

Microwave Backhaul in 5G Networks

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Abstract

Unlike 4G LTE and its predecessor technologies, 5G evolution comprises of many other advanced use cases apart from conventional mobile broadband. With the introduction of 5G technology, networks will incrementally evolve to higher throughput and low latency. To assist such high capacity datarate, reliability and low latency, microwave backhaul is a viable solution. With 5G rollout it is expected that E bands usage will continue to grow. Since 5G incorporates microwave bands, it is also expected that the microwave spectrum for fixed wireless network will go through a major transformation.

Keywords: 5G; Microwave; E-band; SDN; Spectrum; Backhaul

Introduction

With the rollout of 5G technology the mobile broadband will go through two different stages namely, mobile broadband and advanced mobile broadband. At present 80% of the normal mobile broadband, each radio site needs 25 Mbps and considering 100% of the radio sites, maximum backhaul capacity required is 150 Mbps. Since advanced mobile broadband will also come into play, the maximum required backhaul capacity per each radio site would be in the range of 3-5 Gbps.

However, the present microwave backhaul is ready to support up to 10 Gbps traffic in each radio site which makes it a very suitable solution for 5G backhaul network. With the focus on new and enhanced use cases, the transport networks need to support new types of radio networks and interfaces. At the moment microwave technology is on pace with 5G backhaul capacity demands as 10 Gbps and E bands deployment, usage have become a reality. So, in upcoming years it is expected that microwave will be able to support 100 Gbps links using new frequencies and MIMO technology (Figure 1).

Backhaul Network Technologies

Telecommunication networks have now evolved from traditional copper cable networks to fiber cables and microwave radio networks. Demand for high datarate, performance and throughput for traffic in network operator side have made this transformation and those demands begin to grow exponentially.

Figure 2 depicts that Backhaul media distribution worldwide except few countries evolved from copper to fiber or microwave [1] radios. In 2022, we can still see that more than 65% of the networks would be connected by microwave technology. There are regional variations in adapting to or implementing microwave technologies in future however it is obvious that the percentage of networks using microwave as a backhaul remain almost the same since microwave technology is continuously evolving and being able to catch up and deliver a decent KPI in network performance. Figure 3 shows the regional variations in usage of microwave backhaul at present and in 2022.

It is evident that 80% of network operators in developed mobile broadband regions such as Western Europe are embracing microwave technology and planning to introduce 5G with their existing microwave links. Core and intercity aggregation networks are supported by fiber backhaul meanwhile spur areas area networks are connected through microwave [2]. With the introduction of 5G, the demand for aggregated network traffic would increase and microwave can be used as a last mile technology as well as for backhaul with high data

rate. 5G is also being called as the “mobile fiber” for its extreme high-speed broadband connectivity and low latency. In order to achieve this, fixed wireless through microwave can be used. It will be necessary to upgrade or deploy new radios since 5G technology will be using higher frequency bands. As fiber investments have depreciation around 25 years meanwhile for microwave it's in the range of 5.8 years. So it's very important that network operators do a thorough research and study on what backhaul technology to implement and where to use fiber. Fiber networks can be used for core and aggregation networks while microwave can be used to establish long hop backhauls and in uneven terrain where fiber deployment is impossible. And also microwave links can be used as a backup or standby to ensure continuous service in fiber network downtimes.

Spectrum Transformation for Microwave due to 5G

Higher bandwidth, data rate and performance requirements have required 5G to be implemented in microwave spectrum which means that availability and usage of microwave as a backhaul will go through a major transformation in next 5 to 10 years. And also, such impact has made the importance and usage of E-, W-, D- bands to grow eventually. E-band was introduced in US before 10 years and it took more years for other countries to adopt and open the band. E-band has eventually grown and at present more than 80% of countries with a known telecommunication regulatory body status are open for deployment of E-band. The main properties of E-band for network operators to adapt it are higher capacities and low spectrum fees. Following Figure 4 illustrates worldwide approach and towards the use of E-band.

