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Optimization of Heterogeneous Network Performances Based on the Signal Interferences Noise Ration(SINR)

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Abstract

Integration of wireless and mobile networks to new generations constitutes a heterogeneous system, this is the case of LTE and WiFi networks. In this paper, we study and analyze the optimal performances of this system regarding the SINR(Signal Interference Noise Ration), the blocking probability and the user communication loss. The user mobility is represented by random wayPoint(RWP) model and users terminals equipped with multiple accesses interfaces. We have established a Markov chain to assess and analyze the performances obtained from the heterogeneous networks system. So we have proposed an average value of the signal power emitted in down-ling voice, the blocking probability of system connections.

Keywords: LTE, WiFi, Random WayPoint, Handover, Markov chain, SINR, blocking probability, heterogeneous network.

1. Introduction

Considering the current tendency of high demand and the presence communication almost everywhere, the global mobility of services and users, the use and the deployment of wireless access and mobiles become a necessity. As they have different characteristics, these networks can support various services. So, the ideal is to build several networks in the same place to satisfy the diversity user's choices; it is the case of the complementarity Lte (4G) and Wi-Fi networks available presently. The heterogeneousness of these networks must be accompanied by an adequate user mobility such as Random waypoint which better represent the individual movements with stops, departures and other actions were related to an individual movement in the urban places. New methods of saving, transmission and sharing of the bandwidth are imperative. Among these methods we targeted the selection technique of better network based on the SINR whose selection parameters are the blocking probability and connections losses.

In the literature, we have noted the most used selection techniques of a network. The authors (Shen & Zeng, 2008) analyzed the signal power received (RSNS) then the available bandwidth(TBNS) of a heterogeneous networks system. They exploited this system parameters such as the blocking probability and connections losses, but they did not take into account the interference in their selection strategies that they displayed which made less successful the results obtained from the blocking probability and connections losses. Besides the works of (Yang & al., 2007), (Ayyappan & al., 2009), (Al-Ghadi & al., 2011) and (Yang & al., 2007) took into account the interference in the selection techniques that they adopted which is the one based on the SINR, which allowed them to improve the connections losses probability during a vertical handover. However, they did not approach through their analyses the connections blocking parameters. These are studied on the other hand by (Jabban & al., 2012) who obtained more satisfactory results than those of the authors who precede them by taking into account the system performances related to the blocking probability or better connections quality. Besides, (Vuong & al., 2007) took into account the user mobility(terminal-controlled mobility management) and other aspects such as the cost, the battery life cycle and the handover frequency.

But through all these studies, authors did not take into account the constraint based on the number of users occupying these bandwidth units to decrease an available congestion of the system. The peculiarity of our model of connections and disconnections of a user is that if he is connected, the system leaves a given state and moves to an other state before returning to this one in a well defined time interval.

The paper is organized as follows: section 2 introduces the model of studied heterogeneous system where all the parameters are established. The algorithm of the selection technique based on the SINR is studied at the level of the section 3. Through the section 4, we developed the users mobility model, which is Random Waypoint(RWP) which we consider more adequate to the individual users movement. The average access demand rate for a service is established in the section 5. The average demand rate of vertical and horizontal handover is calculated through section 6. In section 7, we established a Markov chain to analyze the numbers of units of busy bandwidth and those of the users having occupied these units. The performances system studied such as the SINR and the blocking probability and connections losses are estimated in section 8. The obtained results are simulated in section 9. We ended our study in section 10 by conclusion and future work.

2. Model of Heterogeneous Networks System

A prototype model of heterogeneous networks system is given by figure 1. Indeed, we have a circular service area Z_1 of radius R_1 covered entirely by the mobile network Lte (4 G). This service area is distributed in several homogeneous circular sub-zones $(Z_j)_{2\leq j\leq m}$ of radius r_i among which each is covered by a wireless network (Wi-Fi). So Lte and Wi-Fi overlap in sub-zones Z_i and the Wi-Fi networks are separated between them. We denote by Z_0 the part of the service area not covered by a Wi-Fi network. Where from we have:

$$Z_O = Z_1 - \sum_{j=1}^{m} Z_j \tag{1}$$

The users is equipped with devices to multiple accesses, have possibility of changing connections in the zones

