Equipment in the LTE Network

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Course Objectives

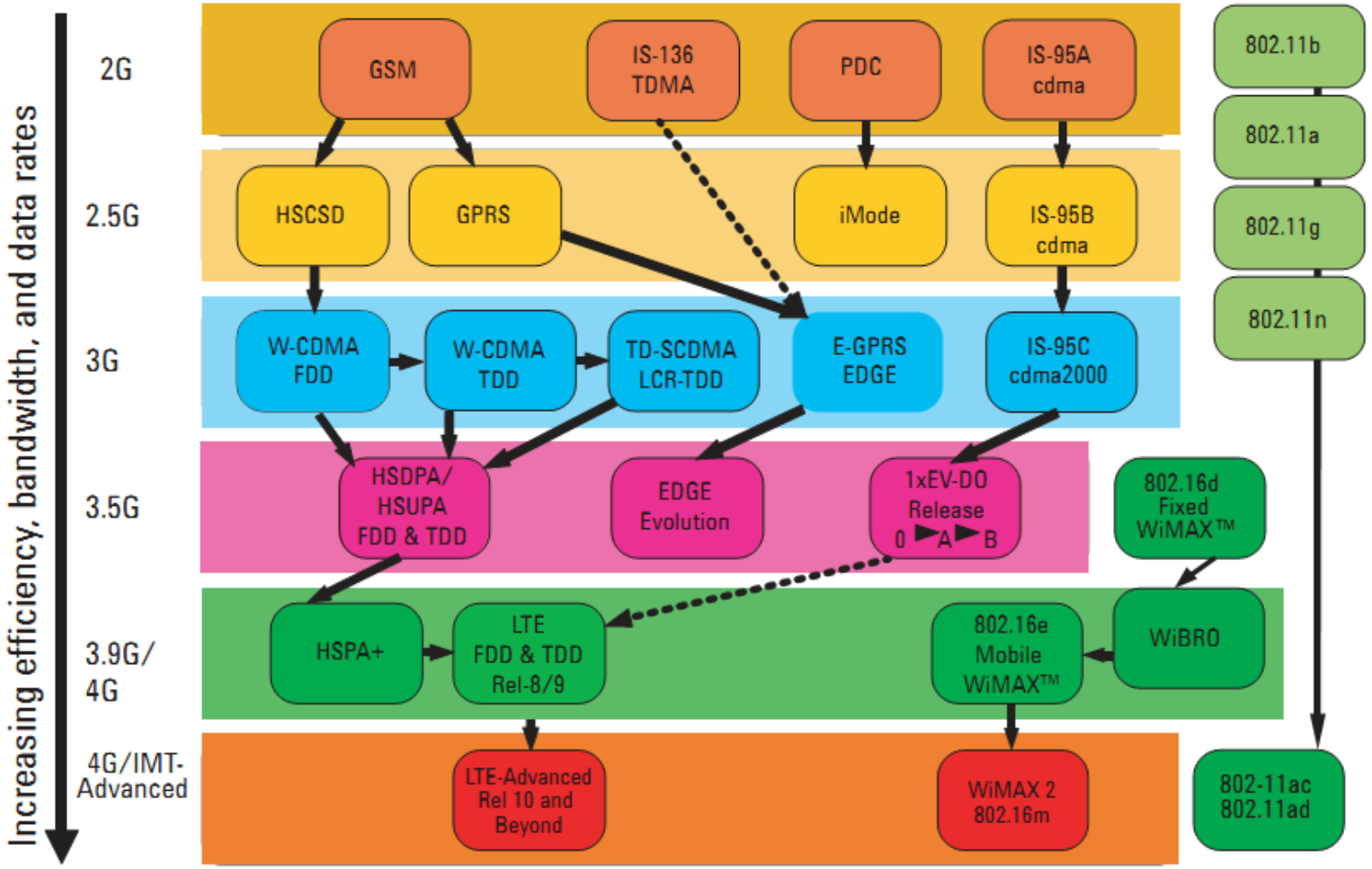
- Understanding the basic structure of the 4G-LTE network
- Knowing basic equipment used in the network and their applications
- Knowing the basic regulations in the test of the LTE equipment

Main Body

- Basic structure of telecom network
- Brief introduction for 4G core network
- Varieties of LTE access network equipment
- The test and regulation for the LTE equipment

What is LTE and what's for?

- 4G

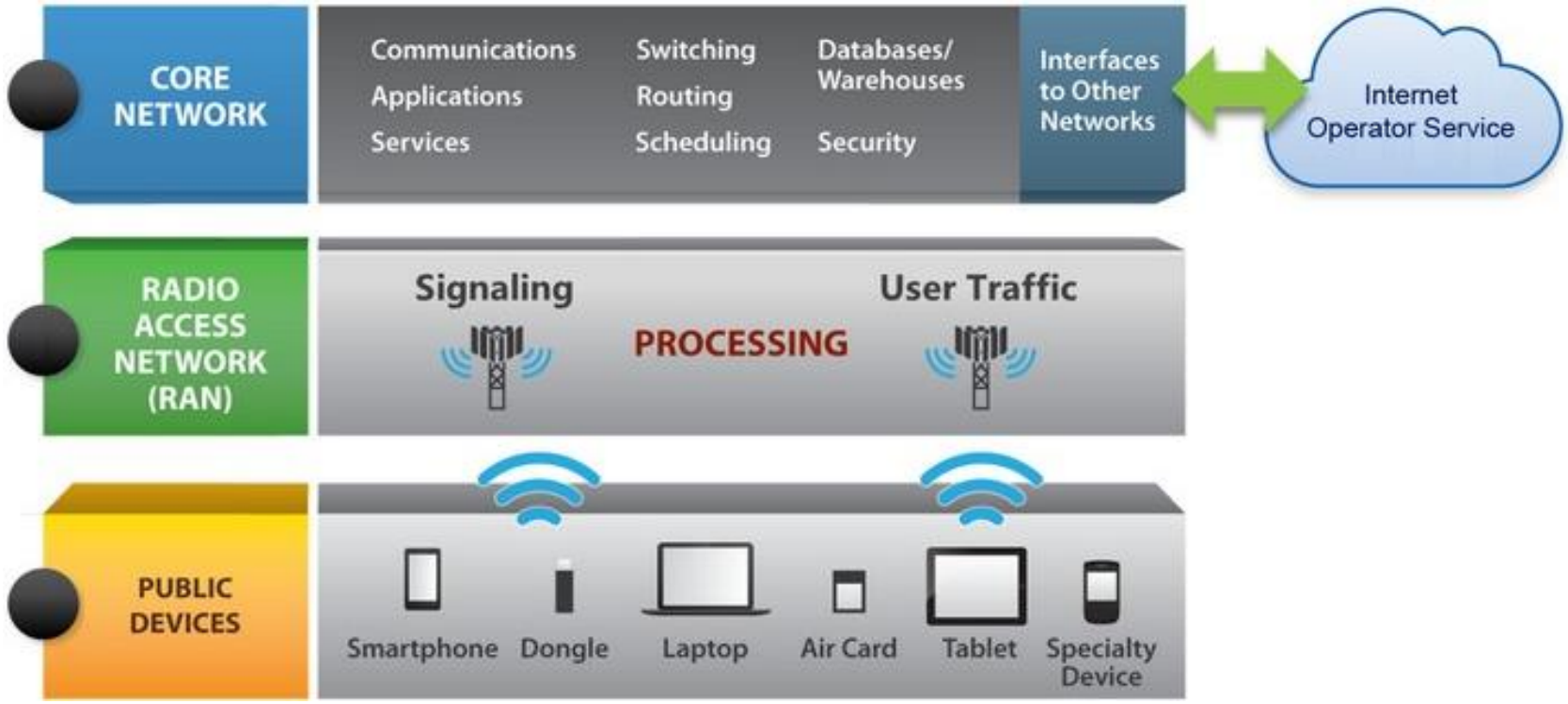


What is LTE and what's for?

- Key knowledge about 4G LTE (Long Term Evolution)
  - Starts by 3GPP in 2004
  - All-IP packet switching (VoIP included)
  - Variable system bandwidth
  - Higher peak data rate
    - LTE: 300 Mbps (DL) / 75 Mbps (UL)
    - LTE-A: 1Gbps (DL) / 500Mbps (UL)
  - Higher capacity (Refer to HSPA in Release 6)
    - 3-4 times (DL), 2-3 times (UL)
  - Low delay access
  - Less complicated UE (User Equipment)
- Faster, Bigger and more flexible
  - Better User Experience

