Dimensioning, configuration and deployment of Radio Access Networks.

part 1:
General considerations

Agenda

- **Mobile Networks Standards**
- **Network Architectures**
- **Call Set Up**
- **Network Roll Out**
- **Site Equipment**
- **Distributed Antenna Systems: DAS**
- **Indoor Systems**

Mobile Telephony Networks

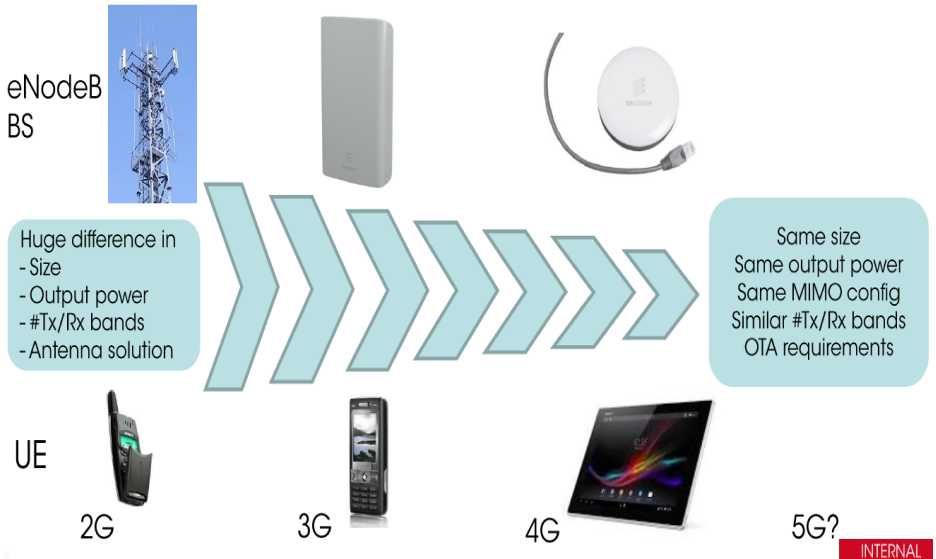
The Evolution of Mobile Telephony

1st Generation	2nd	3rd	4th
Analogue Voice Roaming	Digital Voice Low-rate data European standard	Packet Access Multimedia Services broadcast Services	Broadband Internet Smartphones IP TV
NMT, AMPS	GSM, PDC	IMT-2000	IMT-Advance
TACS	IS-95, IS-136	UMTS, cdma1x	LTE

1980 1990 2000 2010 2020

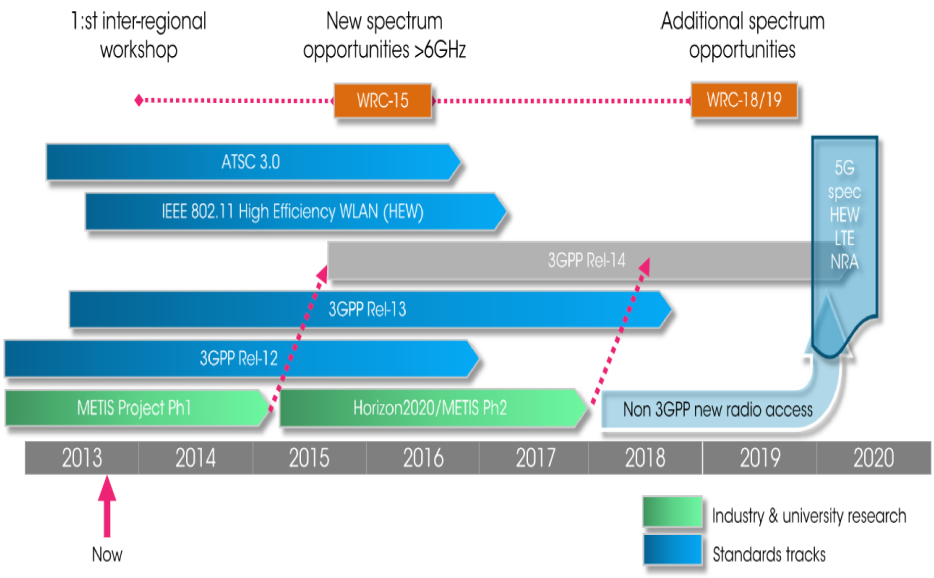
Converging challenges for infrastructure and user devices

