BREAKTHROUGH 5G DATA CALL USING DYNAMIC SPECTRUM SHARING TO ACCELERATE NATIONWIDE 5G DEPLOYMENTS

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Abstract *– Cost-effective and efficient solutions that enable a smooth transition from 4G to 5G have been part of Ericsson and Qualcomm Technologies' pioneering 5G approach from day one. With Ericsson Spectrum Sharing and Qualcomm® Snapdragon™ 5G Mobile Platforms, service providers can tap spectrum currently used for 4G to launch nationwide 5G coverage with a simple network software upgrade.*

Index terms *– 5G, Ericsson, Qualcomm Technologies, mobile platforms, network software upgrade.*

Dynamic Spectrum Sharing (DSS) is emerging as a key part of mobile service providers' 5G strategy. Ericsson's offering in this space offers the lowest total cost of ownership (TCO) to launch 5G in bands currently used for 4G – enabling nationwide 5G coverage in short time after launch. Ericsson Spectrum Sharing allows an existing LTE carrier to operate 5G New Radio (NR) and LTE simultaneously – with a simple software upgrade. The solution is based on innovative intelligent scheduler algorithms that enable optimal performance as the mix of 4G and 5G devices in the network changes over time [1].

Ericsson Spectrum Sharing for immersive, wide-area 5G coverage

With 5G networks going live and consumers getting their hands on the first 5G devices, user expectations are high. Communications service providers need to make the best use of their spectrum assets and utilize each band's performance characteristics to support their business strategies, while maintaining coexistence between all technologies deployed in the network. Ericsson Spectrum Sharing (ESS) allows operators to run LTE and NR simultaneously on the same carrier frequencies and base station hardware.

With a simple software installation, ESS offers quick introduction of 5G over a wide area, for all 5G-enabled devices leveraging 4G spectrum and existing Ericsson Radio System infrastructure.

The challenge

Operators will need new spectrum for 5G, not least because its high expectations are fully achieved in the new mid- and high-bands.

In millimeter-wave frequencies, with extremely wide bands, operators will achieve 5G's ultra-high peak rates and low latency. This will create new capacity and throughput levels for mobile broadband, especially as a way of offloading congested 4G networks (and for new special use cases).

But there is also broad interest in deploying 5G technology in new mid-bands (3.5–6GHz), an optimal compromise between coverage, capacity and latency; as well as existing mid-bands (1.8–2.6GHz), to achieve wide 5G coverage as rapidly as possible.

The solution

ESS is a unique solution, including coordinated scheduling with 1ms granularity and frequency division multiplexing. Deploying ESS in a network is highly TCO efficient – existing Ericsson Radio System baseband and radio units can be upgraded with software to support ESS, without the need for additional hardware. With a simple software update and based on unique, intelligent scheduler algorithms, ESS permits dynamic spectrum allocation to 4G and 5G on the same band.

ESS and inter-band NR carrier aggregation enable a fast introduction of 5G and smooth evolution of 5G networks which maximize the infrastructure usage and spectrum assets. This hands service providers the control to introduce 5G coverage at a pace that suits their business needs. Migration from 4G/LTE to 5G NR can be made simpler, more efficient and faster by giving both technologies instant access to the same spectrum.

Now, together with Qualcomm Technologies, Ericsson has achieved the world's first 5G data call using spectrum sharing on a 3GPP Frequency

Division Duplex (FDD) low band using commercial hardware and software based on Ericsson Radio System, and a mobile test device powered by the Qualcomm® Snapdragon™ X55 5G Modem-RF System. This is a major breakthrough for wireless communication given that frequency sharing had never been done between any cellular generation since 2G. This technology is poised to change how new generation radio access technologies are introduced in operator networks using one of the most limited resources in mobile, which is spectrum.

Ericsson Radio System for 5G

Operators are seeking solutions to both support traffic growth as well as emerging use cases and business opportunities. To assist operators with these challenges and opportunities, Ericsson 5G radio access technologies are being created to provide the infrastructure needed to support the world's growing demand for high-bandwidth connections and support the real-time, high-reliability communication requirements of mission-critical applications.

The specification of 5G will also include the development of a new flexible air interface, NR, which will be directed to extreme mobile broadband deployments. NR will also target high-bandwidth and high-traffic-usage scenarios, as well as new scenarios that involve mission-critical and real-time communications with extreme requirements in terms of latency and reliability. Ericsson is extending the Ericsson Radio System to deliver new radio access products and functionality to smooth the operator's transformation journey to 5G. Ericsson Radio System extensions deliver a high performance, end-to-end 5G access system which includes the industry's first global portfolio of 5G NR radios.

