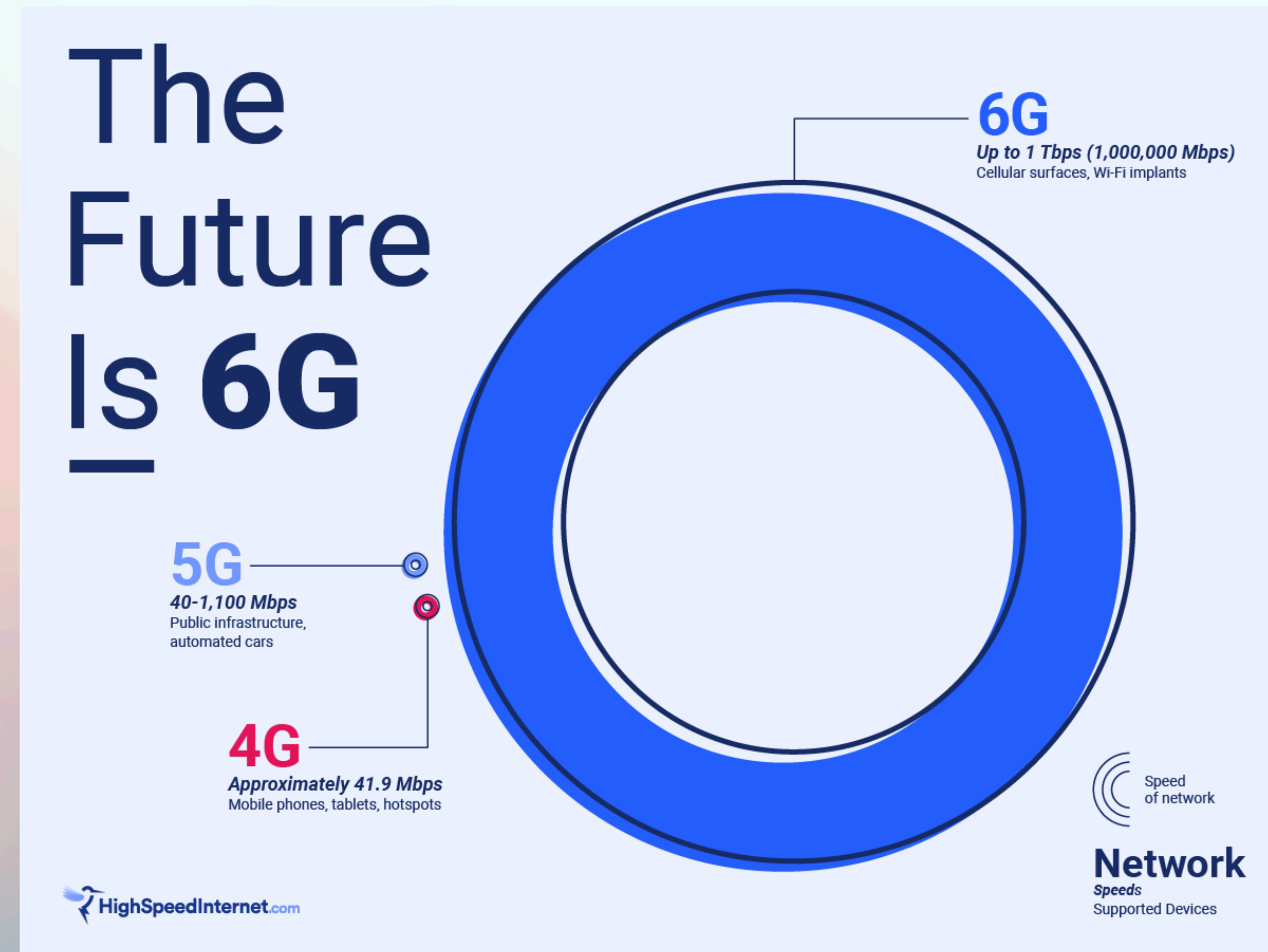


5G/6G Connectivity with AI-Powered Mini Towers

Improving Indoor Coverage, Network Efficiency, Reducing network congestion with AI based routing

