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# 移动网络演化史

- 最新版本： v1.0
- 更新时间： 20200918

## 简介

总结移动网络的演化历史，包括移动网络的概述，相关基础知识，比如信号、信号传输、无线信号传输、蜂窝网络等，总结移动网络组成即接入网RAN和核心网络CN，总结移动网络的代际发展，包括1G、2G的GSM、3G的UMTS和CDMA2000、4G的LTE、5G的NR，及其背后核心技术要点，对移动网络进行总结，包括各种演化细节和常见架构，最后给出一些相关具体实现。且附录了一些名词术语的缩写和个别术语的详细解释。

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## 鸣谢

感谢我的老婆陈雪的包容理解和悉心照料，才使得我 [crifan](#) 有更多精力去专注技术专研和整理归纳出这些电子书和技术教程，特此鸣谢。

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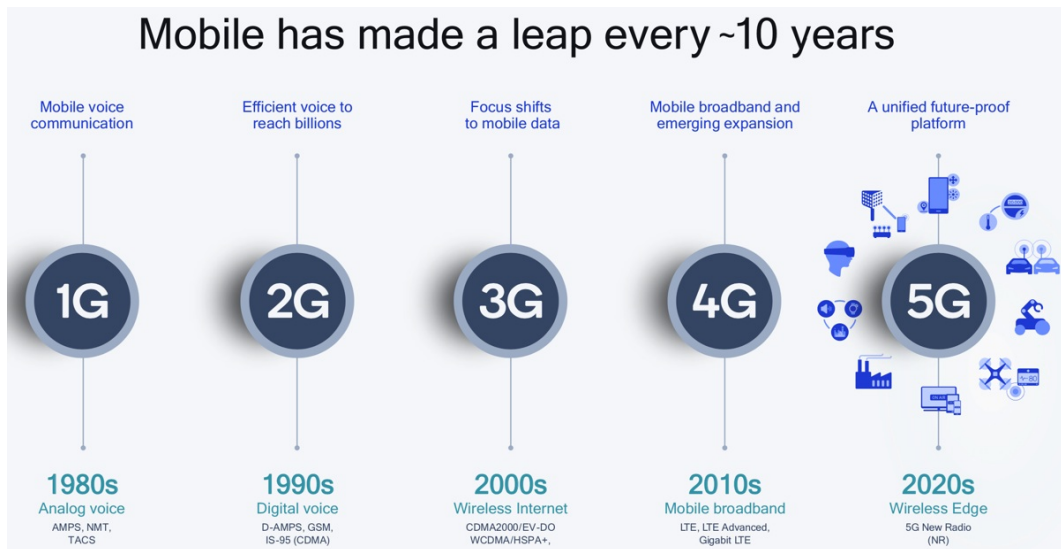
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# 移动网络概述

移动网络 = 移动通信网络 目前经历了从第一代 1G 发展到现在最新的第五代 5G 。

精简概述：

- 图
  - 移动网络平均每10年进化一代



- 文字
  - 1G
    - AMPS
  - 2G = GSM
    - 编码方式： TDMA 和 FDMA
    - 包含
      - 2.5G = GPRS
      - 2.75G = EDGE
  - 3G = UMTS
    - 编码方式： WCDMA
    - 包含
      - 3.5G = HSDPA
  - 4G = LTE
    - 编码方式： OFDMA 和 SC-FDMA
  - 5G = NR

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## 移动网络基础知识

- 移动网络 = 无线网络
  - 信号传输
    - 背景概述
      - 现代蜂窝网络
        - 实现LTE+IMS功能
          - 需要其他配合
            - GSM
              - 包含 GPRS/EDGE 服务
            - UMTS
              - 包含 HSDPA/HSUPA 服务
    - 结论:
      - 现在和将来很长一段时间，多种网络形式并存
        - 各种 无线接入技术=radio access technologies
          - GSM
          - UMTS
          - LTE
        - (组合) 实现 各类服务
          - 传统的电话=traditional telephony
          - 数据包发送=packet transmission
            - =packet data transmission=分组数据传输
          - IMS服务=IMS service
      - 没有哪种网络比另一种好
        - 只是针对不同问题有优化，侧重点不同
- GSM vs UMTS vs LTE
  - 对比

	circuit switching (CSD)	packet switching (GPRS)
GSM	✓ telephony	✓ from R96
UMTS	✓ telephony	✓
LTE	✗	✓ telephony

Figure 1-38 CS and PS services in mobile networks

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# 信号

- 信号 基础知识
  - 信号
    - 模拟信号和数字信号

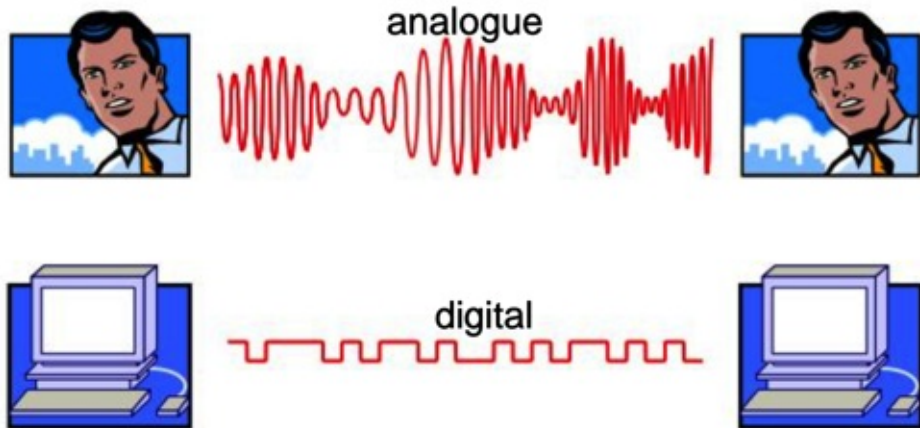


Figure 1-21 Analogue and digital signal

- 重新生成数字信号

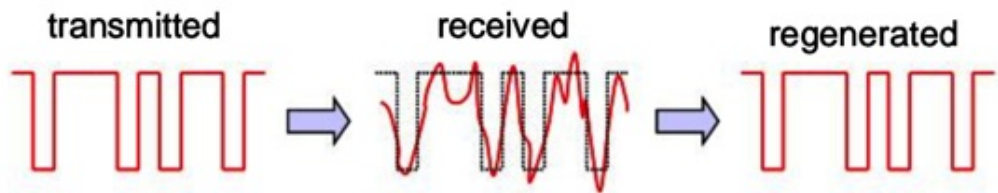


Figure 1-22 Regeneration of digital signal

- A/D转换

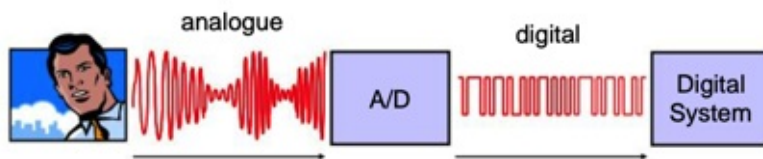


Figure 1-23 A/D conversion

- 采样

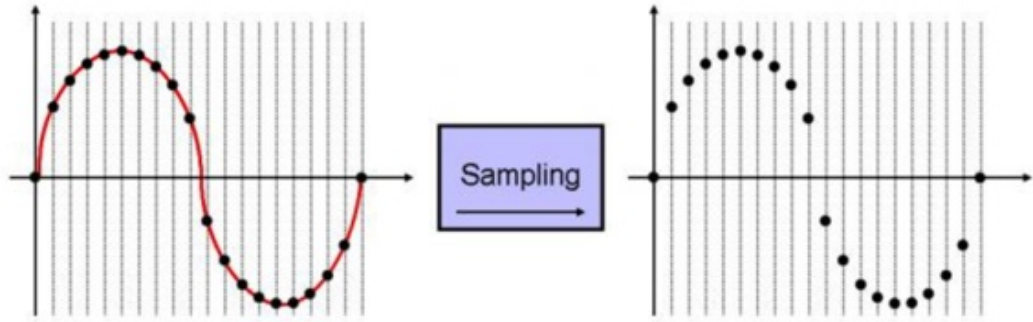


Figure 1-24 Sampling

- 
- 量化

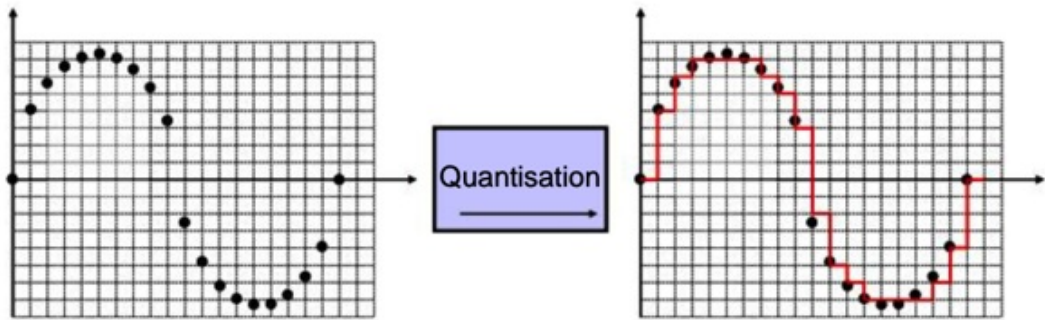


Figure 1-25 Quantisation

- 
- 编码

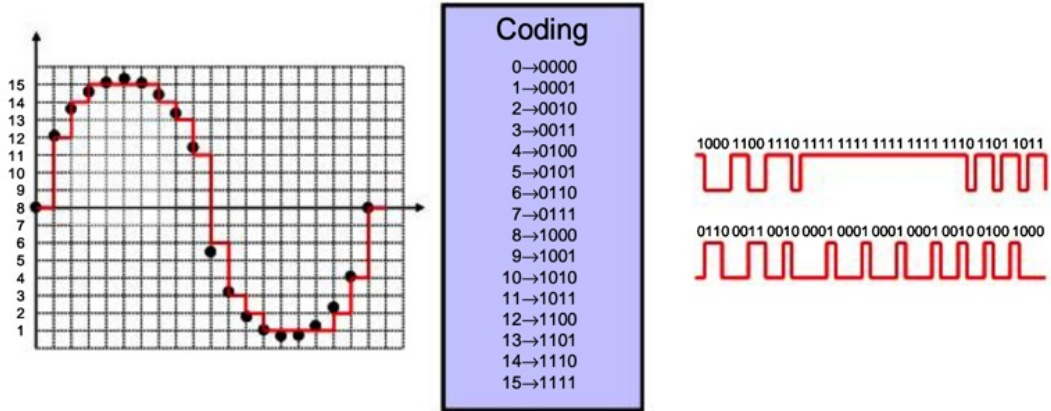


Figure 1-26 Coding

- 
- 分段和语音编码



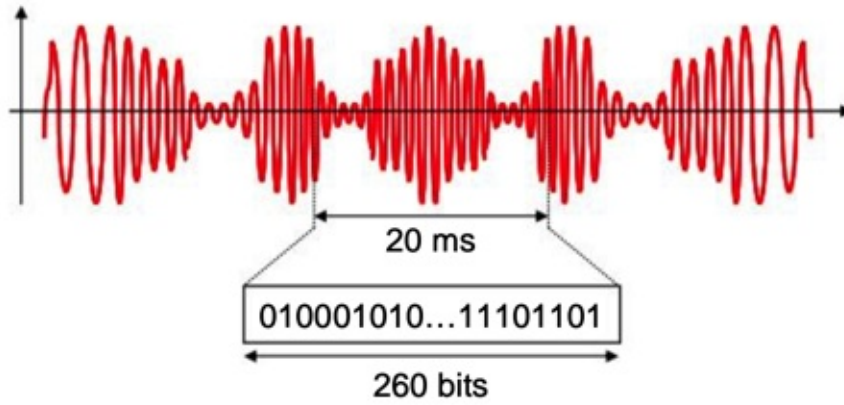


Figure 1-27 Segmentation and speech coding

语音编码类型

codec	bitrate before	bitrate after	PSTN /ISDN	GSM	UMTS	LTE
G.711	64 kbps	64 kbps	✓	✗	✗	✗
HR	104 kbps	5,6 kbps	✗	✓	✗	✗
FR	104 kbps	13 kbps	✗	✓	✗	✗
EFR	104 kbps	12,2 kbps	✗	✓	✗	✗
AMR	104 kbps	4,75 – 12,2 kbps	✗	✓	✓	✓
AMR-WB	224 kbps	6,6 – 23,85 kbps	✗	✓	✓	✓

Figure 1-28 Speech codecs (used across air interface)

# 信号传输

- 复用
  - 时分复用

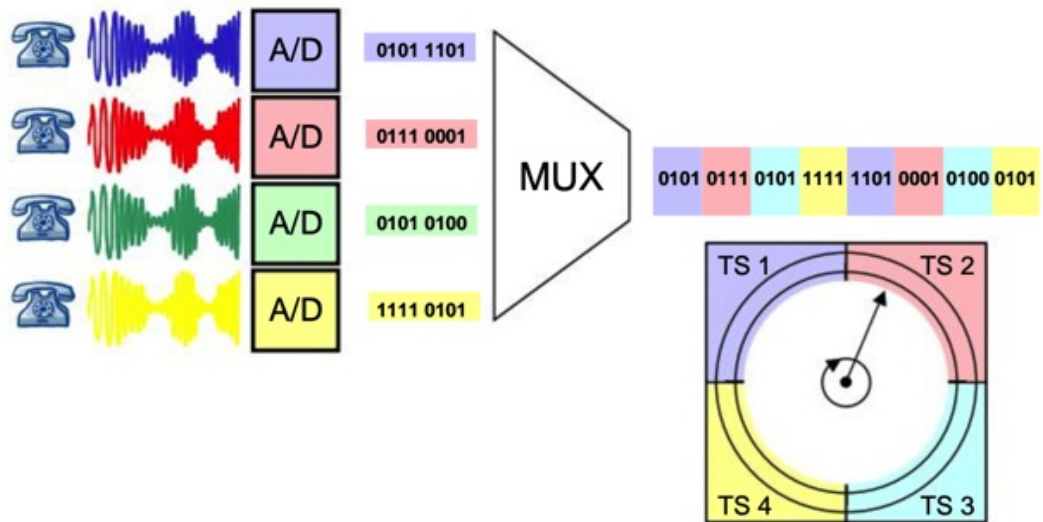


Figure 1-29 Time division multiplexing

- PCM/E1 link 2048kbit/s

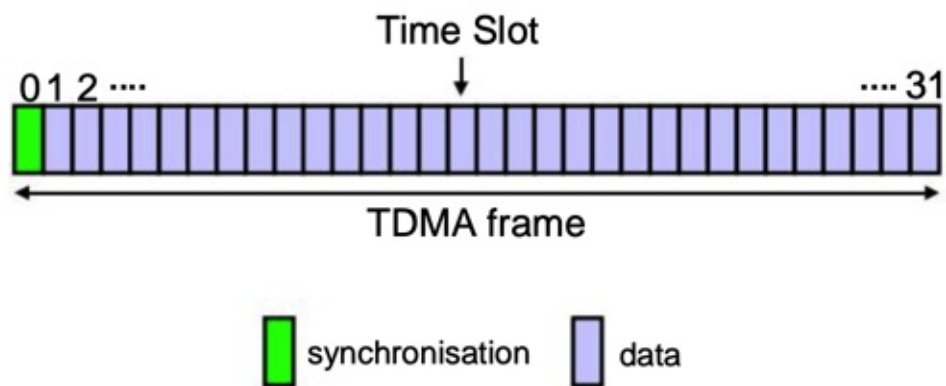


Figure 1-30 PCM/E1 link 2048 kbits/s

- 传输材质
  - 双绞线 (左) 和同轴电缆 (右) =Twisted pair(left) and coaxial cable(right)

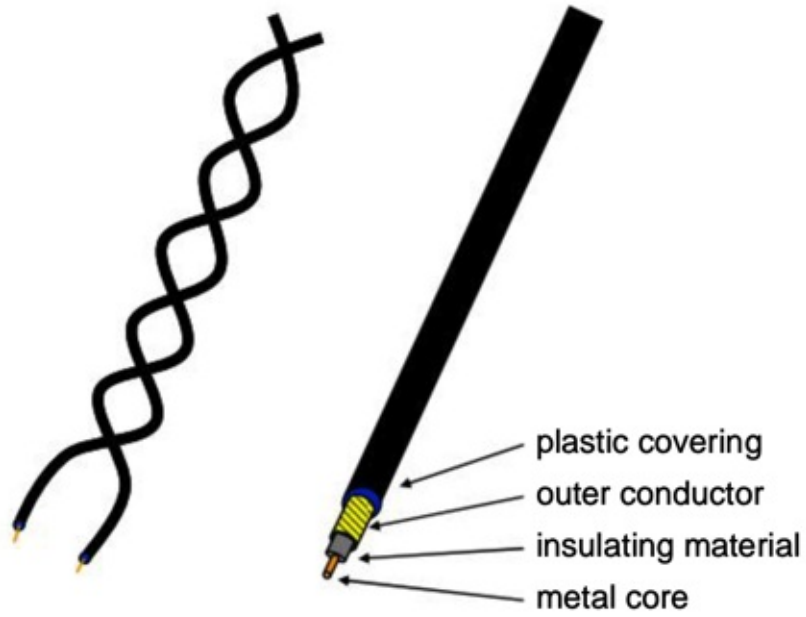


Figure 1-31 Twisted pair (left) and coaxial cable (right).

