LTE Planning and dimensioning

ITU PITA Workshop on
Mobile network planning and security

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I. Radio planning

1. Necessity of network planning

NECESSITY OF NETWORK PLANNING

Necessity of network planning

- Construct a radio network
- Spectrum allocation limitations
- New data services, and new technologies
- Extension in the future of existing network
- Optimization of the cost and guaranteeing the network service quality
- Efficient utilization of resources

2. Purpose

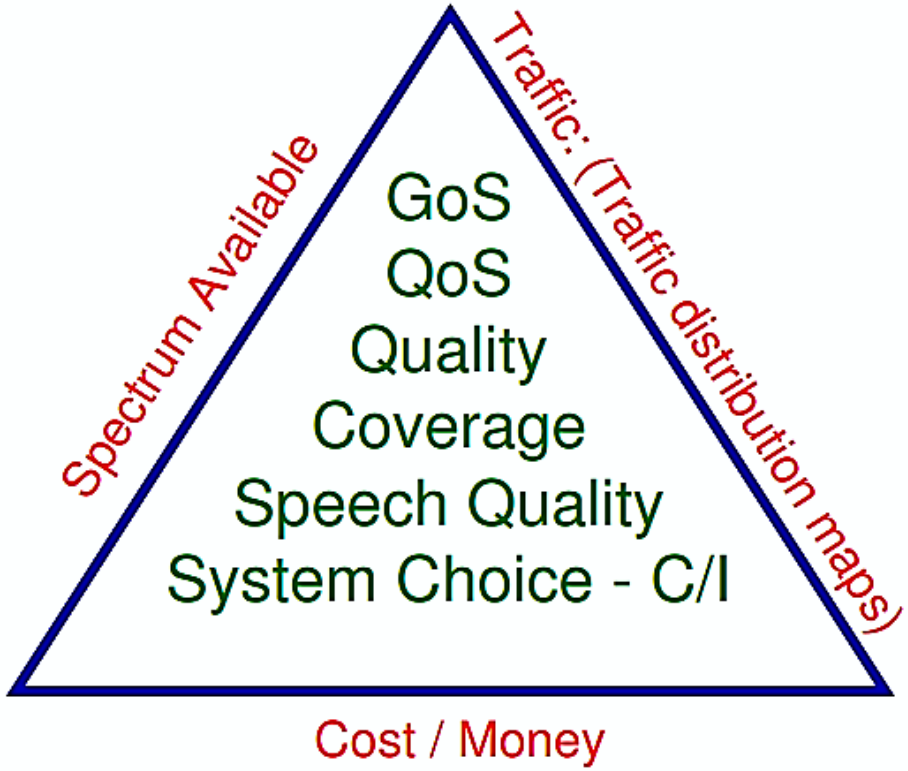
NECESSITY OF NETWORK PLANNING

Purpose

- Reach good quality
- Required radio coverage
- Maximum use of resources
- Maintaining high level of system quality
- Provide both increased capacity and the improvement in required network quality

NECESSITY OF NETWORK PLANNING

- **Input to network planning**

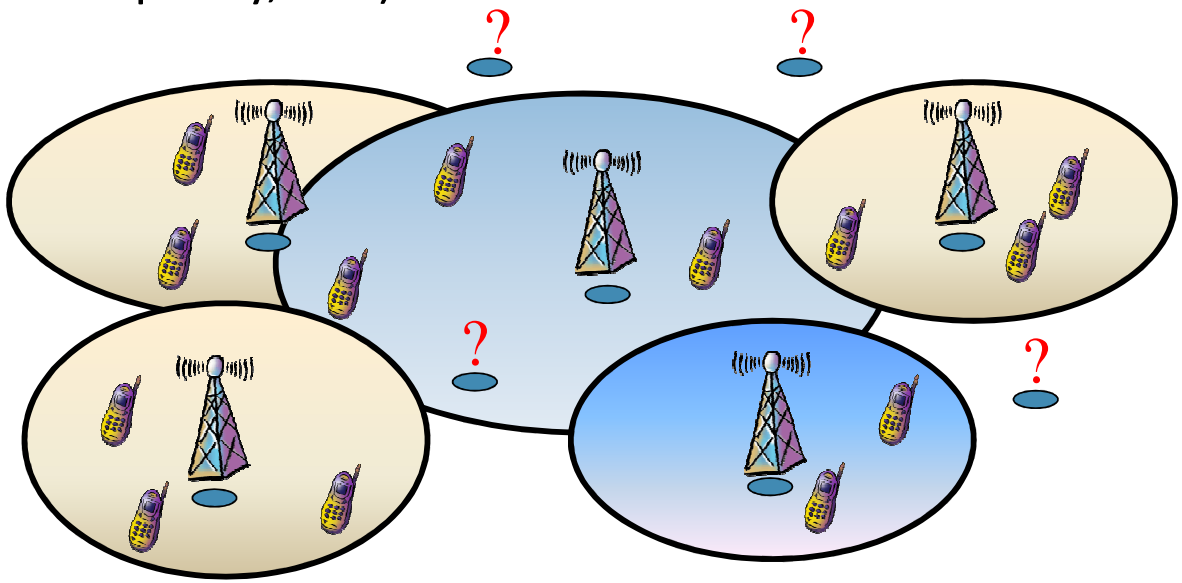


3. Main features of radio planning

MAIN FEATURES OF RADIO PLANNING

The basic decisions that must be taken during the radio planning phase are:

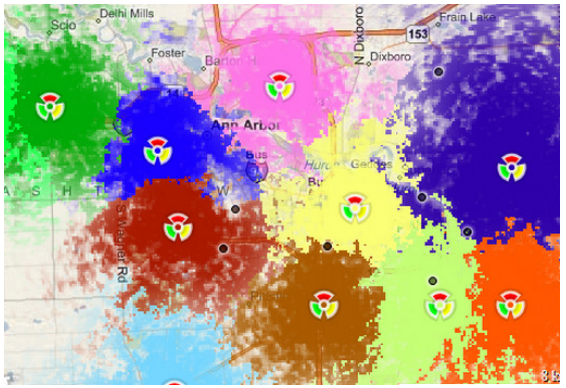
- Where to install base stations
- How to configure base stations (antenna type, height, sectors orientation, tilt, maximum power, device capacity, etc.)



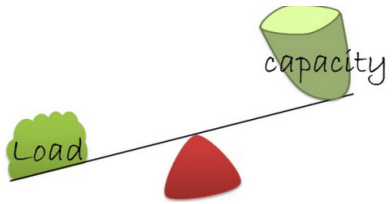
MAIN FEATURES OF RADIO PLANNING

- *FDMA/TDMA/OFDMA* cellular systems adopt a two phases radio planning

➢ **Coverage planning**



➢ **Capacity planning** (*frequency assignment*)



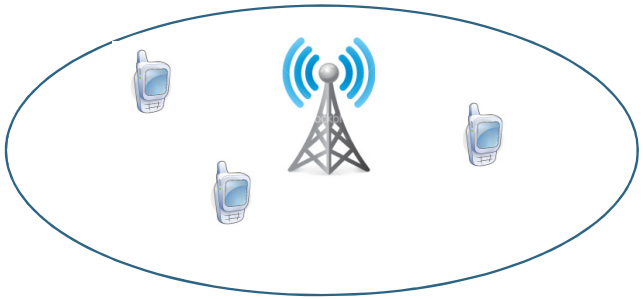
MAIN FEATURES OF RADIO PLANNING

- ***Coverage planning:***

  - Percentage of the geographical area covered by the cellular service where mobile telephony is available

    - Select where to install base stations
    - Select antenna configurations
    - constraints on signal level in the area

➔ Guarantee the signal strength in the service area



MAIN FEATURES OF RADIO PLANNING

- ***Depending on the following factors***
  - *Natural*: geographical aspect/propagation conditions
  - *Human*: landscape (urban, suburban, rural)

- ***Methods***
  - Theoretically through link budget calculation and computer
  - Simulation and optimization through the drive test and other measurements

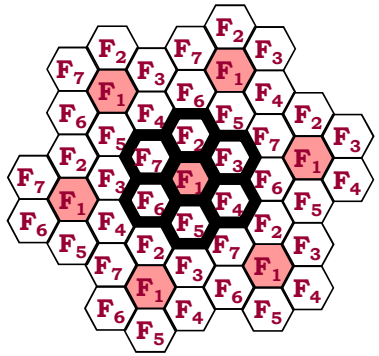
MAIN FEATURES OF RADIO PLANNING

- ***Capacity planning:***

  - Number of calls that can be handled in a certain area within a certain period of time

  - Probability that users will be denied access to a system due to unavailability of radio channels

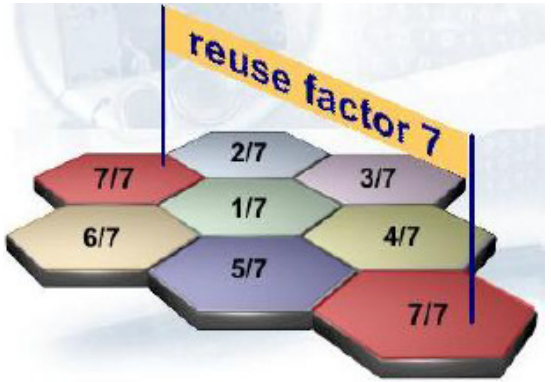
    - Define which radio resources can be used by each cell



MAIN FEATURES OF RADIO PLANNING

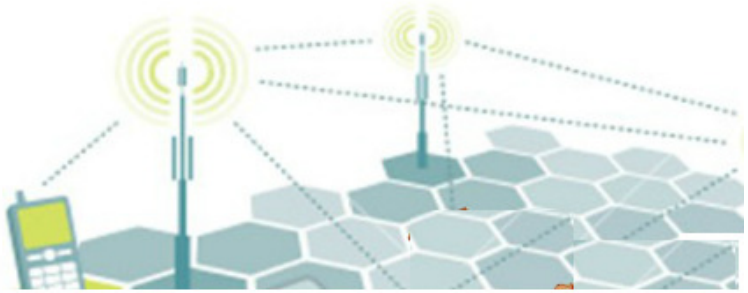
Three essential parameters

- Estimated traffic
- Antenna parameters (height, tilt, azimuth, aperture, gain, …)
- Frequency reuse factor



CONTENTS

II. Planning Procedures



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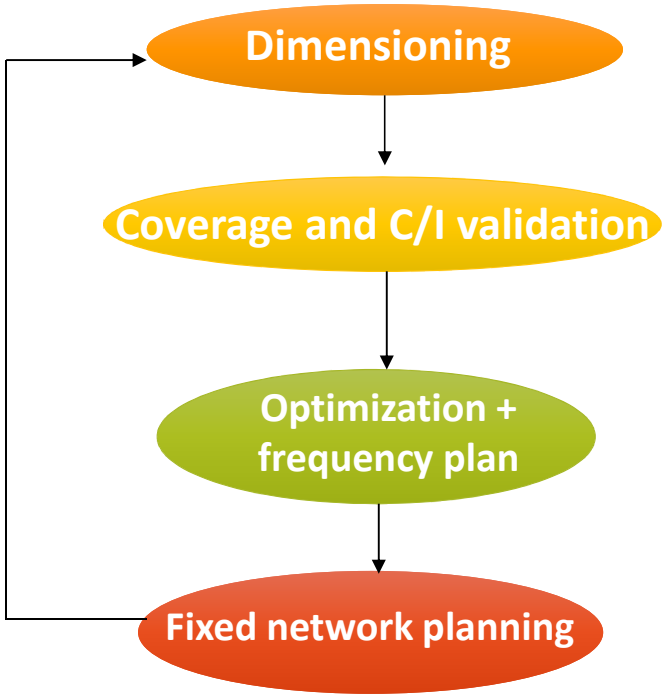
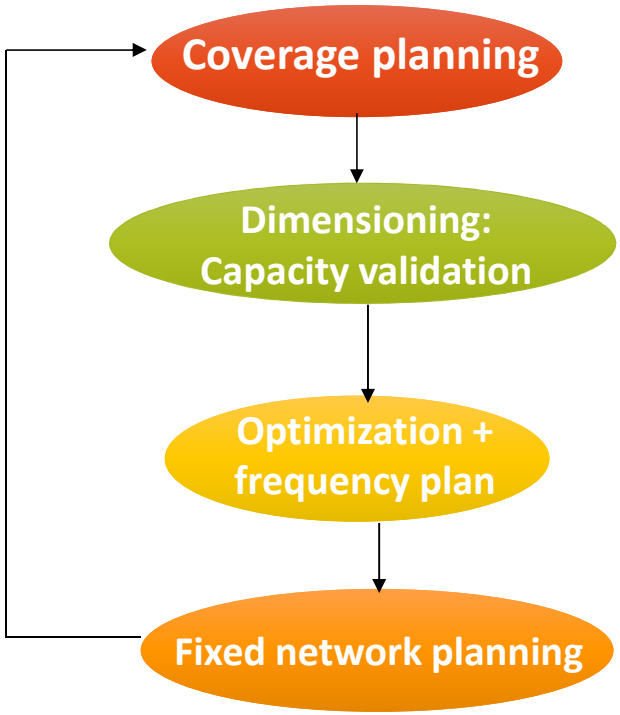
1. Process overview

PROCESS OVERVIEW

«***Traffic***» oriented area



«***Coverage***» oriented area



In FDMA/TDMA cellular systems

PROCESS OVERVIEW

Definition

Strategy:
Coverage,
Quality,
Capacity
-Dimensioning.

Network planning and rollout

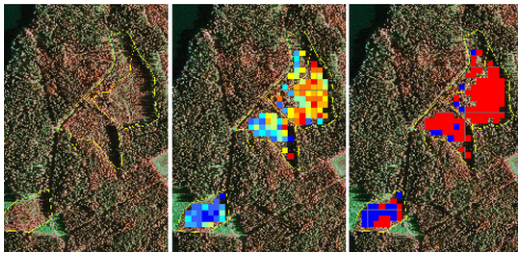
- Coverage planning
- Site selection
- Propagation measurements
- Coverage calculation
- Site acquisition
- Coverage optimization

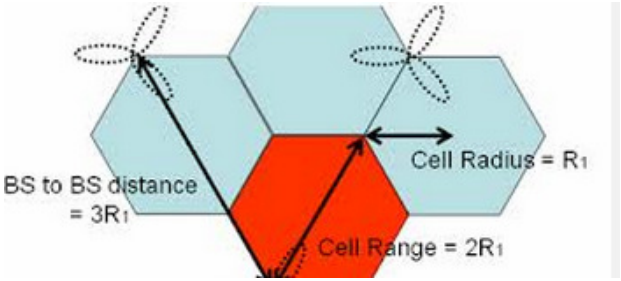
Optimization and measurements

- Network optimization
- Quality measurements
- Performance analysis
- Quality, efficiency, …

1. Preliminary work

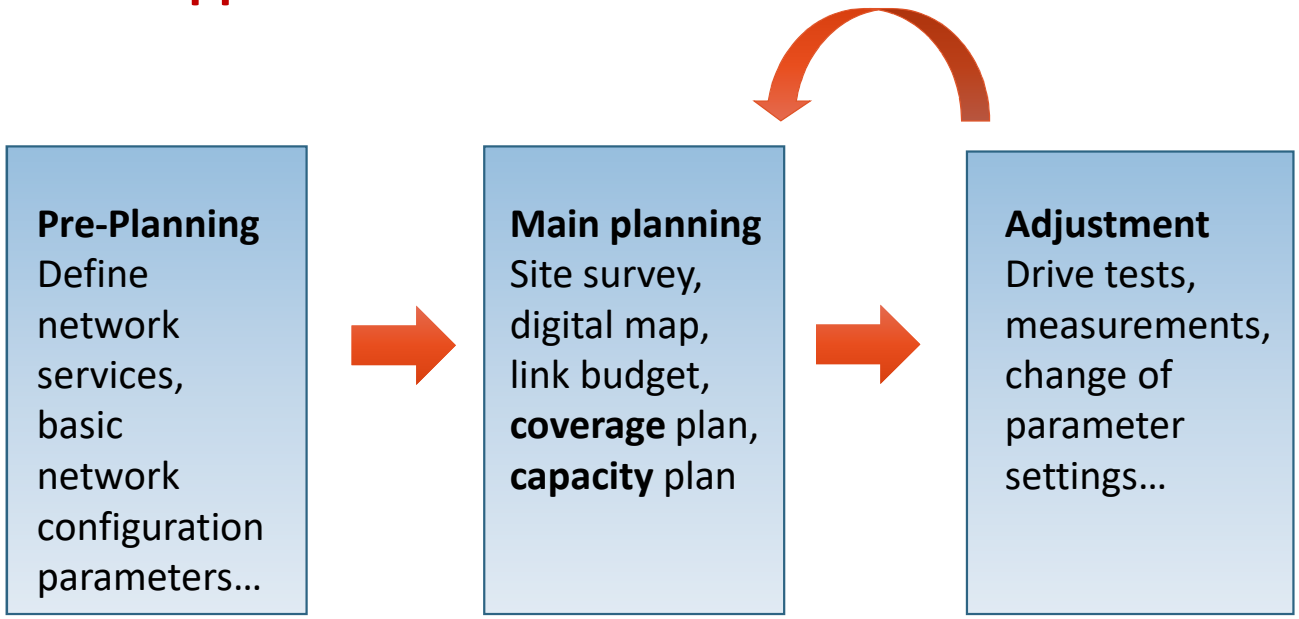
- Propagation tool setup
- Terrain, clutter, vector data acquisition and setup
- Load master lease site location in data base
- Marketing Analysis
- Set initial Link Budget
- Initial cell radius calculation
- Initial cell number estimate





PROCESS OVERVIEW

General approch

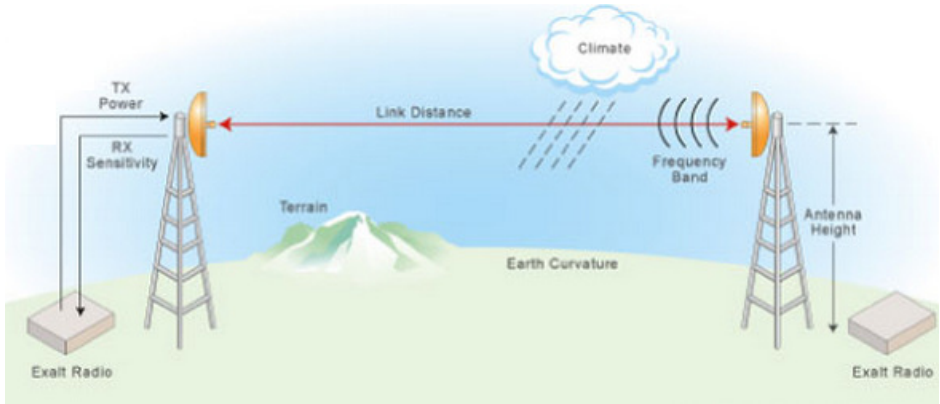


Determine height, tilts and azimuths of the antennas, power ... to meet the QoS constraints

2. Link Budget

LINK BUDGET

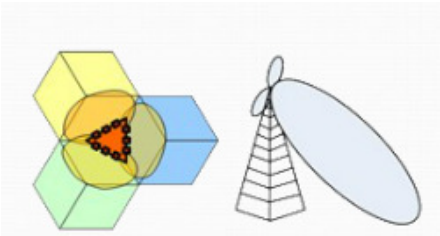
- Link budget calculation
  - Signal strength loss on the path between base station and mobile phone
- Define the cell ranges along with the coverage thresholds
- Important components
  - Sensitivity, Fade margin, Connector and cable losses, Antenna gain