Invention of multi-band boosters and dual-band antennas have supported and driven the growth of E-band usage since two bands of different properties and be transmitted, boosted, and received. By combining lower frequencies with higher frequency signals, high data rate can be achieved for a long hop with incredible link availability. The current market focus is on how to combine traditional bands with

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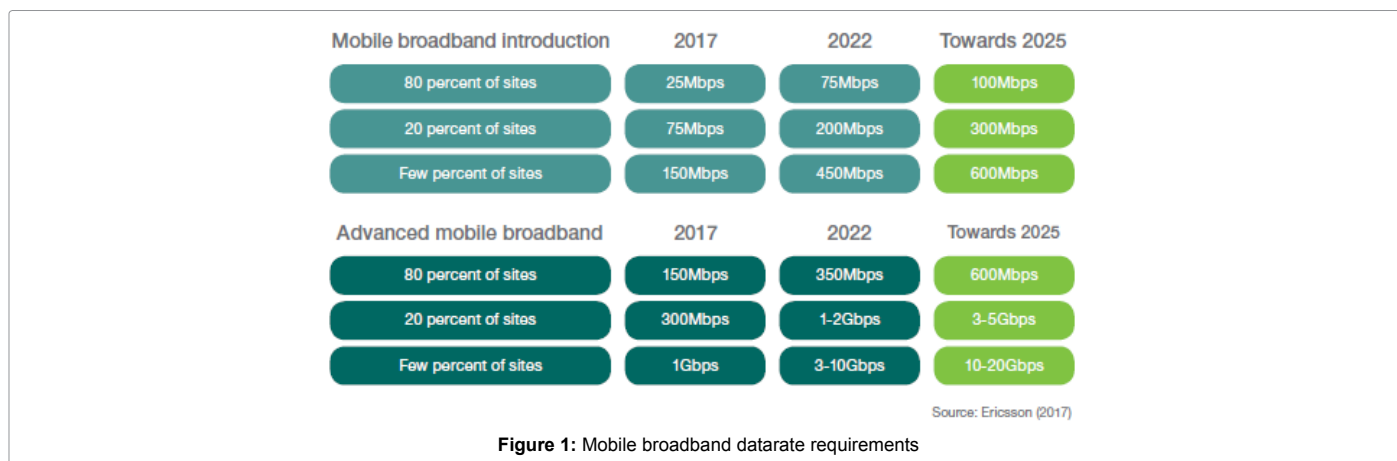


Figure 1: Mobile broadband data rate requirements

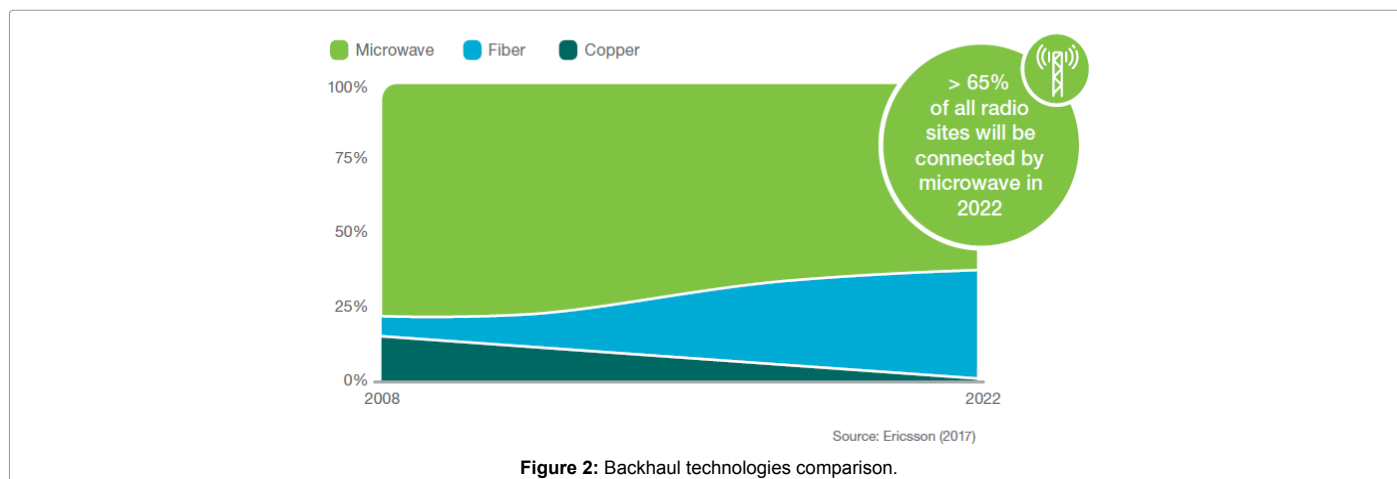


Figure 2: Backhaul technologies comparison.