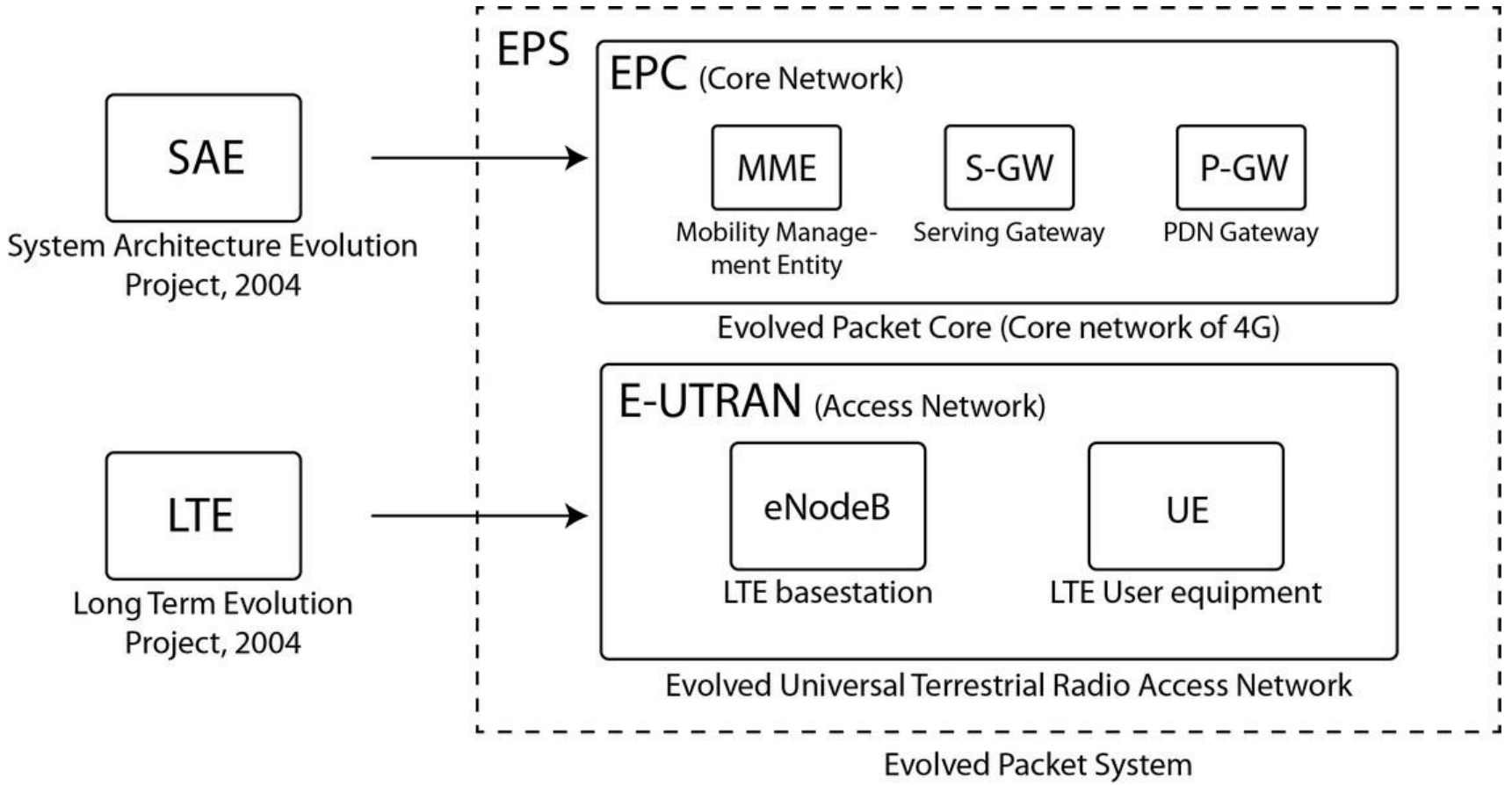
Concepts in 4G network

- Core Network
- Access Network



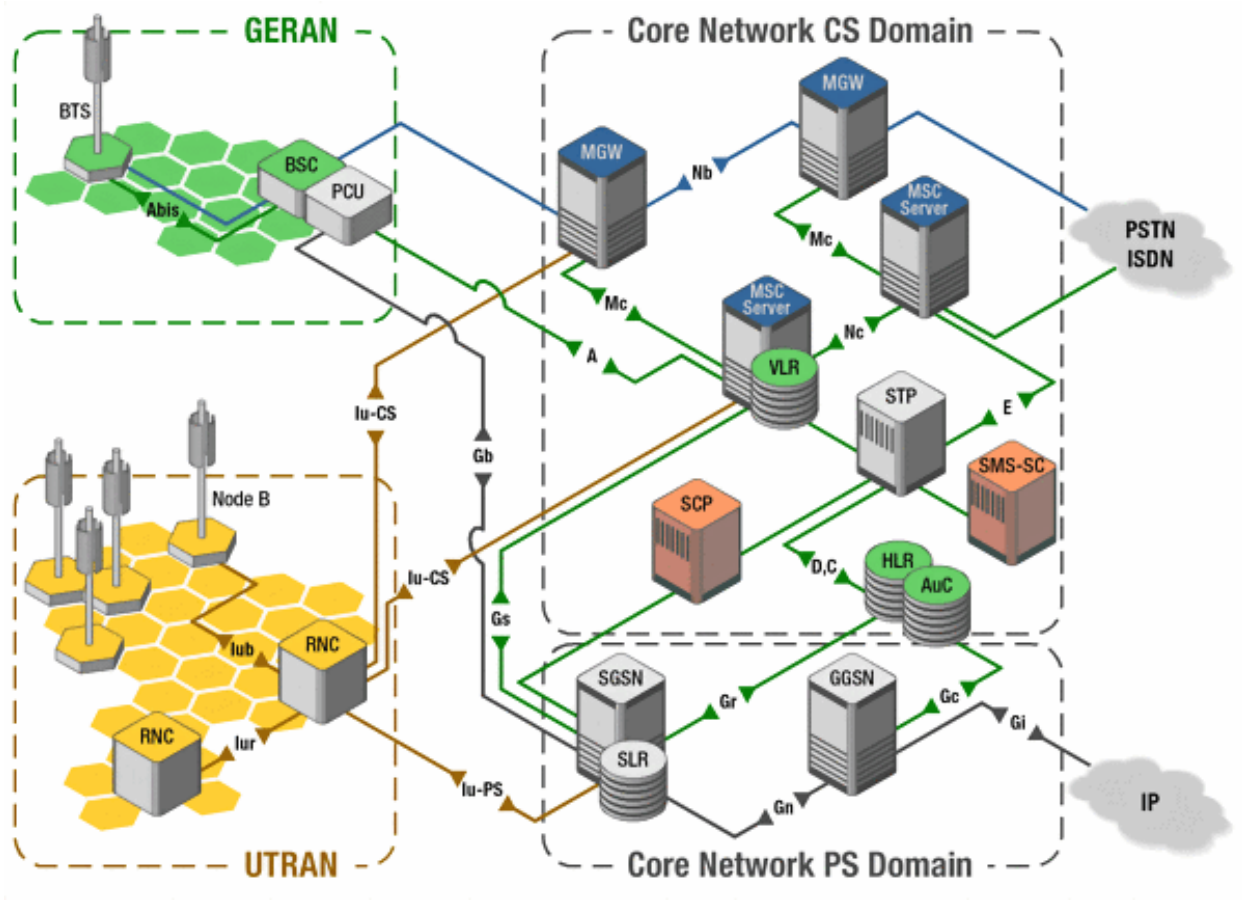
Concepts in 4G network

- LTE
- SAE
- E-UTRAN
- EPC
- MME
- S-GW
- P-GW
- EPS
- eNodeB
- UE
- …



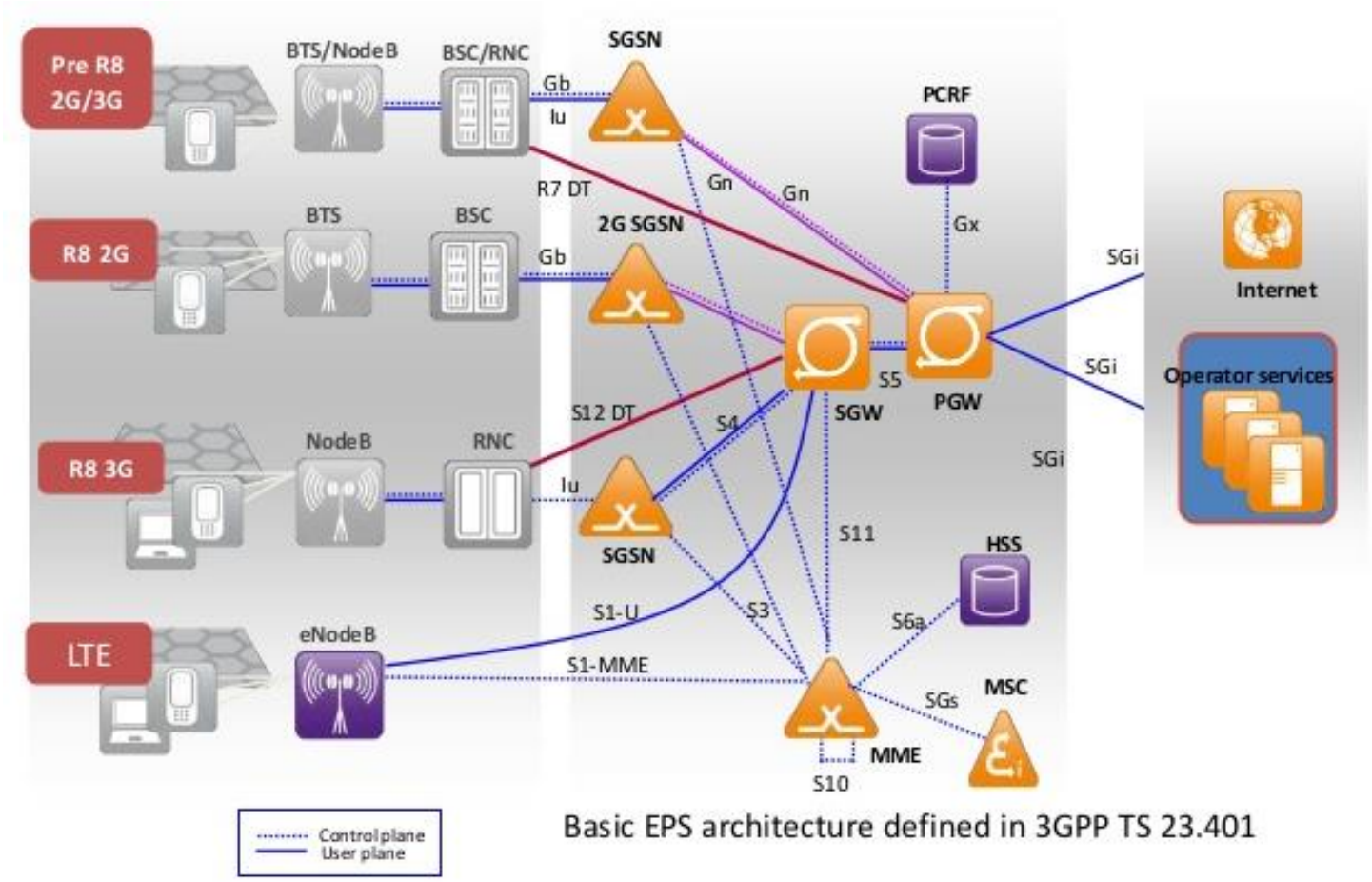
Basic structure of a network

- 2G/3G network architectures
  - Circuit switching domain
  - Packet switching domain
  - BSC / RNC
    - Mobility management
    - Radio resource management
    - Basic call handling
    - Handovers
    - …
  - ‘Base station subsystem’



