IMPROVING HANDOFF MANAGEMENT PERFORMANCE USING 4G NETWORKS

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Abstract

An improved handoff management performance plays significant role in the current and future wireless mobile networks in effectively delivering services to users on the move. Fourth generation '4G' wireless mobile networks support global roaming across multiple wireless networks. The '4G' system is an all IP–based network and provides the user access to different radio technologies, seamless roaming, and always best connectivity. The paper discusses the various ways in which 4G networks can improve handoff management performance, and focuses on the enhancement required to make IPv6 the underlying protocol in 4G networks. Signaling traffic scalability mechanism in 4G network is also discussed, using Hierarchical Mobile Internet Protocol Version 6 (HMIPv6). The paper concludes by eliciting, among other things, some improved handoff management performance in '4G' networks, such as optimal choice of access technology, mobility between access technologies, and adaptation of multimedia transmission.

Introduction

In the telecommunications industry, a commonly adopted piece of jargon is to label the evolution of mobile telecommunication and wireless networks with generations (i.e. 'Gs'). The first generation '1G' denotes analogue networks such as Nordic Mobile Telephone (NMT) and the second generation '2G' denotes the first digital phone networks (i.e 2G cellular networks), such as 'Global System for Mobile communication' (GSM). The GSM is essentially circuit-switched and used mainly for voice transmission. The 2.5G networks, such as General 'Packed Radio Service' (GPRS), used mainly for voice transmission, are an extension of '2G' networks, in that they use circuit switching for voice and packet switching for data transmission. Circuit switched technology requires that the user be billed by airtime rather than the amount of data transmitted since that bandwidth is reserved for the user. Packet switched technology utilizes bandwidth much more efficiently, allowing each user's packets to compete for available bandwidth, and billing users for the amount of data transmitted. Thus, a move towards using packet-switched, and therefore IP networks, is natural ("Issues in mobility", 2013)

The '3G' networks were proposed to eliminate many problems faced by '2G' and '2.5G' networks, like low speed and incompatible technologies 'Time Division Multiple Access/Code Division Multiple Access' (TDMA/CDMA) in different countries. Expectations for '3G' included increased bandwidth. In theory, '3G' would work over North American as well as European and Asian wireless air interfaces. In reality, the outlook for '3G' is neither clear nor certain. Part of the problem is that network providers in Europe and North America currently maintain separate standards' bodies ('3GPP1' for Europe and Asia, '3GPP2' for North America). The standards' bodies mirror differences in air interface technologies. In addition there are financial questions as well that cast a doubt over '3G's' desirability. There is a concern that in many countries, '3G' will never be deployed. This concern is grounded, in part, in the growing attraction of '4G' wireless technologies.

The '4G' (or fourth-generation) network is the name given to an IP-based mobile system that provides access through a collection of radio interfaces (Frederic, Paal & Erik, 2002). The 4G network promises seamless roaming/handover and best connected service combining multiple radio access interfaces (such as High Performance Radio Local Area Network 'HIPERLAN', Wireless Local Area Network 'WLAN', Bluetooth, GPRS) into a single network that subscribers may use. With this feature, a user will have access to different services, increased coverage, the convenience of a single service, one bill with reduced total access cost, and more reliable wireless access even with the failure or loss of one or more networks. At the moment, '4G' is simply an initiative by 'R&D' laboratories to move beyond the limitations, and deal with the problems of '3G' (which is having trouble meeting its promised performance and throughput).

At the most general level, '4G' architecture will include three basic areas of connectivity:

- Personal Area Networking (such as Bluetooth)

- Local high speed access points on the network including wireless LAN technologies (such as IEEE 802.11 and High Performance and Radio Local Area Network 'HIPERLAN'); and,
- Cellular connectivity under this umbrella, '4G' calls for a wide range of mobile devices that support global roaming. Each device will be able to interact with internet-based information that will be modified on the fly for the network being used by the device at that moment. In fact, the roots of '4G' networks lie in the idea of pervasive computing (Mark, 1993).

The glue for all this is likely to be 'Software Defined Radio' (SDR) (Mengi, 2004). 'Software Defined Radio' enables devices as cell phones, PDAs, PCs, and a whole range of other devices to scan the airwaves for the best possible method of connectivity, at the best price. In a 'Software Defined Radio' (SDR) environment, functions (such as the generation of the transmitted radio signal and the turning of the received radio signal) are performed by software. Thus, the radio is programmable and able to transmit and receive over a wide range of frequencies while emulating virtually any desired transmission format.

The expected (or defining) features of '4G' networks include:
High Speed, High Network Capacity, Fast/seamless Handover across Multiple Networks, 'and Next-generation Multimedia Support.

