Extended architecture for home base stations with multimedia services

DOI:
10.1109/ICCE.2011.5722853

Document status and date:
Published: 01/01/2011

Document Version:
Publisher's PDF, also known as Version of Record (includes final page, issue and volume numbers)

Extended Architecture for Home Node Base Stations with Multimedia Services
Digest of Technical Papers

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***Abstract*-- This paper describes the use of mobile access points (home node base stations, femtocells) for providing TV streaming to mobile devices inside the home. The research is focused on finding commonalities between architectures of the home node base station for different technologies. The result is a general architecture, which can be easily extended to provide live media streaming to mobile devices.**

I. INTRODUCTION

In the past years mobile communication technologies and mobile phones have been evolving very fast and now mobile phone has become a tool for entertainment, social networking, TV streaming, music download and other services. Studies [1] show that a considerable amount of the mobile data traffic comes from home or office. At the same time, providing an adequate mobile residential coverage is still a significant challenge for operators [2]. New generations of mobile networks already use mobile access points (e.g. home node base stations or HNB [3], Femtocell [4], LTE eNodeB [5]) to solve coverage problems and to provide additional services like secure home access [6], virtual home phone [6], connected home [7] and others. Even though HNB technology is young, there are different generations of mobile technologies and various mobile standards for which HNBs have been built, which results in numerous HNB architectures.

This paper describes a common architecture that is derived from the study of existing HNBs of various standards (section 2) and illustrates an extension of the common architecture with live DVB-IPTV services to enable live TV content in home environments (section 3). The last section provides the overall conclusions of the work.

II. COMMON ARCHITECTURE

We studied architectures of the existing 3G and 4G HNBs that are based on the UMTS [8] and LTE [9] architectures proposed by 3GPP (3rd Generation Partnership), and the CDMA2000 [10] architecture described by 3GPP2 (3rd Generation Partnership 2) and derived a common architecture for HNBs that is shown in Fig. 1 (common blocks, i.e. `UMTS/LTE/CDMA2000', mean commonly present functionality and not necessarily common implementations). The presented architecture follows the OSI model and the 3GPP model. 3GPP proposed a protocol model for the HNB interface with the CN that is divided into layers and planes that are logically independent of each other. Horizontally, it is separated into the radio network layer (all mobile technology related functionality) and the transport network layer (standard transport technologies only). Vertically, it is split into the control plane (which contains the application protocols and the signaling bearers for transporting the messages) and the user plane (which contains the data streams and the data bearers) [11]. For interface with UE, all three technologies, UMTS, LTE and CDMA2000, have a physical (layer 1) and a MAC layer (layer 2) which implement technologies specific to each standard. Additionally for layer 2, the 3GPP technologies employ radio link control (RLC) - an automatic repeat request fragmentation protocol used over a wireless air interface (also called radio link protocol, or RLP), while the 3GPP2 technology uses a link access control (LAC) sub-layer. LAC provides a reliable delivery of signaling data, while RLP provides a best-effort transport of user packet data whose delivery is no assured.

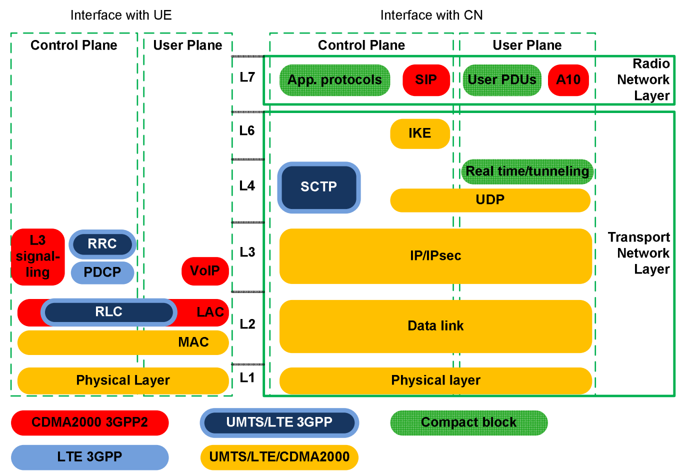

Fig. 1 The HNB common architecture. HNB connects the user equipment (UE) with the core network (CN).

UMTS and LTE use the radio resource control (RRC) protocol that handles the signaling of layer 3. RRC controls the UE behavior by controlling connection and handover within the network, broadcast system information, paging notification, etc. Similar functionality is implemented in CDMA2000 by the L3 protocol. In addition, LTE employs packet data convergence protocol (PDCP) below RRC to perform ciphering, integrity protection and transfer of control plane data [9].

