5G and Wi-Fi co-deployment

Indoor networking solutions for small and medium enterprises and residences

White paper
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Introduction

5G, the latest generation of mobile cellular technology, and Wi-Fi 6, the latest evolution of Wi-Fi have arrived independently in the market at around the same time. While both promise improvements in data rates and bring significant other benefits, their adoption and use by consumers will depend on factors such as security, end user needs, the appetite for new technology, and the relative performance of existing Wi-Fi and cellular networks.

This white paper examines some of the emerging market trends that encourage Wi-Fi and cellular network co-existence to generate greater value. It looks at how Communication Service Providers (CSPs) can make the best use of both of these technologies. The paper explores the benefits of changing business strategies and offering a wider product mix to increase network monetization. Given increasing worldwide security concerns, the paper also addresses the impact of providing 'trustable', robust network security.

Today, consumers often use up to six network-connected devices at a time. Some devices, such as mobile phones and laptops, provide mobility advantages while others such as Smart TVs, gaming stations, and security surveillance cameras are fixed devices. Given this ecosystem, the average consumer would prefer simple connectivity solutions. CSP solutions should enable them to continue with their activities, without requiring them to think about wireless network challenges, the technicalities of technology used, or the security setup. Using the CSP's key asset of licensed spectrum efficiently together with the unlicensed spectrum can improve the user experience by reducing radio congestion and interference.

### Indoor wireless networks enable digital ecosystems and services

- Wi-Fi and mobile technologies have co-existed and will continue to co-exist with the latest evolution
- Reliable and assured indoor networks and the next wave of digitization lead to new use-cases
- End-to-end control of radio spectrum quality creates data highways for intensive applications
- Futureproof technologies can be co-deployed according to individual market needs and segments

### Comparison of technologies

**5G and Wi-Fi 6**

The following summarizes the key differences between 5G and Wi-Fi 6 as outlined in the Nokia Bell Labs research paper [1].

- 5G offers ultra-reliability of 99.999% today, while Wi-Fi 6 is in the early stages of incorporating reliability (L4S) standards
- 5G offers customizable Quality of Service through dedicated spectrum, while Wi-Fi/Wi-Fi6 continues to be a best-effort-based technology
- 5G can be deployed across both licensed and unlicensed (NR-U) spectrum to make effective use of spectrum assets - Wi-Fi 6 remains purely in the unlicensed spectrum
- 5G delivers interference-free communication - Wi-Fi 6 employs ways to overcome interference but without any guarantees of interference-free operation
• 5G and Wi-Fi employ different technologies (RRC/Target wake-up time) to achieve efficient use of batteries and save energy

• 5G is universally secure and doesn’t require the users to understand security configuration. It offers built-in security, protecting the integrity of the user plane. Wi-Fi 6 is an inherently open network that does not offer in-built security. It also expects users to configure security and relies on encryption (WPA3) and VPN protocols implemented by the user to ensure secure communications

There are also important similarities, namely an increase in the supported data speeds, improvements in spectral efficiency with the adoption of mobile-based technologies such as OFDMA and MU-MIMO techniques, and the support for latencies of less than 1ms under test conditions.

**Wi-Fi and Wi-Fi 6**

Wi-Fi 6 is expected to bring significant improvements over the existing Wi-Fi standards. Research by Nokia Bell Labs [1] and independent research commissioned by Cisco [2] compared the two standards and made the following observations.

• Wi-Fi 6 improves network quality in dense urban areas with a large number of access points by using higher bit rate 1024 QAM technology

• When there are a low number of devices connected to an access point, earlier Wi-Fi standards offer superior performance to Wi-Fi 6. This means that not all consumers benefit from switching to Wi-Fi 6

• Wi-Fi 6 trades a small decrease in speed to offer sustained performance with an increasing number of devices. Earlier Wi-Fi standards struggle to scale

• Wi-Fi 6 offers better upload performance with the OFDMA modulation, however, download performance is hampered as OFDMA isn’t robust enough for downlink and struggles to cope

• Wi-Fi 6 and Wi-Fi struggle to achieve high reliability, affecting applications such as augmented reality, surveillance cameras, automation control as well as other industry 4.0 use cases

Based on these observations, the application of Wi-Fi 6 may not always be the most appropriate solution. A dual-technology product offering with 5G/LTE and Wi-Fi increases the market a CSP can serve. This would help them offer optimal solutions tailored to specific use cases, user limitations, cost limitations, and geopolitical aspects.
The product mix

A lack of reliable mobile coverage indoors can hamper the user experience and lead to a poor perception of the brand. Residences and small-medium enterprises need easy, cost-effective solutions that can reuse existing infrastructure to provide secure networks. Several solutions such as small cells, femtocells, Wi-Fi, Wi-Fi 6 and Wi-Fi 6e address this market need. However, there is no ‘one size fits all’ solution.