- 
- 光纤

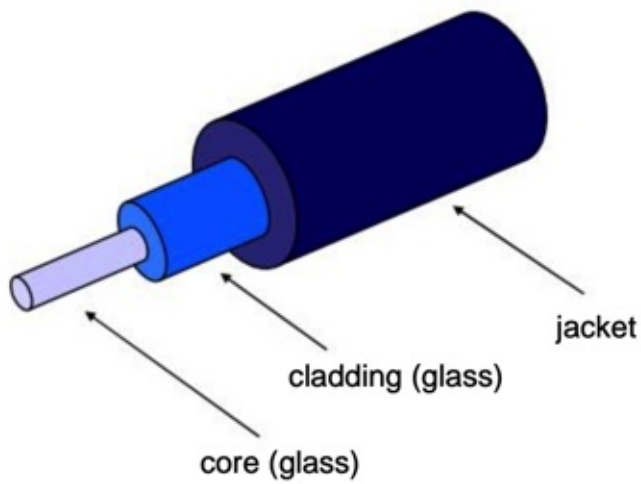
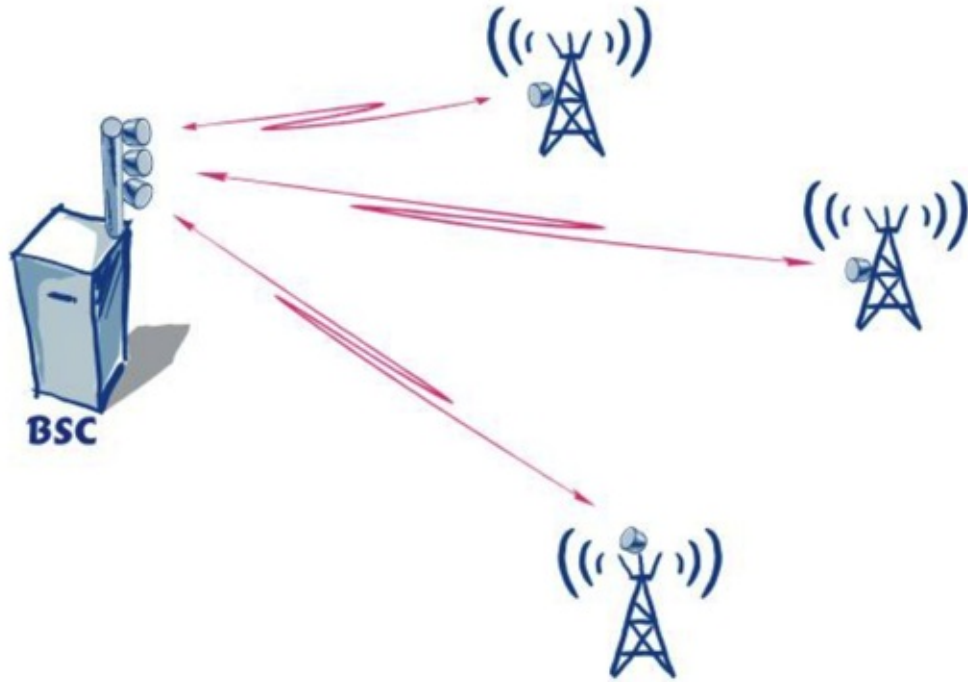


Figure 1-32 Side view of the optical fibre

- 
- 微波 (无线电) 中继



*Figure 1-33 Microwave radio relay*

- 
- 举例
  - GSM信号塔上的微波天线



*Figure 1-34 Microwave antenna at GSM site's tower*



## 无线信号传输

- 信号调制对比

- 
- 交换Switching
  - 电路交换=CS=Circuit Switching=Switching
    - 名词
      - Circuit=电路：物理上的电缆Cables
    - 含义
      - 旧
        - 在两个（订阅）用户中间，建立一条连接
          - 使得两个用户可以互相通话
      - 新=现代含义
        - 切换timeslot时间片
          - 在64kbit/s的传输通道中，通过切换时间片实现数据交换
    - PSTN网络中的电话连接

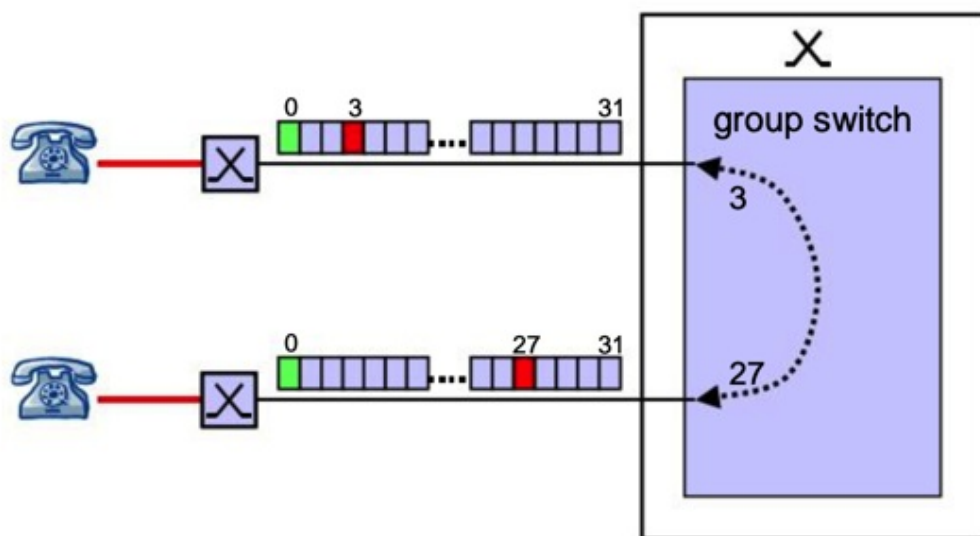


Figure 1-35 Telephone connections in a PSTN network

- 建立连接

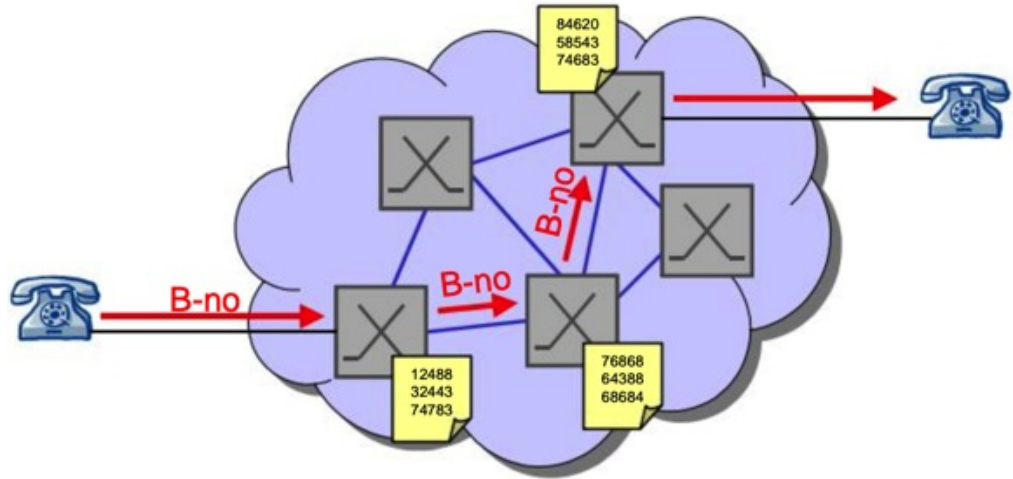


Figure 1-36 Connection set-up

- 
- 典型使用场景
  - 适合：
    - 固定速度传输
    - 实时数据
      - 音频
      - 视频
  - 不适合：
    - 比如 电子邮件
      - 因为：无数据校验
      - 出错时无法检测和纠错
- Packet Switch=包交换
  - 含义：要传输的数据，被分割成多个长度不等的数据包
    - 每个数据包都包含收件人的地址
    - 当数据包达到某网络节点时，先被保存在缓冲区中
    - 读取取出目标地址
    - 根据路由表，再转发到下一个节点
      - 注：每个网络节点都保存了一个路由表

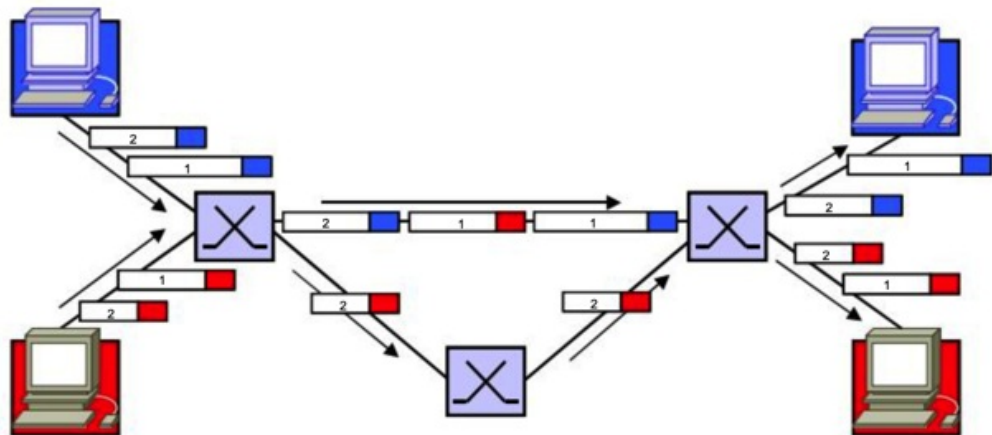


Figure 1-37 Packet switching

- 
- 特点
  - 没有（针对每个用户的）专用通道

- 传输带宽被多个连接所共享
  - 无预留（专用）带宽（容量）
    - 当前网络拥挤（无可用带宽），就只能等
  - （网络带宽）资源利用率较高
- 适用于：
  - 主要用于数字网络中
- 典型使用场景
  - 适合：无需固定速率的
    - 电子邮件、文件
      - （可能）支持 错误检测和校验
        - 检测发现出错，返回异常，要求重传
  - 不适合：需要固定速度的
    - 音频、视频
- GPRS
  - 背景
    - 传统GSM网络的底层数据承载方式是CS
    - 但是多数（订阅）用户却将其用于PS网络的接入，比如Internet因特网和其他IP网络
    - 在如邮件、上网（浏览网页）等典型应用中
      - 举例
        - 浏览网页
          - 下载内容
          - 阅读
          - 下载下一个内容
  - 特点
    - 数据传输不是连续的
      - 是断断续续的
    - 传输数据量往往是：下载 远大于 上传
  - 导致
    - 带宽经常被占用
      - 但是多数时候却闲置的浪费的
    - 资源利用率很低
      - 用户和运营商都不希望这样
  - 结论
    - 出现了GPRS
      - 用于解决旧的CS数据服务的缺点
  - GPRS=General Packet Radio Service=通用分组无线业务
    - GPRS的wireless packets=无线数据包
    - 特点
      - （底层）物理链路只在需要数据传输时才被使用
      - 使用完后，立刻释放
        - 可以用于下一次传输
    - 实现
      - 多个终端（传输，用户）可以共享单条物理链路
      - 单个用户的单次传输也可以被分配（共享）使用多条物理链路
    - 结果
      - 数据传输效率更高





# 蜂窝网络 Cellular Network

- 非蜂窝网络移动系统
  - 普通

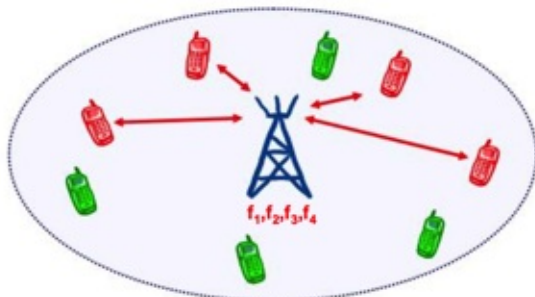


Figure 1-1 Non-cellular mobile system

- 容量增加

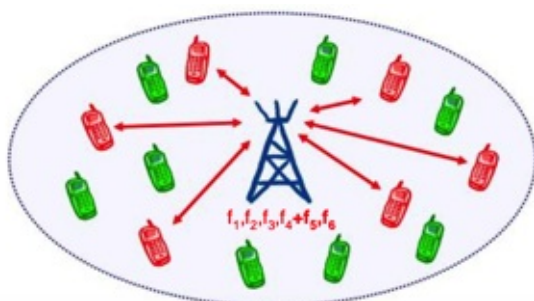


Figure 1-2 Non-cellular mobile system (capacity increase)

- 覆盖面增加

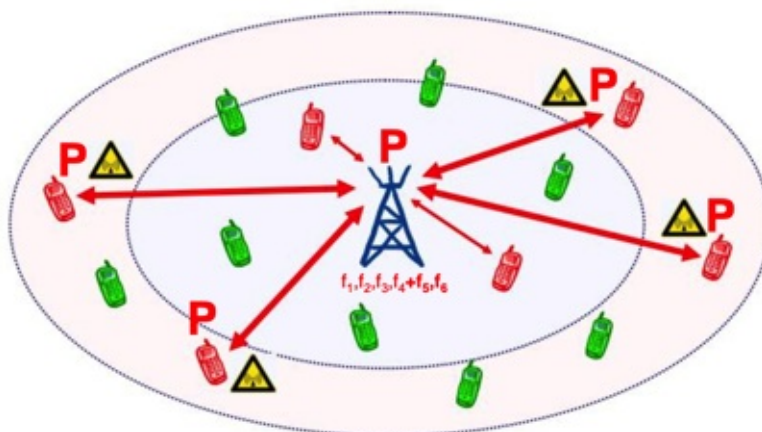


Figure 1-3 Non-cellular mobile system (coverage increase)

- 蜂窝网络移动系统
  - 普通

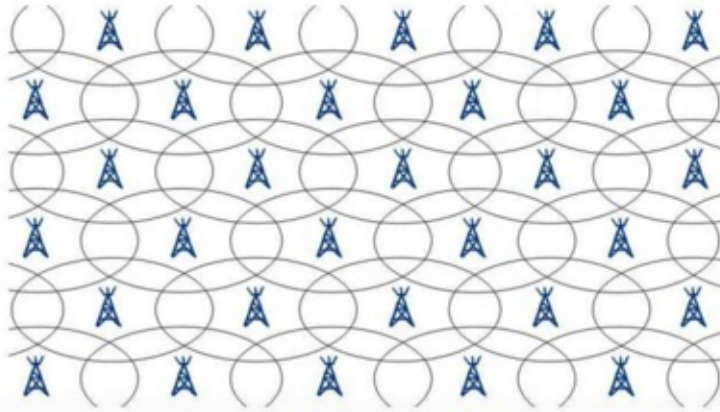


Figure 1-4 Cellular mobile system

- 频谱复用

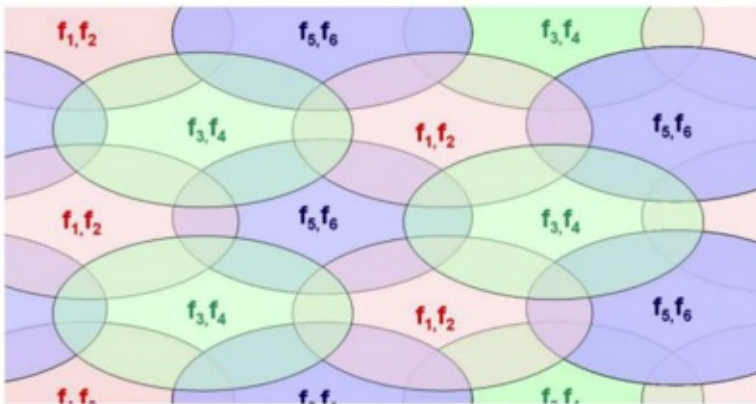


Figure 1-5 Cellular mobile system (frequency re-use)

- 容量增加

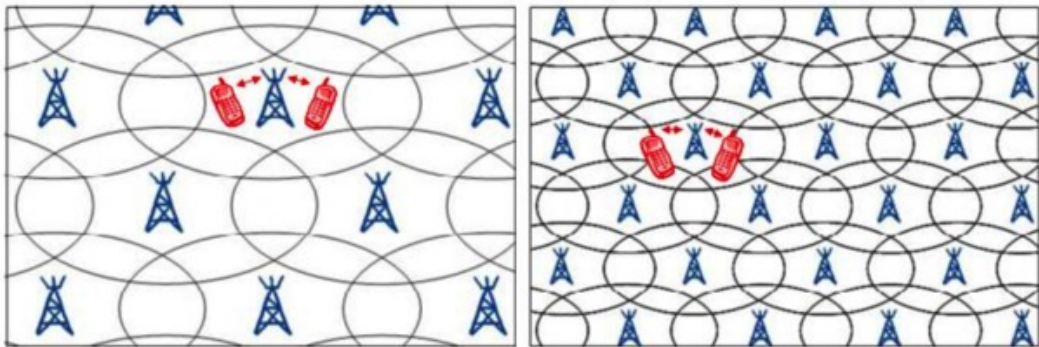


Figure 1-6 Cellular mobile system (capacity increase)

- 单元cell
  - 六角形

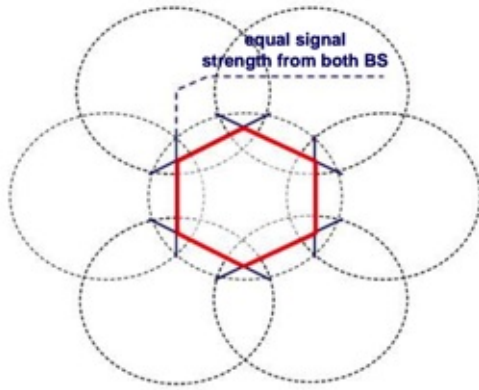


Figure 1-7 Cell – hexagon shape

- 六角形和实际辐射模型

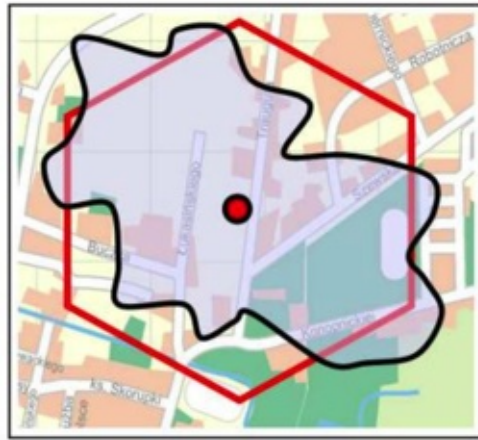


Figure 1-8 Cell – hexagon and real radiation pattern example

- 天线类型

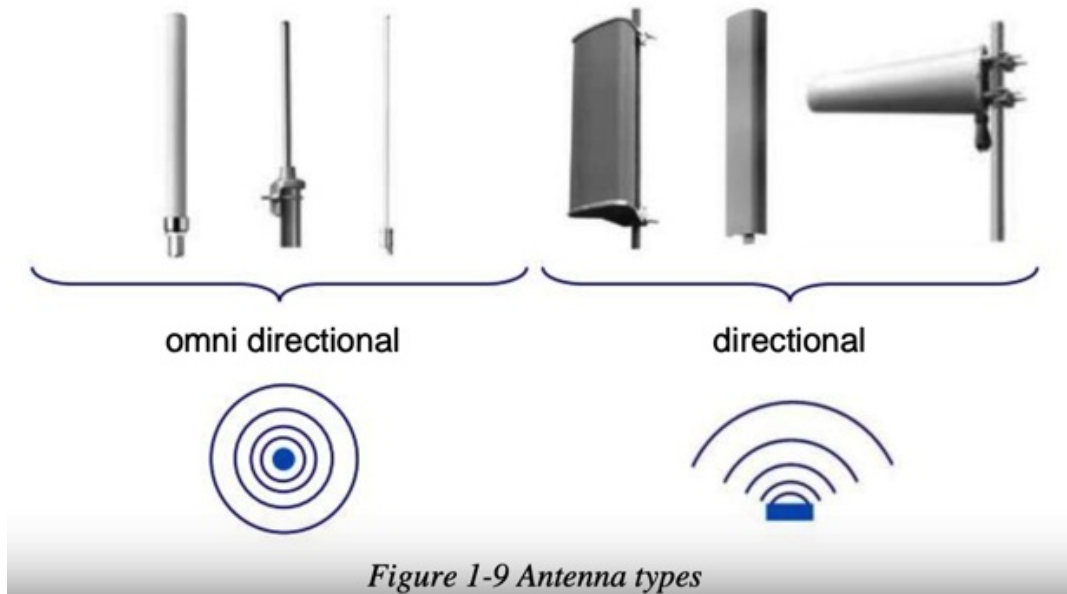
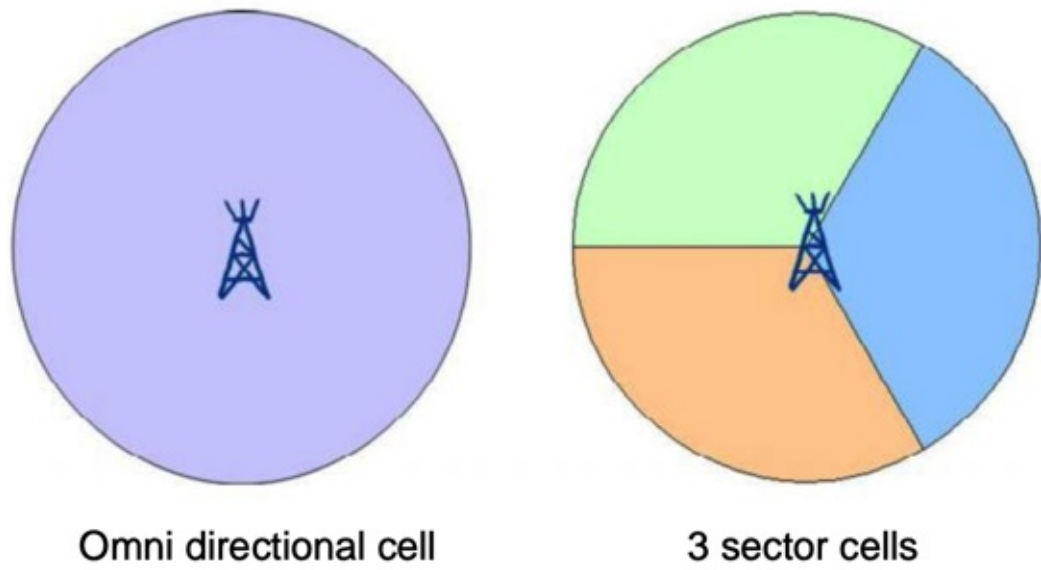