The interface with the core network has a large number of modules because of the different legacy networks with which it needs to integrate. Layer 1 (physical layer), layer 2 (data link layer), layer 3 (IP/IPsec) are similar for all, but have specific implementation according to the technology used. Layer 4 contains a number of protocols that have similar purpose -- real-time and tunneling protocols, such as RTP for CDMA2000, RTP/RTCP for UMTS and GTP-U for UMTS and LTE. Common for all three technologies is UDP on the user plane; and for CDMA2000 also on the control plane. For UMTS and LTE, on the control plane, the common SCTP protocol is used. Layer 6 protocols can be present in any of the architectures, having an Internet Key Exchange protocol block used for security reasons. Layer 7, included in the radio network layer, has the biggest diversity of protocols. On the control plane, the application protocols contain specific protocols for every technology.

III. MULTIMEDIA EXTENSION

For the project we studied the possibility to extend HNBs with live DVB-IPTV services. The first step in extending the HNB architecture towards a new service is by first adding the simplest service and extending it afterwards. In the case of DVB-IPTV, the simplest service (i.e. profile) that can provide live IPTV services is the 'live media broadcast' (LMB) profile.

There are several possible ways of providing the DVB content to the mobile phones using the HNB. One possibility is to completely integrate the DVB tuner with the HNB. This approach gives the possibility to reuse some blocks of the HNB, like IP, UDP, RTP protocols, but requires implementation of DVB-specific functionality. Another approach is to keep the HNB separated from the DVB tuner, thus leaving the tasks of service discovery, selection, and subscription to the stream and passing the stream to the HNB to the tuner. Although, both approaches are investigated [13], in this paper we focus on the latter approach.

In order to add the LMB service to the HNB, the common architecture proposed in the previous section needs to be extended (Fig. 1). Communication between the user equipment and the HNB is not changed; only a few blocks need to be added on top of the general architecture of this interface in order to be able to do re-streaming. An MPEG block is needed to support a content adaptation (if necessary). For transmitting these data RTSP (Real Time Streaming Protocol) will be used (Fig. 2). RTSP is a network protocol for controlling streaming media servers. It uses RTP for the media stream transmission. The data transfer will be done over UDP. Because the packages need IP encapsulation, PDCP needs to be implemented in all the HNB architectures as it performs IP header compression and decompression and transfer of user data.

For the interface between the HNB and the core network, a physical layer and data link need to be added according to the signal they need to receive (DVB-IPTV). The IP/IP sec (layer 3) and UDP (layer 4) of the HNB are reused for DVB services. The RTP block, which is already present in 3G HNB architectures, is needed for transporting the audio/video data. To receive the audio/video data from the RTP, a layer 6 MPEG-2 TS needs to be added. At the application layer, the audio/video and additional data from the TV program(s) is received and processed [12]. On the control plane, an application for selecting the program is needed.

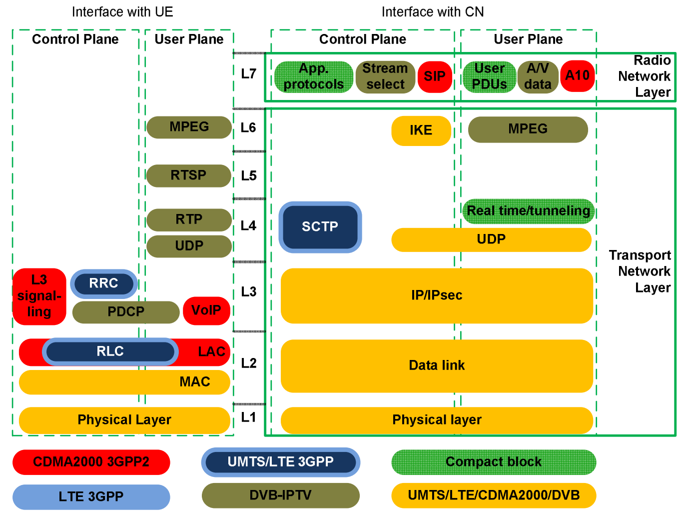

Fig. 2 DVB-IPTV extension of the HNB architecture

IV. CONCLUSIONS

The common architecture derived from the standard of the most popular mobile technologies enables easier extension of a HNB with new services - instead of extending different architectures separately, the extension is only done once and it can be implemented for different technologies at once. We proved feasibility of extending the common architecture with additional TV services based on DVB IPTV by implementing and testing an extended LTE HNB [13] using Neatbox™ [14] environment.

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