A paradigm shift in End to End (E2E) communications

During the first half year of 2019 Hermes Partnership members discussed the state of the art in end to end (E2E) Communications. During these discussions we observed certain developments which lead to a vision on strategies for future E2E communications.

Today, networks and services providers and related manufacturers are expanding their market beyond consumers by targeting the professional market, especially industry, to generate new revenue flows. Key stakeholders are realizing this expansion by supporting verticals from a (5G) centric and holistic approach with a “one system fits all” philosophy, leading to a central core specification producing a multitude of (hopefully) interoperable options, that will survive or not on the market. This is gradually leading to very complex systems, making it very hard for tenders to select the winning options and rather inaccessible for new and smaller players to bring in their innovations. To satisfy the future demands of multiple tenants, like private and public network service providers and application builders on one side, and end users, either consumers or verticals, on the other side, we see the need for open architectures, systems and solutions. Tenants and end-users need to become more active players of this evolution to bring in their own needs and innovations.

In addition, we observe a trend of moving functionality towards the core and cloud infrastructures; this dependency on wired core and the cloud may be a limiting factor for smaller deployments and dynamic environments.

E2E communication involves different network segments each having its own characteristics, community and domain knowledge. Driving end-to-end solutions from one specific community may lead to undesirable simplifications and high-level abstractions of other segments with -as a consequence- sub-optimal operation.

Based on this assessment, we propose a paradigm shift that will enlarge (and bring back) the role of innovative wireless research at academia, SME’s, industries and startup’s in end-to-end (E2E) communications. We further propose to target the professional market to integrate private network and services providers in a new standardization and specification paradigm fostering cooperation, interfaces and openness.

The Paradigm Shift

The paradigm shift we propose is purely driven by end-to-end performance. Additional criteria for the foreseen evolution comprise E2E-system optimizations towards higher resource efficiency, in particular spectrum and energy resources, higher security and improved overall cost efficiency. The end-to-end service should be dynamically composed through cooperation between the most appropriate combination of segments.

We propose evolved standardization processes that focus on open APIs expressing requirements, services and intentions leaving freedom to and within the segments for implementation and distributed optimization based on dynamic contracts. This calls for multidisciplinary involvement, focusing on subsystems and their chaining to fulfill the end-to-end quality requirements. The proposed future end-to-end architecture should decompose the E2E-connection between end devices into smaller network segments handled independently and

autonomously and capable of collectively fulfilling the requested end-to-end QoS, while maximizing efficiency of resources and costs. The only QoS that matters is the one between end devices. The future network has to deliver traffic flows between applications running on end devices with very diverse QoS requirements in terms of bitrate, burstiness, end-to-end latency (standard unidirectional latency or cycle time), reliability (up to 100%), mobility support, etc.

The paradigm shift encompasses introduction of a hyperstrator functionality, either centralized or distributed, interacting with multiple segment orchestrators that can optimally configure their individual segment, assisted by monitoring and auditing capabilities. This approach for orchestrating segments in an E2E-connection has also been introduced in the H2020 ORCA project and is further elaborated within the Hermes Partnership. The hyperstrator makes sure the cooperation of the segments fulfills the E2E contracts. The paradigm delegates the fine-grained optimization to each network segment that is further governed by domain experts and can be accompanied by artificial intelligence (AI) and machine learning (ML) approaches to gain deeper insights in the operation of the network segment to make more informed decisions on the network configurations.

We claim the proposed paradigm shift is technology and actor neutral and can be implemented independently of any specific technology generation and business relationships.
The proposed paradigm shift also targets improving spectrum efficiency. The trend of managing spectrum more centrally is driven by “softwarization” of wireless radio operation. From the point of view of flexibility and reprogrammability and global coverage optimization, this softwarization is interesting, but it comes with a penalty on latency and energy consumption. We claim that spectrum efficiency will benefit from more fine-grained distributed local monitoring in the end devices and fast control loops, coordinated by a local wireless segment orchestrator.

While a lot of research efforts are spent for exploring new spectrum to cope with high application demands (such as mmWave and THz communication), the sub 6 GHz band will always remain the most popular spectral band for its favorable propagation properties and is highly desired for low cost, low-power end devices. However, the spectrum in sub 6 GHz band is not endless and cannot scale with increasing application needs. For every new generation (2G/3G/4G/5G) more exclusive licensed spectrum is allocated. This exclusive spectrum allocation model is not sustainable and leads to waste of spectrum. We therefore recommend instead of continuing to allocate exclusive spectrum, dynamic spectrum sharing in sub 6 GHz licensed spectrum and offloading across multiple radio systems and spectrum bands to avoid unnecessary waste. Selection of radio system should be based on multiple criteria such as the type of application and the context (indoor versus outdoor, short range versus long range, fixed versus mobile, etc.) and switching between systems should be facilitated by open interfaces that allow seamless handover across segments and operator domains.

With this paper, we aim to broaden research and innovation from a telecom-centric view with limited actors to an end-to-end service view driven by the needs of professional markets also targeting private networks involving multiple actors and academia.

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