Figure 1-9 Antenna types

- 单元类型



*Figure 1-10 Types of cells*

- 基站? sector site

- 
- 4/12频谱复用模型

- 
- 3/9频谱复用模型

- - 频谱复用模型和容量

- - 蜂窝系统的频谱复用模型

- - 单元分割之前

- - 单元分割阶段1

- 
- 单元分割阶段2

- 
- 单元网络

- 
- cellular system= (移动通信领域中的) 蜂窝系统
  - 旧
    - 包含
      - GSM
      - UMTS
    - 特性:
      - 基于PS的GPRS/HSPA的方案
  - 新
    - 包含

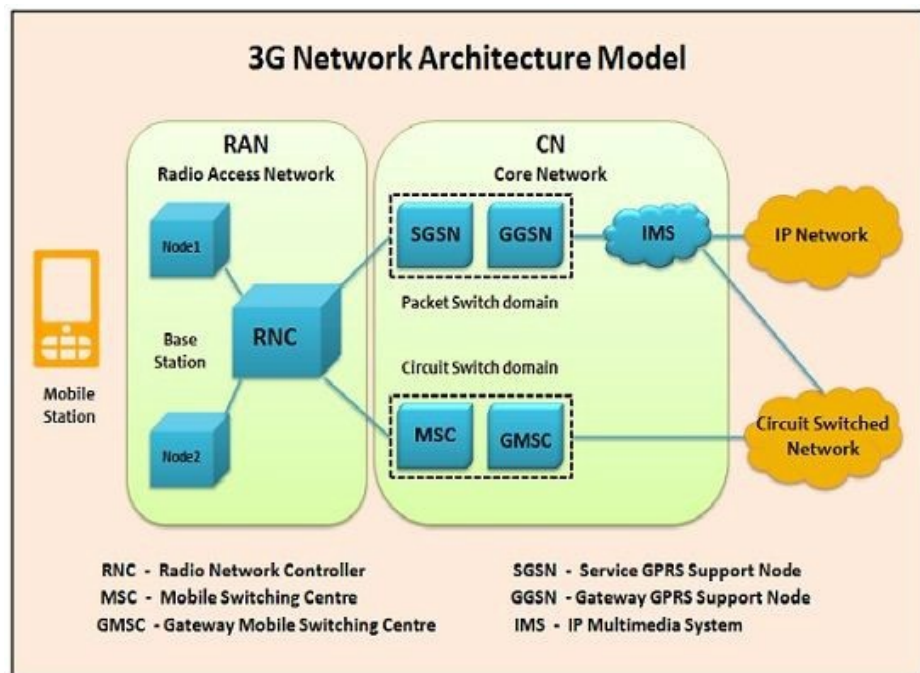
- LTE=Long Time Evolution
- EPS=Evolved Packet System
- 特性
  - 对于终端用户
    - 不提供任何传统的电信服务
      - 电话telephony
      - 视频电话video-telephony
      - 短信messaging
    - 而是基于: packet bearer services数据承载业务
      - 比如
        - 发送IP数据包
          - 且保证QoS质量
  - 通过IMS提供服务
    - 底层通过
      - LTE 访问网络 = LTE access network

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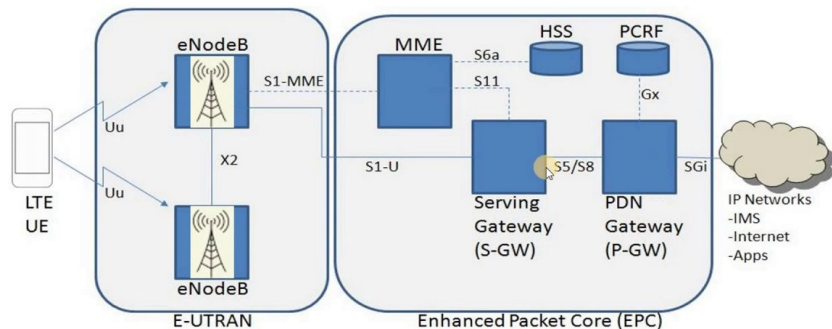
## 移动网络组成

- 移动通信网络 = RAN + CN
  - 包含
    - RAN = Radio Access Network = 无线电接入网络
      - = Access Network = 接入网络
        - Access = 接入
        - 接入技术 = 无线 (电) 接入技术 = radio access technology
          - = 空口 = air interface
          - = 无线电接口 = radio interface
      - CN = Core Network = 核心网络
    - 举例
      - 单代网络
        - 2G
          - GSM = GRAN + Circuit Core
        - 2.75G
          - EDGE = GERAN + Circuit Core
        - 3G
          - UMTS = UTRAN + Packet Core
          - 架构图



- 4G = E-UTRAN + EPC
  - 架构图

# 4G | LTE ARCHITECTURE

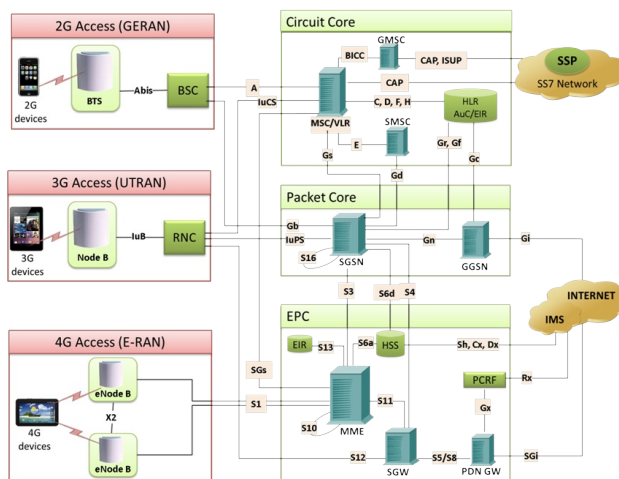


- 5G = ? + NGC
- 多代网络
  - 2G 3G 4G COMMUNICATIONS NETWORKS

GSM, TDM and TDMA, Core interfaces T1 E1 but now migrating to IP

WCDMA, Same Core network as 2G

LTE, OFDMA, SC-FDMA, All IP



- 对比
  - Circuit and Packet Domains

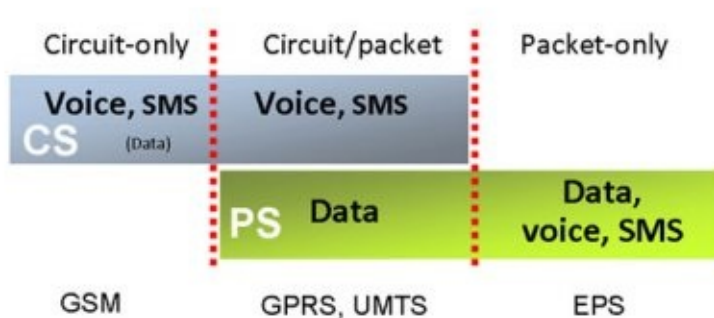


Figure 1: Circuit and packet domains

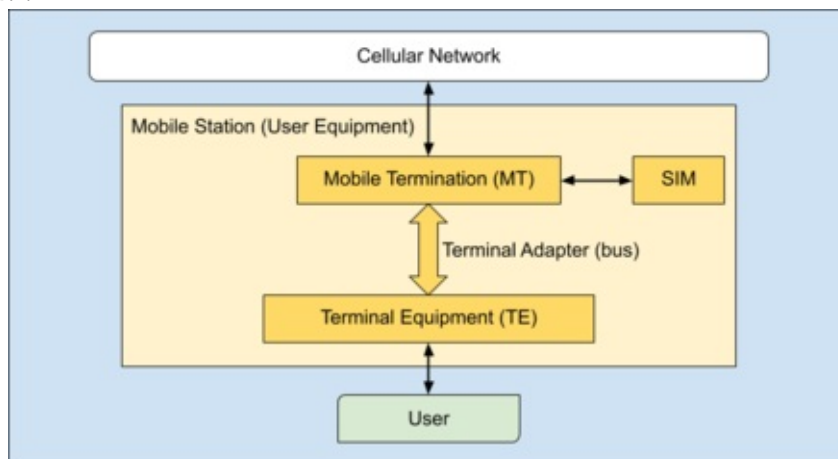
- 名词术语
  - BBU = BaseBand Unit
  - RRH = Remote Radio Heads
  - NGC = Next Generation Core = NG Core = NextGen Core

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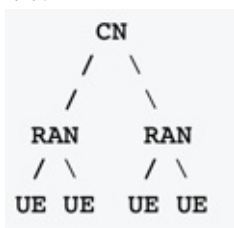
# RAN

- RAN

- RAN=Radio Access Network
- 是什么：移动通信系统的一部分
  - 实现了RAT
- 具体形式
  - 一般存在于移动设备如手机中
  - 用于连接到核心网CN
- 设备端
  - 一般被叫做
    - UE=User Equipment
    - TE=Terminal Equipment
    - MS=Mobile Station
  - 架构图



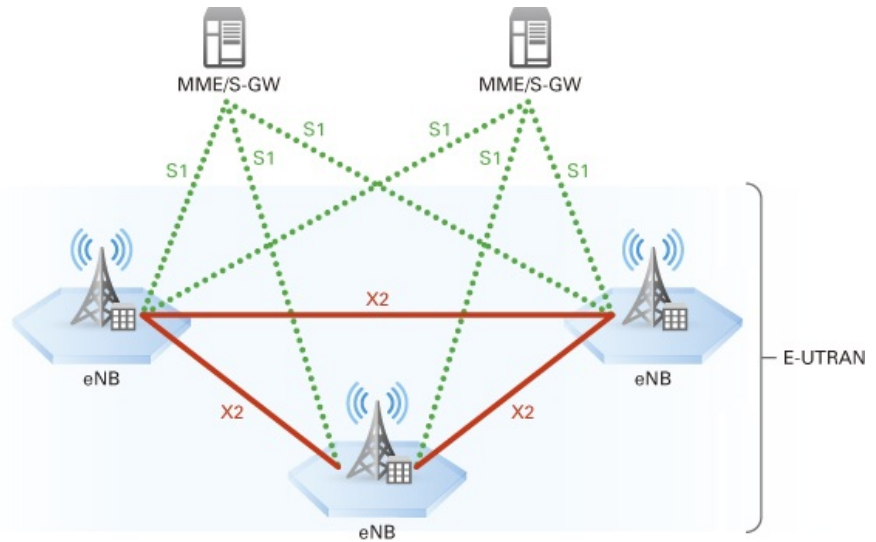
- 举例
  - 移动手机
  - 带SIM卡的笔记本
- 基本架构



- 常见类型

- GRAN = GSM RAN = Generic RAN = Generic Radio Access Network
  - 2G=GSM
- GERAN = GSM Edge RAN = GSM Edge Radio Access Network
  - 和GRAN一样，额外支持EDGE
    - 支持实时的PS
  - 2.5G=EDGE
    - 引申
      - GRAN=不带EDGE的GERAN
      - ERAN=不带GSM的GERAN

- UTRAN = UMTS Terrestrial RAN = UMTS Terrestrial Radio Access Network
  - 3G
  - CS和PS都支持
- E-UTRAN = Evolved Universal Terrestrial RAN = Evolved Universal Terrestrial Radio Access Network
  - 4G
  - (重点在) 只支持PS, 优势是高速率和低延迟
  - LTE版 (高速+低延迟) UTRAN
  - E-UTRAN Architecture



## 相关背景知识

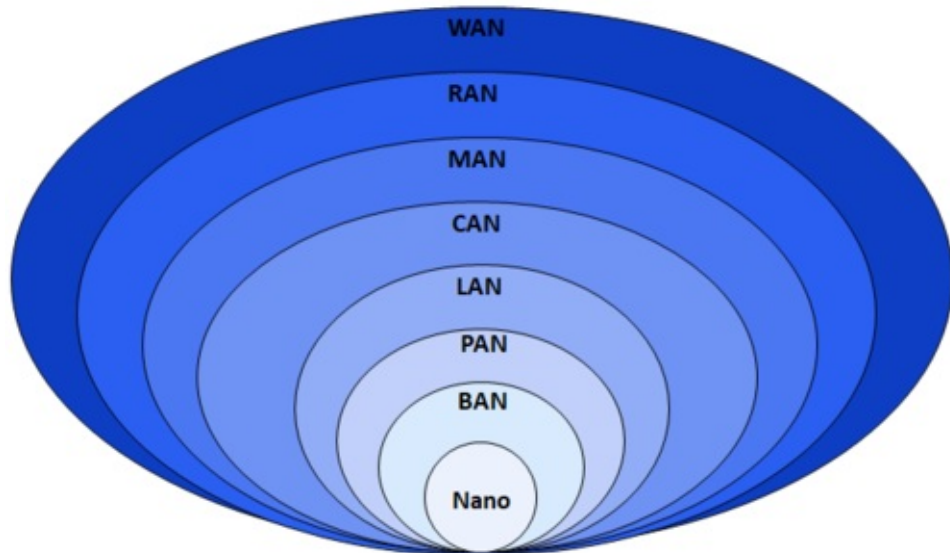
### RAT

- RAT
  - RAT = Radio Access Technology
  - 是什么: 是基于无线电 (广播radio) 的通信网络的底层物理连接方式
  - 常见实现方式
    - Bluetooth
    - Wi-Fi
    - GSM
    - UMTS
    - LTE
    - 5G NR

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# CN

- CN = Core Network = 核心网
  - 按照空间范围，网络可以分为
    - 图



- 
- 文字
  - Nanoscale
  - Near-field (NFC)
  - Body (BAN)
  - Personal (PAN)
  - Near-me (NAN)
  - Local (LAN)
    - Home (HAN)
    - Storage (SAN)
    - Wireless (WLAN)
  - Campus (CAN)
  - Backbone(=Core Network=CN)
  - Metropolitan (MAN)
  - Municipal wireless (MWN)
  - Wide (WAN)
  - Cloud (IAN)
  - Internet
  - Interplanetary Internet

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## 网络阶段

移动网络发展总体上经过了5代，分别是：

- 1G
- 2G
  - GSM
- 3G
  - UMTS
  - CDMA2000
- 4G
  - LTE
- 5G
  - NR

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# 1G

- 1G = AMPS / TACS / NMT / C-Netz
  - 信号编码方式: FDMA
    - FDMA = Frequency Division Multiple Access
  - 协议标准
    - AMPS
      - 美国
      - AMPS = Advanced Mobile Phone System
    - TACS
      - 英国
      - TACS = Total Access Communications System
    - NMT
      - 北欧
      - NMT = Nordisk MobilTelefoni
        - 英语名: Nordic Mobile Telephone
    - C-Netz
      - 名词
        - 德语: Funktelefonnetz-C
        - 英语: Radio Telephone Network C
      - 德国
        - ABC网络=A、B、C Network
          - A=A-line
          - B=B-grid
          - C=C-grid
        - 出现时间: 1992年

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## 2G

- 2G=GSM / D-AMPS / IS-95
  - 概述
    - 2G包含：GSM、CDMA（其他不常用的 D-AMPS、IS-95）
      - 单个手机同时支持GSM和CDMA，被称为双模dual-mode？
      - GSM比CDMA用的更广泛
  - 编码方式=数据接入方式=数据接入技术=access technology
    - TDMA
      - TDMA=Time Division Multiple Access
      - D-AMPS有时候也被叫做：TDMA
  - 协议标准standard
    - GSM=Global System for Mobile Communications
      - 别称：2G
      - 编码方式：FDMA 和 TDMA的组合
      - 频谱
        - 范围
          - uplink上行：890 MHz ~ 915 MHz
          - downlink下行：935 MHz ~ 960 MHz
        - 别称：P-GSM
          - P-GSM=Primary GSM
        - 后续
          - 上下行都新增10MHz
      - 传输速度：
        - 最大14.4 kb/s
          - 基于：传统ABC网络
        - 最大 171.2 kb/s
          - 基于：GPRS
            - GPRS=General Packet Radio Service
              - 是什么：一种服务
                - 介于UMTS和GSM之间
                  - 和设备建立永久连接
                  - 但只在必要时传输数据
              - 相关
                - always-on mode
            - 别称：2.5G
        - 最大 384kb/s
          - 基于：EDGE
            - EDGE
              - EDGE=Enhanced Data for Global Evolution
                - =Enhanced Data Rates for GSM Evolution
              - 是什么：一种传输技术
                - 是GSM网络中的传输技术
              - 基于GSM衍生出的
                - 传输速度：最大384kb/s
              - 基于ECSD扩展出
                - E-GPRS=Enhanced GPRS
                - HSCSD
              - 别称：2.75G

