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MATHEMATICAL MODEL FOR LTE SYSTEM DIMENSIONING

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The objective of this paper is to define a mathematic model for the dimensioning of LTE Rel-8 network, after describing the mechanisms influencing the dimensioning such us the Scheduling, QOS and LTE capacity, we define the strategy of the planning and the objective function which aim to minimize the number of the base stations and the capacities of the wired links to deploy. The mathematical formulation of the model leads to a linear and mixed problem. PLEX method based on "Branch and Cut" algorithm has been used to solve this problem.

Key words: LTE-Rel8; Capacity; Mobile Network; Dimensioning; Optimization

1 Introduction

The main driver for fourth generation (4G) technologies, such as 3GPP LTE, is the premise of rich multimedia content delivered over links capable of high throughput, low latency and having appropriate QoS provisions. To satisfy such quality of service with low infrastructure cost, operators are interested to having a global dimensioning tool that include the cellular part of the system and also the terrestrial part. However, planning of the forthcoming 3GPP Long Term Evolution (LTE) networks, with its specific radio interface features is less covered in the literature yet, most of the works in literature address the optimization of either the transmission links [12] [13] or the cell placement and capacity [14][15]. The aim of this paper is to define and solve an optimization model for the dimensioning of LTE network. We propose a mathematical optimization model which extends previously suggested model for 3G [11] in order to cover LTE system requirements.

The paper is organized as follows. Section 1 explains the LTE techniques that influence the dimensioning. Section 3 presents the mathematic formula of traffic models and the constraints of the LTE dimensioning. Section 4 presents the dimensioning model that defines the objective function, the associated variables and constraints, the last section explains the method of the resolution and the results.

2 LTE Network Model

The modelling of the LTE network take into account service differentiation, admission control and the quality of the service, the network is services integrated and packet switched. The model also incorporates a number of physical protocols that influence the design. These protocols are:

- WFQ (Weighted Fair Queuing) which define the discipline of scheduling the packet at the routers. It has the advantage of ensuring a minimum level of service and a maximum threshold of the delay time of the packet.
- OFDMA: The downlink transmission scheme for LTE is based on conventional OFDMA which allows access of multiple users on the available bandwidth. Each user is assigned a specific time-frequency resource.
- HARQ: or Hybrid Automatic Repeat reQuest, for the retransmission technique on the radio links in case of error. This protocol is taken into account when evaluating transmission delay on the radio link. Our HARQ combining modeling is based on [3] with a chase combining efficiency of 1.0.

2.1. LTE System Architecture

LTE stands for Long Term Evolution and it represents the next step in mobile radio communications. 3GPP is the standardization body behind LTE. The technical specifications for LTE air interface are defined in 3GPP Release 8 and they can be found in the 36-series (TS 36.xxx).

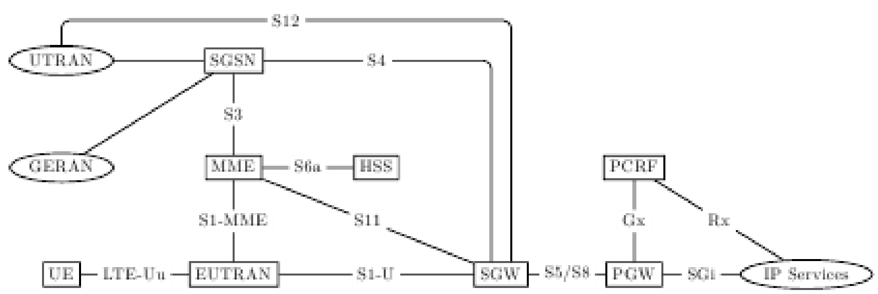

Figure 1: LTE architecture (23.401 [2])

Principles for LTE architecture design are defined in 3GPP TS25.913. Some of those principles:

- Packet based architecture, although real-time and conversational class traffic should be supported
- It should simplify and minimize the number of interfaces
- It should be designed in order to minimize the delay variation for traffic requiring low jitter, i.e., TCP/IP
- End to end QoS should be supported for the various types of traffic

To meet the requirements of reduced latency and cost, LTE has flat system architecture that contains a reduced number of network nodes. Figure 1 illustrates the architecture evolution of LTE architecture [1], an evolved NodeB (eNB) is connected to user equipments (UEs) through the air interface and to the EPC (Evolved Packet Core) via the S1 interface.