SONY make.believe

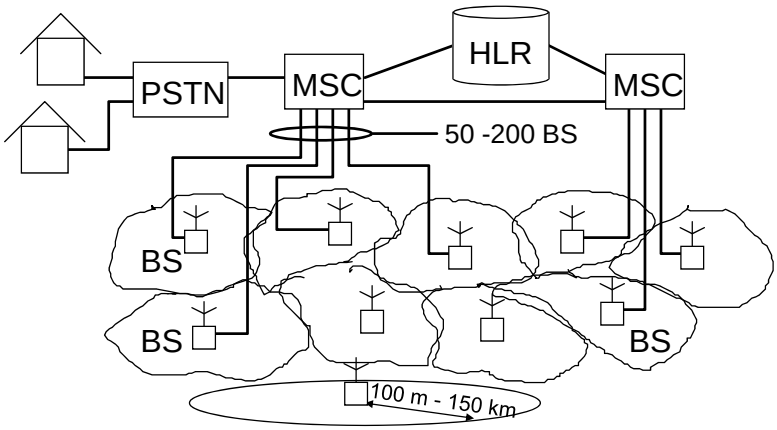


Research and standardisation towards 5G

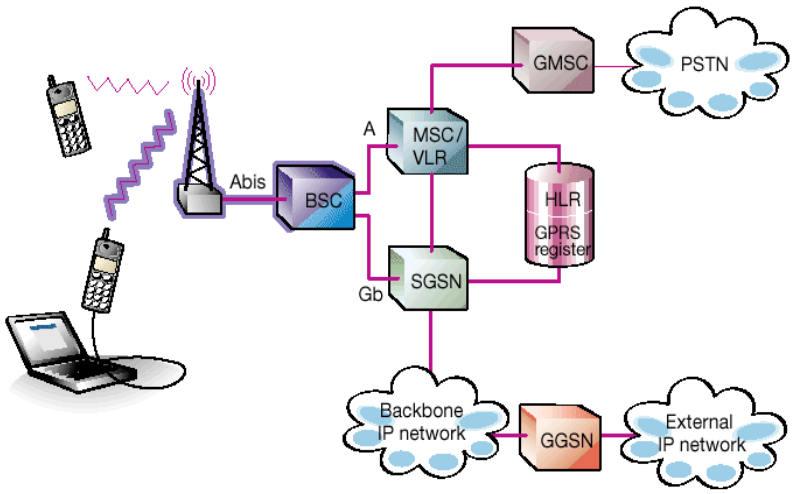
SONY make.believe



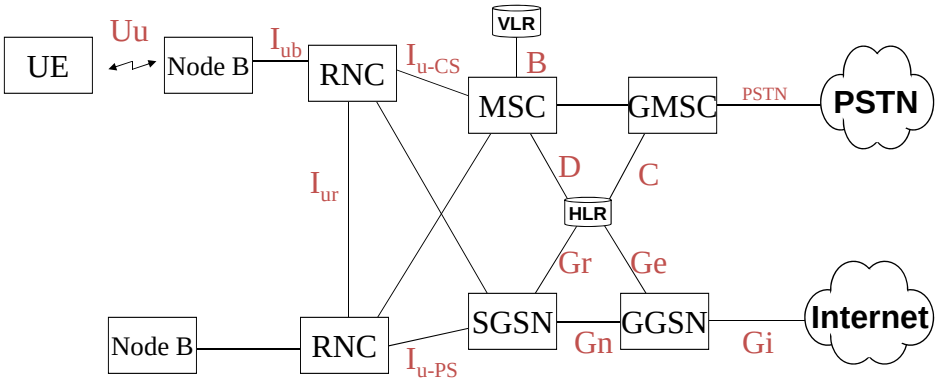
Mobile Network Architecture



GSM Voice and data architecture

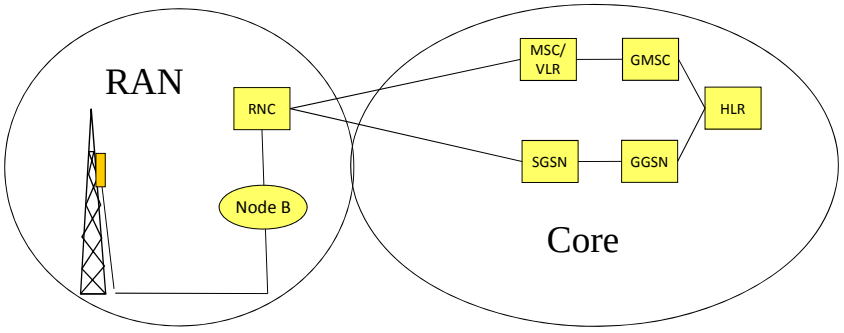


UMTS Network Architecture



The cost of a 3G Network

Mobile Networks generally consist of a Radio Access Network (RAN), a Core Network (Core) and mobiles



