Broadcasting Towers Operation

WEEK 11 – Broadcasting Cellular System Built and Monitoring

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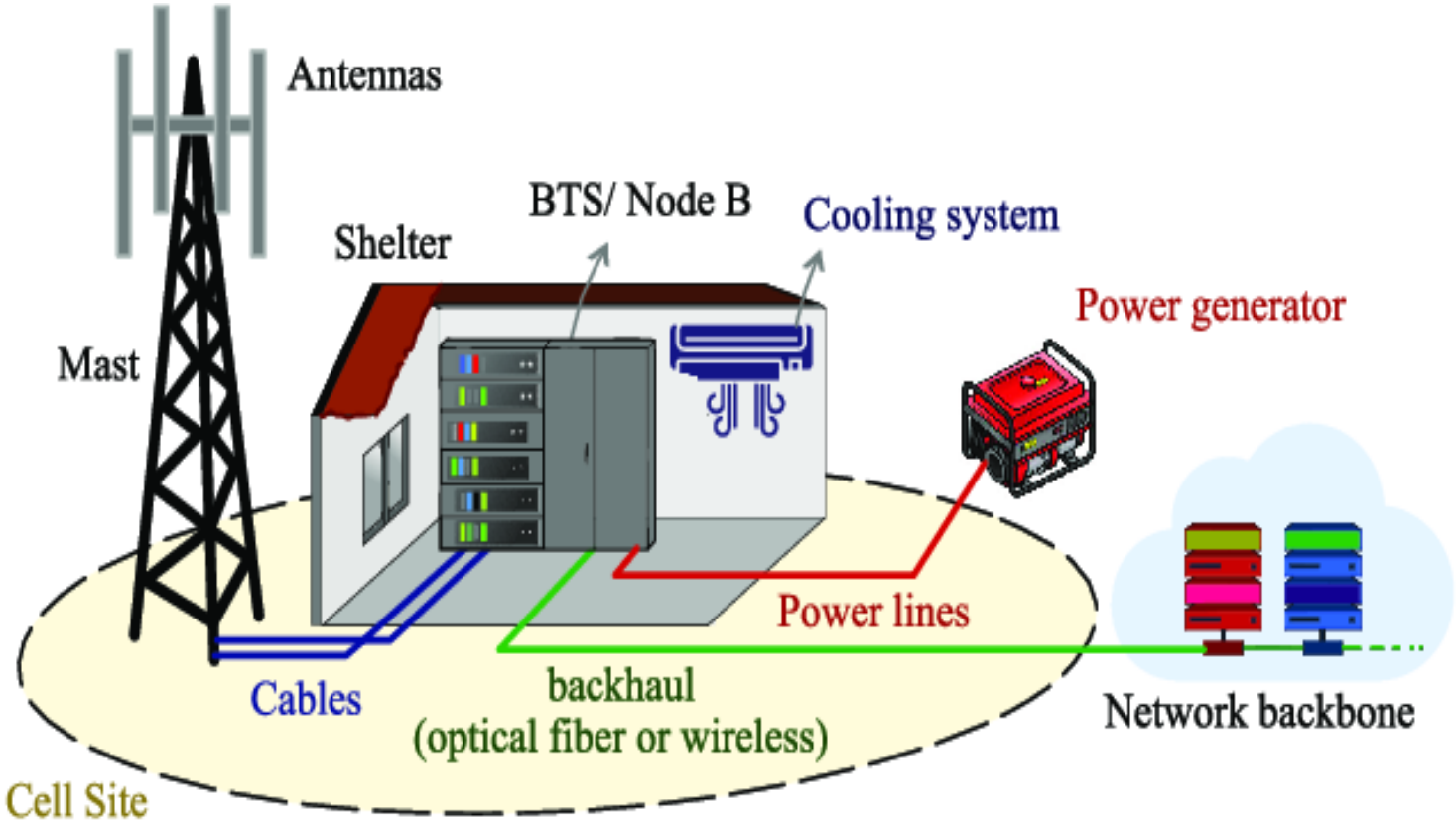
Objectives

At the end of the topic students will be able to:

1. Understand the steps for site set up and mast fixing and parts
2. Explain the transmitted and received signal strength indicators
3. Explain the call set up in a cellular system and broadcasting towers operation.

11.1 Site set up



(The Potential Short- and Long-Term Disruptions and Transformative Impacts of 5G and Beyon d Wireless Networks: Lessons Learnt from the Development of a 5G Testbed Environment, MOHMAMMAD N. PATWARY 1 et al, IEEE Access, 2020.)

11.1 Site set up cont’d

A BTS is usually composed of:

- **Transceiver (TRX)** which provides transmission and reception of signals. It also does send and receive signals to and from higher network entities (like the base station controller in mobile telephony). This can be separated into a dedicated device known as a Remote Radio Head (RRH).