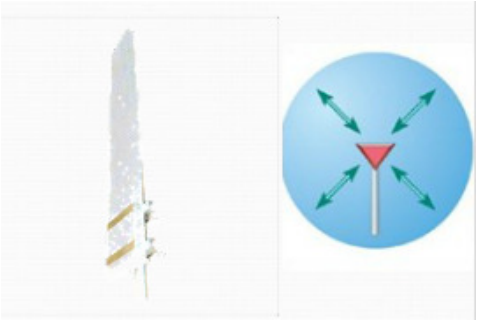
LINK BUDGET

- ***Antenna***

- Directional antenna
  - Sectorized antenna

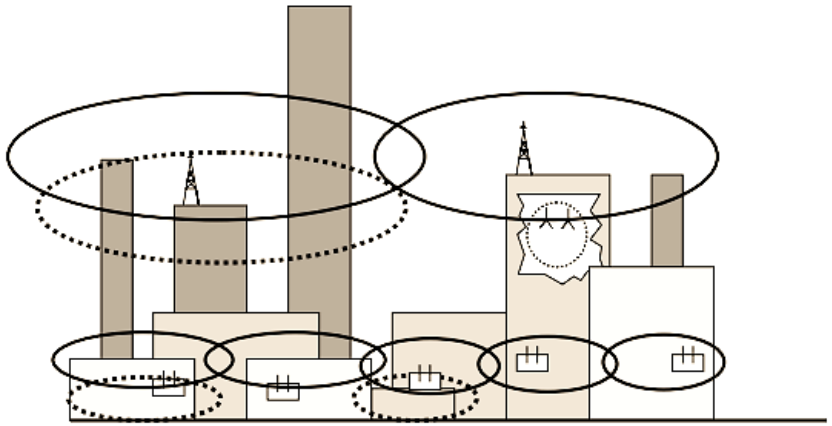


- Omni directional antenna
  - Radiates in all direction



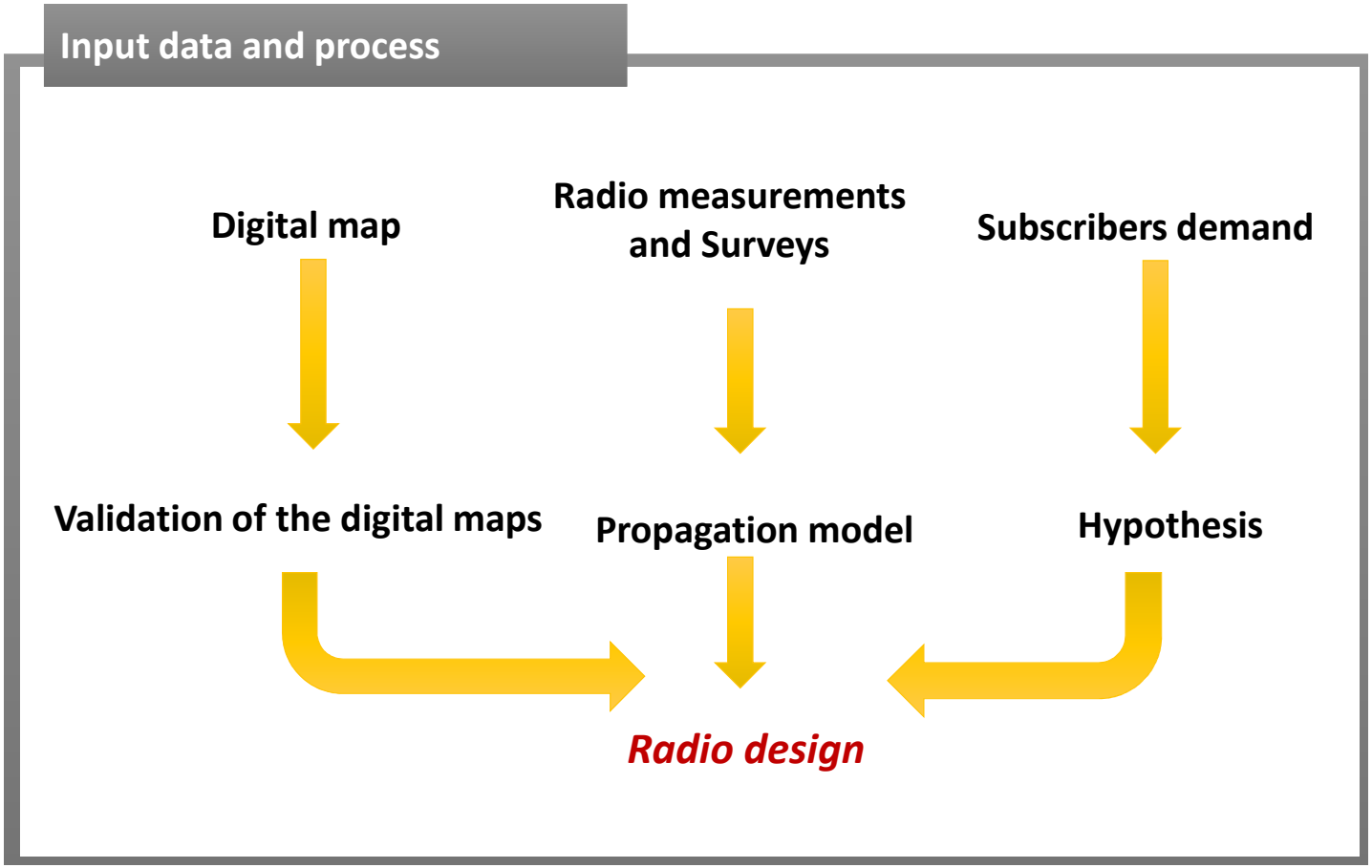
- ***Hierarchical Cells***

- **Macro Cell**
  - Antenna above average rooftop height
- **Micro Cell**
  - Antenna below average rooftop height
- **Pico Cell**
  - Indoors



3. Planning Input

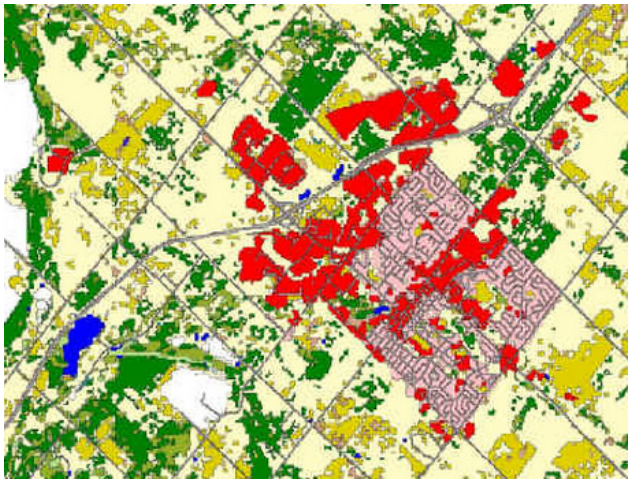
PLANNING INPUT



PLANNING INPUT

- Capacity related
  - Spectrum available
  - Subscriber Growth
  - Traffic density Map(traffic per subscriber)

- Clutter related
  - Dense urban
  - Urban
  - Sub urban
  - Rural



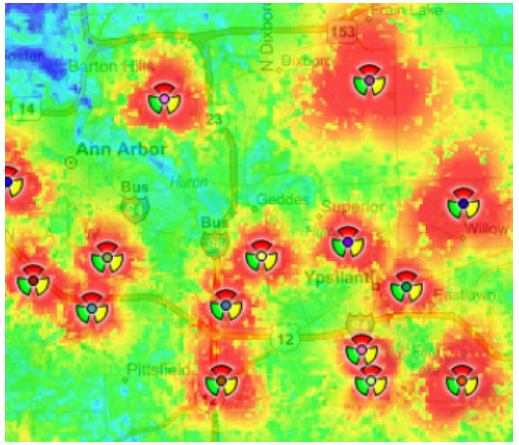
3. Planning phases

PLANNING PHASES

Site choice

1) Determine the *power level* at the cell border (sensitivity, propagation, antennas, …),
2) Choose an *available site*,
3) Compute its *coverage*,
4) Choose other sites and draw their coverage so that they *overlap*.

➔ In a cellular network, all the sites must be considered together.



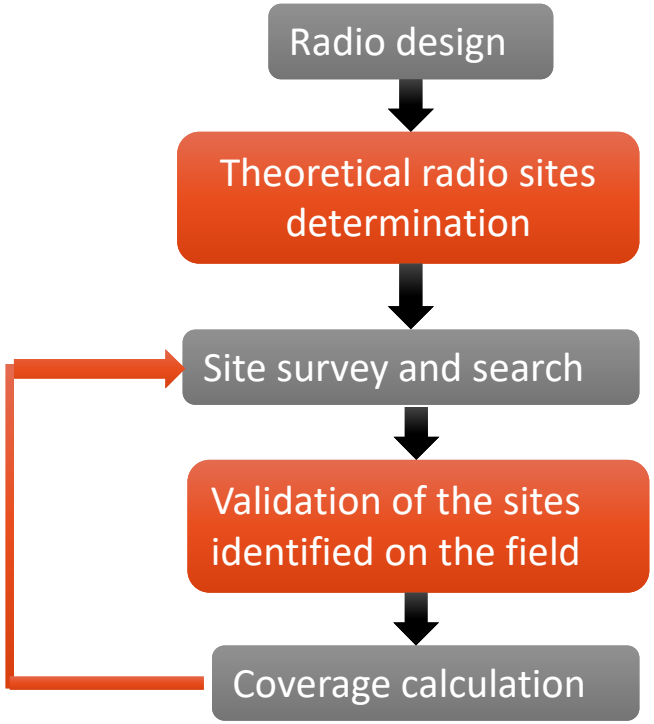
PLANNING PHASES

Radio sites choice criteria

- Examine users needs, service area, frequencies, power constraints, …
- Survey of the service area to identify the preferred sites,
- Search existing sites in the considered areas,
- Validate the sites and determine the possibility of site sharing.

PLANNING PHASES

Radio sites location determination



PLANNING PHASES

A. Radio design

1st constraint: link budget

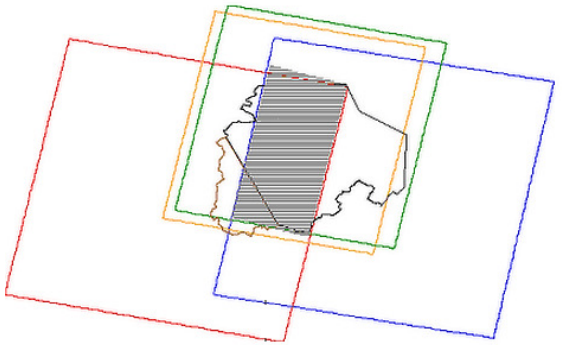
➔ System tuning should allow *uplink* and *downlink* **balancing**.

PLANNING PHASES

A. Radio design

2nd constraint: Minimum cell overlapping required for the handover

➔ Common area between adjacent cells: power difference between the signals received from each cells should be within a margin of a few dBs (e.g., HO_Margin)



PLANNING PHASES

A. Radio design

3rd constraint: Network coverage continuity

➔ Network coverage should be continuous, at least in dense areas or for the main transportation axes (roads, highways, railways, …)

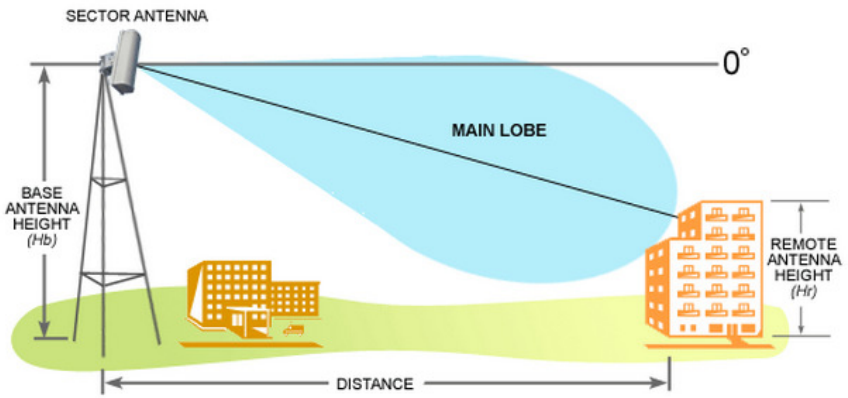
PLANNING PHASES

A. Radio design

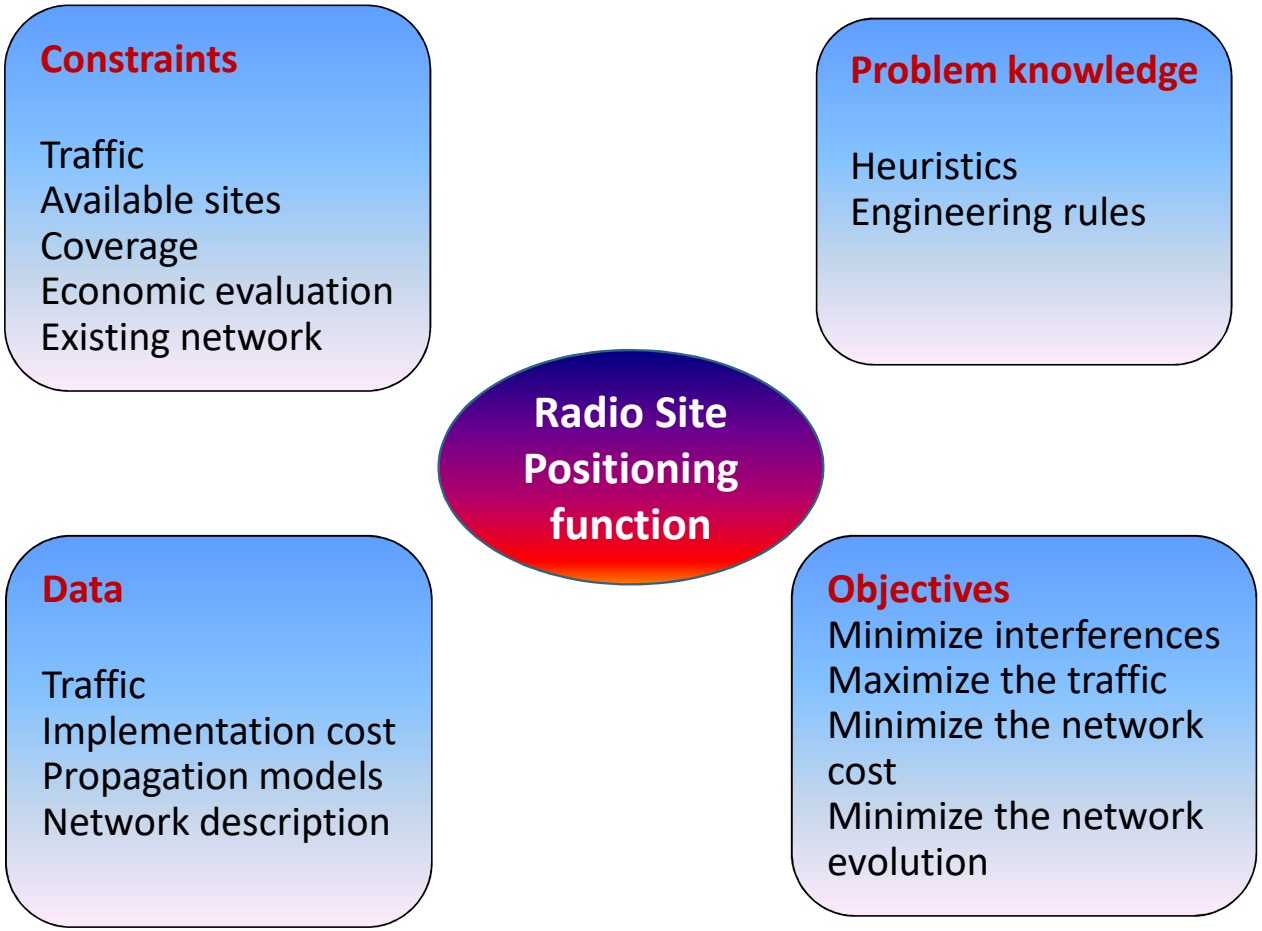
4rth constraint: Homogeneity

➔Sites and antennas parameters should respect, as much as possible, the homogeneity constraint:

- Hexagonal cluster,
- Antennas heights,
- Antennas azimuths,
- Antennas tilts.



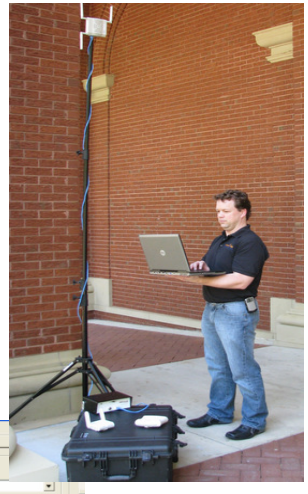
PLANNING PHASES



PLANNING PHASES

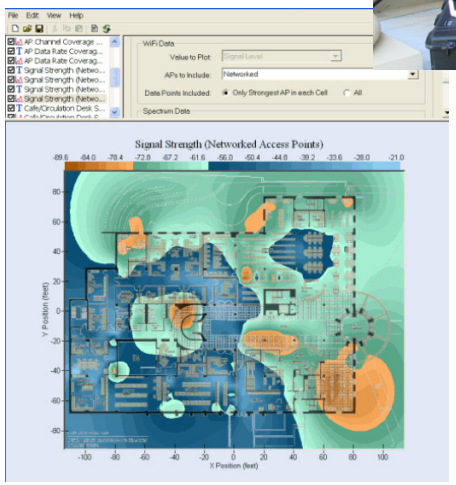
B. Site survey

- Practical sites research for BSs positioning
  - Information about the environment



➢General information (morphology, structure, ...) in **digital maps**,

➢Specific and detailed information.



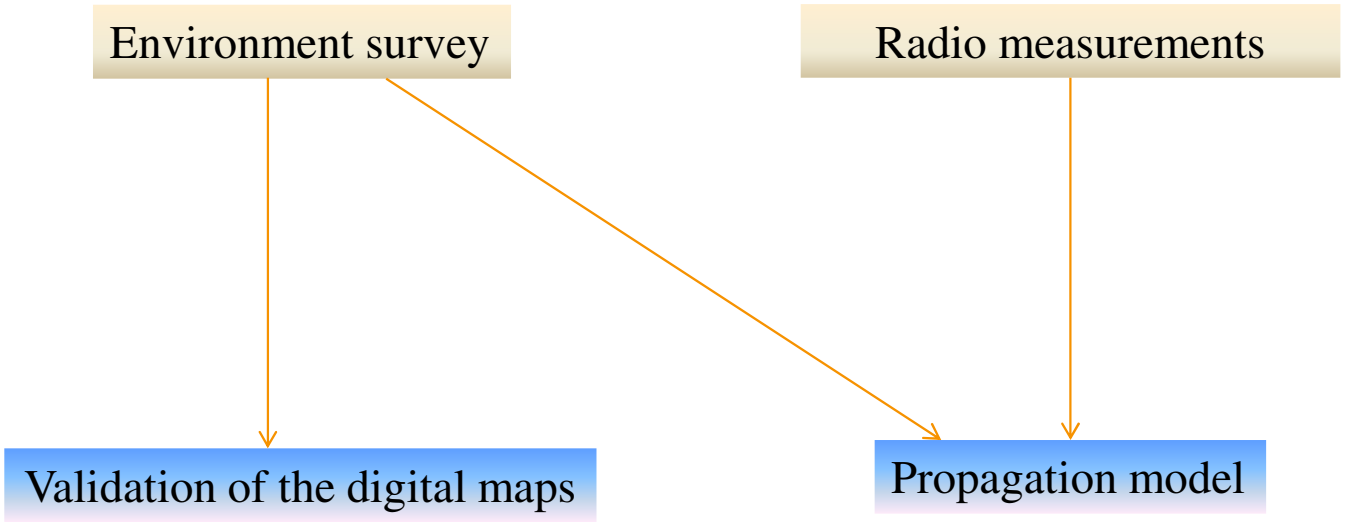
PLANNING PHASES

B. Site survey

- ✓Identify the highest sites,
- ✓Take pictures of the sites and environment,
- ✓Identify the towers and leur height,
- ✓Estimate the cables length (feeder, …),
- ✓Identify the existing infrastructure (buildings, energy, access, ...),
- ✓Collect sites coordinates,
- ✓….

PLANNING PHASES

Steps and process



PLANNING PHASES

Survey outputs

- ✓List of available sites.
- ✓Antennas constraints (type, height, aperture, …).
- ✓EIRP limitations.
- ✓Forbidden areas.

C. Coverage simulation tools

Radio engineering tools

- ✓To benefit from all network deployment required features (coverage calculation, data display, network optimization, …)
- ✓Very important gains in time and costs.

PLANNING PHASES

Propagation prediction tools

prediction: coverage, interference, performance, etc.

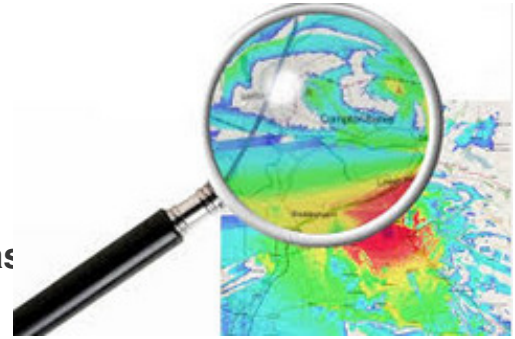
databases:

- geographical: topography, morphology, buildings, highways, etc.
- statistics: marketing, traffic density, …
- antenna systems,
- propagation prediction models,
- frequency allocation algorithms,
- sites (to be positioned),

determine the position of the sites,

distribute the frequencies to the sites,

determine the technical characteristics of the bas



PLANNING PHASES

Software modules

- Graphical user interface,
- Coverage prediction models,
- Frequency allocation algorithms,
- Network dimensioning methods (in BSs and BSCs number),
- Interfaces with data transmission networks (to collect measurements and counters from the OSS),
- Interfaces with radio signal measurements tools,
- Integration of advanced features (diversity, ...),
- Handovers simulation modules, ...