70-80%

20-30%

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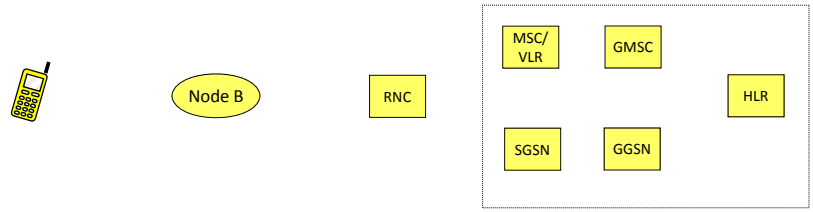
Users of a 3G Network

The relative equipment volumes needed to build a network vary between vendors but can generally be estimated to:



1E6	1E3	10	1
Mobiles	Bas stations	Network Control	Core Net

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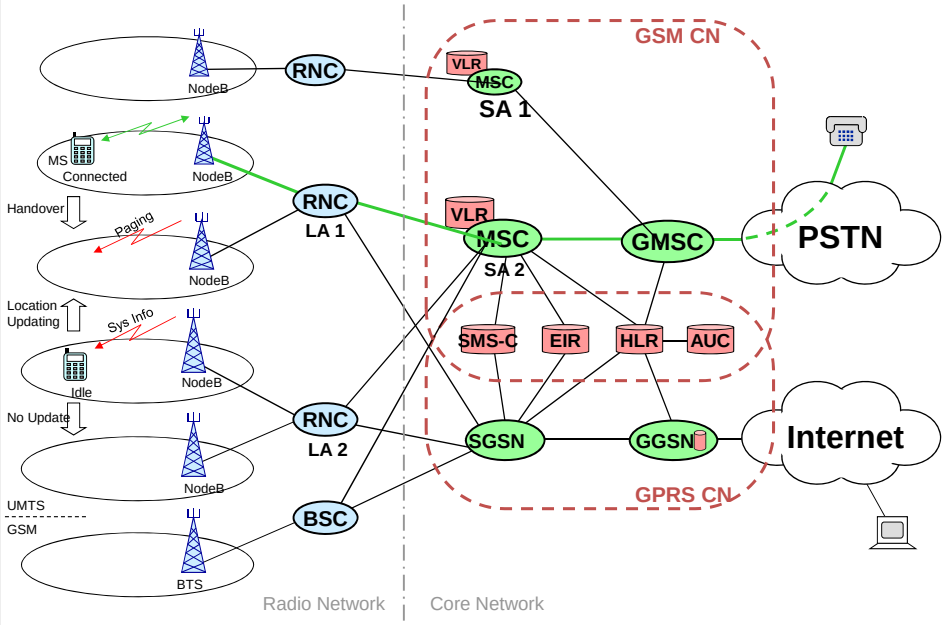
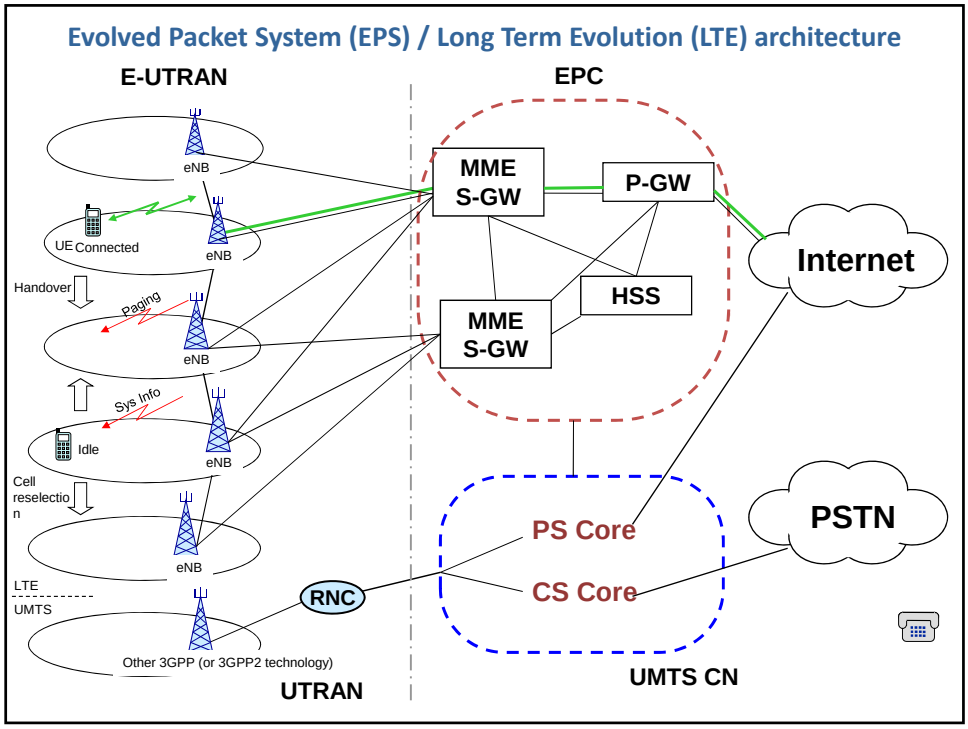
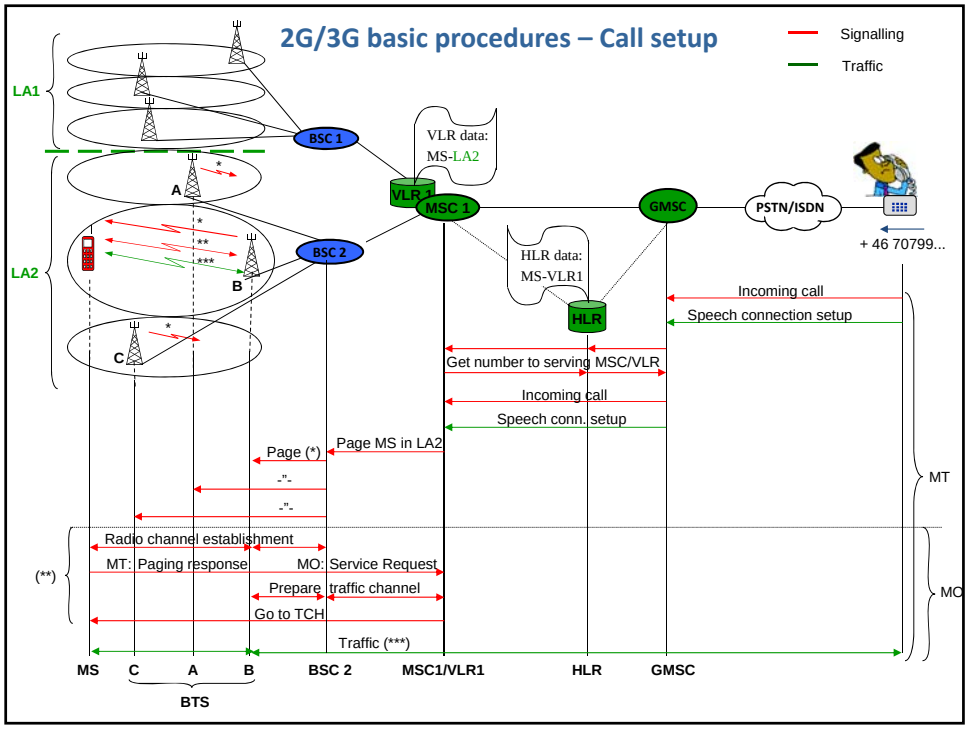
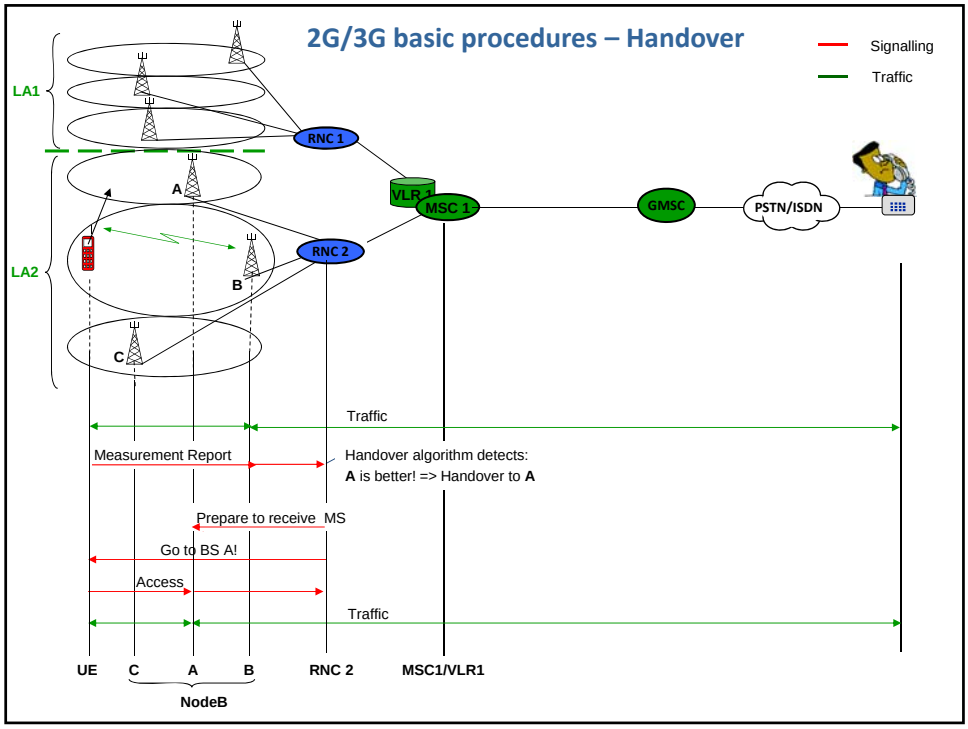
Call Set Up




