Lecture 33: LTE and WiMAX - 4.4 LTE Architecture

4G and 5G Networks

DI05011011: Mobile Communication

Agenda for Today

- 1. WiMAX Overview (Brief)
- 2. Introduction to LTE Architecture
- 3. The E-UTRAN (Radio Access Network)
- 4. eNodeB Functions
- 5. The EPC (Evolved Packet Core)
- 6. Key EPC Components (MME, SGW, PGW, HSS)
- 7. Summary and Q&A

WiMAX: A Brief Look Back

- Worldwide Interoperability for Microwave Access (IEEE 802.16)
- - Aimed to deliver wireless broadband access as an alternative to cable and DSL.
- - Architecture was simpler, resembling a large-scale Wi-Fi network.
- - Struggled with backward compatibility to 2G/3G voice networks.
- - Lacked the immense ecosystem support that 3GPP (LTE) enjoyed.

Introduction to LTE Architecture

- LTE architecture is designed to be flat, IP-based, and highly efficient.
- It is broadly divided into two main parts:
- 1. **E-UTRAN (Evolved Universal Terrestrial Radio Access Network):** The radio access network (the cell towers and air interface).
- 2. **EPC (Evolved Packet Core):** The core network that handles routing, authentication, and connection to the internet.

The E-UTRAN

- The E-UTRAN handles the radio communications between the mobile device and the EPC.
- **Simplification from 3G:**
- - 3G had NodeBs (towers) and RNCs (controllers).
- - LTE eliminates the RNC. All radio control functions are integrated into a single node called the **eNodeB (evolved Node B)**.
- - This 'flat' architecture significantly reduces latency.

Functions of the eNodeB

- The eNodeB is the only node in the E-UTRAN.
- **Key Functions:**
- - Radio Resource Management (RRM).
- - Routing of user plane data towards the Serving Gateway (SGW).
- - Scheduling and transmission of paging messages.
- - Measurement and reporting for mobility (handovers).

The EPC (Evolved Packet Core)

- The EPC is a purely IP-based core network.
- It consists of several specialized nodes:
- 1. **MME (Mobility Management Entity):** The control plane brain.
- 2. **SGW (Serving Gateway):** The local mobility anchor for data.
- 3. **PGW (PDN Gateway):** The exit point to the external internet.
- 4. **HSS (Home Subscriber Server):** The master database of users.

EPC Deep Dive: MME

- **Mobility Management Entity (MME):**
- - The main control node for the LTE access network.
- - Operates strictly in the control plane (no user data passes through it).
- - Handles user authentication (talking to the HSS).
- - Manages idle state mobility (tracking where the phone is).
- - Selects the appropriate SGW for the user.

EPC Deep Dive: SGW and PGW

- **Serving Gateway (SGW):**
- - Routes and forwards user data packets.
- - Acts as the mobility anchor during inter-eNodeB handovers.
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- **Packet Data Network Gateway (PGW):**
- - Provides connectivity from the user equipment to external packet data networks (the Internet).
- - Performs policy enforcement, packet filtering, and charging support.
- - Assigns IP addresses to the mobile devices.

EPC Deep Dive: HSS and PCRF

- **Home Subscriber Server (HSS):**
- - Central database containing user-related and subscription-related information.
- - Provides authentication vectors to the MME.
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- **Policy and Charging Rules Function (PCRF):**
- - Determines policy rules in real-time.
- - Tells the PGW how to handle traffic (e.g., throttling speed if data cap is reached, or prioritizing VoLTE).

Trace a Packet: Loading a Webpage

- Let's trace the path of data when you open a website on LTE:
- 1. **Phone** sends a request via radio waves.
- 2. **eNodeB** receives it and forwards the packet.
- 3. Packet goes to the **SGW**.
- 4. **SGW** forwards it to the **PGW**.
- 5. **PGW** routes it to the **Internet**.
- 6. Data returns via PGW -¿ SGW -¿ eNodeB -¿ Phone.
- *(Notice the MME is not involved in this data path!)*

Lecture Summary

- LTE architecture is flat and IP-based.
- E-UTRAN consists only of eNodeBs, removing the need for a separate controller node.
- The EPC handles the core network functions.
- Key EPC nodes: MME (Control), SGW (Data routing), PGW (Internet gateway), HSS (User database).
- Separation of control and user planes enhances performance and scalability.

Next Lecture Preview

- Next time, we will look at the specific physical layer technologies that make LTE's speed possible.
- We will focus on **4.5 OFDM Technology**:
- - What is Orthogonal Frequency Division Multiplexing?
- - How does it solve multipath fading?
- - What are its advantages in 4G systems?