This paper focuses on the use of femtocells such as Nokia’s recently launched Smart Node to supplement the indoor Wi-Fi network with reliable 5G/LTE networks. While Wi-Fi capability is widely available, it does not always produce a better user experience. Reliable 5G/LTE indoor network coverage gets around these Wi-Fi challenges and helps pave the way for immersive consumer experiences.

The following four broad indoor deployment options are available to CSPs, each with its own merits and use cases.

**Femtocell only deployments**

The adoption of technology is growing at an unprecedented rate. Connecting the next wave of people requires ease of technology use, reducing hurdles of technical know-how, and the optimization of infrastructure setup costs for better monetization of investments.

The most common hurdle in building a viable business case for rolling out macro networks to remote or rural areas is the low density of consumers and challenges in setting up power, backhaul, and other requirements. These are projects which often require substantial subsidies to set up the infrastructure. This large but scattered market segment relies primarily on mobile devices and has a limited ability to invest in Wi-Fi or the know-how to enable important security features.

As CSPs and e-commerce technologies look to connect this market segment, innovations such as the Nokia Smart Node, which offer easy ‘plug and play’ base-stations, can provide viable business solutions. These low-cost devices are easy to deploy. They reuse existing ISP backhaul and domestic power supply reducing operational overheads. They can be valuable products to extend the benefits of mobile technology to these underserved markets.

Some of the key additional advantages include:

- Femtocells are a viable solution for connecting rural communities. This gives access to data to allow activities such as information sharing based on location as well as support for the emerging Agri-Tech industry
- Enables emergency service and secure connectivity for all mobile users, particularly important when handling disasters and coordinating relief activities
- NB-IoT features can provide smart metering and other IoT solutions. These can help improve the operational efficiencies of utility companies significantly and enable tracking of goods for e-commerce

**Wi-Fi 6 stand-alone deployment**

Medium to large enterprises are increasingly providing Wi-Fi-based access for indoor connectivity and ensuring mobility within their premises or office spaces. These access points typically have many device connections that continue to grow in number. Upgrading to Wi-Fi 6 offers substantial benefits in such networks as it leads to immediate gains as well as the ability to scale up performance over time. The independent research by Cisco [2] highlights this point, with the high gains of Wi-Fi 6 in a dense network compared to a lightly loaded network.
Some of the most significant Wi-Fi 6 features that benefit such large enterprises are:

• Better performance from dense Wi-Fi networks by spatial reuse through color code technology. This allows neighboring access points to differentiate transmissions from each other, reducing interference and improving the sharing of channel capacity

• Increased channel capacity by adopting Multi-User MIMO (MU-MIMO) technology from cellular networks. This helps serve multiple simultaneous devices and improves traffic performance in Wi-Fi 6 networks

• Enhanced performance for data uploads by adopting the OFDMA modulation technique from cellular networks

• A case can be made for offloading mobile device traffic to LTE/5G access. Ultra-large and large enterprises should find small cell solutions cost-effective in such scenarios; femtocells may not always be the best answer for these companies

**Femtocells co-deployment with existing Wi-Fi**

Wi-Fi is already widely used in homes and in small and medium enterprises. Swapping existing Wi-Fi routers for Wi-Fi 6 routers incurs setup costs and customers may be put off upgrading until they can see a benefit that justifies these costs. The cost of upgrading to new Wi-Fi 6 CPE is comparable to that of deploying a femtocell for 4G/5G coverage, making the co-deployment of a femtocell beneficial for both the consumer and the CSP.

The more familiar small enterprises, such as essential service providers and retailers, primary health centers such as clinics, delivery endpoints of e-commerce and logistics, and restaurants show commonalities between them. Today's businesses and their clients are increasingly integrated to the internet through mobile devices which generate the majority of indoor traffic.