Challenges faced by network advancements of 5G deployment

- 5G, especially its mmWave (millimeter wave) variant, struggles with *penetration through buildings* and other obstacles.
- Devices using mmWave 5G expend more energy trying to maintain a *stable connection* with distant towers, leading to *higher power consumption* and *overheating* issues in smartphones.
- 6G is expected to utilize even higher frequency bands than 5G, which will likely exacerbate the penetration and coverage issues. These higher frequencies are more *prone to being blocked* by physical obstacles, further diminishing indoor coverage.
- 6G will likely aim for even *lower latency* targets than 5G. However, the higher frequencies used could mean that any physical barrier, no matter how minor, might significantly affect *signal quality and latency*.
- The push for higher data rates and lower latency with 6G could further strain the *energy efficiency* of devices. This would likely lead to even greater overheating problems.



Source: [HighSpeedInternet.com](https://www.HighSpeedInternet.com)

Proposed Solution

AI-powered mini towers

- Standalone mini tower with lower power usage. Jio AirFiber uses a similar tech, Where an outdoor unit is installed in the house, and an indoor unit is installed, and where router is setup and the network is utilised through wifi. The proposed solution is similar.
- A lot of people have used dongles/similar hotspot devices, so the market on buying a small device is good and is considered a good investment. A mini tower could be a good solution, where the mini tower operates under existing towers. Mini towers integrate seamlessly with existing telecom infrastructure, extending network reach. This Significantly improves indoor connectivity for mobile network users. As the outdoor unit is optimised to receive good network, the phones indoor will be connected to it, and will receive better connection.
- 5G, 6G mmWaves doesn't have to penetrate through a lot of environment. This reduces a huge strain on the SoC(network modules in devices) and battery of mobile devices. Easily deployable across urban and rural areas, they just have to be connected under the existing towers. Just the outdoor unit for better connectivity.
- AI: AI-driven data routing enhances overall network efficiency and performance. With AI routing the network, network congestion could be reduced. Devices have been equipped with AI and dedicated ML cores for a long time now, so if the radio network is AI-enabled then a seamless network experience could be guaranteed. "Research results demonstrate substantial performance gains in terms of throughput (up to 30%), signaling overhead reduction (more than 30% reduction with the same performance), and other KPIs like energy efficiency." (Source: Nokia)
- Another perk of this being AI is that, the device posses knowledge, i.e, it could be designed to be a peer to peer network. A network of these mini towers, this can lead to better routing, and lesser network congestion as there are many possible ways to route. AI-driven data routing enhances network efficiency and performance.
- This could also be potentially mass produced for various other kind of devices/vehicles/private buildings/rails etc.

Technical Architecture Concept

- **Outdoor unit:** An outdoor unit is installed externally on the consumer's household, as requested by the consumer. This ensures optimal signal reception from the broader 5G/6G network. Positioned on rooftops or exterior walls, it captures signals with minimal obstruction, maximizing the data rate and connection stability. This unit is equipped with advanced antenna technology capable of receiving high-frequency signals, including mmWaves. This also would greatly contribute to the E-Band microwave performance. (*Source: Nokia, Case study "E-Band microwave backhaul performance field-proven under heavy rainfall"*)
- **Indoor unit:** This personalised for consumer unit distributes the received signal from the outdoor unit throughout the interior space. It creates a local coverage area, ensuring strong and reliable connectivity for all devices within its range. This unit supports multiple frequency bands to accommodate high data throughput and numerous simultaneous connections. Its seamless integration with the outdoor unit ensures low-latency communication. High-quality connectivity for various applications, from smart home devices to immersive entertainment is ensured.
- **AI Module:** The AI module is an integral part of the system, responsible for managing data routing and optimizing network performance. Utilizing advanced machine learning algorithms, it analyzes network traffic patterns, predicts demand, and dynamically adjusts resource allocation to maintain optimal performance. The AI module enhances the efficiency of both the indoor and outdoor units by reducing latency, improving data throughput, and ensuring balanced load distribution.



