INDOOR COVERAGE SOLUTION

FOR 5G NETWORK

CHALLENGES TO MEET 5G REQUIREMENTS

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A Comba Telecom White Paper

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EXECUTIVE SUMMARY

While people are still employing the LTE networks, global mobile network operators and industry partners have already kicked off the fifth generation (5G) of mobile network technology, engaging equipment vendor to conduct POC and trials of some new techniques such as massive MIMO. A couple of lab test results show that the achievable speed of 5G networks is well above the preliminary target - 10Gbps. As such, 5G networks are expected to widely support a range of new applications and services for business transformation, revenue generation and so on.

On the other hand, data-hungry applications, as well as the games utilizing Augmented Reality (AR) and Artificial Intelligence (AI) technologies become popular in the mobile applications market. As a result, Indoor mobile networks will increase in demand. In addition, Internet of things (IoT) applications also introduce numbers of related devices such as sensors and actuators which contribute to internet connections. According to some statistics, 80% of the data traffic is used indoor. upgrades on indoor coverage and capacity are inevitably required to achieve the expected IoT and 5G data traffic. Has current solutions or infrastructures such as distributed antenna system (DAS) ready to receive this challenge?

This white paper will give an overview of 5G technology and discuss the challenges and opportunities arising from indoor 5G coverage.

WHAT IS 5G

The aim of 5G development is to enhance users' experience with ubiquitous connectivity for mobile devices and applications. In the creation of forward and backward compatible networks, 5G solution will not comprise of only one specific radio-access technology. Rather, 5G will be a portfolio of connectivity solutions and interoperable with existing 3G and LTE networks. The solution is designed to address three fundamental requirements: (1) mMTC (massive Machine type communication), (2) URLLC (Ultra reliable and low latency communications) and (3) eMBB (enhanced mobile broadband). No matter in latency, throughput and spectral efficiency, all of these will need to meet the minimum technical performance requirement. Details will be discussed in the following parts.

It is expected that large scale commercial 5G network deployment is not going to happen until year 2022. During this period, the LTE networks will continue to evolve and occupy majority of spectrum (below 3GHz band) until the right time to trigger the migration to 5G networks. The spectrum for a new system roll out has always been the major concern particularly to mobile operators and regulators as they have to coordinate with various parties to free up the identified spectrum to achieve large economies of scale.

From technical perspective, Standard Body has shortlisted the key components of a 5G network when finalizing the specification. These components are air interface flexibility, Massive MIMO, Integrated Access and Backhaul, and Virtualization. With the success on existing MIMO technique for LTE networks, massive MIMO will be the key to achieve the target user throughput and cell capacity performance among these key components.

Technical Performance Requirement

To support diverse services and deployment scenarios, 5G networks should be flexible and scalable to meet the technical performance requirements as summarized in Table 1 under stipulated scenario.

Metric	Requirement
Peak data rate	DL: 20Gbps UL: 10Gbps
Peak Spectral Efficiency	DL: 30bps/Hz UL: 15bps/Hz
User Experienced Data Rate	DL: 100Mbps UL: 50Mbps
User Plane Latency	eMBB: 4ms URLLC: 1ms
Control Plane Latency	20ms
Connection Density	1 M devices per km^2
Bandwidth	>100MHz

Table 1 5G Technical requirement from itu-R report

For instance, 5G networks may only be required to support data rates exceeding 10Gbps on indoor downlink and dense outdoor environment. For rural areas, 10Mbps should be generally available. In view of massive devices connections, the connection density of 1 million devices per square kilometers is proposed as the minimum requirement.

Compared with 3G or LTE networks, the performance of 5G networks is expected to be significantly more promising and capable to realize vast applications in the future. Comparing peak user throughput on downlink as shown in Figure 1, 5G networks target will be 20 times of the latest LTE-A or Gigabit LTE networks.

Ultimately, all of the requirements should serve as a guideline to meet the objectives of 5G networks beyond year 2020.

