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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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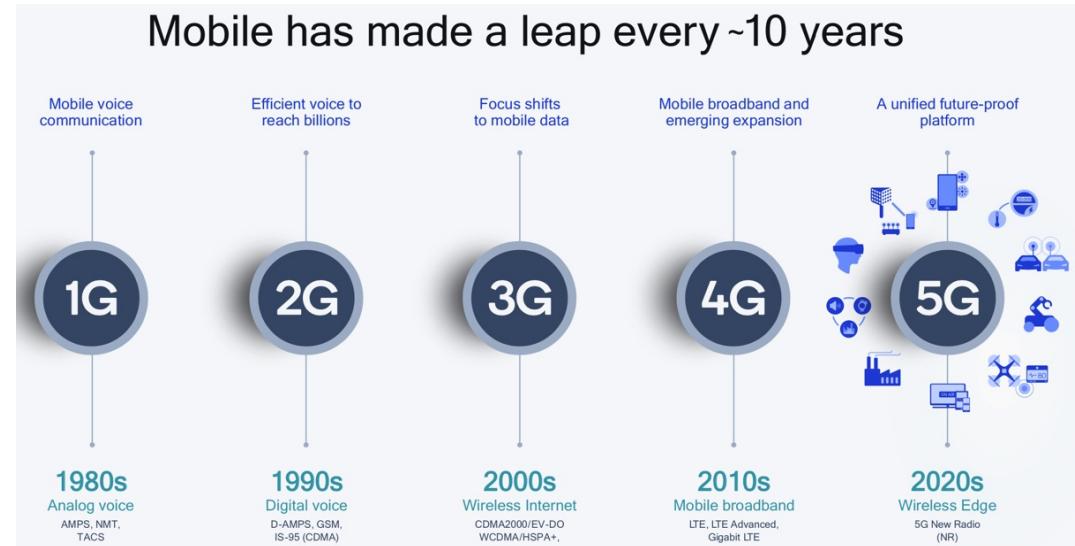
移动网络概述

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

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

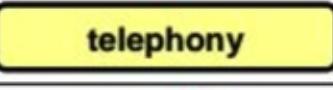
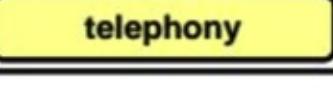
	circuit switching (CSD)	packet switching (GPRS)
GSM	 	 from R96
UMTS	 	
LTE		 

Figure 1-38 CS and PS services in mobile networks

信号

- 信号 基础知识
 - 信号
 - 模拟信号和数字信号

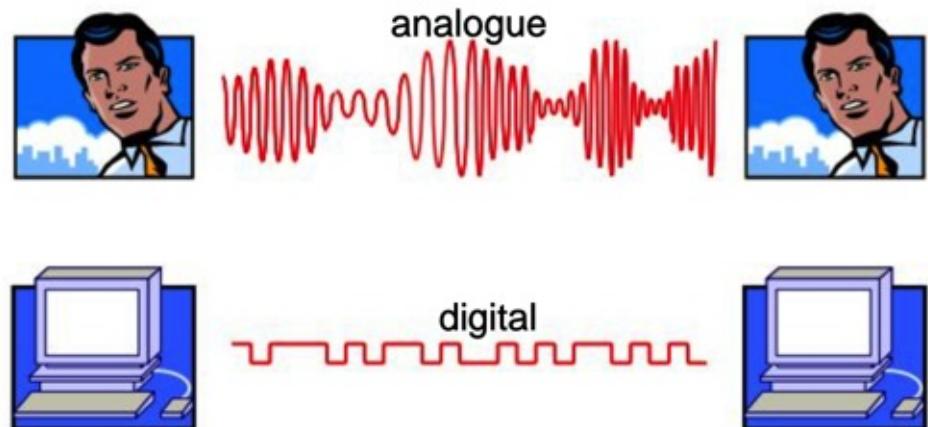


Figure 1-21 Analogue and digital signal

- 重新生成数字信号

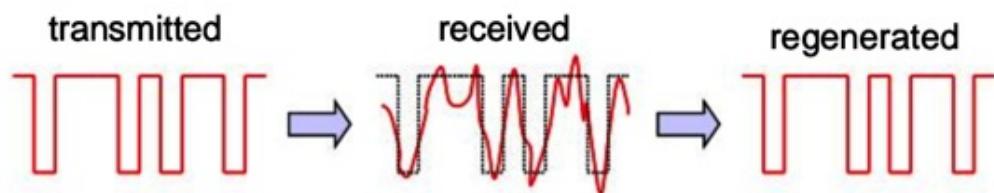


Figure 1-22 Regeneration of digital signal

- A/D转换

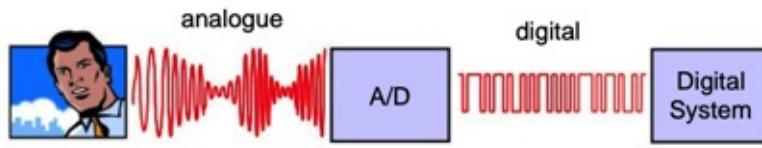


Figure 1-23 A/D conversion

- 采样

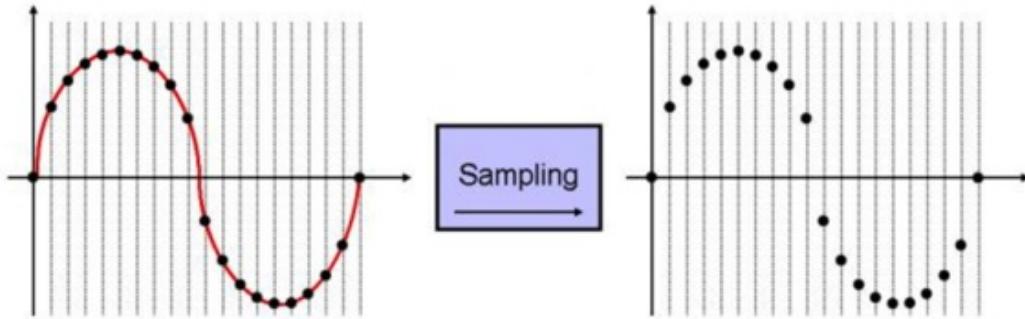


Figure 1-24 Sampling

◦ 量化

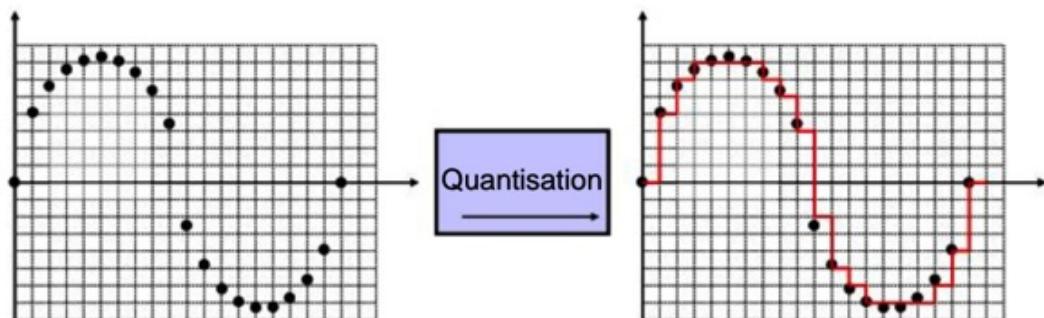


Figure 1-25 Quantisation

◦ 编码

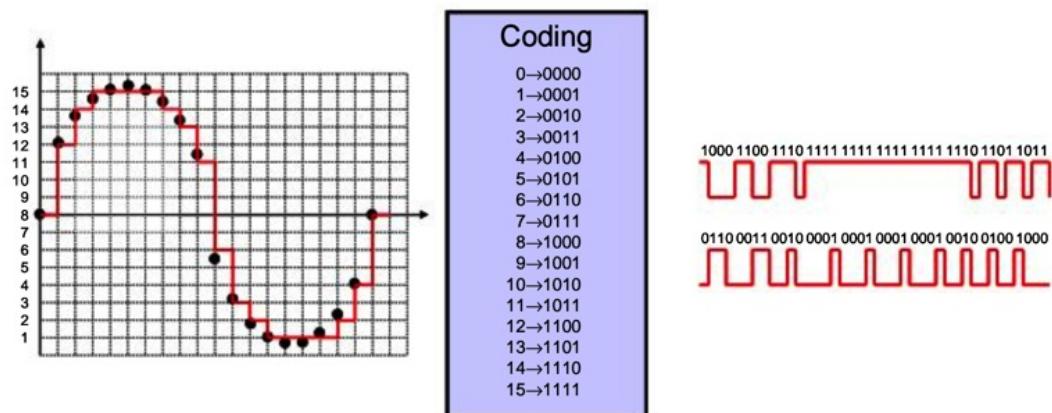


Figure 1-26 Coding

◦ 分段和语音编码

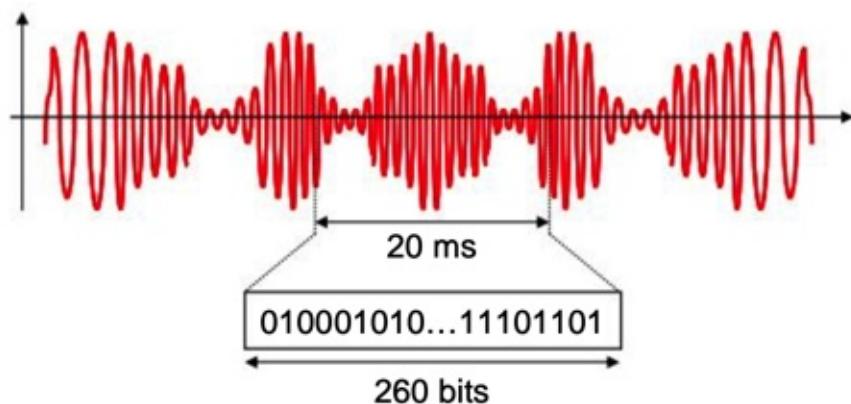


Figure 1-27 Segmentation and speech coding

- 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)

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信号传输

- 复用
 - 时分复用

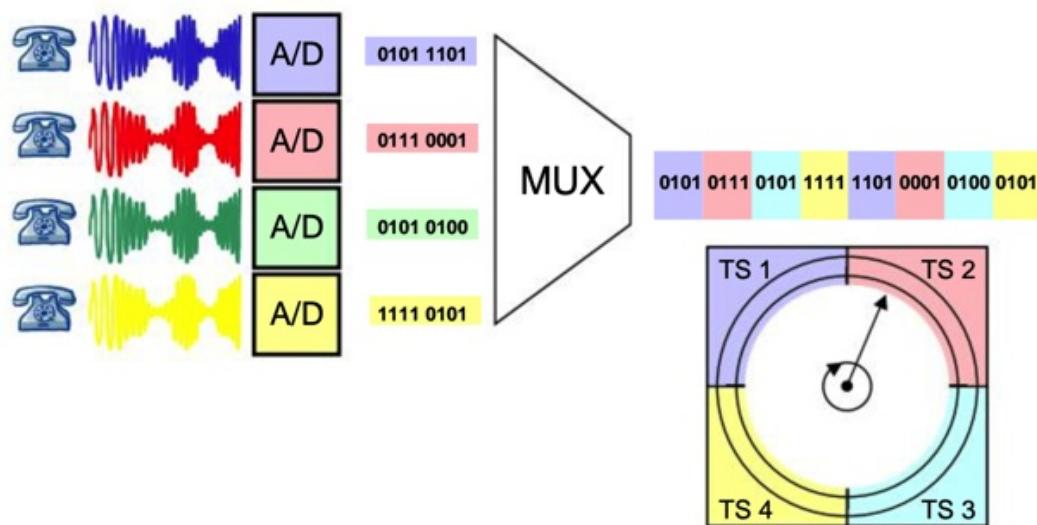


Figure 1-29 Time division multiplexing

- PCM/E1 link 2048kbit/s

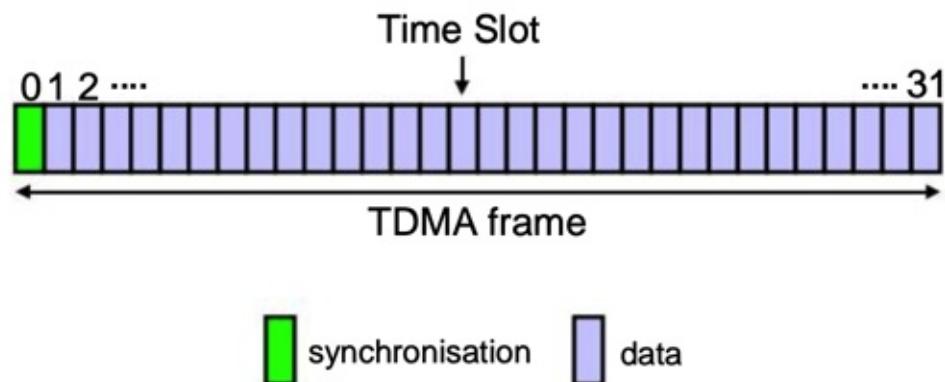


Figure 1-30 PCM/E1 link 2048 kbits/s

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

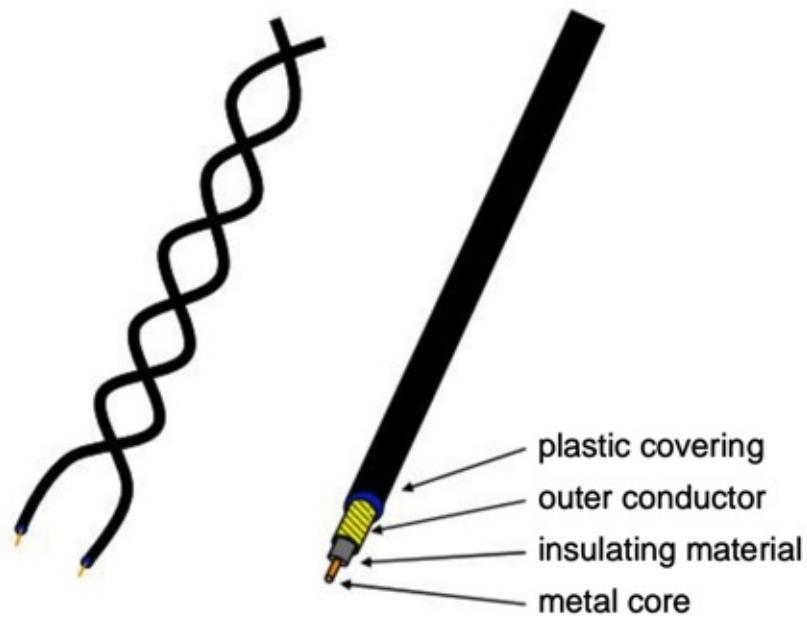


Figure 1-31 Twisted pair (left) and coaxial cable (right).