Basic structure of a network

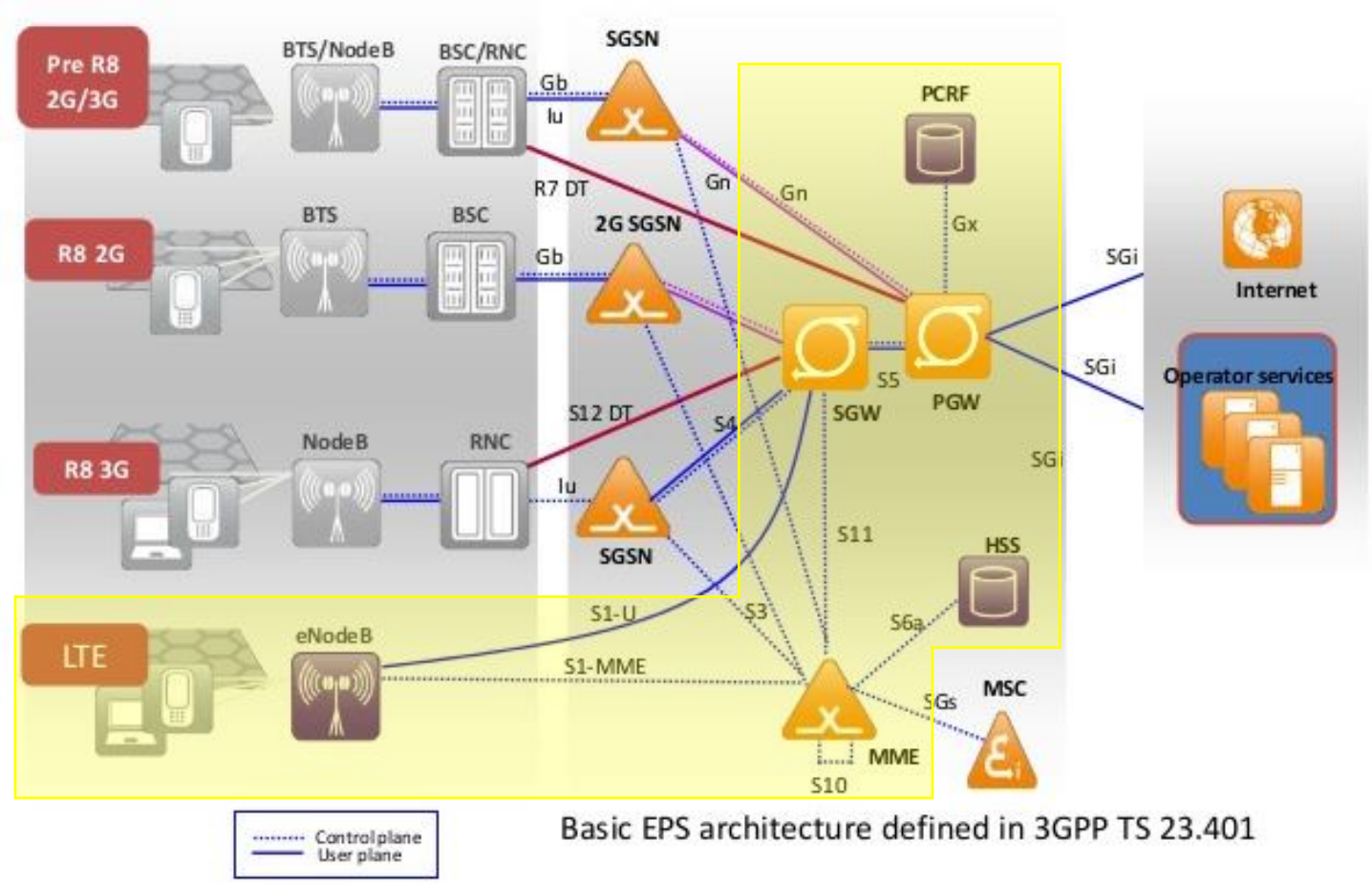
- 2G, 3G to 4G
  - All packet switching system
    - No CS domain
  - Flat structure
    - No BSC/RNC
  - Independent control plane and user plane
  - Multimode Access
    - Downwards compatibility



Basic EPS architecture defined in 3GPP TS 23.401

Brief introduction on EPC

- MME
  - Mobility Management Entity
    - Mobility / Access control / Conversation management …
- S-GW
  - Serving Gateway
    - Route and switching
- P-GW
  - PDN Gateway
    - Port to the Packet Data Network
- Other
  - Policy and Charging Rules Function
  - Home Subscriber Server



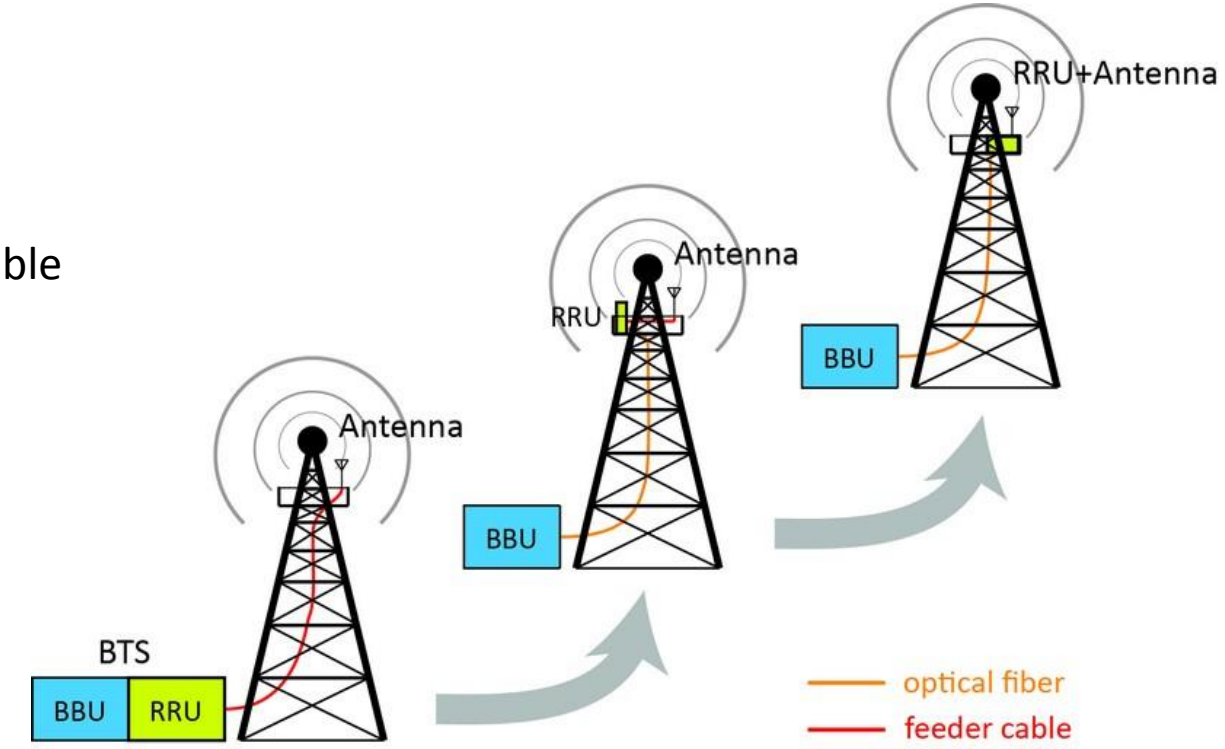
Basic EPS architecture defined in 3GPP TS 23.401

LTE Network Equipment

- What does a base station do?
  - Provide signal coverage
  - Signal processing and data transfer
- Basic parts of an LTE base station
  - Baseband part
    - Data processing and signaling handle
    - Decides the **capacity** of the system
  - Radio part
    - Interconversion of digital data and RF signal
    - Filtering and amplification of RF signal
    - Decides the **coverage** of the system
  - (Antenna)
    - Transmits and receives RF signal
    - Decides the “Shape” of the **coverage**

LTE Base Station – eNodeB

- Outdoor Coverage – Macro Cell
  - Used to cover a relative ‘vast’ area
  - The evolution
    - Traditional base station
      - Lumped structure
      - Loss and interference on RF cable
      - Tower amplifier
    - Distributed base station
      - RRU on the tower
      - Optical fiber to transfer data
      - Flexible deployment
    - ‘Integrated’ base station
      - Integrates antenna with RRU
      - Massive MIMO



Baseband Part

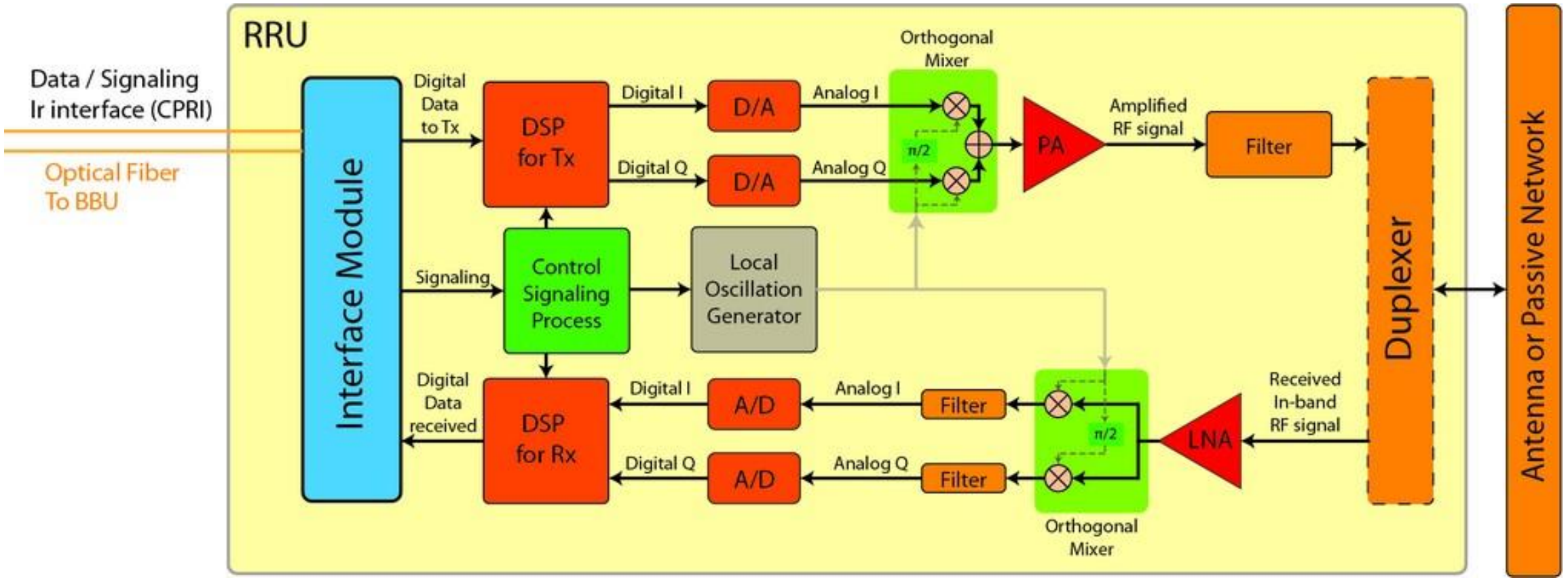
- Building Baseband Unit
  - Provide the physical interface between the base station and the core network
  - Provide the interface to RRU
  - Provide the system clock
  - Manage the whole base station system, including operating / maintenance and signaling processing
  - Process and transfer the uplink and downlink data packages
  - …
  - Act as a core in the base station