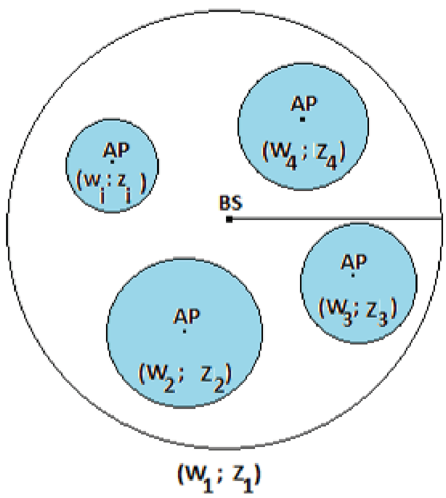

Figure 1. Model of service zone

where networks overlap by choosing automatically the network having the highest SINR. In our study, we suppose that the LTE network supplies two types of services: those Multicasts or Unicasts whose numbers of units of bandwidth are respectively B_1^{mc} and B_1^{uc}. The number of users occupying these units of bandwidth is respectively N_1^{mc} and N_1^{uc}. Besides the numbers of units of bandwidth and users occupying these units at the level of every Wi-Fi network are respectively B_i and N_i.

In the service area Z_1, we consider Q interferences sources distributed following a normal random distribution: $Q = \{I(q), q = 1...Q\}$.

The selection method is based on the SINR then these interferences play a major role at the level of this strategy allowing to select a network. The various parameters of the heterogeneous networks system are assigned in the following table:

Table 1. Parameters Lte and Wifi networks

Parameterstres	Network Lte W_1		Wireless Wifi $W_{i=2...m}$
Interferences	Normal distribution of Q sources		Normal distribution of Q sources
Covered areas	Z_1		$Z_{i=2...m}$
Service quality	Low bandwidth		large bandwidth
Services types	Multicast	Unicast	Unicast
Numbers of bandwidth units	B_1^{mc}	B_1^{uc}	B_i
users' numbers	N_1^{mc}	N_1^{uc}	N_i

3. Selection Technique Based on the SINR

If a user is in a zone Z_i where coexist both Lte and Wi-Fi then he has possibility of connecting recently or by handover to the network Lte or Wi-Fi. If the SINR is raised for the network Lte then the user connects there otherwise he is blocked to connect to the Wi-Fi network.

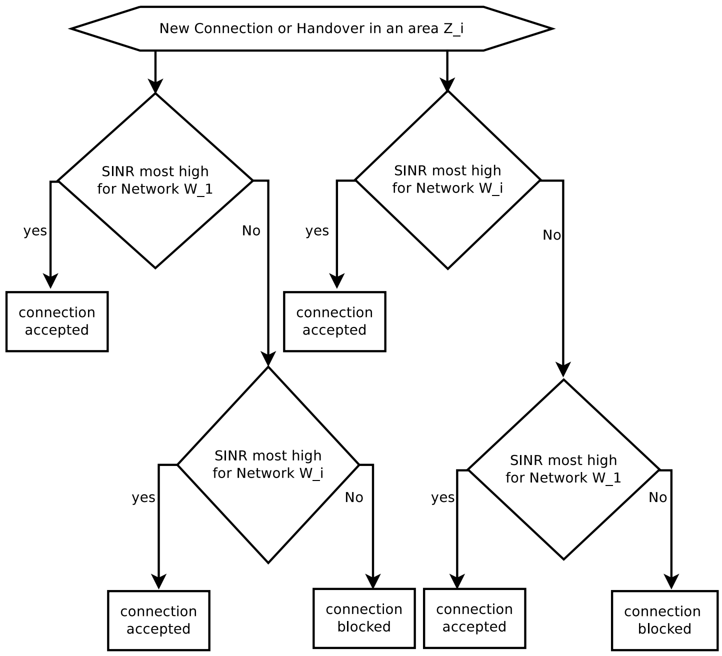

Figure 2. Network selection technique

4. Mobility Model: Random WayPoint (RWP)

The model RWP is the best adapted to the individual users movements. Indeed, it takes into account the individual users behavior such as their stops, departures and any action concerning the individual movement in a given zone.

4.1 Probability Density

The probability density of finding a user situated at a distance x of the convex service area center Z_1 and in a circular zone of radius r_i placed at a distance d_i of the cluster center is defined by (Hyytia & al., June 2006):

$$h(x) = (1 - x^2) \int_0^{\pi} \sqrt{1 - x^2 \cos(\Phi + \alpha - \beta)} d\Phi \quad (2)$$

With

$$x = \sqrt{d_i^2 + 2 d_i r_i \cos\alpha + r_i^2}$$

$$\beta = \arctan(d_i + r_i \cos\alpha; r_i \sin\alpha)$$

4.2 Probability $\mathbb{P}(Z_i)$ of Finding Users in a Sub-zone Z_i

In function of the model RWP and based on results obtained by ()Hyytia & Virtamo, October 2007) , we proved that the average arrival rate of a user in a zone Z_i of radius r_i and situated at a distance d_i of the service area center is established by the equation:

$$\tau_a(Z_i) = \frac{2}{C_v} \int_0^{\pi} \int_0^{\pi} r_i(1 - x^2) \sqrt{1 - x^2 \cos(\Phi + \alpha - \beta)} \sin \Phi d\Phi d\alpha \tag{3}$$