◦ 光纤

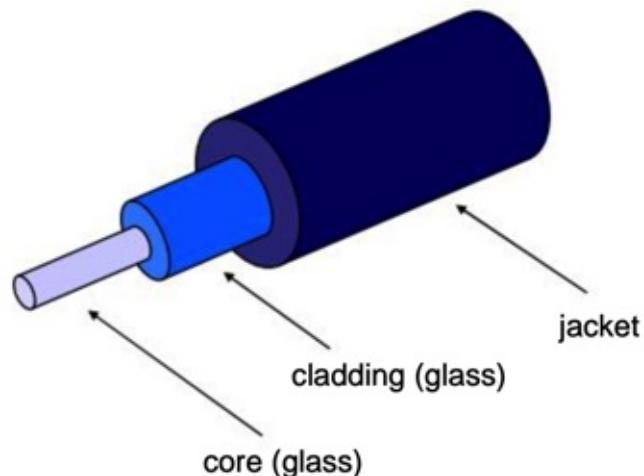


Figure 1-32 Side view of the optical fibre

◦ 微波（无线电）中继

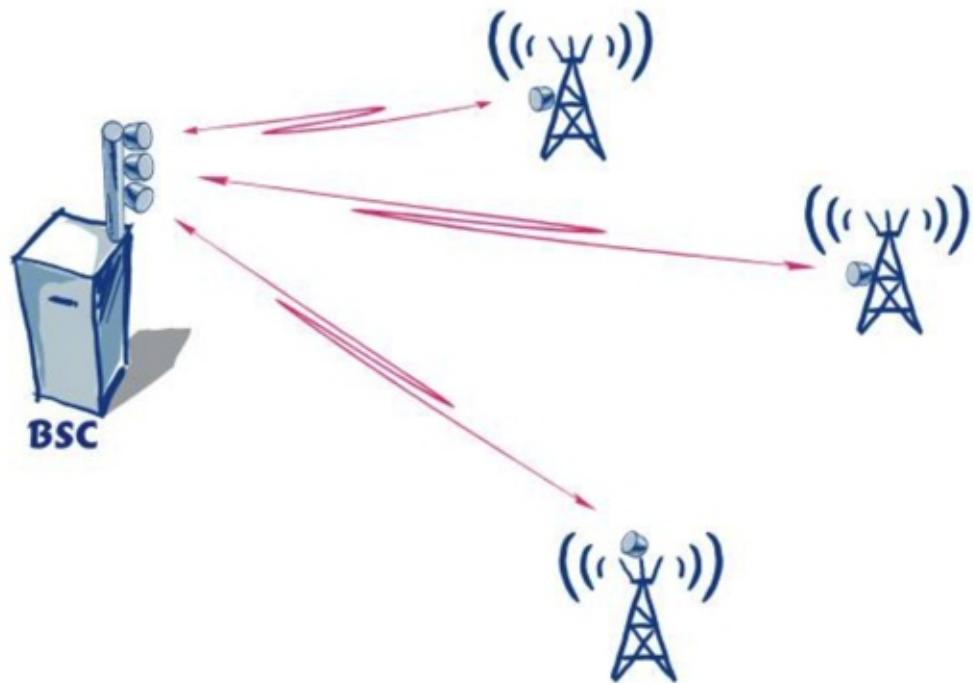


Figure 1-33 Microwave radio relay

- 举例
 - GSM信号塔上的微波天线

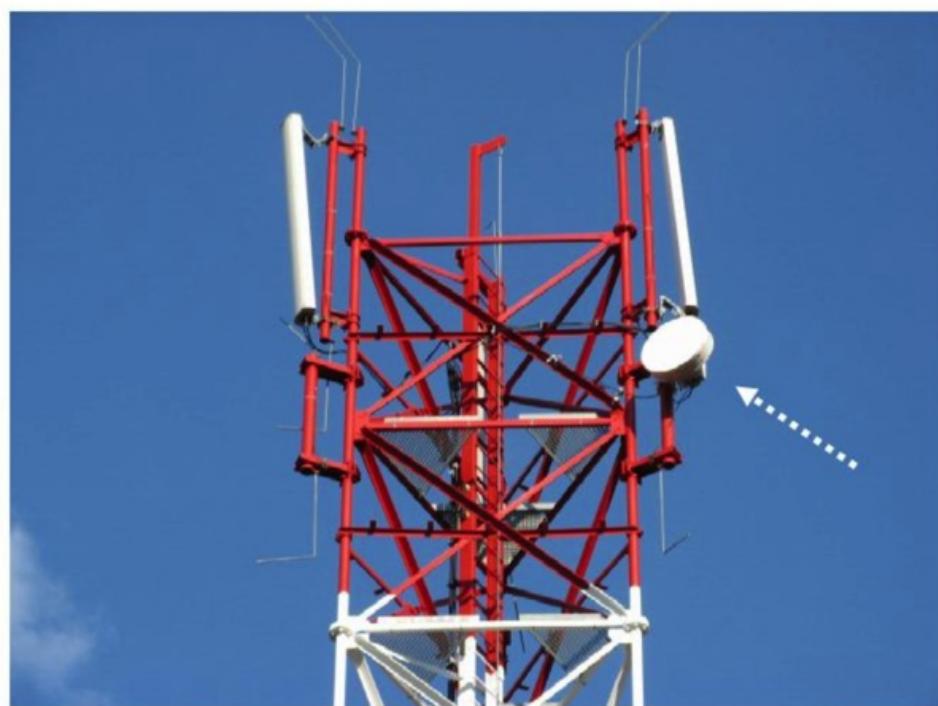


Figure 1-34 Microwave antenna at GSM site's tower

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

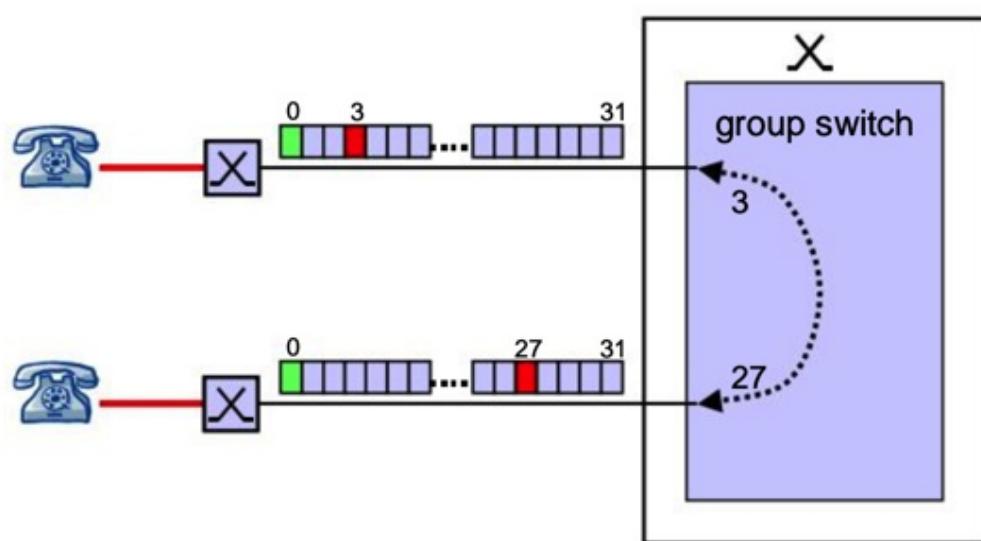


Figure 1-35 Telephone connections in a PSTN network

- 建立连接

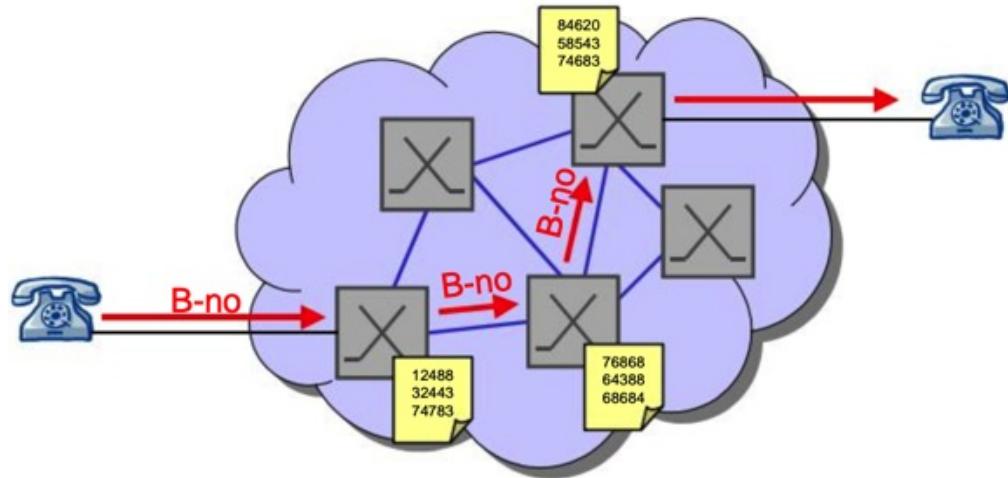


Figure 1-36 Connection set-up

- 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
 - 包交换

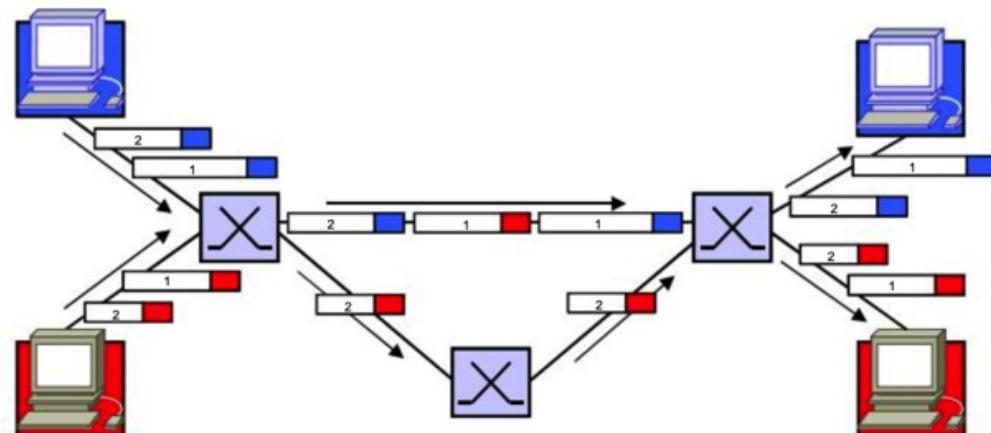


Figure 1-37 Packet switching

- 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

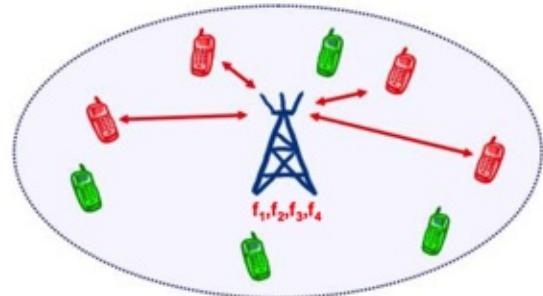


Figure 1-1 Non-cellular mobile system

- 容量增加

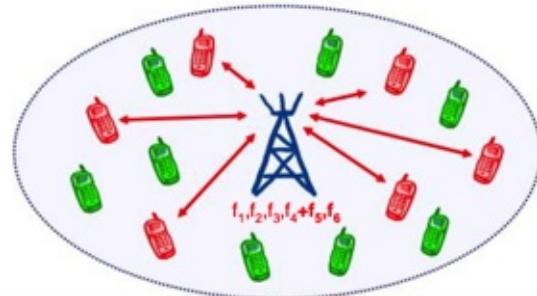


Figure 1-2 Non-cellular mobile system (capacity increase)

- 覆盖面增加

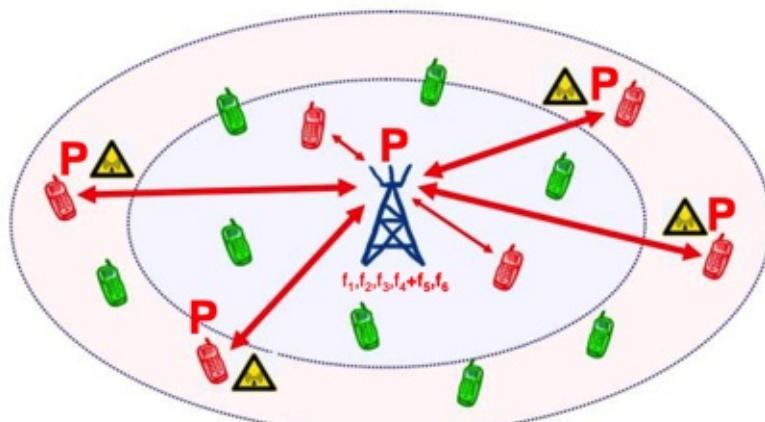


Figure 1-3 Non-cellular mobile system (coverage increase)