2.2. Call Admission Control

Call admission control (CAC) is a fundamental mechanism used for QoS provisioning in a network. It restricts the access to the network based on resource availability in order to prevent network congestion and service degradation for already supported users. A new call request is accepted if there are enough idle resources to meet the QoS requirements of the new call without violating the QoS.

- Admission control for CBR (Constant Bit Rate) applications:
  In this case, the CAC is simple because the source is completely defined by its flow. The session will be accepted only if the rate requested by the source, added to the current load of a link is less than the capacity of the link and for all the links on the way. The session may be refused if the route does not guarantee the maximum delay tolerated. In case of refusal, the session is either re-routed or queued waiting for a subsequent acceptance if a link becomes available or refused in general.
- Admission control for VBR (Variable Bit Rate) applications
  The CAC for these applications is more complex because their throughput has variable rates with periods of bursts. The challenge is to characterize the VBR sources to assess the resources required for their quality of service.

2.3. WFQ

The WFQ scheme provides fair scheduling of the packets from different flows in the buffers. It allows isolation of flows by using weights that prevents monopolization of the bandwidth by some flows. WFQ supports flows with different bandwidth requirements by giving each flow a weight that assigns it a different percentage of the link bandwidth.
Consider a WFQ server Figure 2 with a constant service rate **r**, for N sessions. Flows entering the same queue are given weights, w1, w2, and w3, and share the bandwidth r accordingly. WFQ guarantees for each session **s** minimum service rate g_s:

$$g_s = \frac{w_i}{\sum_{i=1}^{N} w_i} r$$

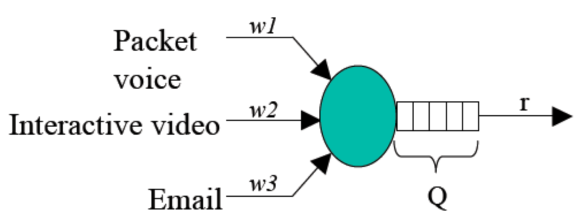

Figure 2: WFQ scheduler mechanism.

Resources are protected against greedy sessions and are redistributed during periods of inactivity. Parekh and Gallager proposed in [4] a particular version of WFQ. The coefficients w, in this version, are assigned to the current sessions in order to respect the relative order of the levels of quality of service required. With this discipline, the coefficient w_i is associated with the declared throughput of the session such as: $w_s = \rho_s$.

We obtain the minimum guaranteed service as follows:

$$g_s = \frac{w_s}{\sum_{s=1}^{N} w_s} r = \frac{r}{\sum_{s=1}^{N} \rho_s} \rho_s$$

As the occupancy rate is necessarily less than 1 so $\sum_{s=1}^{N} \rho_s < r$. It come the following property: $g_s \geq \rho_s$

Parekh and Gallager proposed in [5] a limit D_s^* of the end to end delay by using leacky buckets filter:

$$D_s^* = \frac{\sigma_s + (K-1)L_s}{\rho_s}$$

With (σ_s, ρ_s) are the parameters of the filter of the session s, K the number of the nodes on the links and L_s the packet size.

2.4. LTE Radio Capacity

Service on a radio link is characterized by two factors:

- A Radio Bearer (RB).
- A discrete value of signal to noise ratio SINR (Carrier to Noise Ratio).

In LTE technology, radio resources are structured in slots of length Tslot = 0.5 ms. The Transmission Time Interval (TTI) is set to 1 ms, thus containing 2 slots. Each slot can be seen as a time-frequency resource grid composed by OFDM symbols along the time. Each slot is divided into a number of Physical Resource Blocks (PRBs) consisting of 12 consecutive sub-carriers along 7 consecutive OFDM symbols. Assuming a system bandwidth BW = 10 MHz, there is a total of 600 data subcarriers per OFDM symbol, so the number of PRBs is 600/12 = 5.

LTE uses several techniques for modulating data and control information (MCS). These modulation techniques include:

- QPSK (m=2 bits per symbol),
- 16QAM (m=4 bits per symbol),
- 64QAM (m=6 bits per symbol).