Wi-Fi is cumbersome and often restricted to providing connectivity to clients and employees who aren’t ‘console bound’. A co-deployed femtocell would reduce operational overheads such as password sharing, security systems setup, network separation and so on i.e. that requires technical understanding. Further, co-deployment provides seamless network connectivity to clients on their mobile network and improves brand perception of the CSP. Some key advantages of such a co-deployed solution are:

• Hassle-free network access for clients and the mobile workforce, as it eliminates secure access setup and individual authentication overheads. The enterprises also benefit by reducing the costs involved in setting up their own security controls

• Not all users use VPN or other security safeguards for their network traffic. Wi-Fi systems are prone to snooping which can lead to security lapses. Femtocells offer built-in carrier-grade security for all

• Businesses can be confident about data security in their network communications. Femtocells provide end-to-end security for all users through security features such as IP-Sec tunnels and strong encryption

• Consumers experience seamless mobility on the carrier network through smooth handovers. The user’s time can be spent engaging with the enterprise and its offers rather than on login and authentication

• Reduced traffic on Wi-Fi networks improves Wi-Fi performance

• Femtocells effectively migrate macro traffic to indoor mobile network access points. This reduces macro traffic load and can also reduce the effort for error correction especially in poor coverage or noisy signals spots commonly experienced indoors

• Femtocell local break-out feature reduces data traffic load on the CSP’s core network. This helps reduce operating expenses and improves overall profitability
Co-deploying LTE/5G femtocells with Wi-Fi supplements best-effort networks with predictable performance and global seamless authentication when compared to Wi-Fi standalone deployments. This also allows these enterprises to use digital indoor services for e-commerce, starting with digital wallets and payment systems to AR/VR and IoT.

**Femtocell co-deployment with Wi-Fi 6**

Traditional building construction materials tend to interfere and attenuate indoor network coverage. This is expected to significantly impact network performance in the 5G NR and Wi-Fi 6e spectrum. 5G ‘early adopters’ and VIP consumers will pay a premium for high-quality connectivity. In many cases, it is in the CSP’s interest to ensure indoor coverage gaps are minimized for these VIP and enterprise consumers. A Wi-Fi/Wi-Fi 6 system carries inherent overheads for security, hindering mobility and handovers. This can affect the experience of seamless mobile connectivity especially between indoor Wi-Fi and outdoor macro networks. In addition, guests and enterprise clients would need network access credentials to connect to Wi-Fi and may prefer to rely on mobile networks instead. Poor indoor mobile networks hamper the overall experience and can damage a CSP's brand value.

Some important benefits of a co-located femtocell are:

- Secure network with minimum overheads for the user
- Seamless call handovers between indoor and outdoor networks
- Emergency service support to manage risk and disaster mitigation
- Simple secure network connectivity for visitors and guests

These niche market segments must be managed effectively. A co-located 5G/LTE network delivers reliable, best-in-class quality of service.

These four deployment combinations highlight that there is no single combination that works across all various market segments served by CSPs. The classic notion of Wi-Fi as a competitor to mobile networks should be set aside. CSPs who adopt a combination strategy and educate their end-users on its benefits can maximize the value to their customers and better monetize their investments. Repositioning Wi-Fi and mobile networks as complementary indoor technologies improves the customer experience and places them on the path to 5G immersive experiences.

Co-deployment addresses multiple market segments better than stand-alone deployment solutions. It creates opportunities for application evolution that build on reliable, high quality indoor networks.
Emerging market trends

This paper has so far outlined the various deployment options and their applicability to existing use cases. The following section explores new trends that indicate developments in the market that cannot be addressed by a Wi-Fi-only indoor strategy. It highlights the need for CSPs to include small cells and femtocells in their network deployment strategy.

Remote workers and evolving devices

Many people are adopting remote working for a number of reasons. Many businesses, such as remote luxury homestays and resorts, offer guests safe workspaces with traditional Wi-Fi. However, given the security risks associated with third-party Wi-Fi, many users prefer 3GPP-based mobile access for its superior end-to-end security. In keeping with this trend, many devices such as laptops and tablets come with an integrated eSIM/SIM facility. These consumers are prepared to pay for robust mobile network coverage at these remote working locations. The low cost of femtocells makes them a perfect solution for such use cases and helps increase the pool of high revenue customer base for the CSPs.

