Zeblok COMPUTATIONAL

TRUE 5G MOBILITY TECHNICAL POSITIONING PAPER

Bringing Unified Orchestrator for intelligent mobility to the disconnected, degraded, intermittent and areas with limited communication

LEGACY MOBILE GENERATIONS

In order to appreciate 5G, it is useful to recall the basic purpose of legacy generations.

- First Generation: focused primarily on technologies to provide access to the existing public fixed line telephony network at the time, the PSTN. Collections of non-interoperable standards were used to deploy these networks, and the radio technology was primarily based on analog wireless.

- Second Generation: 2G mobile wireless was the first attempt at a Global System (hence the name Global System for Mobile (GSM)) and was also the first attempt at:
  - A digital telephony standard. The key ingredients included a multiple access radio technology based on time division principles, and an architecture that was primarily circuit-switched.
  - Use cases were primarily centered around two killer apps: Voice and SMS.
  - North American 2G systems were deployed using ANSI-41 architectures and used a mixture of time division and early code division multiple access technologies.

- Third Generation: The key ingredients and use cases of 3G mobile wireless include: Hybrid packet and circuit switched architecture, based on two competing standards (3GPP and 3GPP2)
  - Radio technology is based on Wide-band Code Division Multiple Access (W-CDMA)
  - Primary use-cases include Voice, SMS, Email, and general mobile wireless internet access (including WAP)
- Fourth Generation: 4G was the first attempt to create a broadband mobile wireless system. Key ingredients and use cases include: A universal packet switched mobile wireless architecture based on a System Architecture Evolution of 3GPP (3PP-SAE)
  - Radio technology based on Orthogonal Frequency Division Multiple Access (OFDMA). This radio technology is referred to as Long Term Evolution (LTE) and continues to be a central ingredient of 5G and emerging 6G (true to its name of Long Term)
  - Service architecture based on IP Multimedia Subsystem standards (IMS)
  - Primary drivers and use cases leveraged the growth of broadband video and other multi-media technologies, in addition to voice, SMS, migrating to IMS

An overview document covering the “Why & What” of 5G, particularly for Disconnected, Degraded, Intermittent, and Limited communications

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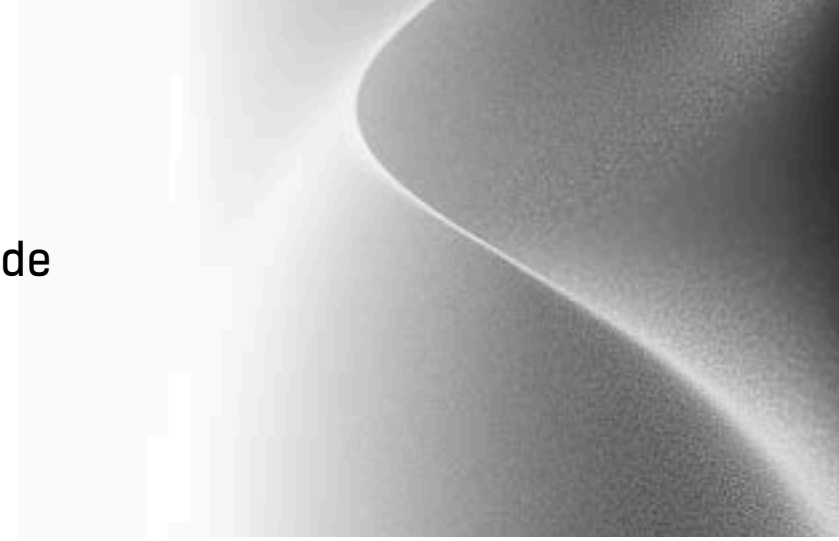
Important Use Cases

- Realtime data view, monitoring and descriptive data
- Quality indicators & anomaly alerts
- Predictive analytics, defect and consumption
- Extensible platform will incorporate IoT sensors, and computer vision with minimal effort

Zeblok brings AI Stack and Mobillty Stack closer to Data. Zeblok is uniquely positioned at the intersection of most innovative technologies such as ML Dev Sec Ops, Edge AI, Edge MEC, Quantum Cryptography and Zero Trust. It’s flagship product Ai-MicroCloud delivers capabilities through its ecosystem.

