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TELICOMM 5G OPPORTUNITY

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1. BACKGROUND

To truly enter the digital age and become smart cities, municipalities need to install thousands of video cameras. This, alongside with recent advancements in video analytics (VA) and artificial intelligence will shape the smart-city in the coming years.

The video stream from each camera is transmitted to a control center (or to the "cloud") to be viewed in real time, recorded for later viewing, and analyzed by VA systems.

In 2017, 10 million cameras were installed worldwide for safe and smart city applications. Most of these projects (over 90%) involved cumbersome, expensive and non-flexible cable installations: using cables to connect the cameras to the city high-speed-backbone (80m of cabling on average, AKA the "last mile gap") and to the control-center. By 2025, the number of camera installations (only for safe and smart city applications) will grow to 35 million per year, with an annual growth rate of 23%, reaching 100 cameras per Km^2.

To answer the above need for today's and tomorrow's rapidly changing cities, an **immediate, flexible, and cost-effective solution for connectivity of thousands of cameras is a must**.

This can only be done using the cellular network. However, due to the limited bandwidth as well as the varying nature of the cellular network, together with the bandwidth requirements of high-definition (HD) video, the cellular network cannot support camera connectivity.

Telicomm's unique P-VAN™ (Predictive Video Aware Network – patent pending) technology utilizes machine learning combined with signal processing algorithms to allow video transmission from all connected cameras over the cellular network in an optimal and robust way.

Thus, **Telicomm enables camera connectivity over the cellular network, allowing to connect thousands of city cameras in a single day.**

In this whitepaper, we discuss the new 5G cellular standard and show that rather being a threat to Telicomm's solution, it **opens a huge business opportunity for Telicomm's technology: once 5G is there, Telicomm will solve the video connectivity over 5G.**

2. 5G OVERVIEW AND TRENDS

5G (Also known as "5G NR", 5G New Radio, by the industry project 3GPP) is the fifth-generation wireless technology for digital cellular networks that began wide deployment in 2019.

5G standard promises higher speeds, lower latency and better robustness than current 4G systems.

The frequency spectrum of 5G is divided into:

Low-band: Uses similar frequency range and offers similar speeds and capacity as 4G.

Mid-band: Uses frequencies from 2.4 GHz to 4.2 GHz (usually between 3.3 GHz and 4.2 GHz). This is the most widely deployed with typical downlink speeds (in a 100 MHz band) of 100–400 Mbps. Many areas can be covered simply by upgrading existing towers, which lowers the cost.

High-band (millimeter waves): Uses frequencies above 24GHz. Thanks to the large available frequency, this band supports the highest speeds of up to 1Gbps. Due to the high frequencies used and the difficulty to traverse obstacles, the reach is short and coverage is limited.

5G latency is typically ~30 ms, 25–40% lower than typical 4G.

This is comprised of:

- The "air latency" (between a phone and a tower).
- The latency to the server, further back in the network.

Adding "Edge computing" (see below) close to the towers can bring latency down to 10–20 ms.

Below a list of new technologies that are part of 5G:

- **Massive MIMO**: Massive MIMO (multiple input and multiple output) antennas increases sector throughput and capacity density using large numbers of antennas and Multi-user MIMO (MU-MIMO). Each antenna is individually-controlled and may embed radio transceiver components. Nokia claimed a five-fold increase in the capacity increase for a 64-Tx/64-Rx antenna system.
- **Edge computing:** Edge computing is delivered by computing servers closer to the ultimate user. It reduces latency and data traffic congestion.
- **Small cell:** Small cells are low-powered cellular radio access nodes that operate in licensed and unlicensed spectrum that have a range of 10 meters to a few kilometers. Small cells are critical to high-band 5G networks, as 5G's higher frequencies radio waves can't travel long distances.
- **Beamforming:** Beamforming is used to direct radio waves to a target. This is achieved by combining elements in an antenna array in such a way that signals at particular angles experience constructive interference while others

experience destructive interference. This improves signal quality and data transfer speeds. 5G uses beamforming due to the improved signal quality it provides. Beamforming can be accomplished using Phased array antennas.