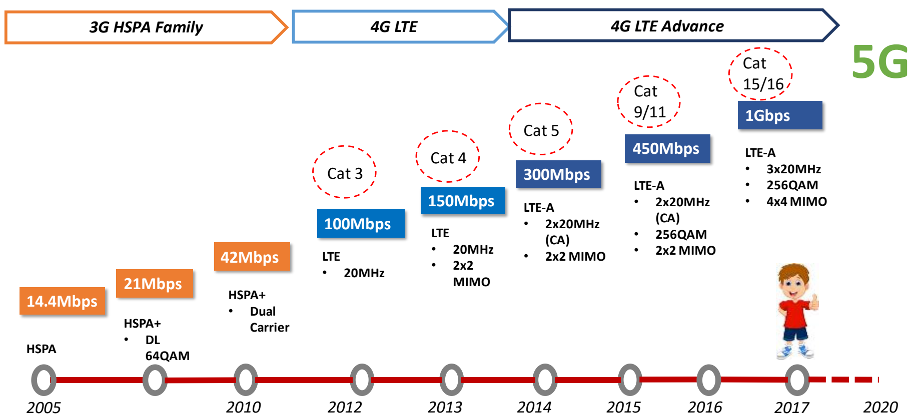

FIGURE 1 MOBILE NETWORK EVOLUTION TOWARDS 5G

Spectrum for 5G

Since the advent of smart phone, mobile data traffic has been growing tremendously, and is moving up at a rate of 66% CAGR from 2012 to 2017 as in Figure 2. Mobile operators have been expanding their networks capacity continuously by tapping into more spectrums for cellular networks.

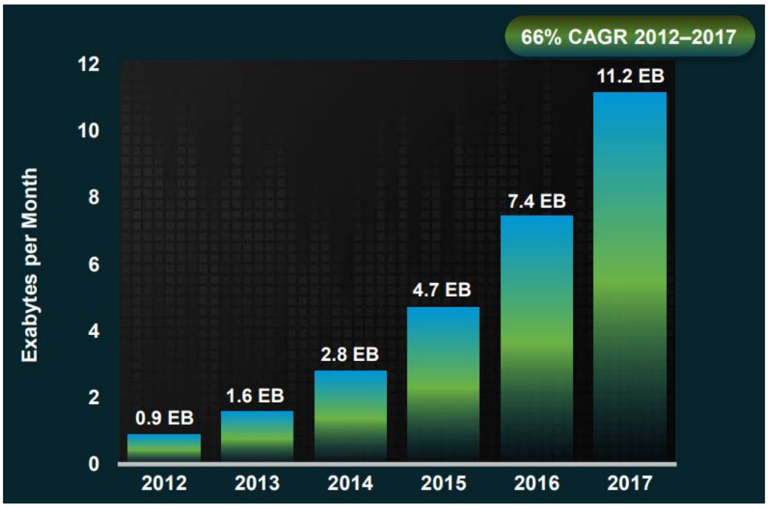

FIGURE 2 MOBILE NETWORK DATA TRAFFIC GROWTH (*SOURCE: CISCO VNI GLOBAL MOBILE DATA TRAFFIC FORECAST, 2012–2017*)

Typically, countries in Asia or Europe shall see a similar deployment as shown in Figure 3. Most of the spectrums below 3000MHz have been occupied by either 3G or LTE networks. In order to further enhance the networks capability by applying carrier-aggregation (CA) technique, spectrums around 700MHz and 800MHz are the next considering spectrums for LTE networks deployment. North America and Europe are the leading regions actively commercialise 700MHz and 800MHz spectrums deployment respectively.