- **UMPT** (Universal Main Processing and Transmission Unit)
- **LBBP** (LTE BaseBand Processing Unit)
- **UELP** (Universal E1/T1 Lighting Protection Unit)
- **UFLP** (Universal FE/GE Lighting Protection Unit)
- **USCU** (Universal Satellite Card and Clock Unit)
- **CPM** (Channel Processing Module)
- **UPEU** (Universal Power & Environment Interface unit)
- **FAN**

Radio Remote Part

- Radio Remote Unit
  - Interconversion between digital signal and RF signal
  - Associated preprocessing, amplification, filtering, carrier generation, etc.
  - [FDD only] Provides the duplex function, allowing up and down link signals shares a same antenna port
  - Relays data from / to other RRU connected in cascade
  - Controlled by the BBU

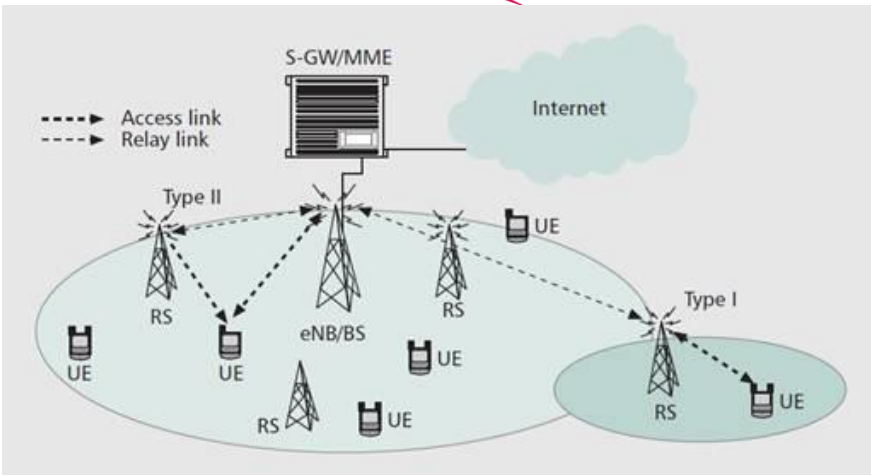
Radio Remote Part

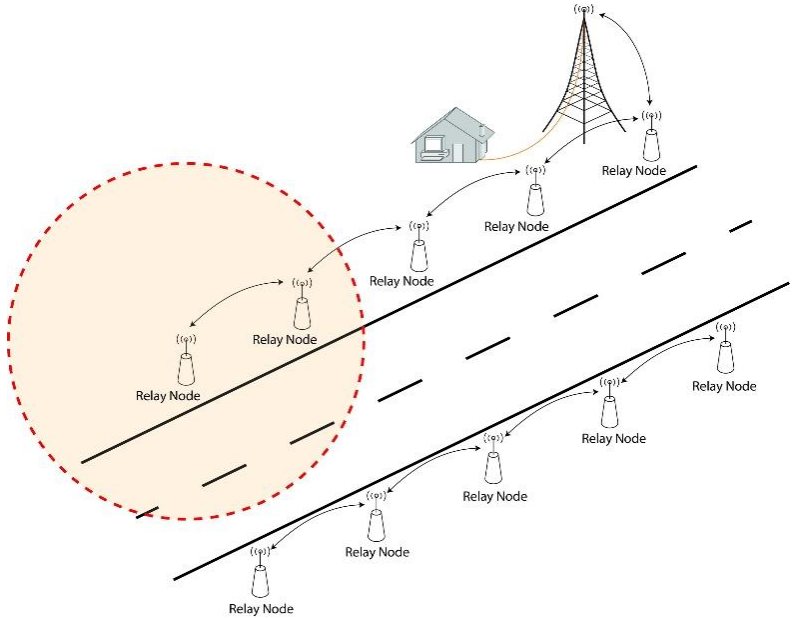


Outdoor Coverage Enhancement

- Relay Nodes
  - Relay the signal
  - Extends the coverage but not the capacity
  - RF Repeaters
  - Microwave Repeaters
  - Optical fiber Repeater

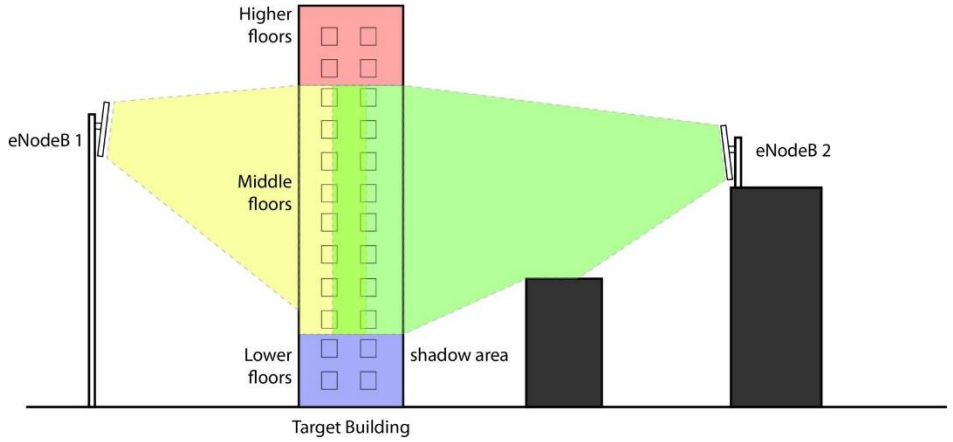
- Application scenarios
  - grassland coverage
  - Along the motorway / Railway
  - …

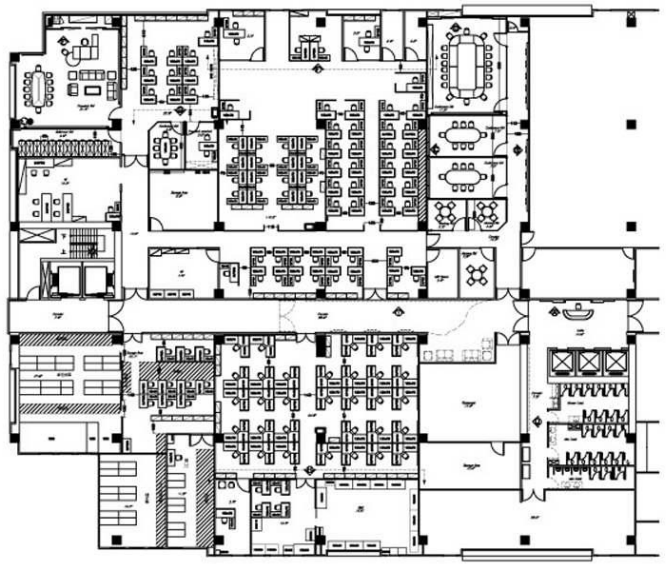




Indoor Coverage

- Indoor Coverage – the challenge
  - About coverage itself
    - Lower floors – shadowing
    - Medium floors – ping pong effect
    - Higher floors – too high to reach
    - Complicated indoor structures
    - Unpredictable decay and reflection
  - About capacity
    - High user density
    - High data rate required

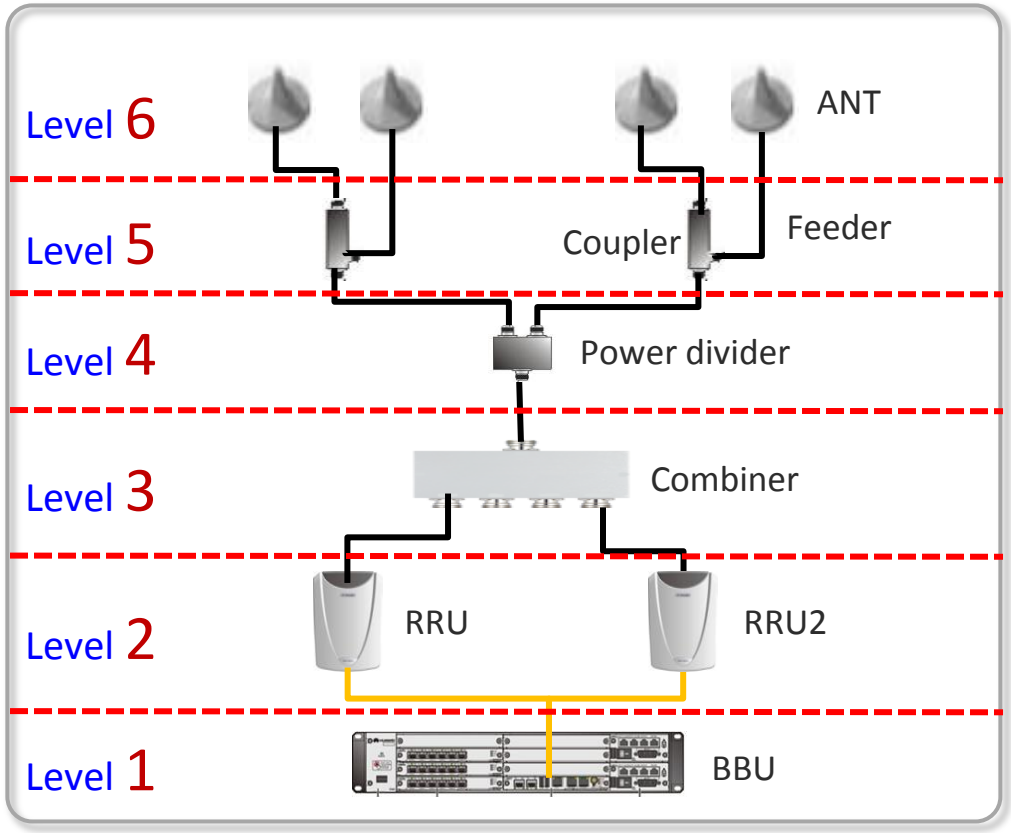




Indoor Coverage

- Indoor Coverage – Traditional method
  - Feed RF signal directly into the building
  - Using passive components (Combiner, power dividers, couplers, etc.) to distribute the signal