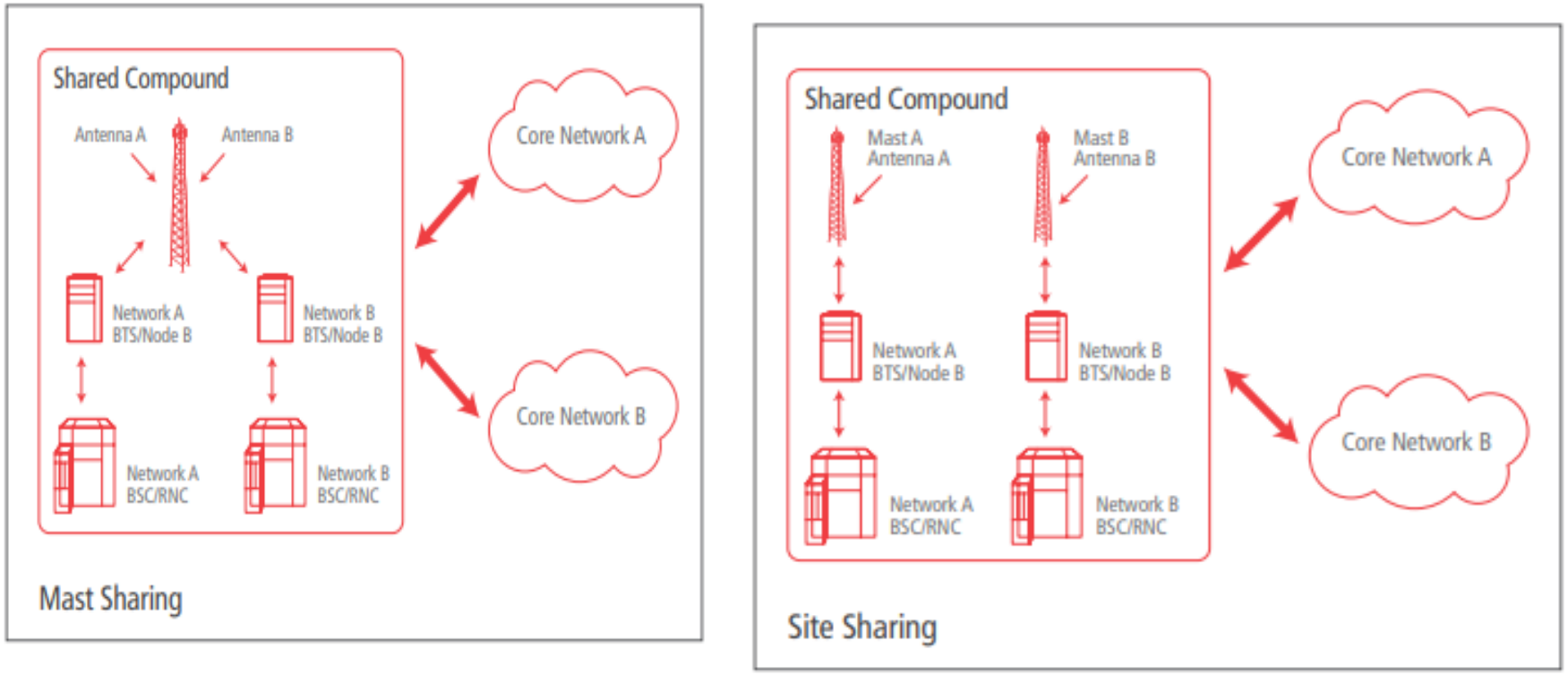
- **Power amplifier (PA)** that amplifies the signal from TRX for transmission through antenna; may be integrated with TRX.

- **Combiner** which combines feeds from several TRXs so that they could be sent out through a single antenna. Allows for a reduction in the number of antenna used. (https://en.wikipedia.org/wiki/Base_transceiver_station)

11.1 Site set up cont’d

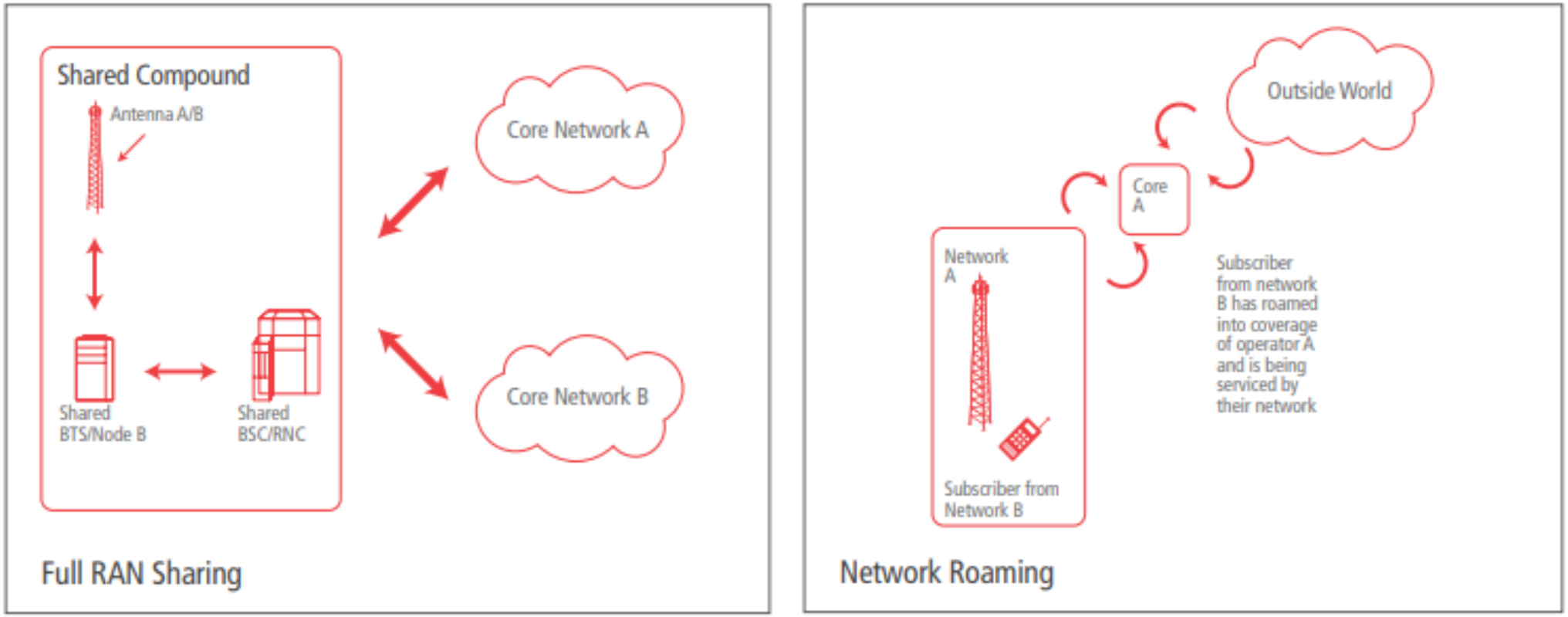
- **Multiplexer** for separating sending and receiving signals to/from antenna. Does sending and receiving signals through the same antenna ports (cables to antenna).
- **Antenna** that is the structure that the BTS lies underneath; it can be installed as it is or disguised in some way (concealed cellular sites).
- **Alarm extension system** which collects working status alarms of various units in the BTS and extends them to operations and maintenance (O&M) monitoring stations.
- **Control function** to control and manage various units of BTS, including any software. On-the-spot configurations, status changes, software upgrades, etc. are done through the control function.
- **Baseband receiver unit (BBxx)** to perform frequency hopping, signal DSP.

11.1 Site set up cont'd



(Mobile Infrastructure Sharing, GSMA (Global System for Mobile Communications Association), 2012.)