The RB in LTE is defined by 2 parameters the MCS used and the number of Symbols affected (in time and frequency domain).

A modulation scheme is selected based on the measured signal to interference plus noise ratio (SINR). Each modulation scheme has a SINR threshold called the required SINR and it has been obtained from a previous work [6] as:

$$SINR = \frac{\frac{1}{LossDL}}{\sum_{K \neq own} \frac{1}{Loss(K)} + \frac{CellBw}{MaxTxPwr} * TND * RxNFigure}$$

where:

LossDL = Total link loss in downlink (W)
Loss(K) = The Total link loss in downlink from the cell K in the allocated bandwidth
RxNFigure = Receiver Noise Figure.
TND= Thermal Noise Density = -174 dBm.
CellBw = Allocated bandwidth of LTE network cell (MHz)
MaxTxPwr = Maximum Power transmitted from eNB (W).
Session is accepted only if the SINR of the flow is high than the lower required SINR to select the lowest possible MCS.

$$SINR \geq RequiredSINRmin$$

3. Dimensioning Constraints

3.1. QoS in LTE System

LTE is a converged all-IP network, and Quality of Service (QoS) provisioning is crucial for providing a range of IP-based services in the new generation networks. Hence an evolved 3GPP QoS concept [7] has been developed. In radio networks, QoS implies traffic differentiation and using multiple bearers (a bearer is a point-to-point communication service between two network elements) with configuration and priorities optimized to ensure sufficient service quality for each user.

The simplified QoS profiles are based on QoS Class Identifiers (QCIs). A QCI is a pointer to a preconfigured set of node specific parameters [2], e.g., scheduling weights, admission thresholds, packet discards timer, etc. A set of pre-defined QCIs is used to ensure class-based QoS is shown in the table 1.

QCI	Resource Type	Priority	PDB	PELR	traffic type example
1	GBR	2	100ms	10^{-2}	Conversational Voice
2		4	150ms	10^{-3}	Conversational Video (Live Streaming)
3		5	300ms	10^{-4}	Non-Conversational Video (Buffered Streaming)
4		3	50ms	10^{-3}	Real Time Gaming
5	non-GBR	1	100ms	10^{-4}	IMS Signaling
6		7	100ms	10^{-3}	Voice, Video (Live Streaming), Interactive Gaming
7		6	300ms	10^{-4}	Video (Buffered Streaming), Transmission Control Protocol (TCP)-based
8		8			
9		9			

Table 1: QoS Profiles in LTE System

For simplicity, in our model we distinguish 2 type of application:

- real time CBR (packet switched constant bit rate real time) services, defined by required guaranteed bit rate, delay constraints and traffic e.g. high-quality voice over IP , videoconference over IP,
- real time VBR (packet switched variable bit rate real time) services, defined by mean guaranteed bit rate, peak bit rate, delay constraints and traffic e.g. voice over IP using compression , WEB games.

3.2. Session Model

We assume that connections are always between a mobile user and a fixed user belonging to an external network, and it is assumed that mobile user does not generate multiple sessions simultaneously.

The network is divided into two parts:

- The wired, denoted WL, which includes all nodes, wired links external access to the eNBs.
- The radio part denoted RL, which includes radio links between eNB and the UE.

The modeling session is illustrated in figure 3.

