What Fundamental Features are required to deliver Ubiquitous Mobility in Next Generation Networks and how can they be realised in such Architectures?

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Abstract: This paper introduces key characteristics (fundamentals), which are essential to delivering mobility in Next Generation Networks. Current implementations of Session Mobility (Handover) is analysed and further used as an example of the technical options and challenges facing Communications Providers in achieving true fixed-mobile convergence.

1. Introduction

Communications Providers across all markets, fixed, mobile, internet and niche[1], are implementing strategies[1] to deliver fixed mobile convergence products and services – where location, physical device and access network do not affect the end user experience[2]. Voice calls can be delivered to a mobile handset, a PDA, traditional fixed line, through your computer or even via your set top box / broadband hub. The recipient telephone number[3] called can be the same in all instances, albeit with internal network translations.

A key enabler for such services is a Next Generation Network (NGN) [4] with a transport layer which can be integrated with several different access mechanisms such as PSTN, Broadband, and WiFi etc... The service control logic and intelligence must therefore support different types of access-specific private identities for an end customer whilst maintaining a mapping to their public identities, e.g. those present in business card. Service Intelligence on top of a consolidated transport is key to mobility.

But simply implementing an NGN in this manner is not enough to deliver true mobility which would be capable of delivering increased session duration with 24x7 reachability essential for ARPU[4] increase and customer retention[2]. The rest of this paper looks at the additional requirements and explores further the issues facing one of the main fundamentals, session continuity or "handover"

2. Mobility Fundamentals

Mobile networks and applications place a number of requirements arise, some unique to wireless/mobile needs and other more generic ones placing additional requirements on NGNs.

Air Interface/Access network Security and encryption

Traditional networks delivered "walled gardens" with physical security where of the access layer and complex protocols. Access to service would be through secure locations, such as the home or office.

Today, users are able to access a multiplicity of public networks and expect to access their services, including private information. Further, some of these networks are wireless and built on de-facto standards (e.g. TCP/IP) easily accessible, making fraud feasible. Physical security is not longer possible and other forms of security are required such as encryption algorithms.

Ubiquitous Authentication

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[1] E.g. Emergency services, transportation

[2] "Anytime, Any place, Anywhere" access to services

[3] Or indeed "new age" internet addresses such as you MSN or Skype username

[4] Average Revenue Per User – a measure of the value services can achieve per customer

Networks have historically been vertically engineered, each with their own network access solutions. Access to multiple networks therefore adds the need for different forms of authentication from username and password, to digital certificates and GSM's challenge-response.

This places an enormous burden on service providers, users and their devices: these multiple mechanisms need to be supported, integrated and automated in such a way that a voice call started on one network can continue, uninterrupted one another using different credentials and mechanisms.

[Adaptive] QoS

Quality of Service refers to control mechanisms for resource reservation, policing and enforcement. QoS parameters (bit rate values, latency, and jitter), can provide different priority to different users or data flows, or even guarantee a certain levels of performance to specific data flows.

QoS guarantees are particularly important where network resources are limited, as in wireless networks where the cost per Mbyte is at a premium especially during peak periods. Applications, such as real-time voice and broadcast TV are less tolerant of poor QoS enforcement and require fixed or minimum bit rates, whilst others such as internet browsing are rarely affected. Efficient usage of resources, requires **Adaptive**[5] mechanisms to be employed to satisfy application demands.

Session Continuity / Multimedia Handover (across heterogeneous access networks)

Continuous, un-interrupted, service delivery is an industry requirement increasingly becoming a "commodity" for certain applications. Re-establishing a phone call that "drops" when moving, is however, less serious than a real-time dealing on the stock exchange over a mobile device.

Different levels of session continuity exist, from nomadic loss-less persistence (>1 sec) through to intra-technology real-time handover (<50ms) and, more complex inter-technology (GSM to WiFi) handover where physical connectivity, authentication credentials and QoS parameters, etc… change

In future it will be possible for end users with multiple devices to specify rules allowing seamless connectivity to "best-of" networks providing a blend of manual and automated session continuity.