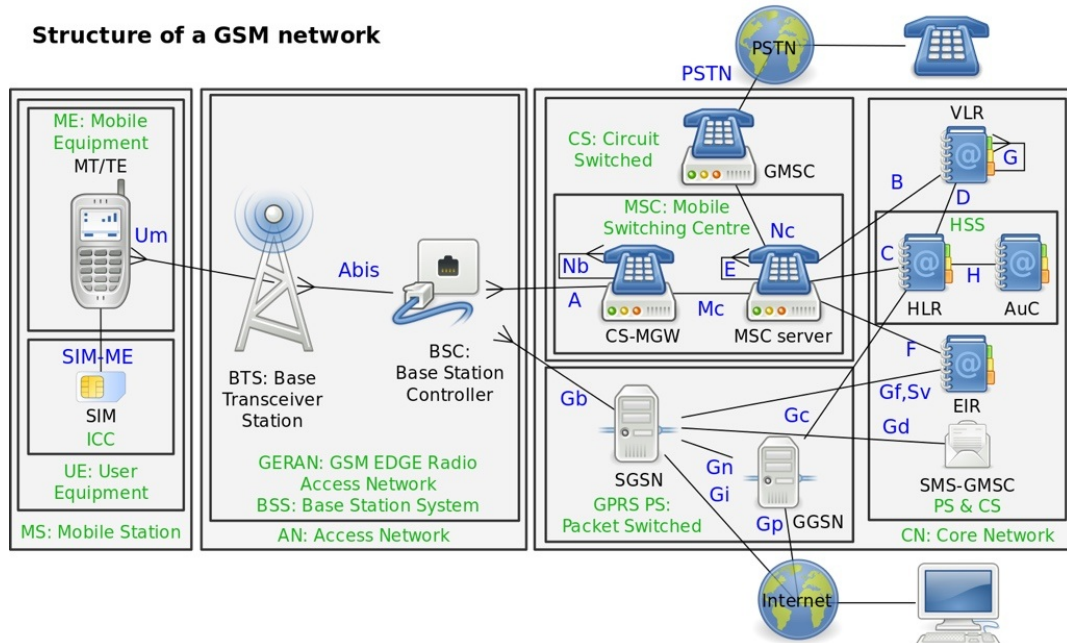
- 主要用途:
  - 打电话☎
    - 老式电话telephony
  - 也用于
    - 数据传输
    - 短消息=SMS=短信
  - 基于
    - CS=Circuit-Switched
    - PS=Packet-Switched

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# GSM

- GSM
  - 架构

Structure of a GSM network

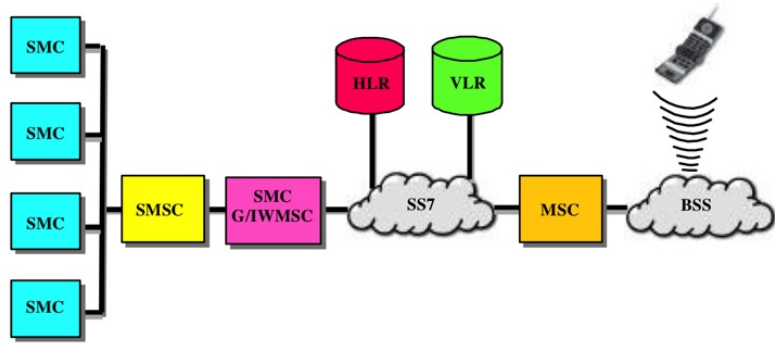


- 
- 包含
  - NSS
  - UTRAN
    - RNC
    - RBS
  - Operation and maintenance Support Subsystem
    - OSS

## NSS

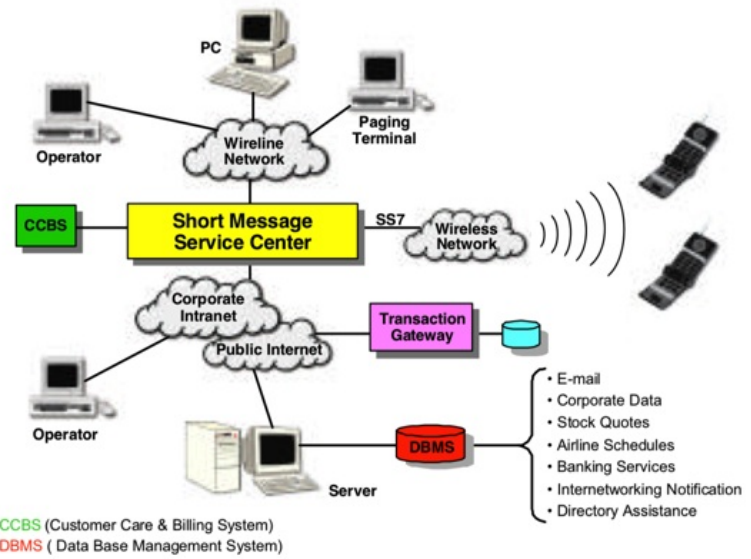
- NSS = Network Switching Subsystem = 网络交换子系统
  - 别称: GSM核心网络 = GSM core network
  - 特点
    - 2G和3G网络公用(都有)
  - 包含
    - MSC = Mobile Switching Center
      - MSCS = Mobile Switching Center Server
      - 有2种
        - SMSC = Short Message Service Center
          - 全称: SMS-SC = Short Message Service - Service Center
          - 是什么: 一个网络节点
            - 移动电话网络中的一个节点
          - 作用: 存储、转发、转换、传送SMS短信
          - 具体实现
            - 举例
              - Network Elements and Architecture

Figure 1: Network Elements and Architecture



- Network Infrastructure

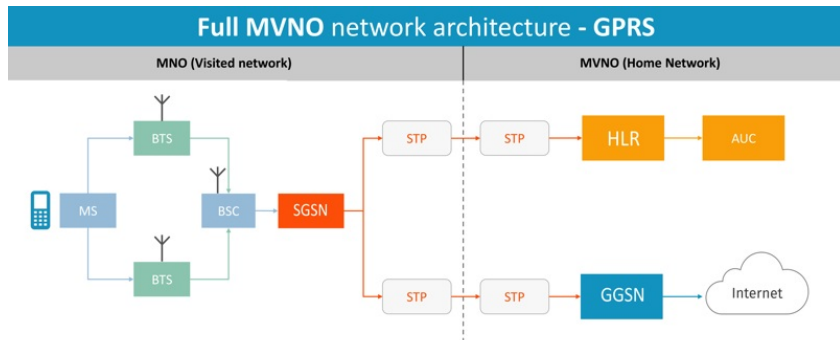
Figure 2: Network Infrastructure



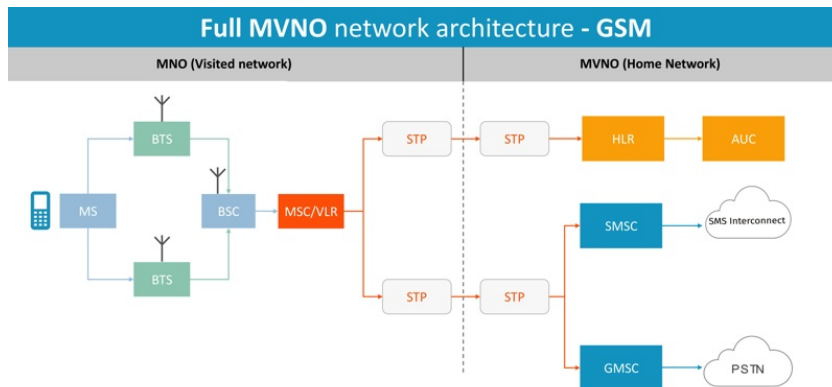
- GMSC = Gateway Mobile Switching Center

■ 相关架构

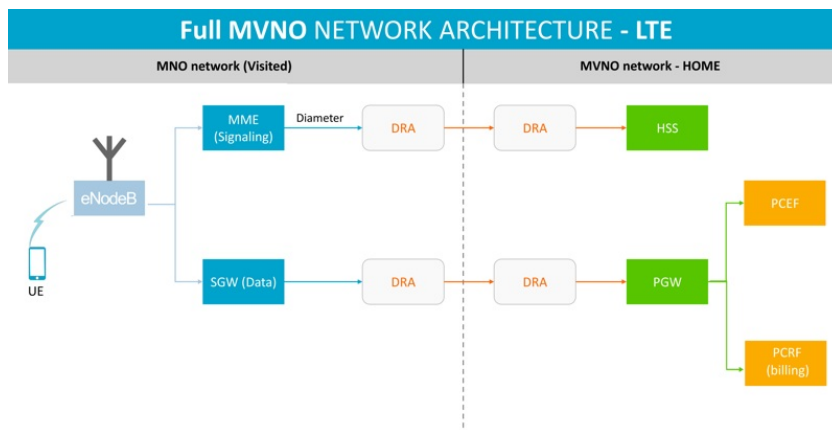
- Full MVNO network architecture - GPRS



- Full MVNO network architecture - GSM



■ Full MVNO network architecture - LTE



■ 连接到 MSC 的元素

- HLR = Home Locator Register
  - 获取SIM和MSISDN（如手机号）等数据
- BSS = Base Station Subsystems
  - 负责2G和2.5G手机的无线电通讯
- UTRAN = UMTS Terrestrial Radio Access Network
  - 负责3G手机的无线电通讯
- VLR = Visitor Location Register
  - 提供用户的信息
    - 当用户不在家庭网络中
- VLR = Visitor Location Register = 访客位置寄存器 = 漫游者位置寄存器
- HLR = Home Locator Register
  - 是什么：一个数据库
    - 数据：已注册到移动核心网络的移动用户数据
      - 即所有的SIM卡信息
        - 每个SIM卡有个唯一的IMSI
        - 每个SIM卡有个MSISDN
          - MSISDN：手机号码
- AuC = Authentication Center
  - 是什么：是一个功能function=模块
  - 功能：认证（想要连接到GSM网络的）SIM卡
    - 比如：当手机开机（上电）后
    - 目的：确保有权限使用相关服务
- EIR
- MGW

## GSM相关架构

- GSM相关架构

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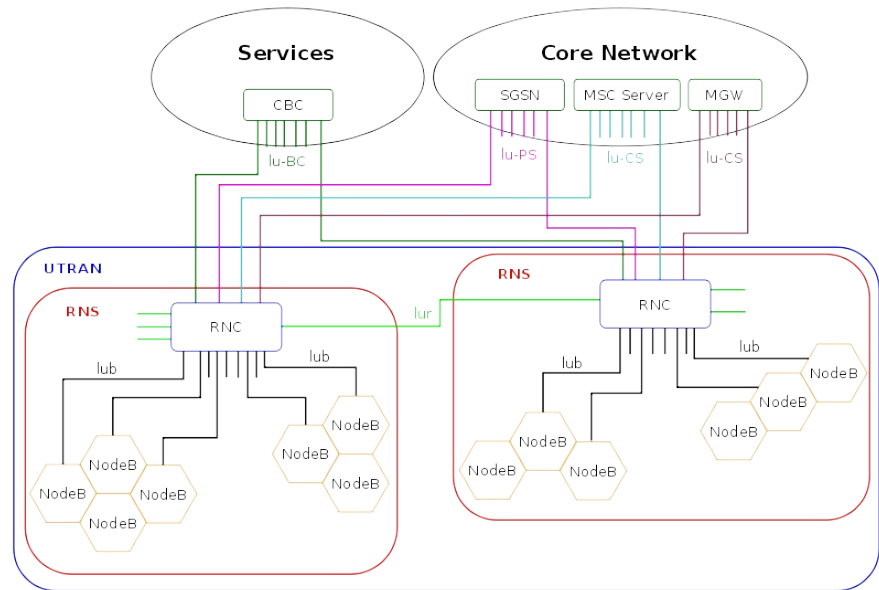
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# 3G

- 3G= UMTS / CDMA2000
  - 概述
    - 3G的标准叫法: IMT-2000
      - ITU 制定了 IMT-2000规范
    - IMT-2000
      - 不同地方有具体实施标准
      - 所支持的: 无线接入技术
        - W-CDMA
          - = WCDMA
        - CDMA2000
        - TD-SCDMA
        - WiMAX
    - 编码方式
      - 都是
        - CDMA
          - CDMA=Code Division Multiple Access
    - IMT-2000的具体实现 = (主要有) 2条技术路线 track
      - 欧洲: UMTS
        - 演化历史
          - 从GSM发展而来
            - 别称: 3GSM
              - 强调结合了 3G 技术而且是 GSM 标准的后续标准
        - 无线接入技术: WCDMA
          - channel: (wide) 5 MHz
          - voice codec: AMR
            - 语音质量比传统 (固定电话线路) 更好
          - 允许同时传输语音和数据
          - 最大速度:
            - downlink: 384 kbps
            - uplink: 64~384 kbps
          - UMTS 网络架构



- 美国: CDMA2000
  - 演化历史
    - 从 2G 的 IS-95 (和 D-AMPS) 演化而来
      - IS-95
        - 别称: cdmaOne
  - 别称:
    - CDMA2000 1xRTT
    - IS-2000
  - CDMA2000有多种类型
    - 1xRTT
    - 1xEV-DO
    - 1xEV-DV

○ 协议标准standard

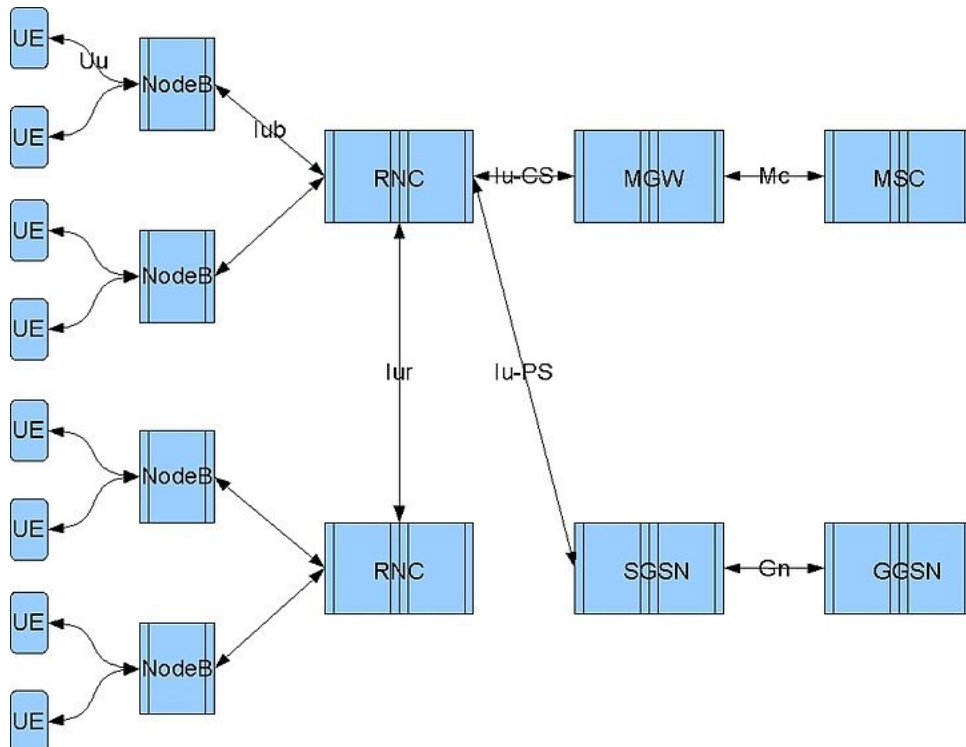
- UMTS
- CDMA2000

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# UMTS

- UMTS
  - UMTS = Universal Mobile Telecommunication System
    - = UMTS broadband
    - = 3G
      - = the third generation
  - 属于
    - PS=Packet-Switched网络
      - 之前的GSM和EDGE也是PS网络
        - 可利用现有资源=网络节点
          - SGSN
          - GGSN
  - 编码和传输
    - 最大速度
      - downlink下行: 2 Mb/s + uplink上行: 128 kb/s
        - 基于: WCDMA
          - WCDMA=Wideband Code Division Multiple Access
      - 21 Mb/s
        - 基于: HSPA
          - =HSPA+
            - HSDPA=High Speed Packet Access
          - downlink下行: HSDPA
            - HSDPA=High Speed Downlink Packet Access
              - 别称
                - =3.5G
                - =3G+
                - UMTS broadband
              - 是什么: UMTS网络中的一种传输技术
              - 最大速度: 3.6Mb/s ~ 7.2Mb/s
              - 发布时间: 2007年
              - 特点
                - 支持 (在移动网络中) 实现DSL-like = xDSL 数据传输
              - 相关网络运营商
                - Vodafone
                - E-Plus
                - O2
                - Swisscom
                - Sunrise
                - Orange
                - A1
                - T-Mobile
        - uplink上行: HSUPA
          - HSUPA=High Speed Uplink Packet Access
            - 是什么: UMTS网络中的一种传输技术
            - 最大速度: 5.8 Mb/s
              - 具体
                - HSUPA Category 6: 5.76 Mb/s
                - HSUPA Category 9: 23 Mb/s

- 逻辑关系
        - 是UMTS Release 9的一部分
  - 出现时间：2004年
  - 相关历史
    - 最早是ETSI制定的UMTS
    - 后来被ITU采纳了
    - 以及出现了3GPP
      - 3GPP=3rd Generation Partnership Project
        - 其中的3rd Generation, 就是3G
          - 就是为了3G弄了个组织, 用于协调统一各方标准, 实现3G网络推广
  - 最新情况：3GPP制定的UMTS标准
  - 核心逻辑：UE <-> UTRAN <-> CN
  - 架构：



- UMTS的RAN包含
      - UE：用户终端=移动设备=手机
      - Node B：一个网络节点
        - 负责：连接UE和RNC
        - 对应着：GSM中的BTS
          - BSC=Base Station Controller：（网络）基站
      - RNC：在UTRAN网络中的, 一个网络控制（管理）节点

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# CDMA2000

- CDMA2000
  - 最大速度
    - EV-DO = EVDO
      - EVDO = Evolved Data Optimized
      - 下行downlink: 14.7 Mb/s
      - 上行uplink: 5.4 Mb/s

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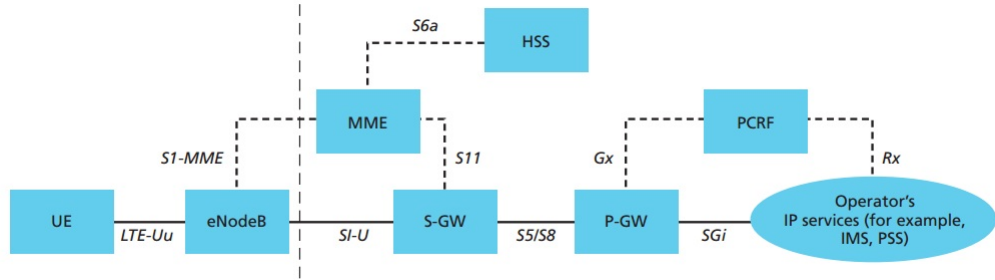
# 4G

- 4G= LTE / WiMax
  - LTE = Long Term Evolution (of mobile networks)
    - = 4G = the fourth generation = 4G standard
  - 最大速度: 300 Mb/s
  - 2条技术路线
    - LTE
      - 演化自UMTS和CDMA2000
      - 目前主流是LTE
    - WiMax
      - WiMax=Worldwide Interoperability for Microwave Access
  - 协议标准
    - LTE

