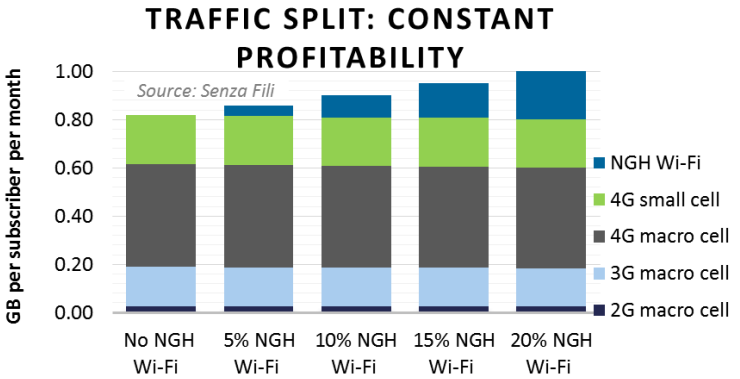
Per-GB RAN costs. As expected, the per-GB RAN costs (top graph) decrease as NGH Wi-Fi traffic increases. The per-GB cost is highest when NGH Wi-Fi is not used ($9.63) and lowest when NGH Wi-Fi carries 20% of the traffic ($7.92), an 18% cost difference. Correspondingly, profitability in the no-NGH Wi-Fi scenario is 82% of the 20% NGH Wi-Fi scenario.

Lower costs or higher per-subscriber traffic allowance? If we assume a constant subscriber traffic level (1 GB per subscriber per month in these scenarios), adoption of NGH Wi-Fi results in a lower TCO. However, we can interpret these results in an alternative way. The operator may decide to keep its level of investment constant and increase capacity as it adds NGH Wi-Fi, thus being able to support more subscribers or raise subscriber quotas for the existing subscribers (without increasing plan fees). In the bottom graph on the right, we show the results of this second approach.

We kept profitability constant across scenarios to match that of the 20% NGH Wi-Fi scenario, and computed how that limits monthly traffic per subscriber in the scenarios with lower Wi-Fi usage. When there is no NGH Wi-Fi, the average traffic per subscriber per month has to be no higher than 0.82 GB per month to retain the same profitability of the 20% NGH Wi-Fi scenario with 1 GB per month. This means that with the adoption of NGH Wi-Fi, the operator can provide an additional 22% of traffic to subscribers without seeing any impact on profitability.







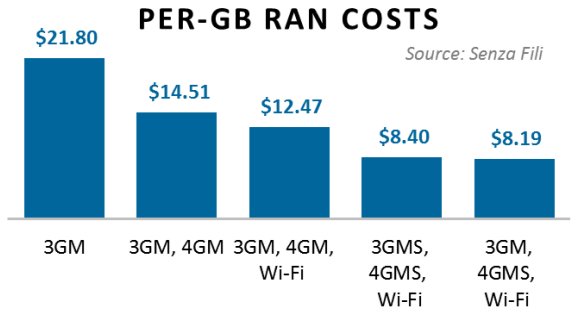
6. A complementary role for Wi-Fi, 3G and 4G small cells.

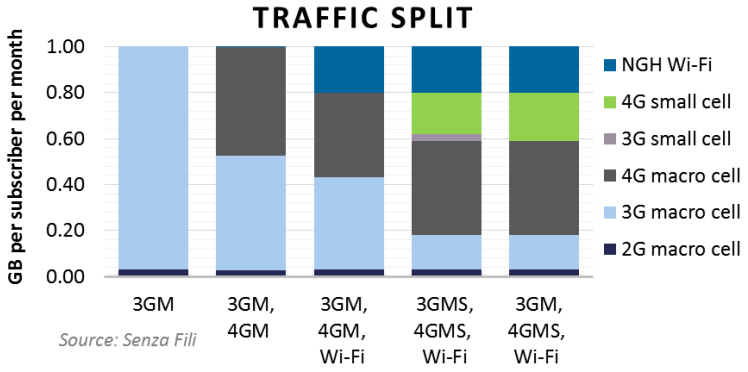
The incremental cost savings from adding cellular small cells