Service Delivery: IP Multimedia Subsystem (IMS)

IMS is an access-agnostic, standards based multimedia architecture which makes it possible to deliver Communications and Internet services alike[13]. With IP chosen as the network (OSI layer 3) protocol for all their voice and data services, IMS also facilitates roaming/session continuity between IP-aware networks such as the Internet and Next-Generation Networks. IP protocols (TCP, DHCP, SIP etc…), run efficiently on different layers 1 and 2 infrastructures and helps to isolate services from changes in underlying physical networks.

There are a number of supplementary [mobility] fundamentals each with a role to play in delivering mobility within Next Generation Networks but more localised to specific applications and/or less stringent on "real-time" requirements:

- **Number Portability** – The transfer of addresses between providers and physical locations.
- **Subscriber Presence** – whether or not the end user is on-line, off-line and available for communication or not ("Away", Busy", "In Meeting"). Both actual and preferred "presence"
- **Subscriber Location maintenance** – The actual geographic location of the end user. Useful to for value-added services, as well as network routing data.
- **Charging / Billing** – The need to address a multiplicity of difference charging scenarios including fixed, mobile, contracts, pre-pay advertising etc… and billing models. The impact of Session Continuity across different access networks must be supported

[5] Mechanisms which can flex increasing/decreasing parameters thus making most effective use of resources

3. Next Generation Networks Architecture & the impact of mobility

The ITU[4] defines a Next Generation Network as packet-based network able to provide telecommunication services and using multiple broadband, QoS-enabled transport technologies. Service-related functions are independent of underlying transport-related technologies. NGNs provide support for generalized mobility allowing consistent and ubiquitous provision of services to users.

BT's NGN, the 21st Century Network (21 CN), replaces a number of stove pipe, technology and service constrained, networks with a single IP Core Network with associated signalling and media gateways and routing nodes. The addition of Call Processing Servers and protocol translation nodes together allow the replication of key services such as the PSTN, 0800, emergency calls etc…

Whilst 21 CN will deliver major cost reductions and an infrastructure to rapidly deliver new services, and the introduction of key aspects of mobility into the network will allow Fixed-Mobile Convergence services to be delivered in a way which is seamless to the customer.. The engineering of these mobility fundamentals into 21CN needs to consider existing and new Services being sufficiently flexible to support different access technologies, QoS enforcement and authentication mechanisms.

4. Application of Session Continuity in NGN

BT's various convergent products introduced their own individual requirements for mobility. Below is a summary of the key handover methods, and their relationship to the OSI 7-layer reference model:

- ⇨ **BT's Openzone**[6] implements mobility at layer 2 by tracking the mobile station's (MS) identifier against the points of attachment, performing routing table updates, triggered MS re-attachments. Layer 3 handover is achieved by proprietary Access Node Controller (ANC).
- ⇨ **BT Fusion uses the Unlicensed Mobile Access** (UMA)[7], a service-agnostic technology at OSI layer 4delivering circuit-switched mobility across GSM, Bluetooth and WiFi access points – whilst maintaining the signalling protocol unchanged.
- ⇨ **Session Initiation Protocol (SIP)-initiated handover** coupled with a 3GPP's Voice Call Continuity (VCC)[8] server and terminal client is used to deliver session continuity between a Circuit-Switched (CS) GSM access network and a Voice Over IP Packet-Switched (PS) WiFi access network. This begins to address the evolution of service migration from CS to the PS Domains, with some restrictions on handover scenarios and commercial conditions to be met.

Mobile IP[9] (MIP), a layer 3 and one the oldest mobility management protocols, has suffered from a number of issues such as triangular routing[11] and latency. Whilst BT does not currently offer services enabled by MIP, it is making a come-back (cdma2000, 802.16e/WiMAX) with an improved variant **-** "Proxy Mobile-IP" [11] and its role in Packet-Switched Networks will be important.