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# LTE

- LTE 背景概述
  - 之前3GPP的无线技术：有电路交换承载=CS bearer=Circuit Switched bearer
  - 而LTE：没有CS bearer
    - 没法直接支持语音传输
      - 想要：在LTE之上传输语音 = Voice over LTE = VoLTE
        - 可能的方案：VoIP=Voice over IP
          - 需要支持LTE终端的把2G或3G信号转成语音电话
            - 缺点：会降低音质，甚至导致 PS=Packed Switched 服务暂停
        - 所以：GSMA推出了：VoLTE=Voice over LTE
          - = IP Multimedia Subsystem (IMS) Profile for Voice and SMS document
        - VoLTE出现之前的临时的方案
          - 包括
            - CSFB=Circuit Switched FallBack
            - SMSoSGs
              - 作用：从LTE转到CS GSM/UMTS时建立连接
              - 目的：当网络中IMS不可用时，通过LTE实现CS call或发送传统SMS短信
          - 作用
            - 背景：当运营商还没完全支持VoLTE时
            - 可以和VoLTE配合工作以支持
              - 网络漫游
              - 紧急电话
  - LTE 技术细节
    - 编码方式：
      - downlink下行：OFDMA
        - OFDMA=Orthogonal FDMA
          - 适合多用户
      - uplink上行：SC-FDMA
        - SC-FDMA=Single-Carrier FDMA
          - 能效比高，适合用电池的移动手机
    - 最大传输速度
      - LTE
        - 下行：300 Mb/s
        - 上行：75 Mb/s
      - LTE-A = LTE Advanced
        - 下行：1Gb/s
      - LTE Advanced Pro
        - 下行：3Gb/s
    - LTE Advanced Pro
      - 支持
        - MIMO = Multiple-Input Multiple-Output
        - CA = Carrier Aggregation
    - 架构
      - 总体架构



■ EPC架构

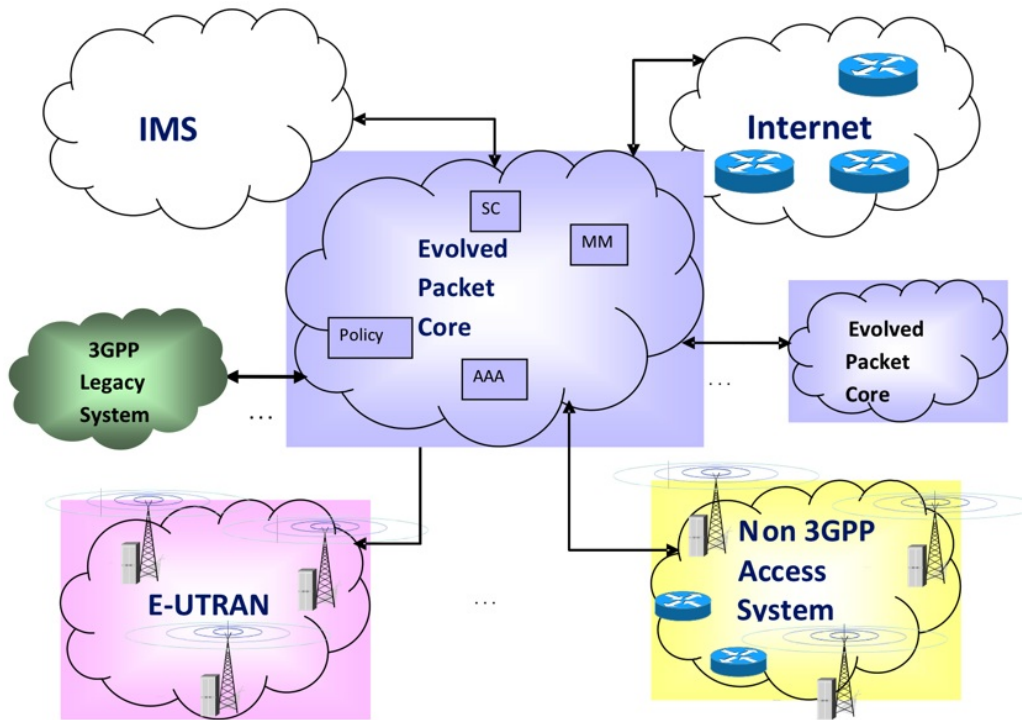
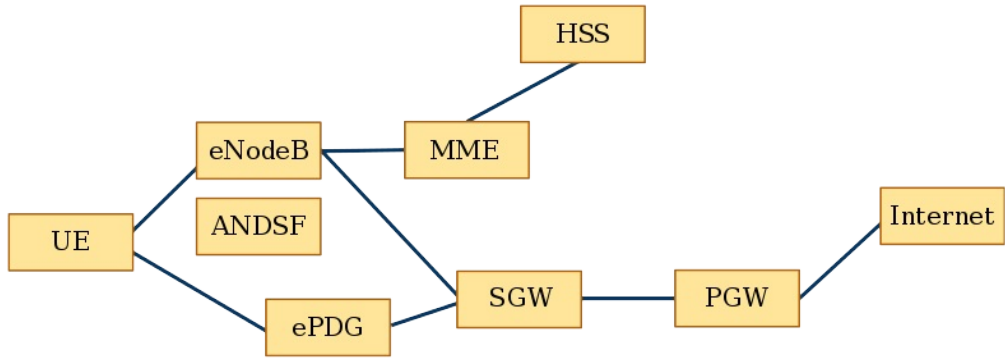


Figure 8. The Evolved Packet Core

○ 核心元素

- MME = Mobility Management Entity
- SGW = S-GW = Serving Gateway
- PGW = P-GW = PDN Gateway
- HSS = Home Subscriber Server
- PCRF = Policy and Charging Rules Functions
- ANDSF = Access Network Discovery and Selection Function = 接入网络发现和选择功能
- ePDG = Evolved Packet Data Gateway = 演进的分组数据网关

- 相关名词

- TTI = Transmission Time Interval
- HARQ = Hybrid Automatic Repeat Request

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# 5G

TODO:

把

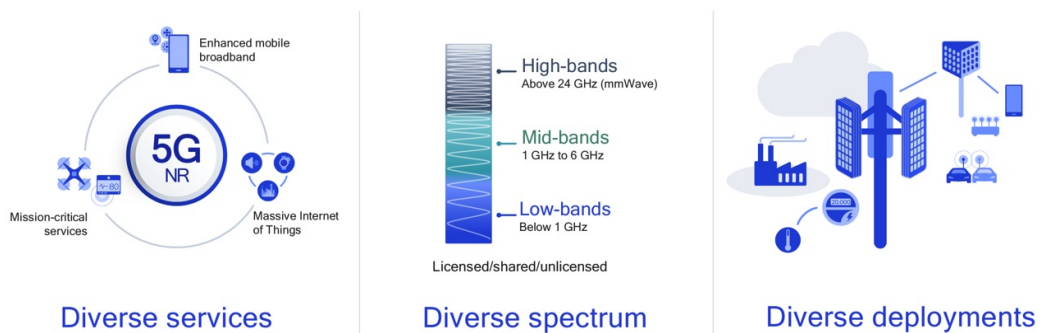
- [Qualcomm Future of 5G Building a unified, more capable 5G air interface for the next decade and beyond](#)
- [The-5G-Guide\\_GSMA\\_2019\\_04\\_29\\_compressed.pdf](#)

中关于5G技术内容整理过来

关于5G更多细节，详见：[5G技术概述](#)

- 5G
  - = fifth generation
  - 3GPP 组织制定的标准
  - 概述

## 5G NR is a unified, more capable air interface



**10x**  
Decrease in  
end-to-end latency

**10x**  
Experienced  
throughput

**3x**  
Spectrum  
efficiency

**100x**  
Traffic  
capacity

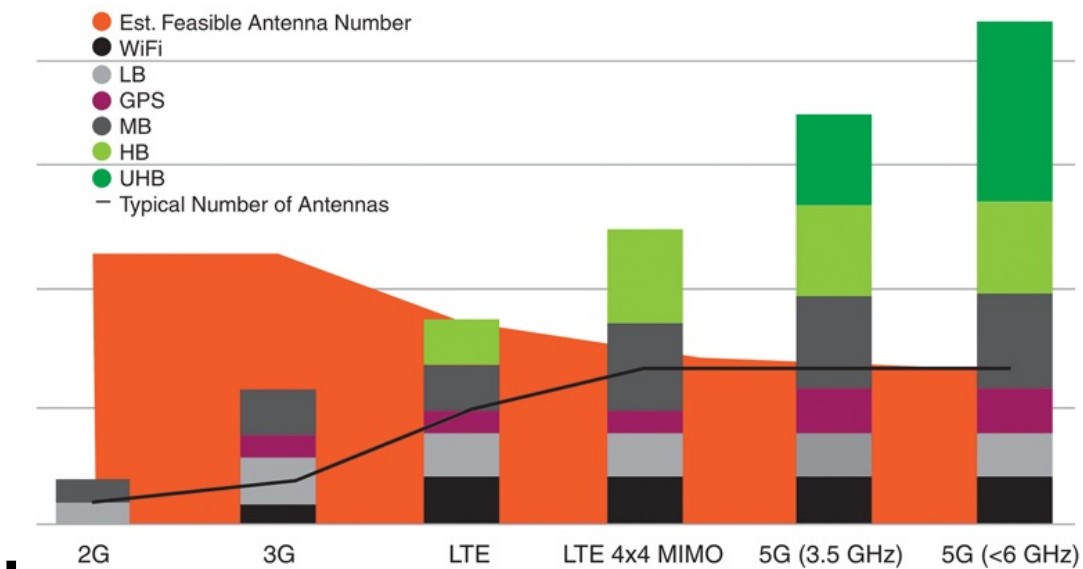
**100x**  
Network  
efficiency

**10x**  
Connection  
density

Based on ITU vision for IMT-2020 compared to IMT-advanced; URLLC: Ultra Reliable Low Latency Communications; IAB: Integrated Access & Backhaul

- 频段范围
  - FR1 = Frequency Range 1
    - 包括 sub-6 GHz
  - FR2 = Frequency Range 2
    - 包括了 mmWave = mm-wave 的24–100GHz
- 2G到5G频谱对比

As handset RF content increases, the ability to add antennas is limited.



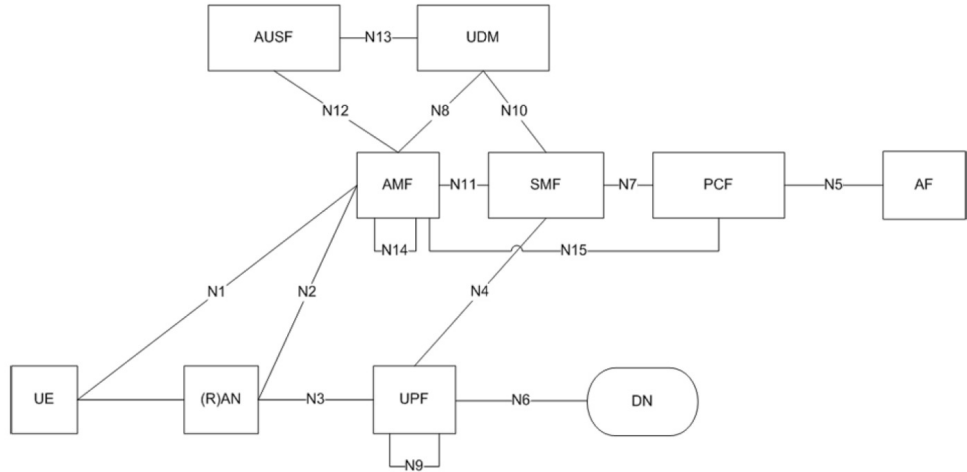
相关技术

- Massive MIMO

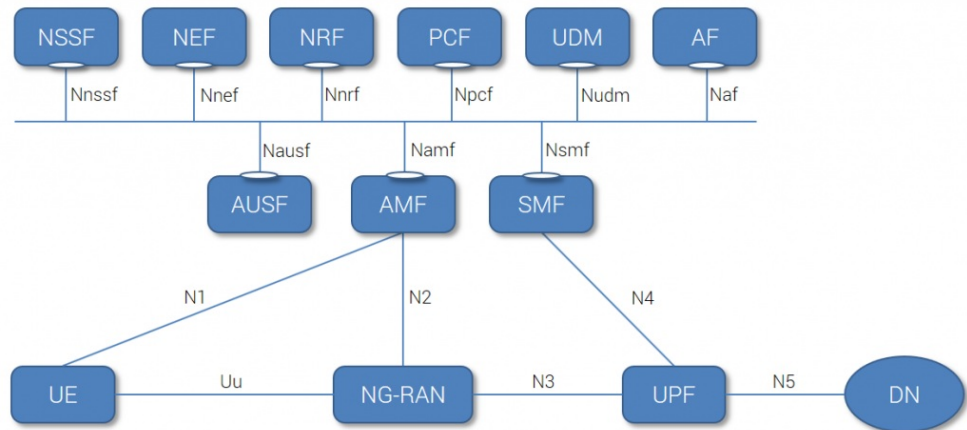


架构

- 总体架构
  - Reference Point Architecture of 5G Core Network

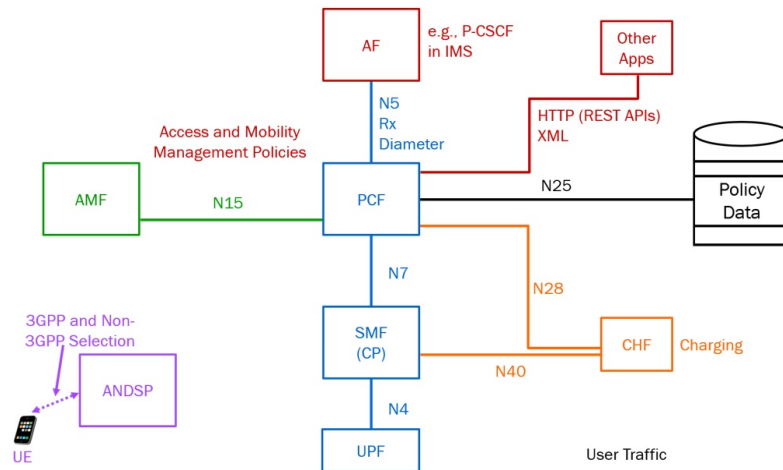


■ Service-based Architecture of 5G Core Network



■ 细节

■ Policy Control Mechanism in 5G Core Network



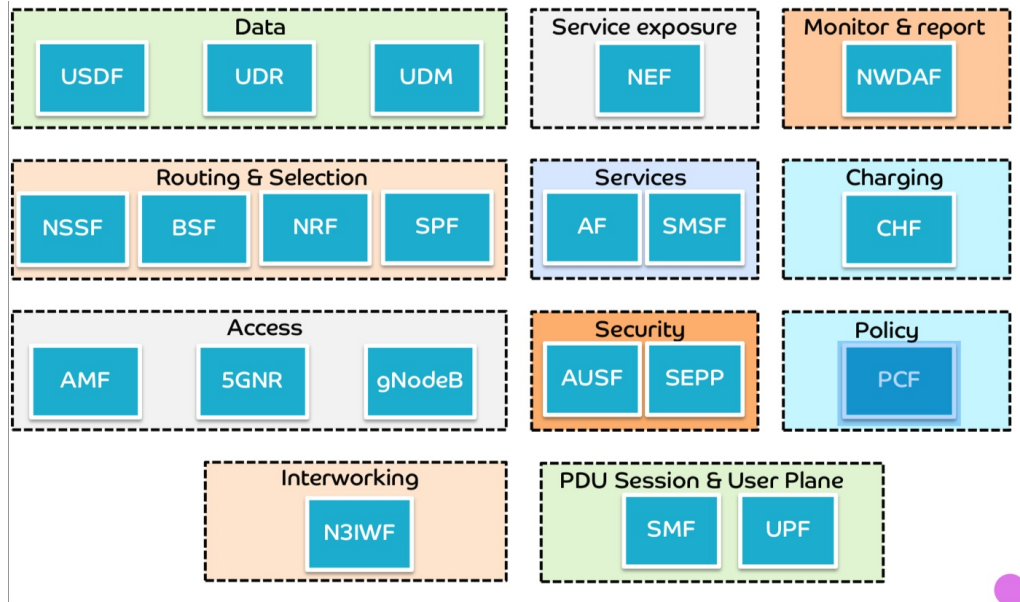
○ 核心元素=核心功能(function)

■ 包含

- AMF = Access and Mobility Management function
- SMF = Session Management function
- UPF = User plane function
- PCF = Policy Control Function

- AUSF = Authentication Server Function
- UDM = Unified Data Management
- AF = Application Function
- NEF = Network Exposure function
- NRF = NF Repository function
- NSSF = Network Slice Selection Function

- Classification of 5G Core Networks



## 4G vs 5G

- 4G和5G技术参数对比

| Technology | Data Rates                   | Latency    | Mobility Support | Spectrum Efficiency                          | Users Density         | Energy Efficiency |
|------------|------------------------------|------------|------------------|--|-----------------------|-------------------|
| 5G (NR)    | Avg 100 Mb/s<br>Peak 20 Gb/s | ~ 1 ms     | >500 Km/h        | x3 Better<br>DL- 30 bits/Hz<br>UL- 15bits/Hz | 1000K/Km <sup>2</sup> | x100 Better       |
| 4G (LTE)   | Avg 25 Mb/s<br>Peak 300 Mb/s | ~10- 50 ms | <=350 Km/h       | DL – 6 bits/Hz<br>UL- 4 Bits/Hz              | ~ 2K/Km <sup>2</sup>  | Moderate          |