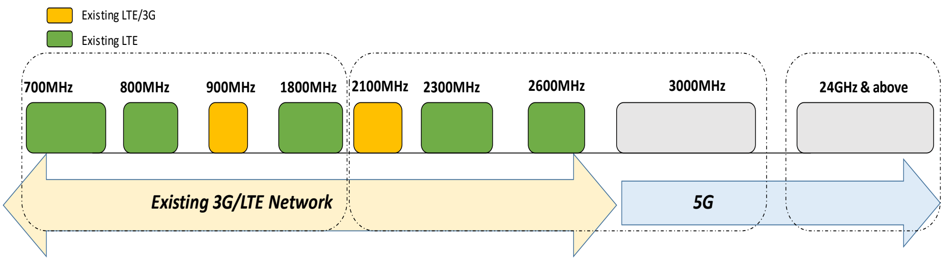

FIGURE 3 *TYPICAL SPECTRUM DEPLOYMENT IN ASIA/EUROPE COUNTRIES*

To enable the applications which require high data rates, 5G will have to extend frequency range. These include spectrum in 3.5GHz or 6GHz with the range above 24GHz or milli-meter wave band. Yet, though 3GPP has not identified a specific band for 5G, the industry is widely recognised that initial 5G roll out will most likely take up the spectrum in the range of 3.5GHz or 6GHz and followed by milli-meter wave band later on. Milli-meter wave band is a promising band of spectrum whereby wide bandwidth is available. However, 5G signal carried on high frequencies will incur higher pathloss and also present different propagation characteristics. Hence, a lot of researches have been started to evaluate the feasibility of 5G deployment in real situations. Nevertheless, high frequency bands can only serve as a complement to lower frequency bands and will mainly provide additional system capacity as and when require. It is strongly believed that lower bands will still remain the backbone for mobile-communication networks in the 5G era, providing ubiquitous wide-area connectivity.

Key 5G Technology Components – Massive MIMO

According to Shannon's law, cell capacity is determined by three factors: MIMO order, Spectrum Bandwidth and the Coverage Signal to Noise Ratio (SINR). The real gain benefits from MIMO has been verified in existing 4G networks. Both peak user throughput and cell capacity have significantly improved by MIMO.

Moving one step further, larger order MIMO will be incorporated with advanced 3D beamforming in 5G networks, to further improve both capacity and coverage. From cell coverage perspective, large pathloss introduced by high frequency band likes milli-meter wave could be partially compensated by the large antenna array gain together with 3D beamforming. Considering the upgrade from 4T4R MIMO to 64T64R MIMO, LTE cell peak and average throughput could potentially increase by 6.4 times and 3.4 times respectively as shown in Figure 4.

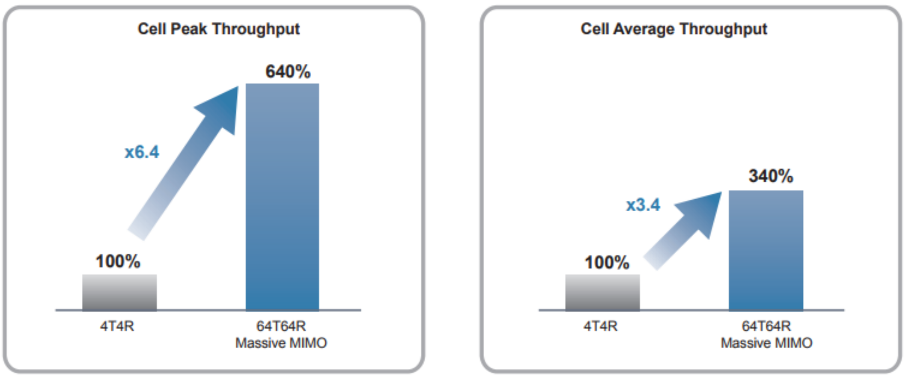

FIGURE 4 MIMO PERFORMANCE OF 4T4R AND 64T64R (*SOURCE: SAMSUNG)*

CHALLENGES - EXISTING INDOOR INFRASTRUCTURE

Indoor mobile coverage is getting important as lots of applications demand quality indoor connectivity with relatively high data throughput. In addition, enterprise or building owner is willing to invest more in the infrastructure which provides seamless mobile connectivity as a kind of services to their end customers.

Before small cell solution starts gaining traction, indoor Distributed antenna system (DAS) was the single solution for indoor coverage only. Now, they have been deployed extensively in different buildings to serve numbers of indoor users. However, in the coming 5G era, integrating 5G system into existing infrastructure seems to be challenging and costive, unlike LTE system, it was just added by simply changing out the front-end combiner. The rest of the infrastructure remains mostly intact.