Radio penetration thresholds

- Based on statistical techniques,
- Modeled by an additional loss (in-building),
- Model predicted loss = outdoor loss + indoor loss.

Type of penetration	*Loss*	*Standard deviation*
Dense urban	20 dB	8 dB
Urban	15 dB	8 dB
Suburban	10 dB	8 dB
Rural	8 dB	8 dB
In-car	6 dB	6 dB

PLANNING PHASES

Tuned parameters

- When coverage or quality criteria are not fulfilled, sites characteristics are modified:

  - Transmission power,
  - Antennas azimuths,
  - Antennas tilts,
  - Sites sectorisation,
  - Sites position changing,
  - Sites addition,
  - ...

PLANNING PHASES

Optimized and considered data

Transmitted data

- antenna,
- technical parameters (power and frequency margins, sensitivity, …).

Data network

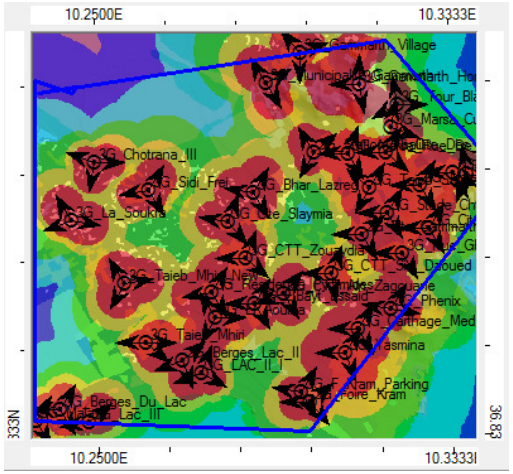
- Sites,
- Cells, sectors, links,
- Neighbors,
- Frequency plan, reuse clusters.

Interfering networks data

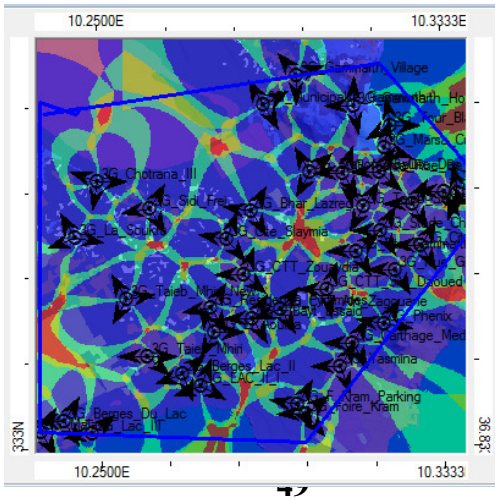
- Other operators offering the same service,
- Other services,
- Other countries.

PLANNING PHASES

Coverage by transmitter:
Display the best server coverage



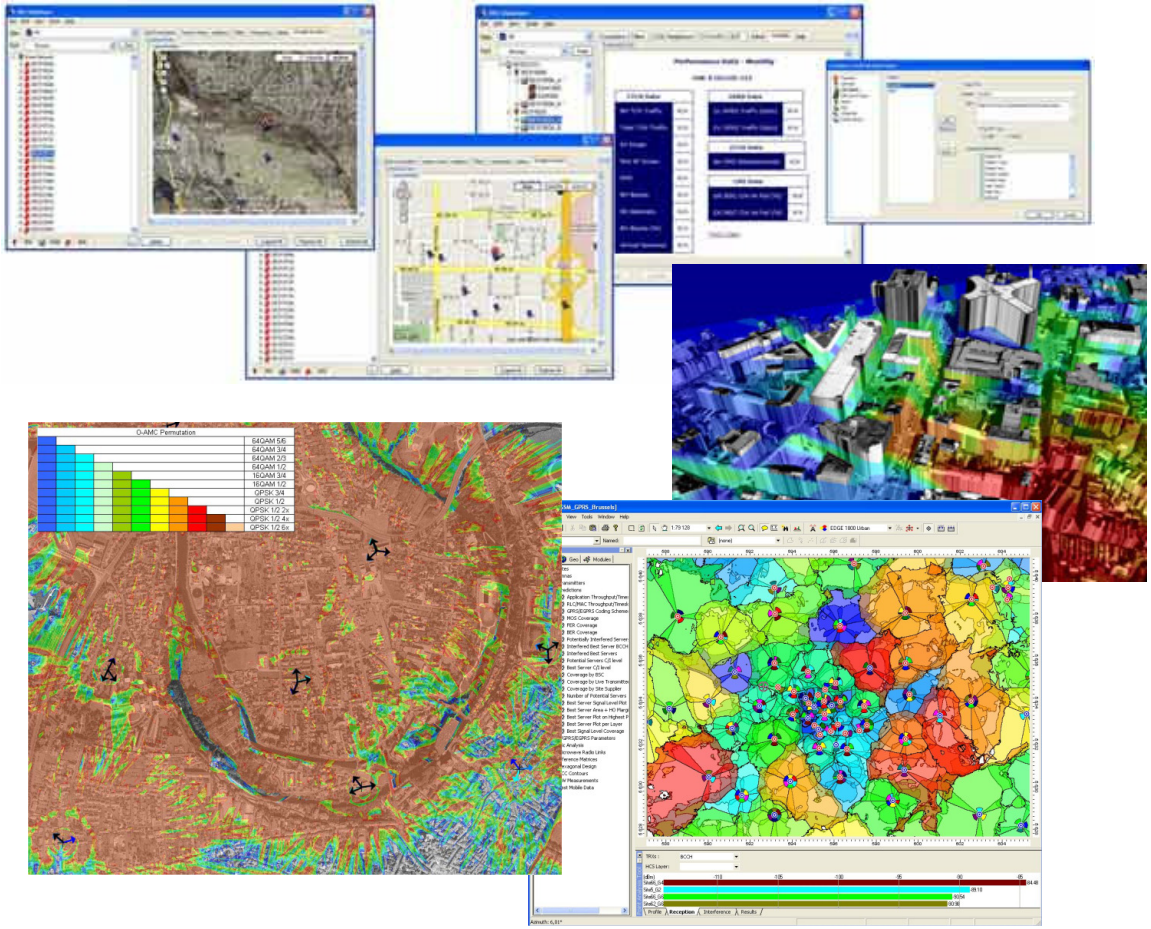
Coverage by signal level:
Display the signal level across the studied area



Overlapping zones:
Display the signal level across the studied area

8. Tools

TOOLS USED FOR RADIO PLANNING



Main Planning Tools:

- Aircom Asset
- Mentum Planet
- Atoll FORSK
- ATDI
- WinProp
- EDX Signal Pro
- CelPlan
- Siradel
- Pathloss

Main Optimization Engines

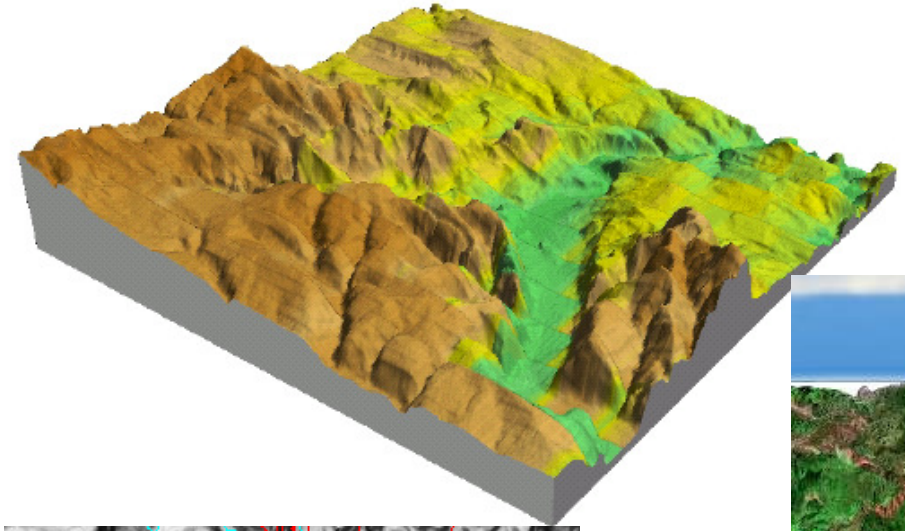
- Actix
- Capesso

TOOLS USED FOR RADIO PLANNING

- Used to assets designing an optimizing Wireless network by :
  - Prediction of coverage
  - Frequency planning automatically
  - Creating neighboring list
- With a data base takes into account :
  - Clutter
  - Antenna radiation
  - Terrain
  - Number of users
  - Services supported

- ***Geographical databases***
  - Digital terrain map (DTM).
  - Clutter.
  - 3D databases.
  - Indoor architecture.

TOOLS USED FOR RADIO PLANNING



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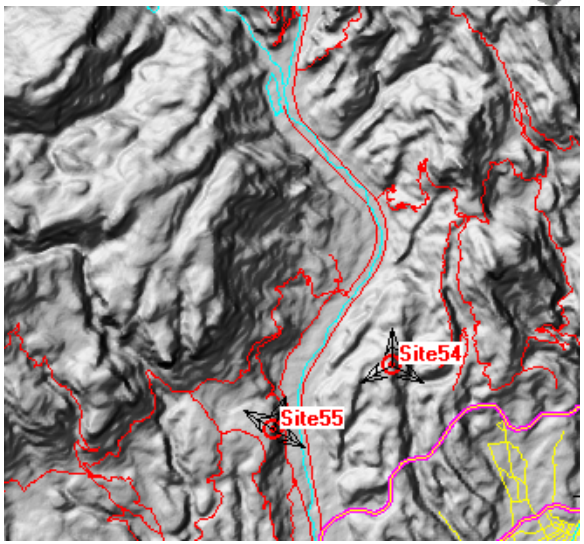
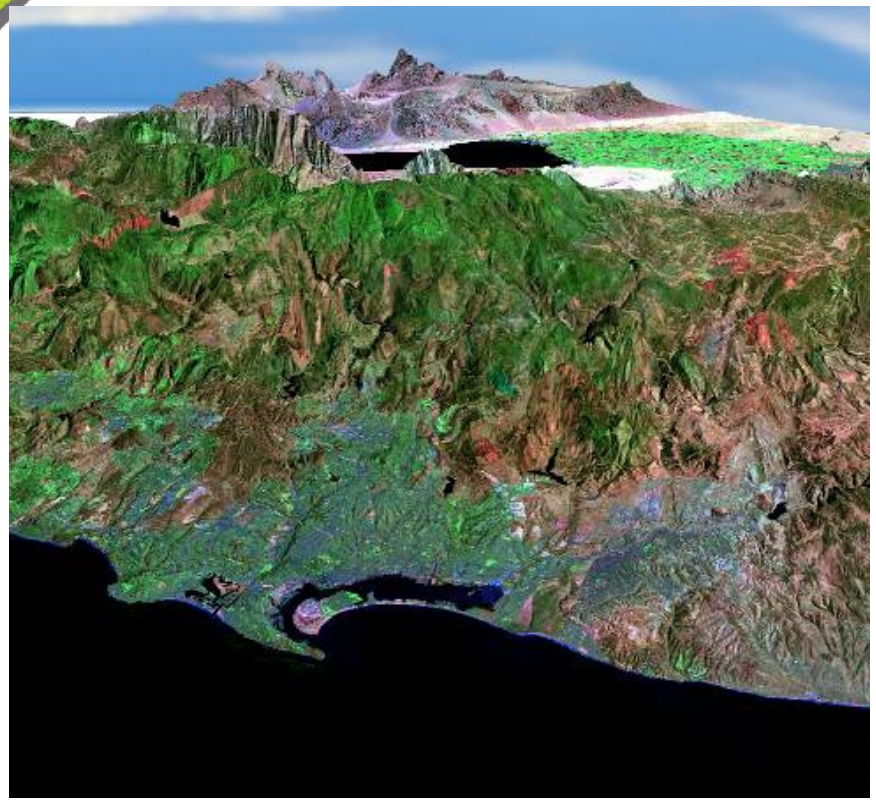
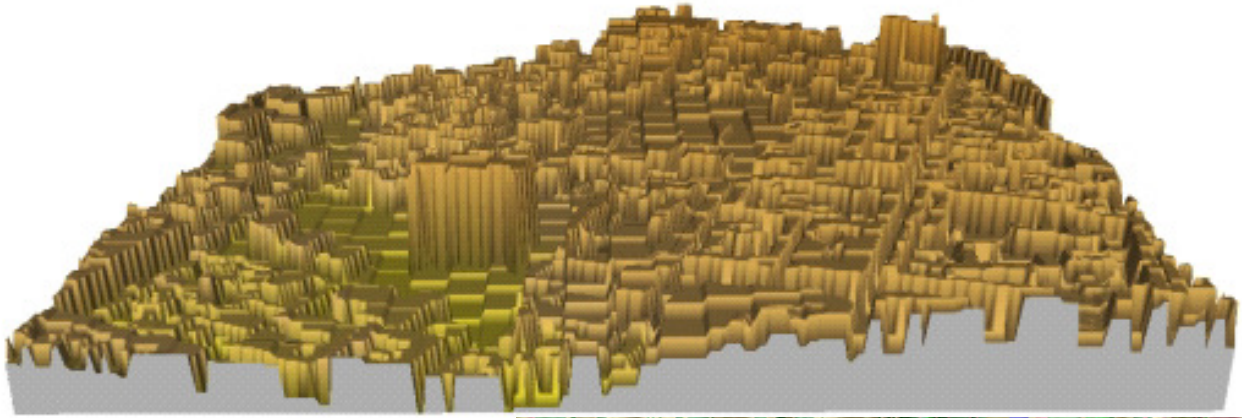
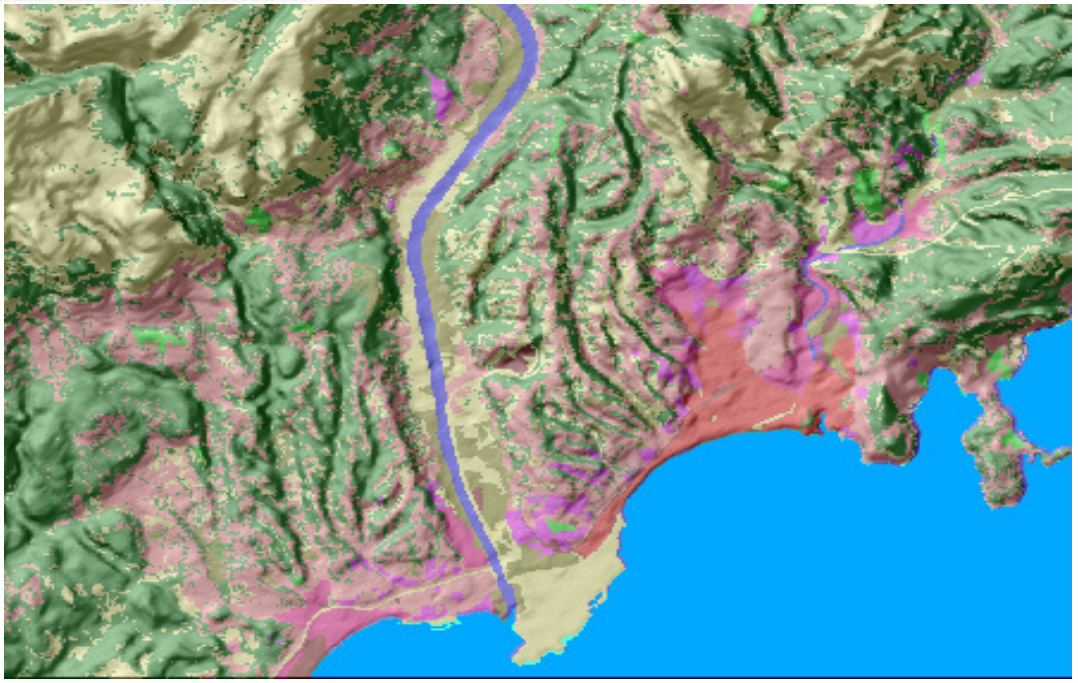




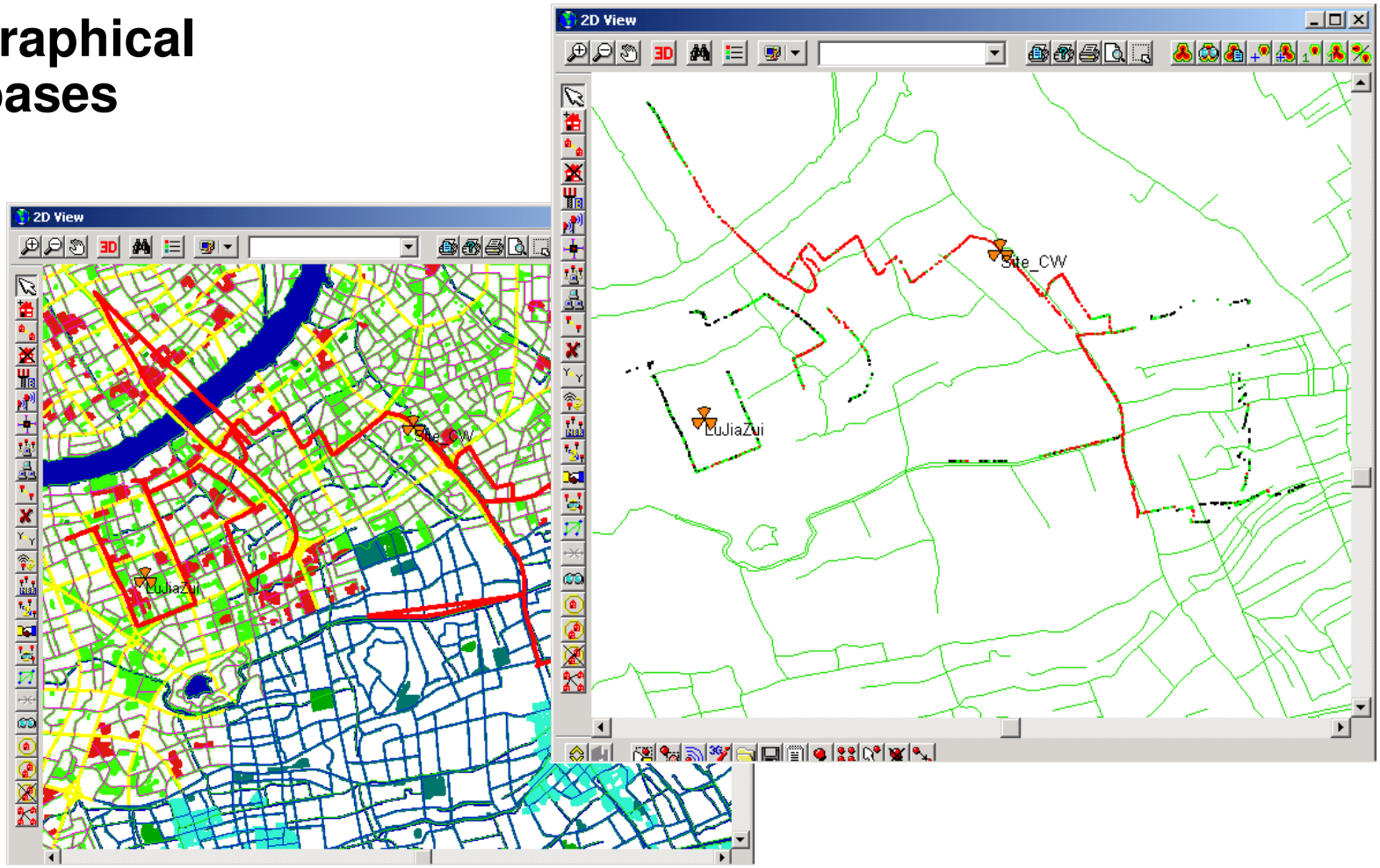
TOOLS USED FOR RADIO PLANNING



MNT + Clutter



Geographical databases



TOOLS USED FOR RADIO PLANNING

- **DTM – Digital Terrain Model**
- **DEM – Digital Elevation Model**

Sources

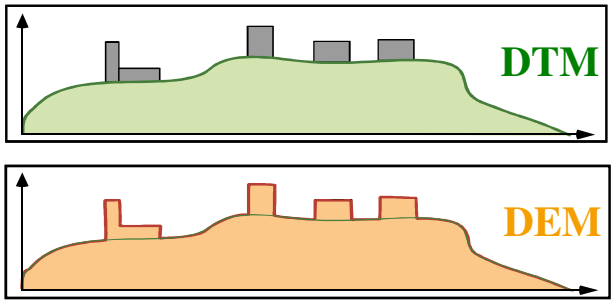
– paper maps

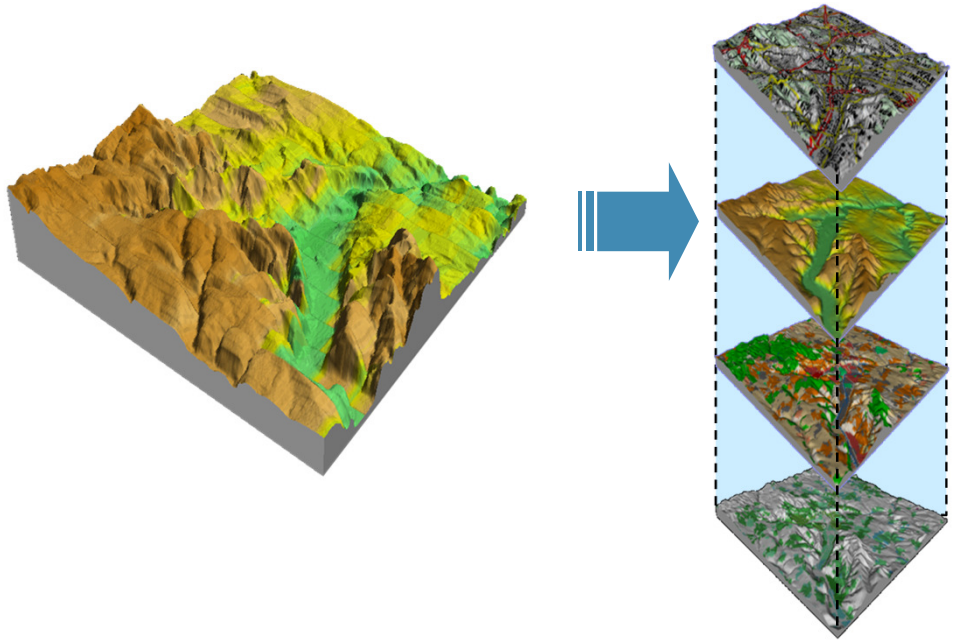
– satellite images

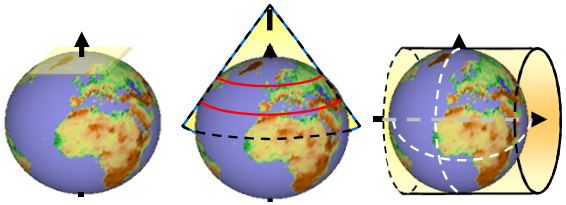
– …

Typical resolution:

– 20m – 1000m per pixel



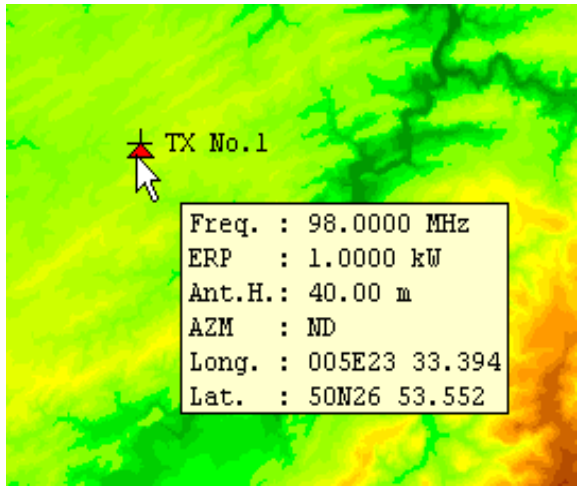


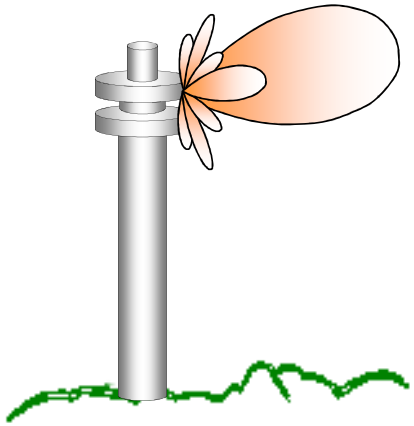


TOOLS USED FOR RADIO PLANNING

- *Parameters used for coverage prediction*

- Coordinates of the transmitter
- Radiated power
- Frequency
- Antenna diagram

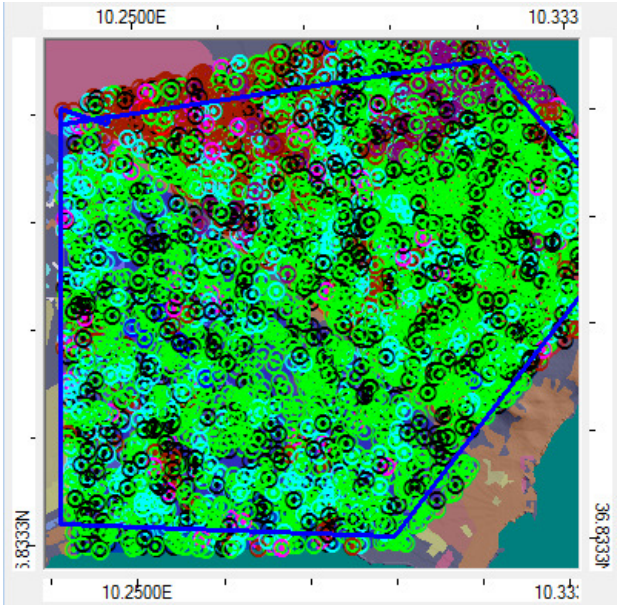




TOOLS USED FOR RADIO PLANNING

- *Coverage simulation*

- Static/Dynamic simulation
- Distributions (snapshots)
- By iteration,



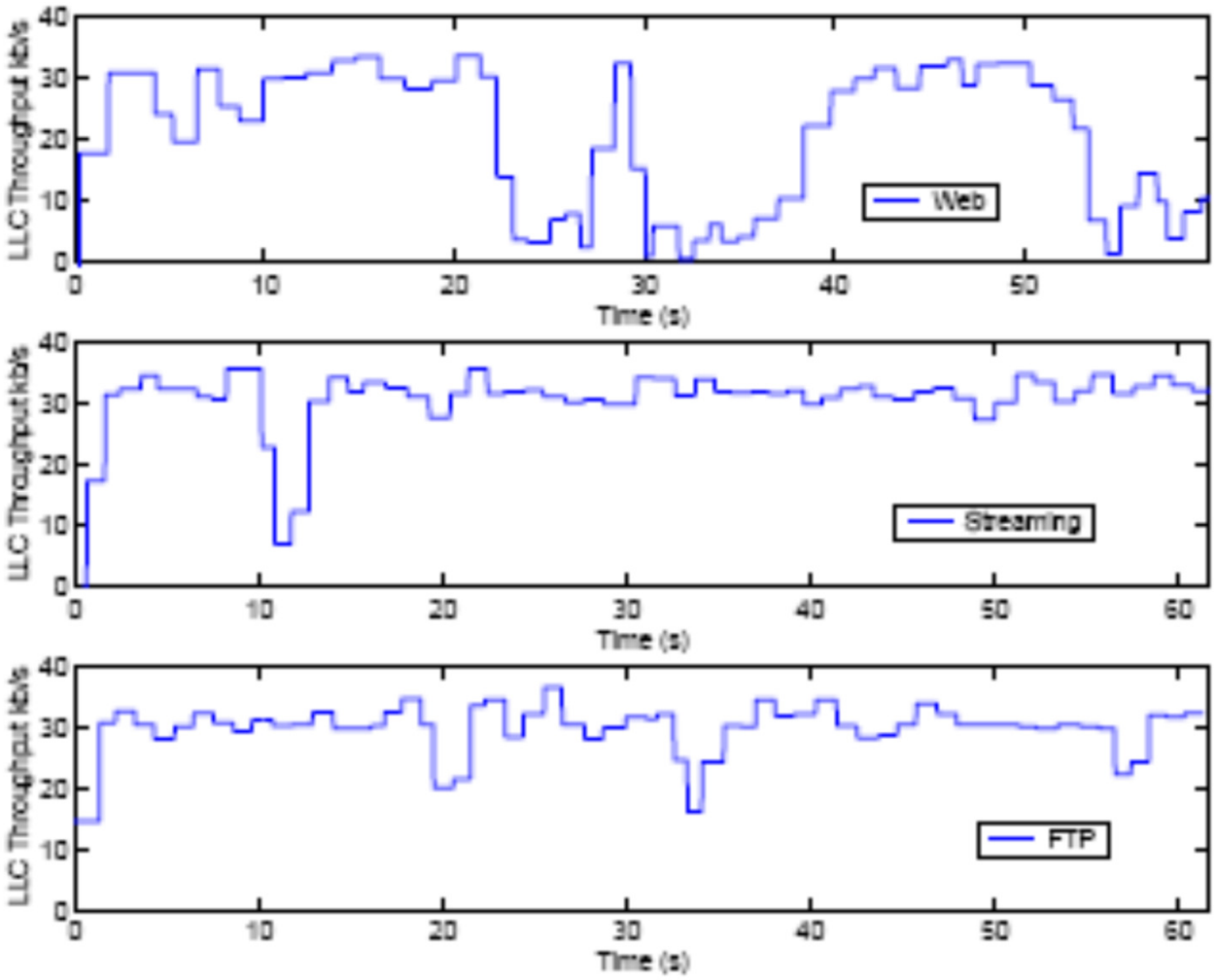
➔ UL/DL cell load, connection status and rejected reason for each mobile

II. Dimensioning

CIRCUIT SWITCHED VERSUS PACKET SWITCHED DIMENSIONING

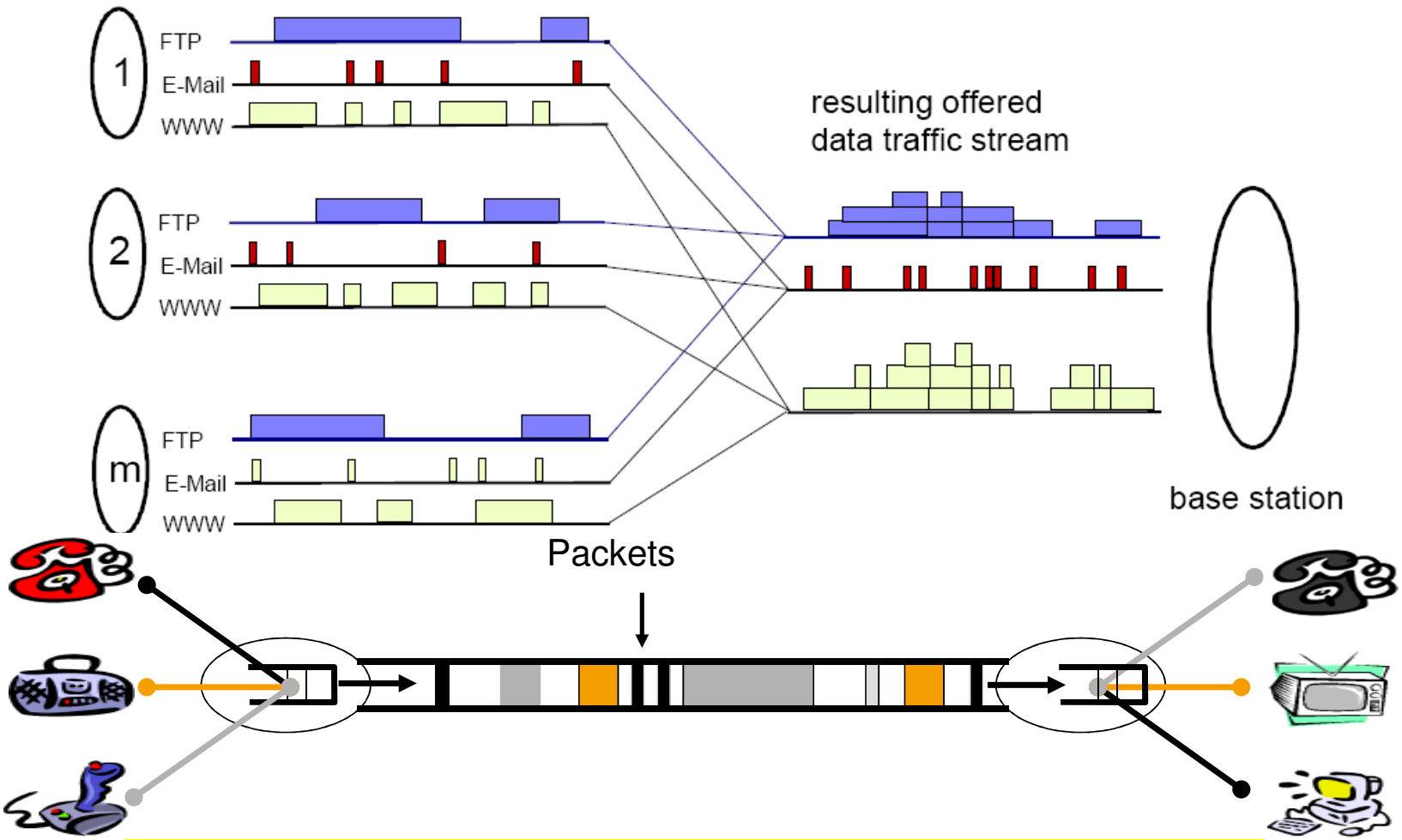
	Circuits	Packets
Maximum bitrate / connection	Fixed (limited)	Variable (≤ maximum)
QoS (GoS, throughput, data loss …)	Deterministic	Unpredictable
Traffic models	Simples	Complexes
Simultaneous connections number	Limited	Adaptable and flexible
Network resources	No optimization, possible waste	Optimization with complex resource allocation algorithms
Resource management	Simple	Complex

EXAMPLES OF TRAFFIC TRACES



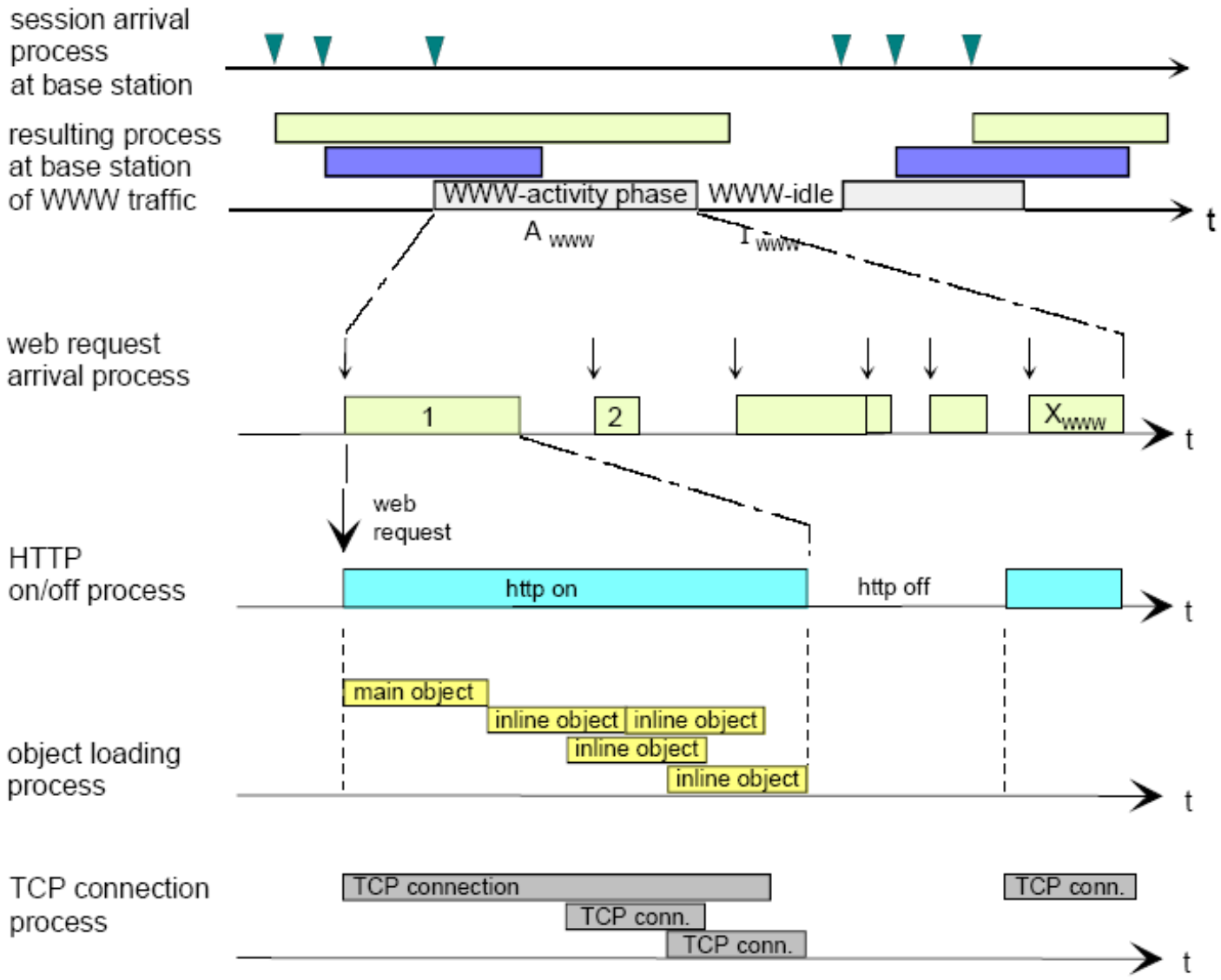
http service traffic is more bursty than video streaming and ftp services traffic

TRAFFIC AGGREGATION

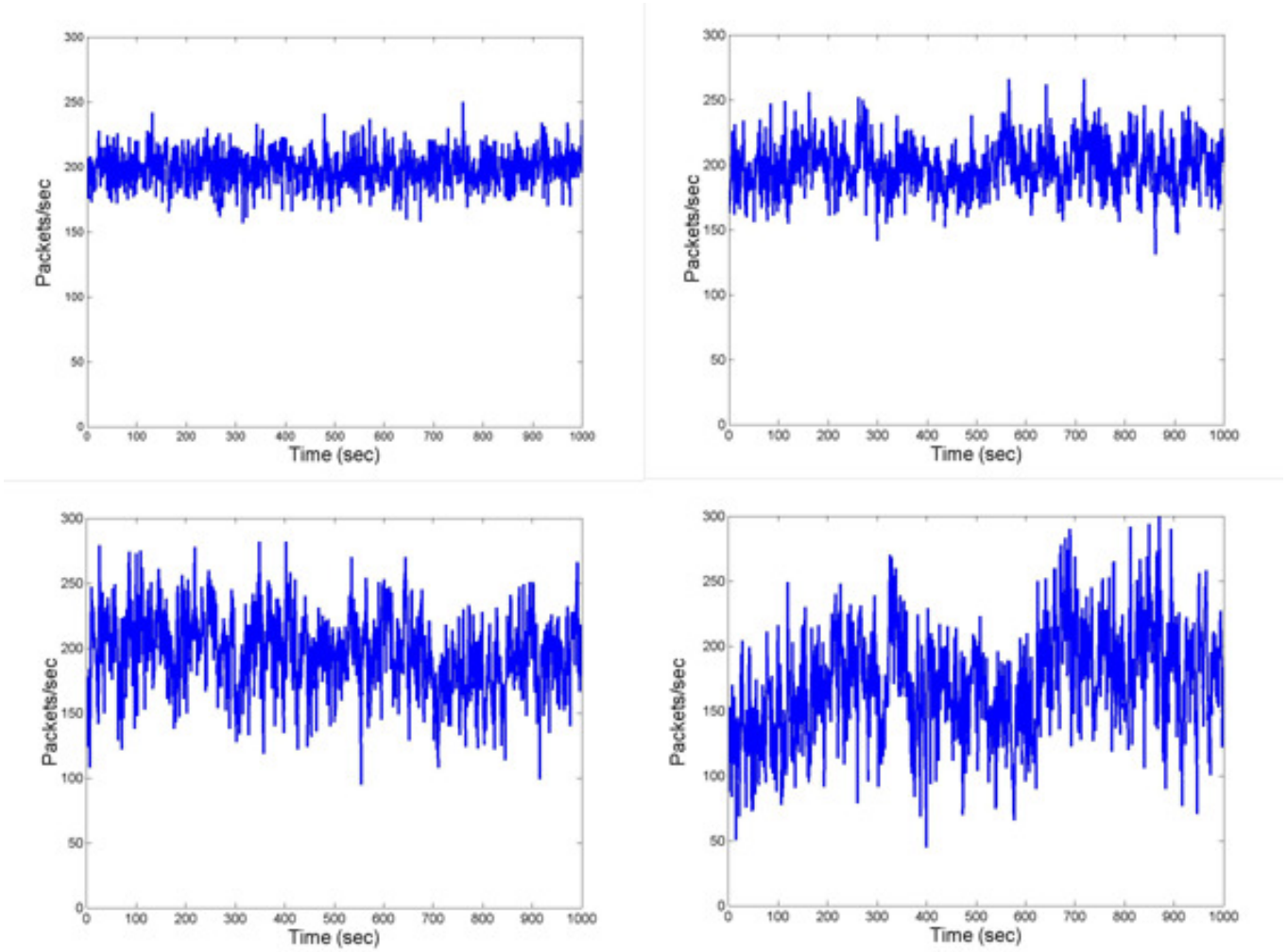


Dimensioning objective: determine the total required bandwidth to carry the aggregated traffic with related QoS targets