4G Networks: Handoff Management Performance Improvement

4G Networks:

The goal of '4G' Networks is to replace the current proliferation of core mobile networks with a single worldwide core network standard, based on IP for control, video, packet data and voice. This will provide uniform video, voice, and data service to the mobile host, based entirely on IP.

The above arrangement offers seamless multimedia service to users accessing an all IP-based infrastructure through heterogeneous access technologies.
IP is assumed to act as an adhesive for providing global connectivity and mobility among networks.

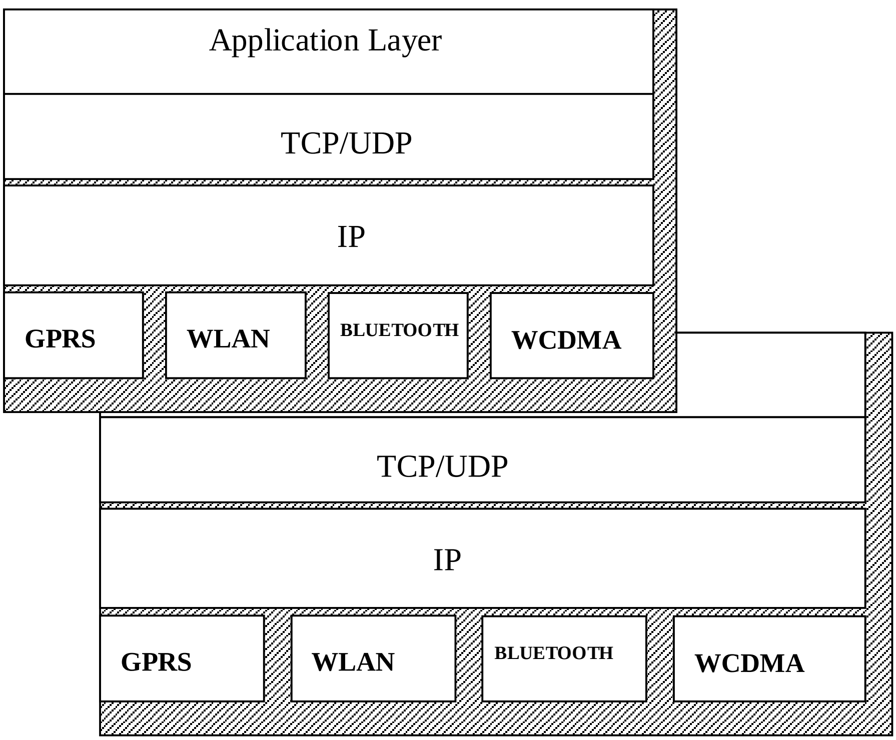
An all IP-based '4G' wireless network has inherent advantage over its predecessors. It is compatible with, and independent of the underlying radio access technology (https//research.sun.corn/features/49wirless/).

An IP wireless replaces the old 'Signaling System 7' (SS7) communications protocol, which is considered massively redundant.

From the above discussion, handoff management performance improves tremendously in the '4G' networks as a result of three main issues, thus:

- *Optimal choice access technology (i.e. how to be best connected):*

Given that a user may be offered connectivity from more than one technology at any one time, one has to consider how the terminal and an overlay network choose the radio access technology suitable for services the user is accessing, as shown in the diagram below.



*4G networks optimal choice of radio access technologies.

- *Handoff between access technologies:* The design of a handoff enabled 'IP' networking architecture, which contains the functionality to deal with mobility between access technologies is needed. This includes fast, seamless vertical (between heterogeneous technologies) handovers (IP micro-mobility), 'Quality of service' (QoS), security and accounting.

Real-time applications in the future will require fast/seamless handovers for smooth operation. To enhance handoff in IPv6, "micro-mobility" protocols such as HAWAII (Ramjee et al., 1999): Cellular IP (WWW.ctr.columbia.edu/-andras/cellularip), and Hierarchical Mobile IPv6 (http://www.iett.org/internet-drafts/draft-ietf-mobileiphmipy6-07.txt) have been developed for seamless handovers (i.e handovers that result in minimal handover delay, minimal packet loss, and minimal loss of communication state).

- *Adaptation of multimedia transmission across 4G Networks:*

The multimedia will be a main service feature of '4G' networks, and changing radio access networks may in particular result in drastic changes in the network condition. Thus, the framework for multimedia transmission must be adaptive.