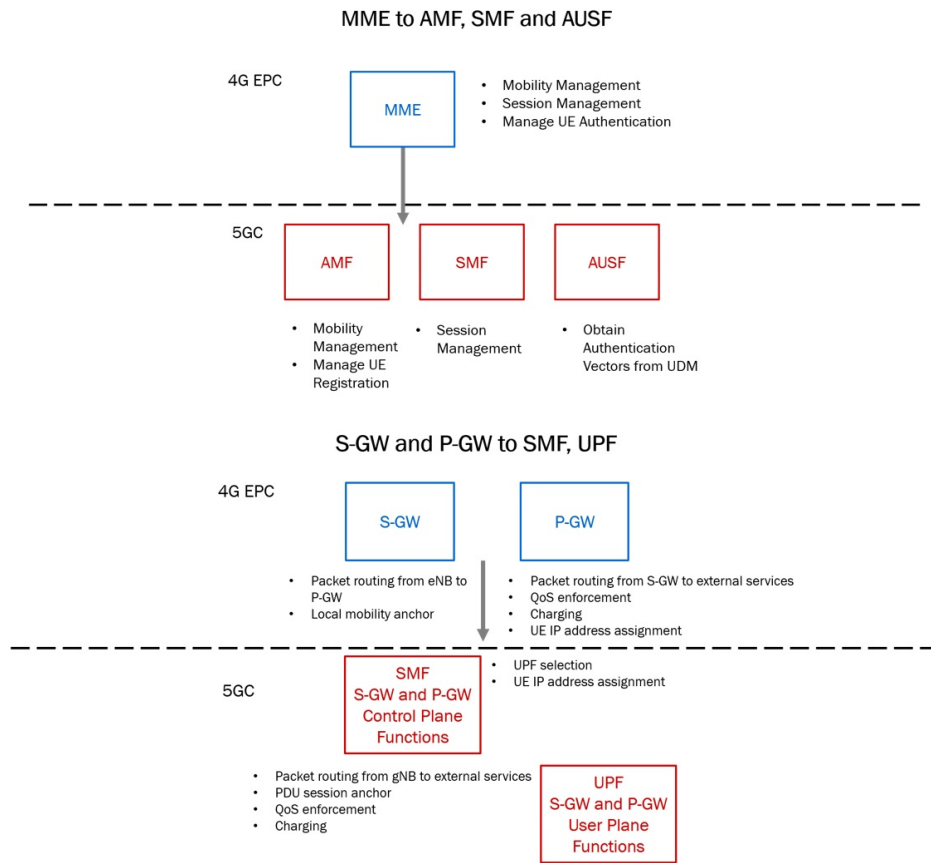
- 4G和5G核心网络功能演化对比

- Comparison of 4G Core Network and 5G Core Network



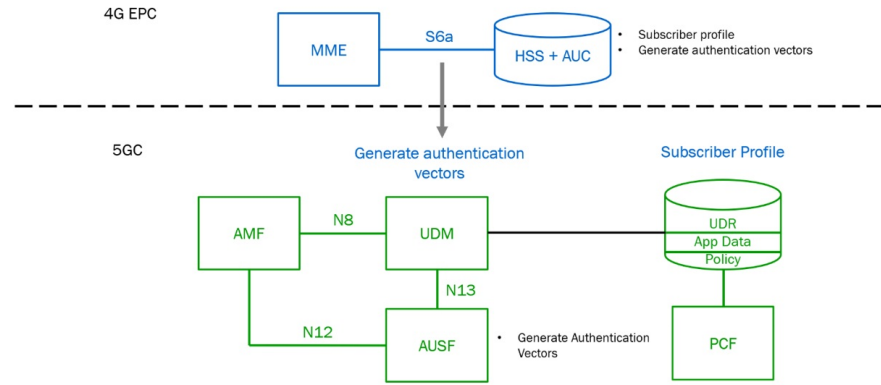
|      | MME | S-GW | P-GW | HSS | PCRF | AF | New |
|------|-----|------|------|-----|------|----|-----|
| AMF  | ✓   |      |      |     |      |    |     |
| SMF  | ✓   |      | ✓    |     |      |    |     |
| UPF  |     | ✓    | ✓    |     |      |    |     |
| PCF  |     |      |      |     | ✓    |    |     |
| AUSF |     |      |      | ✓   |      |    |     |
| UDM  |     |      |      | ✓   |      |    |     |
| AF   |     |      |      |     |      | ✓  |     |
| NEF  |     |      |      |     |      |    | ✓   |
| NRF  |     |      |      |     |      |    | ✓   |
| NSSF |     |      |      |     |      |    | ✓   |

Transformation of 4G Core Network Functions to 5G Core Network Functions



■ 具体细节

■ Transformation of MME into AMF&UDM



## 5G应用

- 应用
  - 概览



**5G** 5G is essential for next generation mobile experiences

- Fiber-like data speeds
- Low latency for real-time interactivity
- More consistent performance
- Massive capacity for unlimited data

Enabler to the factory of the future | Safer, autonomous transportation | Reliable access to remote healthcare | Precision agriculture

Efficient use of energy and utilities | Private networks for logistics, enterprises, industrial, ... | Sustainable smart cities and infrastructure | Digitized logistics and retail

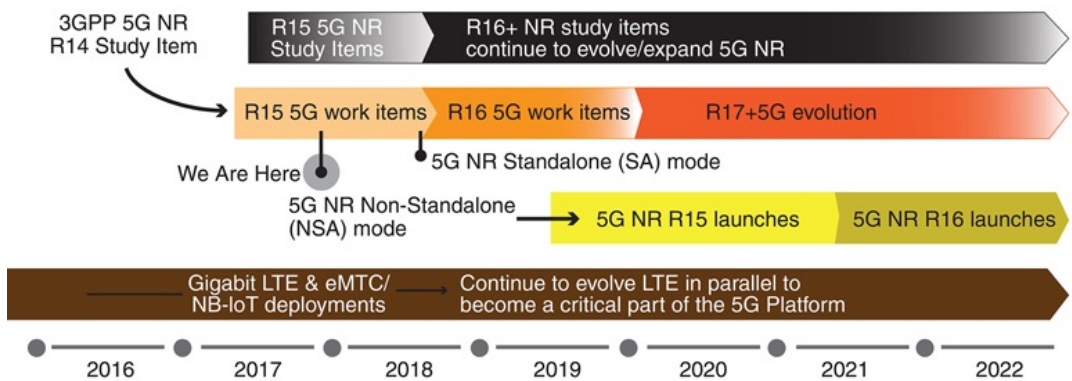
**5G** 5G will expand the mobile ecosystem to new industries

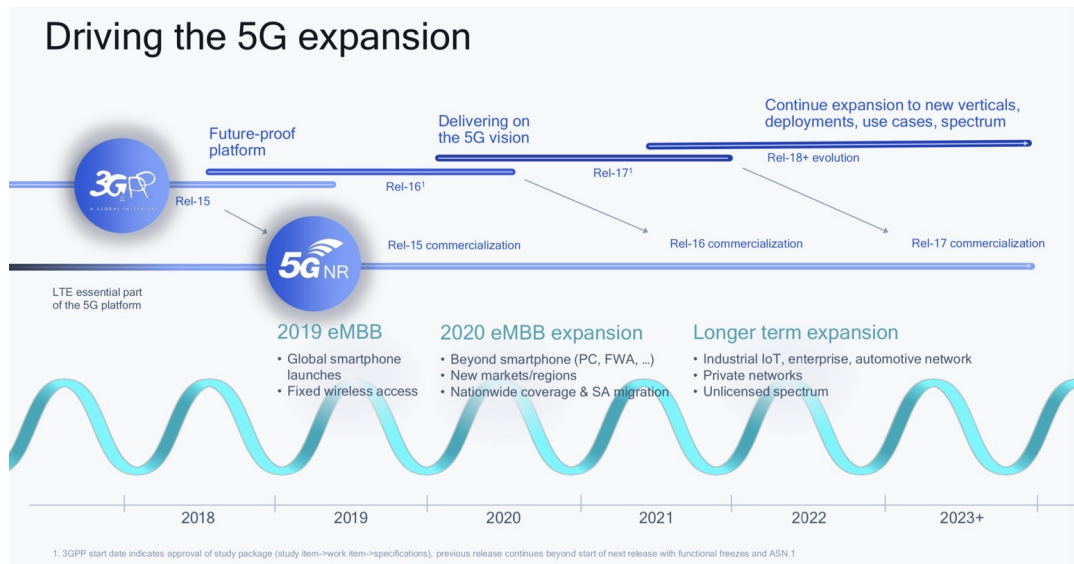
Powering the digital economy  
**\$13.2 Trillion**  
 In goods and services by 2035

## 5G标准版本历史

• 5G标准版本历史

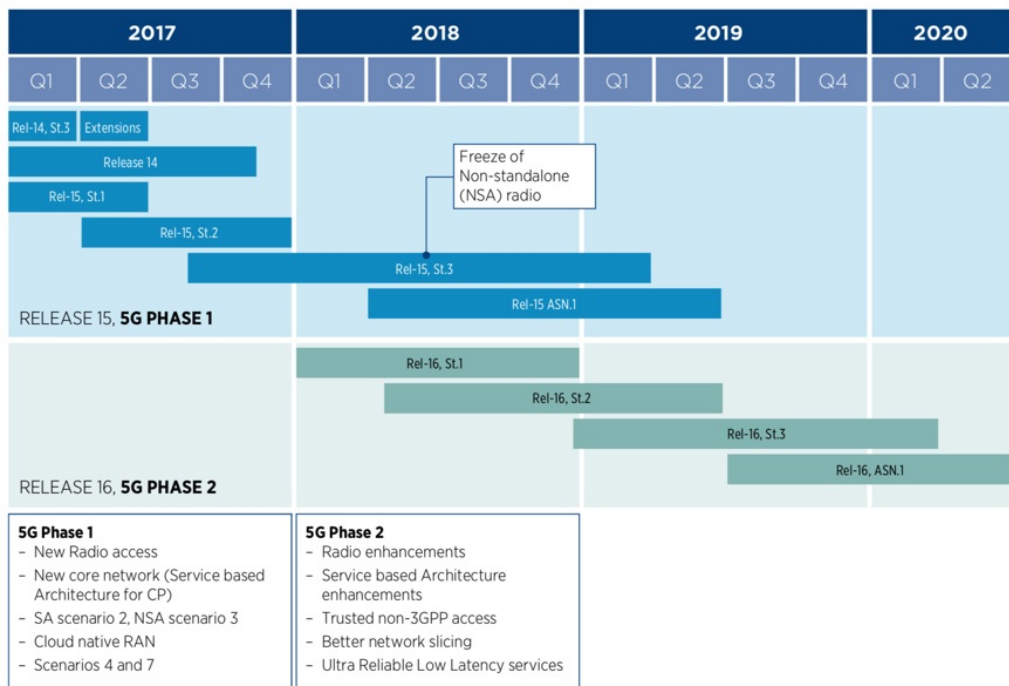
◦ 图





THE 3GPP ROADMAP FOR RELEASE 15 AND 16

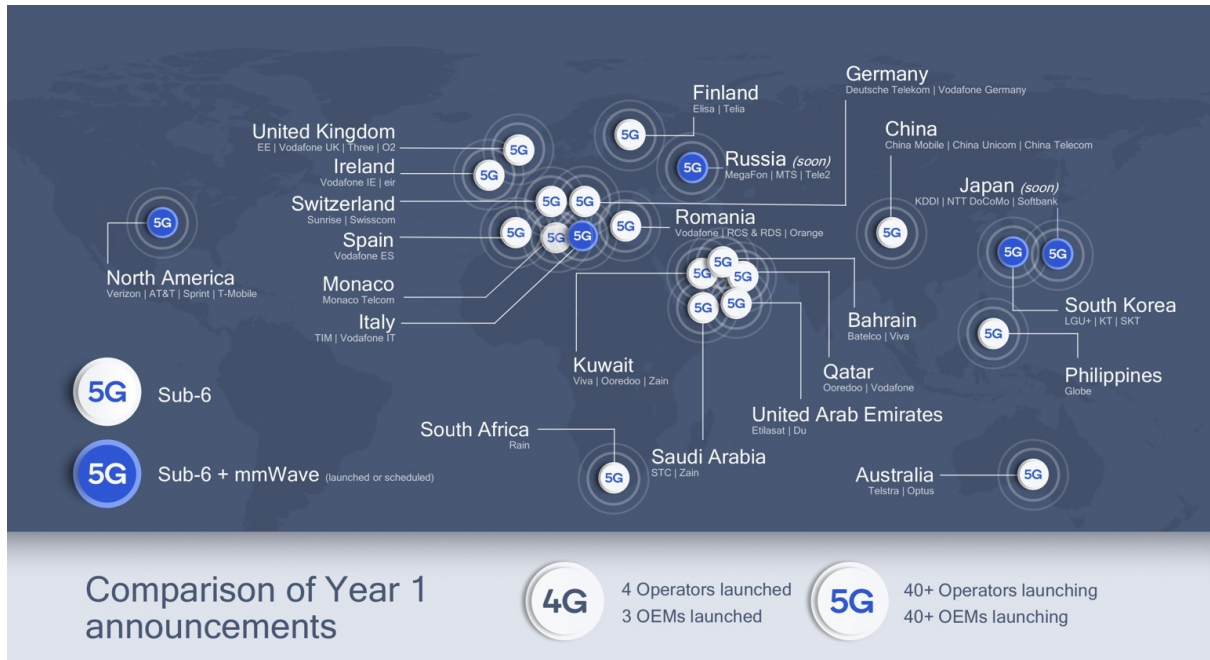
THE 3GPP ROADMAP FOR RELEASE 15 AND 16



文字

- 2015年：开始研究
- 2017年：第一次发布 5G NSA
- 2018年：3GPP Release 15 =5G phase 1
  - eMBB = Enhanced Mobile Broadband
  - URLLC = Ultra-Reliable and Low Latency Communication
- 2020年6月：3GPP Release 16 =5G phase 2
  - mMTC = massive Machine Type Communication
  - V2V = Vehicle to Vehicle
- 预计2021年：Release 17

## 运营商支持5G情况



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# NR

- NR

- o = New Radio
- o 编码方式: OFDM
- o 路线图

- 5G NR TECHNOLOGY ROADMAP

- 5G NR TECHNOLOGY ROADMAP

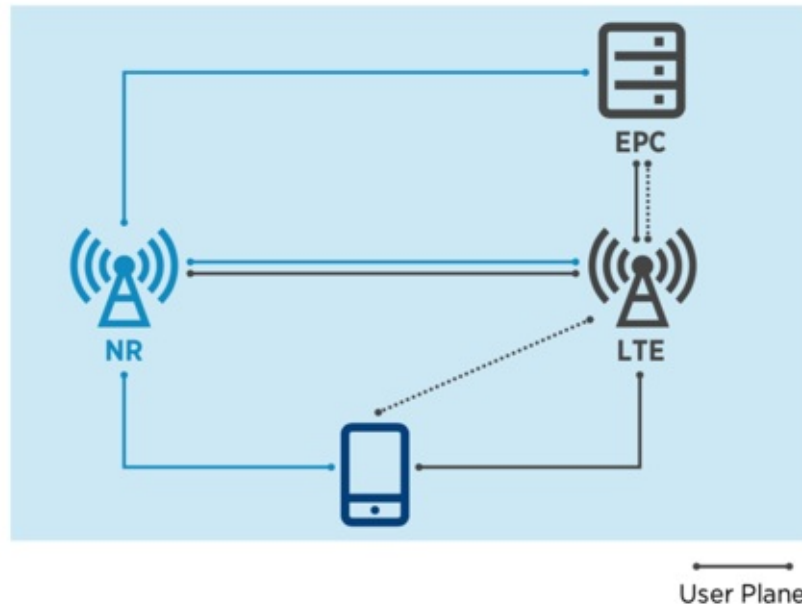
|                 | 2018  | 2019  | 2020   | 2021  | 2022  |  |
|-----------------|---|---|--|---|---|--|
| STANDARDISATION | <ul style="list-style-type: none"> <li>NR early drop SA and EPC-based NSA</li> <li>3GPP Release 15</li> </ul> | <ul style="list-style-type: none"> <li>NR Late drop 5G Core based NSA</li> </ul>              | <ul style="list-style-type: none"> <li>3GPP Release 16</li> <li>IMT-2020 candidate submission</li> </ul> | <ul style="list-style-type: none"> <li>3GPP Release 17</li> </ul>           |   |  |
| CHIPSETS        | <ul style="list-style-type: none"> <li>Qualcomm X50 (Rel-15)</li> <li>Huawei Balong 5G01 (Rel-15)</li> </ul>  |   | <ul style="list-style-type: none"> <li>Qualcomm chipset (Rel-16)</li> <li>Intel (Rel-15)</li> </ul>      |   |   |  |
| DEVICES         | <ul style="list-style-type: none"> <li>FWA CPE VZ5G specs</li> </ul>  | <ul style="list-style-type: none"> <li>AT&amp;T "Puck"</li> <li>Samsung Galaxy S10</li> </ul> | <ul style="list-style-type: none"> <li>Devices based on Qualcomm X50 (sub 6GHz)</li> </ul>               | <ul style="list-style-type: none"> <li>Apple smartphones</li> </ul>         | <ul style="list-style-type: none"> <li>Smartphones &gt; 6GHz</li> </ul> |  |
| EQUIPMENT       | <ul style="list-style-type: none"> <li>NR gNodeB</li> <li>LTE enhancements</li> </ul>                         |   | <ul style="list-style-type: none"> <li>5G Core (based on Rel-15)</li> </ul>                              | <ul style="list-style-type: none"> <li>5G Core (based on Rel-16)</li> </ul> |   |  |

- 部署

- 2种模式: NSA 和 SA
    - 包含
      - 基于已有4G LTE的: NSA = Non-StandAlone

FIGURE 2.1.2

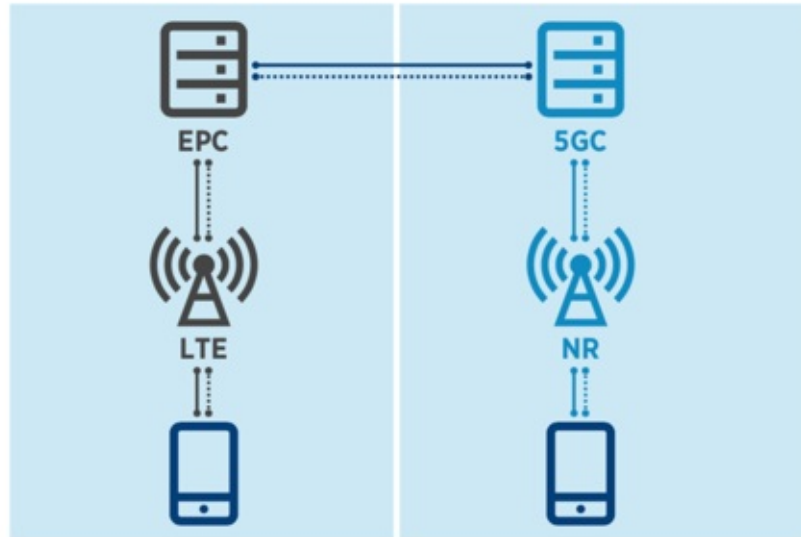
NSA CONFIGURATION (OPTION 3). NR  
CONNECTED TO, AND CONTROLLED BY  
EXISTING 4G CORE NETWORK



- 纯5G的: SA = StandAlone

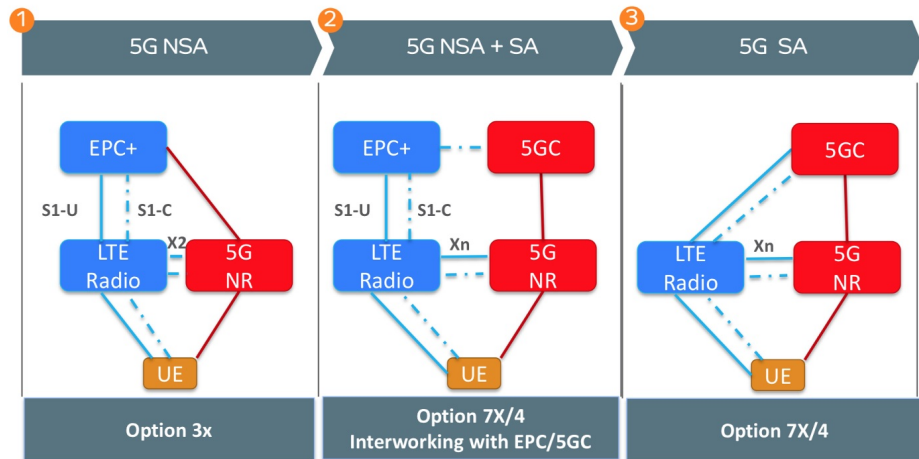
FIGURE 2.1.3

SA CONFIGURATION (OPTION 2). NR CONNECTS TO THE 5G CORE ONLY. THE STANDALONE 5G SYSTEM INTERWORKS AT CORE NETWORK LEVEL WITH LEGACY 4G SYSTEM