Traditional indoor distribution system

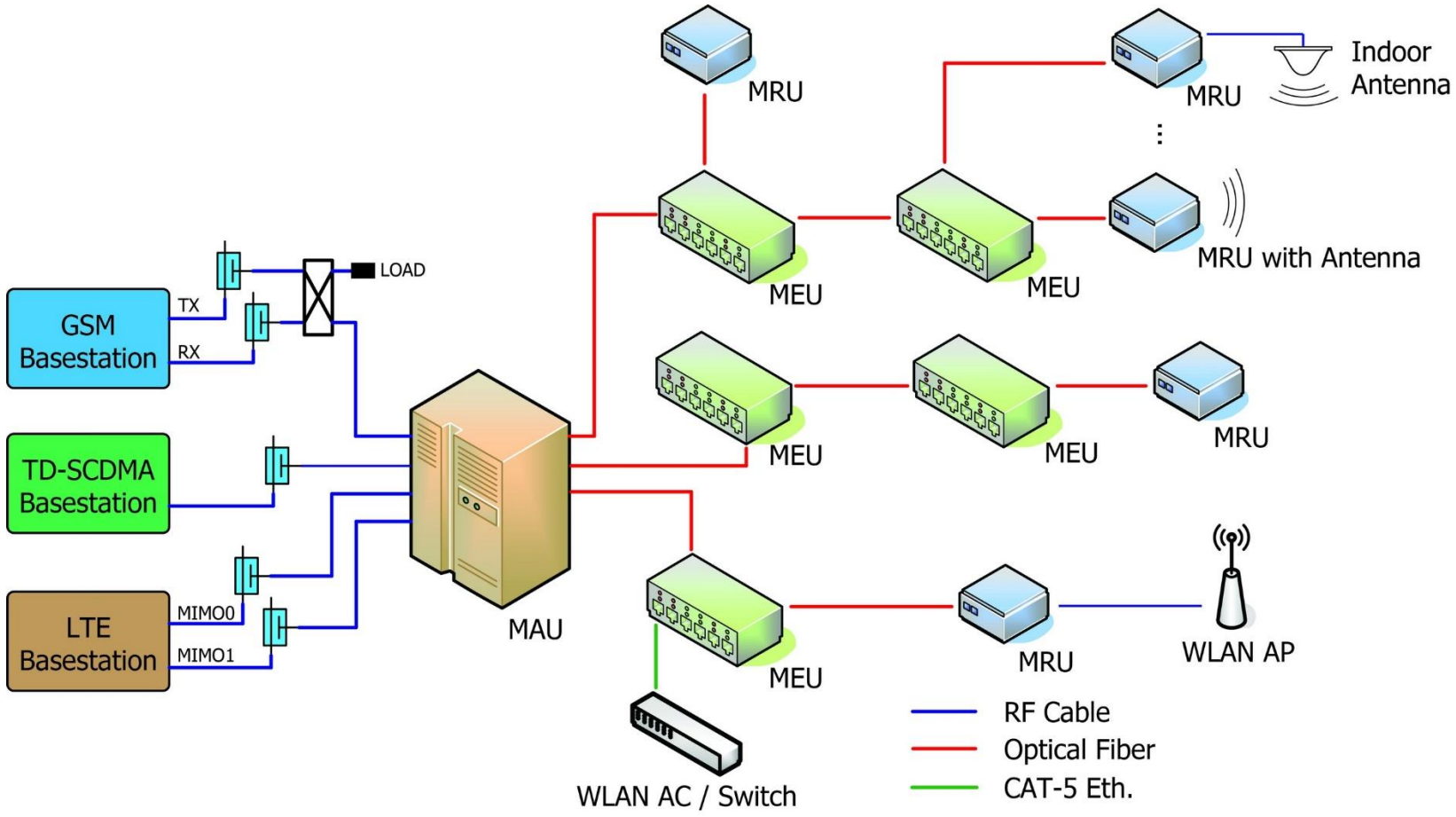


Indoor Coverage

- Indoor Coverage – Traditional method
  - Advantage
    - Direct and simple
    - Nothing to configure
    - Suitable for any system
    - No need for power supply
  - Disadvantage
    - Loss on the distribution / cable
      - Trunk amplifier
      - Works under high power
    - Additional space needed

Indoor Coverage

- Indoor Coverage – MDAS

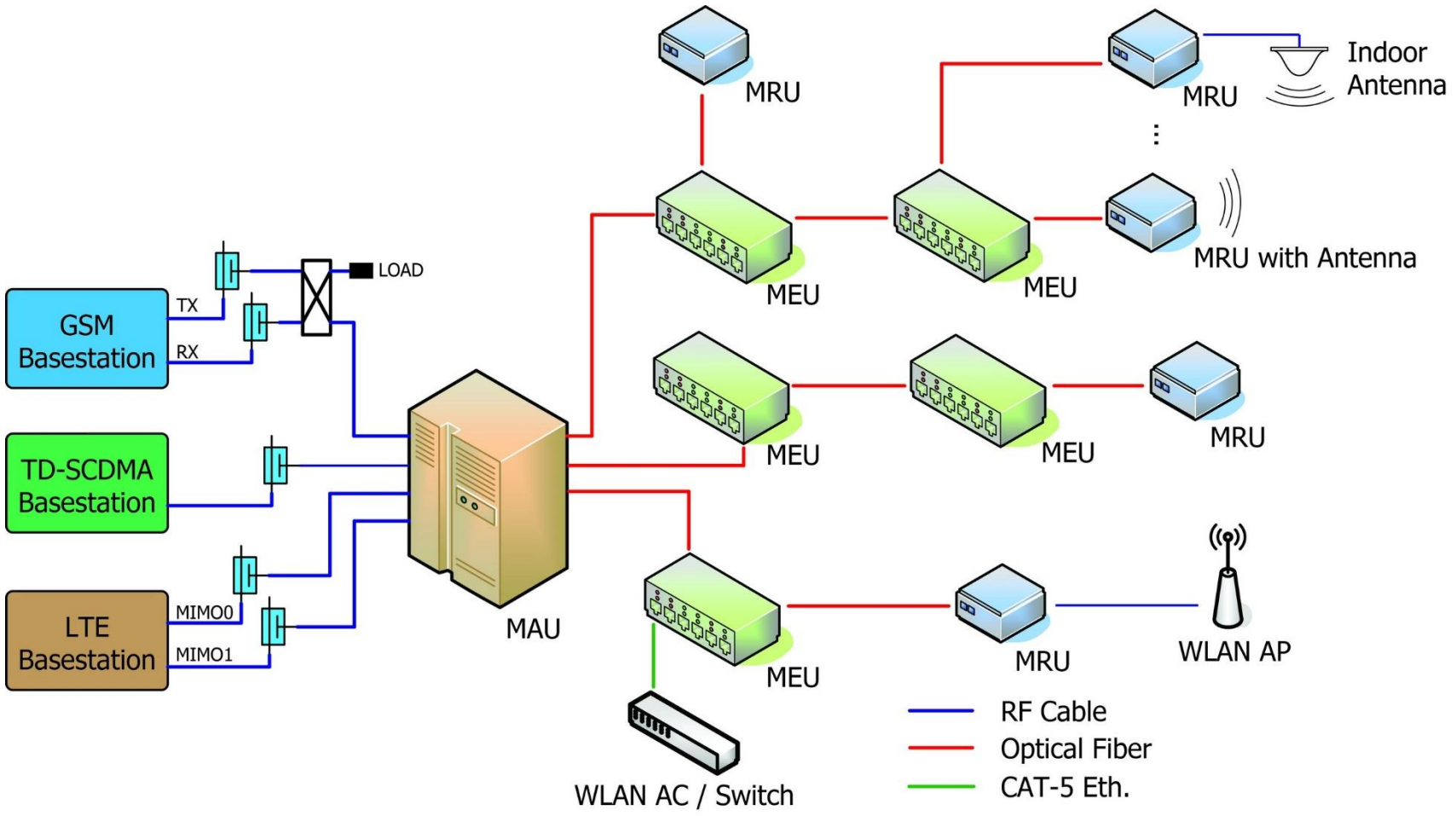


Indoor Coverage

- Indoor Coverage – MDAS
  - Multiservice Digital Access System
    - MAU - Multiservice Access Unit
      - Interconversion between RF signal and digital signal
    - MEU – Multiservice Extension Unit
      - Extension component
    - MRU – Multiservice Radio Unit
      - Interconversion between RF signal and digital signal
  - Advantage
    - Eliminates the loss in the cable and during distribution
    - Fewer interference and better quality
    - No need for extra spaces
    - Cost-effective when scale is large