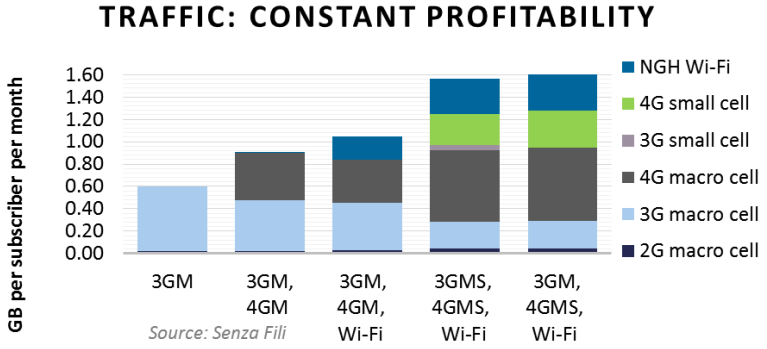
Adding small cells. In the previous section, we showed that increasing NGH Wi-Fi traffic reduces the per-GB RAN costs, allowing operators either to increase traffic allowances to subscribers without a negative impact on profitability, or to reduce the investment in new RAN infrastructure. Now we look at the impact that the combination of Wi-Fi and cellular small cells has on cost and profitability, when the two technologies are deployed within the same network footprint, but are not co-located. We look at five scenarios that all have macro cells: two without Wi-Fi or small cells (one with only 3G macro cells, one with 3G and 4G), one adding only Wi-Fi, and two adding Wi-Fi and small cells (4G in one of them, 4G and 3G in the other). In all scenarios, Wi-Fi captures 20% of traffic. Traffic over cellular small cells is set to be 21% of overall traffic in both small-cell scenarios.

Deeper cost savings with small cells. Because the per-bit RAN costs for small cells are lower than for macro cells, the deployment of small cells generates further cost savings on top of the savings from NGH Wi-Fi. For a 3G macro-cell network, the per-GB RAN costs are $21.80. In a network that also has Wi-Fi and 4G small cells, these costs are $8.19, or 38% of the 3G macro-cell network. If a mix of 3G and 4G macro and small cells and Wi-Fi is deployed, the per-GB RAN costs are slightly higher, $8.40, because the TCO for 3G small cells is higher than for 4G small cells.

Impact on traffic allowances. As in the previous section, we also looked at the implications for traffic allowances if we keep profitability constant. As we add both NGH Wi-Fi and small cells, subscriber traffic can grow from 0.60 GB to 1.60 GB while keeping profitability constant. This represents an increase in traffic of 167% as we move from 3G macro cells only to a network that also includes NGH Wi-Fi and 4G macro and small cells. If NGH Wi-Fi alone were added to the 3G network (not shown), the traffic quota could increase by 75% to 1.05 GB per subscriber per month.







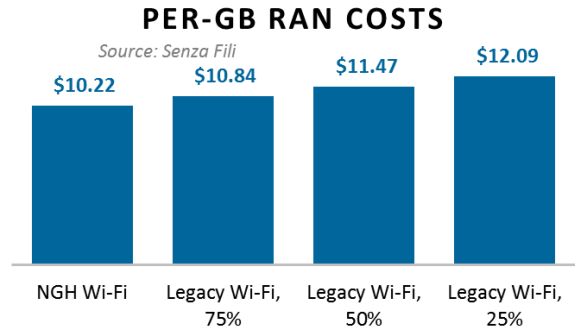
7. The benefits of NGH Wi-Fi over legacy Wi-Fi.

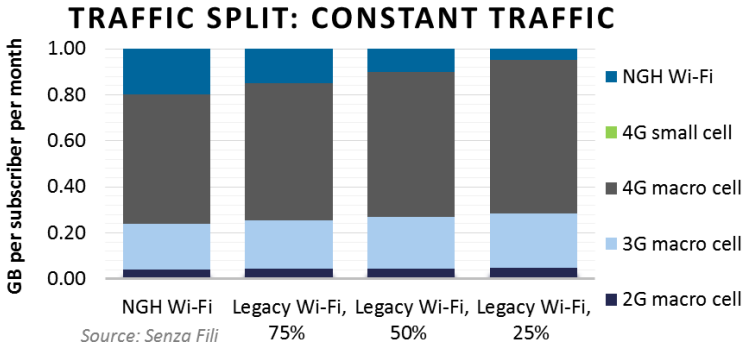
Leveraging NGH functionality to increase traffic over Wi-Fi

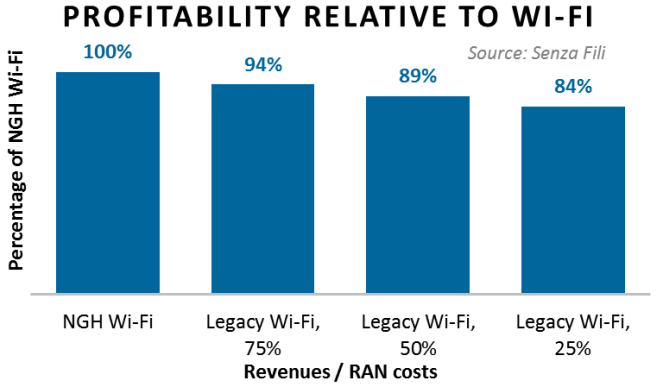
Impact of NGH on Wi-Fi traffic. This transition from legacy-hotspot Wi-Fi to NGH Wi-Fi entails additional costs and complexity in managing Wi-Fi infrastructure. Under what circumstances is this transition worth it from a financial perspective? We looked at this issue by comparing an NGH Wi-Fi scenario with three scenarios in which the legacy Wi-Fi network carries a fraction of the amount of traffic that we assigned to NGH Wi-Fi. These legacy scenarios lack the seamless network selection and authentication that drives higher levels of usage in NGH Wi-Fi, within the same infrastructure architecture and density (e.g., the same number and location of Wi-Fi APs).