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Bringing Private Mobile Network inside and outside large building and workspaces

WHY 5G?

Limitations of 4G: In 4G networks, most data processing occurs in centralized cloud and/or core network locations, which introduced higher latency and limited the ability to support real-time applications. This is primarily due to a centralized architecture that is intended to provide access to mobile applications in the cloud. This introduced higher latencies (compared to fixed line WiFi), limited the richness of video content to serve lower definition video through adaptive bit-rate technologies, and was not inefficient at handling IoT devices.
5G standards addressed these limitations comprehensively through:

- eMBB with massive MIMO
- Massive IoT (mMTC)
- URLLC – Ultra Reliable Low Latency Communications

5G APPROACH

A crucial observation that highlights a key distinction between 5G and previous cellular generations. While earlier transitions from 1G to 4G were marked by radical shifts in radio access technology (RAT), 5G builds on 4G's foundational RAT (OFDMA) while focusing on architectural innovation and spectrum expansion. Notably, this led to Radio Access Technology Continuity, i.e., OFDMA in 4G vs. 5G

- 4G LTE: Uses Orthogonal Frequency-Division Multiple Access (OFDMA) for downlink and Single-Carrier FDMA (SC-FDMA) for uplink. OFDMA splits bandwidth into smaller subcarriers to improve spectral efficiency and handle high data rates.
- 5G NR (New Radio): Retains OFDMA but introduces scalable numerology, allowing flexible subcarrier spacing (15, 30, 60, 120 kHz) to support diverse use cases. This flexibility is a major refinement over 4G.
- The primary reasons for this persistence in RAT include: OFDMA was already highly efficient for handling high data rates and mitigating interference.
- Retaining OFDMA simplified backward compatibility (e.g., 5G NSA networks rely on 4G cores) and accelerated deployment.

While OFDMA remains foundational, 5G introduced critical advancements:

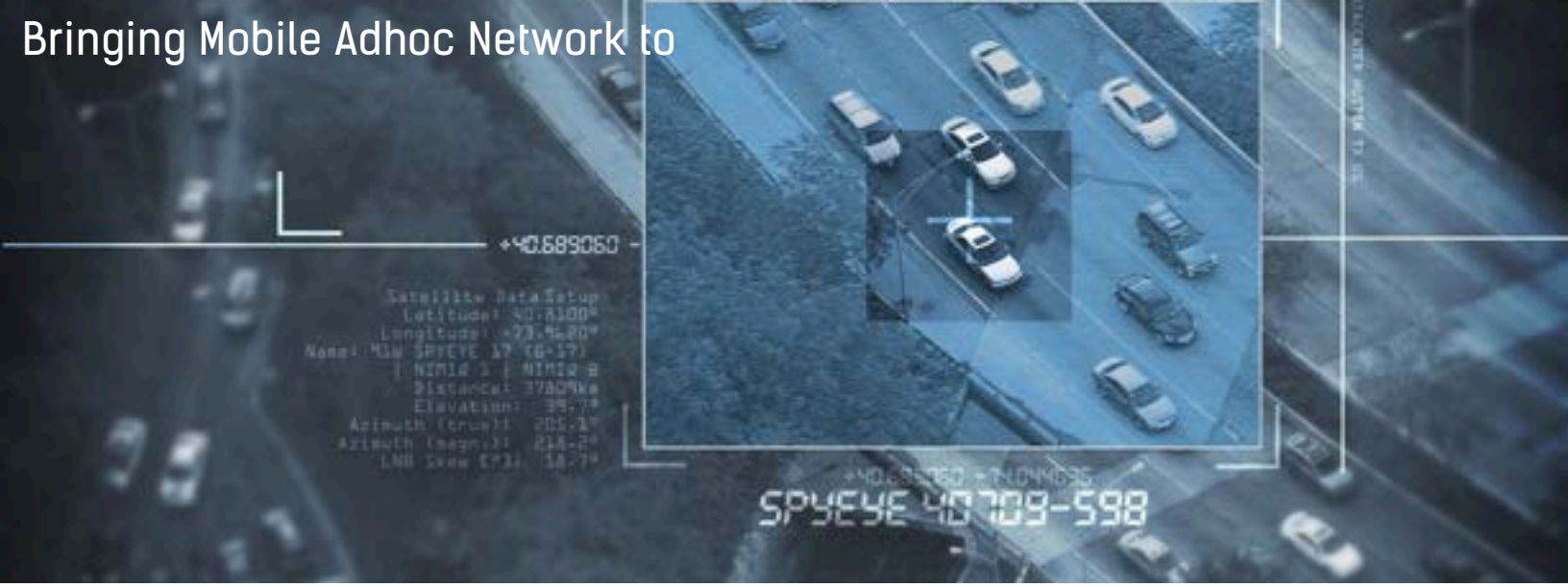
- Millimeter Wave (mmWave): Uses high-frequency bands (24–100 GHz) for extreme bandwidth, though with limited range.
- Massive MIMO: Deploys hundreds of antennas to boost capacity and coverage.
- Beamforming: Focuses signals directionally to improve efficiency.
- Dynamic Spectrum Sharing (DSS): Allows 4G and 5G to coexist on the same spectrum.
- Network Slicing: Creates virtualized sub-networks tailored to specific use cases.
- MEC: Multi-access Edge Computing

