5G Network Slicing Management for Challenged Network Scenarios

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1 5G "CHALLENGED NETWORK" SCENARIOS / 5G NETWORK SLICING

The 5th generation of mobile networks (5G,[1,2,3]) differs significantly from prior generations in that the service types of "critical Machine Type Communication" (cMTC) and "massive Machine Type Communication" (mMTC) are regarded as key drivers (in addition to providing mobile broadband access). This leads to challenging requirements in terms of network scale (number and distribution of connected devices as well as network elements/functions), low latency (*<10 ms* e2e latency) and high resilience, in addition to the general, ever-increasing need for virtually "ubiquitous" coverage and virtually "unlimited" capacity.

The envisaged diversity of service types implies also a wide range of deployment and operational network scenarios. Examples include vehicular, UAV [4], public safety and disaster response networks. But e.g., also factory automation networks [5] exhibit drastic requirements like frequent changes in the equipment setup and surrounding conditions, thereby affecting the device and network setup incl. the radio propagation conditions and network topology. Furthermore, such scenarios exhibit combined local and wide area communication requirements.

Hence, a significant part of the network scenarios 5G aims to address can be considered "challenged networks". The key aspect here is to realize 5G as the unifying wide area mobile networking technology covering "challenged network" scenarios together with more traditional but also highly demanding scenarios (like providing ultra-broadband capacity in metropolitan hotspots).

Besides the 5G "New Radio" technology, several key architectural building blocks to address the described 5G requirements are being developed. These include

- Multi-connectivity (resilience)
- Ultra-dense small cells (capacity)
- Virtualized (radio access) networks allowing for variable network architecture instantiations (flexibility / programmability, cost efficiency)
- Mobile edge computing (low latency / traffic localization, multi-tenancy)

In addition, a key concept combining all of the above building blocks is network slicing. A network slice is a logical instantiation of an e2e network available to a specific group of users / devices and managed by a "tenant". Research in network slicing is about:

- Mapping different resources (radio scheduler, RAN/core network functions, transport network connectivity) into the slice instance and managing them over time
- Making the slice instance available to a tenant and managing the slice instance during deployment and operation

2 5G NETWORK (SLICING) MANAGEMENT

Considering all of the 5G characteristics introduced above, it is clear that Network Management (NM) concepts for 5G networks are crucial to deal with the anticipated network and service complexity. NM addresses the cost efficiency for 5G deployment and operation, making 5G economically viable. The baseline are existing 3GPP "Self-Organizing Networks" (SON, [6]) concepts across the areas of configuration, optimization and troubleshooting / healing.

However, due to the anticipated network and service dynamics and distribution, 5G NM will be largely "data driven" where static management rules and algorithms will be replaced by learning "cognitive" management functions which are able to adapt to different network instantiations and operating points. Furthermore, novel requirements like, e.g., the joint optimization (scaling) and troubleshooting (diagnosis) of physical and virtualized resources need to be addressed.

Network Slicing Management thus consists of combining the different cognitive management capabilities at the network function-level and making them "slice-aware". Additionally, at

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the network slice instance level, a dedicated slice lifecycle management, optimization and troubleshooting with feedback to the slice tenant is required [7]. The Network Slicing Management also includes generic building blocks like the maintenance of the slice management knowledge both wrt. separation (isolation of slices) and sharing (for the operator of the physical network infrastructure) and a policy framework (to derive low-level function targets from high-level tenant objectives / intents).

In summary, with 5G Network Slicing Management, slice tenants and network operators will be enabled to manage diverse service types on top of a diverse set of network scenarios (incl. "challenged" ones) in a comprehensive way. The complexity of the underlying network infrastructure will be shielded by autonomous, cognitive management functions which are able to exploit the measurement and context data generated within the network infrastructure and the corresponding deployment environment.

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