Tech insights

Reusing the same spectrum for 5G and 4G deployments

ERICSSON

Communication Service Providers frequently need to repurpose spectrum from the older to the new, more efficient generations of mobile technology.

A part of our 5G introduction topic, this paper focuses on reusing the spectrum between 4G and 5G technologies.By reusing the spectrum between 4G and 5G technologies Communication Service Providers can allocate spectrum following traffic demand and efficiently utilize the spectrum asset.

Reusing the spectrum for 5G and 4G deployments

Communication Service Providers (CSPs) will typically start 5G deployment in the newly acquired spectrum. However, over time CSPs will also repurpose spectrum currently used for 4G and redeploy it for 5G technology.

CSPs can efficiently repurpose from 4G to 5G FDD[1] spectrum (800MHz, 1.8GHz, and 2.1GHz spectrum) using Ericsson's led standardization of the industry solution that allows usage of the same FDD spectrum for 4G and 5G simultaneously. This industry solution is Dynamic Spectrum Sharing (DSS) or Ericsson Spectrum Sharing (ESS) in Ericsson's implementation.

CSPs may also need to repurpose from 4G to 5G TDD[2] spectrum (2.3GHz, 2.6GHz, and 3.5GHz spectrum). There is no standardized industry solution that allows the usage of the TDD spectrum for 4G and 5G simultaneously. However, in this paper, we present that it is possible to deploy the same TDD spectrum on the neighboring 4G and 5G sites without a standardized industry solution for spectrum sharing. By deploying the same TDD spectrum on the neighboring 4G to 5G sites, CSPs will increase their efficiency in repurposing the TDD spectrum as allocation of the spectrum will follow traffic demand per site. Reusing the TDD spectrum on the neighboring 4G to 5G sites will allow CSPs to efficiently utilize their spectrum asset.

FDD[1] spectrum (800MHz, 1.8GHz, 2.1GHz)

TDD[2] spectrum (2.3GHz, 2.6GHz, 3.5GHz)

1. FDD – Frequency Division Duplex, the communication to and from a device is conducted in the different frequency spectrums.
2. TDD - Time Division Duplex, the communication to and from a device is conducted in the same frequency spectrum, separated in the time domain.

A need to reuse the TDD spectrum between 4G and 5G sites

Several CSPs in the Gulf Countries and globally are deploying or planning to deploy 5G in the TDD bands already used for 4G.

Typically these CSPs are using part of TDD bands (such as 2.3GHz or 2.6GHz bands) for 4G deployments, and they secured additional spectrum in the same TDD band for 5G deployment.

The straightforward deployment approach would be to use

the newly secured additional spectrum for 5G. Figure 1 illustrates such an example. A CSP already uses 60MHz in the TDD spectrum for 4G and secures an additional 40MHz in the same TDD band for 5G deployment.

However, this deployment may not be optimal for all the sites across the network.

For some 4G sites, 60MHz of the spectrum might not be required, and CSP might prefer to use 60MHz for 5G technology to provide a better experience for 5G users.

On other 4G sites, 60MHz might not be sufficient for the offered traffic. A CSP might want to temporarily use an additional spectrum for 4G traffic to meet the demand and quickly monetize the new spectrum.

In these situations, there is a need for non-uniform distribution of TDD spectrum between 4G and 5G sites across the network.

The typical approach to address the non-uniform spectrum distribution between two technologies, operating in the same frequency band, is to create a separation between the sites, a "buffer" zone. Figure 2 illustrates a buffer zone in deployment.

A buffer zone creates limitations in the deployment and reduces efficiency in spectrum utilization.

Eventually, all the spectrum will be used for 5G. As 5G is the most spectrum efficient technology, it is in CSPs' interest to migrate the spectrum to 5G as quickly as possible. However, non-uniform traffic distribution and deployment limitations with the buffer zones may slow down the migration process.

5G will eventually use all the spectrum.