11.1 Site set up cont'd



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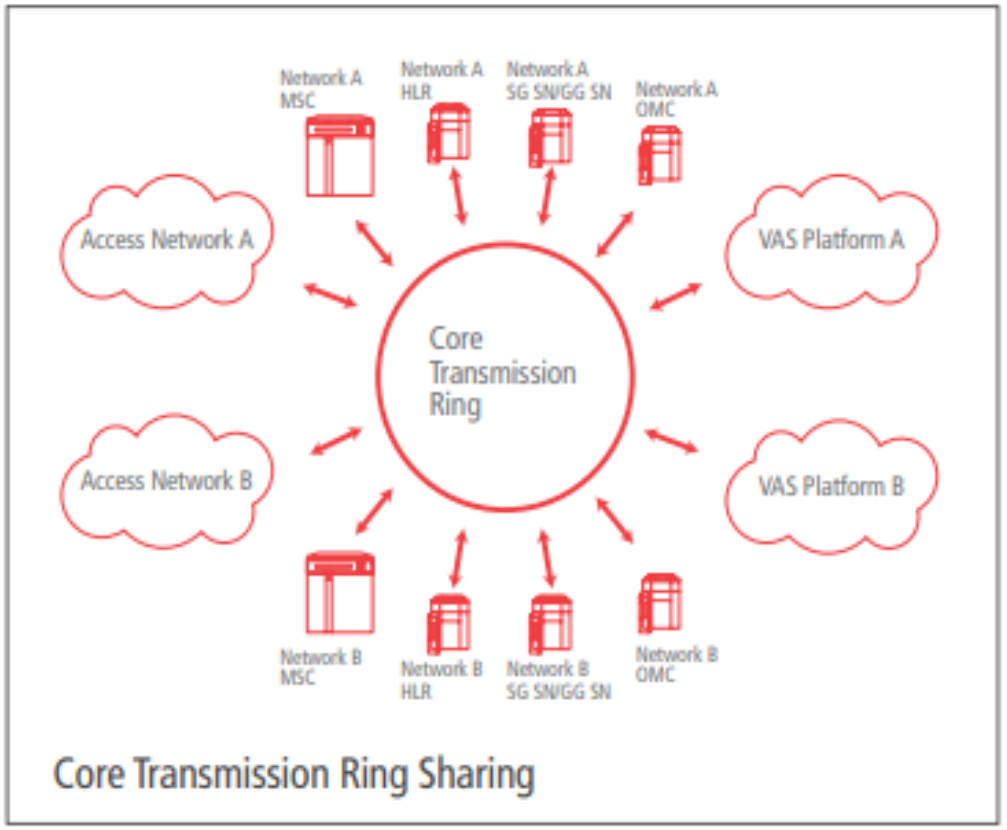
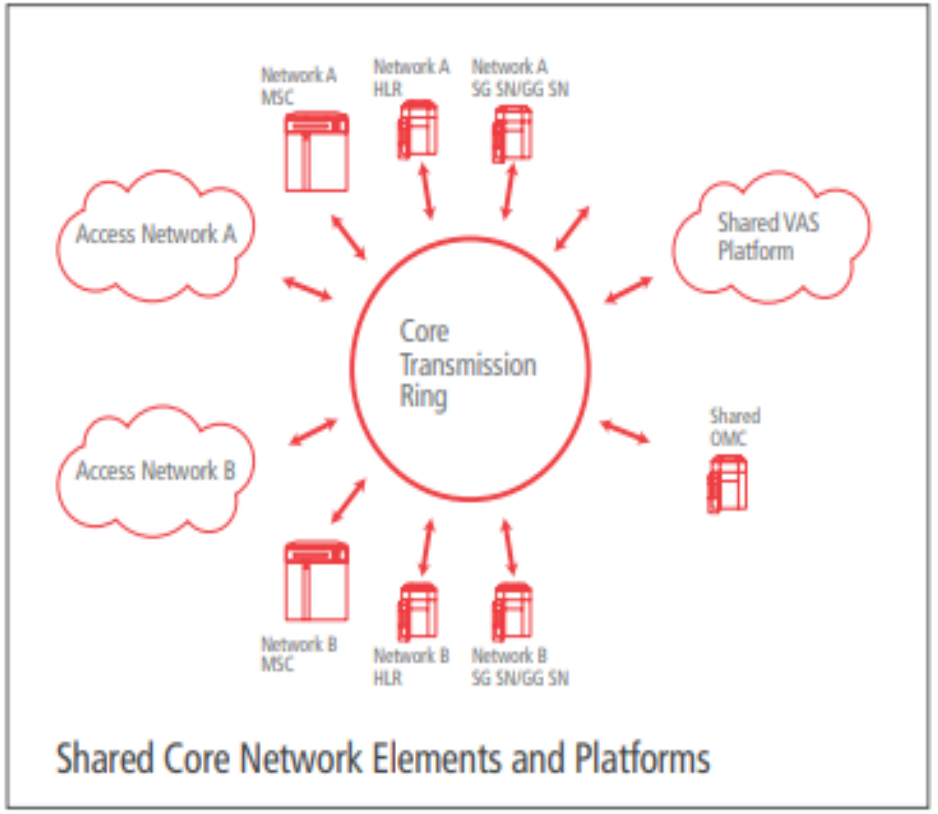
11.1 Site set up cont'd