Required Enhancements for the Mobile IPv6 Mobility Management Protocols For Amenability with 4g Networks:

The goal of **'**4G' networks is to replace the current proliferation of core mobile networks with a single worldwide core network standard, based on the mobile IP, which would provide uniform video, voice, and data service to the mobile host. The Mobile Internet Protocol (i.e Mobile IP or simply, IP) is an internet 'Engineering Task Force' (IETF) standard communication protocol that is designed to allow mobile device users to move from one network to another while maintaining a permanent home IP address. The 'IETF' is an organized activity of the Internet Society (ISOC). **'**ISOC' is a non-profit organization founded in 1992 to provide leadership in internet-related standards, education, and policy. 'ISOC' is dedicated to ensuring the open development, evolution and use of the internet for the benefit of the people throughout the world (http://ww.53.kth.se/radio/4GW/). The mobile IP (or IP) has undergone through series of evolutions, resulting to some versions of which the latest version is the mobile IPv6 (or IPv6) which has the following features of handoff management (Johnson, 2002):

- 128-bit address space that provides a sufficiently large number of address.
- High quality support for real-time audio and video transmission, short/bursty connections of web applications, peer-to-peer applications etc.
- Faster packet delivery, decreased cost of processing, on header checksum at each relay, fragmentation only at endpoints; and
- Smooth handoff when the mobile host travels from one subnet to another, causing a change in its Care-of-Address. Some mobile 'IP' (or 'IP') mobility management protocols include 'Internet Group Management Protocol' (IGMP), **I**nternet 'Control Message Protocol' (ICMP), 'User Datagram Protocol' (UDP), and 'Transmission/Transport Control Protocol' (TCP).

Although the features of IPv6 mentioned above are suited for '4G' networks, recently, there has been almost universal recognition that IPv6 needs to be enhanced to meet the need for future '4G' cellular environments (Ramjee, 1999.,). In particular, the absence of a location management hierarchy (IPv6 uses only simple location updates for location management) leads to concerns about the signally scalability and handoff latency. This is especially significant when we consider that '4G' aims at providing mobility support to potentially billons of mobile devices, within the stringent performance bounds associated with real time multimedia traffic.

There are three main areas where IPv6 needs to be enhanced before being used as the core networking protocol in '4G' networks These areas are paging support, scalability issues and in heterogeneous access technologies:

Reducing Mobility Signaling Traffic Using HMIPv6

The IPv6 hosts have a home agent (HA) and co-located care of address (CCoA). As the hosts move from domain to domain or subnet, they send binding updates (or Bus) to inform their respective HA and their corresponding hosts 'CHs' of the change in binding between their permanent IPv6 address and their 'Co-Located Care of Address' (CCoA). When the binding updates 'Bus' reach the 'Corresponding Hosts' (CHs), the corresponding host may send packets directly to the 'Mobile Hosts' (MHs).
Although this approach of sending packets to mobile hosts provides the convenience of a single IPv6 that is independent of the point of attachment of the mobile host, it is not scalable. As the number of mobile hosts in a given domain increases, the number of binding updates (which are sent out periodically) increases. This in turn causes more signaling within the domains and across the internet (for hosts that are not within their home domains). This overhead may lead to longer network delays. Also the more the user mobility is inter-site, the more the binding updates are sent to home agents and corresponding hosts. Most of the signaling traffic due to BUs can thus be reduced if local mobility is hidden from corresponding hosts and home agents (Mark, 1993). This is why a hierarchical mobility management scheme should be used if local and global mobility management are to be handled separately.

The Hierarchical mobile IPv6 (or HMIPv6) is an IETF proposal that divides networks in domains and subnets, with each administration domain having a 'Mobility Anchor Point' (MAP) at the highest level. Intra – domain mobility of a host is handled separately from inter- domain mobility.

When the MH changes point of attachment within the same domain, the MAP of that domain is informed of the changes in care–of address (CoA) of the MH through binding updates. Binding updates are also sent to the correspondent host (CHs) within the same domain. The MAP functions as a 'Foreign Agent' (FA) by intercepting IP datagrams destined for the MH and forwarding them to the appropriate CoA inside the domain. This way, intra domain handoff can be performed transparent to the MH's Home Agent (HA) or external corresponding hosts (i.e. the MH does not need to send its HA or CHs binding updates).

This reduces signaling traffic due to ‘reduced binding updates’. It also reduces handoff latency as far–off home agent and correspondent host changes point of attachment. This may be crucial to ensuring minimal handoff latency to ensure QoS for real-time data.

Conclusion

The paper shows that ‘4G’ network is a single worldwide core network standard, based on IP, for control, video, packet data, and voice. It therefore provides uniform video, voice, and data services for the mobile hosts, based entirely on IP. The IP based mobile telecommunications networks are the next big leap in the mobile telecommunication industry. The 4G networks allow users to roam over a variety of radio access networks such as WLAN, W-CDMA, and CDMA2000 by integrating mobility management mechanisms and vertical handoff schemes at the network layer.

The paper discussed three key issues concerning handoff management in ‘4G’ networks such as optimal choice of access technology, mobility between access technologies and adaptation of multimedia transmission. Finally, some improvements necessary in the mobile IPv6 handover management protocols for use as a core networking protocol in ‘4G’ networks were highlighted.

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