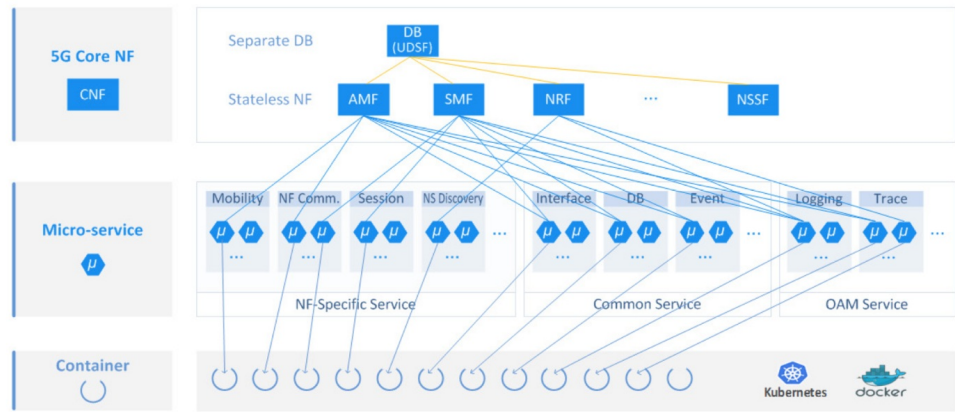
Control Plane

- 对比
  - Core Network SA and NSA Modes

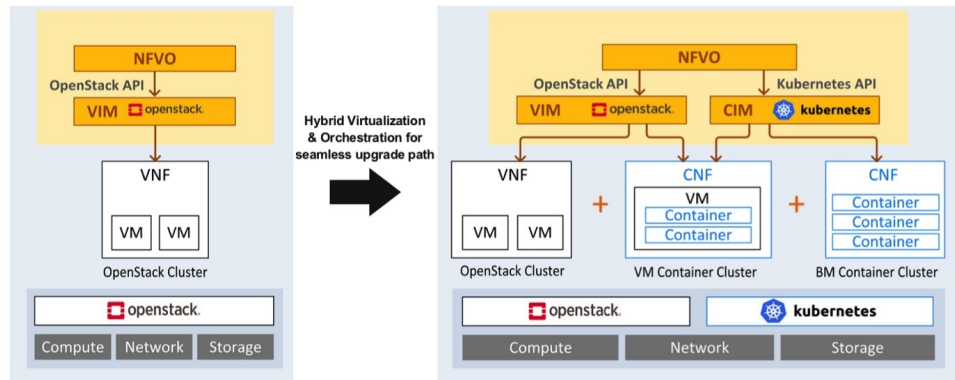


- 云模式
  - Container Based Cloud Native 5G Core





Hybrid Cloud Native 5G Core Architecture



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# 移动网络总结

- 概览

- 
- 网络演化历史
  - 文字
    - 详细
      - 1G
        - AMPS 、 NMT 、 C-Netz 、 TACS
          - 编码方式： FDMA
      - 2G
        - GSM
          - 编码方式： FDMA 和 TDMA
          - 传输方式
            - GPRS
              - = 2.5G
            - EDGE
              - 2.75G
        - D-AMPS
        - IS-95 = cdmaOne
      - 3G
        - UMTS ： 来自 GSM
          - WCDMA
          - HSPA+
            - 3.5G = HSDPA
          - DC-HSPA+
        - CDMA2000 ： 来自 IS-95 = cdmaOne
          - EVDO
      - 4G
        - LTE
          - TD-LTE
          - FDD

- 5G
  - NR

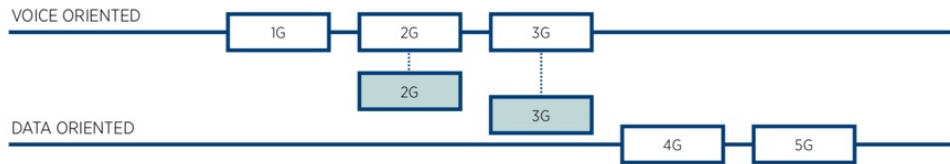
● 不同代的网络

○ 演化图

■ 1G到5G

■ 4G和5G在语音和数据方面的发展路线

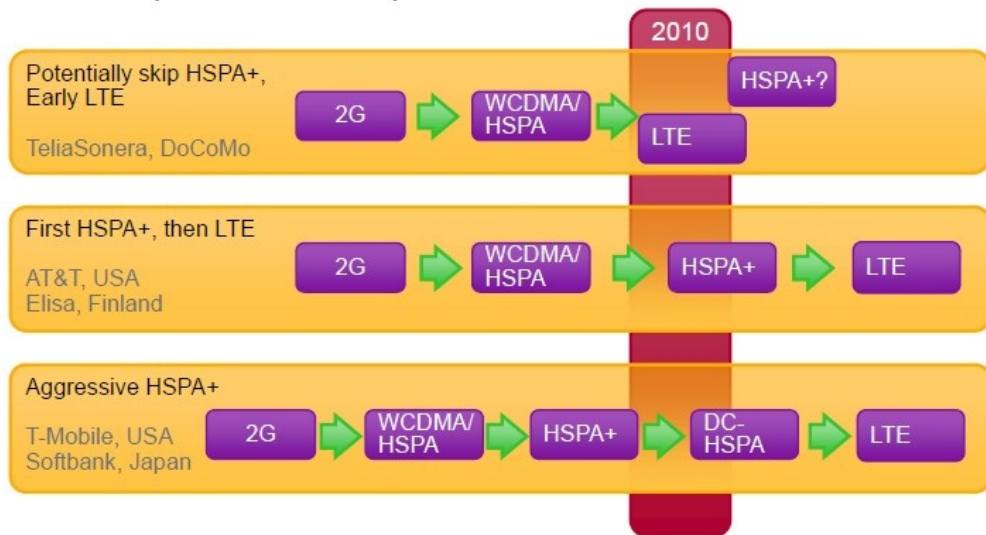
4G AND 5G ARE BASED ON THE SAME TECHNOLOGY PHILOSOPHY



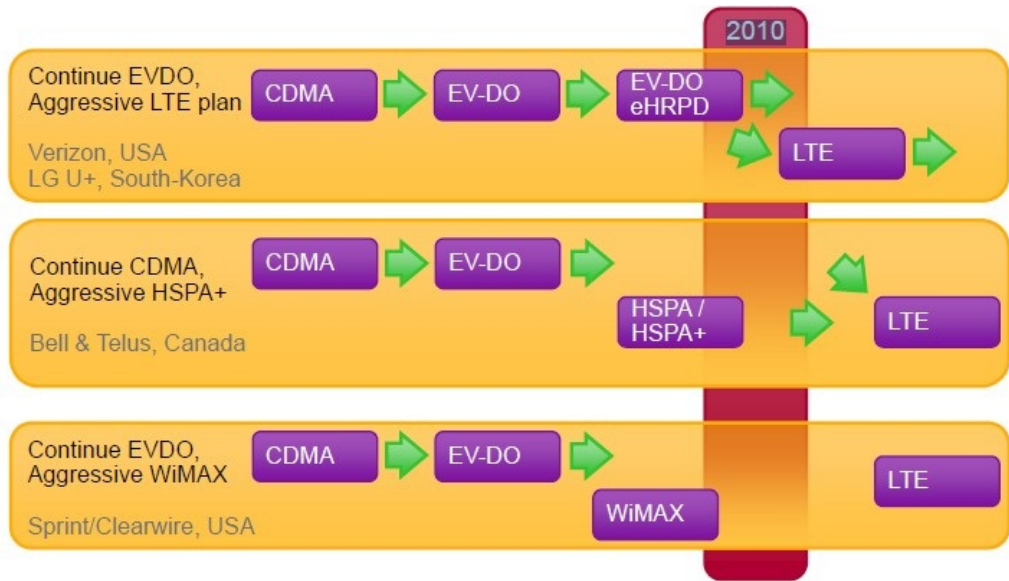
■ 相关名词和术语

- 5G Core
  - gNB, AMF, SMF, NSSF, UDM, AUSF, UPF
- 4G LTE
  - eNB, MME, SGW, PGW, HSS, EIR, PCRF, OCS & OFCS
- IMS
  - CSCFs, HSS, MGCF, MGW, AS, OCS & OFCS
- 3G
  - NB, HNB, HNBGW, RNC, MSC, SGSN, GGSN
- 2G
  - BTS, BSC, MSC, HLR, EIR, VLR, SMSC, GMSC
- TDM | PSTN
  - ISDN, ISUP, CAS
    - requires additional PSTN Network setup
- Supports IPsec, TLS, SRTP, and MSRP

■ 2G到LTE



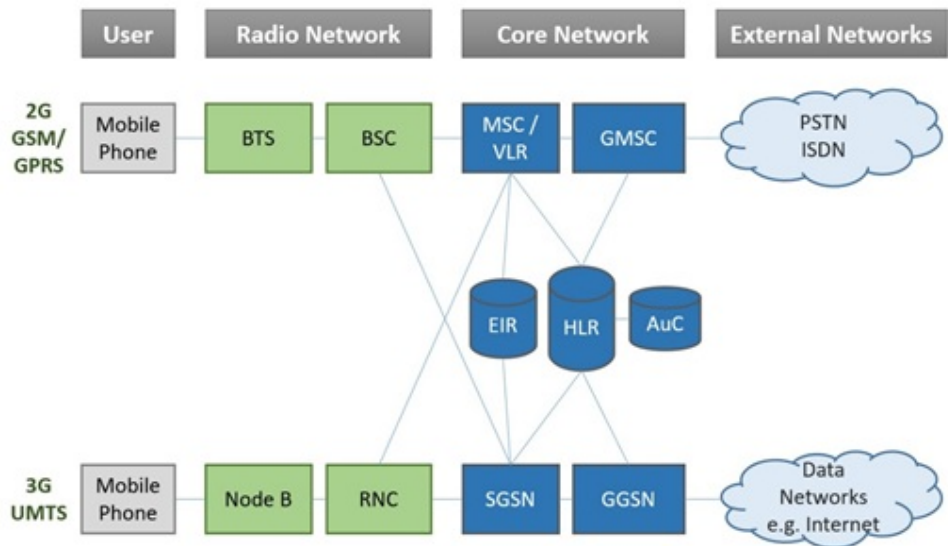
■ CDMA到LTE



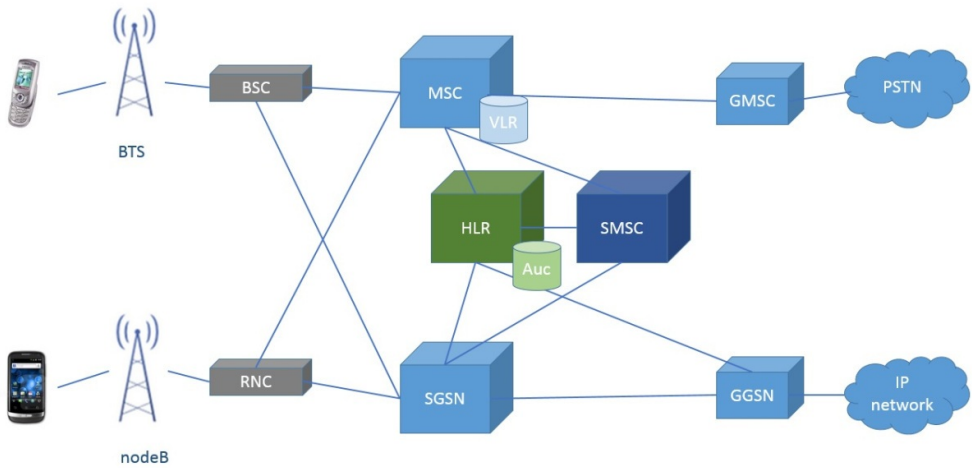
架构图

2G和3G

High-level network diagram for GSM (2G) and UMTS (3G)

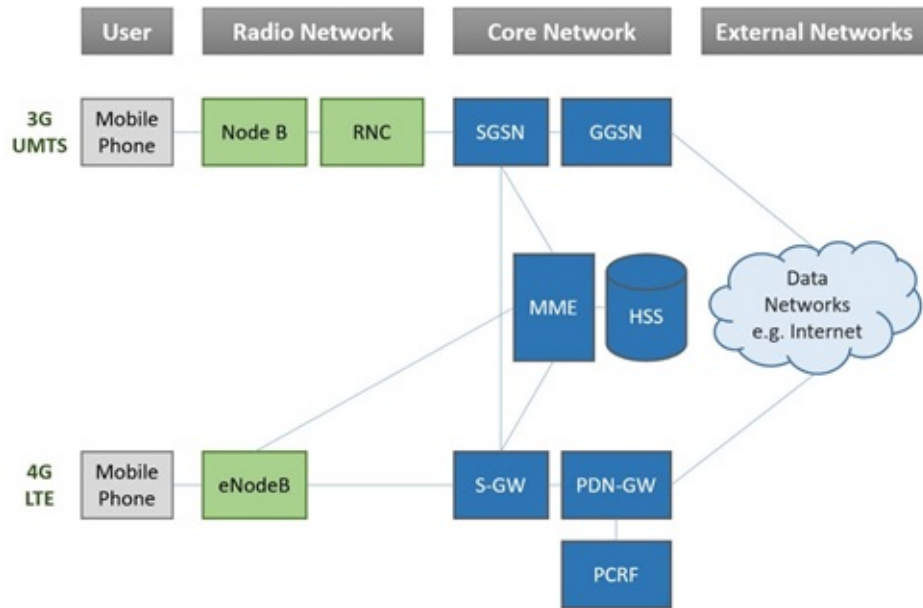


SMS in 2G/3G network architecture

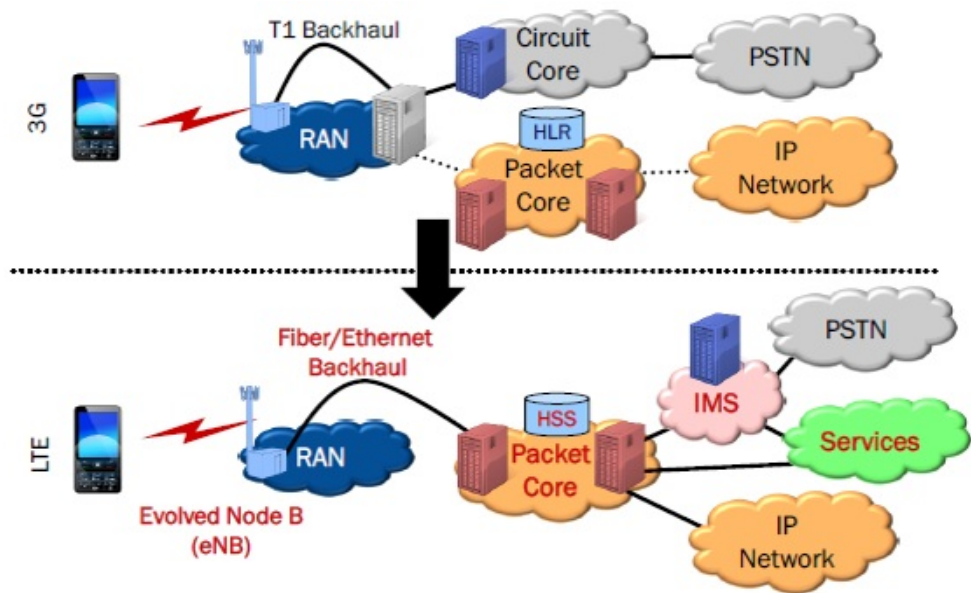


- 3G和4G

- High-level network diagram for UMTS (3G) and LTE (4G)

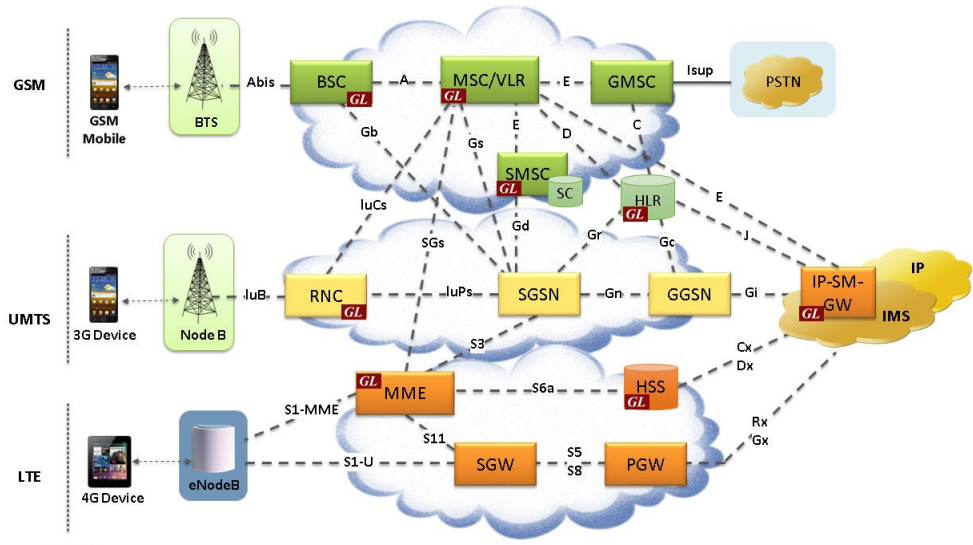


- Evolution of 3G Core Network to 4G Core Network



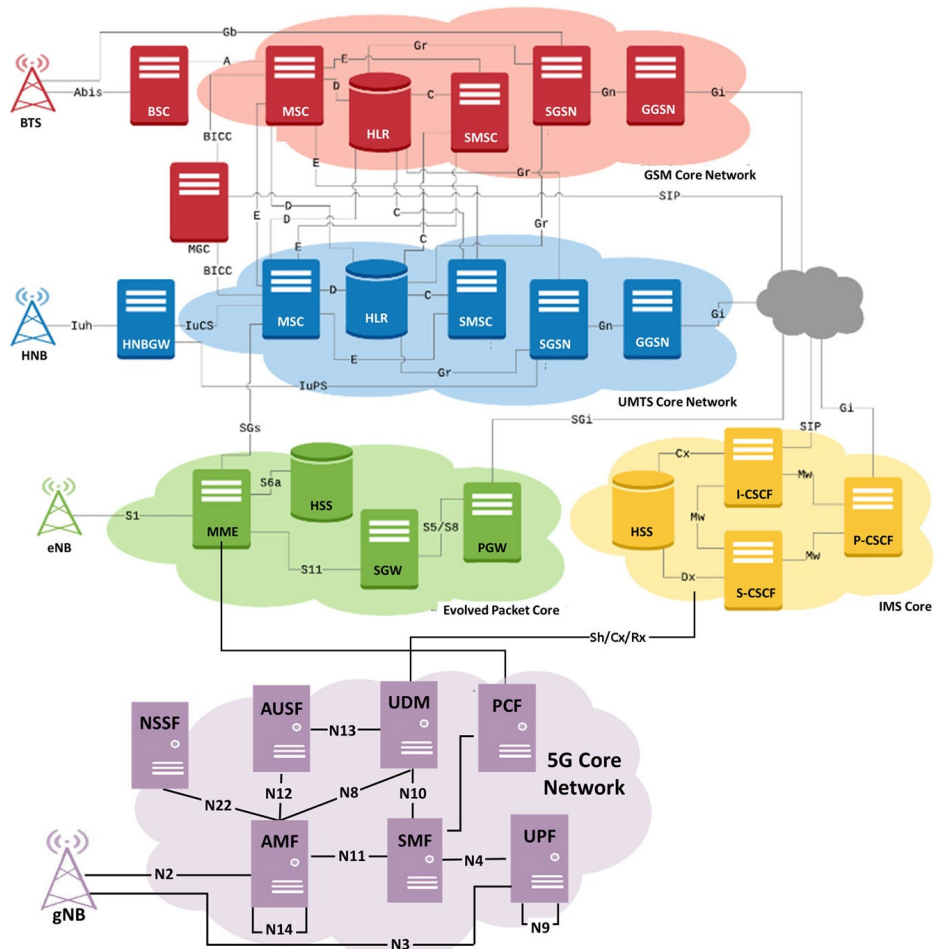
- 2G、3G、4G

- GL's SMS Test Suite for LTE, UMTS, and GSM Networks



**GL** GL's SMS Test Solution Suite  
2G, 3G, and 4G

- 2G、3G、4G、5G
  - Wireless Network Simulation (5G, 4G, 3G, 2G, IP, TDM)