WEB SERVICE

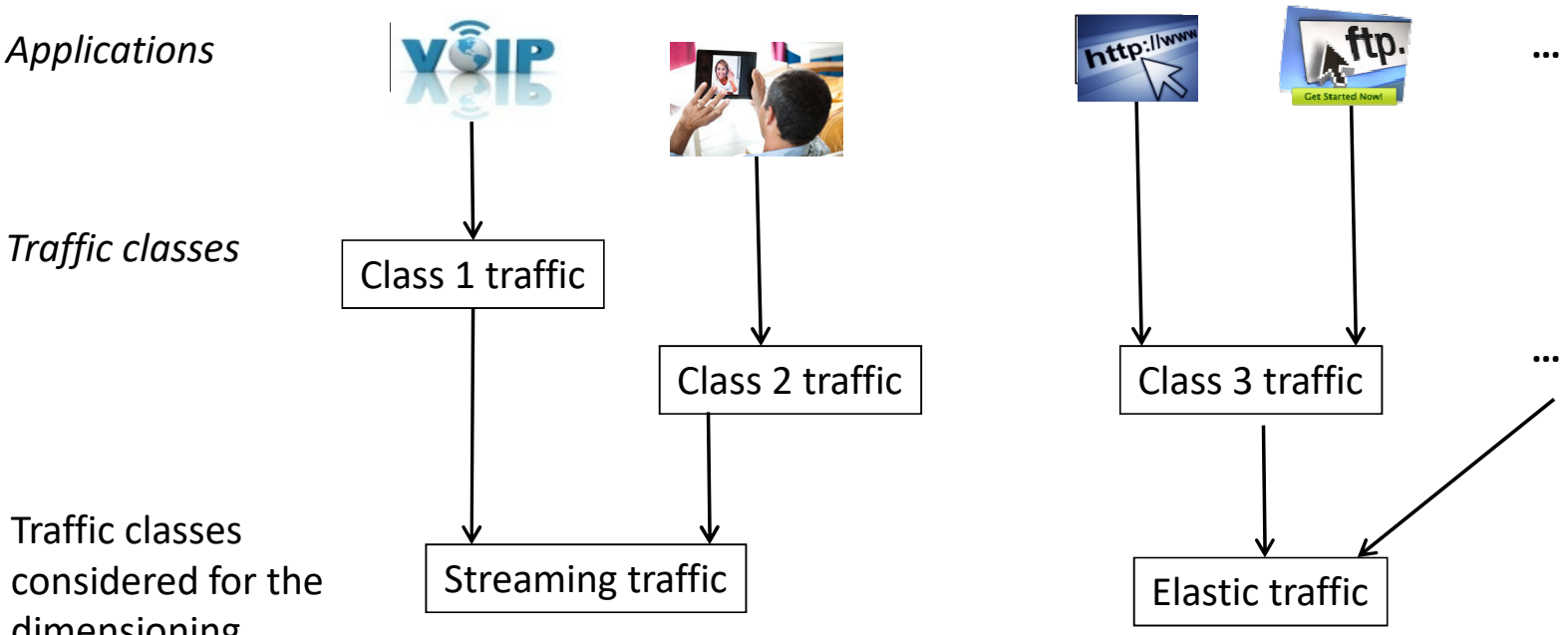

session arrival process at base station
resulting process at base station of WWW traffic
WWW-activity phase
WWW-idle
A www
I www
t
web request arrival process
1
2
X www
web request
HTTP on/off process
http on
http off
main object
inline object
inline object
inline object
inline object
object loading process
TCP connection process
TCP connection
TCP conn.
TCP conn.
TCP conn.

DIFFERENT BURSTINESS LEVELS EXAMPLE AT SAME PACKET RATE



DATA SERVICES DIMENSIONING PROCESS

Classification of the traffic for priority handling



- Models integrated into a **simulator** which generates, for different scenarios (e.g., service usage, subscriber types, codecs, …) an aggregated traffic volume used to dimension the capacity of the nodes and/or the interfaces.
- ***Drawback***: complex, time consuming and requires accurate hypothesis.

QOS ASPECTS: EXAMPLE OF LTE QCI VALUES

QCI	RESOURCE TYPE	PRIORITY	PACKET DELAY BUDGET (MS)	PACKET ERROR LOSS RATE	EXAMPLE SERVICES
1	GBR	2	100	10^{-2}	Conversational voice
2	GBR	4	150	10^{-3}	Conversational video (live streaming)
3	GBR	5	300	10^{-6}	Non-conversational video (buffered streaming)
4	GBR	3	50	10^{-3}	Real-time gaming
5	Non-GBR	1	100	10^{-6}	IMS signaling
6	Non-GBR	7	100	10^{-3}	Voice, video (live streaming), interactive gaming
7	Non-GBR	6	300	10^{-6}	Video (buffered streaming)
8	Non-GBR	8	300	10^{-6}	TCP-based (for example, WWW, e-mail), chat, FTP, p2p file sharing, progressive video and others
9	Non-GBR	9	300	10^{-6}	

Bandwidth based dimensioning

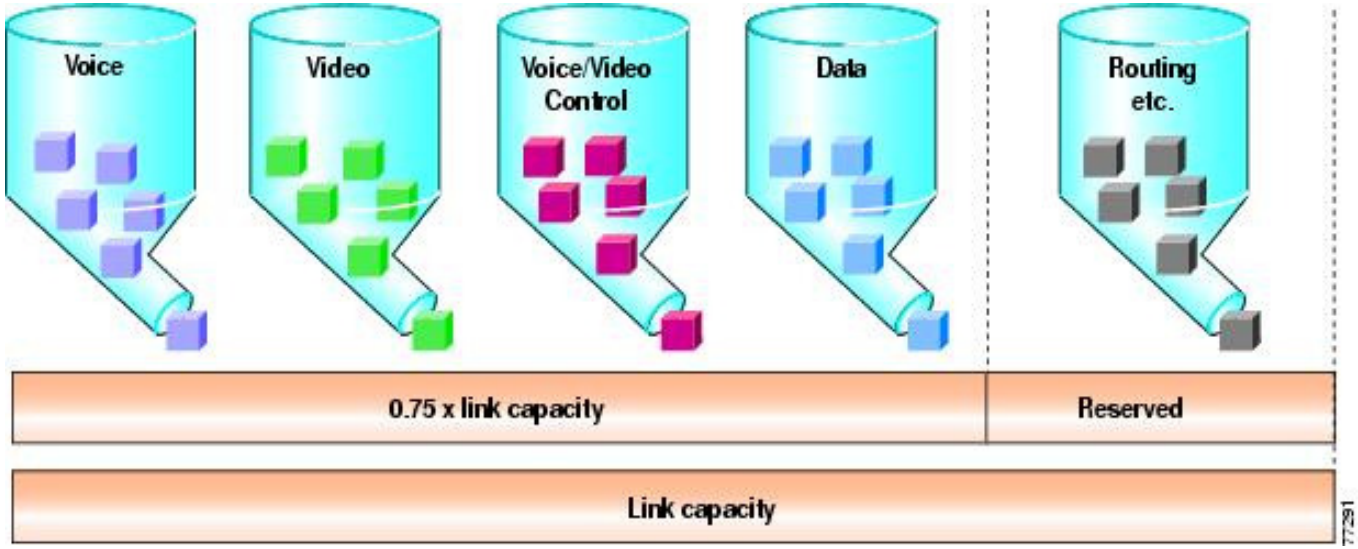
GENERAL APPROACH DESCRIPTION

- Dimensioning (UL or DL): based on the services required bandwidth estimation.
- **Contention ratios**: to reflect the bursty nature of the ***traffic*** and of the ***service activity*** as well as the ***priorities*** of the users and services.
- **Aggregation of the traffic** flows bitrates: to estimate the ***total link*** or ***node capacity***.
- If overload (unpredicted users and services behavior): ***scheduling*** and ***queuing*** mechanisms maintain the QoS of high priority traffic. QoS parameters of some services will be degradated (e.g., bitrate, jitter, delay, BLER, …).

ELASTIC APPLICATIONS

Elastic

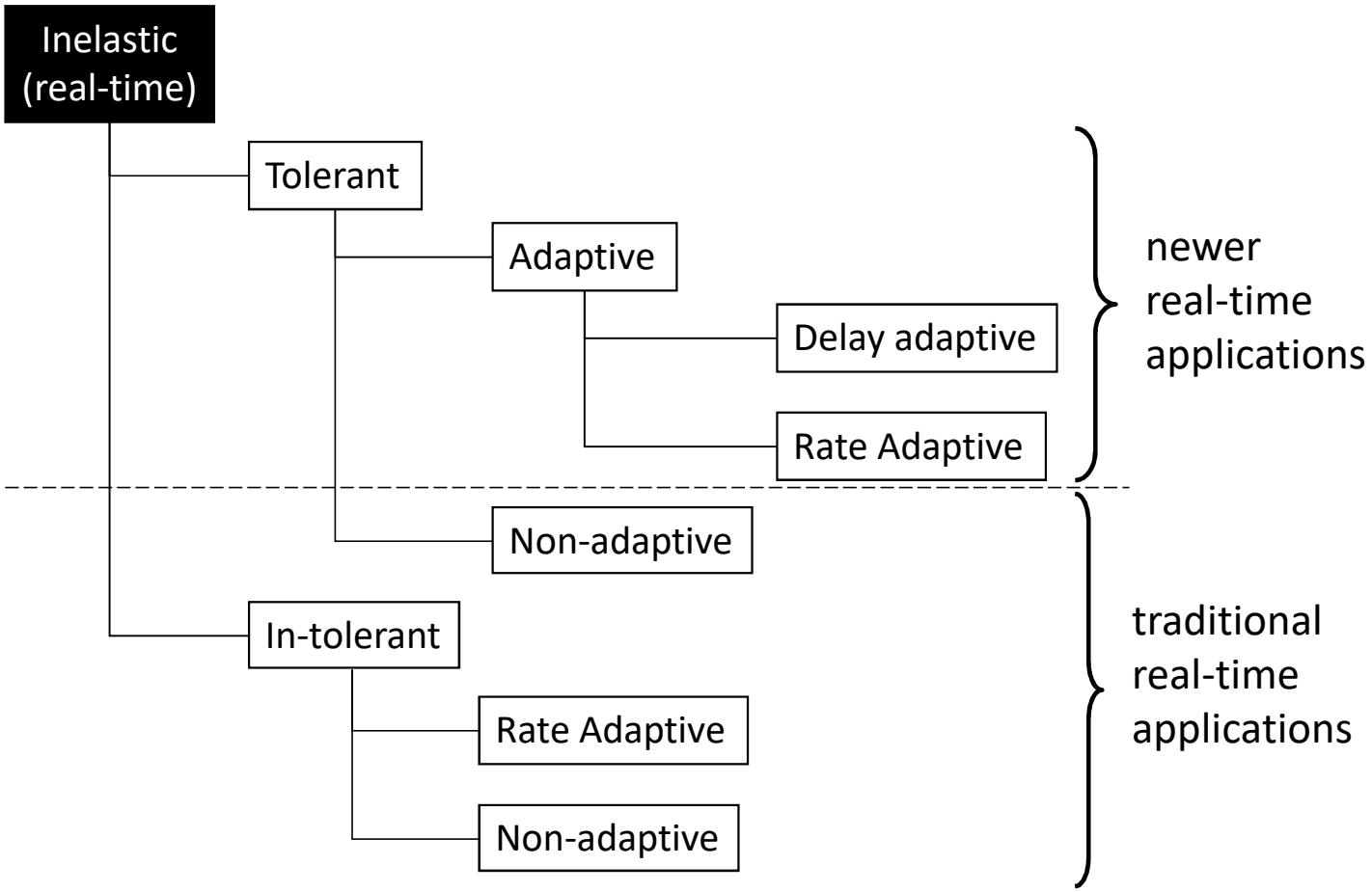
- Interactive — e.g. Telnet, X-windows
- Interactive bulk — e.g. FTP, HTTP
- Asynchronous — e.g. E-mail, voice-mail



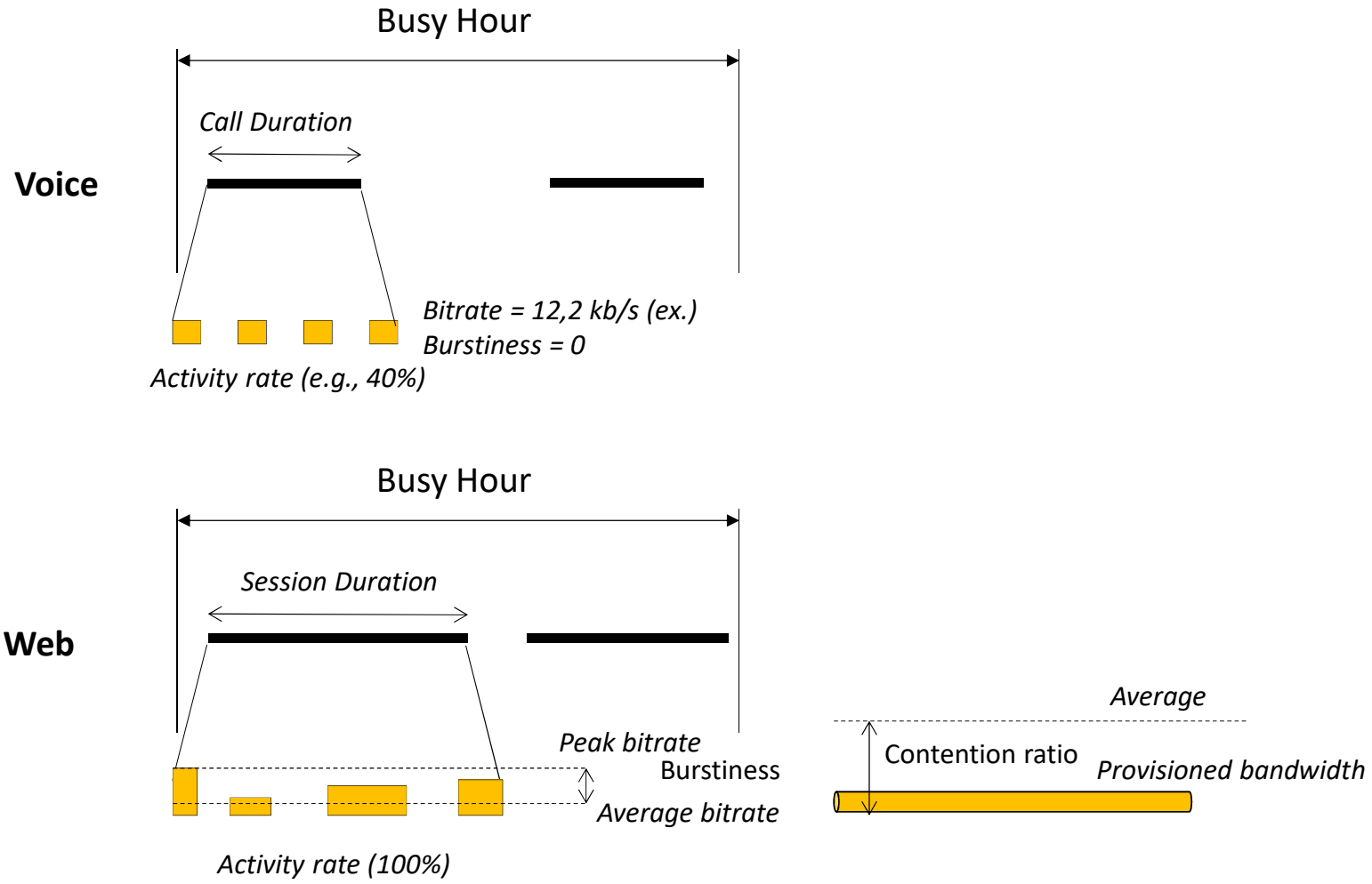
EXAMPLES OF ELASTIC APPLICATIONS

- E-mail:
  - asynchronous
  - message is not real-time
  - delivery in several minutes is acceptable
- File transfer:
  - interactive service
  - require “quick” transfer
  - “slow” transfer acceptable
- Network file service:
  - interactive service
  - similar to file transfer
  - fast response required
  - (usually over LAN)
- WWW:
  - interactive
  - file access mechanism(!)
  - fast response required
  - QoS sensitive content on WWW pages