- **Wifi-cellular convergence:** One expected benefit of the transition to 5G is the convergence of multiple networking functions to achieve cost, power, and complexity reductions. LTE has targeted convergence with Wi-Fi band/technology via various efforts, such as License Assisted Access (LAA; 5G signal in unlicensed frequency bands that are also used by Wi-Fi) and LTE-WLAN Aggregation (LWA; convergence with Wi-Fi Radio), but the differing capabilities of cellular and Wi-Fi have limited the scope of convergence. However, significant improvement in cellular performance specifications in 5G, combined with migration from Distributed Radio Access Network (D-RAN) to Cloud- or Centralized-RAN (C-RAN) and rollout of cellular small cells can potentially narrow the gap between Wi-Fi and cellular networks in dense and indoor deployments. Radio convergence could result in sharing ranging from the aggregation of cellular and Wi-Fi channels to the use of a single silicon device for multiple radio access technologies.
- **NOMA (non-orthogonal multiple access):** a proposed multiple-access technique for future cellular systems via allocation of power.
- **Network slicing:** network architecture that enables the multiplexing of virtualized and independent logical networks on the same physical network infrastructure. Each network slice is an isolated end-to-end network tailored to fulfil diverse requirements requested by a particular application. The realization of this service-oriented view of the network leverages on the concepts of software-defined networking (SDN) and network function virtualization (NFV) that allow the implementation of flexible and scalable network slices on top of a common network infrastructure.
- **Channel coding:** The channel coding techniques for 5G NR have changed from Turbo codes in 4G to polar codes for the control channels and LDPC (low-density parity check codes) for the data channels.
- **Operation in unlicensed spectrum:** Like LTE in unlicensed spectrum, 5G NR also supports operation in unlicensed spectrum (NR-U). In addition to License Assisted Access (LAA) from LTE that enable carriers to use those unlicensed spectrum to boost their operational performance for users, in 5G NR it supports standalone NR-U unlicensed operation that allows new 5G NR networks to be established in different environments without acquiring operational license in licensed spectrum, for instance for localized private network or lower the entry barrier for providing 5G internet services to the public.

3. 5G EXPECTED TRENDS

Below are expected 5G trends for the next 3-5 years. Information is based, among other resources, on information from CTO offices at Ericsson and Nokia.

The metropolitan infrastructure is expected to be based on the 3-4 GHz mid-band with up to 100MHz per carrier frequency. Division between downlink and uplink will continue to be in the range of 70% (DL) to 30% (UL).

Thanks to the wider frequency band as well as other 5G-NR improvements, uplink data-rates in the metropolitan cellular network are expected to improve between 3x to 6x compared to 4G.

High-band networks are expected to be dedicated infrastructure for industry, robotics, and other such applications where very low latency and very high data-rates are required.

These networks will give significant improvement over 4G in BW (up to 400 MHz) and latency (approaching 1ms) at the cost of very short range (up to 100m).

Out of the various 5G technologies, edge computing is expected to reduce significantly the end-to-end latency over the cellular network and enable new applications.

4. TELICOMM TECHNOLOGY TOWARDS 5G

As detailed above, although 5G promises higher BW, in the metropolitan networks that will work in the 5G mid-band, uplink data-rates are expected to improve between 3x to 6x compared to 4G.

This will come alongside with significantly higher demand for uplink data-rates due to increased number of users and applications.

On the video side, higher quality video requirements of video analytics (VA) systems together with migration to Ultra-High-Definition video (UHD) will further increase the BW requirements.

It is clear that video surveillance over 5G networks is a main use case for 5G networks, and optimal management of the video over 5G network is a must.

Such management cannot be done merely within the cellular domain.

Only a management system, such as Telicomm's, that takes into account both the cellular capabilities as well as the video management systems (VMS) and VA requirements can give an adequate solution.

As Telicomm's P-VAN™ technology is readily adaptable to 5G networks, **this opens a huge business opportunity for Telicomm's technology: once 5G is there, Telicomm will solve the video connectivity over 5G.**

5. SUMMARY

Although the new 5G cellular standard opens new frequencies and increases overall supported data-rates, it does not improve significantly enough the uplink rate required for camera connectivity in the metropolitan networks of the upcoming years.

This was validated both by detailed study of the new standard as well as information from multiple 5G leaders: Nokia, Ericsson and others. Furthermore, due to increased camera resolution and higher number of users and applications, **the bandwidth limitation for connecting multiple cameras over cellular will remain in 5G networks**.

On the other hand, since 5G significantly improves the robustness and reliability of the network, many customers will prefer to connect IoT, sensors and cameras over Cellular.

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