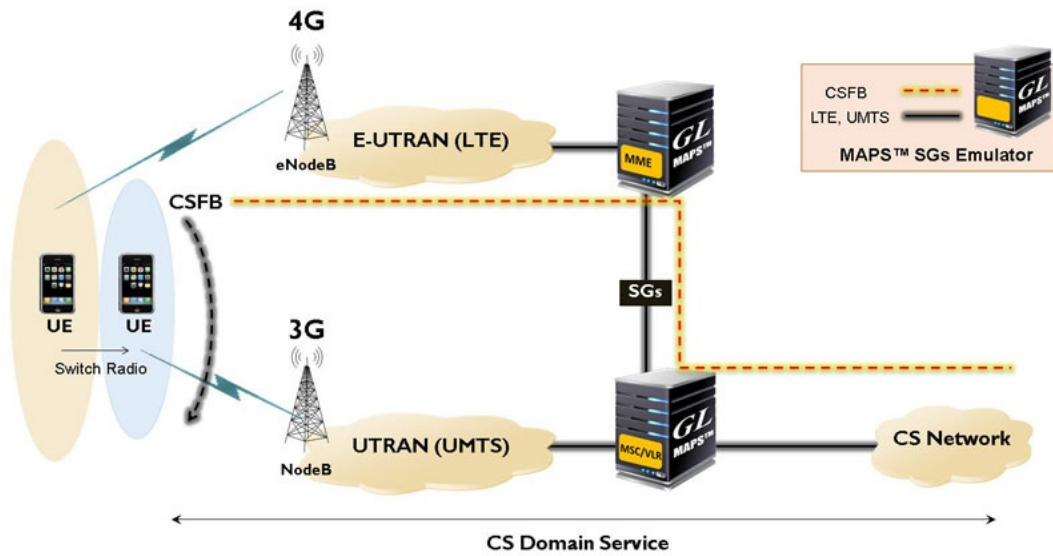




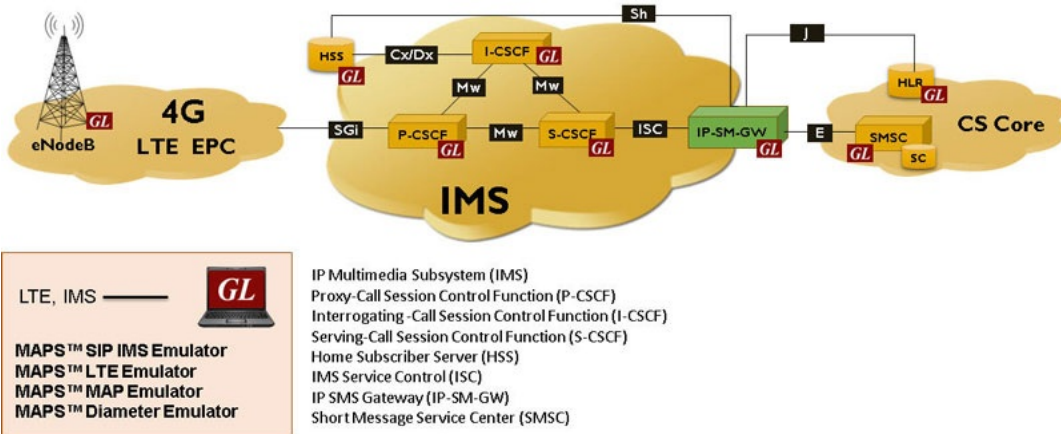
# 移动网络技术实现

## 不同实现

- GL
  - Simulation of CSFB for Voice and SMS over SGs Interface



- Simulation of IP-SM-GW for SMS over IMS Network



- 其他



◦

## 网络接口

- 背景
  - 不同网络，不同运营商，很复杂
  - 希望不同用户可以互相沟通
- 涉及到
  - 不同网络之间的沟通
    - NNI = Network-to-Network Interface
  - 终端网络和用户之间的沟通
    - UNI = User-to-Network Interface

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## 附录

下面列出相关参考资料。

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## 名词术语

- AMPS = Advanced Mobile Phone System
- MMSC = MultiMedia Service Center
- SMSC = SM-SC = Short Message Service Center
- TACS = Total Access Communications System
- NMT = Nordisk MobilTelefoni
- C-Netz
  - 德语: Funktelefonnetz-C
  - 英语: Radio Telephone Network C
- D-AMPS = Digital Advanced Mobile Phone System
- IS-95 = Interim Standard 1995
- IRAT = Inter Radio Access Technology
- IMT2000 = International Mobile Telecommunication specifications - 2000
- CDMA = Code-Division Multiple Access
- TD-SCDMA = Time Division-Synchronous CDMA = Time Division-Synchronous Code-Division Multiple Access
- TDD = Time Division Duplex
- BS = Base Station
  - BSS = Base Station System = 基站系统
  - BSC = Base Station Controller
- SS = Switching System = 交换系统
- CN = Core Network
- BTS = Base Transceiver Station
- RNC = Radio Network Controller
- eNB = eNodeB = evolved Node B
- CSFB = Circuit Switched Fallback
- VoLGA = Voice over LTE via Generic Access
- CS = Circuit Switched
- PS = Packet Switched
- ViLTE = Video over LTE
- VoLTE = Voice over LTE
- NR = New Radio
- IMS = IP Multimedia Subsystem
- ABG = Australian Broadband Guarantee
- DSL = Digital Subscriber Line = 数字用户线路
- ADSL = Asymmetric Digital Subscriber Line = 非对称数字用户线路
- DSLAM = Digital Subscriber Line Access Multiplexer = 数字用户线接入复用器
- EPC = Evolved Packet Core = 核心分组网演进
- UTRAN = UMTS Terrestrial RAN=UMTS Terrestrial Radio Access Network
- telco = Telephone Company = 电话公司
- 

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# ABG


- ABG
  - = Australian Broadband Guarantee
    - = IPSTAR Broadband = IPSTAR Satellite Service
  - 适用范围：只用于澳大利亚（的农村乡下偏远地方）
  - 现状：2011年6月30日其已停止服务
    - 被 NGN （的 ISS ）取代
- NBN
  - = National Broadband Network
    - = NBN Sky Muster Satellite service
- ISS
  - = Intersim Satellite Service
- 总结
  -

## Bringing Fast Broadband To The Bush NBNCo


Australian Broadband Guarantee (ABG) provides up to \$2750 in subsidies to rural Australians who can only access satellite broadband services

2007


**Australian Broadband Guarantee**



\$2,750



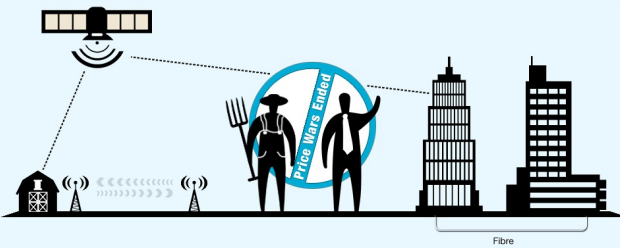
**Rural And Remote Areas**



Providers → Govt Subsidised Rebate

2009


National Broadband Network (NBN) announced. A network will be built using fibre optic, wireless and satellite technology covering all Australians. Accessing the NBN will cost retail providers the same, ending the price difference between metropolitan and regional areas



Fibre

2011

ABG is scrapped and replaced by the Interim Satellite Service (ISS). Homes and small businesses of 20 or fewer employees receive same agreement and same conditions

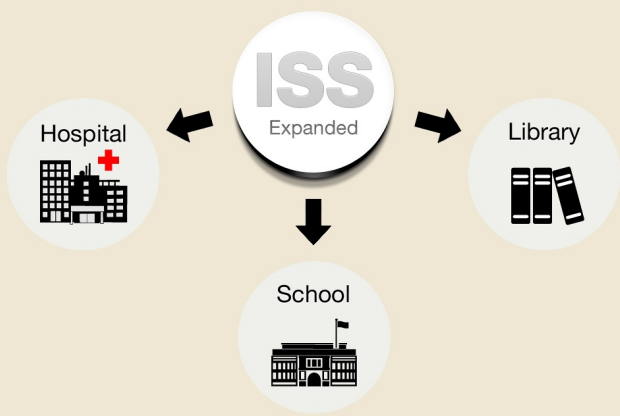


ISS

Interim Satellite Service

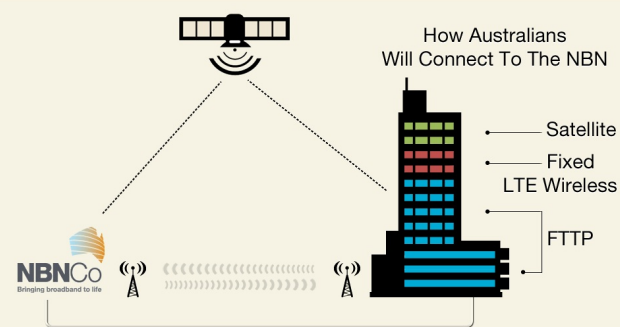
2012

ISS scheme expanded to schools, health clinics and libraries in the most remote regions of Australia



2015

Fixed LTE Wireless and satellite technologies, which will service 7% of the population, will be finished. Two Ka-Band satellites are to be launched as part of NBNCo's long term solution to providing broadband across Australia.



How Australians Will Connect To The NBN

- Satellite
- Fixed
- LTE Wireless
- FTTP

COMPARE BROADBAND

Need Help? Call **1300 764 000** We're in Australia

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# DSLAM

- 背景

- xDSL

- DSL

- = Digital Subscriber Line = 数字用户线路

- 包含

- HDSL

- SDSL

- VDSL

- ADSL = Asymmetric Digital Subscriber Line = 非对称数字用户线路

- DSLAM

- = Digital Subscriber Line Access Multiplexer = 数字用户线接入复用器

- 一句话描述：透过电话线提供高速互联网接入服务

- 详解

- DSLAM 是一种安装在近客户端的网络设备

- 利用多任务技术将大量用户的 DSL 线路连接至高速骨干网络

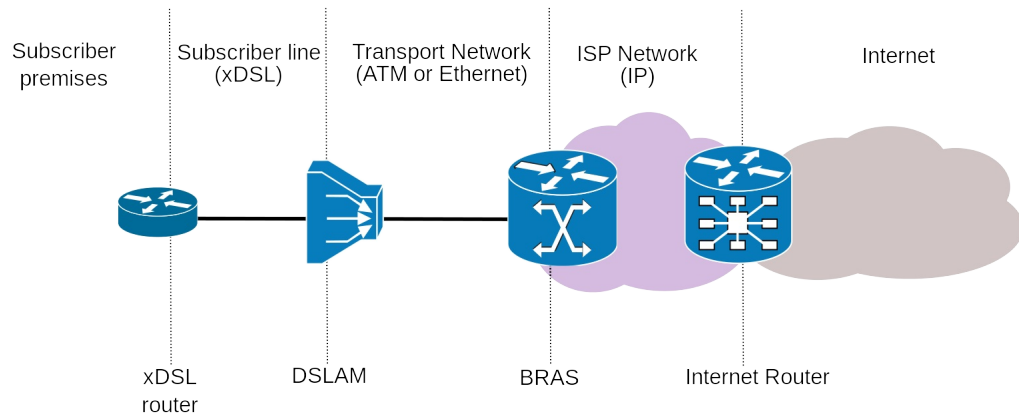
- DSLAM 的聚合 DSL 线路方式=接入方式

- ATM = Asynchronous Transfer Mode = 非对称传输模式

- FR = Frame Relay = 帧中继

- Internet Protocol Network = IP网络

- xDSL连接图



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# telco

- telco
  - = Telephone Company = 电话公司
  - 别称
    - TSP
      - = Telephone Service Provider = 电话服务提供商
      - = Telecommunications service provider = 电信服务提供商
    - CSP
      - = Communications Service Provider = 通讯服务提供商
  - 后期演化出
    - 移动网络
      - MNO = Mobile Network Operator = 移动网络运营商
      - wireless carrier = 无线网络运营商
    - 基于Internet
      - ISP = Internet Service Provider = (因特) 网络服务提供商
  - 举例
    - 中国
      - 中国移动

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## 参考资料

DOING:

- 
- 

TODO:

\*

DONE:

- **【整理】** 什么是IBCF CBGF SBC
- **【整理】** 什么是MSC SMSC GMSC
- **【整理】** 什么是HLR AuC
- **【整理】** ETSI和TISPAN和NGN协议标准及相关内容
- **【整理】** 什么是GPRS GSM LTE
- **【整理】** 什么是ABG
- **【整理】** 什么是DSLAM
- **【整理】** RCS相关基础知识：无线网络信号传输基础知识
- **【整理】** RCS相关基础知识： GSM SS BSS
- **【整理】** 什么是GERAN UTRAN E-UTRAN RAN
- **【整理】** 什么是Telco和Telco platform
- 
- [5G技术概述](#)
- [5G消息RCS技术总结](#)
- [RCS技术开发总结](#)
- 
- [Full MVNO Architecture - HSS/HLR, GMSC, GGSN, PGW and SMSC](#)
- [What is GSM, EDGE, GPRS, UMTS 3G, HSDPA, HSUPA, LTE – 4G LTE Mall](#)
- [CDMA vs GSM vs LTE: The Differences & What You Need to Know | US Mobile](#)
- [What is the difference between GSM, UMTS and LTE? - Commsbrief](#)
- [Past and present reports - Mobility Report - Ericsson](#)
- [june2020-ericsson-mobility-report.pdf](#)
- [Difference between digital and analogue mobile networks - Commsbrief](#)
- [What is a GSM network and how does it work? - Commsbrief - Mobile Networks & Devices](#)
- [What is the average speed of 4G LTE? Commsbrief Mobile Networks & Devices](#)
- [3G - 维基百科，自由的百科全书](#)
- [3G - Wikipedia](#)
- [High Speed Packet Access - Wikipedia](#)
- [5G NR - Wikipedia](#)
- [What is the Difference Between 5G NR and 4G LTE? – Router Switch Blog](#)
- [What is the difference between 5G NR and 4G LTE?](#)
- [Differentiate Between 4G LTE and Non-Standalone 5G NR Antennas | Microwaves & RF](#)
- [Qualcomm Future of 5G Building a unified, more capable 5G air interface for the next decade and beyond](#)
- [The-5G-Guide\\_GSMA\\_2019\\_04\\_29\\_compressed.pdf](#)
- [Telecoms & Internet converged Services & Protocols for Advanced Networks - Wikipedia](#)
- [Telecommunication and Internet Converged Services and Protocols for Advanced Networks - Wikipedia, la](#)

- [enciclopedia libre](#)
- [draft-ietf-sip-isup-03 - ISUP to SIP Mapping](#)
- [SIP-AS - SIP Application Server](#)
- [Plain old telephone service - Wikipedia](#)
- [How Telephones Work | HowStuffWorks](#)
- [DOCSIS - Wikipedia](#)
- [CableLabs - Wikipedia](#)
- [SCTE- ISBE Live Learning Webinar Series: Getting Ready for DOCSIS 4.0 | Light Reading](#)
- [Cable\\_Architecture\\_Declaration\\_01.14.10.pdf](#)
- [PTT : Push-To-Talk](#)
- [WAG - WLAN Access Gateway](#)
- [What is the difference between a Hotspot and an Access Point and a Wireless Access Point?](#)
- [Difference between WiFi and HotSpot - GeeksforGeeks](#)
- [热点 \(Wi-Fi\) - 维基百科，自由的百科全书](#)
- [What does WAP or WAG or WDM written over train engine signifies? - Quora](#)
- [Wi-Fi Access Gateways - TechLibrary - Juniper Networks](#)
- [GPRS core network - Wikipedia](#)
- [CENELEC - About CENELEC - Who we are - Technical Bodies](#)
- [What is DSLAM \(Digital Subscriber Line Access Multiplexer\)? - Definition from WhatIs.com](#)
- [ADSL和DSLAM的概念-cxkong-51CTO博客](#)
- [数字用户线接入复用器 - 维基百科，自由的百科全书](#)
- [Signalling in GSM BSS - Training Materials - Training offer - Leliwa](#)
- ["Signalling in GSM BSS" - Chapter 11 MSC in Pool \(sample\) by Leliwa - issuu](#)
- [What is the Radio Access Network \(RAN\)? — SDxCentral](#)
- [The Evolved Packet Core](#)
- [系统架构演进 - 维基百科，自由的百科全书](#)
- [What is Evolved Packet Core \(EPC\) ? - Definition from WhatIs.com](#)
- [LTE 4G & 5G Radio Access Network \(RAN\) - CableFree](#)
- [Evolution of Core Network\(3G vs. 4G vs. 5G\) | by Sarp Köksal | Medium](#)
- [Evolution of Core Networks](#)
- [VoLTE\\_RCS\\_TECHNOLOGY\\_ECO-SYSTEM\\_AND\\_EVOLUTION\\_Final\\_for\\_upload.pdf UMTS Terrestrial Radio Access Network - Wikipedia](#)
- [Radio Network Controller - Wikipedia](#)
- [Node B - Wikipedia](#)
- [Radio access network - Wikipedia](#)
- [Base transceiver station - Wikipedia](#)
- [Radio access technology - Wikipedia](#)
- [Backbone network - Wikipedia](#)
- [Mobile station - Wikipedia](#)
- [GERAN - Wikipedia](#)
- [E-UTRA - Wikipedia](#)
- [UTRAN - 维基百科，自由的百科全书](#)
- [LTE Tutorial: E-UTRAN Architecture](#)
- [The platform business model: the new way for telcos to compete | BearingPoint](#)
- [The opportunity for telcos in the coming platform revolution | Platform Strategy – by Sangeet Paul Choudary](#)
- [How do platform principles apply to telcos? - TM Forum Inform](#)
- [The Platform Economics of Telco](#)
- [Telco platform | Fortumo.com](#)
- [Mobile network operator - Wikipedia](#)
- [What is Carrier Network | IGI Global](#)
- [Carrier Network - an overview | ScienceDirect Topics](#)

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