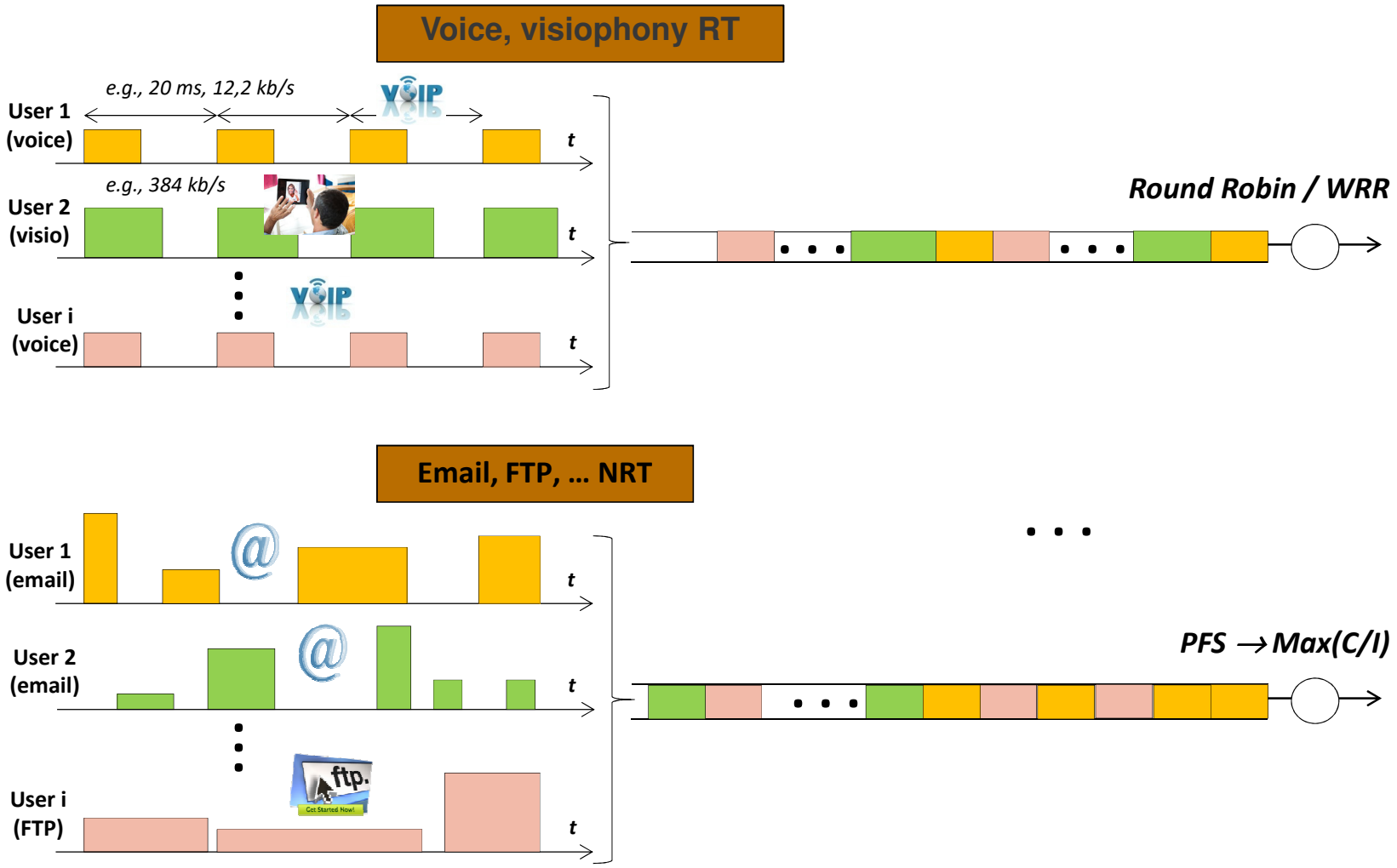
INELASTIC APPLICATIONS



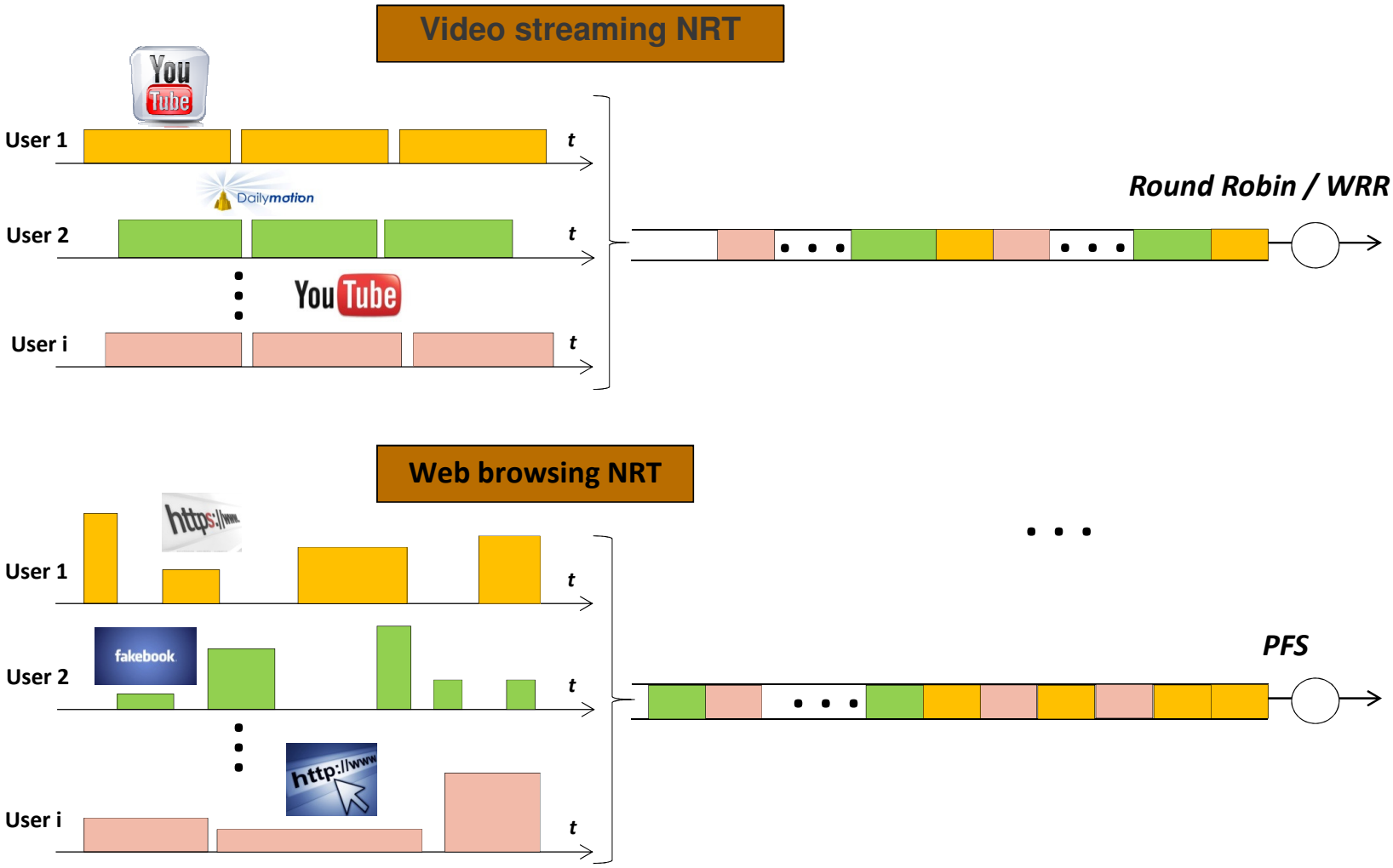
BURTSINESS, ACTIVITY RATE, CONTENTION RATIO



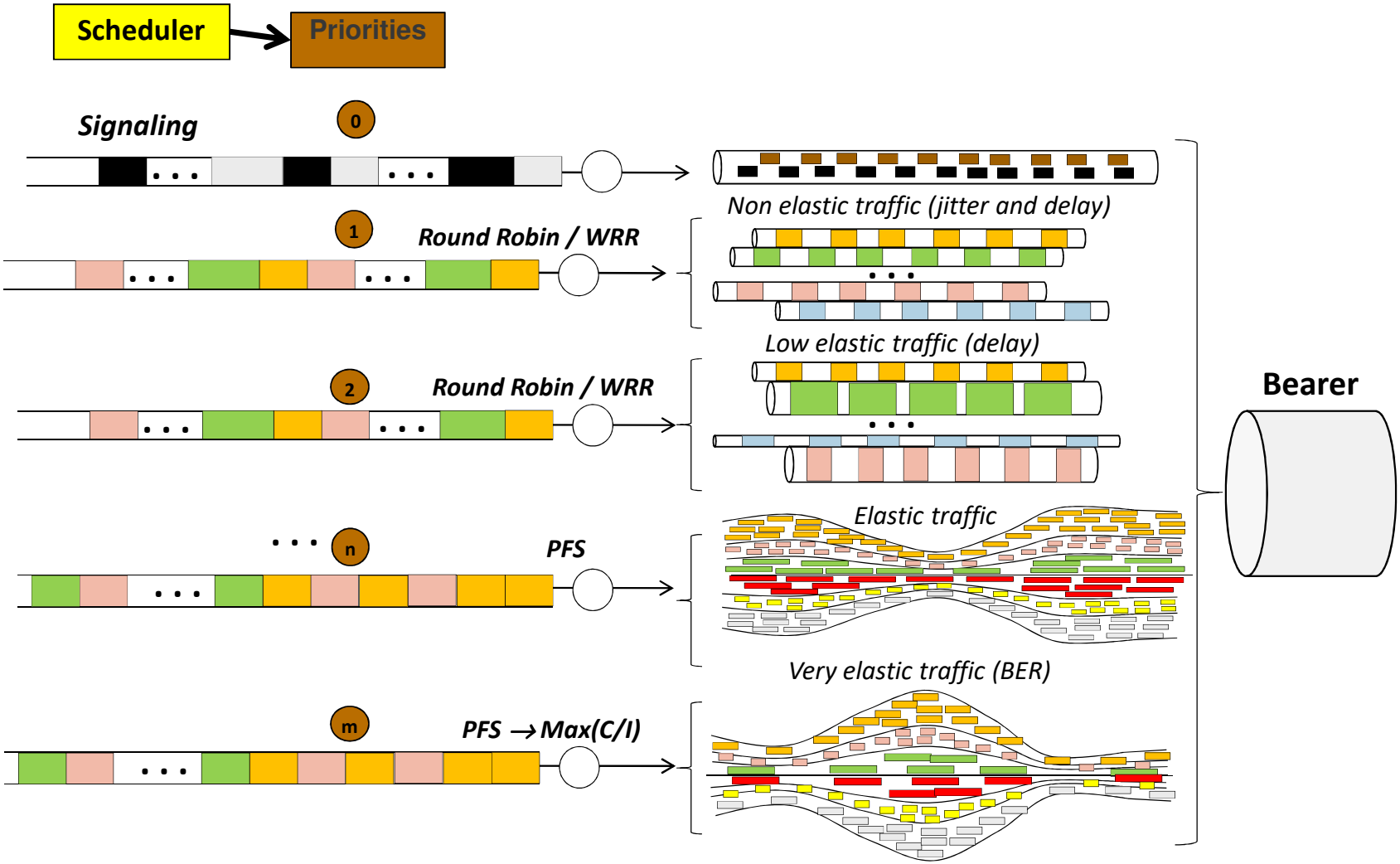
SERVICES CLASSIFICATION AND QUEUING EXAMPLE



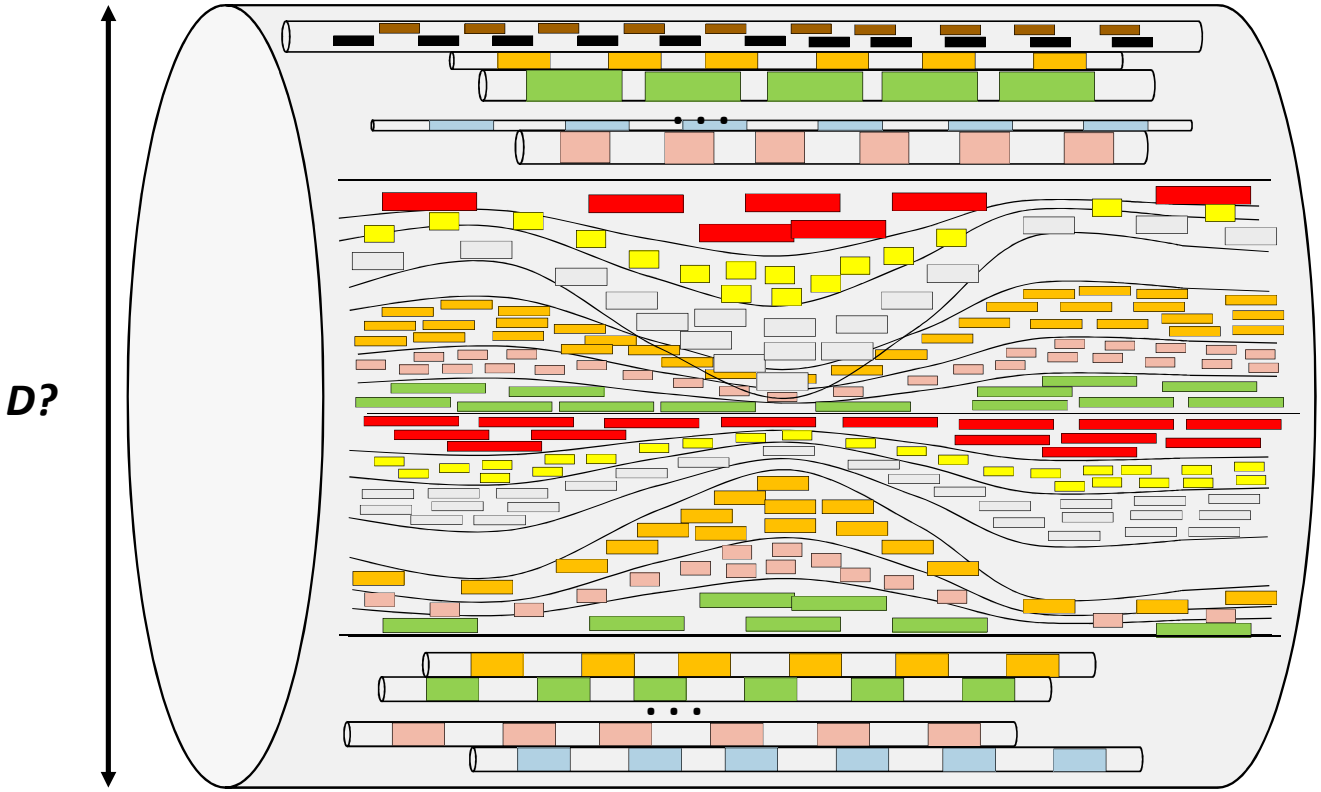
SERVICES CLASSIFICATION AND QUEUING EXAMPLE



SERVICES TRAFFIC AGGREGATION AND PRIORITIZATION EXAMPLE



Aggregated bearers



Dimensioning purpose: determine the bearer bitrate ***D***

THEORETICAL CELL AVAILABLE BANDWIDTH

Cell load	Inter site distance	
	500 m.	1732 m.
0%	2.17384	1.68426
5%	2.16822	1.44588
10%	2.07655	1.25680
15%	1.96951	1.16004
20%	1.86613	1.12126
25%	1.77003	1.08615
30%	1.67839	1.03514
35%	1.59381	1.03514
40%	1.51367	1.02943
45%	1.44084	1.01242
50%	1.37164	1.00934
55%	1.30975	1.00622
60%	1.25242	1.00491
65%	1.20192	1.00328
70%	1.15599	1.00211
75%	1.11735	1.00000
80%	1.08236	1.00000
85%	1.05467	1.00000
90%	1.03153	1.00000
95%	1.01523	1.00000
100%	1.00000	1.00000

Loading factor — Scaling factor

Capacity = C_{total}*Loading Factor*Scaling Factor

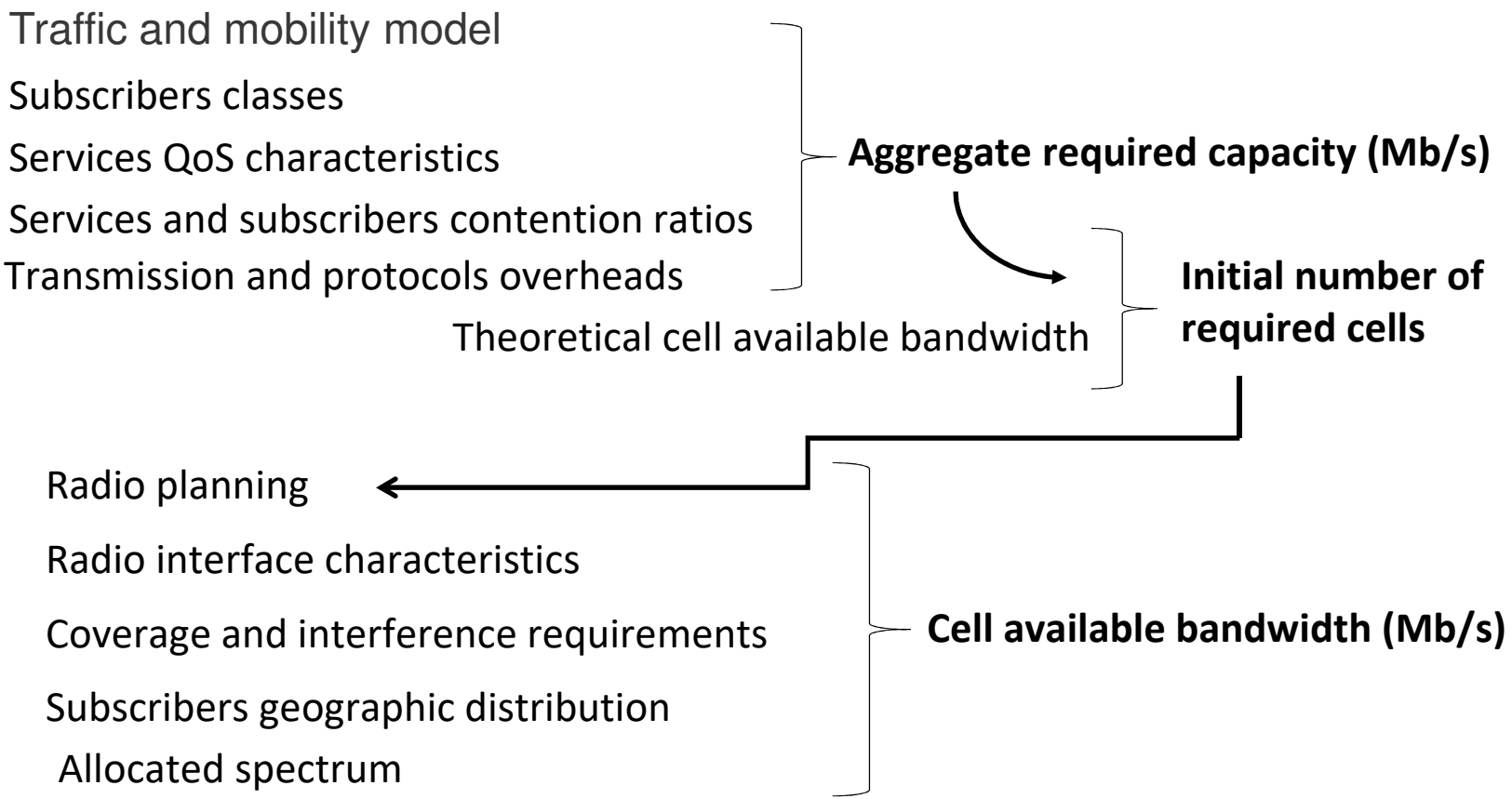
3GPP Release	User Equipment Category	Maximum L1 datarate Downlink	Maximum number of DL MIMO layers	Maximum L1 datarate Uplink
Release 8	Category 1	10.3 Mbit/s	1	5.2 Mbit/s
Release 8	Category 2	51.0 Mbit/s	2	25.5 Mbit/s
Release 8	Category 3	102.0 Mbit/s	2	51.0 Mbit/s
Release 8	Category 4	150.8 Mbit/s	2	51.0 Mbit/s
Release 8	Category 5	299.6 Mbit/s	4	75.4 Mbit/s
Release 10	Category 6	301.5 Mbit/s	2 or 4	51.0 Mbit/s
Release 10	Category 7	301.5 Mbit/s	2 or 4	102.0 Mbit/s
Release 10	Category 8	2998.6 Mbit/s	8	1497.8 Mbit/s

Theoretical capacity: C_{Total}

Example: ***C_{total}*** = 150.8 Mb/s, ***Loading Factor*** = 60% and ***Scaling Factor*** = 1.25242 (for cell radius = 500m.)
Capacity = 150.8*0.60*1.25242 = 113.319 Mb/s

DIMENSIONING PROCESS

Step 1: initial configuration (dimensioning and planning)



DIMENSIONING PROCESS

Step 2: final configuration

Cell available bandwidth (Mb/s)

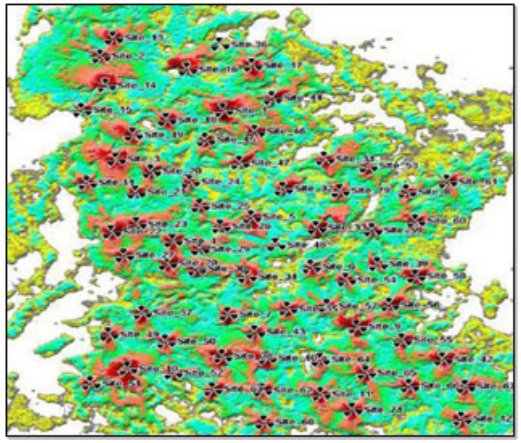
Aggregate required capacity (Mb/s)

Coverage and interference characteristics

Radio interface characteristics

New radio planning: optimization

Final number of required cells and sites configuration



INPUTS

- Subscribers classes,
- Service usage/subs. class,
- Contention ratios/subs. class,
- Subscribers geographic distribution,
- Services bitrates,
- Services and protocols overheads.