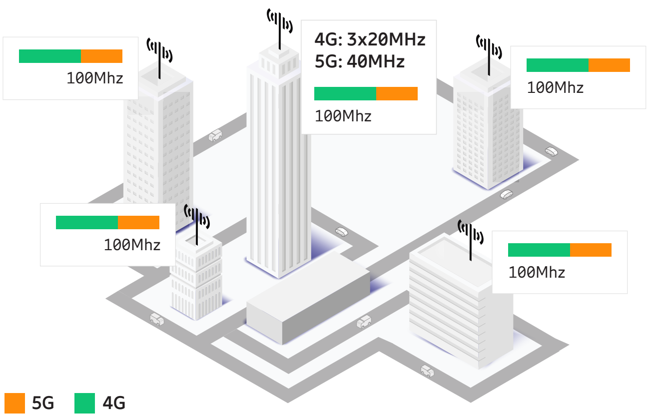

Figure 1: Constant distribution of TDD spectrum between 4G and 5G technology

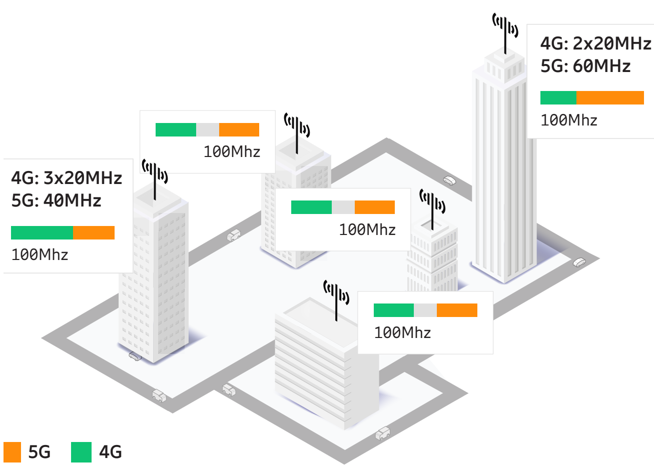

Figure 2: Non-uniform distribution of TDD spectrum with a buffer zone

5G and 4G technologies share many similarities in the air interface

When trying to answer the question of the required size of the buffer zone between 4G and 5G sites, we can start by comparing interference created between 4G and 5G sites with interference created between two 4G sites.

The two neighboring 4G sites, operating in the same TDD spectrum, will create random interference toward the devices close to the cell border.

The interference will be manifested by colliding Physical Resource Blocks[3] (PRBs). In other words, a device close to the cell border might not correctly decode information in one or more PRBs due to collisions with the PRBs sent from the neighboring cell (colliding PRBs illustrated with a red star in Figure 3).

With the assumption that there is no tight coordination between two neighboring 4G sites (i.e., no low delay link, below 1ms, to coordinate PRB scheduling), the interference caused by PRB collisions will occur randomly.

If we look at the interference between the two 5G sites, it is similar to 4G.

5G uses the same downlink modulation in the air interface as 4G (i.e., Orthogonal frequency-division multiple access or OFDMA). In addition, 5G frame structure is compatible with 4G frame structure as it is based on multiples of 15kHz Sub-Carrier Spacing[4] (SCS) used in 4G.

Figure 5 illustrates interference between two 5G sites. The interference will be manifested by randomly colliding PRBs in a similar way as in 4G technology.

3. PRB – Physical Resource Block is the smallest resource element that can be allocated to one device. A set of PRBs will carry all the user data to the device.
4. SCS – Sub-Carrier Spacing is the frequency shift between OFDMA sub-carriers.