Stringent network security requirements

Although increasing numbers of people are adopting smart mobile devices, many users may not be aware of security configurations or the need for security. Wi-Fi networks are inherently open, and their security configurations are separately implemented by the end-user or by someone on their behalf. Furthermore, consumers and corporations are increasingly averse to using public or shared Wi-Fi networks because of the risks of security breaches and hacking.

Governments across the world are increasingly focused on effective policies for network security and implementing legal frameworks to protect their citizens. Indoor femtocells offer robust carrier-grade security for every mobile network user. Mini base stations such as the Nokia Smart Node offer easy deployment that utilizes existing backhaul infrastructure. This ensures robust security without the overheads of dedicated backhaul or user knowledge on VPN setup.

The network security requirements and capabilities of users vary and hence both technologies can co-exist to cater to these different needs.

Traffic segregation based on usability

Enterprises such as high touch services offer digitized services such as e-wallets, online menus, AR/VR experiences, and so on. Using Wi-Fi for the enterprise’s back-end needs and integrating a femtocell to support guests on mobile networks provides balanced segregation of traffic based on need. Femtocells use SIM-based authentication with minimal interaction, giving clients seamless mobility. Femtocell-based network infrastructure can support digital services such as payment, social media engagement, and digital experiences such as AR/VR on premises. The ease of deployment and use makes them the right solution to address the needs of small to medium enterprises. Robust traceability with SIM-based authentication mechanisms protects enterprises from unlawful usage of their networks.

Reserving Wi-Fi networks for secure back-office connectivity helps separate the enterprise traffic. This ensures network bandwidth on the Wi-Fi network is available for the office staff. It further prevents customers from clogging all available bandwidth to meet the needs of their data-intensive applications. This optimized setup reduces the load on the Wi-Fi network and provides an enhanced network experience for employees using enterprise applications. Traffic segregation helps cater to different use cases with the appropriate technology.
Indoor networks

The demand for indoor fixed-line internet speeds is expected to grow, driven by new immersive applications. The backhaul capacity is a key differentiating element among internet service providers’ offerings. However, traditional Wi-Fi-based Customer Premises Equipment (CPE) becomes a significant bottleneck and damages user perception of the CSP, particularly among the majority of consumers who don’t understand the limitations of radio networks.

Co-deploying 5G/LTE femtocells and Wi-Fi can employ unlicensed and licensed spectrum to use the backhaul effectively and improve overall performance. This creates a favorable ecosystem that benefits customers, the internet service provider, the CSP, and application/service providers. While backhaul infrastructure provides high-speed connectivity to both Wi-Fi and 5G/LTE, consumers can use network connectivity across a variety of devices and radio technologies for both human interaction and machine-to-machine services.

Conclusion

Co-deployment of technologies is a balanced approach to address various segments

Consumers who preference ultra-reliable and robust networks can be seen as premium users valuing access to licensed spectrum indoors and being willing to pay for quality. CSPs are looking to effectively capture and address multiple market segments in their wide consumer base, requiring a mix of technologies to cater to different needs.

Service providers create ecosystems for future applications; co-deployment offers key features

Integrating Wi-Fi and mobile technologies, CSPs can increase the range of services offered to their customers. This leads to upselling opportunities that improve revenue and profitability. Positioning the technologies as complementary solutions leads to effective use of existing ecosystems and development of new tailored applications that ultimately increase overall value. The market is evolving towards supporting a multi-access indoor network that CSPs should capitalize on and use to drive future business growth.

Figure 1. Femtocell mobile access complementary to Wi-Fi
References
1. 5G vs Wi-Fi (802.11ax) Simulations for Industry Environment, Nokia Bell Labs
2. Wi-Fi 6: The Next Generation of Wireless, Cisco

Abbreviations
CPE Customer Premise Equipment
eSIM Embedded Subscriber Identity Module
IoT internet of Things
LTE Long Term Evolution
MIMO Multiple Input Multiple Output
MU-MIMO Multi-user Multiple Input Multiple Output
NR New Radio = 5G
NR-U New Radio – Unlicensed
OFDMA Orthogonal Frequency Division Multiple Access
QAM Quadrature Amplitude Modulation
RRC Radio Resource Control
SIM Subscriber Identity Module
UE User Equipment
URLLC Ultra-Reliable Low Latency Communication
VPN Virtual Private Network
WPA3 Wi-Fi Protected Access 3

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