4.2 Probability $\mathbb{P}(Z_i)$ of finding users in a sub-zone Z_i

The probability to find users in a zone Z_i of radius r_i situated at a distance d_i of the cluster center depends directly on the user mobility. So we are based on the RWP and the authors (Bettstetter & Wagner works, March 2002)to prove the probability as following equation:

$$\mathbb{P}(Z_i) = \int_0^{R} \int_0^{\pi} \int_0^{2\pi} r_i(1 - x^2) \sqrt{1 - x^2 \cos(\Phi + \alpha - \beta)} d\Phi d\alpha dr_i \tag{4}$$

5. Average New Access Demand Rate $\lambda_{Z_i}^{c(k)}$ for a Service

We denote by $\lambda_{Z_1}^{c(k)}$ the average access demand rate for a service k in a zone Z_1. So the average access demand rate for a service k, $\lambda_{Z_i}^{c(k)}$, situated in a sub-cell Z_i is defined by formula:

$$\lambda_{Z_i}^{c(k)} = \mathbb{P}(Z_i).\lambda_{Z_1}^{c(k)} \tag{5}$$

6. Average Demand Rate of Handovers

6.1 Horizontal

Let $n_{Z_0}^{k}$ average user number accessing to the service k in the zone Z_0. The average demand rate of horizontal handover $\tau_{Z_0}^{c(k)}$ to the network W_1 for a service k is given by relation:

$$\tau_{Z_1}^{H(k)} = n_{Z_0}^{k}.\eta_{Z_0}^{Z_1} \tag{6}$$

Where $\eta_{Z_0}^{Z_1}$ is the exit flow of users from the zone Z_0 outside of the cell Z_1 and is defined by:

$$\eta_{Z_0}^{Z_1} = \frac{\mathbb{P}(Z_0)}{\Delta_{c(k)}}$$

With $\Delta_{c(k)}$ the average residence time of users in a zone Z_i.

6.2 Vertical

Let us denote by $n_{Z_0}^{k}$ the average number of users mobile accessing to the service k in the zone Z_0. The average demand rate of vertical handover $\tau_{Z_0}^{V(k)}$ to the network W_i users accessing to the service k in the zone Z_0 and moving towards the zone Z_i without having finished their connections is given by formula:

$$\tau_{Z_i}^{V(k)} = n_{Z_0}^{k}.\eta_{Z_0}^{Z_i} \tag{7}$$

Where $\eta_{Z_0}^{Z_i}$ is the exit flow of users from the zone Z_0 towards the cell Z_i and is defined by:

$$\eta_{Z_0}^{Z_i} = \frac{\mathbb{P}(Z_0)}{\Delta_{c(k)}}$$

With $\Delta_{c(k)}$ the average residence time of the users in a zone Z_i.

7. Modeling Approach Based on a Markov Chain

We have established a Markov chain to model and define all the stages and the states of heterogeneous networks system in function of the number of units of busy bandwidth and users numbers occupying these units at real time.

By denoting M and S all the zones of the cluster and services which are available on it, so the size of our Markov chain is: $s.(2m-1)$ with $|M| = m$ and $|S| = s$.

7.1 Various Stages and States of the System

When we consider the system at the given moment then we characterize it as being a stage of dynamic change. Besides, the users connections and disconnections of the system define the states space which is given by:

$$\mathcal{E} = \{((n_{1,1}^k; b_{1,1}^k); (n_{1,2}^k; b_{1,2}^k); ...; (n_{1,i}^k; b_{1,i}^k); ...; (n_{1,m}^k; b_{1,m}^k); (n_2^k; b_2^k); ...; (n_i^k; b_i^k); ...; (n_m^k; b_m^k))\} \quad (8)$$

$$s.q/ \begin{cases} \sum_{j=1}^{m}\sum_{k=1}^{s}(b_{1j}^k) & \leq & B_1^{uc} \\ \sum_{j=1}^{m}\sum_{k=1}^{s}(n_{1j}^k) & \leq & N_1^{uc} \\ \sum_{k=1}^{s}(b_i^k) & \leq & B_i \\ \sum_{k=1}^{s}(n_i^k) & \leq & N_i \end{cases}$$