Ericsson is also first to market with solutions that enable 4G LTE networks to evolve smoothly on the journey to 5G, such as Ericsson's new 5G platform for combined core and radio use cases . The platform comprises the 5G core, radio and transport portfolios, together with digital support systems, transformation services and security.

Per Narvinger, Head of Product Area Networks, Ericsson, says, "With Ericsson Spectrum Sharing, service providers can reuse their Ericsson Radio System investments on bands currently used for LTE to support the introduction of 5G. With the TCO advantages offered by Ericsson Spectrum Sharing, we are convinced that it will be a catalyst to drive the rapid build-out of wide area 5G coverage. This first call marks an important milestone in evolving the 5G networks to cater for the extreme demands ahead."

"This achievement is the result of our long-standing collaboration with Ericsson and is a critical step toward enabling operators worldwide to utilize DSS for a seamless global transition to nationwide 5G," said Durga Malladi, senior vice president and general manager, 4G/5G, Qualcomm Technologies, Inc. "With DSS support included in our comprehensive Snapdragon X55 5G Modem-RF System architecture, we're looking forward to helping fast-track the mobile industry to nationwide coverage during the second phase of 5G commercialization next year."

A unique technology milestone over 5G

The dynamic spectrum-sharing data call was set up earlier in August at Ericsson's lab in Ottawa, Canada using an Ericsson macro radio that supports both 4G and 5G, along with a mobile test device powered by the Snapdragon X55 5G Modem-RF System, and a commercial LTE smartphone.

The LTE smartphone and 5G testing device data call sections were running simultaneously on the same FDD spectrum. Making this 5G call aided by DSS is an important milestone as it shows that operators can avail of this unique solution to share spectrum for fast and smooth deployment of 5G coverage. As 5G commercial rollouts move ahead, spectrum sharing represents an attractive option for service providers looking to rapidly roll out 5G on FDD bands without the need to re-farm spectrum. This milestone achieved by Ericsson and Qualcomm Technologies shows real progress towards rapid 5G commercialization, with dynamic spectrum sharing playing a key role.

Traditionally, new generation radio access technologies are deployed on separate spectrum blocks – as was the case with 2G, 3G and 4G. This would require operators to buy new spectrum or re-farm the existing spectrum to allocate the new generation. This is a very slow and costly process. Spectrum re-farming could take a decade but with spectrum sharing, this can be done overnight.

Dynamic spectrum sharing revolutionizes the introduction of new technologies with a breakthrough innovation that allows the deployment of both 4G and 5G in the same band and dynamically allocates spectrum resources between 4G and 5G based on user demand.

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**Qualcomm Snapdragon and Qualcomm Snapdragon X55 5G Modem-RF System are products of Qualcomm Technologies, Inc. and/or its subsidiaries.

***Ericsson study on 15 largest markets in the world that have 4G (Data from Ovum WCS database)

The time to act is now

Gaining a first-mover advantage has significant benefits. According to an Ericsson study*, 73 percent of the service providers that were the first to move on 4G have gained market share in their respective markets. The combination of faster time-to-commercialization and low investment requirements has made spectrum sharing an essential part of operator's 5G strategies.

Ericsson also provides an opportunity for service providers to extend the coverage of new 5G NR mid and high bands by applying Inter-band NR Carrier Aggregation between low-mid and low-high frequency bands. Here, Ericsson Spectrum Sharing is key to allowing an easy introduction of NR on low bands. In combination with NR Carrier Aggregation, spectrum sharing can typically double the coverage area of new 5G mid and high band cells, delivering hundreds of megabits per second indoors and at cell edge.

The new 5G NR solutions that enable far-reaching performance fast

No matter where in the world you need to provide 5G coverage, there are now more ways than ever to evolve your Ericsson radio access network quickly and cost-efficiently [2].

Our standalone 5G solutions ensure super-fast response times as well as the future-readiness of your network architecture, opening up new service-creation opportunities. NR Carrier Aggregation extends the capacity and coverage of mid- and high bands when combined with NR on low bands. With us, you can switch on 5G on low bands using your existing Ericsson Radio System radio and baseband, and share spectrum between 4G and 5G carriers based on traffic demand. And with our two new 16-transceiver Massive MIMO radios, you can build your 5G network with precision.

The key benefits of our latest 5G access solutions

Creating new opportunities

NR enables super-fast response times, better 5G coverage and an immersive media experience. It secures a service-based architecture, and supports network slicing and the swift creation of new services.