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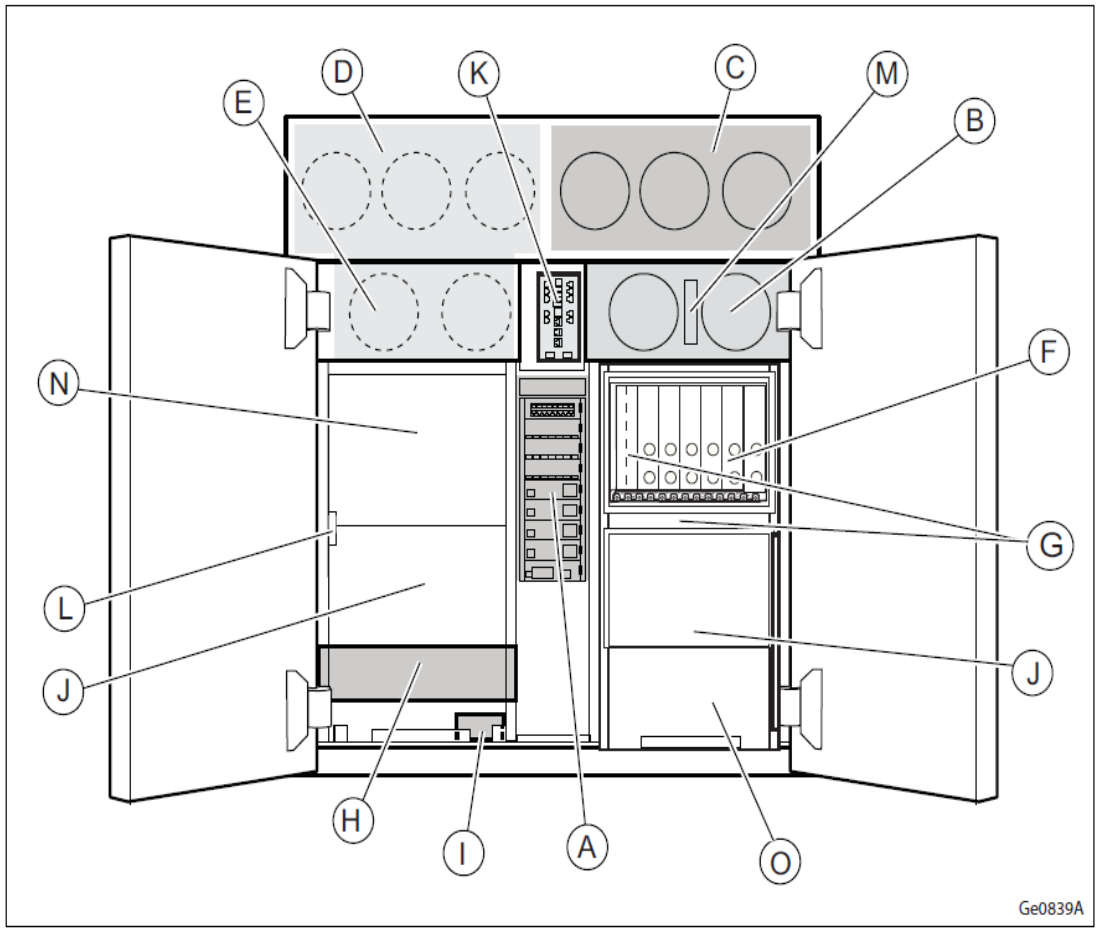
11.1 Site set up cont'd



For **A**: Power sub-rack includes

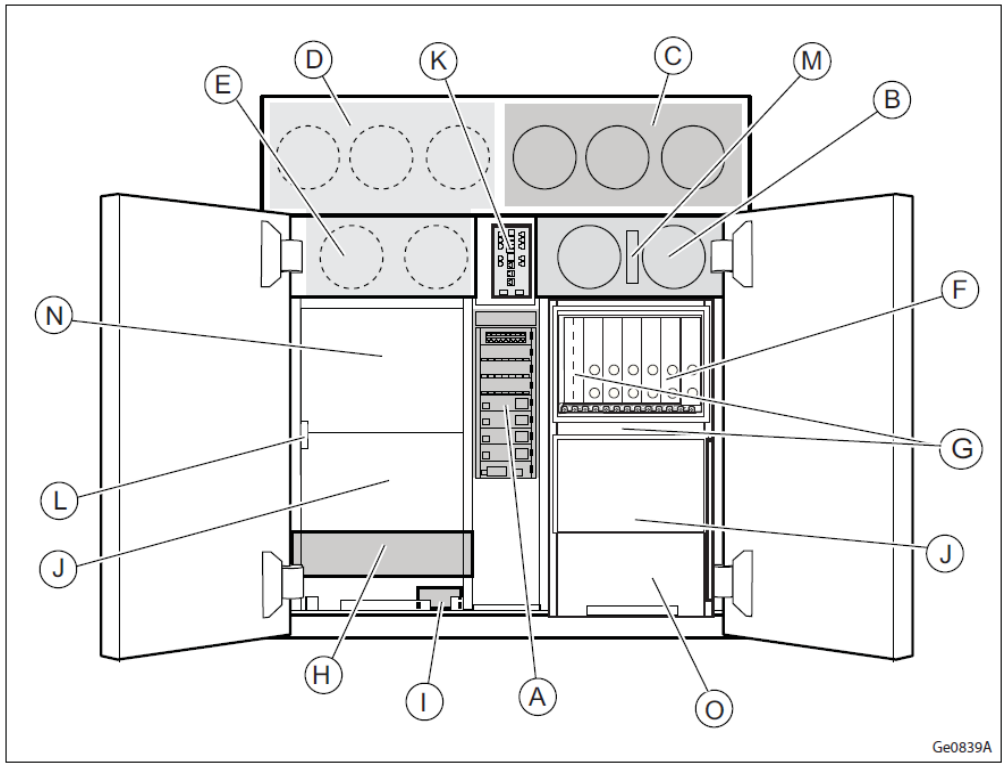
- Support Hub Unit (SHU)
- Power Distribution Unit (PDU)
- Power Supply Unit (PSU)
- Battery Fuse Unit (BFU) or Power Connection Unit DC (PCUDC)

B Internal fans (standard climate)
C External fans (standard climate)
D External fans (extended climate; optional)
E Internal fans (extended climate; optional)
F Radio Unit (RU)

Overview of the Cabinet with DU with location of the units in the cabinet shown for *RBS Outdoor Cabinet with DU*.

(Installing RBS 6102, Erickson, 2010.)

11.1 Site set up cont'd



Overview of the Cabinet with DU with location of the units in the cabinet shown for *RBS Outdoor Cabinet with DU*.