Table 2. Definition parameters system

Notations	Definitions
$n_{1,1}^k$	Number of users connected to the Lte network to the service k in the zone Z_0
$n_{1,i}^k$	Number of users connected to the Lte network to the service k in the zone Z_i
n_i^k	Number of users connected to the Wi-Fi wireless to the service k in the zone Z_i
$b_{1,1}^k$	Number of units of busy bandwidth units of the Lte network of the service k in the zone Z_0
$b_{1,i}^k$	Number of units of busy bandwidth units of the Lte network of the service k in the zone Z_i
b_i^k	Number of units of busy bandwidth of the Wi-Fi wireless of the service k in the zone Z_i
N_{PBR}^k	Number of resources blocks needed to supply a service k by the network Lte

Table 3. System parameters

Notations	Definitions
$\sum_{k=1}^{s} n_{1,1}^k = n_{1,1}$	Number of users connected to the network Lte in the zone Z_0
$\sum_{k=1}^{s} n_{1,i}^k = n_{1,i}$	Number of users connected to the network Lte in the zone Z_i
$\sum_{k=1}^{s} n_i^k = n_i$	Number of users connected to the Wi-Fi wireless in the zone Z_i
$\sum_{k=1}^{s} b_{1,1}^k = b_{1,1}$	Number of units of busy bandwidth of the network Lte in the zone Z_0
$\sum_{k=1}^{s} b_{1,i}^k = b_{1,i}$	Number of units of busy bandwidth of the network Lte in the zone Z_i
$\sum_{k=1}^{s} b_i^k = b_i$	Number of units of busy bandwidth of the wireless Wi-Fi in the zone Z_i

• Stage 0:
$E_0 = ((n_{1,1}^k; b_{1,1}^k); (n_{1,2}^k; b_{1,2}^k); ...; (n_{1,i}^k; b_{1,i}^k); ...; (n_{1,m}^k; b_{1,m}^k); (n_2^k; b_2^k); ...; (n_i^k; b_i^k); ...; (n_m^k; b_m^k))$
• Stage 1:
$E_1 = ((n_{1,1}^k + \gamma n_0^k; b_{1,1}^k + \gamma N_{PRB}^k); (n_{1,2}^k; b_{1,2}^k); ...; (n_{1,i}^k; b_{1,i}^k); ...; (n_{1,m}^k; b_{1,m}^k); (n_2^k; b_2^k); ...; (n_i^k; b_i^k); ...; (n_m^k; b_m^k))$

$$\gamma = \begin{cases} 1 & \text{If a user } n_0 \text{ connects to the network Lte in the zone: } Z_0 \quad \text{State}(E_{1,1}) \\ -1 & \text{If a user } n_0 \text{ disconnects from the network Lte in the zone } Z_0 \quad \text{State}(E_{1,2}) \\ 0 & \text{Otherwise} \quad \text{State}(E_{1,3}) \end{cases}$$

• Stage 2:
$E_2 = ((n^k_{1,1}; b^k_{1,1}); (n^k_{1,2}; b^k_{1,2}); ...; (n^k_{1,i} + \gamma n^k_0; b^k_{1,i} + \gamma N^k_{PRB}); ...; (n^k_{1,m}; b^k_{1,m}); (n^k_2; b^k_2); ...; (n^k_i; b^k_i); ...; (n^k_m; b^k_m))$

$$\gamma = \begin{cases} 1 & \text{If a user } n_0 \text{ connects to the network Lte in the zone } Z_i \quad \text{State}(E_{2,4}) \\ -1 & \text{If a user } n_0 \text{ disconnects from the network Lte of the zone } Z_i \quad \text{State}(E_{2,5}) \\ 0 & \text{Otherwise} \quad \text{State}(E_{2,6}) \end{cases}$$

• Stage 3:
$E_3 = ((n^k_{1,1}; b^k_{1,1}); (n^k_{1,2}; b^k_{1,2}); ...; (n^k_{1,i}; b^k_{1,i}); ...; (n^k_{1,m}; b^k_{1,m}); (n^k_2; b^k_2); ...; (n^k_i + \gamma n^k_0; b^k_i + \gamma); ...; (n^k_m; b^k_m))$

$$\gamma = \begin{cases} 1 & \text{If a user } n_0 \text{ connects to the WiFi wireless in the zone } Z_i \quad \text{State}(E_{3,7}) \\ -1 & \text{If a user } n_0 \text{ disconnects from the WiFi wireless of the zone } Z_i \quad \text{State}(E_{3,8}) \\ 0 & \text{Otherwise} \quad \text{State}(E_{3,9}) \end{cases}$$