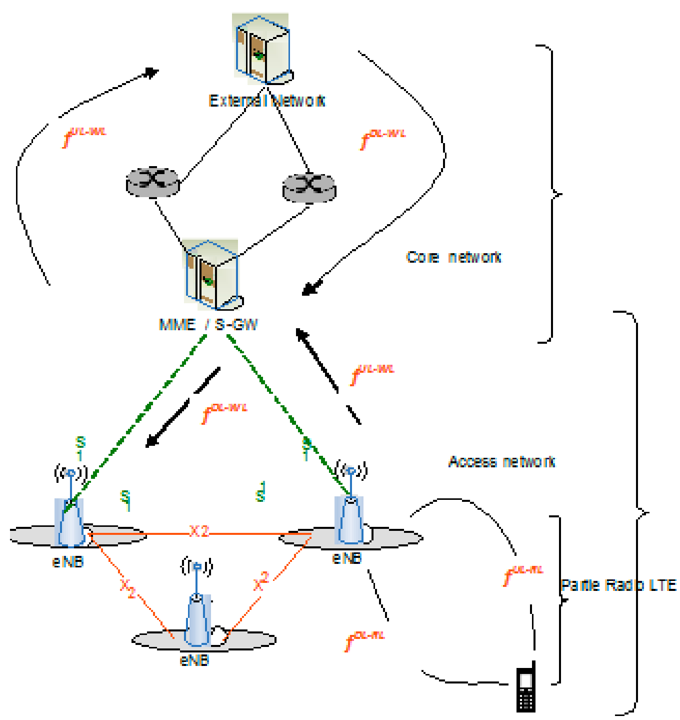

Figure 3: Session Decomposition on 4 flows: $f^{UL-WL,}$ $f^{DL-WL,}$ $f^{UL-RL,}$ f^{DL-RL}

When the application is interactive, the session is modelled with two flows:

- A flow in the uplink direction, denoted $\boldsymbol{f^{UL-WL}}$ for the flow on the wired link and $\boldsymbol{f^{UL-RL}}$ for the flow on the radio link.

- A flow in the downlink direction, denoted $f^{DL\text{-}WL}$ for the flow on the wired link and $f^{UL\text{-}RL}$ for the flow on the radio link.

  When the application is not interactive, the session is modeled only with one flow on DL or UL direction.

3.3. Througput assignement

In our model, the throughput assignment to the flow is related to the type of application:

- CBR Applications.

The throughput on the wired and radio links are fixed by the type of the used encoder. The optimization procedure must therefore accept these sessions with the reported throughput. It has the choice between several coding schemes for different rates depending on the SINR of the session; this choice is influenced by the priority of the user and its quality of service.

- VBR Applications.

The throughput on the wired and radio links may vary. In contrast, maximum and minimum limits are set for each stream. The optimization procedure should therefore choose a continuous value between these bounds for wired links and a MCS that meet these limits for the radio links. In order to avoid packets accumulation on the eNB which lead to uncontrolled delays, it is assumed that the uplink throughput on the radio link $f^{UL\text{-}RL}$ is less than or equal to the rate of the wired links $f^{UL\text{-}WL}$, and also the downlink throughput of the radio link $f^{DL\text{-}RL}$ is greater than or equal to the rate of the wired links $f^{DL\text{-}WL}$.

$$\text{Througput}[f^{UL\text{-}WL}] \geq \text{Througput}\ [f^{UL\text{-}RL}] \quad (1)$$

$$\text{Througput}\ [f^{DL\text{-}WL}] \leq \text{Througput}\ [f^{DL\text{-}RL}] \quad (2)$$

3.4. Delay Constraints Model

The delay of a packet of a session **s** in the uplink (respectively descending) direction, noted D_s^{ul} (D_s^{dl} respectively) is the amount of delay accumulated on the cable (WL) and on the radio (RL) of the network.

$$D_s^{ul} = D_{f[ul-wl]} + D_{f[ul-rl]}$$

$$D_s^{dl} = D_{f[dl-wl]} + D_{f[dl-rl]}$$

- Delay Time on wired link:

The delay experienced by a packet on the wired links is due to the transmission delay and the propagation delay on the links. In addition, there is a delay in WFQ queues and processing time at routers:

$$D_{ful-wl} = D^{trans}_{ful-wl} + D^{propag}_{ful-wl} + D^{trait}_{ful-wl} + D^{attente}_{ful-wl}$$

$$D_{fdl-wl} = D^{trans}_{fdl-wl} + D^{propag}_{fdl-wl} + D^{trait}_{fdl-wl} + D^{attente}_{fdl-wl}$$

- Transmission delay:

If we took the size of a packet as reference in an IP transmission network and According to (1), the minimum flow on the wired links is the flow value r_t^{ul} of the MSC selected for the uplink and r_t^{dl} for the downlink.