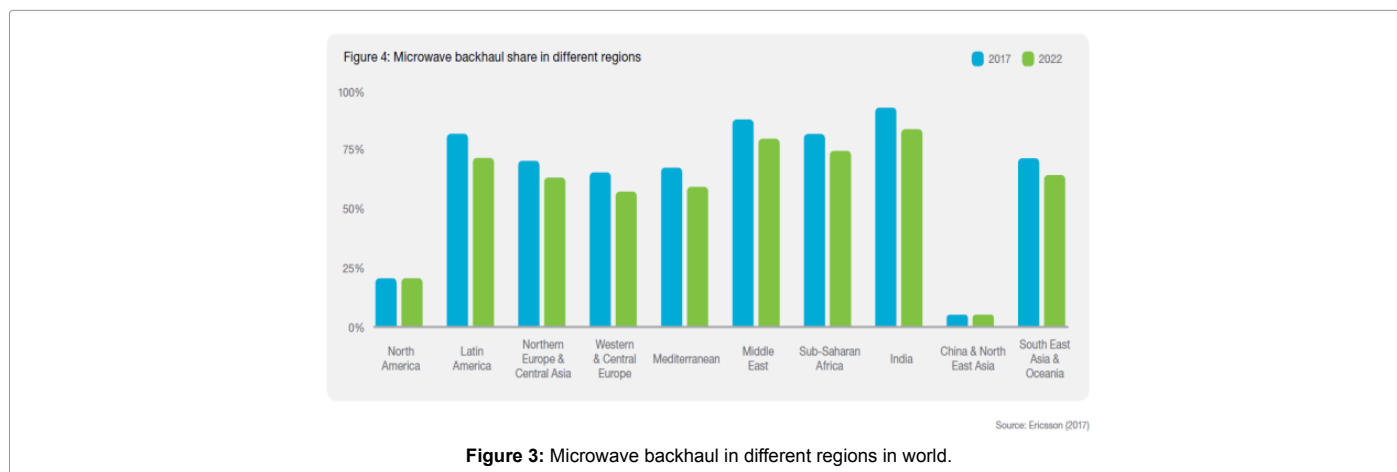


Figure 3: Microwave backhaul in different regions in world.

E-bands and get the best output. Figure 5 illustrates optimum multi-band booster configurations for traditional bands in combination with E-bands. It can be seen that for mild climate, the same hop length can be achieved at 70/80 GHz as for ≈ 26 GHz. For severe climate, the same hop length can be achieved at 70/80 GHz as for ≈ 20 GHz. By applying some flexibility both up and down on the availability target for the traditional band, it can be seen that the most relevant bands to combine with 70/80 GHz are 18-28 GHz in mild climate, and 15-23 GHz in severe climate. This kind of multi-band combinations is extremely useful for countries which has considerable temperature variations and climate changes.

E-band is able to assist 5G rollout meanwhile in near future W-band (92.00-114.25 GHz) spectrum and D- bands (130.00-174.80 GHz) spectrum will also be standardized to support upcoming wireless technologies. At present 4-5 GHz microwave links are used as long backhaul but soon they ought to be replaced with different spectrum because 5G rollout will start with 3 GHz but 5G networks will continue to expand and operate at 5 GHz to enable high bandwidth and good coverage. And also for special cases such as 5G hotspots, industry applications and other use cases, some other spectrum bands such as 25 GHz, 38 GHz could be used. Figure 6 shows the current and future