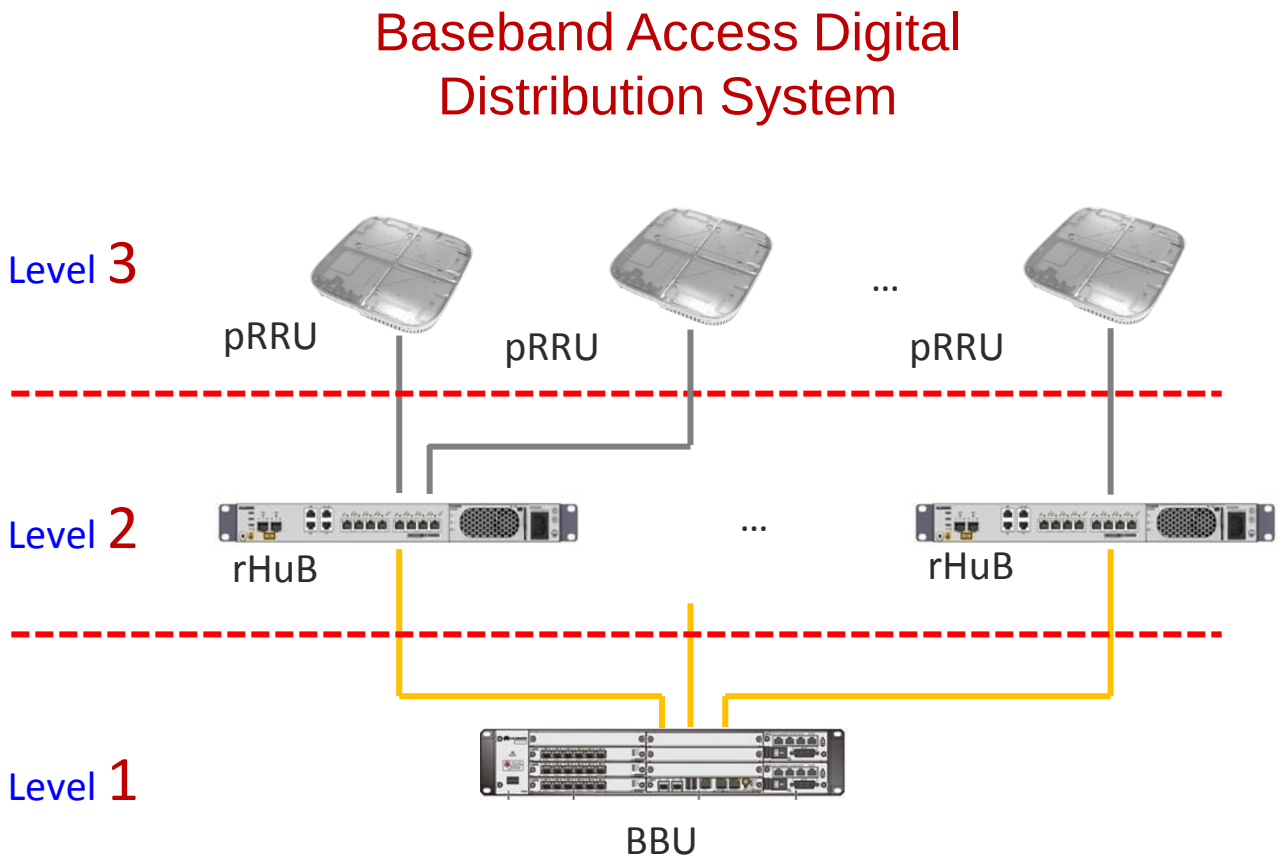
Indoor Coverage

- Indoor Coverage – MDAS



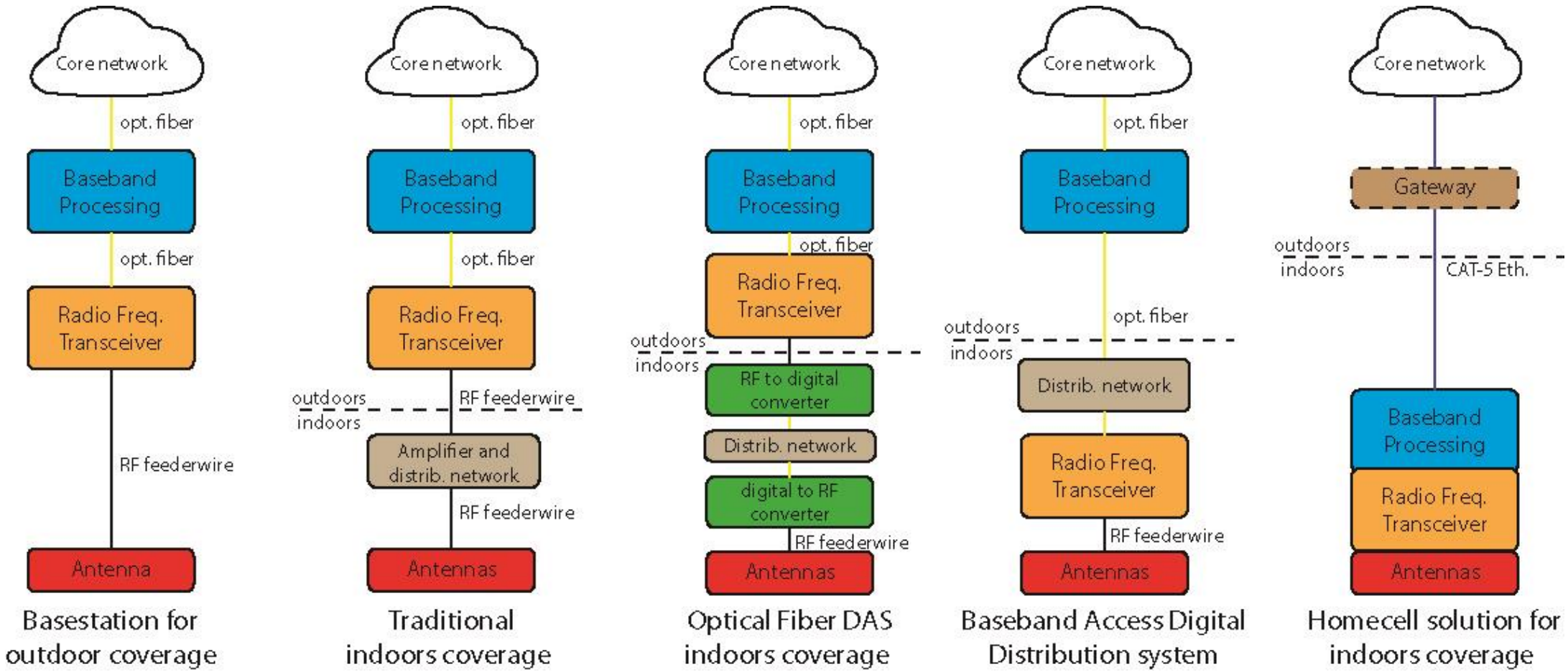
Indoor Coverage

- Baseband Access Digital Distribution System
  - rHUB: the switching component
  - pRRU is capable of processing the signaling
  - Similar architecture as the macro cell base station
  - Optical fiber and Cat-5e LAN Cable
- Advantage
  - No RF cable, no loss
  - Digital signal transmission
  - pRRU / rHuB able to process control signling



Indoor Coverage

- Indoor Coverage – the evolution



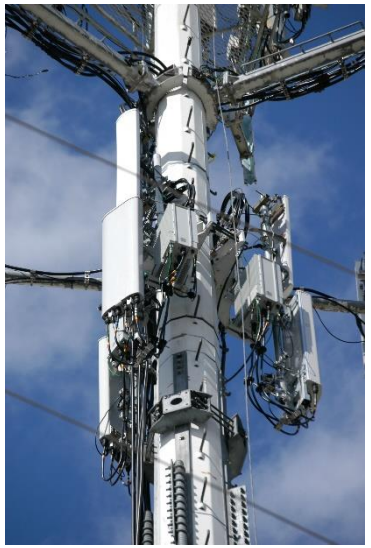
Indoor Coverage

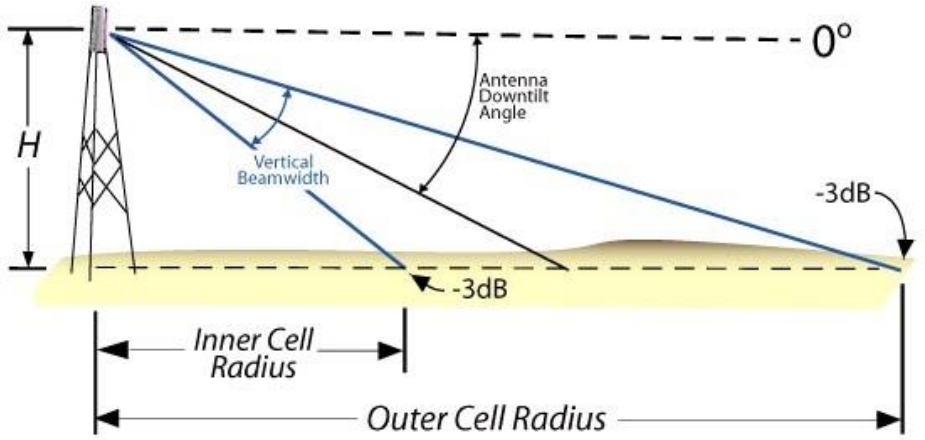
- Indoor Coverage – Homecell
  - Integrated solution
  - Backhaul by broadband network
    - Dedicated gateway for homecells
    - IPSec tunnel encryption

- Advantage
  - Multiservice
  - Small, light in weight
  - Low cost
  - Flexible deployment
  - Capacity extension