Scenario assumptions. We assume that legacy Wi-Fi traffic will carry only 75%, 50% and 25%, respectively, of the 20% of network total assigned to the NGH Wi-Fi scenario. The estimated traffic reductions for the legacy scenarios are based on estimates from mobile operators that have evaluated the NGH and legacy options. For this analysis, we exclude small cells, assume that 3G macro cells carry 20% to 24% of overall traffic, and assume that 4G macro cells carry 56% to 77%. Wi-Fi traffic accounts for 20% in the NGH Wi-Fi scenario and decreases 5% in the legacy Wi-Fi 25% scenario. The per-subscriber traffic is constant across scenarios.

Per-bit RAN costs and profitability. The RAN TCO remains the same across NGH and legacy scenarios because the equipment costs are unchanged. The costs associated with the transition from legacy to NGH Wi-Fi are not captured by the per-bit RAN costs; they are incurred in the core network, and we do not expect them to have a major impact on the results presented here. In the NGH Wi-Fi scenario, per-GB RAN costs are $10.22. In the legacy Wi-Fi scenarios, the same number of Wi-Fi APs carries less traffic; hence the per-GB RAN costs grow to $12.09 in the legacy 25% scenario – an increase of 18%. As per-bit RAN costs increase, profitability goes down. In the legacy 25% scenario, profitability is 84% of that in the NGH Wi-Fi scenario.







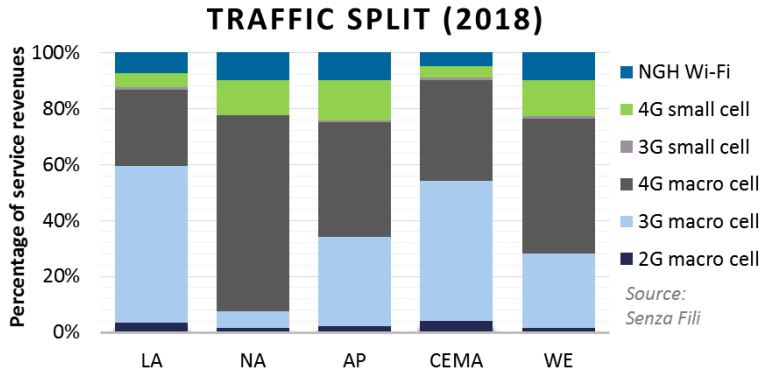
8. The global revenue potential for NGH Wi-Fi.

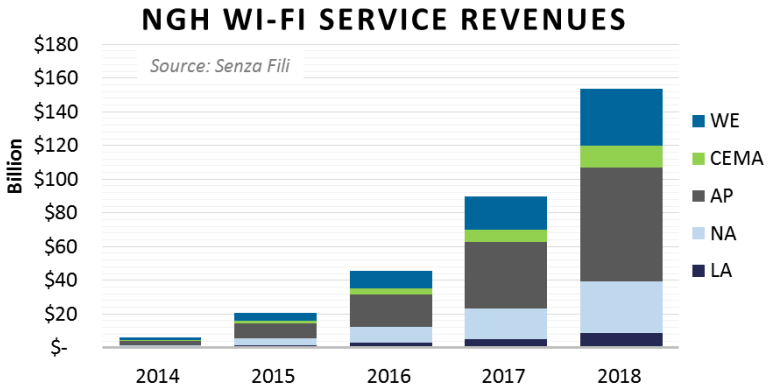
Allocating service revenues by wireless interface

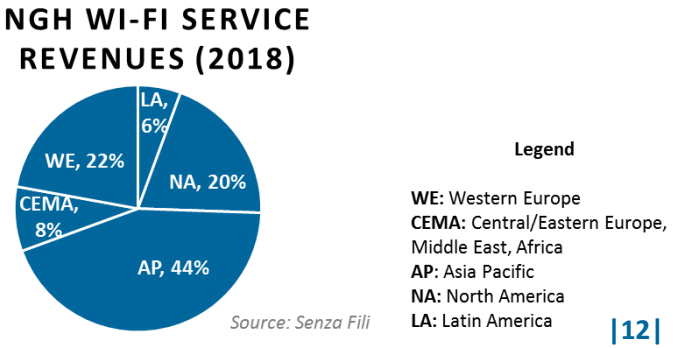
The global impact of NGH Wi-Fi. Based on analysis at the single network level presented in the previous pages, and on the commitment from operators, we can estimate the global service revenues of NGH Wi-Fi. In line with our previous approach, we estimated the percentage of mobile traffic that will be routed through NGH Wi-Fi and allocated to NGH Wi-Fi a corresponding percentage of service revenues (i.e., 1% of traffic translates into 1% of service revenues).