For **G**: Baseband cassette includes:

- Control Base Unit (CBU)
- Exchange Terminal (ET) board
- Random Access and Receiver (RAX) board
- Transmitter (TX) board
- Radio Unit Interface (RUIF)

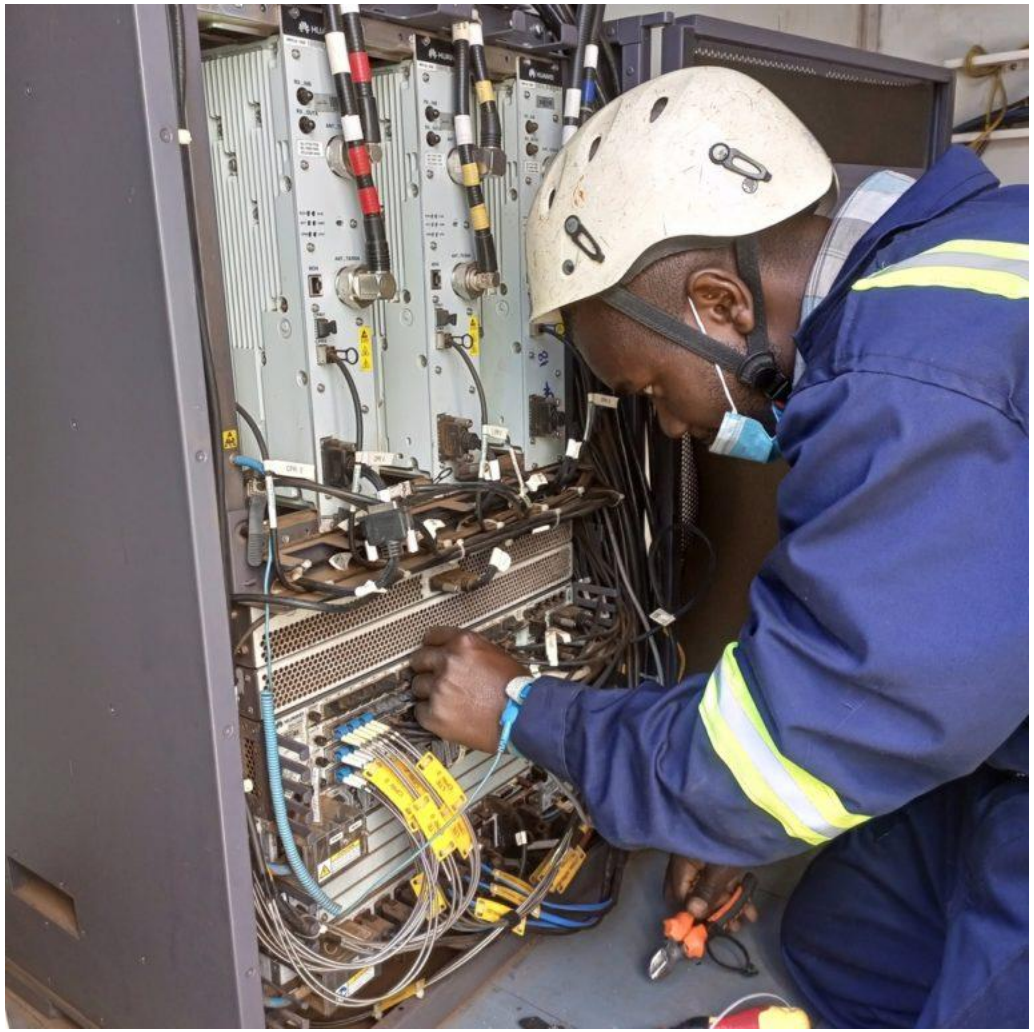
H Power Connection Unit AC (PCU AC)
I Power Connection Filter (PCF)
J Space for transmission equipment or backup batteries (optional)
K Support Control Unit (SCU)
L Support Alarm Unit (SAU) (optional)
M Heater (AC or DC) (optional)
N Space for future use
O Space for transmission equipment (optional)

(Installing RBS 6102, Erickson, 2010.)

11.1 Site set up cont’d

(https://nolmoat.com/our-services/technology-management/bts-tower-installation/)

11.1 Site set up cont’d



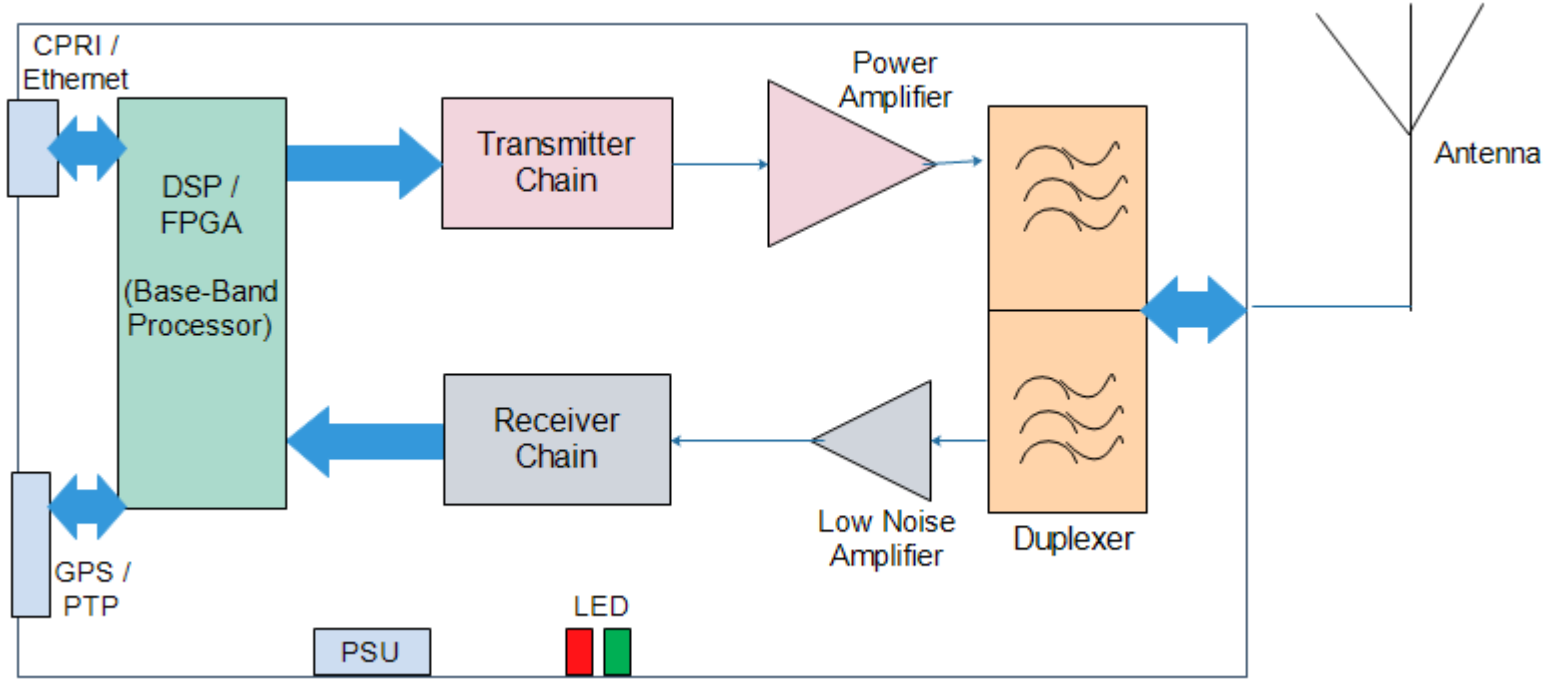
(https://pentacom.co.ke/bts-equipment-installation-and-commisioning/)