Moreover, 5G innovations focus on software-driven agility rather than reinventing the traditional monolithic appliance approaches. A few crucial enabling technologies include:

- Software driven Mobile Networking – this includes Control-Plane-User-Plane Separation (CUPS), CU-DU architectures in the RAN
- Cloud Native software Architectures – example: Docker plus Kubernetes for all 5G functions
- Unified edge-to-cloud orchestration across every architectural layer – RAN, Edge, Core, and Applications – that embraces cloud native technologies to simplify and realize functionality such as Slicing and new use cases.
- Open systems approach to leverage and expand on existing mature ecosystems

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Bringing Mobile Adhoc Network to



ASHIFT IN PRIORITIES

The decision to retain OFDMA reflects a broader trend in mobile telecommunications. Cost Efficiency with combination of “stand alone” and “evolutionary” deployment models that avoid “rip-and-replace” upgrades by building on 4G. Leveraging 4G ecosystems maturity and expand in new ways. Focus on new use cases, including (but not limited to) **Private Mobile Networks** and **Mobile Adhoc Networks** like Smart factories, smart cities, smart buildings, Drone-tech, etc. Spectrum sharing technologies, like CBRS

MEC: CRITICAL 3GPP INNOVATION FOR 5G

Mobile Edge Computing (or Multi-access Edge Computing) is a network architecture that processes data closer to the user/device by leveraging edge nodes rather than centralized cloud servers. This proximity reduces latency, enhances real-time decision-making. The standardized version of an MEC architecture is purpose built to satisfy two critical requirements – namely, Ultra Reliable Low Latency (URLL), and Ultra High Definition (UHD) communications. Notable, MEC as a concept was not part of the original 4G standards. MEC was introduced as a response to the growing demand for low-latency, high-bandwidth applications and became a key enabler in the 5G ecosystem.
MEC is Integral to 5G. MEC complements 5G by leveraging its high-speed, low-latency capabilities to enable advanced use cases. Moreover MEC the following important features:

- Reduces network congestion in addition to latency
- Supports applications requiring real-time responsiveness
- Supports applications that require High Definition
- Delivers distributed services efficiently
- Delivers on finer granularity QoS and SLAs
- Supports the enforcement of security policies at the edge on a per UE and per application basis, while maintaining centralized management control.

The combination of efficient distributed service execution, coupled with granular security and QoS policies, creates the opportunity for a wide range of secure next generation services including private mobile networking services.