- 蜂窝网络移动系统
 - 普通

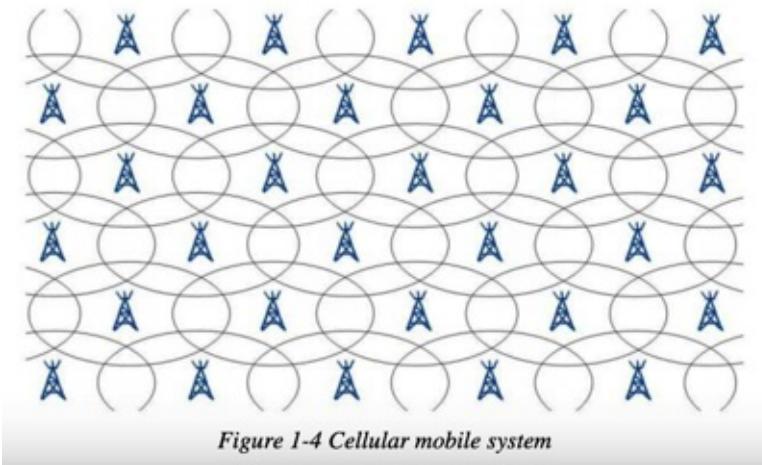


Figure 1-4 Cellular mobile system

- 频谱复用

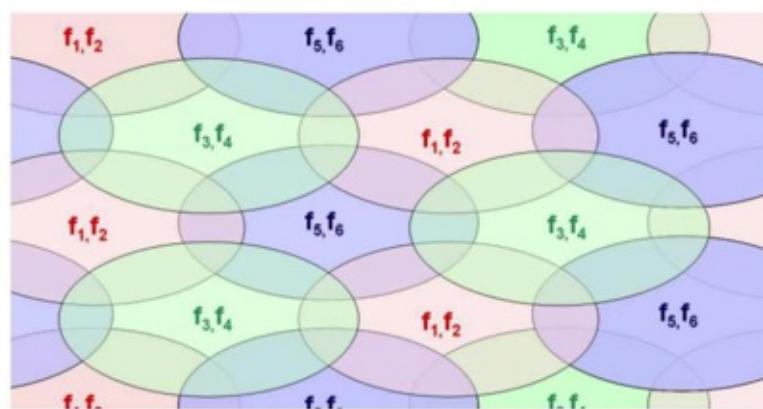


Figure 1-5 Cellular mobile system (frequency re-use)

- 容量增加

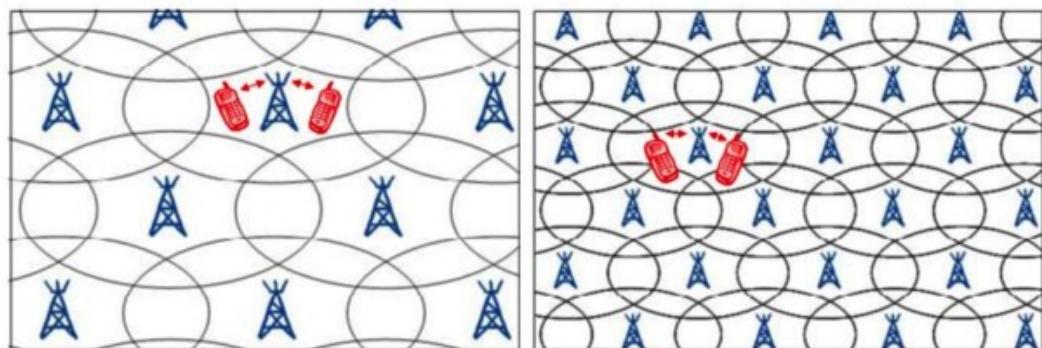


Figure 1-6 Cellular mobile system (capacity increase)

- 单元cell
 - 六角形

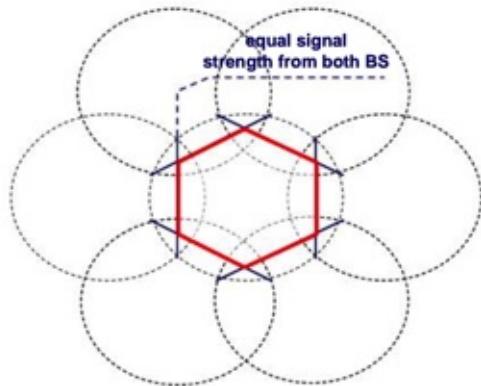


Figure 1-7 Cell – hexagon shape

- 六角形和实际辐射模型

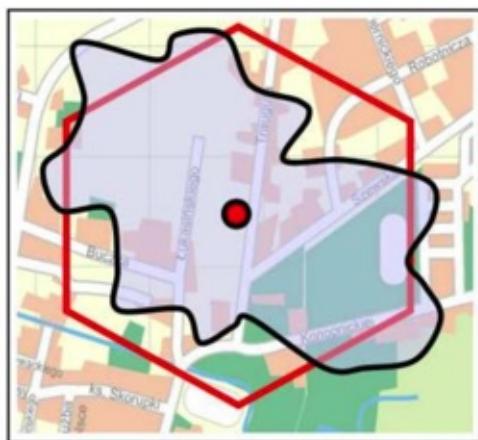


Figure 1-8 Cell – hexagon and real radiation pattern example

- 天线类型

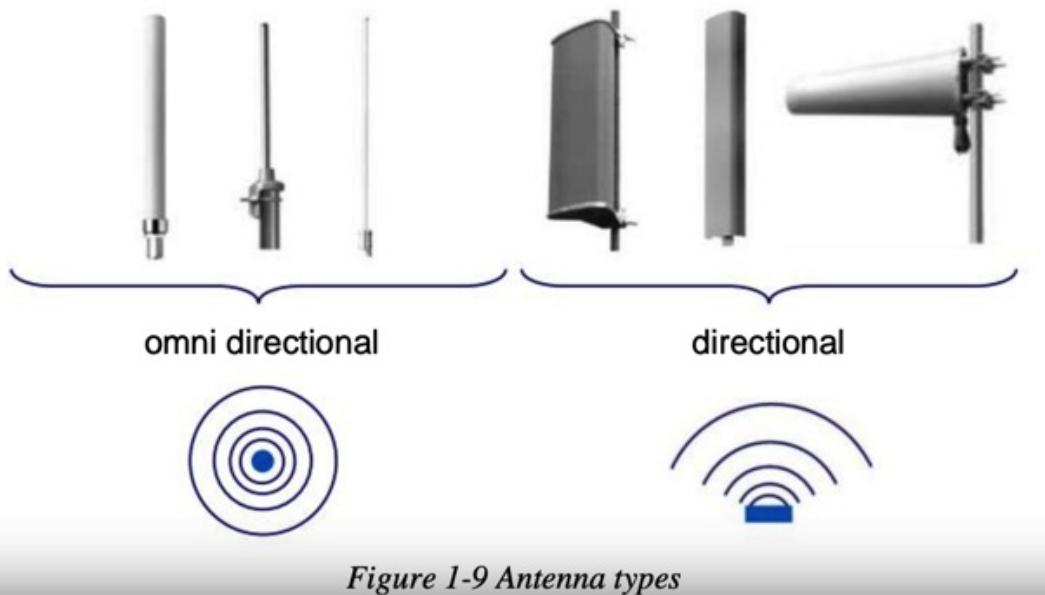


Figure 1-9 Antenna types

- 单元类型

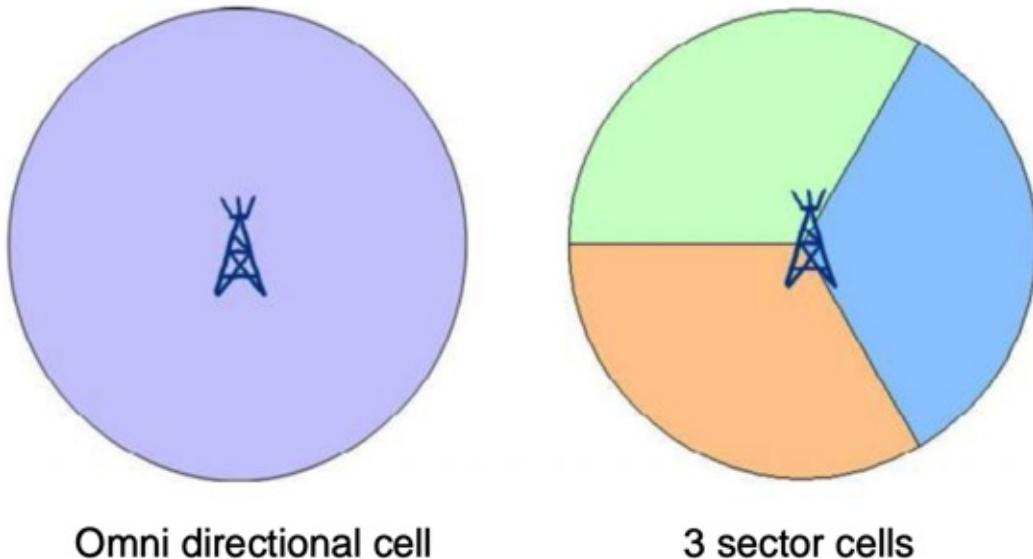


Figure 1-10 Types of cells

- 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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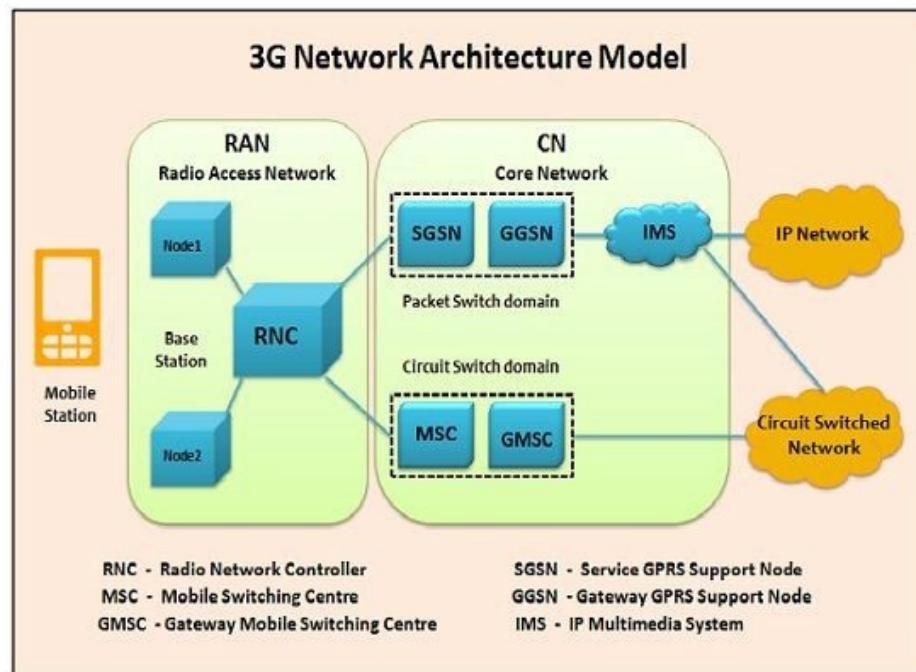
移动网络组成

- 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

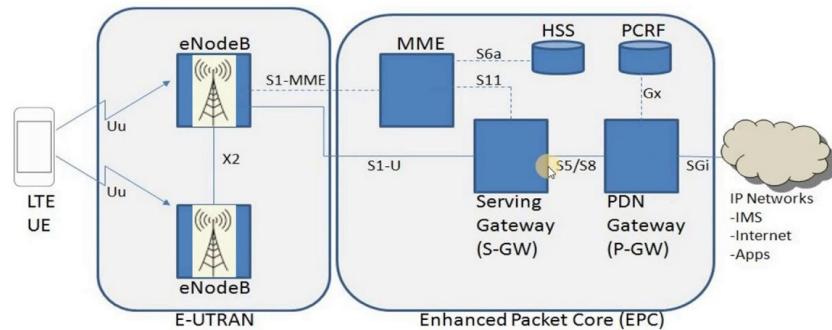
- 单代网络

- 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

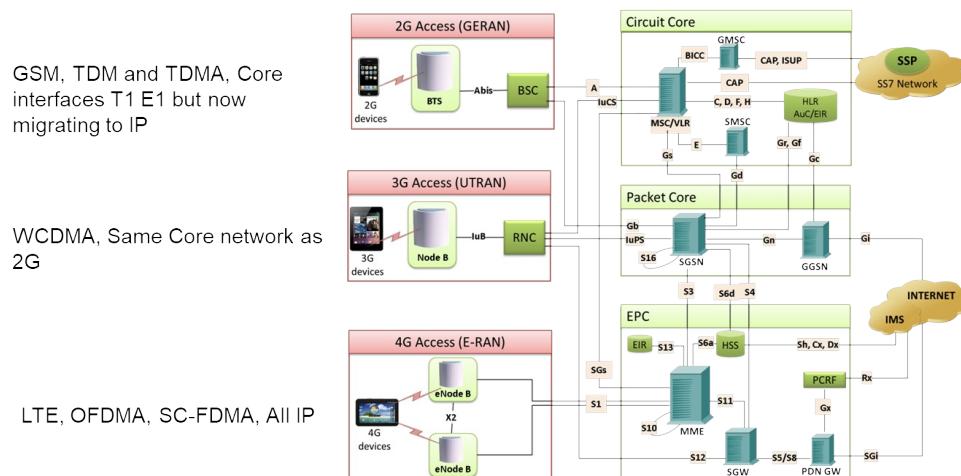
4G | LTE ARCHITECTURE



- 5G = ? + NGC

- 多代网络

- 2G 3G 4G COMMUNICATIONS NETWORKS



- 对比

- Circuit and Packet Domains

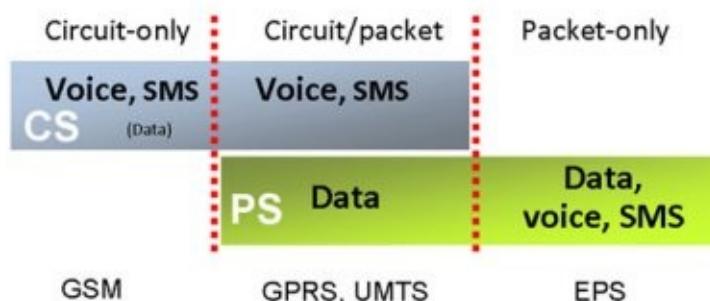


Figure 1: Circuit and packet domains

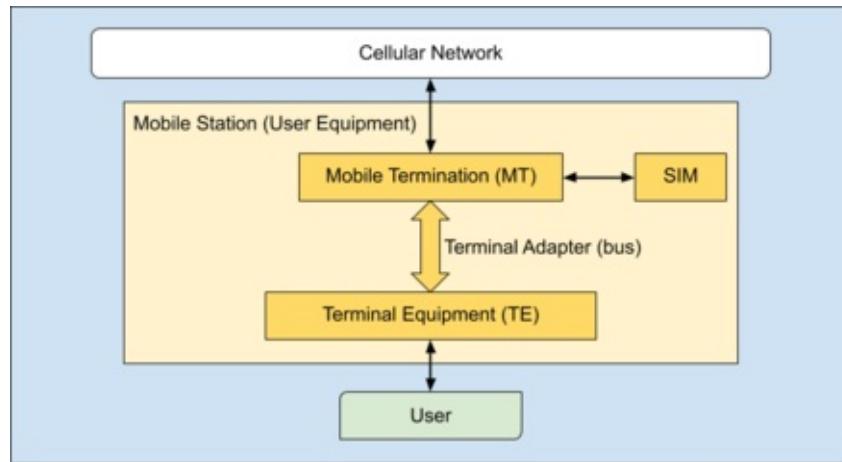
- 名词术语

- 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

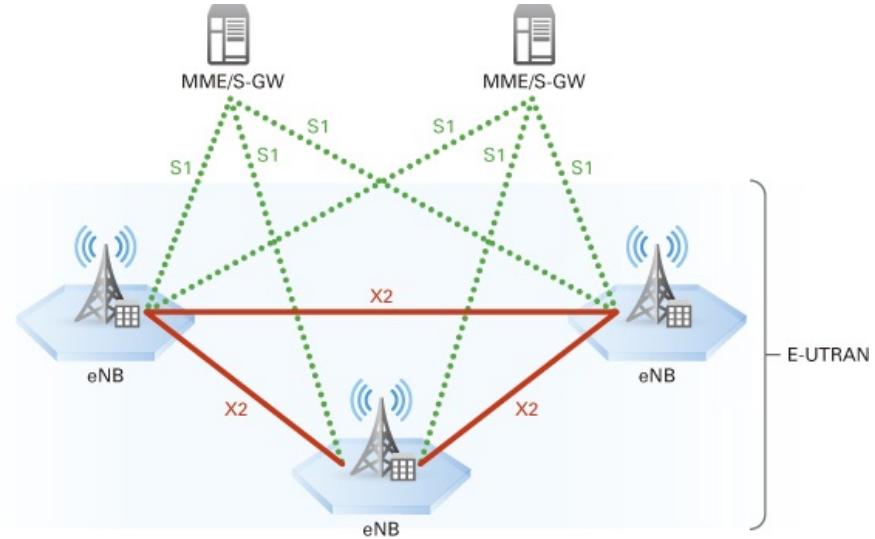


- 举例
 - 移动手机
 - 带SIM卡的笔记本
- 基本架构


```

graph TD
    CN --- RAN1[RAN]
    CN --- RAN2[RAN]
    RAN1 --- UE1[UE]
    RAN1 --- UE2[UE]
    RAN2 --- UE3[UE]
    RAN2 --- UE4[UE]
  