11.1 Site set up cont’d

(https://pentacom.co.ke/bts-equipment-installation-and-commisioning/)

11.2 Transmitted power and RSSI

- BTS is also referred to as the radio base station (RBS), *node B* in 3G Network or, simply, the base station (BS). For discussion of the LTE standard the abbreviation *eNB* for evolved node B is widely used.



(https://www.techplayon.com/bts-unit-bts-consumes-power/)

11.2 Transmitted power and RSSI cont'd

- PA unit of the BTS consumes most of the power consumed by BTS. Here is the example calculating power consumed by power amplifier out of total BTS power consumed.
- Suppose, BTS is single TRX (means 1TX, 1RX), and consumes around 140W.
- Output power of BTS at antenna port = 10W (40dBm)
- Output power of BTS at PA Output port = 20W (43dBm) ; Considering 3dB loss of duplexer after the PA.
- PA efficiency (approx.) = 25%
- Power consumed by PA = PA output power / Efficiency = 20W / 0.25 = 80W.
- So, 80W power is consumed by PA only, out of 140W total power consumed by BTS.
- And rest 60W is used by transceiver part, base-band part etc.
- Efforts are being made to increase the efficiency of the PA and there are some techniques already available,, such as Doherty Amplifier configuration, Tracking etc.

11.2 Transmitted power and RSSI cont’d

- Transmitted power refers to the amount of energy a Base Transceiver Station (BTS) radiates in the form of electromagnetic waves to provide coverage to mobile devices within its service area. The transmitted power is typically measured in watts (W) or decibels milliwatts (dBm), and it directly influences the coverage area and the quality of the signal received by mobile devices.
- The power level is carefully controlled by network operators to balance coverage and interference. If the transmitted power is too high, it may result in unnecessary interference with neighbouring cells, while insufficient power could lead to weak signal strength and poor user experience, particularly at the cell edges. Therefore, BTS transmit power is optimized based on factors such as traffic density, terrain, antenna height, and the type of service being provided (e.g., voice, data, etc.).

11.2 Transmitted power and RSSI cont’d

- The transmitted power of a BTS is influenced by several factors that are aimed at maintaining efficient network operation. These factors include the antenna type and orientation, terrain and environmental conditions, cell size, and network traffic demand. In densely populated areas or urban environments, the power levels might be lower to minimize interference and to support more efficient frequency reuse across the network.
- On the other hand, in rural or less populated areas, BTSs may need to increase their transmitted power to ensure adequate coverage over larger distances. Additionally, weather conditions, such as rain or snow, and physical obstructions like buildings or hills, can also affect the propagation of the transmitted signal and may require adjustments in power settings for reliable service.

11.2 Transmitted power and RSSI cont’d

- The Received Signal Strength Indicator (RSSI) is a critical metric used to evaluate the signal quality a mobile device receives from a BTS. RSSI is typically measured in dBm and indicates the power level of the received signal at the mobile station’s antenna. A higher RSSI value indicates a stronger signal, which usually corresponds to better network performance, faster data rates, and fewer dropped calls.
- Conversely, a lower RSSI value signifies a weaker signal, which could lead to connectivity issues, reduced data throughput, and an increased likelihood of call drops. RSSI plays a vital role in the operation of mobile networks, especially in terms of handover and cell selection. Mobile devices rely on RSSI measurements to determine the best BTS to connect to, ensuring seamless service as users move between cells.

11.2 Transmitted power and RSSI cont’d

- RSSI is not just a measure of signal strength but also an important indicator of network performance and quality of service (QoS). In a well-designed cellular network, the RSSI value should be sufficiently high to provide adequate coverage across the entire service area.
- However, RSSI alone does not always represent the full picture of signal quality, as it does not account for noise or interference, which can degrade the overall user experience. To evaluate the true quality of the signal, additional metrics such as Signal-to-Noise Ratio (SNR) and Signal-to-Interference Ratio (SIR)are used in conjunction with RSSI. Together, these metrics help determine the optimal transmitted power levels for BTSs, ensuring reliable communication, efficient network capacity utilization, and a high-quality user experience across various environmental conditions and traffic scenarios.

11.3. Recall a transceiver (TRX)

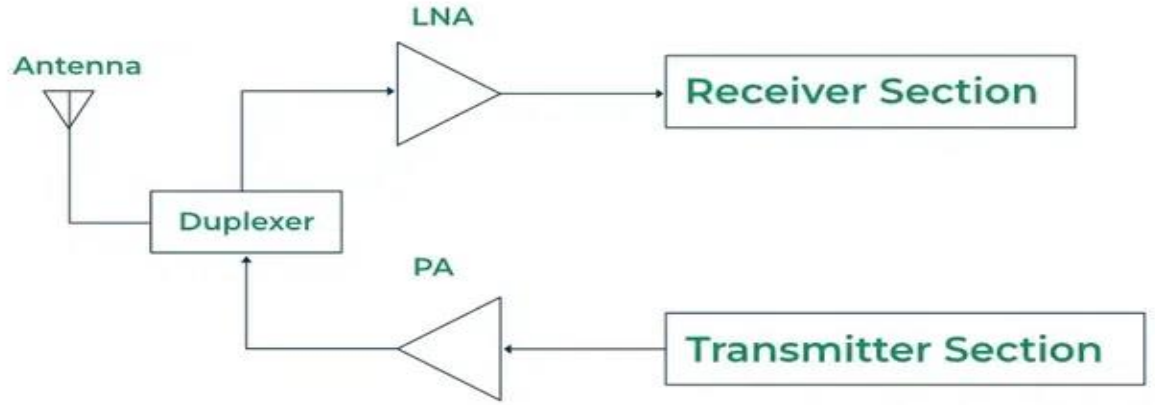
- Transceivers or TRANSmitter - reCeiver allow for two-way communication by sending and receiving data, voice, or other types of signals over a communication medium such as radio waves or optical fibres in a shared circuitry.
- To work, the transmitter and receiver are linked to the same antenna with the help of an electric switch.
- The TRX generates a signal, which could be electrical optical, radiofrequency, depending on the medium of communication. The signal is then subjected to modulation. The modulated signal is then sent out through an antenna or thro ugh a cable. At the receiving end, another transceiver is waiting to capture the incoming signal.