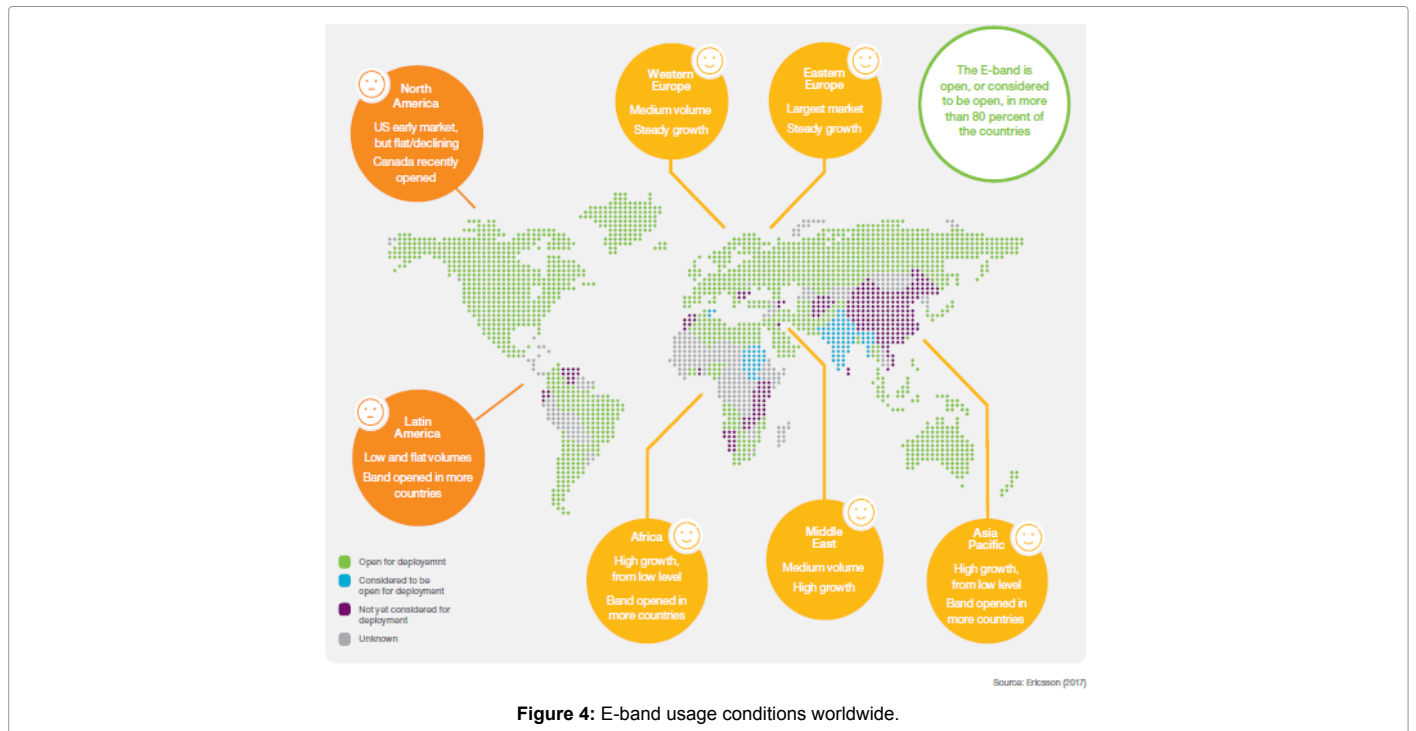


Figure 4: E-band usage conditions worldwide.