Image representing Jio AirFiber outdoor unit. Source: Google

Benefits and Value Proposition

- **Enhanced Coverage:** Significantly improves indoor connectivity for both WiFi and mobile network users.
- **Scalability:** Easily deployable across urban and rural areas. Consumer can request, and upon request the module can be installed.
- **Cost-Effectiveness:** Low-cost solution leveraging existing infrastructure. Consumer will be paying a small deposit for the unit as an one-time investment, thus will be very cost-efficient.
- **Peer-to-Peer Support:** AI-driven data routing enhances overall network efficiency and performance. Peer to peer network while the device is idle. This also means that, as more contributors rise in the network, the coverage could be expanded aswell.

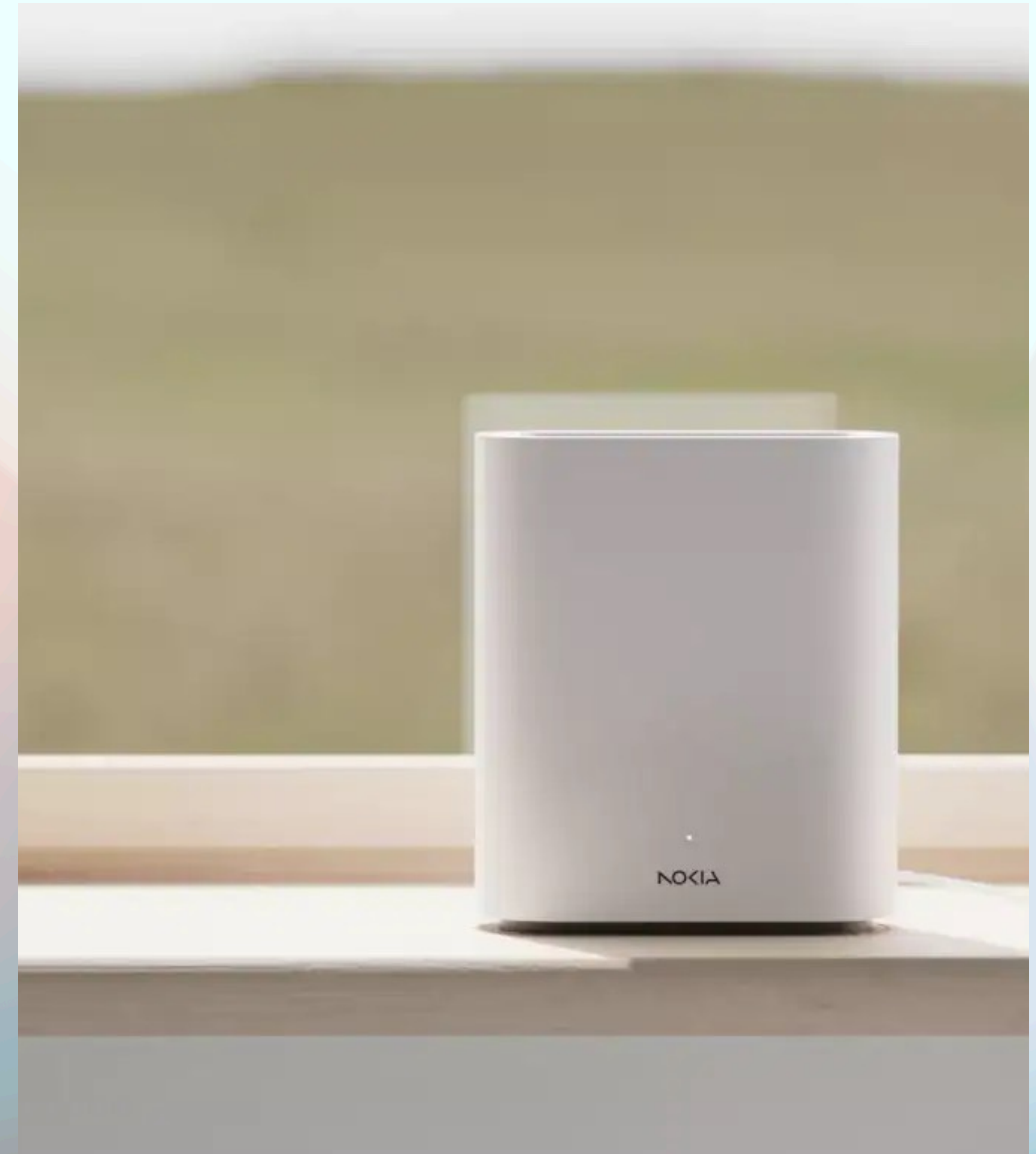


Image Representing Nokia FWA Source: Nokia

Role of AI in networking

- There are numerous facets of wireless technology capabilities that can be enhanced with AI including, but not limited to, power saving, channel estimation, positioning, MIMO detection, environmental sensing, beam management. Network optimization involves improving computer networks' performance, efficiency, and reliability. It involves analyzing and fine-tuning various network components. AI can help telecom businesses gain a competitive edge by improving their operations and customer experience.
- *"It's impossible to overstate the growing influence that AI will have"* - Nokia on AI.
- *"AI adoption is essential to efficient network management and operations"* - Jonas Åkeson, Head of Automation & AI, Ericsson.
- *"In the future, sub-meter level positioning is hoped for, alongside the expansion of network fingerprint dimensions and more innovative applications"* - Huawei, MWC 2018