11.3. Recall a transceiver (TRX) cont'd

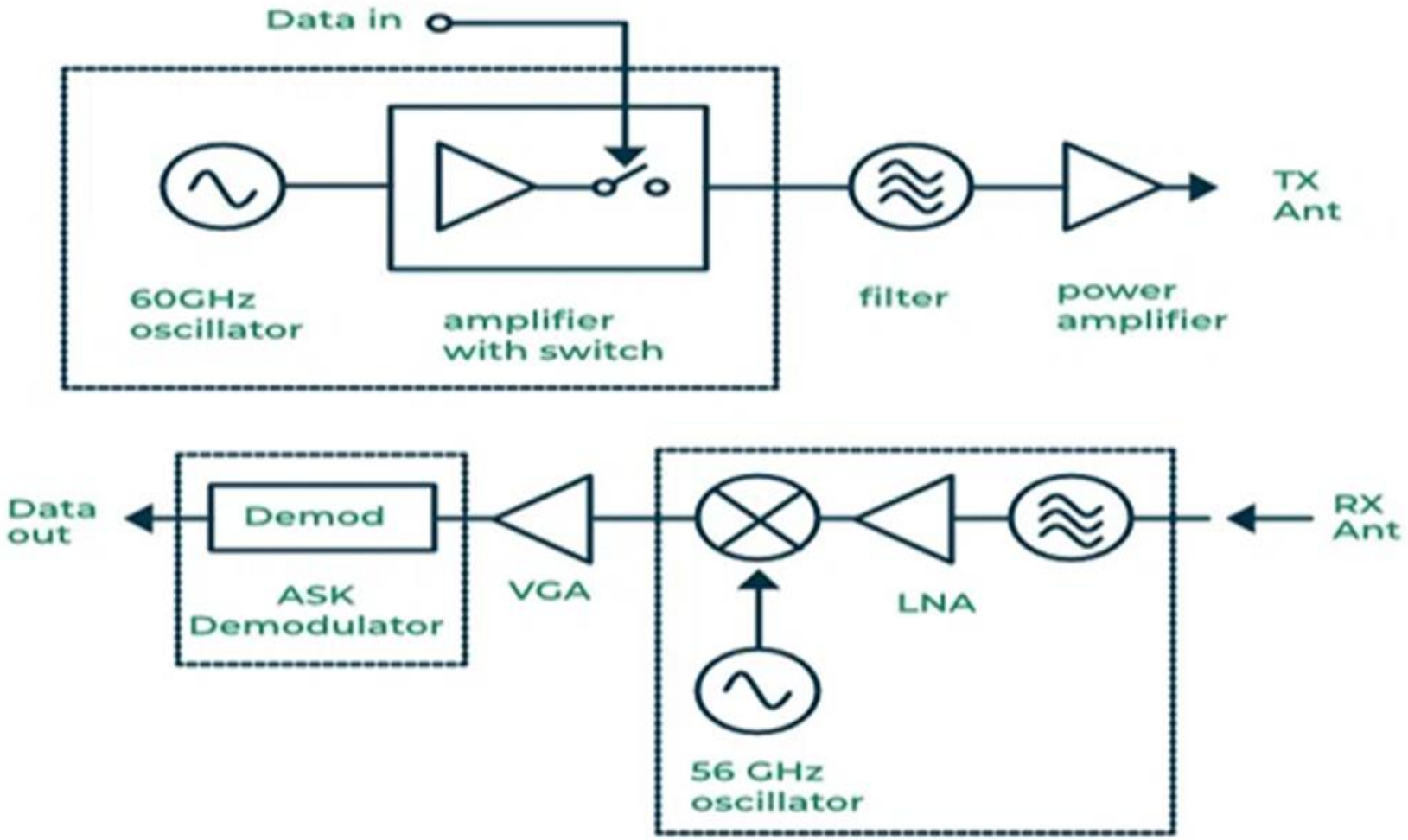
- Then finally the signal gets subjected to demodulation and transmitted data gets recovered and the data gets provided to system for further processing or display.
- Both the transmitter and the receiver work at distinct frequencies, which prevents the signal from the transmitter to interfere with the signal from the reception. Phones that are cordless as well as cellular phones employ this mode of operation.
- A Wireless TRX has these basic important blocks in structure and design.
- Antenna or antenna array: to change electrical signal into EM waves.
- Duplexer: Isolates transmitting and receiving segments allowing bidirectional communication to take place along a single channel with proper interference prevention

11.3. Recall a transceiver (TRX) cont'd

- Transmitter section: Base band signal is manipulated through modulation and other processes to prepare the appropriate signal with enough and strong power to be transmitted.
- Receiver section: The received signal is manipulated through demodulator and others processes ensuring the necessary SNR value to avoid the loss of the signal at the target recipient.



11.3. Recall a transceiver (TRX) cont'd



11.3. Recall a transceiver (TRX) cont'd

Key Features and functions of Transceivers (processes)

- **Modulation and Demodulation**: They can modulate outgoing signals for transmission and demodulate incoming signals for reception. Modulation involves encoding data onto a carrier signal for transmission, while demodulation extracts the original data from received signals.
- **Signal Amplification:** Transceivers can amplify signals for transmission, ensuring that they are strong enough to travel over long distances or through various media.
- **Frequency Conversion**: Some transceivers can change the frequency of the signals, allowing for compatibility with several types of networks or devices.
- **Signal Encoding/Decoding**: They often handle encoding and decoding schemes to represent digital data as analog signals for transmission and vice versa.