```
- 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



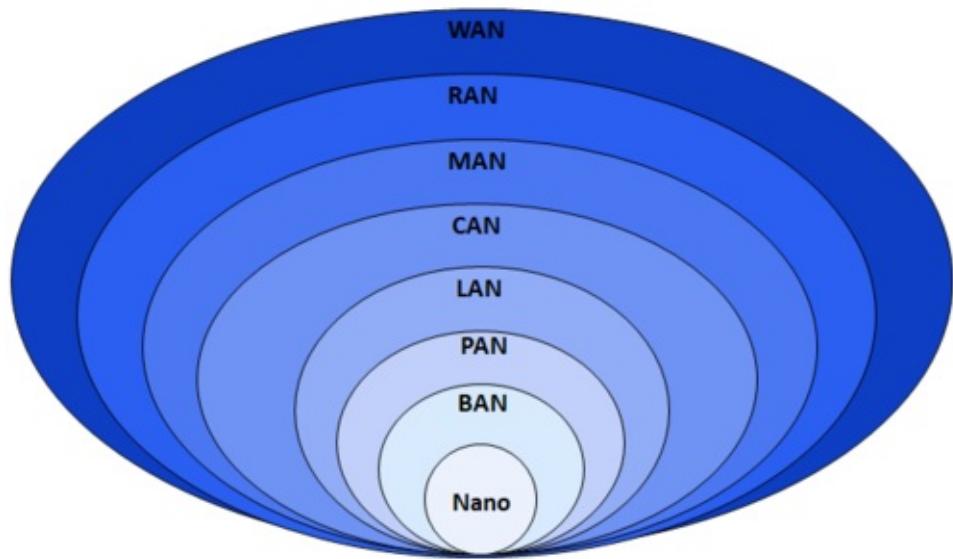
相关背景知识

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

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

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

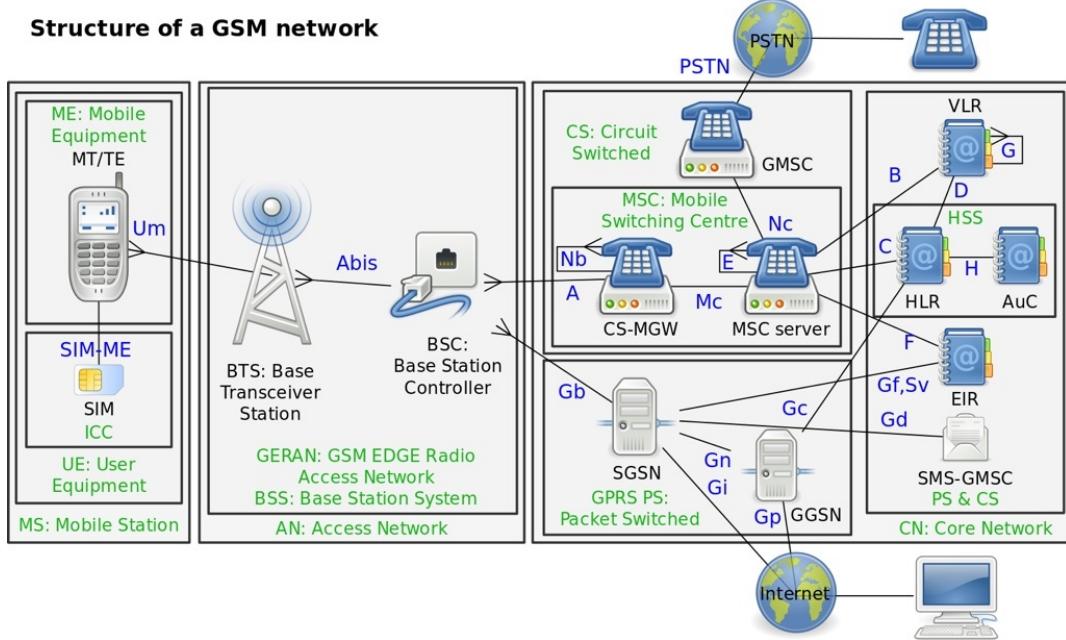
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2G

- 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

GSM

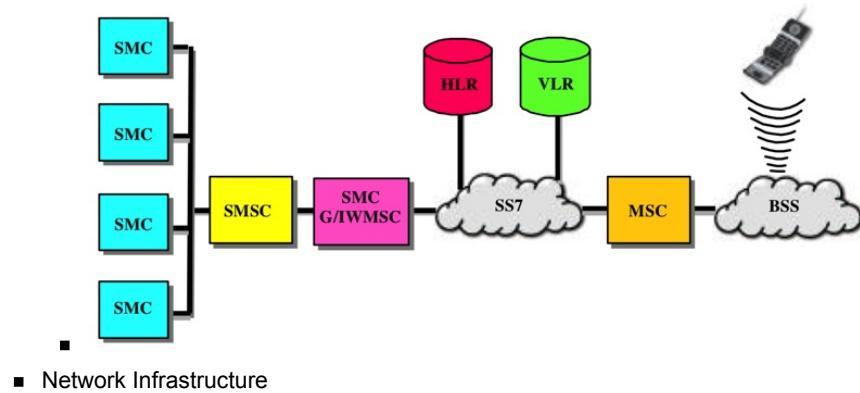
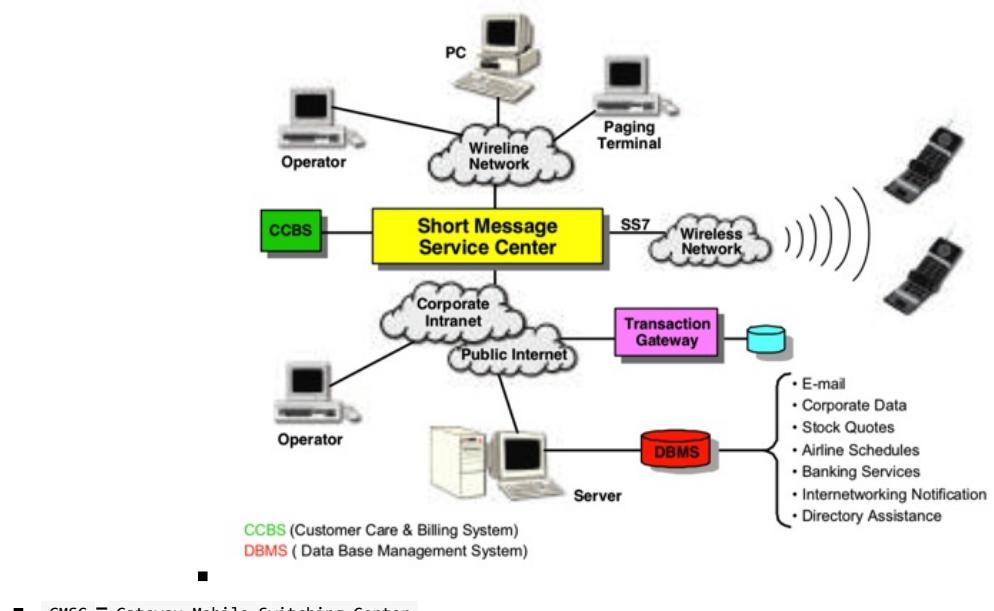
- GSM
 - 架构



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

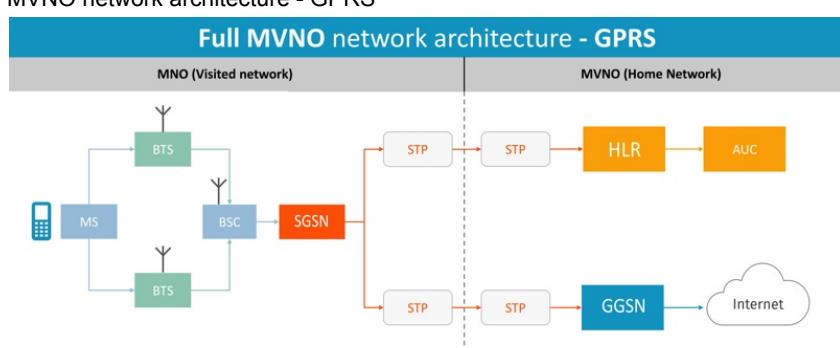
NSS

- 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

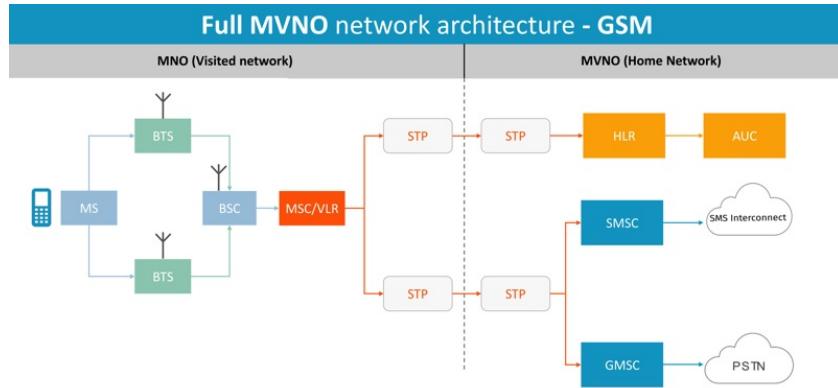
Figure 1: Network Elements and Architecture**Figure 2: Network Infrastructure**

- 相关架构

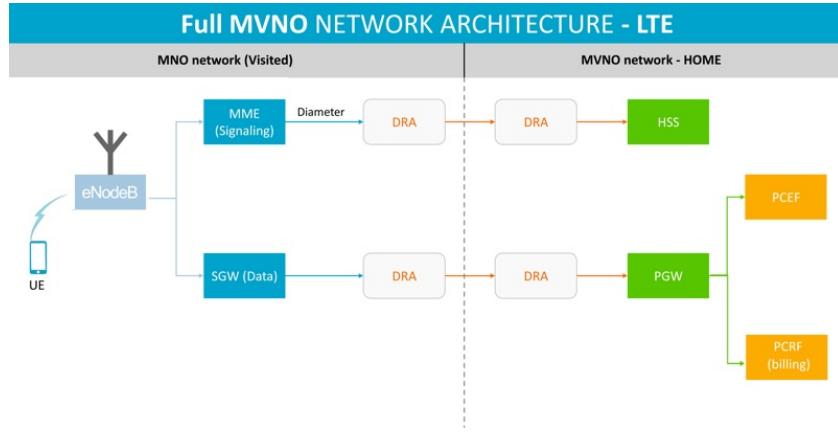
- Full MVNO network architecture - GPRS



- 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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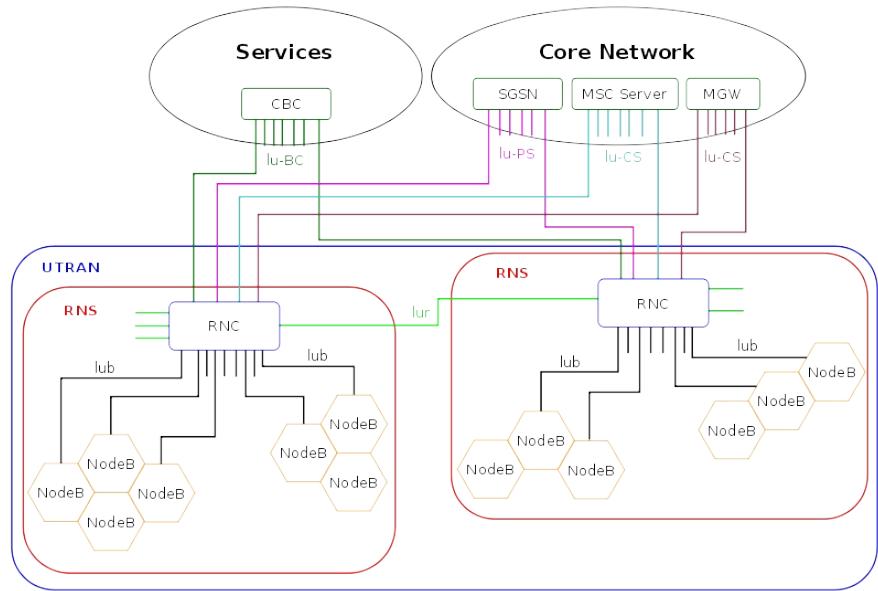
◦

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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