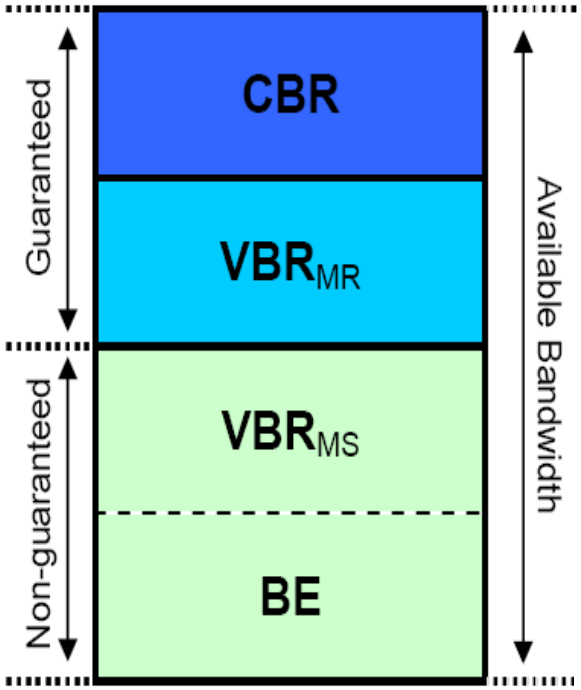
MCS DESCRIPTION AND REQUIRED RECEIVER SENSIBILITY

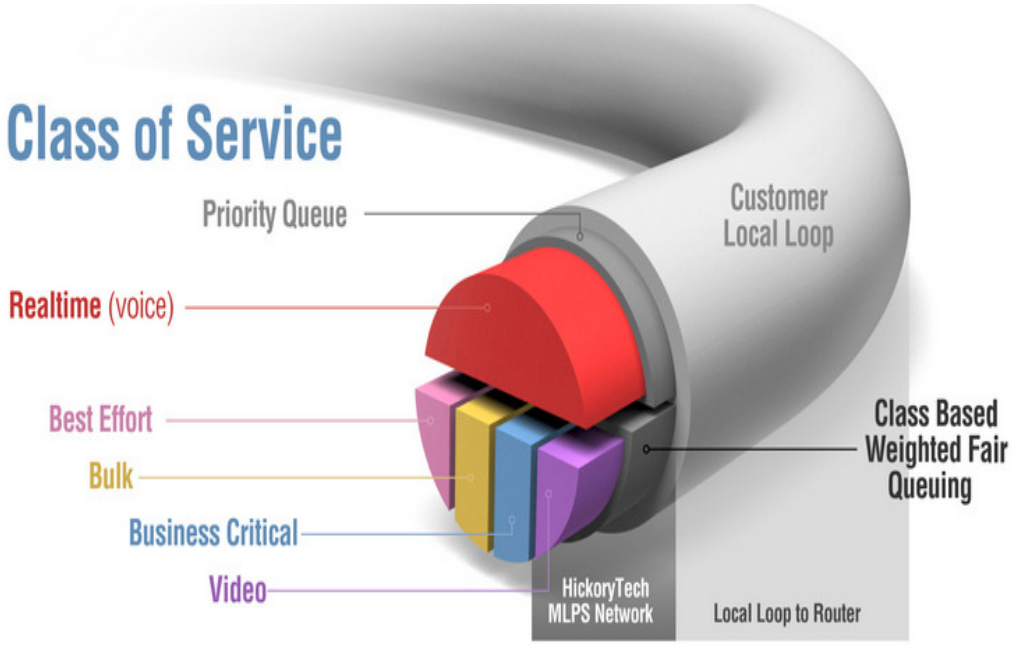
Modulation Type	Coding Rate	SNR	S_{RX} 5 MHz	S_{RX} 10 MHz
QPSK	1/2	5	-92,30	-89,29
	3/4	8	-89,30	-86,29
16-QAM	1/2	10,5	-86,80	-83,79
	3/4	14	-83,30	-80,29
64-QAM	1/2	16	-81,30	-78,29
	2/3	18	-79,30	-76,29
	3/4	20	-77,30	-74,29

MSC DISTRIBUTION AMONG USERS IN THE CELL EXAMPLE

Modulation Type	Coding Rate	Weight	K
BPSK	1/2	5.0%	1
QPSK	1/2	2.5%	2
	3/4	2.5%	2
16-QAM	1/2	5.0%	4
	3/4	5.0%	4
64-QAM	2/3	40.0%	6
	3/4	40.0%	6

DISTRIBUTION OF THE CAPACITY PER QOS TYPE





CONTENTION RATIO

- Measures the simultaneity of users requesting bit rate from the BS because most users won't demand data at the same time. The absolute peak demand on shared resources rarely occurs. User simultaneity is defined by the ***contention ratio***.
- If many of the connected subscribers demand data, their packets will be delivered assuming some latency or jitter (less priority).
- *Example*: if 2 **contention ratios** are defined for the non-guaranteed partition of the bandwidth (e.g., **30** for *residential users* (less priority) up to **10** for *business users* (higher priority and throughput)), we have:

Subscriber class	DL BE service	Offered data rates
Residential Class	X = 512 kbps	X' = 512/30=17 kbps
Business Class	Y = 1 Mbps	Y' = 1000/10=100 kbps

↯ Actual data-rates considered in the system capacity calculations.

OVER SUBSCRIPTION RATIO (1)

- OSR = ratio of the total subscriber's demand over the reference capacity of the base station when taking into account the adaptive modulation.
- The reference capacity of the base station corresponds to the available bit rate of the lowest modulation scheme served with that BS (here BPSK1/2).

$$C_{ref} = FFT_{used}/2T_s$$

- FFT_{used} and T_s (symbol duration) values depend on the channel bandwidth (in LTE: from 72 to 1200) and the Cyclic Prefix factor respectively (=CP/Symbol duration).

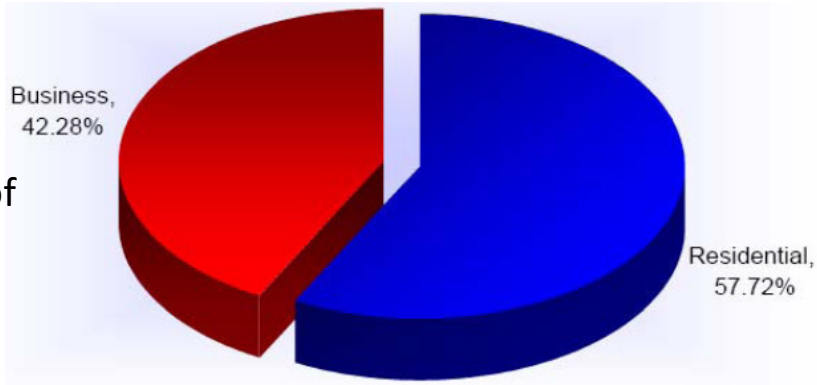
OVER SUBSCRIPTION RATIO (2)

- *Residential class* = **A%** of the users in the cell,
- *Business class* = **B%** of the users in the cell.
- Total capacity for OSR calculation:

$$C_{tot} = N*(A\%*X + B\%*Y)$$

$$OSR = C_{tot}/C_{ref}$$

Worldwide distribution of service classes



DL CHANNEL RAW BANDWIDTH

$$BW_{raw} = \frac{FFT_{used} \times \sum (\%P \cdot k \cdot OCR)}{T_S}$$

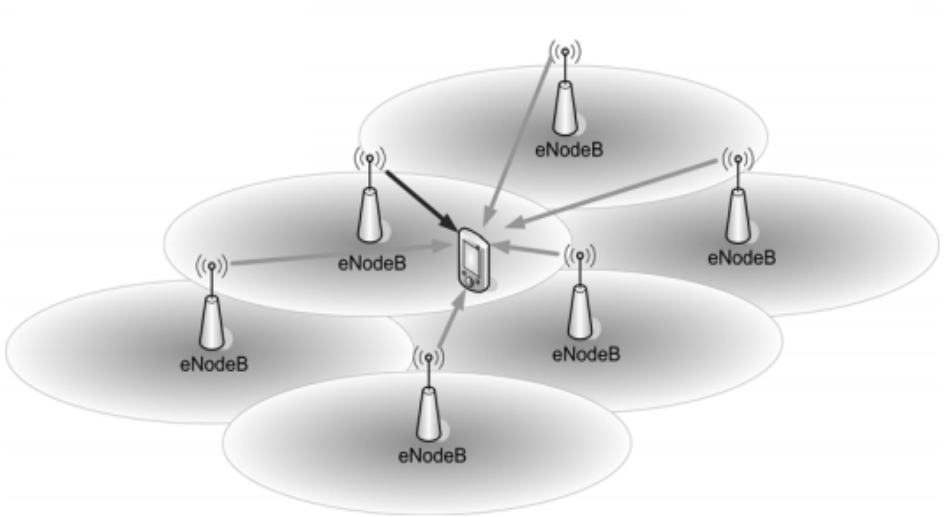
- FFT_{used} = number of data subcarriers dependent on the channel bandwidth (from 72 to 1200 in LTE).
- $\%P$ = percentage (weight),
- k = number of bits per symbol,
- OCR = overall coding rate.

APPLICATION BANDWIDTH AND AVERAGE USAGE

Application	Data rate (kbps)	Weight (average usage during a session)
Multiplayer interactive gaming	D1 = 50	W1 = 25.0 %
VoIP and Video Conference	D2 = 32	W2 = 10.0 %
Streaming Media	D3 = 64	W3 = 12.5 %
Web browsing and instant messaging	Nominal	W4 = 32.5 %
Media content downloading	BE	W5 = 20.0 %

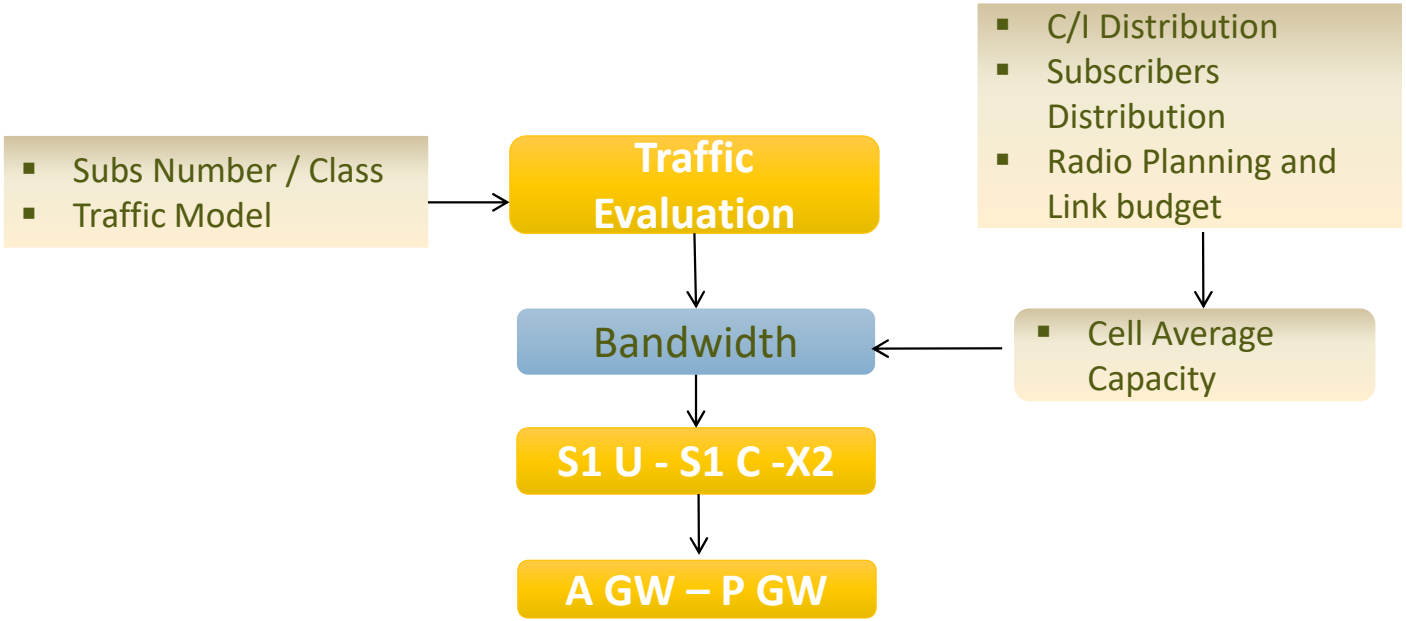
Dimensioning Method

Planning Design: Application to LTE



PLANNING DESIGN

- LTE dimensioning requires three steps:



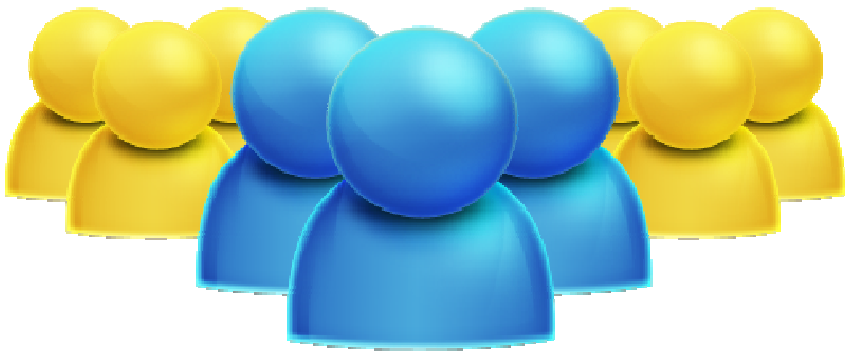
CONTENTS

Traffic Estimation

1. Subscribers population
2. Mobility and Traffic Model
3. Cell Characteristics and Planning assumptions

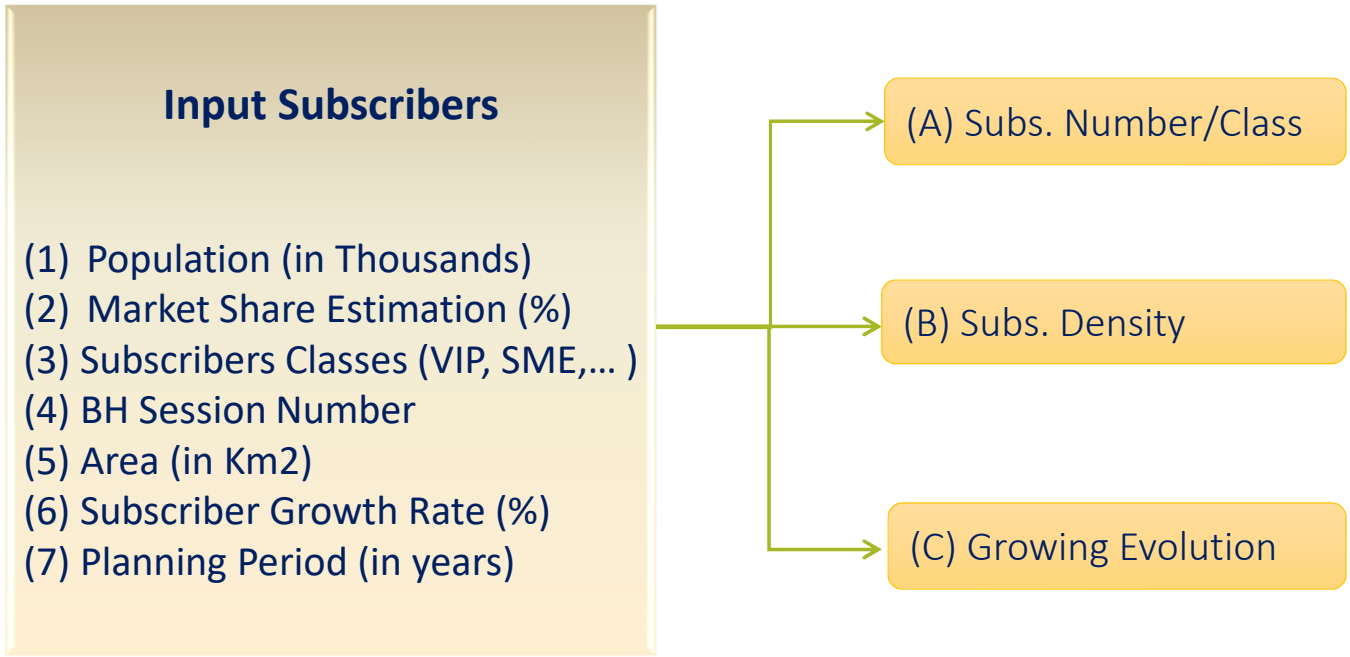
TRAFFIC ESTIMATION

1. Subscribers population



SUBSCRIBERS POPULATION

- **Inputs - Outputs**



SUBSCRIBERS POPULATION

Formulas

- (A) Subs. Number/Class = (1) x (2) x (3)
- (B) Density / Subs. Class = (A) ÷ (5)
- (C) Subs. Growth for n year(s) = (B)[**1**+ (6)] [7]

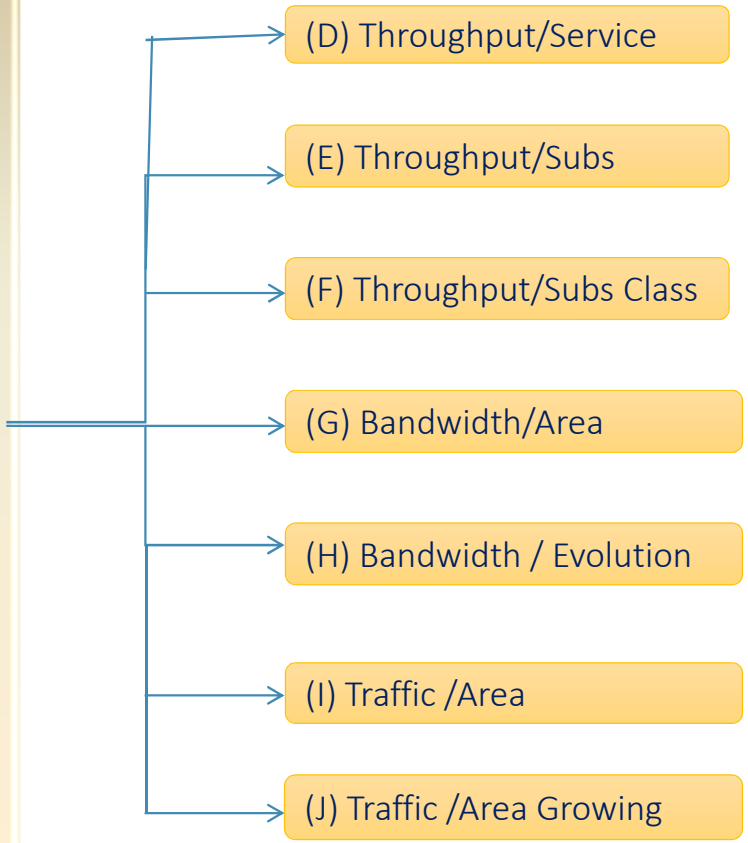
2. Traffic Model

TRAFFIC MODEL

- **Inputs – Outputs**

Mobility & Traffic Model

(8) Service Average Bitrate (kb/s)
(9) Service Activation Number at BH per Subs Class
(10) Service Activity Rate
(11) Burstiness Margin / Service
(12) Service or Signaling Procedure Average Duration
(13) Average BLER (for NRT services)
(14) Contention Ratio / Service / Subs. Class
(15) TAUs number / Subscriber at BH
(16) HO number / Subscriber at BH
(17) Mobility Margin (for the area)
(18) Security Margin (for total traffic volume). Here taken instead of OSR
(19) Signaling bitrate / Procedure
(20) Low layers overhead
(21) Carrier Bandwidth (MHz)



TRAFFIC MODEL

Formulas

- (D) Service bandwidth = (8) x (10) x [**1** + (11)] x [**1** + (13)] x [**1** + (20)]
- (E) Throughput / Subscriber class = (D) x [(9) x (12) x (14) / 3600] + (19) x [((4), (15), (16)) x (12) / 3 600]
- (F) Bandwidth/ area = [∑ (A) x (E)] x [**1** + (17)] x [**1** + (18)]
- (G) Bandwidth Evolution = ∑ (C) x (F)
- (H) Bandwidth / km^2 = (F) / (5)

TRAFFIC MODEL

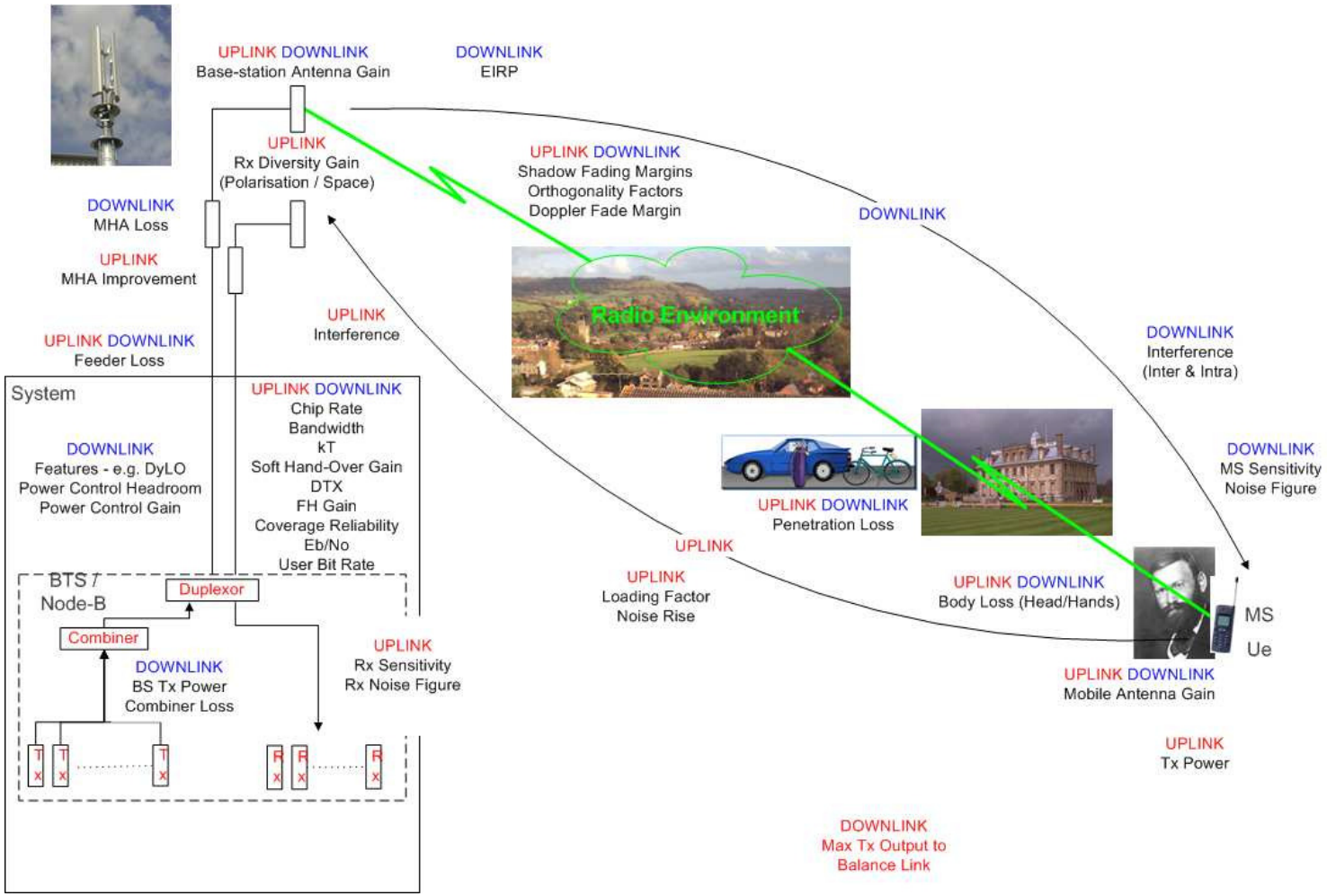
Assumptions

- (K) Initial Cell Capacity value (Starting Assumption) = Peak Rate (100 Mb/s for LTE) x (21) / 20 MHz (for LTE) x 70%
- (M) Number of Cells (First estimation) = (F)/(K)