If m_{ful} and m_{fdl} are the numbers of wired links on the ways of the session on UL and DL Respectively then the maximum transmission time can be calculated by:

$$D^{Max-trans}_{ful-wl} = m_{ful} \times \frac{packet\_size\_UL}{r_t^{ul}}$$

$$D^{Max-trans}_{fdl-wl} = m_{fdl} \times \frac{packet\_size\_DL}{r_t^{dl}}$$

- Propagation delay:

The propagation delay is the propagation delay of a bit; it depends on the length of the link. For simplicity we take an average value of that period.

$$D^{propa}_{ful-wl} = m_{ful} \times Temps_{propagation}/Link$$

$$D^{propa}_{fdl-wl} = m_{fdl} \times Propag_{time}/Link$$

- Processing delay:

It is the time of processing, queuing, error checking on each router of the links, the original node is not considered as router, but the destination node, which is the eNB on the downlink direction, will be counted as a router.

The number of routers is equal to the number of wired links of the way of the session:

$$D^{trait}_{ful-wl} = m_{ful} \times Temps_{traitement}/Router$$

$$D_{fdl-wl}^{trait} = m_{fdl} \times Temps_{traitement}/Router$$

- WFQ delay:

At each router, the packet is placed in the queue and assigned to a session, with WFQ discipline, described in the previous section, the delay time accumulated by the packet in the queue is bounded by the worst case D_s^*

In the uplink direction, from (1) the rate on the wired links is greater than or equal to the rate of the RB allocated on the radio link in order to avoid accumulation at the eNB so there is no need for a filter on the uplink and the bucket depth of WFQ is zero (ρ = 0), the source is not allowed to send packets in bursts at a rate higher than the rate of the filling.

$$D_{ful-wl}^{délai} = D_s^* = 0$$

In the descending direction, the packet suffers from a delay at the routers as we place leaky packet filter with filling rate equal to the declared rate of the session and not the maximum throughput allowed, the delay experienced is as follow:

$$D_{fdl-wl}^{délai} \le D_s^*$$

- Delay on the radio link:

  At the eNB, the IP packet is segmented to a frames in the DL and reassembled in the UL direction, transmission delay of the packet corresponds the time to transmit or receive all the frames involved in an IP packet.

  The duration of a frame is 10 ms; the number of bits of the transmitted frame depends on the RB selected by the optimizer. If N_{rul} and N_{rdl} are the number of frames needed to transmit a packet with the throughput r_t^{UL} and r_t^{DL} on the radio link in UL and DL direction respectively, it comes:

$$N_{rul} = \frac{8 \times paquet\_size\_ul(octets)}{frame\_duration \times r_t^{ul}}$$

$$N_{rdl} = \frac{8 \times paquet\_size\_dl(octets)}{frame\_duration \times r_t^{DL}}$$

4 Dimensioning Model

4.1. Objective function

The aim of the design is to minimize the hardware resources, ie the wired links and base stations. Assuming that the cost associated with a wired link is proportional to its length and capacity, the objective function is:

$$\min(w_c \sum_{l=1}^{m} d_l\, C_l + w_c \sum_{l=1}^{n_{bs}} d_{l_{BSi}} \;\; C_{l_{BSi}} + w_{BS} \sum_{l=1}^{n_{bs}} x^{BSi})$$

where:

s: a session

m: Number of total wired links of the core network

d_l : Length of link l.

C_l : Capacity of link l

w_c : Cost associated to links

w_{BS} : Cost associated to eNB.

n_{bs} Number of potential eNB.

T_s^{ul} : Ensemble of RBs for the session **s** on the uplink

T_s^{dl} : Ensemble of RBs for the session **s** on the downlink

$C_{l_{BSI_i}}$: Continue variable for wired link Capacity $C_{l_{BSI}}$= 0 if the eNB hasn't been selected by the optimization procedure.

x^{BSi} : Binary variable for the selection the eNB **i**

$$x^{BSi} = \begin{cases} 1 \text{ if eNB i is selected once to hande a session} \\ 0 \text{ otherwise} \end{cases}$$

4.2. Variables Definition

c : continue variable for the rate flow f.

$x_{f^{wl\_ul}}$: Rate of the flow f for wired link on the uplink.

$$y_s = \begin{cases} 1 \; if \;\; the \; flots \;\; f \in F_s \text{ has been accepted} \\ 0 \; otherwize \end{cases}$$

$\bar{\rho}_{f}$, $\underline{\rho_f}$: Maximal and minimal throughput on the wired link of the flot when s is of type VBR.

ρ_f : Declared throughput of the flot f when s is of type CBR.