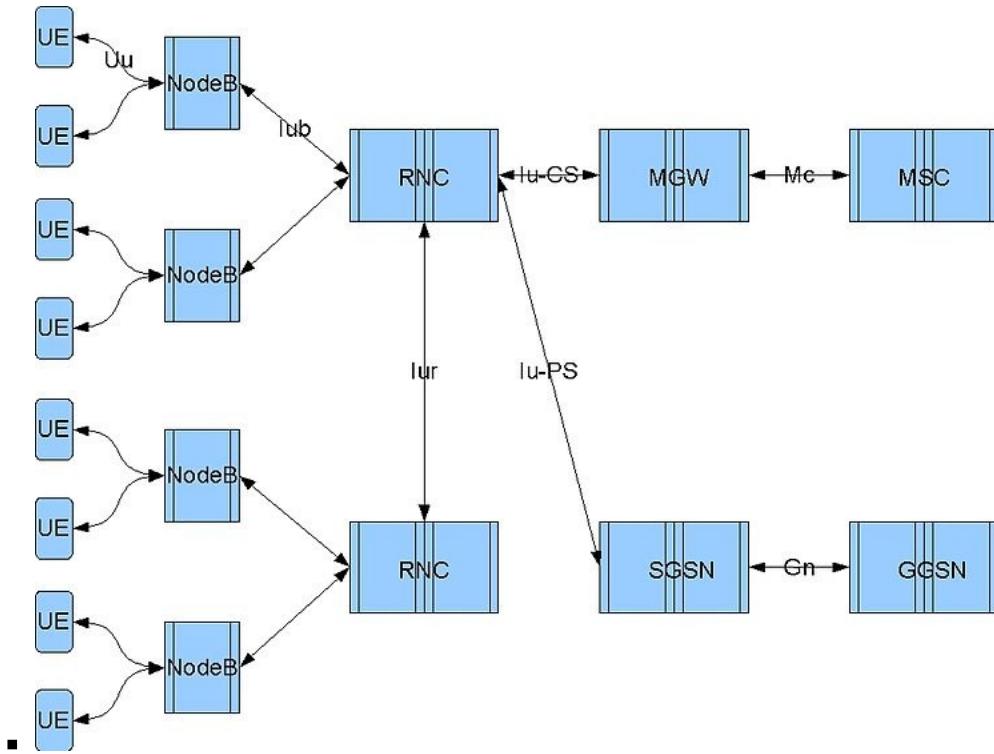
- 美国: CDMA2000
 - 演化历史
 - 从 2G 的 IS-95 (和 D-AMPS) 演化而来
 - IS-95
 - 别称: cdmaOne
 - 别称:
 - CDMA2000 1xRTT
 - IS-2000
 - CDMA2000有多种类型
 - 1xRTT
 - 1xEV-DO
 - 1xEV-DV
 - 协议标准standard
 - UMTS
 - CDMA2000

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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

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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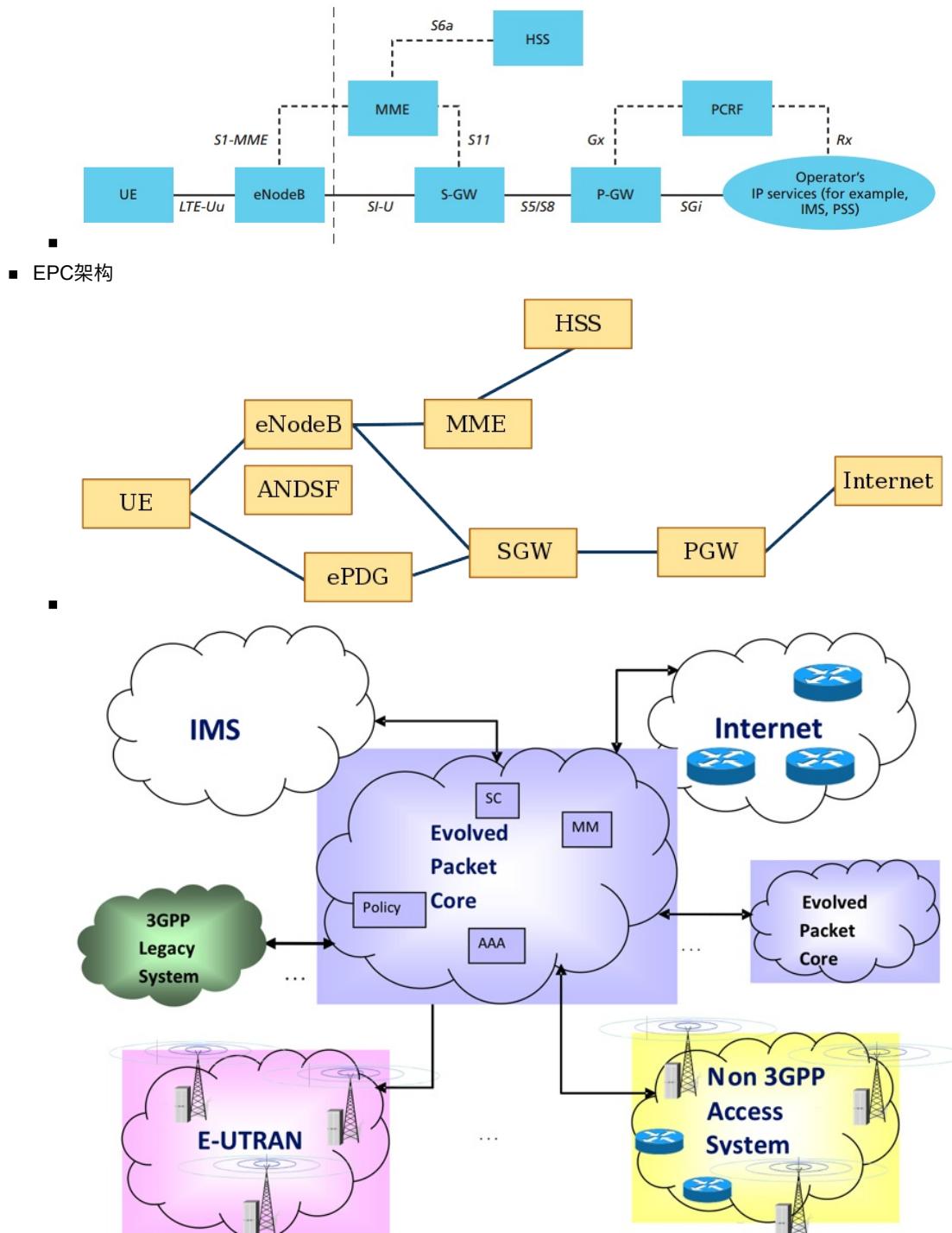
4G

- 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

■ *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](#)

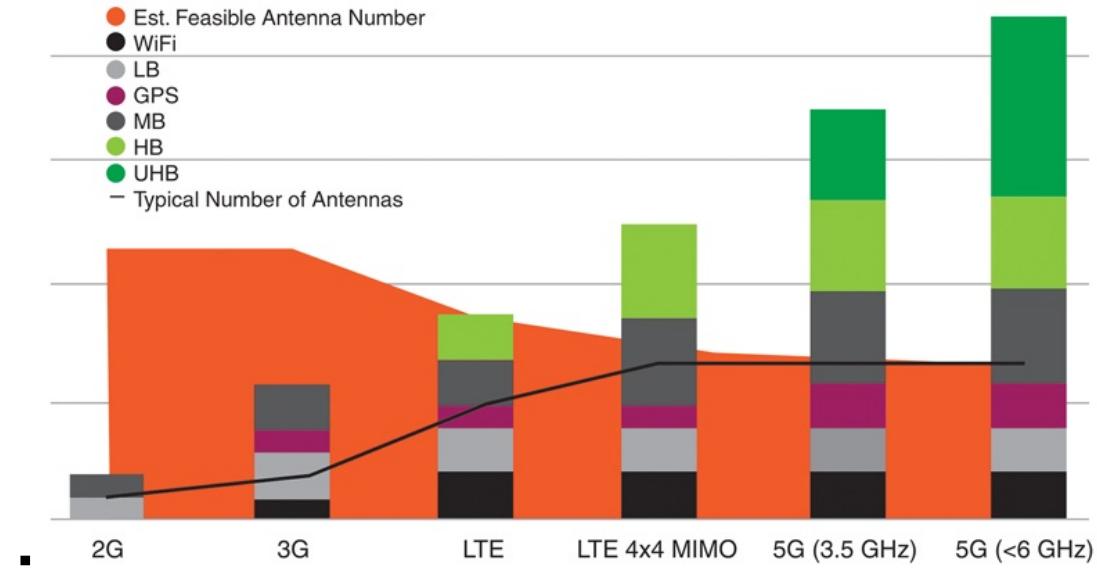
- 5G
 - = fifth generation
 - 3GPP 组织制定的标准
 - 概述

5G NR is a unified, more capable air interface



- 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

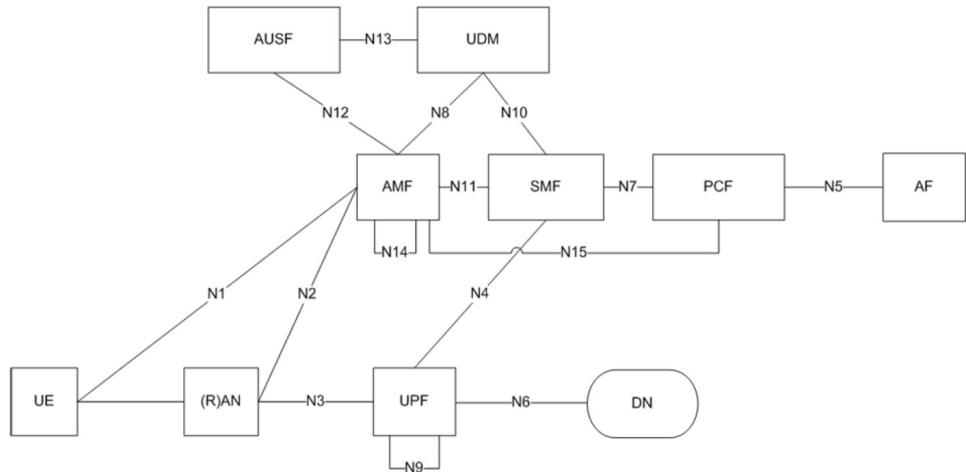
- Massive MIMO



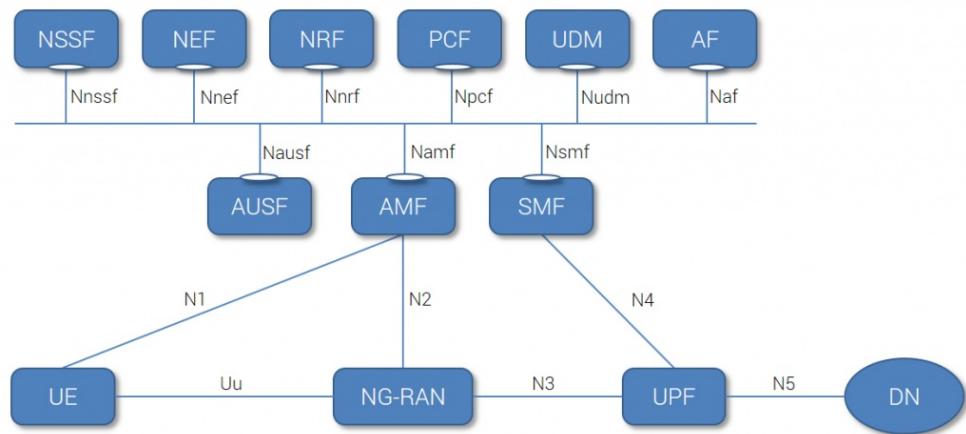
- 架构

- 总体架构

- Reference Point Architecture of 5G Core Network

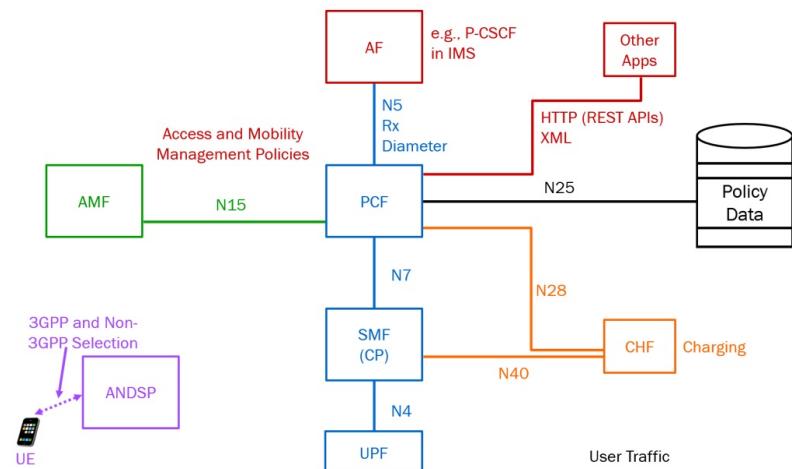


■ Service-based Architecture of 5G Core Network



■ 细节

■ Policy Control Mechanism in 5G Core Network



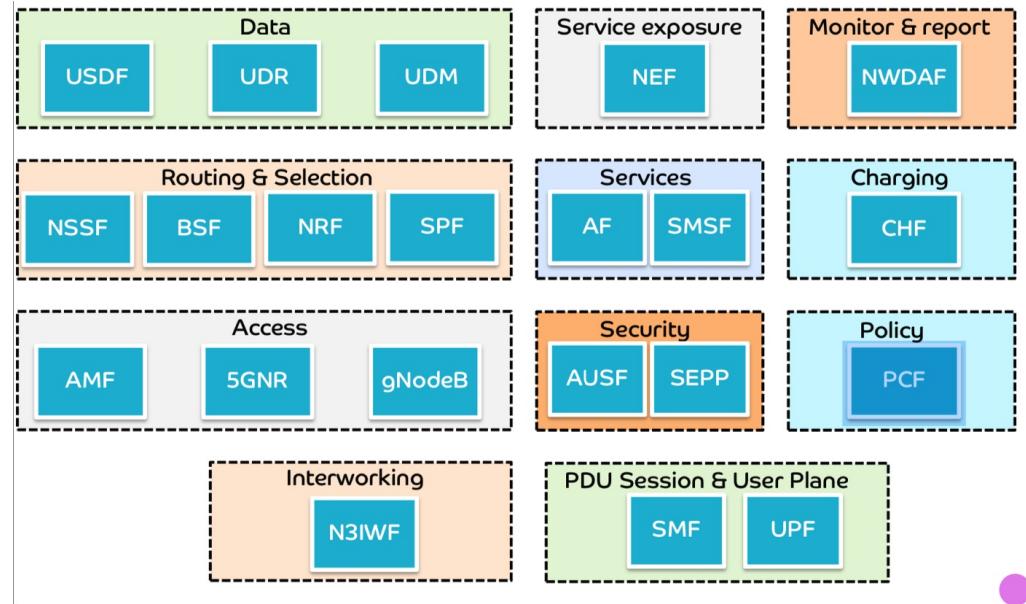
○ 核心元素=核心功能(function)

