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5G and 6G: Smart Connectivity in the City of the Future

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From autonomous cars to unmanned drones and on-demand air taxis — the smart city of the future will enable individual mobility at all times. New concepts are already needed today. Concepts that must be able to monitor and control traffic flows in a comprehensive, autonomous, intelligent, and real-time manner. To realize such a future, not only are data-based solutions necessary, but also network infrastructures that can transmit data as close as possible to instantaneously, with as little latency as possible. Particularly with regard to autonomous driving, the smart city places high demands on low latency.

For context, a person's reaction time can be 0.5 seconds. An autonomous driving stack needs almost super-human performance with significantly lower reaction times, with end-to-end latencies as low as 50 to 100 milliseconds for perception, planning, and driving functions. To move people and vehicles safely, quickly, and reliably through the mobility world of tomorrow, smart control systems must be able to recognize critical situations in advance and control autonomous traffic in real time.

Whether it's smart traffic control centers or clever applications that make cities cleaner, more livable, and more sustainable, services like these also enable new business models. Revenues in global smart cities markets are forecast to reach more than $72 billion in 2024, with Asian markets like Singapore currently in the lead. And the growth is set to continue, rising to over $100 billion worldwide by the end of the decade if the technological conditions are right. 5G is a good example of this. Already today, 5G enterprise IoT connections outpace consumer connections, and are expected to double by the end of the decade. With an estimated 1.6 billion connections in total in 2024, 5G is expected to become the dominant mobile technology by 2029, according to the data from the GSMA (Global System for Mobile Communications Association), but even then it will still only cover 56 percent of the world's population.

Smart City with 5G: Sharing and Processing Data

As a complete technology stack, 5G offers numerous advantages over previous versions. For example, software-integrated functions can be linked, services can be virtualized, and edge networks can be operated. Data can be transmitted at speeds of up to 20 Gbit/s, and more reliably than with previous mobile phone technologies. Not only does 5G make better use of the available bandwidth

than previous standards, but it also achieves a coverage density of up to one million devices per square kilometer. This improves mobile Internet coverage in a full football stadium or during an open-air event. In addition, 5G makes it possible to orchestrate many IoT devices to share and process data for smart city services — from smart garbage cans to real-time traffic control. No wonder some analysts estimate that the 5G IoT market will secure a CAGR of 31.1 percent from 2023 to 2033 and reach $55.1 billion by 2033.

Mobile communications also ensure smooth processes elsewhere. For example, cities can use digital 3D models to map construction sites in order to better plan, control, and document the work. Cameras and sensors transmit images and data to the construction teams. Similarly, 5G can be used to monitor the structural integrity of bridges to prevent collapses or, thanks to alarm systems, to respond quickly in an emergency. Connected garbage cans automatically report when they need to be emptied. Smart meters can be read remotely. And sensors also measure water consumption or air pollution. In public buildings, heating and air conditioning are controlled on the basis of the measured temperature and humidity, and ventilation on the basis of oxygen levels.

Real world examples include San Francisco, which deployed 1,000 IoT sensors for waste management, decreasing the city's overflowing trash cans by 80 percent. In Colombia, the city of Cartagena uses a smart irrigation system for the efficient use of water. Not only does it monitor soil conditions to maintain the city's parks and gardens, but it can also detect leaks in real time to avoid water wastage and, importantly, avoid puddles that can lead to soil erosion and the accumulation of mosquitos. Back in the States, Chicago's Array of Things initiative has sensors across the city to monitor air quality, including sound and vibration. This data can be used to suggest the walking routes and times with the least pollution around this busy, futuristic metropolis.

Digital Twins: the 6G Application of the Future

The successor to the existing mobile communications standard, which builds on the advantages of 5G, is already at the starting blocks. 6G is expected to be available by the end of this decade, offering greater performance, a range of new functions, and is projected to power future smart cities thanks to its increased speeds and enhanced robustness. According to a study by Capgemini, 6G will eclipse 5G. The standard will enable data transfers of up to 1 terabit per second (Tbit/s), latency times of 10 to 100 microseconds, a supply density of ten million devices per square kilometer, and a five fold more efficient use of the radio spectrum. Thanks to all this, 6G is considered an enabler for digital twins.

Digital twins are considered to be one of the most important 6G applications of the future. Smart city planners can use digital twins to create digital duplicates where the real and virtual worlds merge with each other in simulations. Not only to map and smartly control all traffic flows, but also all procedures, processes, and workflows in an entire city — from the individual intelligent pedestrian light and connected garbage can to decentralized power production from distributed wind turbines, solar parks, and cogeneration plants. When connected, data can be processed in the digital twin, linked across systems and used to create new digital services. In addition, 6G integrates different systems and platforms, from antennas on the ground to satellites in space, to provide seamless mobile coverage. 5G Advanced is scheduled to launch this year, ahead of 6G availability. 5G Advanced forms the foundation for the future 6G technology stack and extends existing 5G functions (for example, to integrate AI applications).

Data Center Meets Mobile Communications: Mobile and Interconnected

To connect cars, people, and devices in the smart city a suitable mobile coverage is necessary. This is the only way to collect information across the board and also process it in a smart way. Corresponding terrestrial network technology and other digital infrastructure are also needed. This is the only way to exchange large amounts of data in real time and across domains. For this level of networking, as well as for processing and analyzing data for forecasts, adjustments, and optimizations, an increasing number of interconnected data centers are needed in addition to mobile connectivity.

Many cities are already collecting and analyzing their data centrally on open cloud platforms. To be able to transfer large amounts of rapidly changing information in real time, high-performance interconnection is required. This will call for the development of a suitable infrastructure in the coming years. The goal: to be able to transfer big data with low latency and high bandwidth. An architecture that is designed to process decentralized data in such a way that it is comprehensively networked makes interconnection platforms the centerpiece of any smart city connectivity strategy. These not only ensure more stable Internet connectivity through direct interconnection and peering services, but also cloud connectivity through cloud exchanges and cloud routers. The operator of an interconnection platform can thus ensure secure, reliable, and high-performance data transmission.

High-performance Infrastructure Maximizes Performance and Minimizes Latency

One thing is certain: the performance and intelligence of all mobile applications in the smart city can only be as good as the infrastructure on which they are operated. Without a high-performance connection to clouds, mobile and fiber optic networks, and geographically distributed data centers, the desired latency times and speeds cannot be achieved. Only with a high-performance infrastructure for data exchange can 5G and 6G-based mobile devices, sensors, and smart city applications realize their full potential.