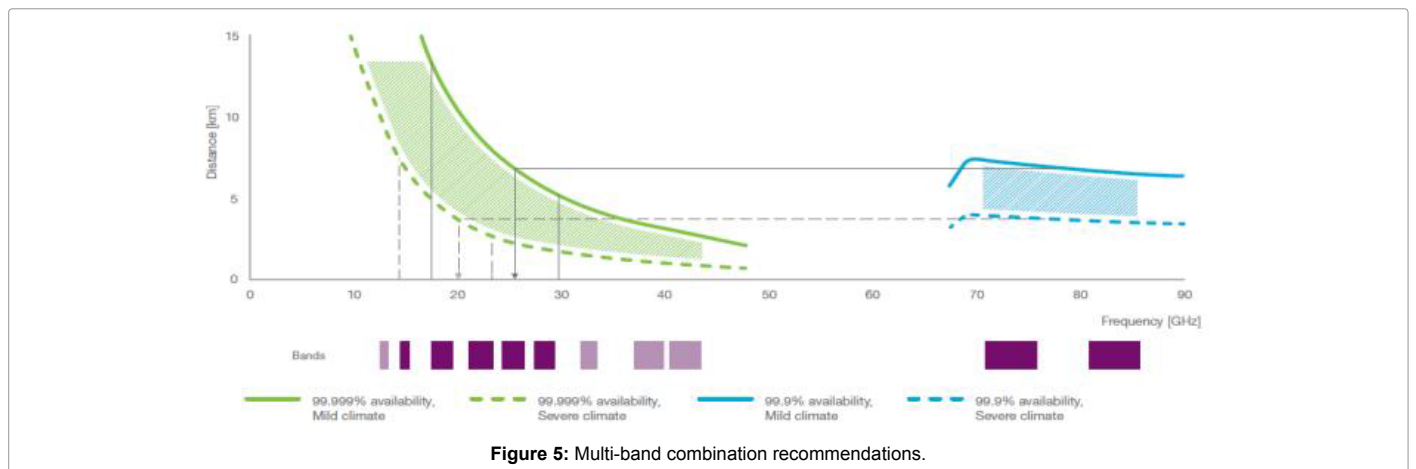


Figure 5: Multi-band combination recommendations.

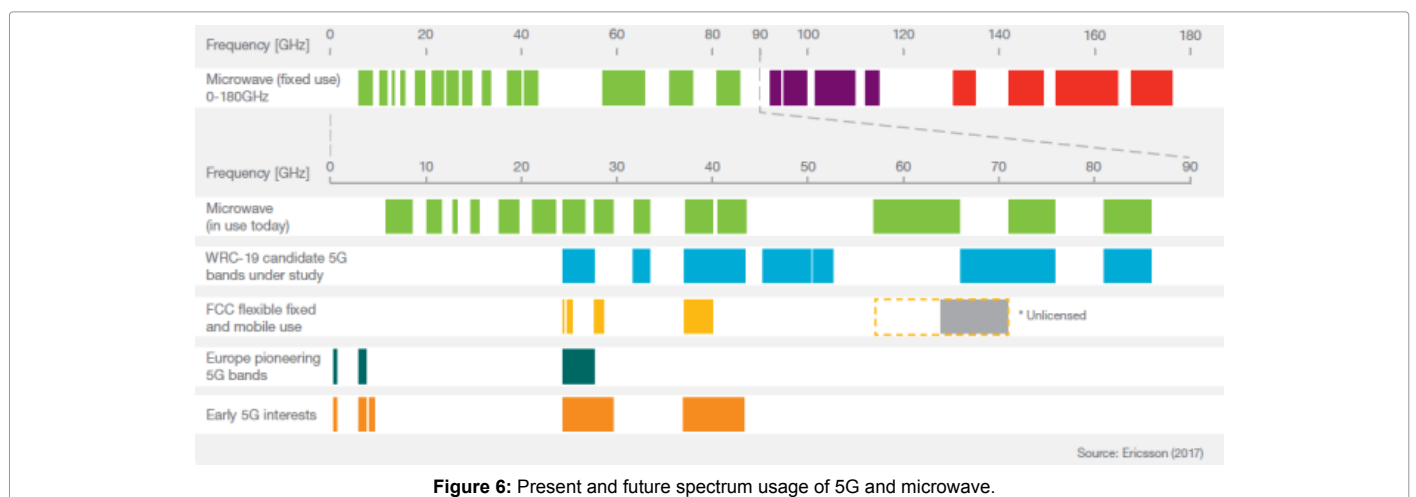


Figure 6: Present and future spectrum usage of 5G and microwave.

trend in spectrum allocation and usage.

5G technology will comprise of low-band, mid-band and high-band. Low-band will be used for rural connectivity and indoor connections in urban areas. Mid-band enables decent coverage and good bandwidth. High-band will be used in special industrial purposes and high capacity connections such as space stations and research labs.

5G Network Capacity and Performance Requirements

The following figure shows the relationship between spectrum efficiency and Channel Bandwidth. From Figure 7 we can see that a channel bandwidth of 1.75 GHz with efficiency of 60% can achieve data rate of 100 Gbps and also same data rate can be achieved by a channel of bandwidth 4 GHz with channel efficiency of 25% in microwave technology. The network operator ought to trade off efficiency, available spectrum in order to achieve maximum data rate.