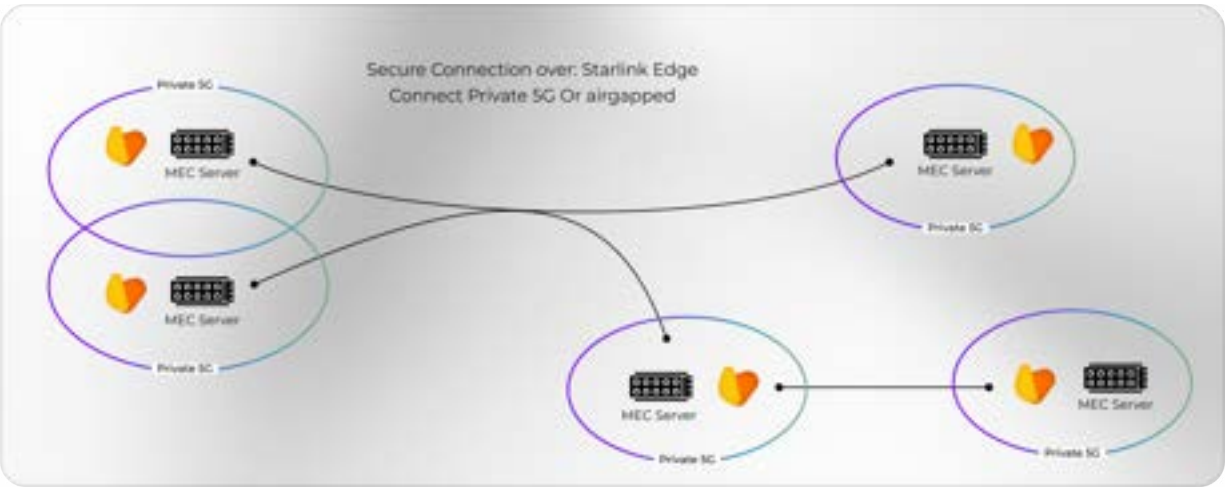
How MEC Works: MEC operates by deploying computing resources at the edge and manages such resources on an on-demand basis, by orchestrating compute, memory and storage across a collection of edge nodes placed closer to devices generating / consuming data. This decentralized approach minimizes the need to transmit large volumes of data to distant cloud servers, enabling faster processing and decision-making locally. Policy enforcement is supported through a mixture of secure interfaces between edge nodes and centralized management nodes.

EDGE-TO-CLOUD UNIFIED SOFTWARE ORCHESTRATIOIN

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Given the adoption of software driven mobile networking architecture (discussed above) by 3GPP into 5G standards, most implementations are dominated by cloud native software technologies involving containerization and orchestration. Recall, the need for orchestration (with corresponding intelligent controllers aka orchestrators) applies to: Software defined RAN, Software defined Core, Mobile Edge computing, Network slicing, and 5G use-cases

Additionally, given the maturity of a diverse ecosystem, multi-vendor collaboration is necessitating a unified orchestrator across layers that is in turn catalyzing open 5G initiatives. Simply put, orchestration involves the concept of selective placement and invocation of a subset of software microservices of any software system related to a 5G deployment and use-case. Unified Orchestration, also referred to as Edge-to-Cloud Orchestration, allows for a unified controller that scales and supports multiple vendors seamlessly. Moreover, this allows for rapid development / deployments of new “Apps” in every layer – RAN/Core/Edge/Cloud!



Key Benefits of Unified Orchestration include:

- Critical requirement for Network Slicing
- Efficient realization of URLL and UHD communications
- Bandwidth Efficiency: Reduces data transmission costs by processing at the edge
- Lower software footprint at the edge, by selective placement of specific micro-services in real time

- Enhanced Reliability: Operations can continue even with intermittent cloud connectivity
- A few Concrete Examples RAN Apps: Unified Orchestrators, include software components that act as the "brain" of Private 5G RAN systems. It uses AI/ML and real-time data to optimize RAN performance, enabling dynamic control of radio resources (e.g., spectrum, power, beamforming). Unlike legacy RAN systems (which relied on proprietary, vendor-locked hardware), the Unified Orchestrator operates in a multi-vendor-neutral framework, fostering interoperability.
- Network Slicing: As noted earlier Unified Orchestrators are critical for Network Slicing. They act by allocating optimal resources for “slices” of traffic across traffic types as well as on a per-device basis. One of the key ingredients of slicing is the use of AI/ML algorithms to decide on various rules dynamically, which are then enforced at the appropriate layer by the Unified Orchestrator.
- Core Apps: This refers to near-real-time and real-time analogs for optimized use and multi-vendor neutral frameworks in the core, using Unified Orchestrators.

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