■ 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

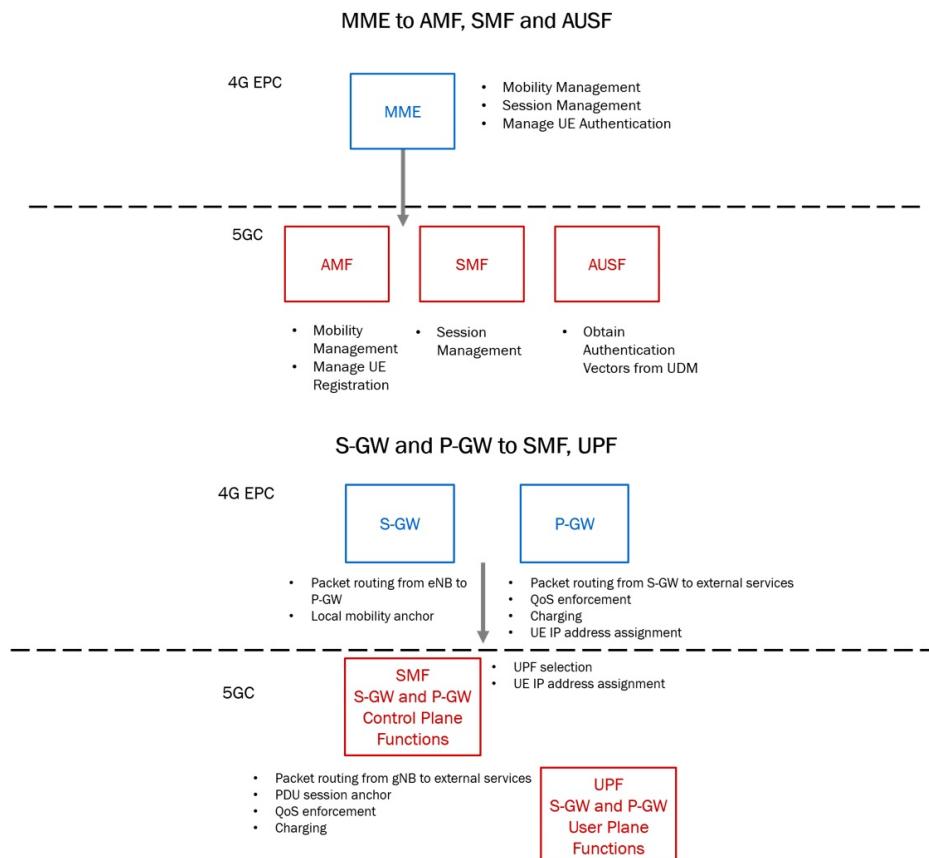
Technology	Data Rates	Latency	Mobility Support	Spectrum Efficiency	Users Density	Energy Efficiency
5G (NR)	Avg 100 Mb/s Peak 20 Gb/s	~ 1 ms	>500 Km/h	x3 Better DL- 30 bits/Hz UL- 15bits/Hz	1000K/Km ²	x100 Better
4G (LTE)	Avg 25 Mb/s Peak 300 Mb/s	~10- 50 ms	<=350 Km/h	DL – 6 bits/Hz UL- 4 Bits/Hz	~ 2K/Km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

- 4G和5G核心网络功能演化对比

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

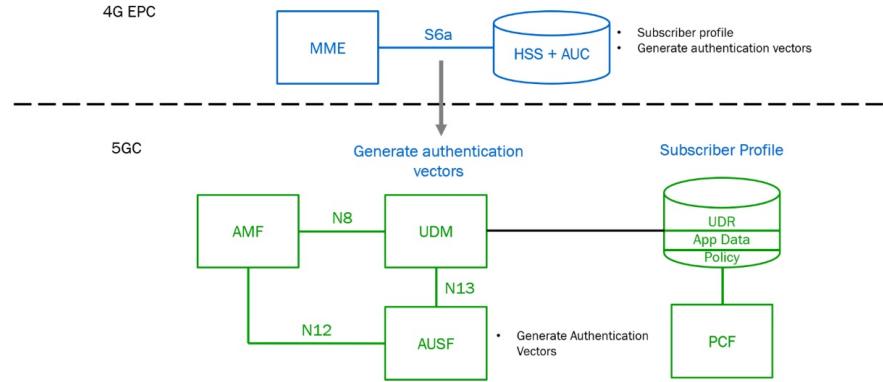
	MME	S-GW	P-GW	HSS	PCRF	AF	New
AMF	✓						
SMF	✓		✓				
UPF		✓	✓				
PCF					✓		
AUSF				✓			
UDM				✓			
AF						✓	
NEF							✓
NRF							✓
NSSF							✓

- 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

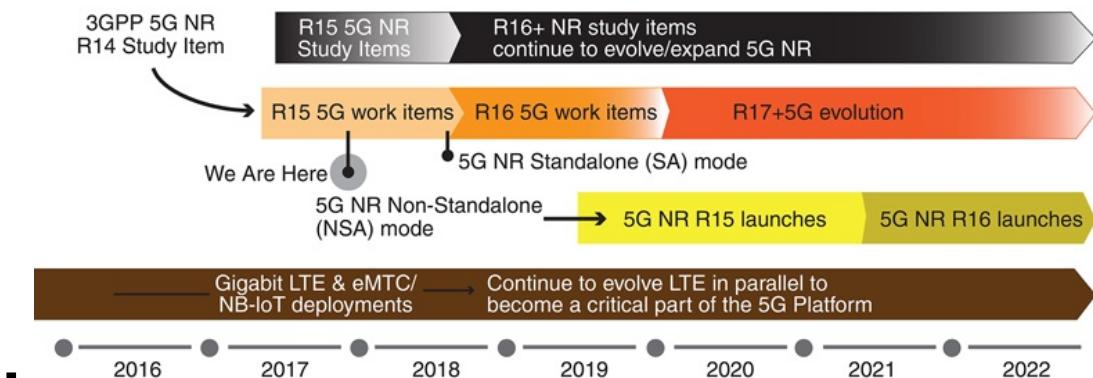




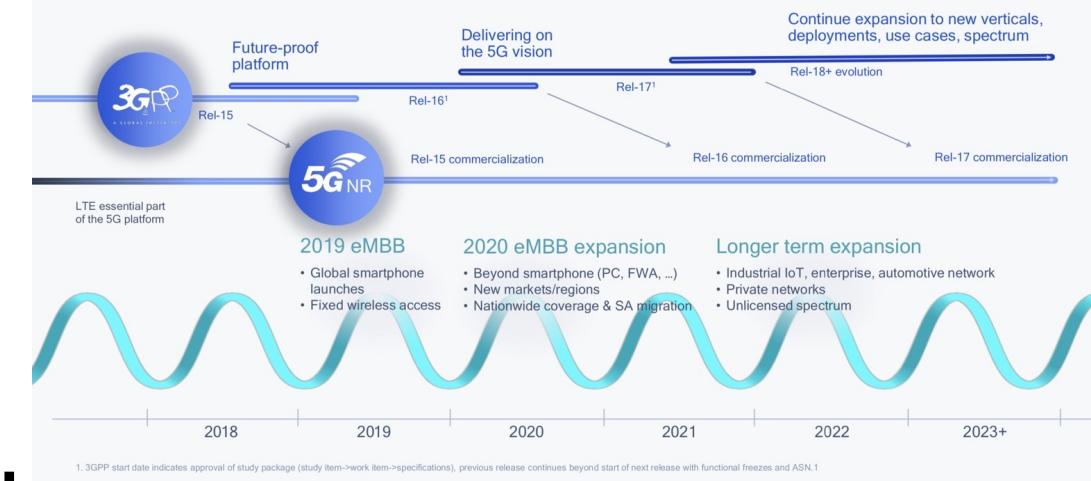
5G标准版本历史

- 5G标准版本历史

- 图

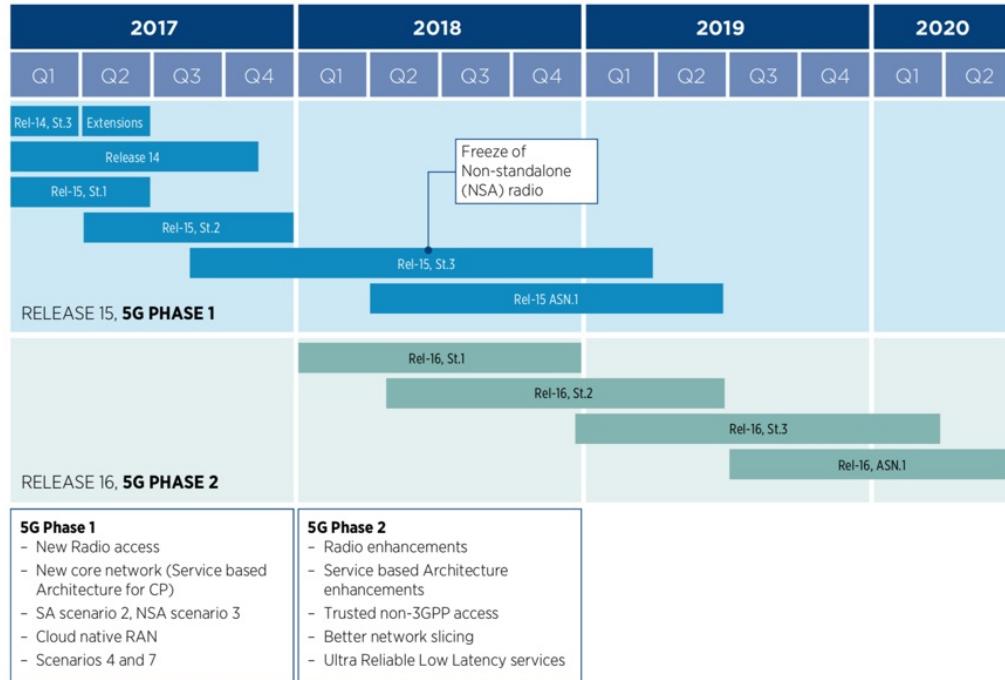


Driving the 5G expansion



■ THE 3GPP ROADMAP FOR RELEASE 15 AND 16

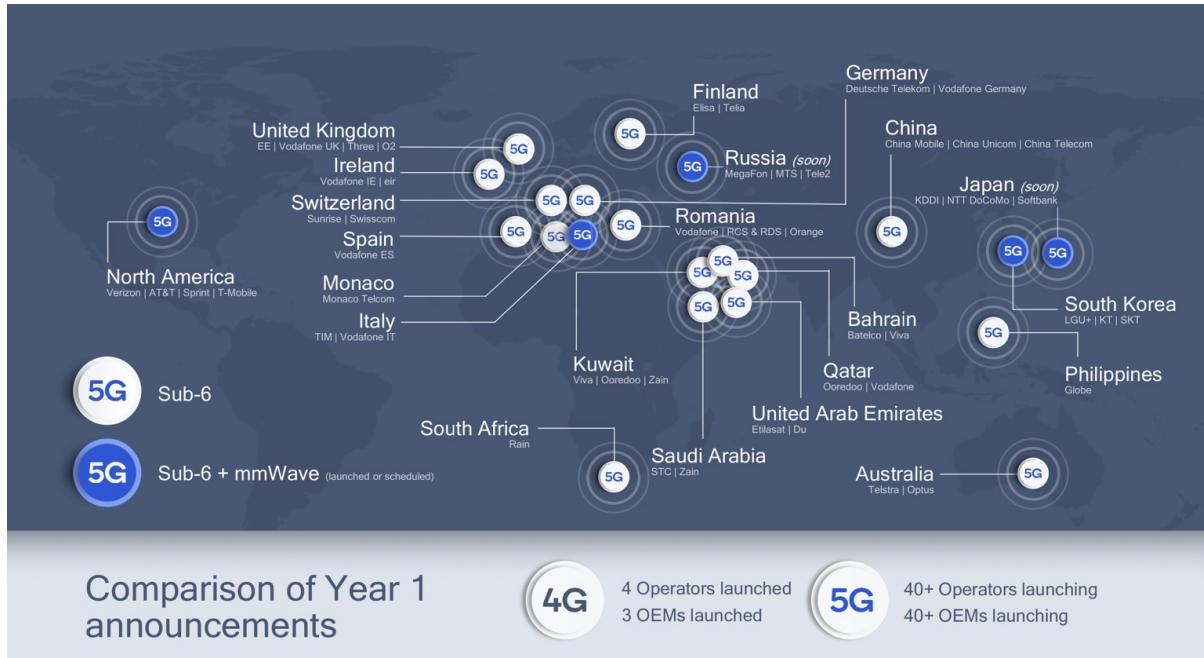
THE 3GPP ROADMAP FOR RELEASE 15 AND 16



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

■ 5G NR TECHNOLOGY ROADMAP

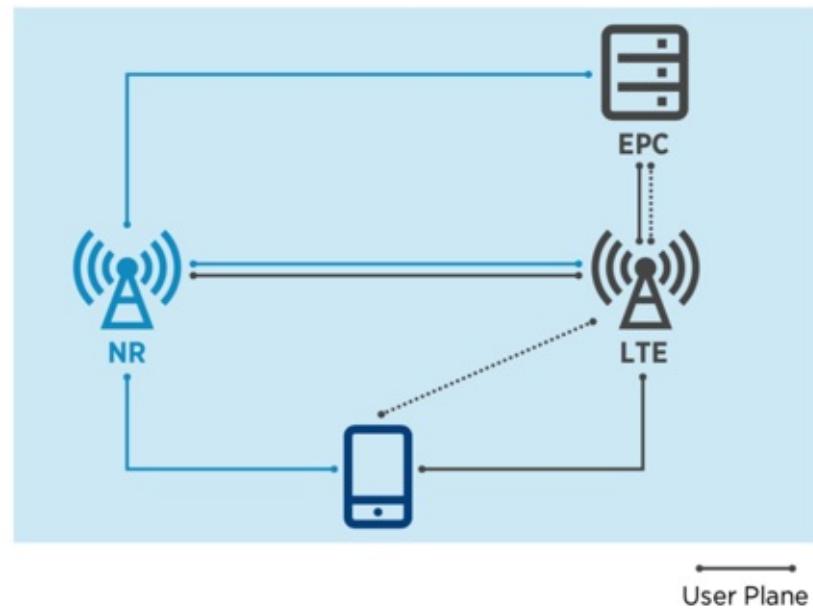
5G NR TECHNOLOGY ROADMAP

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

- 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

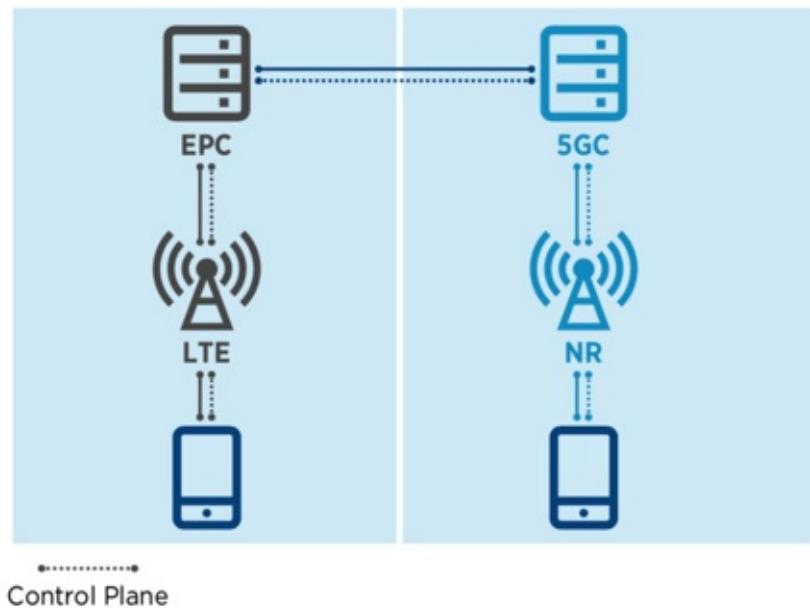
NSA CONFIGURATION (OPTION 3). NR CONNECTED TO, AND CONTROLLED BY EXISTING 4G CORE NETWORK