α_{irf} : Binary Variable for RB selection on the radio link, it is defined for the eNB i and the rate $r \in T_s$.

$$\alpha_{irf} = \begin{cases} 1 & \text{if eNB } i \text{ is selected and rate } r \text{ is selected for the flow } f \\ 0 & \text{sinon} \end{cases}$$

4.3. Constraints definition

- CAC Contraints

For each session **s** with its flows $Fs = \{f_s^{ul\_wl}, f_s^{dl\_wl}, f_s^{ul\_rl}, f_s^{dl\_rl}\}$

If **s** is of type CBR:

- On the wired link

$$x_{f^{ul\_wl}} = y_s \times \rho_{f^{ul\_wl}}$$
$$x_{f^{dl\_wl}} = y_s \times \rho_{f^{dl\_wl}}$$

- On the radio Link

$$x_{f^{ul\_rl}} = y_s \times \rho_{f^{ul\_rl}}$$
$$x_{f^{dl\_rl}} = y_s \times \rho_{f^{dl\_rl}}$$

If **s** is of type VBR:

- On the wired link

$$y_s \times \underline{\rho}_{f^{ul\_wl}} \leq x_{f^{ul\_wl}} \leq y_s \times \overline{\rho}_{f^{ul\_wl}}$$
$$y_s \times \underline{\rho}_{f^{dl\_wl}} \leq x_{f^{dl\_wl}} \leq y_s \times \overline{\rho}_{f^{dl\_wl}}$$

- Throughput Contraints

This relationship conditions the throughput x_f. if the session is CBR it must take the declared rate at the wired links and if the session is VBR, x_f take continuous value between 2 limits which dependent to the RBs associated to the session.

For CBR applications:

$$x^i_{f^{ul\_wl}} = \rho_{f^{ul\_wl}} \sum_{r \in T_s^{ul}} \alpha_{irf^{ul\_rl}}$$

$$x^i_{f^{dl\_wl}} = \rho_{f^{dl\_wl}} \sum_{r \in T_s^{dl}} \alpha_{irf^{dl\_rl}}$$

If the eNB **i** is selected then **i** $\sum_{r\in T_S^{ul}} \alpha_{irf^{ul\_ri}} = 1$, in this case x_f is equal to the declared rate on the wired link ρ_f.

For VBR Application

- In the Uplink:

$$\sum_{r\in T_S^{ul}} r_t\, \alpha_{irf^{ul\_ri}} \leq x^i_{f^{ul\_wl}} \leq C_1 \sum_{r\in T_S^{ul}} r_t\, \alpha_{irf^{ul\_ri}}$$

C_1 is an arbitrary constant which force $x^i_{f^{ul\_wl}} = 0$ if the eNB **i** is not selected. If the eNB **i** is selected, this constraint force the throughput on the wired link to be greater or equal to the throughput on the radio r_t.

- In the Downlink:

$$0 \leq x^i_{f^{Dl\_wl}} \leq \sum_{r\in T_S^{dl}} r_t\, \alpha_{irf^{dl\_ri}}$$

This constraint force $x^i_{f^{ul\_wl}} = 0$ if the eNB **i** is not selected, and ensure the throughput on the radio link on DL is superior to the rate on the wired link.

➢ Capacity Contraints

- Core Network Links capacity:

The optimization procedure should minimize the capacity C_l for each link of the core network; the sum of all rates going through the link should inferior to its capacity.

$$\sum_{s\in S} \sum_{f\in F_S^{wl}} a_{lf} x_f \leq c_f$$

- Access Network Capacity:

For each link l_{BSi} between the eNB **i** and its SGW:

$$\sum_{s\in S} \sum_{f\in F_S^{wl}} b_{lf} x^i_f \leq c_{lBSi}$$

- Radio Capacity

Let RBi the total radio bloc available on the eNB **i** and $N_{s,i}$ the number of radio bloc allocated to the session **s** when it is attached to the eNB **i**, $N_{s,i} = 0$ if the session **s** is not linked to this eNB.
Attachment condition of the session **s** to eNB **i** is as follow:

$$SINR_{i,s} \geq RequiredSINR$$

Radio link Capacity:

$$\sum_{t \in S} \sum_{f \in F_s^{ul}} N_{ts} x_f^t \leq RB_s$$

4 Resolution & Implementation

4.1. Assumptions & Parameters

We consider a geographic area to cover and a wired network topology, the surface is divided into several equivalent surfaces to be covered by each potential eNB, which will be connected to a fixed MGW covering the surface, initially, we creates an over sizing system with a high number of eNB.