3. Cell Characteristics and Planning assumptions

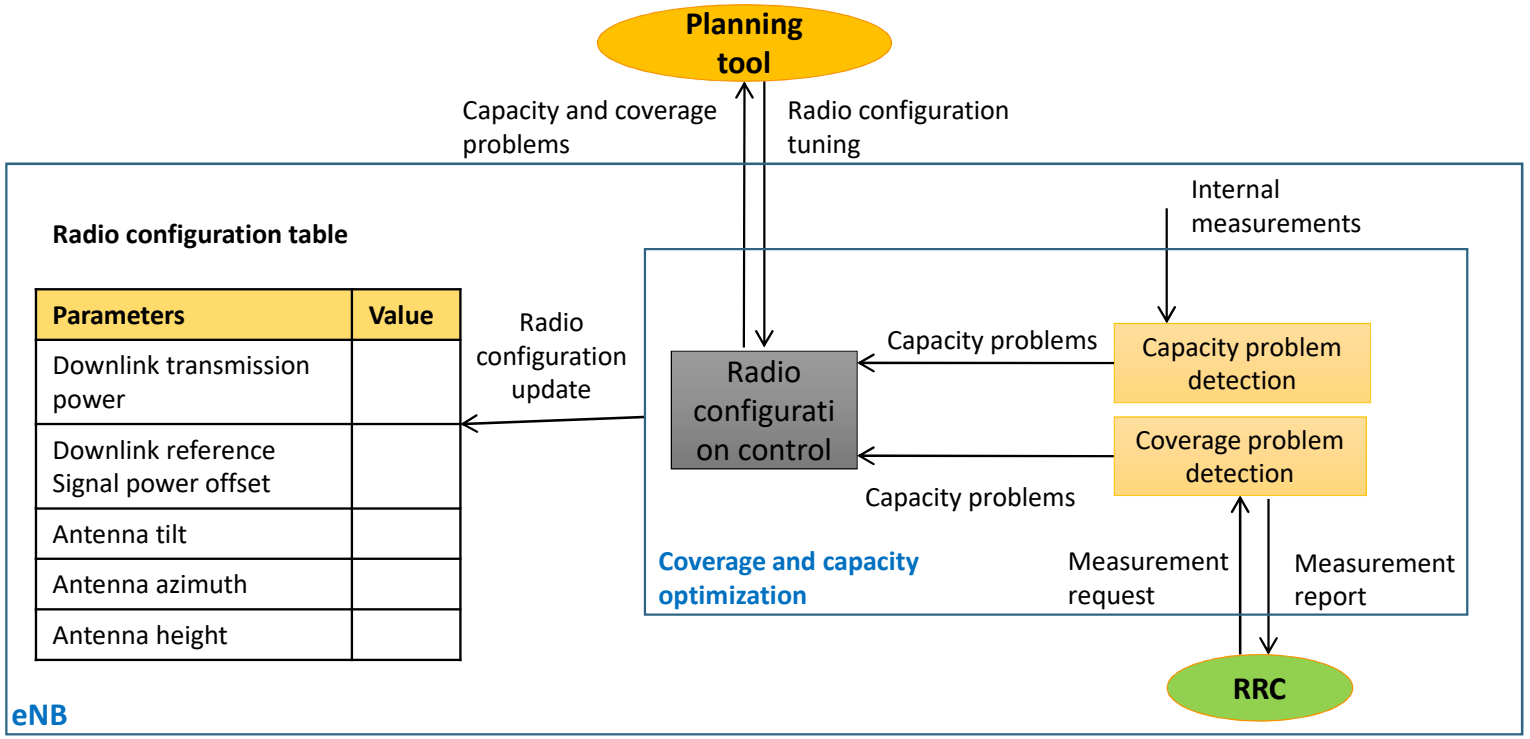
CELL CHARACTERISTICS AND PLANNING ASSUMPTIONS

- **Link Budget principle**



CELL CHARACTERISTICS AND PLANNING ASSUMPTIONS

- **Radio Planning Overview**



CELL CHARACTERISTICS AND PLANNING ASSUMPTIONS

- **Planning Process**

Initial Planning

1. Model Tuning
2. User density and distribution
3. Site Selection
4. eNB number (M)
5. Configuration Planning (Tilt, Azimuth, Height,…)

Planning

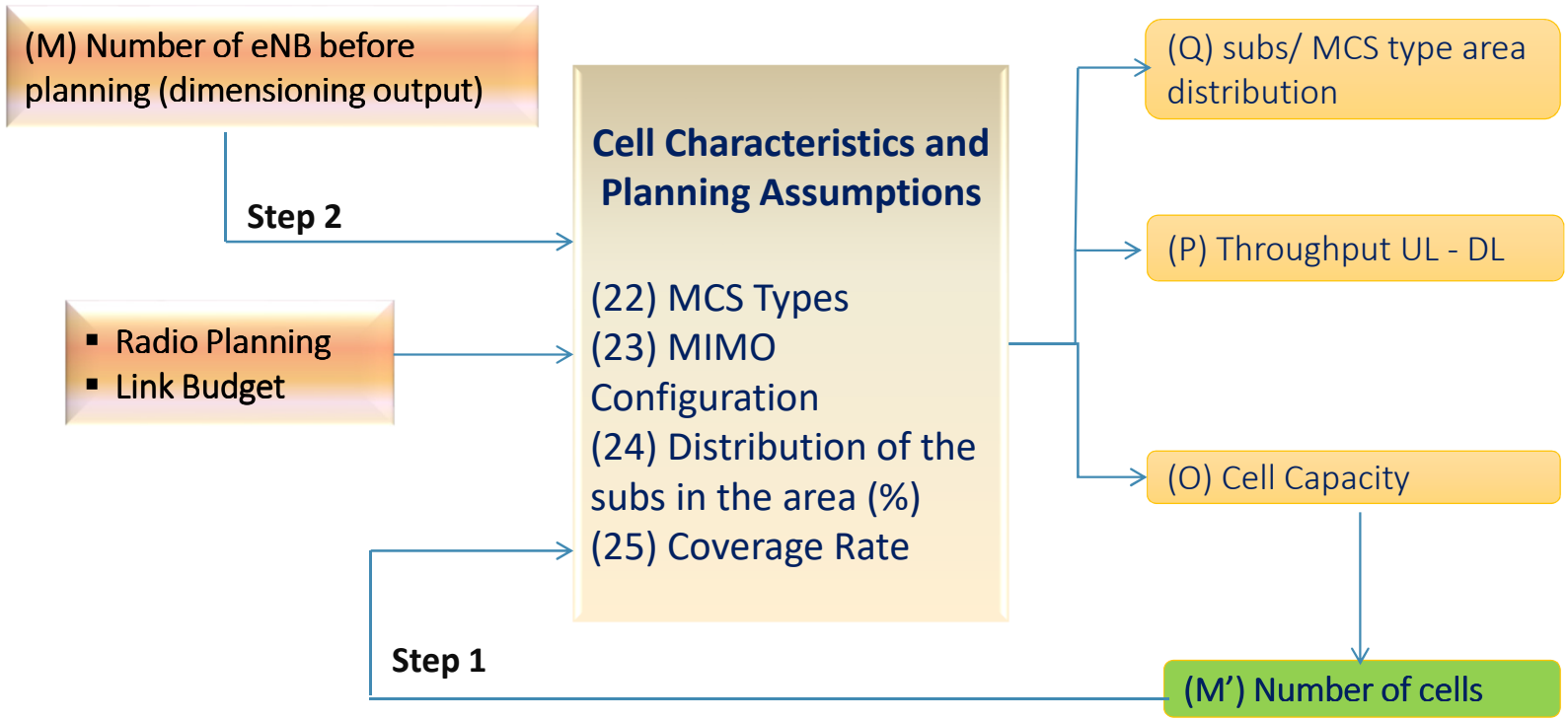
Coverage Planning

Optimization

1. Coverage Rate
2. Parameters Tuning
3. Interference Rate

CELL CHARACTERISTICS AND PLANNING ASSUMPTIONS

- **Inputs - Outputs**



CELL CHARACTERISTICS AND PLANNING ASSUMPTIONS

- **Coverage estimation**

(21) MCS	(22) Bandwidth (MHz)	(23) MIMO Configuration	(24) Distribution of the subscribers	f[(21), (22), (23)}
QPSK 1/8	1,4 3 5 10 15 20	SISO SIMO MISO MIMO	x	x
QPSK 1/5			x	x
QPSK 1/4			x	x
QPSK 1/3			x	x
QPSK 1/2			x	x
QPSK 2/3			x	x
QPSK 4/5			x	x
16 QAM 1/2			x	x
16 QAM 2/3			x	x
16 QAM 4/5			x	x
64 QAM 2/3			x	x
64 QAM3/4			x	x
64 QAM 4/5			x	x

(O) Cell Capacity = ∑ (24) x f{(21), (22), (23)}

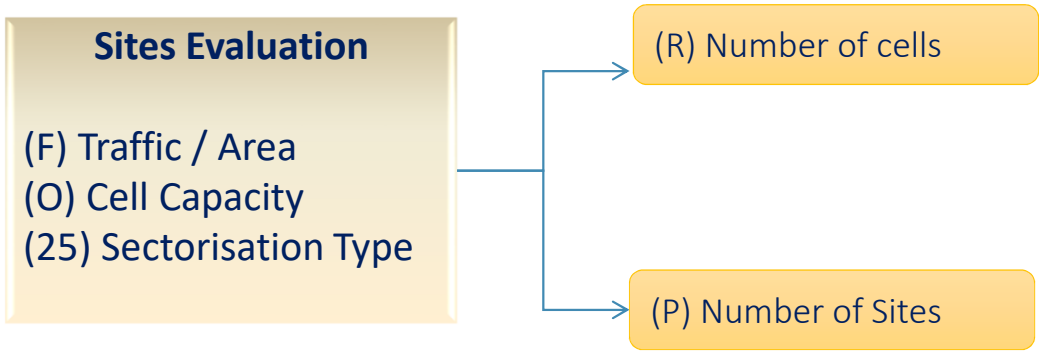
PEAK DATA RATES DL AND UL (IN LTE)

Modulation coding		1.4 MHz	3.0 MHz	5.0 MHz	10 MHz	15 MHz	20 MHz
QPSK 1/2	Single stream	0.7	2.1	3.5	7.0	10.6	14.1
16QAM 1/2	Single stream	1.4	4.1	7.0	14.1	21.2	28.3
16QAM 3/4	Single stream	2.2	6.2	10.5	21.1	31.8	42.4
64QAM 3/4	Single stream	3.3	9.3	15.7	31.7	47.7	63.6
64QAM 4/4	Single stream	4.3	12.4	21.0	42.3	63.6	84.9
64QAM 3/4	2x2 MIMO	6.6	18.9	31.9	64.3	96.7	129.1
64QAM 1/1	2x2 MIMO	8.8	25.3	42.5	85.7	128.9	172.1
64QAM 1/1	4x4 MIMO	16.6	47.7	80.3	161.9	243.5	325.1

Modulation coding		1.4 MHz	3.0 MHz	5.0 MHz	10 MHz	15 MHz	20 MHz
QPSK 1/2	Single stream	0.7	2.0	3.5	7.1	10.8	14.3
16QAM 1/2	Single stream	1.4	4.0	6.9	14.1	21.6	28.5
16QAM 3/4	Single stream	2.2	6.0	10.4	21.2	32.4	42.8
16QAM 1/1	Single stream	2.9	8.1	13.8	28.2	43.2	57.0
64QAM 3/4	Single stream	3.2	9.1	15.6	31.8	48.6	64.2
64QAM 1/1	Single stream	4.3	12.1	20.7	42.3	64.8	85.5
64QAM 1/1	V-MIMO (cell)	8.6	24.2	41.5	84.7	129.6	171.1

CELL CHARACTERISTICS AND PLANNING ASSUMPTIONS

- **Numbers of sites**



(R) Number of cells = (F) / (O)

(P) Number of sites = (R) / (25)

If (R) ≠ (M') new radio planning process is required. (O) may change and the new (R) may also change.
Iterative process is then required until (R) = (M').

CONTENTS

S1 U, S1 C and X2 Dimensioning

1. Bandwidth Inputs-Outputs
2. Traffic Model
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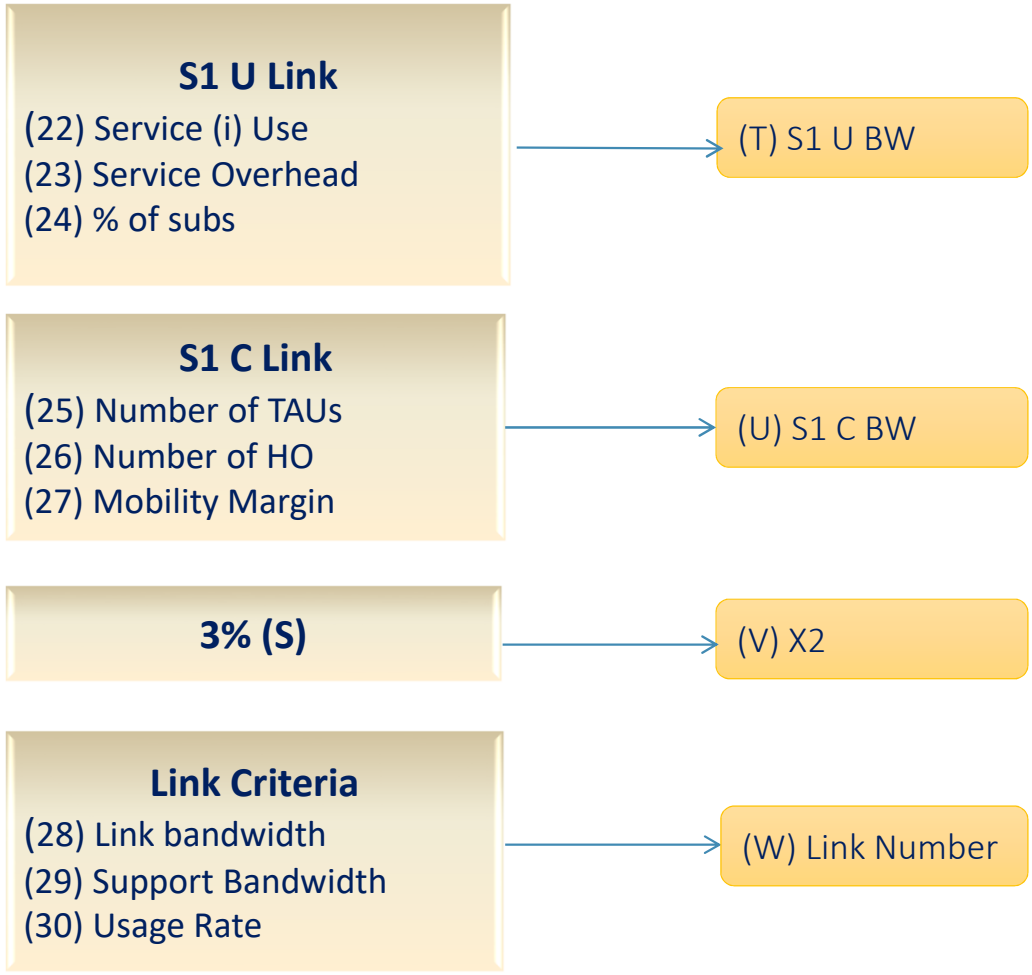
S1 U, S1 C AND X2 DIMENSIONING

1. Bandwidth Inputs-Outputs

S1 U, S1 C AND X2 DIMENSIONING

- **Inputs - Outputs**



2. Traffic model

- **Codecs Model**

Traffic Model	Codecs	Radio Interface with HO compression	Compression Ratio	Radio Interface without HO compression
VoIP	AMR	x	x	x
Video Conference	MPEG4	x	x	x
HTTP	x	x	x	x
Web Browning	x	x	x	x
FTP	x	x	x	x
Video Streaming	MPEG4	x	x	x
email	x	x	x	x
Interactive Gaming	x	x	x	x

VoIP DIMENSIONING FOR G.711 AND G.729A

- The amount of bandwidth required to carry voice over an IP network depend on:
  - Codec (coder/decoder) and sample period
  - IP header (includes IP, UDP and RTP protocol layers)
  - Transmission medium
  - Silence suppression

RTP adds 12 octets, UDP adds 8 octets, IP adds 20 (v4) or 40 (v6) octets.

Sample period of 20 ms and 40 octets headers ➔ 16 kbps additional bitrate

- **G.711** codec and 20 ms sample period ➔ payload = 160 octets

With 40 octets of IP header, total is 200 octets ➔ **80 kbps for VoIP**

Ethernet adds 38 octets ➔ **95.2 kbps for VoIP over Ethernet**

- With **G.729a**, the bitrate would be **39.200 kbps for VoIP over Ethernet**

Silence suppression reduces the demand for BW by 50%.

CODEC THROUGHPUTS

Codec	Bandwidth	Sample period	Frame size	Frame/packet	Ethernet bandwidth
G.711 (PCM)	64 kbps	20 ms	160	1	95.2 kbps
G.723.1A (ACELP)	5.3 kbps	30 ms	20	1	26.1 kbps
G.7231A (MP-MLQ)	6.4 kbps	30 ms	24	1	27.2 kbps
G.726 (ADPCM)	32 kbps	20 ms	80	1	63.2 kbps
G.728 (LD-CELP)	16 kbps	2.5 ms	5	4	78.4 kbps
G.729A (CS-CELP)	8 kbps	10 ms	10	2	39.2 kbps
AMR (ACELP)	4.75 kbps	20 ms	12	1	36.0 kbps
AMR (ACELP)	7.4 kbps	20 ms	19	1	38.8 kbps
AMR (CELP)	12.2 kbps	20 ms	31	1	43.6 kbps
AMR-WB/G.722.2 (ACELP)	6.6 kbps	20 ms	17	1	38.0 kbps

S1 U, S1 C AND X2 DIMENSIONING

- **Traffic Model on S1 U link**

(22) Traffic Model	Codecs	Bit Rates (Kbps)	(23) IP Overhead (byte)	(24) % of use
VoIP	AMR	12,2	40	50 %
Video Conference	MPEG4	64	1 000	30 %
HTTP	x	0,576	1071	60 %
Web Browning	x	1,209	600	20 %
FTP	x	2 000	2 000	10 %
Video Streaming	MPEG4	64	400	10 %
email	x	80	22,7	10 %
Interactive Gaming	x	128	300	5 %
P2P		500	500	20%

S1 U, S1 C AND X2 DIMENSIONING

- **Link Mobility Model on S1 C link**

(25) Number of TAUs	500
(26) Number of HO	475

3. Formulas

S1 U, S1 C AND X2 DIMENSIONING

Formulas

- (T) S1 U BW = ∑ 8kb/s x (23) x (24)
- (U) S1 C BW = 8 kb/s [(25) + (26))]
- (V) "X" _"2" = 3% S1 BW
- (W) Number of Links = (28) / [(29)/(30)]

Thank You