Impact of High Frequency Band Deployment

In many countries, spectrums which are available for the initial roll out of 5G networks will be located in high frequency bands like 3.5GHz, 6GHz or even milli-meter wave band. From RF perspective, these bands will result in a much higher cable loss, pathloss and penetration loss.

A quick study is conducted by taking DAS as an example to assess the impact of high frequency band on cable loss and pathloss. LTE on 3.5GHz and 5GHz is compared with existing LTE 2600MHz deployment. For shopping mall as an instance, 5GHz will incur 6.3 dB more than 2.6GHz. In addition, pathloss of LTE 3.5GHz and LTE 5GHz for a typical 15m cell radius design is approximately 2.6dB and 5.7dB higher than LTE 2600MHz.

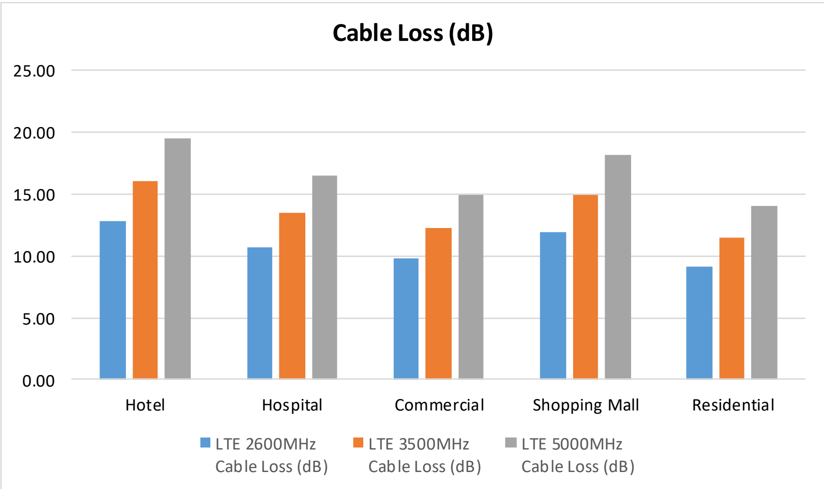

FIGURE 5 COMPARISON OF CABLE LOSS FOR DIFFERENT FREQUENCY BAND DEPLOYMENT (*NOTE: AVERAGE CABLE LOSS BASED ON PAST DESIGN IS EXTRACTED FOR DIFFERENT TYPE OF INDOOR ENVIRONMENT)*

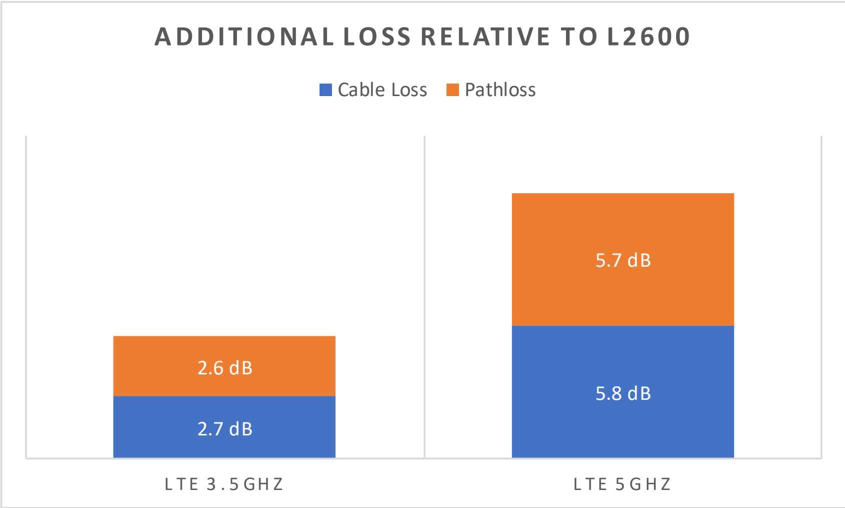

FIGURE 6 ESTIMATED LOSS RELATIVE TO LTE2600

On average, the total additional loss incurred will be around 5.3dB and 11.5dB for LTE 3.5GHz and LTE 5GHz respectively. To achieve similar performance as LTE 2600MHz, the additional loss has to be overcome somehow through other options such as increasing cell output power, adding more sectors or remote unit or deploying super low loss cable. However, the CAPEX becomes higher due to higher rental charge for equipment, higher power consumption and higher hardware cost for the roll out indoor 5G system by applying current DAS architecture.