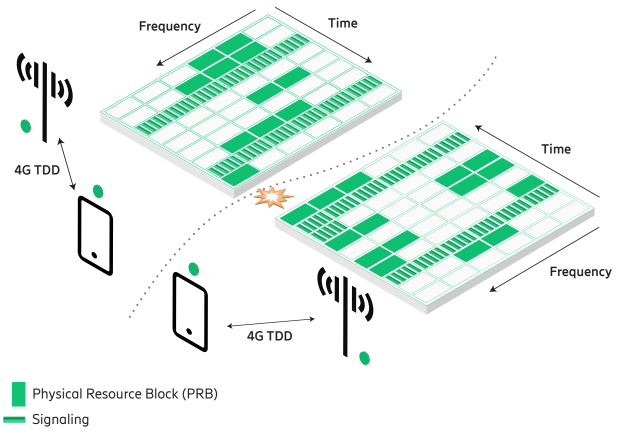

Figure 3: Interference between neighboring 4G sites

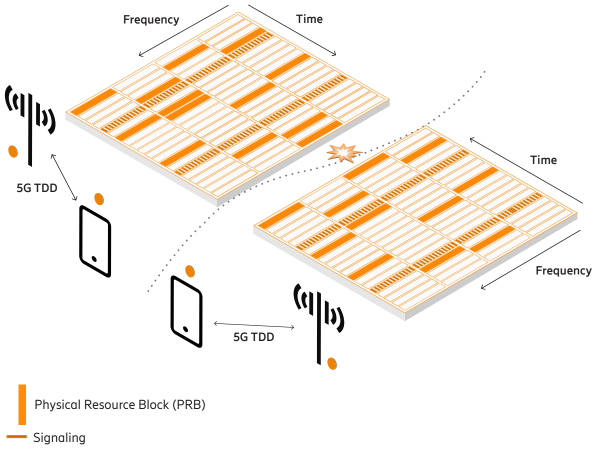

Figure 4: Interference between neighboring 5G sites

Let us look now at how interference will look between a 4G site and a 5G site operating in the same frequency band and with the "aligned TDD patterns"[5], Figure 5.

Note that in the presented example, 5G PRBs are two times shorter in the time domain and two times longer in the frequency domain as based on 30KHz sub-carrier spacing (i.e., two times 15KHz sub-carrier spacing used in 4G). However, the interference between neighboring 4G and 5G sites will still be manifested by randomly colliding PRBs similarly to the interference between two 4G sites or the two 5G sites.

This similarity in the interference manifestation between 4G and 5G sites results from the similarities of the air interferences and compatible frame structure between 4G and 5G technologies.

One area where interference between the 4G and 5G sites will be greatly different is interference caused by control channels.

4G technology generates considerable interference from the "always-on" control channels. 4G control channels constantly radiate signals regardless of traffic. 5G is designed much more efficiently with reduced control channels signaling if there is no traffic on the site. Due to this, the interference from 5G control channels will be much lower if there is no traffic on the site.

5. Aligned TDD pattern – communication to and from a device for both 4G and 5G is synchronized. To avoid interference, 4G and 5G must have aligned TDD patterns when operating in the same band, even if not reusing the same spectrum.

Figure 6 illustrates the difference in the idle mode (i.e., no traffic) signaling for 4G and 5G sites.

Due to "always-on" control channels, 4G site will create more interference from the control channels toward the neighboring 5G site.

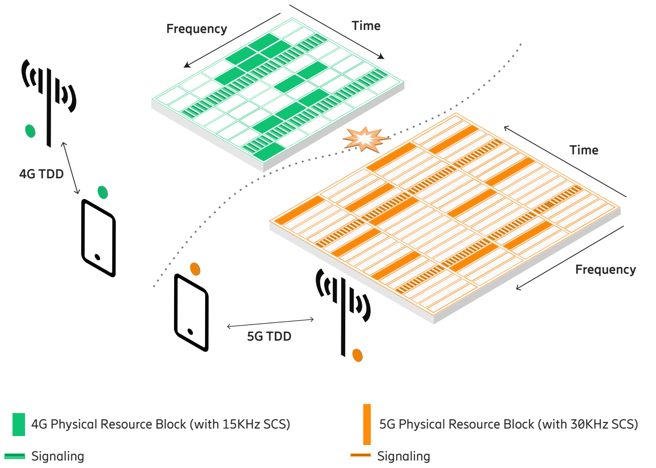

Figure 5: Interference between neighboring 4G and 5G sites

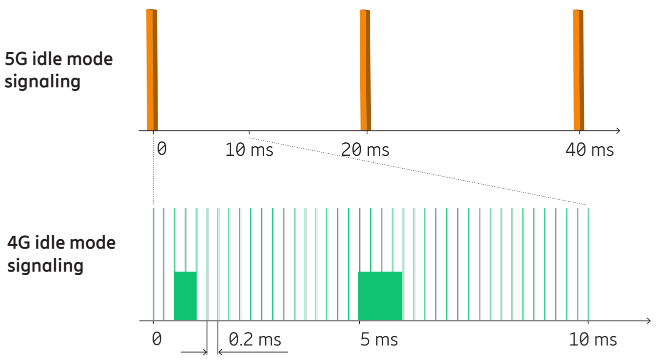

Figure 6: 4G vs. 5G idle mode signaling

Under certain limitations, it is possible to use the same TDD spectrum on the neighboring 5G and 4G sites

Based on the similarities in the generated interference between neighboring 4G and 5G sites to the neighboring sites in the same 4G or 5G technology, we can conclude that it is possible to use the same TDD spectrum for the neighboring 4G and 5G sites.