11.3. Recall a transceiver (TRX) cont'd

- Transceivers are essential and important in modern communication system for several reasons: Bidirectional communication, combination of separate transmitter and receiver components into a single device makes it highly efficient, allows data exchange, transmission of voice, video, over various mediums as wired or wireless, remote sensing like weather monitoring or space exploration, Versatile, Telemedicine, Security, etc.

(https://www.geeksforgeeks.org/transceivers/)

11.4 Call set up

- The process of setting up a call through cellular networks involves multiple systems working in concert, with broadcasting towers (also known as cell towers or base stations) playing a critical role in connecting mobile devices and facilitating communication between two parties.
- Broadcasting towers, or cellular base stations, are the backbone of wireless communication systems. They serve as the interface between mobile devices (such as smartphones) and the core network (including switches, routers, and other infrastructure components).
- The primary function of a broadcasting tower is to transmit and receive signals from mobile devices in its coverage area, handling voice, data, video and text communications.

11.4 Call set up cont’d

- The call setup process can be broken down into several stages, from when a user initiates a call to when both parties are able to communicate. The process includes the interaction of different components of the telecommunications network, including the mobile device, cell towers, and core network infrastructure.

Step 1: Mobile device initiates call

- The user dials a phone number on their mobile device. The device uses its radio module (transmitter and receiver) to send a request to the nearest broadcasting tower.
- Radio interface: The mobile device communicates via radio waves using a specific frequency allocated by the cellular network operator.

11.4 Call set up cont’d

Step 2: Connection to the nearest cell tower

- The Cell Tower or Base Station: The mobile device is in range of a nearby cell tower (base station) within the radio coverage area. Each base station has a limited coverage radius (called a cell) and can serve multiple mobile users simultaneously.
- Transceiver (TRX): Inside the base station, a TRX handles the wireless communication between the mobile device and the tower, modulating and demodulating signals.
- Antenna: The base station’s antenna transmits and receives signals to and from mobile devices within its coverage area.

11.4 Call set up cont’d

Step 3: Establishing connection to the Mobile Switching Center (MSC)

- Base Station Controller (BSC): Once the mobile device has connected to the nearest base station, the signal is sent to the BSC, which is responsible for managing the base stations, including managing radio resources and handovers (if the call is moved between cells).
- Mobile Switching Center (MSC): The BSC routes the call request to the MSC, which serves as the central hub for call routing and switching in the cellular network. The MSC is responsible for setting up the call, managing the user’s location, and controlling call routing to other parts of the network (e.g., landline networks or other mobile devices).

11.4 Call set up cont’d

Step 4: Call routing

- Home Location Register (HLR): The MSC checks the HLR, which contains the subscriber's profile and information such as the mobile number, services subscribed to, and current location (i.e., the cell the user is in).
- Visitor Location Register (VLR): The MSC also interacts with the VLR, which temporarily stores location and service information about the user’s device when they are in a new area (away from their home network).

Step 5: Call setup and ringing

- Signalling and call setup: The MSC initiates call setup signalling to the recipient's mobile device. This includes routing the call through the appropriate network elements to reach the recipient’s device.

11.4 Call set up cont’d

- For calls to a landline or another mobile device in a different network, the MSC coordinates with other network systems (e.g., PSTN or another MSC).
- Outward routing: The call is sent to the appropriate switching node in the case of inter-network communication (if the recipient is using a different network).
- Call establishment: Once the recipient's device is located (via the recipient’s MSC and HLR/VLR lookup), the call is established, and the recipient’s device rings.
- The signalling protocol used for call setup is typically SS7 (Signalling System 7) or Diameter (for newer IP-based networks).

11.4 Call set up cont’d

Step 6: Handover and call continuity

- Handover (HO): If the call is ongoing while the user moves (e.g., from one cell to another), the call must be handed over to the next nearest cell tower. The BSC and MSC manage this handover, ensuring the call is not dropped. The call may involve several base stations as the user moves around the network.
- Inter-cell Handovers: When a user moves from one cell tower’s coverage to another, the call is handed over between base stations without interrupting the connection, using mechanisms like Soft Handover or Hard Handover, depending on the network type (GSM, UMTS, LTE, 5G).

11.4 Call set up cont’d

Step 7: Communication established between two parties

- Voice/Data Transmission: Once the call setup process is completed, the voice or data transmission begins. The signals between the two mobile devices (or a mobile and a landline) are now routed through the core network, where the media stream is established, for real-time communication between both parties.
- Media Gate Way (MGW) : In some network types, a media MGW is involved in the conversion of voice signals between different network segments, such as between cellular and the Public Switched Telephone Network (PSTN).

11.4 Call set up cont’d

- VoLTE/VoNR: For modern networks, Voice over LTE (VoLTE) or Voice over New Radio (VoNR) protocols may be used for high-quality voice calls over 4G/5G networks, with all signalling and data transmission taking place over IP-based protocols.

Step 8: Call termination

- End of Call: Once the call has ended, one of the parties hangs up, sending a termination signal to the MSC. The MSC then clears the resources allocated to the call (such as radio resources in the base stations and network resources), and the communication session ends.

11.5 Technologies and protocols

- Radio Access Network (RAN): This includes all the components involved in radio communication between the mobile device and the cell tower, including antennas, transceivers, and the base station controllers.
- Core Network elements: This includes the MSC, HLR, VLR, and media gateways, responsible for routing the call through different networks and ensuring the necessary signalling and data transmission.

Signalling Protocols:

- SS7(Signalling System No. 7): A traditional signalling protocol used to establis h connections and manage call routing across telephone networks.
- Diameter: A newer protocol used for authentication, authorization, and accoun ting in next-generation networks like LTE and 5G.

11.5 Technologies and protocols cont’d

- IP-based Networks: For LTE and 5G, calls are transmitted over IP, which allow s higher-quality voice communication and supports advanced services like Vo LTE and VoNR.
- The role of broadcasting towers in the call setup process is fundamental to ensuring reliable and effective communication between two mobile parties.
- The combination of radio equipment in the towers (BTS), BSC, MSC, and signalling protocols ensures the call is set up, routed, and maintained through out its duration, regardless of geographic location or the mobile network type in use.
- This complex arrangement of the system with interconnected components ensures that mobile communications remain seamless, reliable, and of high quality.

Thank you for your good attention

Q&A

References

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