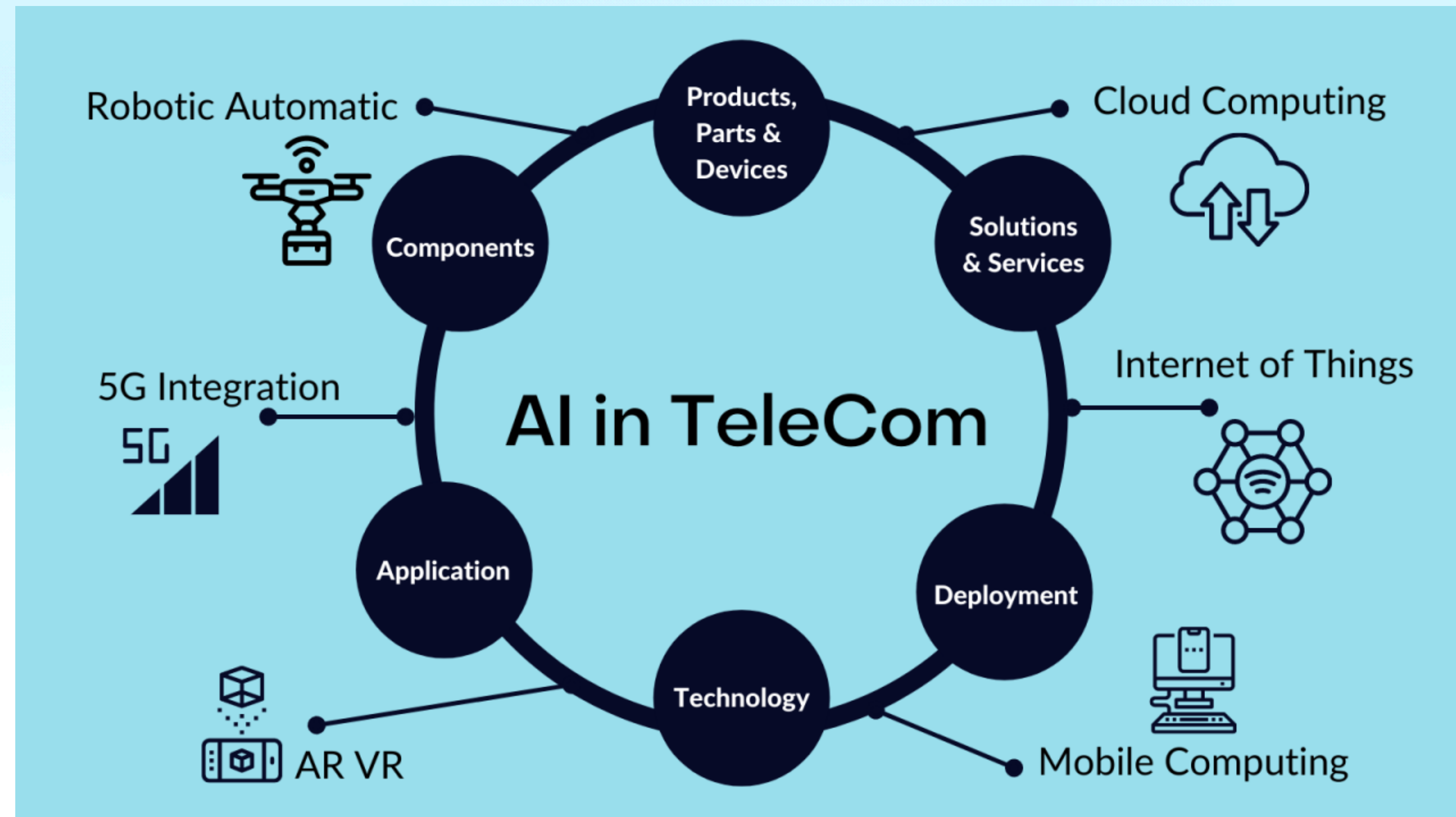


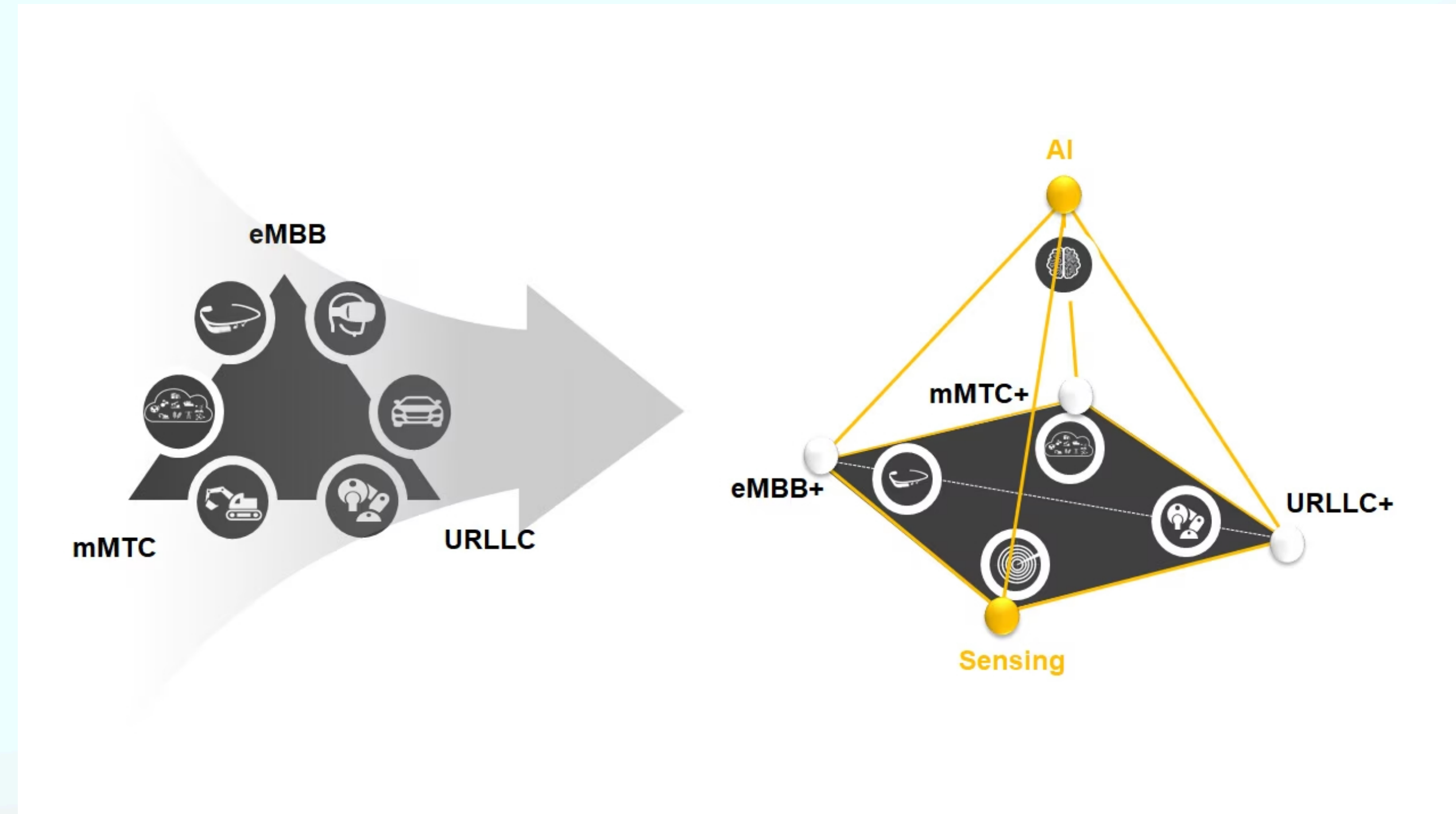
Image source: LinkedIn

6G and Innovations

- 6G, the sixth generation of cellular networks, will revolutionize connectivity by merging digital and physical realities. Key technologies include advanced AR, zero-energy sensors, and cognitive networks, enabling applications like precision healthcare, smart agriculture, and immersive XR experiences. 6G aims to support intelligent machines and the Internet of Senses.
- Research areas focus on network fundamentals, automation, and semiconductors. Innovations like L4S (Low Latency, Low Loss, Scalable throughput) drastically reduce latency, essential for next-gen applications. L4S flips the dynamic by focusing on the lowest latency, which is key for next generation use cases like extended reality and interactive video conferencing, and mission-critical services such as remote driving and medical procedures. (Source: Nokia)

Importance deploying these network advancements across diverse fields