Evolved Packet System (EPS) / Long Term Evolution (LTE) architecture
E-UTRAN
EPC
eNB
UE Connected
Handover
Paging
Sys Info
Idle
Cell reselection
LTE
UMTS
Other 3GPP (or 3GPP2 technology)
MME S-GW
P-GW
HSS
Internet
PS Core
CS Core
PSTN
RNC
UTRAN
UMTS CN


2G/3G basic procedures – Call setup
Signalling
Traffic
LA1
LA2
BSC 1
BSC 2
VLR data:
MS-LA2
VLR 1
MSC 1
GMSC
PSTN/ISDN
+ 46 70799...
HLR data:
MS-VLR1
HLR
Incoming call
Speech connection setup
Get number to serving MSC/VLR
Incoming call
Speech conn. setup
Page (*)
Page MS in LA2
-"-
-"-
Radio channel establishment
MT: Paging response
MO: Service Request
Prepare traffic channel
Go to TCH
Traffic (***)
(**)
MT
MO
MS
C
A
B
BSC 2
MSC1/VLR1
HLR
GMSC
BTS



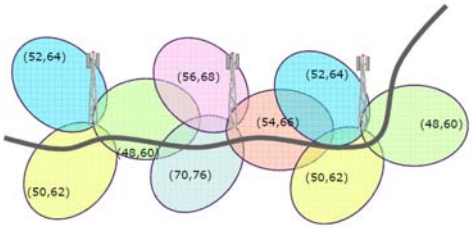
Network Roll-out

Network roll-out involves a number of processes for planning of

- Radio
- Capacity
- Coverage
- Transmission

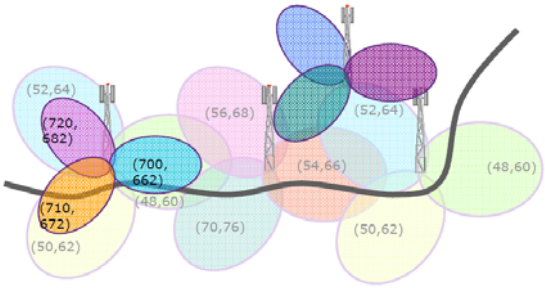
GSM 900 initial roll-out

- 4/12 Reuse pattern for control Channels
- 3/9 for Traffic Channels
- Required sensitivity > 9 dB C/I



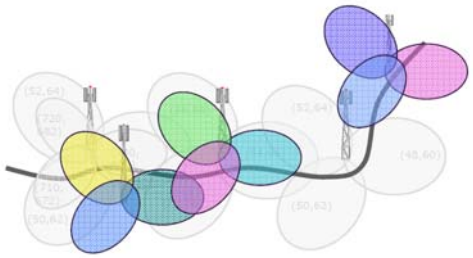
GSM 1800 adding voice capacity

- Co-incident cell boundaries or
- Seperate networks



UMTS (3G) adding data capacity

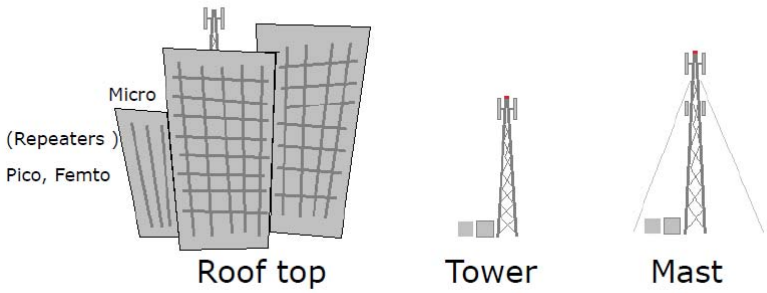
- 3G rel 99 both voice and data
- HSPA adds packet data up to 24Mbps
- Where needed…



Capacity and Quality Improvments

- Building New sites (GSM, UMTS or LTE)
  - Coverage
  - Capacity
- Adding Frequencies (e.g. 1800)
- Swapping network elements
  - New technology
  - Adding carriers
- Network optimization
  - Kpi based
  - SON