Traffic split. The graph at the top shows the percentage of mobile traffic by interface (3G, 4G, Wi-Fi) and cell type (macro cell, small cell, AP). We assume that by 2018 NGH Wi-Fi will carry from 5% to 10% of mobile traffic, depending on the region; this is a conservative forecast based on NGH early deployments to start in 2014. We expect higher adoption of NGH Wi-Fi in markets, such as North America, Asia Pacific and Western Europe, where higher per-subscriber traffic levels put more intense pressure on mobile operators to increase capacity.

Service revenues. Global service revenues allocated to NGH Wi-Fi grow from less than 1% of total service revenues in 2014 to 9%, or $150 billion, in 2018. With 44% of revenues, Asia Pacific has the largest share of service revenues in 2018, consistent with its overall market share and, relative to other regions, high adoption of NGH Wi-Fi.







9. Implications.

NGH Wi-Fi as a cost-effective way to add capacity in wireless networks

Wi-Fi is more than an access technology that subscribers like to use because of performance, availability and cost. With NGH, Wi-Fi gives operators an additional radio interface that complements their wireline or wireless infrastructure, adding capacity where they need it the most: high-density public areas and indoor locations.

Our analysis shows that, when deployed alongside wireline and cellular networks, NGH Wi-Fi has a lower per-bit TCO than 3G and 4G, both for macro cells and small cells, because Wi-Fi combines lower per-site costs with higher bandwidth.

Operators' rapidly growing interest in building out and managing their own Wi-Fi infrastructure, coupled with the cost efficiency of Wi-Fi, will generate growth in mobile traffic routed through Wi-Fi. In turn, this will expand operator revenues from NGH Wi-Fi, and increase the available capacity of cellular networks to support new services and more subscribers.

Acronyms

2G	Second generation
2GM	2G macro cell
3G	Third generation
3GM	3G macro cell
3GMS	3G macro and small cells
3GPP	3rd Generation Partnership Project
3GS	3G small cell
4G	Fourth generation
4GM	4G macro cell
4GMS	4G macro and small cells
4GS	4G small cell
AP	Access point
ARPU	Average revenue per user
B2B	Business to business
EAP	Extensible Authentication Protocol
EAP-TTLS	EAP–Tunneled Transport Layer Security
GPS	Global Positioning System
GSM	Global System for Mobile Communications
GSMA	GSM Association
HSPA	High Speed Packet Access
IEEE	Institute of Electrical and Electronics Engineers
LTE	Long Term Evolution
NGH	Next Generation Hotspot
RAN	Radio access network
SIM	Subscriber Identity Module
TCO	Total cost of ownership
UMTS	Universal Mobile Telecommunications Service
VoLTE	Voice over LTE
WBA	Wireless Broadband Alliance

About the Wireless Broadband Alliance

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, Google and Intel. WBA member operators collectively serve more than 1 billion subscribers and operate more than 5 million hotspots globally. The WBA Board includes Arqiva, AT&T, Boingo Wireless, BT, China Mobile, Cisco Systems, Intel Corporation, iPass, KT Corporation, NTT DOCOMO and Orange.

About Senza Fili

Senza Fili provides advisory support on wireless data technologies and services. At Senza Fili we have in-depth expertise in financial modelling, market forecasts and research, white paper preparation, business plan support, RFP preparation and management, due diligence, and training. Our client base is international and spans the entire value chain: clients include wireline, fixed wireless, and mobile operators, enterprises and other vertical players, vendors, system integrators, investors, regulators, and industry associations. We provide a bridge between technologies and services, helping our clients assess established and emerging technologies, leverage these technologies to support new or existing services, and build solid, profitable business models. Independent advice, a strong quantitative orientation, and an international perspective are the hallmarks of our work. For additional information, visit www.senzafiliconsulting.com or contact us at info@senzafiliconsulting.com or +1 425 657 4991.

About the author

Monica Paolini, PhD, is the founder and president of Senza Fili. She is an expert in wireless technologies and has helped clients worldwide to understand technology and customer requirements, evaluate business plan opportunities, market their services and products, and estimate the market size and revenue opportunity of new and established wireless technologies. She has frequently been invited to give presentations at conferences and has written several reports and articles on wireless broadband technologies. She has a PhD in cognitive science from the University of California, San Diego (US), an MBA from the University of Oxford (UK), and a BA/MA in philosophy from the University of Bologna (Italy). She can be contacted at monica.paolini@senzafiliconsulting.com.