On the other hand, with large bandwidth requirement (>100MHz) in place for specific applications, 5G system will likely rely on high frequency band beyond 5GHz or milli-meter wave band. Therefore, most of the existing cabling system, passive components and antenna solution which only support up to 3GHz will have to be phased out and replaced.

High Capacity Demand

On top of massive MIMO, large bandwidth deployment is one of the conditions that is needed to achieve target spectral efficiency as promised in 5G networks.

Up to now, most of the inbuilding solutions are only equipped with 2T2R MIMO. 4T4R MIMO is still rare for commercial deployment. Cost is the main concern as today indoor coverage solution is not cost-effective to drive further upgrade to higher level of MIMO. Laying of additional cables and adding extra hardware modules for every upgrade will not work if a much higher level of MIMO is required. To achieve massive MIMO (> 8T8R MIMO), large number of indoor antennas in reasonable size are needed to be accommodated.

Referring to typical LTE networks deployment on single frequency band, the bandwidth is 20MHz and could be extended to 40MHz or 60MHz if there are two or three carriers aggregations. However, 5G networks target to have more than 100MHz bandwidth for typical deployment. The total bandwidth of multi-operator networks may easily exceed 300MHz if there are more than three operators. Small cells or active DAS optical repeaters are unable to fulfill this requirement in this stage. Besides, current fiber networks between the baseband unit and the remote unit may need upgrade to support large bandwidth RF signal.

Hence, the idea to simply upgrade the existing infrastructure to provide indoor 5G coverage may not work perfectly.

COEXISTENCE – EXISTING AND NEW INDOOR COVERAGE SOLUTION

Following the evolution of mobile technology since year 1980, the records suggest that LTE networks will co-exist with 5G networks for at least 10 years to support population of mobile users during the transition period.

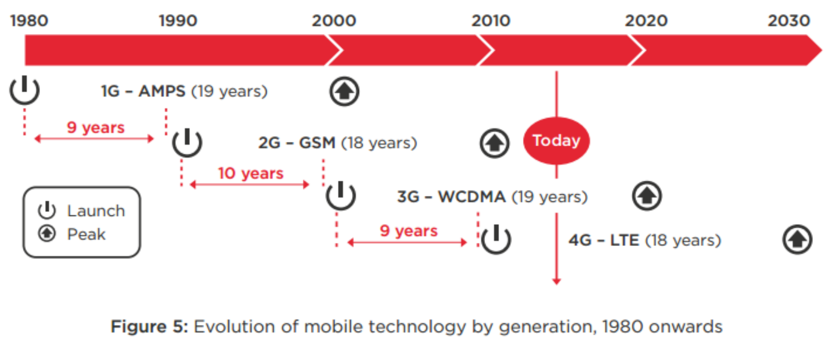

FIGURE 7 EVOLUTION OF MOBILE TECHNOLOGY BY GENERATION, 1980 ONWARDS (SOURCE: QUALCOMM)

As discussed in previous Chapter, existing infrastructure is not suitable to carry high frequency signal with large bandwidth requirements in 5G networks. Alternatively, to embrace the coexistence of both legacy and 5G systems, an overlay of new solution on top of existing infrastructure can be another option.

Inbuilding System Requirement

Generally, all the buildings can be categorized on their size and system requirements, as summarized in Figure 8. Large venue such as airport, stadium, exhibition hall wherewith large number of mobile subscribers, will need a comprehensive solution to accommodate multi-operator, multi-system and multi-band networks. In addition, high capacity is a must to cater crowds.

The system requirements of smaller buildings will depend on the deployment model and the business case. Typically, operators led deployment at small venues with single-operator system whereas neutral hosts or enterprises led a model with multi-operator system. Each mobile operator has its own business strategy, and different enterprise/customer/ subscriber base distributions, inbuilding infrastructure cost will be justified by different business cases. Hence, single-operator solution which is less complicated and cheaper may fit those scenarios.