Antennas

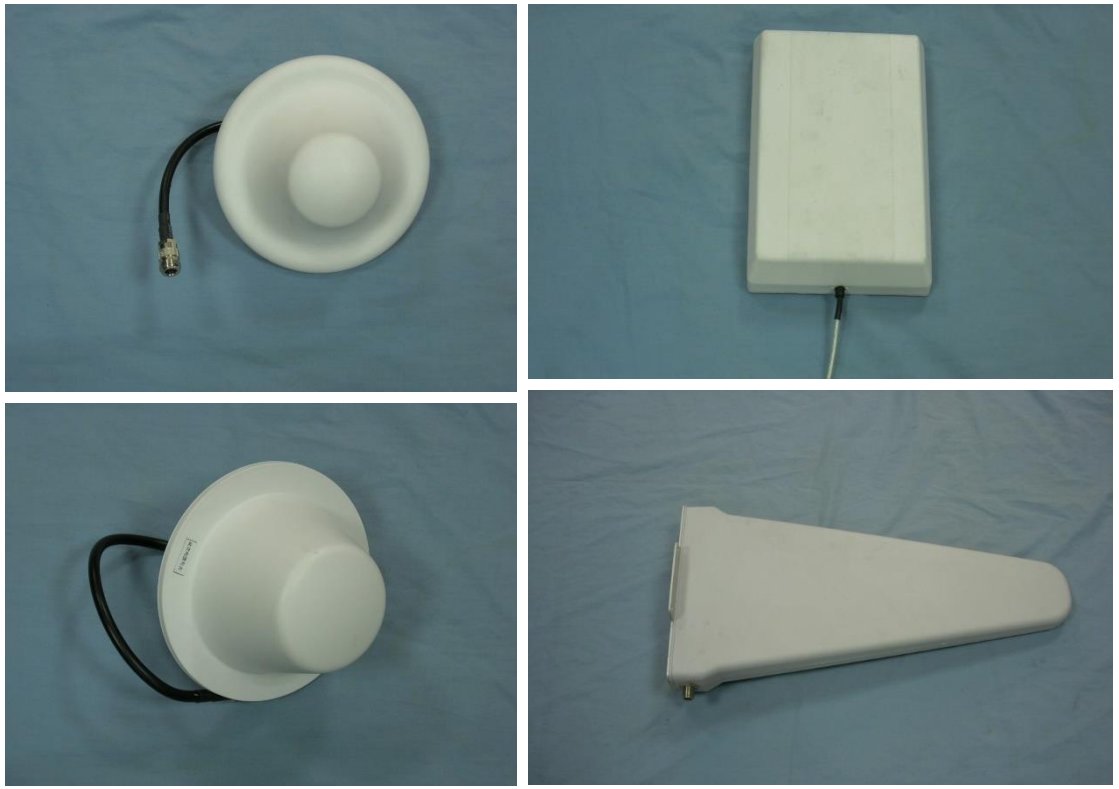
- Antennas
  - The end of system facility, decides the ‘shape’ of signal coverage
  - Is the coverage the larger the better?
- Two examples of outdoor coverage
  - Countryside / outskirt
    - Simple communication channel
    - Small traffic / Few users
  - Downtown / CBD
    - Multipath effect
    - High density of users / heavy data traffic
    - High base station density





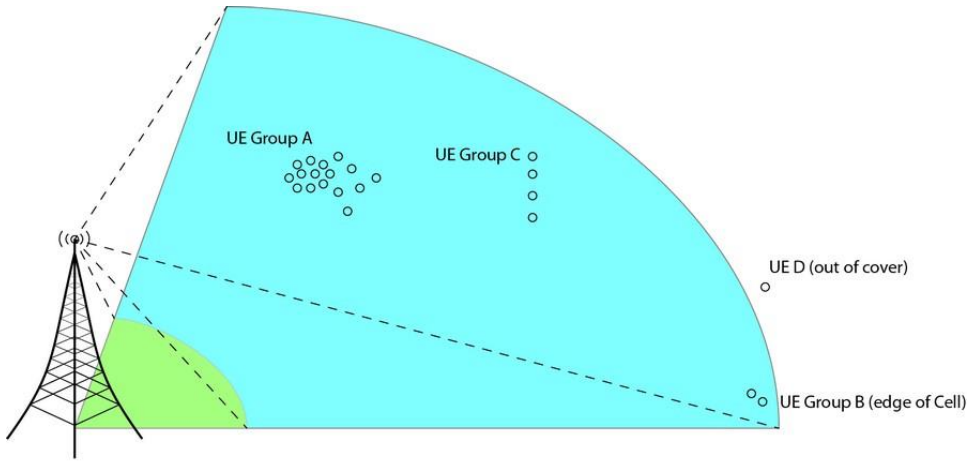
Antennas

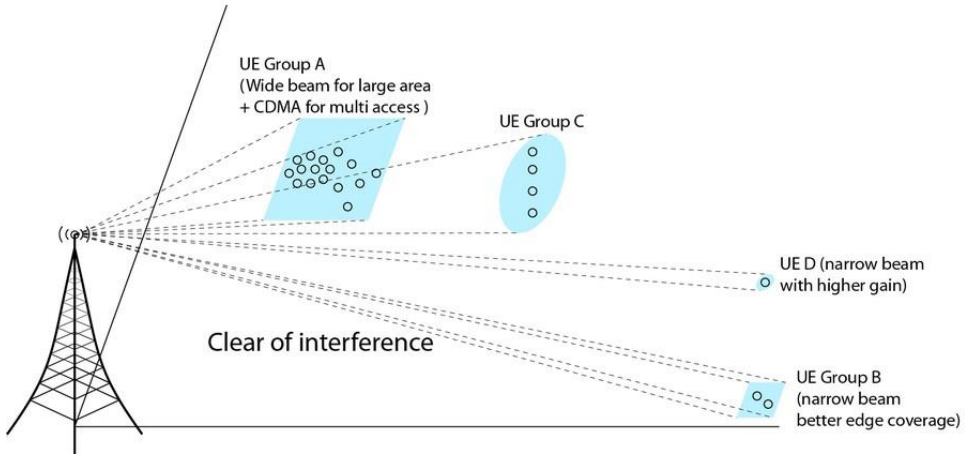
- Antennas for indoor coverage
  - Ceiling omnidirectional antenna
  - Ceiling Directional antenna
  - Wall-mounted directional antenna
  - Narrow-beam directional antenna
  - …



MIMO Antennas

- MIMO (Multiple Input Multiple Output)
  - Transmit diversity
    - Transfers multiple duplicates of the data
    - The ‘diversity gain’ promotes the coverage, but not the data rate
  - Beam forming
    - ‘Configure’ the coverage
    - A more flexible choice for coverage
    - more expensive signal processing





Antennas

- Antennas
  - Decorative Antennas





Test and Regulations

- Why
  - To ensure the equipment / components working in the network meet the requirements in the standards and regulations.
- What
  - All equipment and components in the network
    - Macro / Home cell base stations
    - Repeaters / Relay nodes
    - Antennas
    - Indoor distribution system
      - Passive components
      - Feeder cables
      - …

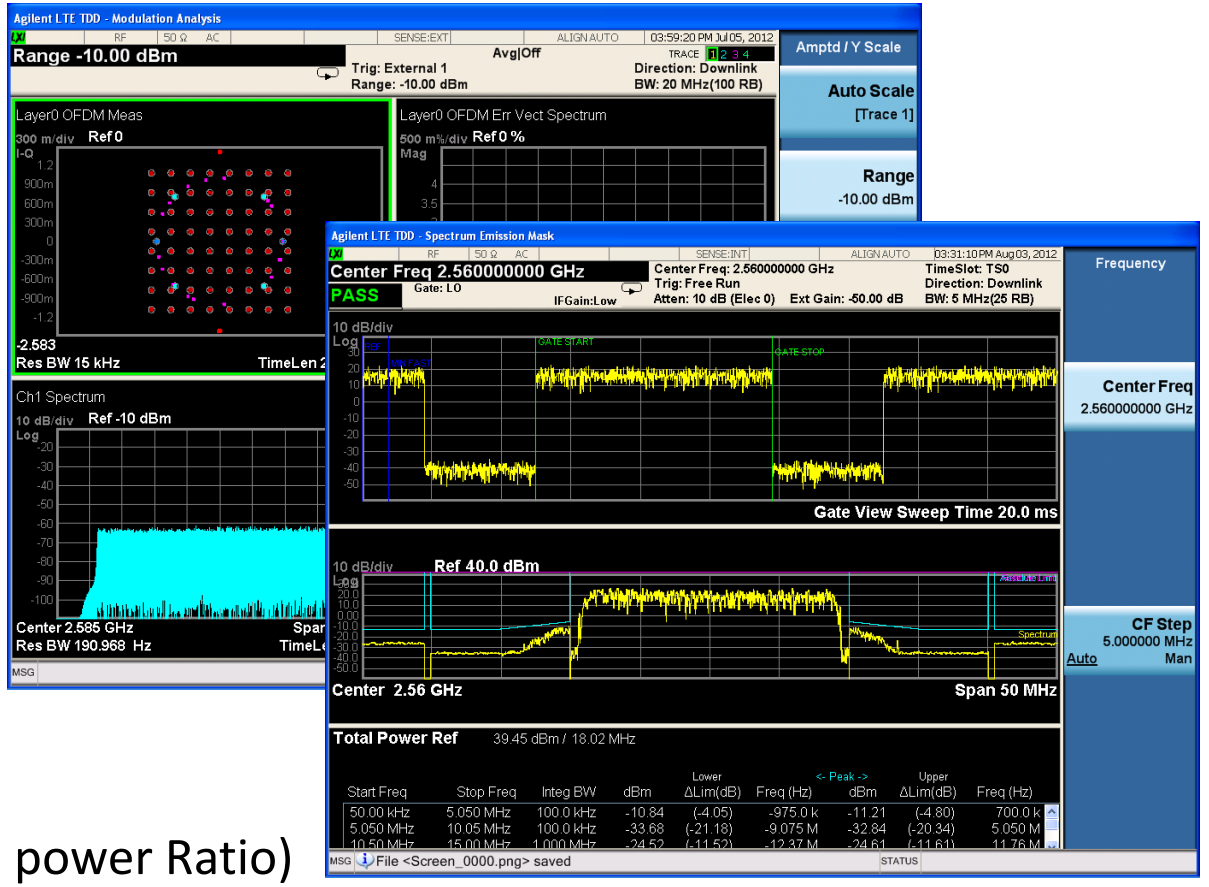
Test and Regulations

- When
  - Before use
    - Network Access License
    - Commissioning Test
  - In use
    - Sampling Test

- How
  - Qualified testing laboratory - ISO/IEC 17025 CNAS
  - Calibrated Instrument / qualified personnel
  - International / domestic standards and regulations
    - Testing method
    - Technical requirement