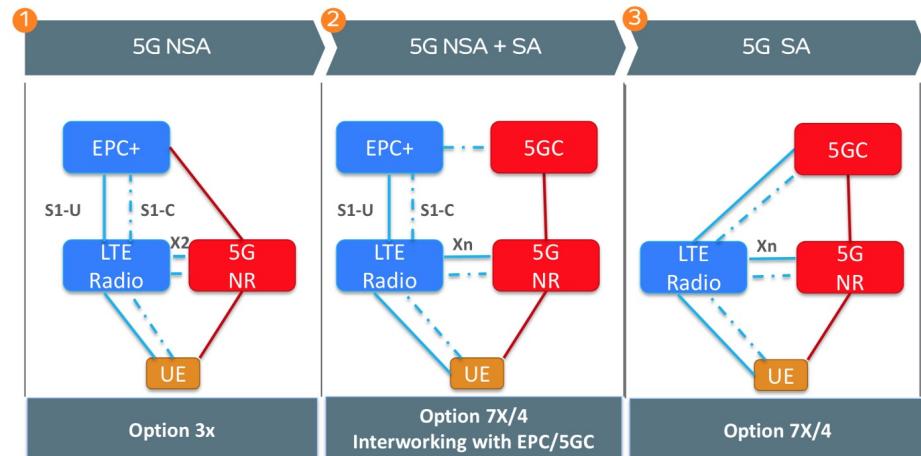
- 纯5G的: SA = StandAlone

FIGURE 2.1.3

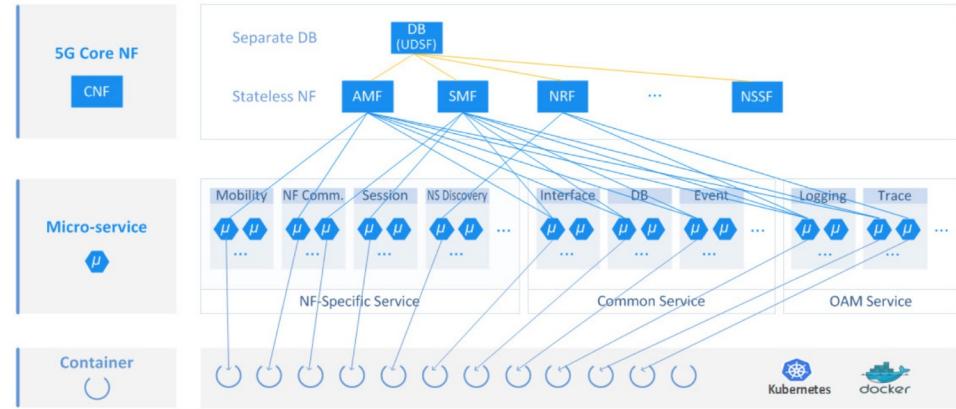
SA CONFIGURATION (OPTION 2). NR CONNECTS TO THE 5G CORE ONLY. THE STANDALONE 5G SYSTEM INTERWORKS AT CORE NETWORK LEVEL WITH LEGACY 4G SYSTEM