The work of IEEE 802.21, a layer "2.5" protocol, has been analysed by BT and Intel resulting in a Proof of Concept prototype which demonstrates the viability of such approaches in session continuity. It offers a layer 2 abstraction layer, and the potential to reduce handover latency through the informed management of multiple radio modules ported by FMC devices. Reductions in handover from around 10 seconds using conventional techniques to circa 305 milliseconds have been achieved[12].

Whilst each of the above mechanisms play a role in addressing industry needs for session continuity, and whilst it is clear that there is a wide range of solutions implementeable at different layers of the OSI stack, none can address the whole spectrum of requirements. The work carried out in[12] demonstrates that a collaborative approach can yield better results than any one specific technique.

To deliver ubiquitous session continuity, and other mobility fundamentals, the author is of the opinion of the need to choose layered solutions sufficiently flexible to use multiple techniques, acting at potentially multiple layers of the OSI stack. But "**When and in which layer of the OSI stack is it more efficient[6] and feasible to use each technique to deliver the 'best' solution?** A mapping of the

[6] Efficiency must cover cost as well as non-functional requirements such as low-latency and QoS enforcement

various techniques available (SIP/VCC, Mobile-IP, Layer 2 MAC address tables) proves useful in answering this question and analysis is currently in progress.

The current focus of work into the applicability of session continuity in NGN networks is looking at this question by analysing the different options available and the future research required to define the necessary policies.

5. Conclusions

This paper has introduced the key mobility characteristics (fundamentals), which are essential to delivering mobility in Next Generation Networks and provided a summary definition. We've looked at BT's 21CN and mapped a number of key areas which are impacted by the need to provide support for these fundamentals, if ubiquitous mobility is to be achieved in Next Generation Networks capable of supporting FMC services.

Enabling mobility in Next Generation Networks is a complex project due to the variety of access technologies which needs to be supported and the wide range of devices available today. In order to implement cost-effective and user-friendly solutions it is important to not only look at what is available today but to also take a step back and look across the end-end services, as opposed to vertical solutions.

Session Continuity is currently one of the major areas which require a more universal solution which takes into account the features available at different layers of the OSI 7 layer stack and it worthy of further research.

6. Acknowledgments

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7. References

[1] The Yankee Group, Anywhere Enterprise--Large: 2007 European Fixed-Mobile Convergence Survey, www.yankeegroup.com

[2] Wharton S (Pacific Telecommunications Council 2007 Proceedings), FMC: Beyond the dual-mode handset, 2007

[3] Morris S, Network Management, MIBs and MPLS: Principles, Design and Implementation, June 2003, ISBN: 0131011138, Prentice Hall

[4] ITU-T, General Overview of NGN, ITU-T Y.2001, December 2004

[5] ITU-T, IP framework – A framework for convergence of telecommunications network and IP network technologies, ITU-T Y.1001, November 2000

[6] BT Openzone, available at: http://www.btopenzone.com, 2007.

[7] Unlicensed Mobile Access (UMA), available at: http://www.umatechnology.org/, 2007.

[8] Introduction of Voice Call Continuity (VCC) for Q.FMC, available at: http://www.itu.int/md/T05-SG19-050905-D-0019/en, 2007.

[9] IP Mobility Support for IPv4, http://www.ietf.org/rfc/rfc3220.txt, January 2002

[10] Schulzrinne H and Wedlund E, Application-Layer Mobility using SIP, ACM Mobile Computing and Communications Review, Vol. 4, No. 3, July 2000, pp. 47-57

[11] Configuring Proxy Mobile IP, available at: http://www.cisco.com/en/US/products/hw/wireless/ps4570/products_configuration_guide_chapter09186a00802091bd.html#wp1035594, 2007.

[12] Choong K, Kesavan V, Ng S, de Carvalho F, Low A and Maciocco C, SIP-based 802.21 Media Independent Handover: A BT Intel Collaboration, BTTJ Vol. 25 No.2 April 2007

[13] 3rd Generation Partnership Project, www.3gpp.org, Definitions and Specifications