Site Equipment

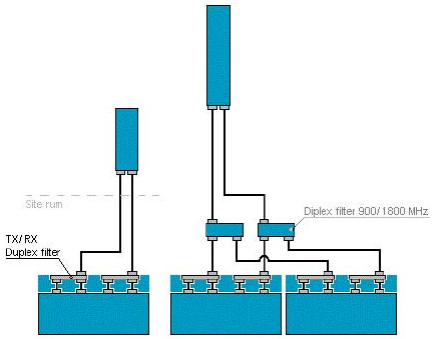


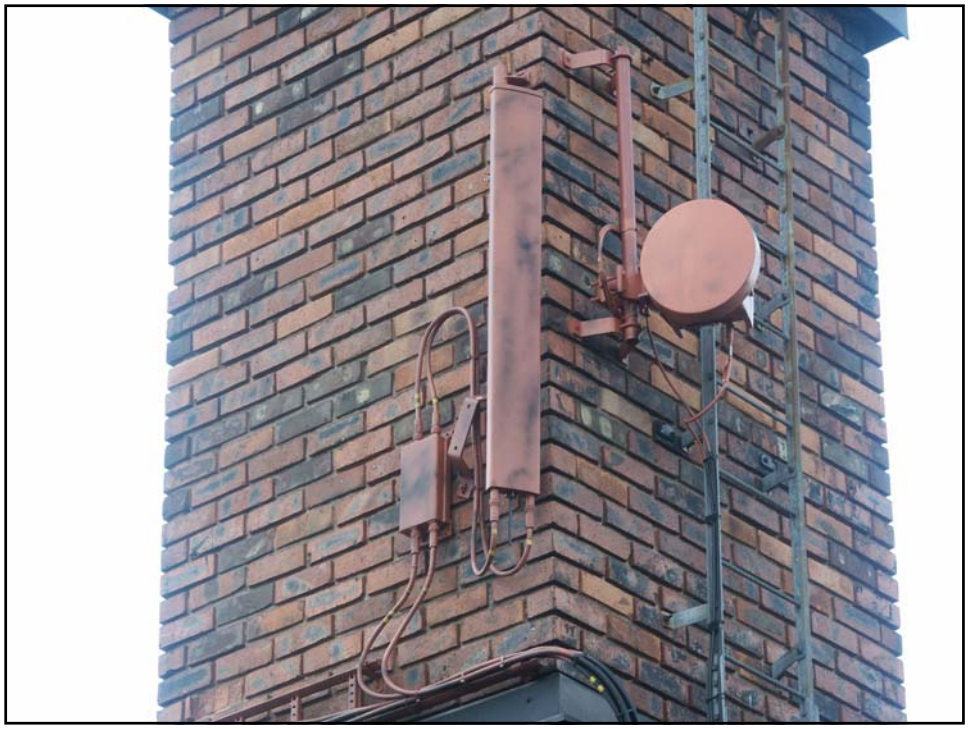
Site Room Equipment

- Active equipment
  - BTS/NodeB/ (RRU)/MRS
  - (Repeaters / Booster)
- Transmission
  - Modem, Fibre, radio/micro wave link.
- Support system
  - Electrical system /BBU
  - Air condition
  - Alarm/monitoring
- Antenna System
  - Coaxial Cables / Jumpers / Connectors /lightning protection
  - (TMA's)
  - Antennas

Tower/Antenna Equipment

- Active equipment
  - BTS/NodeB/ (RRU)
  - (Repeaters / Booster)
- Transmission
  - Modem, Fibre, radio/micro wave link.
- Support system
  - Electrical system /BBU
  - Air condition
  - Alarm/monitoring
- Antenna System
  - Coaxial Cables / Jumpers / Connectors /lightning protection
  - (TMA's)
  - Antennas

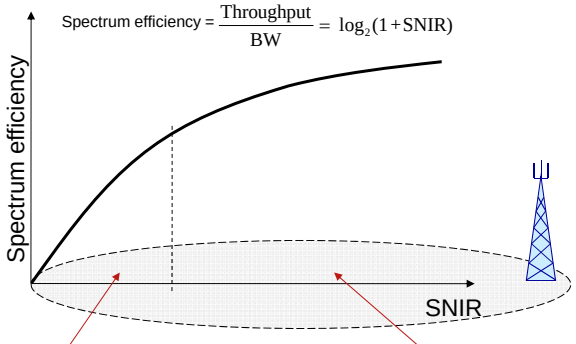




Tower Mounted Amplifiers: TMA

- The tower mounted Amplifier is a low noise amplifier with a Noise figure of less than 0.5dB and a gain of typicall y around 13dB
- It is used to compensate for the loss in the feeder cable (~3dB) between the base station and the antenna which otherwise would have directly reduced the sensitivity of the receiver