Microwave and SDN Automation

The first wave of software defined networking (SDN) has hit the industry and the initial approach is to focus on automation and centralization of network and services. 5G evolution calls for

operational simplicity, flexibility and dynamic response.

Figure 8 shows that SDN in microwave technology is exponentially growing and very soon it will surpass all other trends leading the way towards network automation. The microwave SDN use cases described have been confirmed by the European Telecommunications Standards Institute in report ETSI GR mWT 16. The selected use cases are to be deployed commercially in nearby future. At first the network automation will be introduced in regions with high network complexity where the conventional network management can be replaced. Eventually such approach will be adopted by network operators for their whole network management and it is expected that in 2022, networks will benefit from network automation worldwide. SDN approach is based on decoupling network management and control from data forwarding in the nodes and its purpose is to make a programmable centralized controller with a global view. The resources could be allocated and used dynamically which would eventually increase whole system efficiency and ensuring very high quality of service. The need to simplify handling of several complex networks and optimizing network traffic flow could be achieved by microwave technology when the microwave nodes will be embedded with advanced packet control functionality. Limited deployment of SDN traffic control in microwave along with 5G backhaul is expected

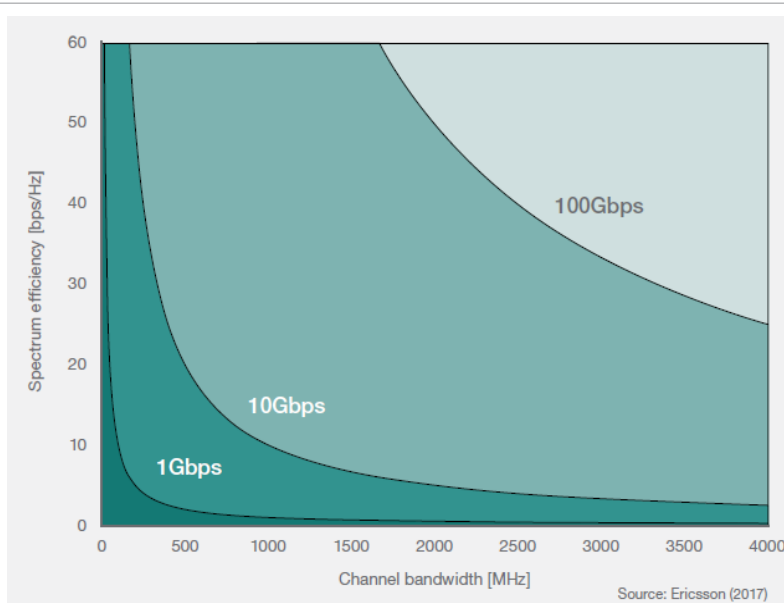


Figure 7: Channel bandwidth and spectrum efficiency.

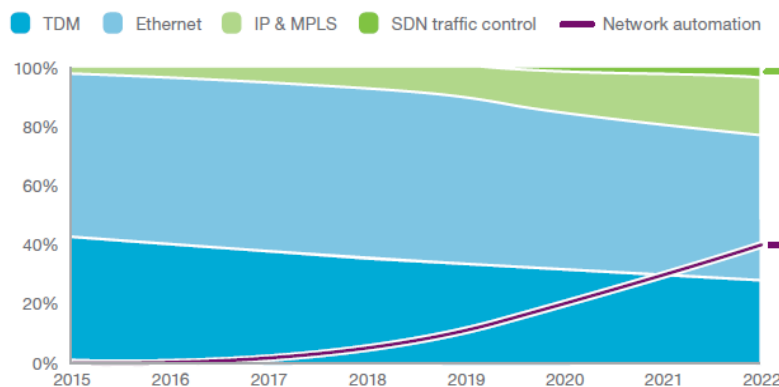


Figure 8: Technology evolution in microwave backhaul.

to be seen in 2020. Such demands and future technology empowerment using machine learning and artificial intelligence can also be supported by microwave technology.

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