Besides, high deployment cost has been the main reason why there are still lots of small to medium buildings remain unwired nowadays.

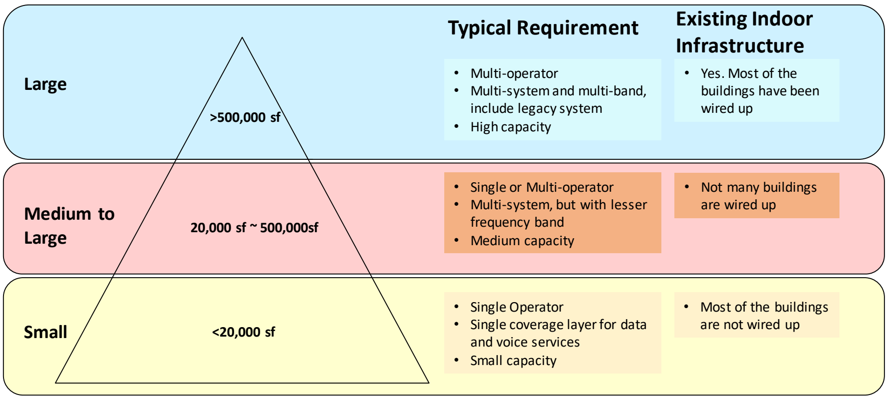

FIGURE 8 INDOOR SYSTEM REQUIREMENT FOR DIFFERENT SIZE BUILDINGS

Demand for New Indoor 5G Coverage Solution

Inevitably, 5G network coverage has to reach out to indoor users. The better option is to put up dedicated infrastructure which provides reasonably user experience. Three types of buildings may be prioritized for indoor 5G coverage:

A. Existing buildings which have been wired up to support legacy system (2G/3G/4G)
B. Existing medium to large buildings which are not wired up
C. Other newly built medium to large buildings

The first priority is believed to be Category A as those buildings are either politically important or housing large number of enterprise customers or making large contribution to the mobile revenue. Category A will be the bigger market opportunity for indoor solution vendors or system integrators. It is believed that two layers of infrastructure could be the best option for Category A buildings in order to support both legacy and 5G networks.

Next priority for expanding inbuilding coverage is to wire up Category B and C buildings. Comparing with Category A, a more comprehensive multi-operator and multi-system solution is necessary as both legacy and 5G system are equally important at the beginning stage of 5G roll out. In addition, LTE networks could serve as a backup or offload to 5G networks in future.

TABLE 2 TYPE OF NEW INDOOR 5G COVERAGE SOLUTION

Type of New Indoor Solution	Supported System	Carriers	Scenario	Deployment Cost
1	Legacy and 5G System	Multi-operator	Category B, C	Highest
2	5G System Only	Multi-operator	Category A	Medium
3	5G System Only	Single-operator	Category B, C	Low

As summarised in Table 2, new indoor solution has to be technically flexible and cost-effective in order to well support the demand under different circumstances.

CONCLUSION

Nowadays people want to keep connected to the network whenever they go. A quality cellular coverage which provides reliable connectivity has become essential no matter outdoor or indoor. As such, many buildings have been wired up with dedicated infrastructure cater for indoor users. Four to five years down the road, 5G is expected to be commercially deployed from indoor to outdoor sites. Apparently, existing DAS or small cell infrastructure is not ready to deliver 5G connectivity for indoor users. New solution development will focus on simple and flexible architecture to meet 5G system requirements. The demand of new indoor solutions for 5G network deployment will create opportunities as well as bring in more competition among existing market players.

INFOGRAPHICS

Download infographics for more details.

About Comba Telecom

Comba Telecom is a leading supplier of infrastructure and wireless enhancement solutions to mobile operators and enterprises to enhance and extend their wireless communications networks. With over 50,000 system deployments around the world including turnkey in-building systems, urban/rural wireless systems, and transport wireless networks, Comba Telecom's end-to-end network solutions include consultation, network design, optimization and commissioning.

Comba Telecom's product portfolio includes DAS, small cells, tower mounted systems, antennas, subsystems, passive accessories, Wi-Fi systems and digital microwave links.

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