In other words, it is possible to have non-uniform spectrum distribution between 4G and 5G technologies, operating in the same TDD band, without separating 4G and 5G sites that use the same spectrum, i.e. with a "buffer" zone.

However, a few important limitations need to be considered during the deployments. It is paramount to ensure the border between neighboring sites stays the same regardless of whether neighboring sites are deployed with the same or different technologies. Extending coverage for one of the technologies (typically 5G) will considerably increase the interference.

Figure 8 illustrates extended coverage from 5G sites resulting in the reduced distance between the device and the neighboring 4G sites causing increased interference.

The presented situation can occur in 5G non-standalone (NSA) deployment when the system parameter setting allows 5G to anchor on the neighboring site.

A similar situation can occur in 5G stand alone (SA) deployments if 5G is not deployed on the neighboring sites. In 5G SA deployments, both neighboring sites must have 5G deployed.

In addition, the neighbor relations between 4G and 5G sites need to be the same to ensure an unchanged border between 4G and 5G sites.

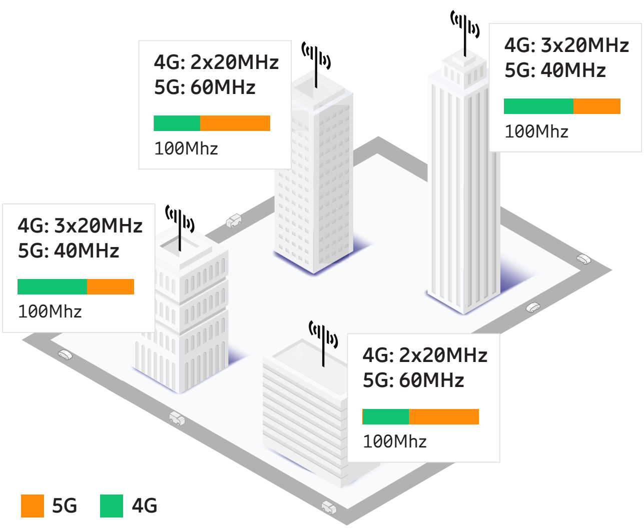

Figure 7: Non-uniform distribution of TDD spectrum between neighboring 4G and 5G sites

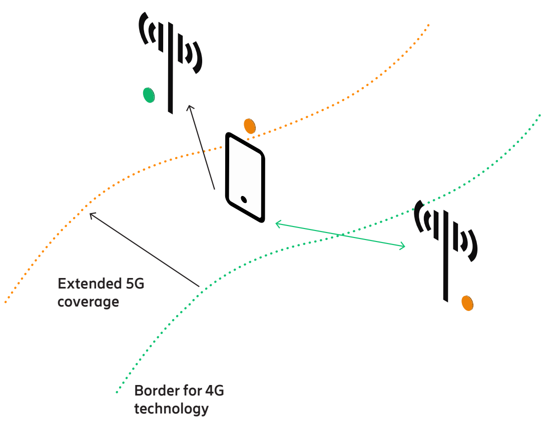

Figure 8: Extended 5G coverage compared to 4G coverage

Conclusion

With technology development, CSPs always need to repurpose the spectrum from the old to the new technology.

While the same applies to 4G and 5G, similarity in the air interface between 4G and 5G allows for a more efficient spectrum repurpose compared to any other technology.

For the scarce low-band spectrum, used for FDD technology, there is an industry standardized Dynamic Spectrum Sharing (DSS) solution that enables usage of the same FDD spectrum for both 5G and 4G simultaneously.

The Spectrum Sharing solution is not standardized for the TDD technology. However, due to similarities in the air interfaces, it is possible to share TDD spectrum between the neighboring 4G and 5G sites.

By sharing TDD spectrum between neighboring 4G and 5G sites, it is possible to gradually repurpose the spectrum from one technology to another following traffic demand. This way, CSPs can effectively utilize existing and newly acquired spectrum assets.

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Zoran has over 20 years of experience in the telecom industry from the Middle East, Europe, and North America in leadership positions in both areas of planning and implementation of mobile networks. Zoran holds Dipl. Eng. Electrical Engineering from the University of Belgrade, Serbia, department of Telecommunications.

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