Increased capacity and coverage

Carrier Aggregation boosts network capacity by 27 percent or brings coverage to 25 percent more people using the mid-band for the downlink.

Peak performance

The latest radio solutions bring optimized 5G performance – by providing wider coverage for longer inter-site distances – and easy site build with the lowest total cost of ownership.

The 5G Switch made easy

Ericsson has played a pivotal role in the advancement of 5G technology. Together with our partners, we have led an ecosystem of expertise from the early stage of network trials to making this technology a commercial reality. As a result, our 5G leadership position is evident in several critical areas:

- Ericsson is currently supporting more than 20 5G live networks across 4 continents. That is more networks, on more regions, than any other vendor. All those

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networks use Ericsson Radio, Ericsson Core, or both.

• We provide a smooth evolution path, enabled by the Ericsson 5G platform and the 4 million 5G ready radios we have shipped.

• We have the largest number of supported 5G devices on live networks, currently more than 15. We have also successfully completed comprehensive interoperability tests, across all main spectrum bands.

• We are on the top when it comes to estimating essential 5G patents, and applying a rapidly increasing number of new standards to our portfolio.

A new standard for Dynamic Spectrum Sharing

Software bugs are part and parcel of product development. You identify it, fix it, move on. However, what happens when you discover a bug in the 5G specification at the eleventh hour of 3GPP standardization? And when that very bug can affect performance of a business-critical product by up to 15 percent? In this blog, Mattias Frenne, a principal researcher and an Ericsson RAN1 delegate for 3GPP, reveals exactly what happens next [3]. This blog entry is part of Ericsson's Standardization Stories series.

My position as an Ericsson delegate for 3GPP takes me across the world – from Busan in South Korea, via Athens in Greece, to Vancouver, Canada – to help secure the best possible standards across telecom. It's a coming-together of hundreds of actors from across industry, government and other sectors to jointly develop the best possible technologies into a shared global standard.

Last year, as with many of the previous years, I was part of the Ericsson RAN1 delegation (comprising approximately 25 expert delegates) quietly working on, among other things, Ericsson's business-critical Dynamic Spectrum Sharing solution as part of the upcoming 3GPP Release 15. The outcome would ultimately form the final specifications for the 5G standard and would follow years of daily technical debate and discussion across hundreds of stakeholders.

In mid-autumn 2018, I received a phone call from a colleague in an Ericsson product development team that was looking into the fine details needed to support Dynamic Spectrum Sharing. By this stage, the 5G New Radio (NR) specifications were all but complete, the hardware design all but settled and the standard all but good to go. I took the call, spoke for a couple of minutes and then hung up. We had a problem.

The how and why of Dynamic Spectrum Sharing

To gauge the scale of the problem, it's important that you know a little more about the strategic importance of Dynamic Spectrum Sharing as part of the migration story from 4G LTE to stand-alone 5G.

Dynamic Spectrum Sharing is a unique piece of Ericsson innovation and the piece in the puzzle which makes it easier for our customers to be first to market with nationwide 5G coverage through only a single software upgrade. It allows them to dynamically switch between both LTE and 5G NR coverage on existing 4G assets. In fact, the technology is so intuitive that it would be easy to overlook the years of complex research and development which went into the product.

From the early stages of our research into 5G NR, when we began to map 5G transmissions to time-frequency resources, we created the possibility for holes in the 5G transmission grid which could be used for 4G LTE transmissions. This means that, by simultaneously sharing frequency bands which are already available today, service providers can fire up 5G on existing LTE bands without actually shutting off LTE. This means that, as well as having the option to roll out 5G on existing Ericsson 4G hardware, operators can keep the LTE network up and running while starting 5G. This can truly make it easier for thousands of operators to transition to 5G in the coming years.

To find out more about the technology, visit Ericsson's Spectrum Sharing page.

An unprecedented challenge awaits

Back to that phone call. During the systemization phase, we identified a specification bug which led to some 5G reference signals colliding with those of 4G, meaning that a 5G terminal would not be able to receive the data transmission. A potential workaround for this bug would likely result in a huge 15 percent drop in expected NR downlink throughput whenever Dynamic Spectrum Sharing was used. The stakes couldn't have been higher. With such a drop, the full potential of Dynamic Spectrum Sharing would never be realized.

However, the real challenge wasn't the fix itself. This was swiftly identified and resolved by our standardization team, following consultation with the major chipset vendors. I won't get too technical, but we found a solution which would allow the 5G devices to receive the data transmission without the need for the 15% throughput drop. The real challenge would be in persuading all other stakeholders to push through such an amendment so late in the game – something unprecedented in the history of 3GPP.