- Enhanced Mobile Broadband (eMBB) will enable a range of use cases in entertainment, education, manufacturing, and navigation, transforming the way we live, learn, work, and travel. Seamless user experience in the target activity areas must be guaranteed along the E2E routes of activities, regardless of the high mobility in extreme cases.
- URLLC is the continuous evolution of ultra-reliable low-latency communications (URLLC) for critical machine-type communication in Industry 4.0 and beyond. AI can improve the latency significantly by better network routing, during network congestion.
- Massive Machine Type of Communication (mMTC), 5G focused on connecting various IOT alike machine devices, with 6G advancements, these devices can be pushed forward to greater extents. Home devices requiring pull, push requests/packet arrival time at millisecond level latency could be established.
- AI will be a massive factor in pushing forward these technologies to greater boundaries.



Source: Huawei

Conclusion

- This new era has seen a substantial increase in data consumption, with 5G users consuming 3.6 times more data than their 4G counterparts, leading to a remarkable monthly mobile data traffic of 17.4 EB in 2023. The report projects that by 2026, 5G will contribute 310 EB annually, with a subscriber base of 575 million, driven by enhanced 5G availability, affordable devices, and data-intensive applications. (Source: Nokia)
- The integration of AI-powered mini towers presents a promising solution to address the challenges of connectivity in the context of 5G and the anticipated hurdles of 6G. By leveraging AI to optimize signal strength and network efficiency, these mini towers offer enhanced coverage for users, improving user experience and service quality. The scalability and cost-effectiveness of this solution make it viable for deployment across urban and rural areas, paving the way for seamless transition to future generations of wireless technology.