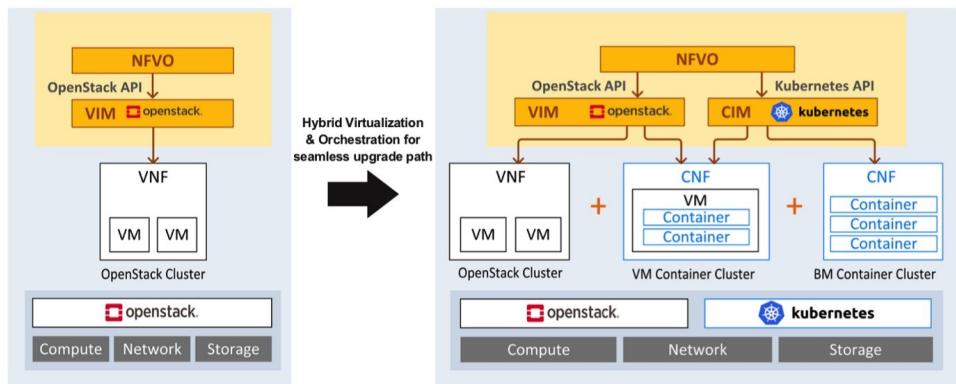
- 对比
 - Core Network SA and NSA Modes



- 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

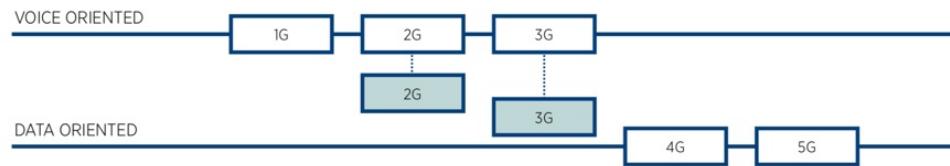
- 不同代的网络

- 演化图

- 1G到5G

- 4G和5G在语音和数据方面的发展路线

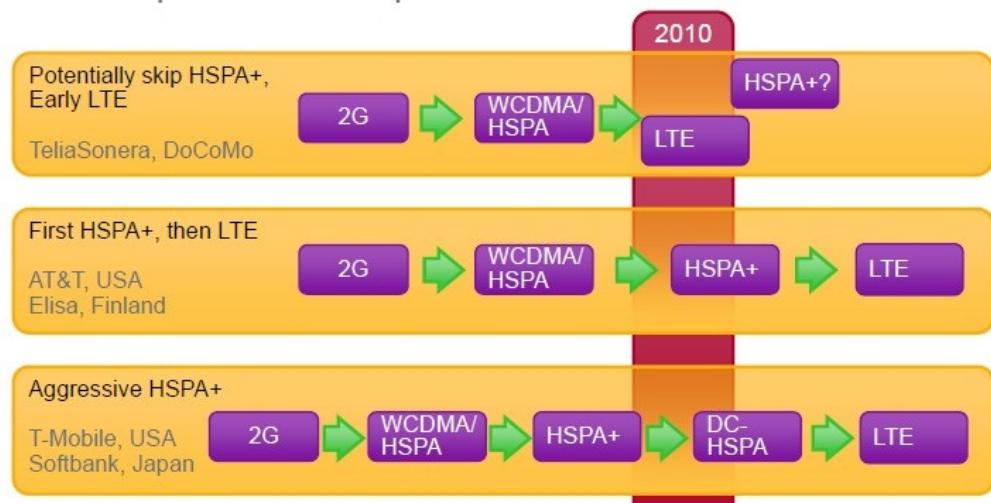
4G AND 5G ARE BASED ON THE SAME TECHNOLOGY PHILOSOPHY



- 相关名词和术语

- 5GC 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



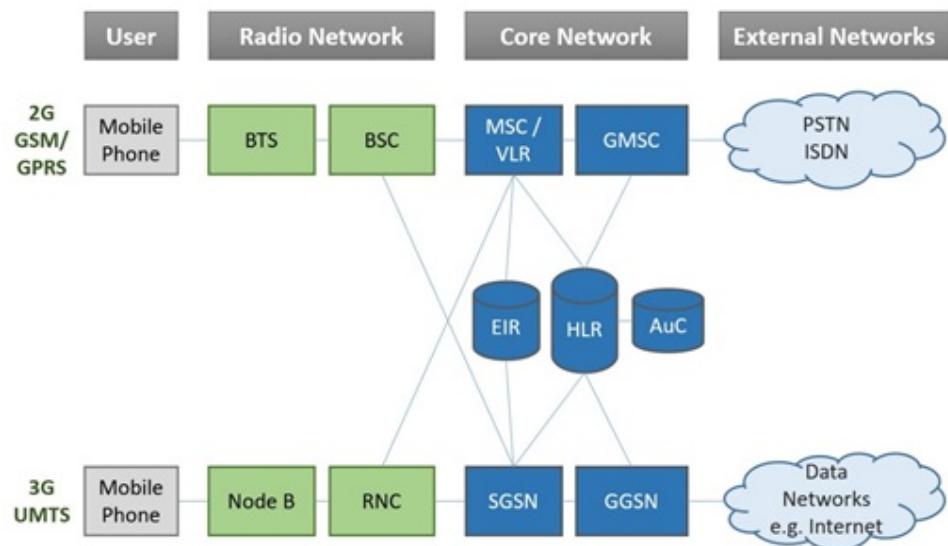
- CDMA到LTE



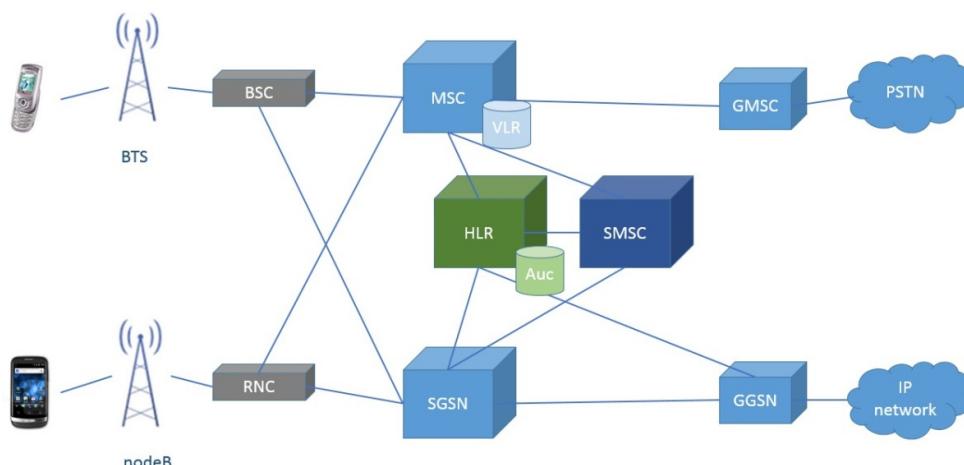
◦ 架构图

▪ 2G和3G

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

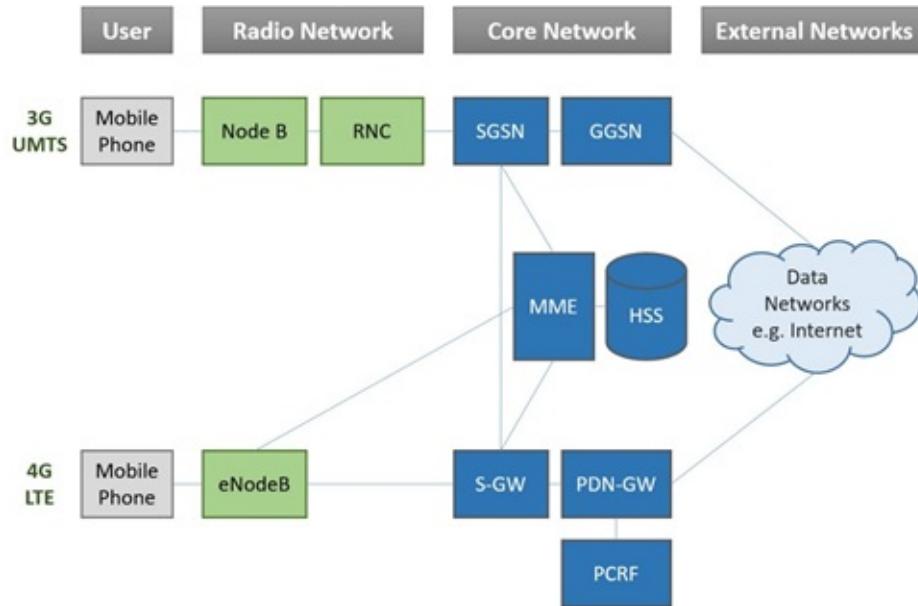


- SMS in 2G/3G network architecture

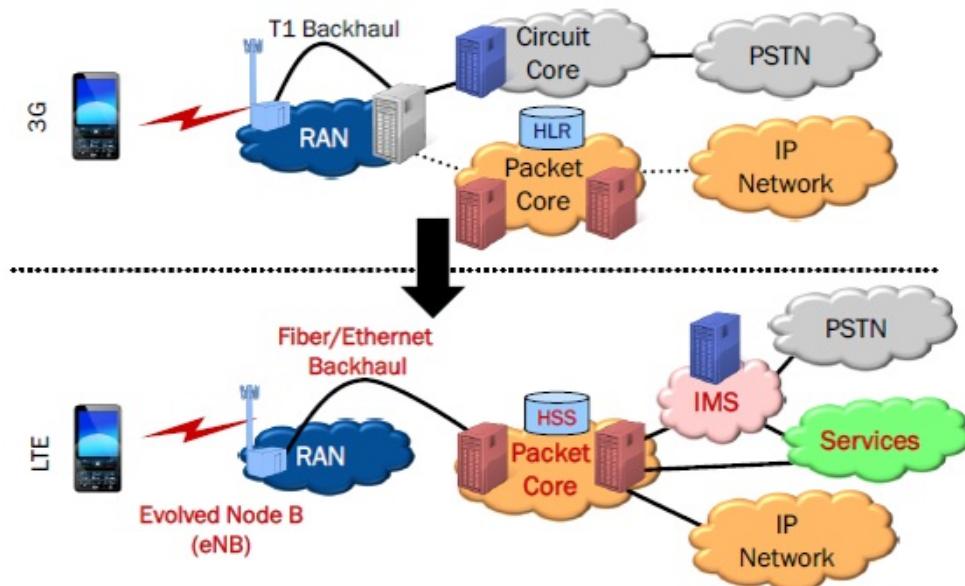


- 3G和4G

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

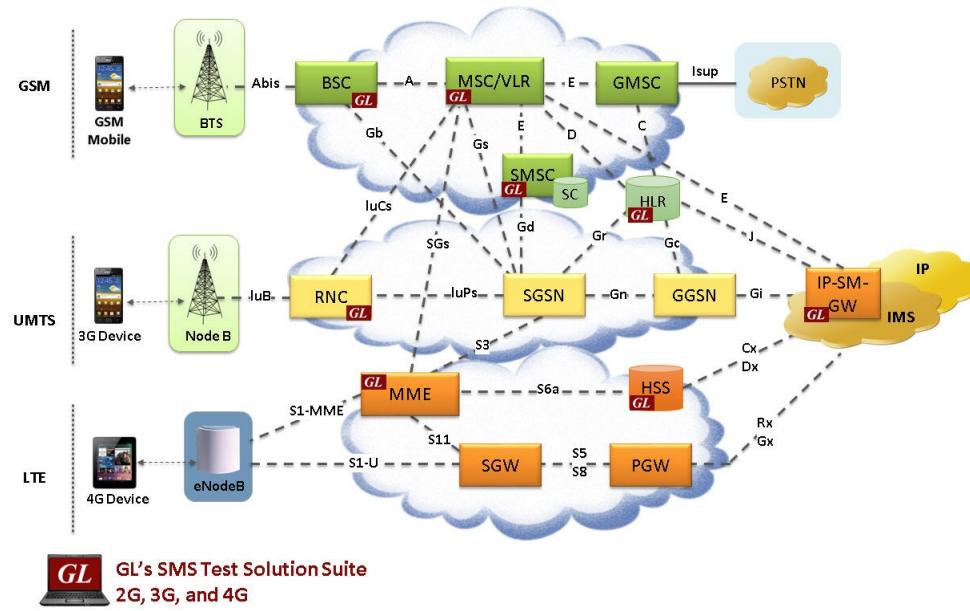


- Evolution of 3G Core Network to 4G Core Network



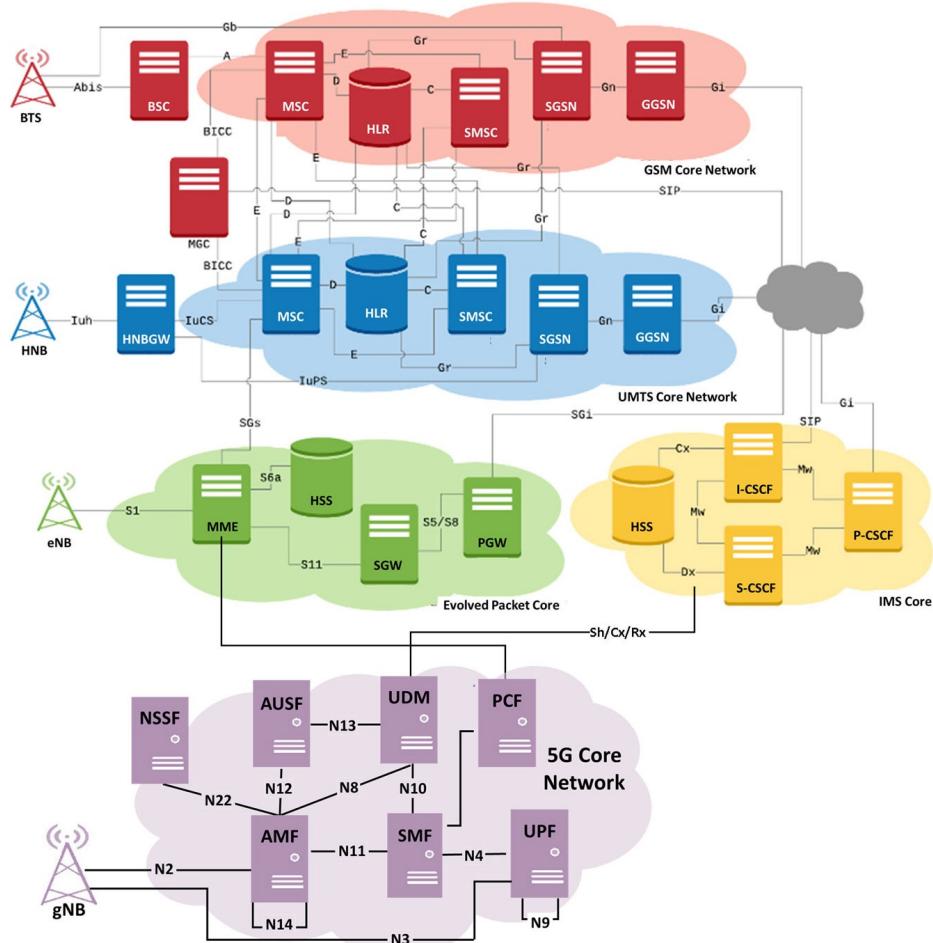
- 2G、3G、4G

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



■ 2G、3G、4G、5G

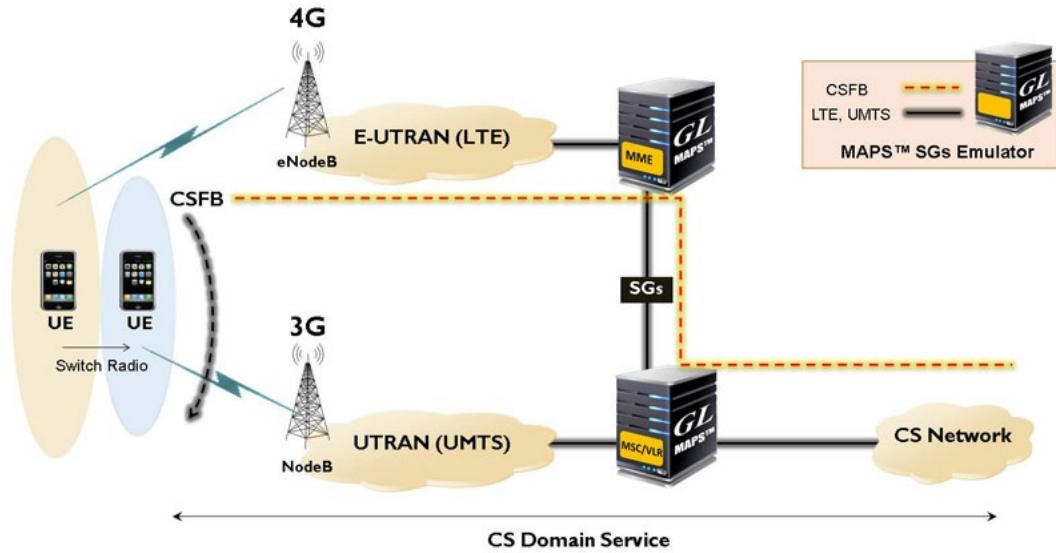
■ Wireless Network Simulation (5G, 4G, 3G, 2G, IP, TDM)



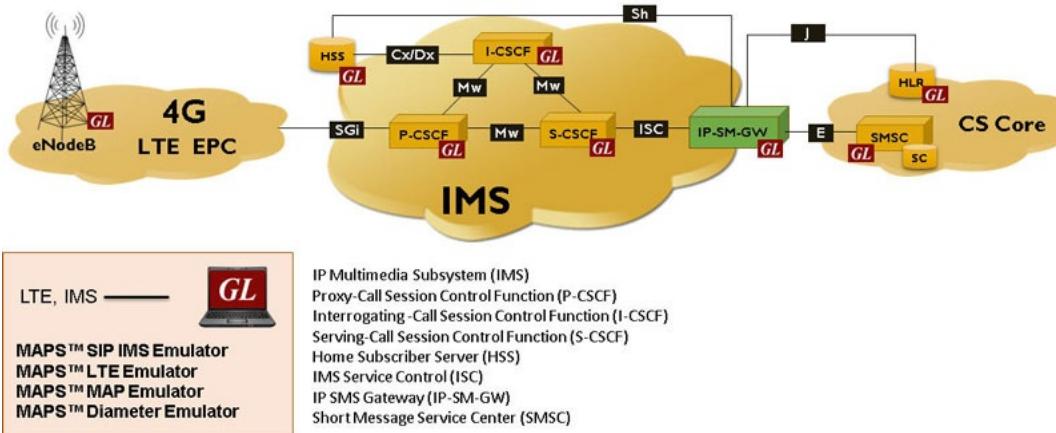
移动网络技术实现

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。

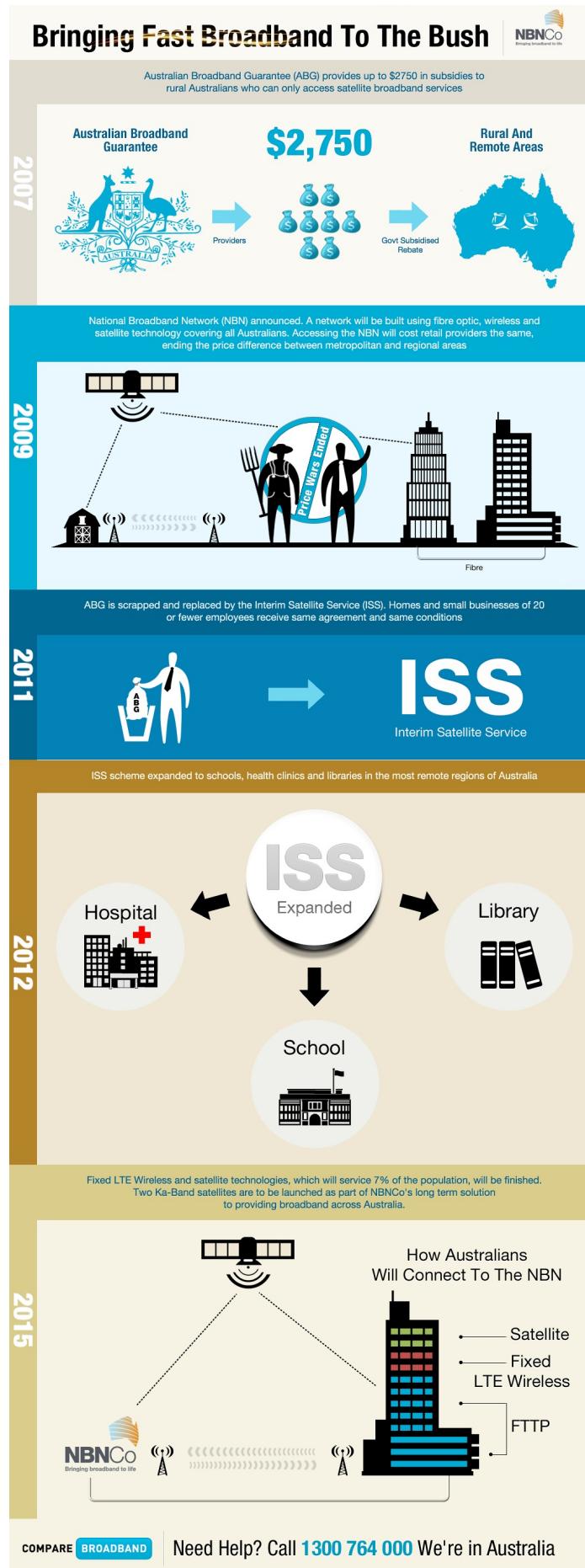
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名词术语

- 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
-

ABG

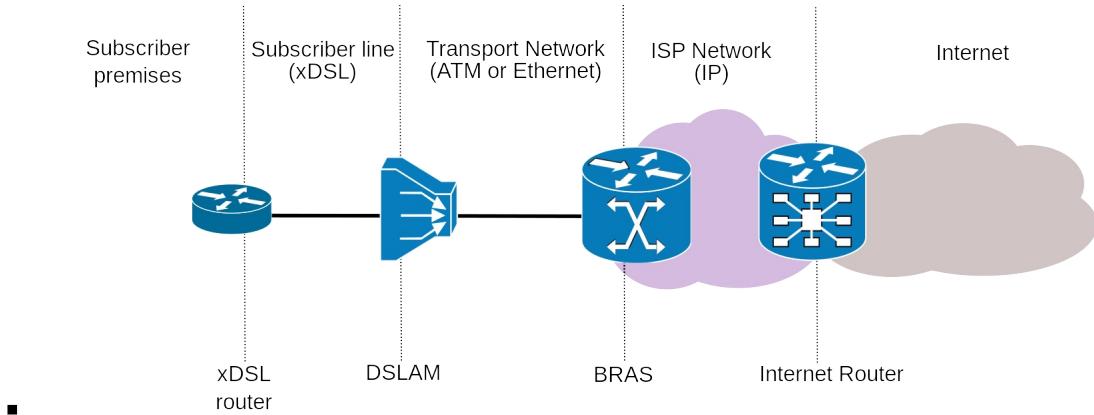
- ABG
 - = Australian Broadband Guarantee
 - = IPSTAR Broadband = IPSTAR Satellite Service
 - 适用范围: 只用于澳大利亚 (的农村乡下偏远地方)
 - 现状: 2011年6月30日其已停止服务
 - 被 NGN (的 ISS) 取代
- NBN
 - = National Broadband Network
 - = NBN Sky Muster Satellite service
- ISS
 - = Intersim Satellite Service
- 总结
 -



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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:

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-

TODO:

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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
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- RCS技术开发总结
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- [Signalling in GSM BSS - Training Materials - Training offer - Leliwa](#)
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