# End-to-end Service Architectures for 4G Mobile Systems

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The expense of deploying Third Generation (3G) Mobile Telecommunications Systems is huge. Only within the European Union the auctions for 3G spectra are likely to exceed 150 billion Euros, with 50 billion Euros already committed in Germany and 40 billion Euros in the United Kingdom. Network development outlays are likely to match spectrum expenses. These amounts are spent even before any kind of mid- or short-time revenue is conceivable. In addition to this, it is still unclear for what kinds of new services and applications --enabled by the higher 3G bandwidth-- the subscribers will be willing to pay for and of course even less clear how much will they be willing to pay. Furthermore, the widespread liberalization of the telecommunications sector has made available today cheap network bandwidth within a highly competitive environment. This environment creates high consumer expectations of commodity mobile communications availability, thus making pricing of premium 3G services problematic. This is particularly evident by the slow adoption of GPRS, 2.5G or mobile IP services available currently. In fact, very few of the most popular mobile applications in common use today would benefit from higher data transfer rates and this has given rise to a quest for the "3G killer application".

A further characteristic of the transition towards 3G systems and beyond is that highly integrated telecommunications service suppliers fail to provide effective economies of scale. This is primarily due to deterioration of vertical integration scalability with innovation speed up. Thus, the new rule for success in 4G telecommunications markets will be to provide one part of the puzzle and to cooperate with other suppliers to create the complete solutions that end customers require.

A direct consequence of these facts is that a radically new end-to-end service architecture will emerge during the deployment of 3G mobile networks and will became prominent as the operating model of choice for the Fourth Generation (4G) Mobile Telecommunications Networks. This novel end-to-end service architecture is inseparable from an equally radical transformation of the role of the telecommunications network operator role in the new value chain of end service provision. In fact, 4G systems will be organized not as monolithic structures deployed by a single business entity, but rather as a dynamic confederation of multiple—sometimes cooperating and sometimes competing—service providers.

Specifically, we anticipate the following characteristics to define the 4G end service provision models:

- *Service access heterogeneity*: 4G systems will offer polymorphic services over a wide variety of end user access devices, carrier networks, services, applications, service providers and content providers. Although standardisation is desirable, it is also equally unlikely. End-to-end service architectures will have to exploit software mediation to achieve interoperability.

- *Network access heterogeneity*: A variety of network technologies will be in use at the same time including centralised carrier topologies like EDGE, HSCSD, GPRS and UMTS but also peer-to-peer networks supported by Wi-Fi and Bluetooth technologies. 4G architectures must provide service transparency by abstracting the fundamentally different modes of operation of these networks.
- *Service branding*: The service architecture must enable business entities to provide enhanced services, as a primary means of differentiating one provider from another. Supported by the service/net architectures. This is where the value will be.

Keeping in mind the above 4G characteristics, end-to-end service architectures should have the following desirable properties:

- Open service and resource allocation model. End-to-end service frameworks should provide for independent creation, establishment, and placement in overlapping domains of service providers. This property fulfils partly the requirement of the intermediary "market maker" that can hide the details of the state of the participating providers' resource pools. On the other hand it raises a new issue: the desirability of peer-to-peer systems versus a centralized market mechanism that might serve as a potential single point of failure. Provider resources, capabilities, and current status need to be described, and exchanged between confederated service providers, whether it is for the purposes of "reselling resources" where they are collocated, or for implementing functionality through local provisioning.
- Open capability negotiation and pricing model. The nature of capability negotiation needs to be understood in this more complex, more heterogeneous environment than that found in conventional telephony networks. These requirements naturally imply a market based service allocation model. Indeed, dynamic allocation mechanisms based on economic methods, such as electronic auctions, coupled with real-time accounting/billing/settlement systems for the resources used.
- Trust management. Mechanisms for managing trust relationships among clients and service providers, and between service providers, based on trusted third party monitors. Existing interrelationships among service providers are based on contracts between large and well-established commercial enterprises. Such assumptions may not be suitable as the number and scope of service providers increase dramatically. Trusted third parties might audit the behavior of service providers, a kind of "better business bureau," providing a rating service that separates the reliable participants from those who are unreliable.
- Collaborative service constellations. A framework used for forming dynamic service constellation through federation mechanisms is required. Possible desirable properties include the ability to discover potential confederates, the

mechanisms to establish trust relationships, to manage transitive and possibly decentralised trust relationships and last but not least to manage the variable levels of transparency (that is efficient and effective mobile identity management systems that allow to reveal –under contract-- aspects of internal information to peers or trusted third parties about performance, user information, and so on). It is worth noting that not all confederates need be potential competitors. Collaborative constellations can be formed of heterogeneous, collocated access networks to improve support for particular end-to-end service needs. For example, a Wi-Fi operator (possibly an enterprise) may confederate with a cellular network provider to provide two separate pipes for high bandwidth data and low bandwidth voice streams in support of a user's multimedia conferencing application. In this case, the underlining assumption is that in the vicinity of the user exist a mobile phone and some type of screen-oriented computing device, and that these devices have now formed a confederation to transparently support an application with audio service over the phone and video service over the Wi-Fi network.

- Service fault tolerance. The possible confederated, collaborative service constellations provide the opportunity for advanced fault tolerance. Desirable properties in this respect include fault discovery, notification service and recovery through multi-access modes.