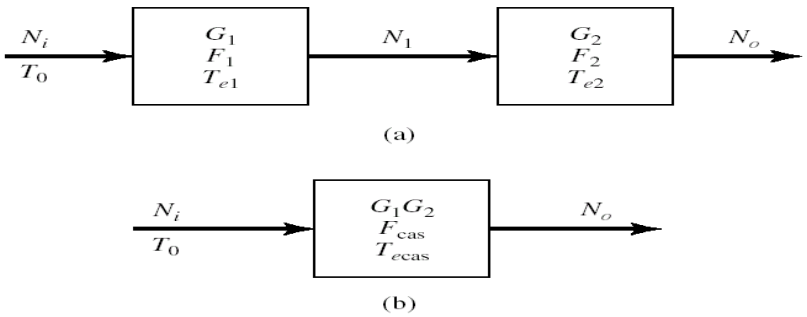
High data rates in mobile communications – Shannon's limit



Power-limited region (cell edge)
• Low SNIR → Throughput proportional to SNIR
• Low bandwidth utilization (spectrum efficiency)

BW-limited region (close to the site)
• High SNIR → Throughput proportional to **log(SNIR)**
• Throughput saturation due to very high SNIR (close to site)
• Large SNIR increase leads to small throughput increase
• High bandwidth utilization (spectrum efficiency)

Noise Figure in Cascaded Systems



$$T_{cas} = T_{e1} + \frac{T_{e2}}{G_1} + \frac{T_{e3}}{G_1 G_2} \ldots$$

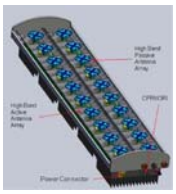
$$F_{cas} = F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 G_2} \ldots$$

Remote Radio Units (RRU)

- This Radio equipment is remote to the BTS/NodeB/eNodeB, and is also called Remote Radio Head.
- They are generally connected to the BTS/NodeB/eNodeB via a fiber optic cable using Common Public Radio Interface, CPRI protocols

Active Antenna Systems: AAS

- An active antenna system is today a merge between a RRU and a passive antenna.
- It is fed via on optical cable and, hence, is easy to install and ha no cable losses between that deteriorates the reception
- Ericsson, Huawei, Nokia etc all now have AAS in their portfolio



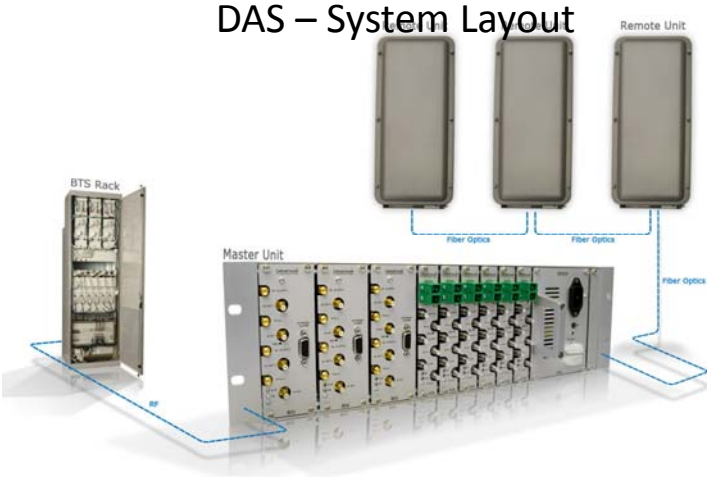
CPRI and OBSAI

- The **Common Public Radio Interface (CPRI)** standard defines the interface of base stations between the Radio Equipment Controllers (REC) in the standard, to local or remote radio units, known as Radio Equipment (RE).
- The **Open Base Station Architecture Initiative** (**OBSAI**) with the aim of creating an open market for cellular network base stations. The hope was that an open market would reduce the development effort and costs traditionally associated with creating base station products

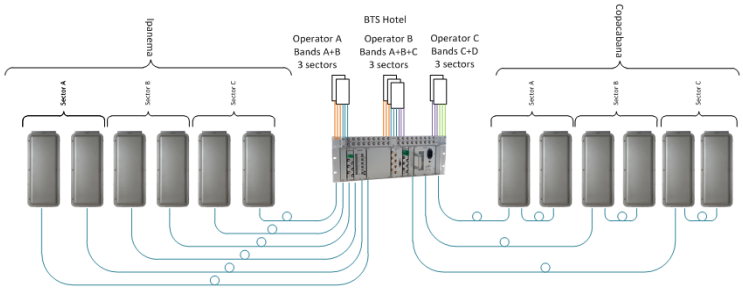
Distributed Antenna Systems: DAS

- In Building will account for the majority of Data Traffic but are hard to reache through the wall
- Roadtunnels, subways and Metros are hi capacity Hotspots where it may be impossible to build more than one network