The number of the eNB is an input data, which may vary for a given network topology. The size of the geographical area to be covered is also an input data, in our case we consider surface to cover of 5 kmx4 km, and the n_{bs} nodeBs are distributed uniformly on that surface.

For CBR applications, the throughput on the radio links is fixed as follows as shown in the table2.

Table 2: Throughput requirement for CBR Application

		ρ_f
CBR Application	voice	10 kbps
	Video conference	150 kbps
	Video flow	150 kbps

For the VBR application, the throughput is variable and its maximum and its minimum limits are set as shown in the table 3.

Table 3: Example of VBR application and throughput limits requirements for calculation

		$\underline{\rho}_f$	$\bar{\rho}_f$
VBR Application	Internet Navigation	20 kbps	300 kbps
	Emails	10kbps	80 kbps

The Traffic per type of application is distributed uniformly on the surface and we study two scenarios, the table 4 shows the percentage of each type of application per scenario.

Table 4: User Profiles per type of application

		Scenario 1	Scenario 2
VBR Application	Voice	30 %	60%
	Video conference	15%	3%
	Video flow	10%	8%
VBR Application	Internet Navigation	25%	12%
	Emails	20%	17%

4.2. Proposed resolution Method

CPLEX optimization software is developed by ILOG [10] and Executed as Tomlab solver, it can solve optimization of mixed linear problem (MLP) by using the integrated version of MIP (Mixed Integer Programming).

In our study we use the algorithm "branch and cut" which is integrated into the MIP of the CPLEX. This method combined the efforts of the algorithm "Branch and Bound" and the « Polydrales" method.

For the LTE profiles and the propagation model used, we use the same parameters as in our last study in [9].

4.3. Results & Discussion

The table 5 shows the number of eNB to be deployed after optimization for different instances; the wired link cost has been also calculated. This cost represents the total capacity in kbps on the entire network.

Table 5: LTE network Dimensioning on traffic load

Scenario	Scenario 1		Scenario 2	
Number of sessions simulated	50 sessions	100 sessions	100 sessions	200 sessions
Number of Active eNB	7	12	27	35
Wired link Cost	125403.0	16545.5	25765.15	390345.2
Cell Radius (meter)	870	760	670	500

It is clear that the infrastructure of LTE networks will be big and expensive if the number of session increase, it depends also on the traffic profiles as the number of eNB increase for scenario 2 when the data traffic is privilege than voice.

The table 5 specifies also for each instance the average of coverage radius of the eNB, it is calculated by dividing the geographical area by the number of eNB. Radius coverage for each base station is obtained by calculating the distances from the eNB to the farthest mobile attached, we can observe that the obtained radius after optimization is very high and this is explained by the fact that the planning procedure optimizes both the cost of the wired links and the number of eNBs. Therefore, to minimize the wired links of radio access network, the procedure can attach a mobile user to a eNB farther than another.

From the cell radius evolution, we can conclude that it is interesting for operators to deploy microcells LTE to cover small area where there is high traffic demands otherwise the planning will lead to higher cost network and expensive infrastructure

4.4. Model limitation

Resolution method with CPLEX cannot satisfactorily solve the problems when the planning is needed for high traffic profiles because the number of variables increase with the number of session, it was difficult to solve our problem when the number of session is beyond 200, it would be interesting to develop an algorithm exploiting the relationships between variables, or improving the resolution time by starting from an initial solution found by an heuristic algorithm.

Traffic distribution is assumed to be homogeneous on the geographical area size, this assumption is necessary for the calculation of the LTE capacity formulas. However, it becomes restrictive if the planning surface is extended to urban or to the whole day, indeed, in an urban center, the traffic in a day is not concentrated in one place, also our models doesn't take in to consideration the user mobility and handover mechanism.

The CAC model used also is simplified as it doesn't take into account the future requests in time and does not include the HARQ protocol used in the LTE network.

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