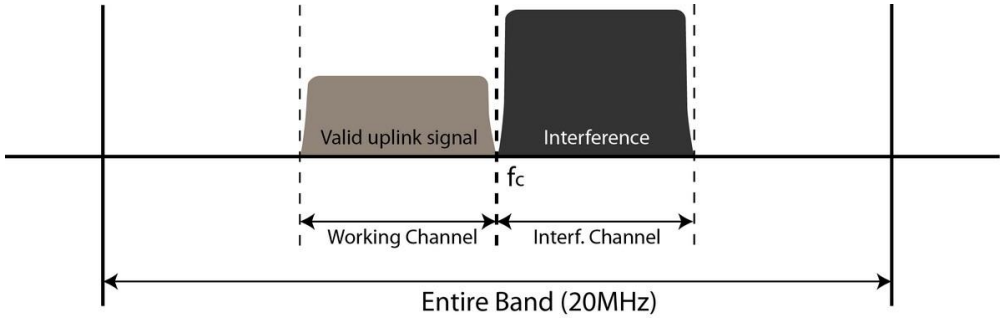
Test and Regulations

- Major test items for eNodeBs (Transmitter)
  - Transmit power
    - Base station output power
    - Total power dynamic range
  - LO and Modulation
    - Frequency Error
    - EVM (Error Vector Magnitude)
  - Time domain
    - Time alignment between transmitter branches
  - Interference
    - Spectrum emission mask
    - ACLR (Adjacent Channel Leakage power Ratio)
    - Unwanted emissions

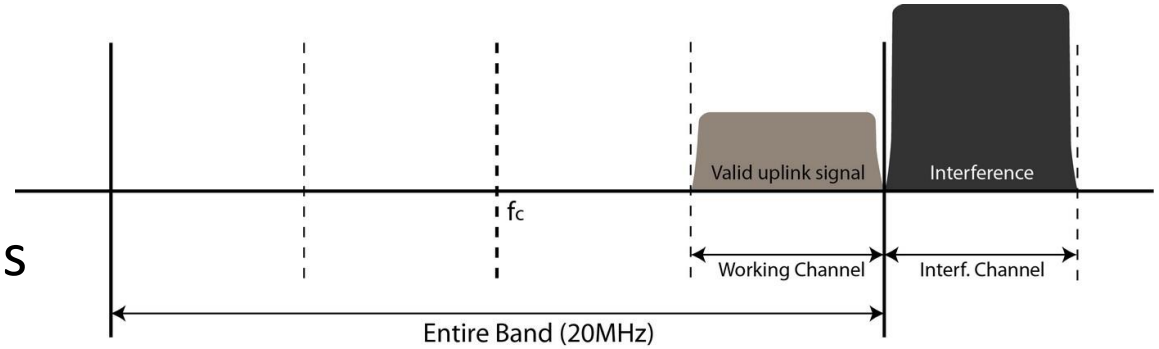


Test and Regulations

- Major RF test items for eNodeBs (Receiver)
  - Reference sensitivity level
  - Dynamic range
  - ICS (In Channel Selectivity)
  - ACS (Adjacent Channel Selectivity)
  - Blocking
  - …

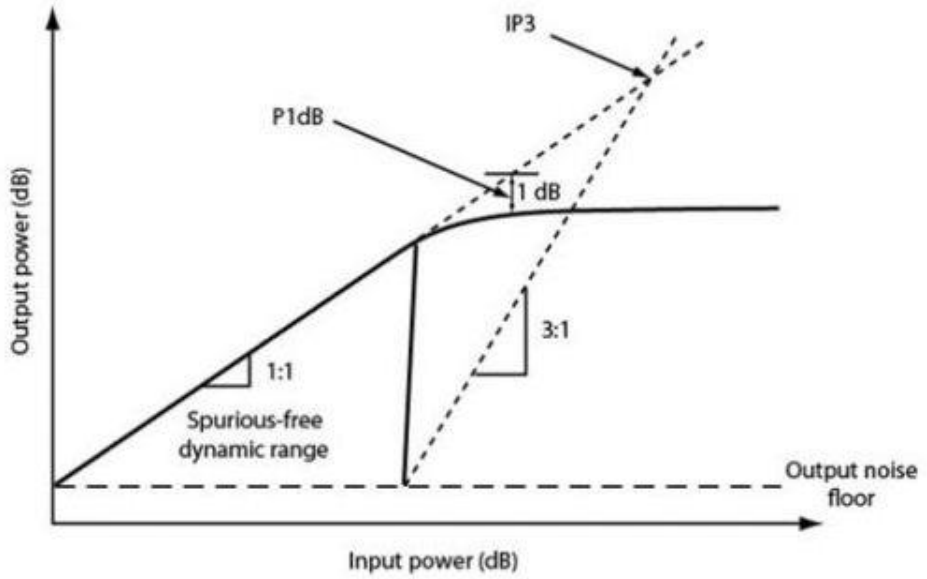


- Environment adaptability
  - Tested under different circumstances
    - High / Low suppling voltage
    - Extremely high / low temperatures



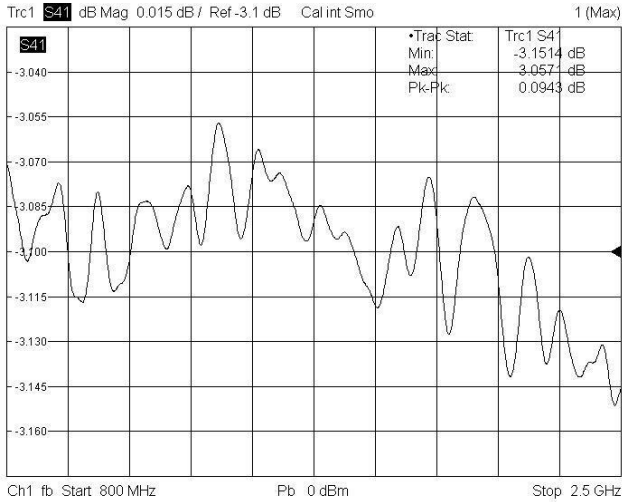
Test and Regulations

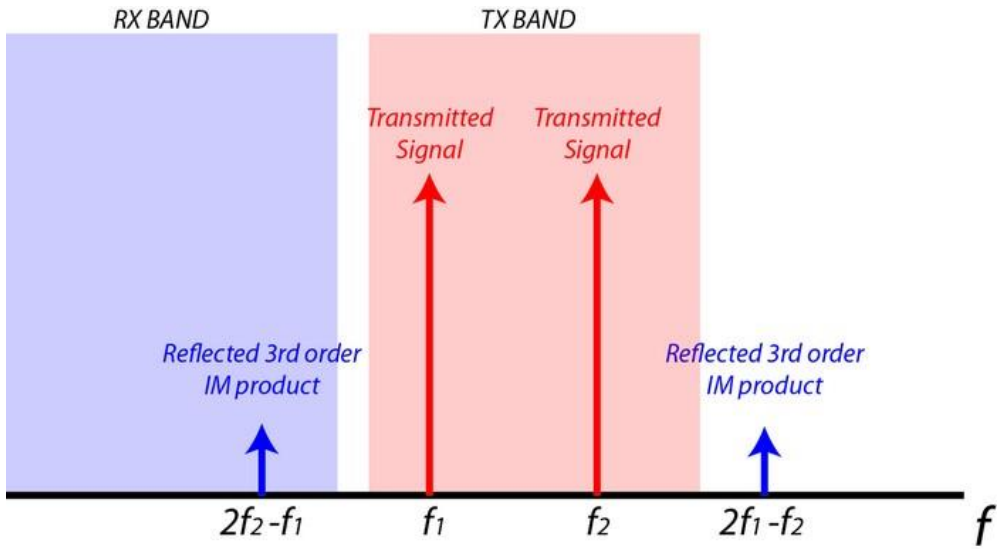
- Major test items for repeater and distributed access systems
  - Output power
  - Gain linearity
  - Frequency error
  - Noise rejection
  - Switching time in TDD system
  - In-band fluctuation (ripple)
  - EVM
  - …

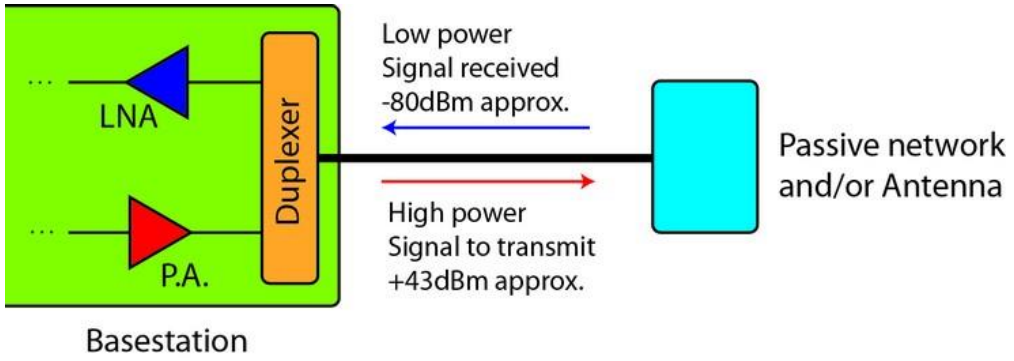


Test and Regulations

- Major test items for passive components
  - S-Parameters
  - Power handling
  - PIM (Passive InterModulation)







About CTTL

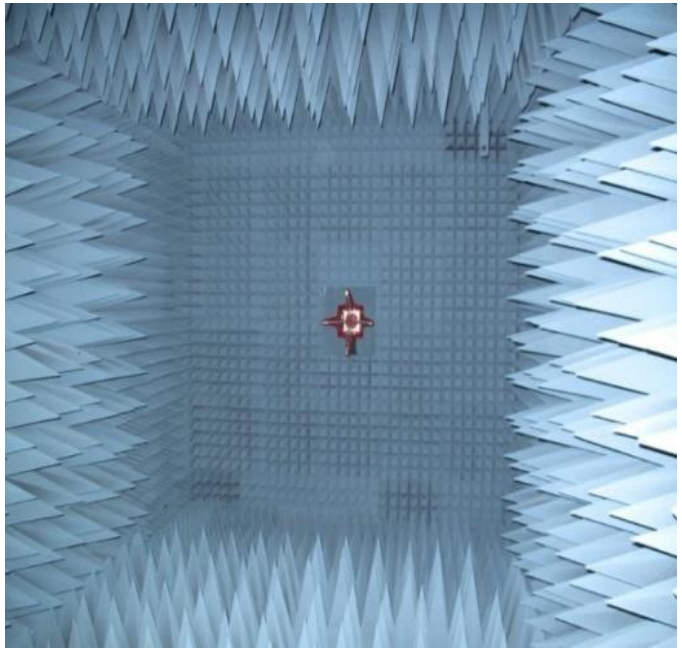
- About the tests for LTE equipment

About CTTL

- About the test for passive components

About CTTL

- About the test for Antennas



Thank You

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