DAS – System Layout



DAS system to drive the Beaches in Rio



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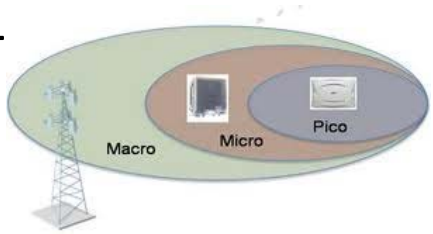
DAS vs BT



	Basestation	DAS	Pico / Metro
Coverage	Wide	Multiple and Wide	Limited
Capacity	Large	Large and Flexible	Limited
Capability	Pre Defined	Existing and Future	Limited
Frequency Band	Dual	Multi	Single
Service	Dual	Multi	One
Scalability	Pre Defined	Full	No
Deployment	Outdoor/large indoor	Outdoor/large indoor	Indoor

Indoor Systems

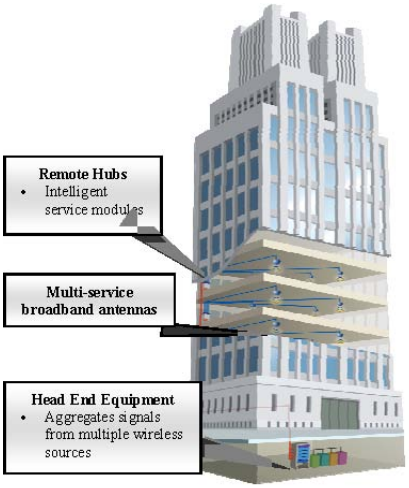
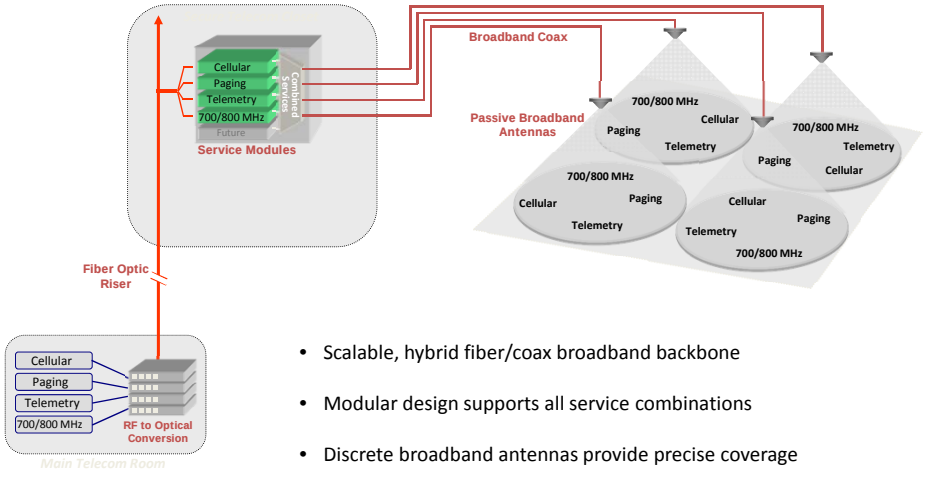


Figure 1. Illustration of a DAS servicing a high rise building

A jungle of alternatives

Modular Architecture Scales in Breadth and Depth

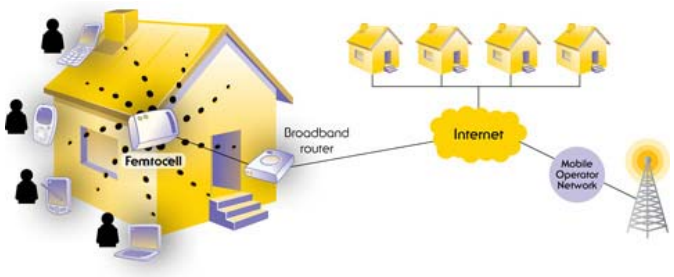


- Scalable, hybrid fiber/coax broadband backbone
- Modular design supports all service combinations
- Discrete broadband antennas provide precise coverage

Ericsson DOT

- A DAS system which uses CAT5 cables!

Femto Cells!


Femtocell
Broadband router
Internet
Mobile Operator Network