Release 15 completion was literally weeks away. Actually, the NR completion date had already passed in June 2018 and specification work was now in maintenance mode whereby only very minor non-critical fixes were allowed. The spec was "frozen" to prevent any delay to eventual product launches. A consensus to modify the specifications would require extensive negotiations and convincing of many different stakeholders across vendors, customers and the major 3GPP stakeholders. Yet, even so, there would still be no guarantee of a desirable outcome for our team.

Securing a consensus at the eleventh hour

And so, with commitment and conviction, our delegation got to work. Drawing on Ericsson's wider trust in the 3GPP domain, our delegates began an extensive campaign across several fronts together with our product management team. With the right solution in place, and following weeks of intense technical discussions with major 3GPP partners, the 3GPP RAN1 working group agreed by consensus to our late change request on the specification. Approved just a matter of weeks before the final close of implementation of Release 15 NR in products, this unprecedented feat looks set to secure a significantly easier migration to 5G for thousands of operators – and, by extension, consumers and industries alike – over the coming years. Achieving such a feat was a clear demonstration of the credibility, trust and integrity which Ericsson is known for across the wider telecom industry. Here's to many more successes on the forthcoming 3GPP Release 16.

About Ericsson and 3GPP standardization

3GPP is the body responsible for global standardization of 2G, 3G, 4G and 5G mobile networks. As a technology leader with an extensive patent portfolio, Ericsson places strategic importance in leading 3GPP initiatives so as to align new telecom standards with our vision for the future. In our series of Standardization Stories, we showcase that, through leadership and innovation, Ericsson plays a leading role in building today's and tomorrow's global eco-system of Core and Radio Access Networks.

Here's what you need to know about 5G and C-V2X

Vehicle to everything (V2X) is a term that refers to high-bandwidth, low latency and highly reliable communication between a broad range of transport and traffic-related sensors. 5G mobile networks will be key to providing connectivity for vehicle to vehicle (V2V) and vehicle to infrastructure (V2I) communications. The V2X ecosystem will feature a broad range of transport-related applications: cars communicating with one another, with traffic lights or parking spaces, with nearby pedestrians, or with central planning systems that are coordinating the flow of traffic. All of these use cases will have different sets of requirements, which need to be handled efficiently and cost-effectively.

Current cellular networks already provide a wide variety of tools that address some of the technology and business requirements of connected vehicles. For example, LTE Cat-M and Narrow Band-Internet of Things (NB-IoT) are excellent low-power sensor communication technologies. Network slicing, already possible with existing 4G connectivity, is yet another tool that enables operators to provide virtualized end-to-end networks, optimized for certain use-cases or industry segments. However, in order to enable complex vehicle maneuvering, it must be feasible for autonomous vehicles to share their driving intentions in rapid two-way communications. These interactions will make it possible for vehicles to behave as smart clusters rather than inert, individual units.

In Europe, a broad consortium of companies, led by Ericsson, is helping to develop an overall 5G system architecture to provide optimized end-to-end vehicle to everything (V2X) connectivity. The 5GCAR project, which is supported by the EU Commission, involves a total of 14 European organizations including the PSA group, Bosch, Orange, and Volvo Cars.

In June 2019, the consortium demonstrated a unique lane-merge coordination use case at the UTAC-TEQMO test track in France. The demonstration showcased how to optimize a merging process for vehicles entering a highway. As part of the demonstration, connected vehicles near a highway entrance shared their status information with a central maneuver planning system that was then able to recommend individual actions, including acceleration, deceleration, and lane changes, on behalf of connected vehicles in the area.

By investigating the value of 5G for connected cars, the 5GCAR project represents an important step towards making the V2X ecosystem a reality. However, there are still challenges ahead including the legal frameworks and spectrum availability. Different regions are at different stages of their V2X maturity. China for example plans to install sensors on 90 percent of the country's highways by 2020. The US is re-evaluating past usage restrictions and in Europe, the CEOs of 24 companies (including BMW, Daimler, Deutsche Telekom and Ericsson) have urged the EU to allow for C-V2X and wide-range cellular as a solution for Cooperative Intelligent Transport Systems (C-ITS).

5G as a technology has the potential to have wide-ranging effects on the V2X ecosystem. To take full advantage of its capabilities, operators and industry leaders must familiarize themselves with the tools that modern cellular networks provide and understand how these tools can best be applied in end-to-end solutions. Ericsson has been connecting vehicles for the last 10 years and now connect more than four million vehicles globally on the Connected Vehicle Cloud platform.

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