• Stage 4:
$E_4 = ((n^k_{1,1} + \gamma n^k_0; b^k_{1,1} + \gamma N^k_{PRB}); (n^k_{1,2}; b^k_{1,2}); ...; (n^k_{1,i} + \gamma' n^k_0; b^k_{1,i} + \gamma' N^k_{PRB}); ...; (n^k_{1,m}; b^k_{1,m}); (n^k_2; b^k_2); ...; (n^k_i; b^k_i); ...; (n^k_m; b^k_m))$

$$(\gamma, \gamma') = \begin{cases} (1, -1) & \text{If a user } n_0 \text{ connects to the network Lte in the zone } Z_0 \\ & \text{by disconnecting from the network Lte of the zone } Z_i \quad \text{State}(E_{4,10}) \\ (-1, 1) & \text{If a user } n_0 \text{ disconnects from the network Lte of the zone } Z_0 \\ & \text{by connecting to the network Lte in the zone } Z_i \quad \text{State}(E_{4,11}) \\ (0, 0) & \text{Otherwise} \quad \text{State}(E_{4,12}) \end{cases}$$

• Stage 5:
$E_4 = ((n^k_{1,1} + \gamma n^k_0; b^k_{1,1} + \gamma N^k_{PRB}); (n^k_{1,2}; b^k_{1,2}); ...; (n^k_{1,i}; b^k_{1,i}; ...; (n^k_{1,m}; b^k_{1,m}); (n^k_2; b^k_2); ...; (n^k_i + \gamma' n^k_0; b^k_i + \gamma')); ...; (n^k_m; b^k_m))$

$$(\gamma, \gamma') = \begin{cases} (1, -1) & \text{If a user } n_0 \text{ connects to the network Lte in the zone } Z_0 \\ & \text{by disconnecting from the WiFi network of the zone } Z_i \quad \text{State}(E_{5,13}) \\ (-1, 1) & \text{If a user } n_0 \text{ disconnects from the network Lte of the zone } Z_0 \\ & \text{By connecting to the WiFi network in the zone } Z_i \quad \text{State}(E_{5,14}) \\ (0, 0) & \text{Otherwise} \quad \text{State}(E_{5,15}) \end{cases}$$

• Stage 6:
$E_5 = ((n^k_{1,1}; b^k_{1,1}); (n^k_{1,2}; b^k_{1,2}); ...; (n^k_{1,i} + \gamma n^k_0; b^k_{1,i} + \gamma N^k_{PRB}); ...; (n^k_{1,m}; b^k_{1,m}); (n^k_2; b^k_2); ...; (n^k_i + \gamma' n^k_0; b^k_i + \gamma'); ...; (n^k_m; b^k_m))$

$$(\gamma,\gamma') = \begin{cases} (1,-1) & \text{If a user } n_0 \text{ connects to the network Lte in the zone } Z_i \\ & \text{by disconnecting from the WiFi wireless of the zone } Z_i \quad \text{State}(E_{6,16}) \\ (-1,1) & \text{If a user } n_0 \text{ disconnects from the network Lte of the zone } Z_i \\ & \text{en se connectant au réseau Wifi dans la zone } Z_i \quad \text{State}(E_{6,17}) \\ (0,0) & \text{Otherwise} \quad \text{State}(E_{6,18}) \end{cases}$$

7.2 Their Transition Rate

$$\checkmark\, \tau_{(E_0 \rightleftarrows E_{1,1})} = (\lambda^{c(k)}_{Z_0} + \lambda^{H(k)}_{N_1}).(\tfrac{b^k_{11}}{N^k_{PRB}} + 1)(\tfrac{n^k_{11}}{n^k_0} + 1).(\tfrac{1}{\Delta_{c(k)}} + \eta^{Z_1}_{Z_0}) \quad s.q/ \begin{cases} \sum_{j=1}^{m}(b_{1j} + N^k_{PRB}) & \leq & B^{uc}_1 \\ \sum_{j=1}^{m}(n_{1j} + n^k_0) & \leq & N^{mc}_1 \end{cases}$$

$$\checkmark\, \tau_{(E_0 \rightleftarrows E_{1,2})} = (\lambda^{c(k)}_{Z_0} + \lambda^{H(k)}_{N_1}).(\tfrac{b^k_{11}}{N^k_{PRB}})(\tfrac{n^k_{11}}{n^k_0}).(\tfrac{1}{\Delta_{c(k)}} + \eta^{Z_1}_{Z_0}) \quad s.q/ \begin{cases} b^k_{11} & \geq & N^k_{PRB} \\ n^k_{11} & \geq & n^k_0 \end{cases}$$

$$\checkmark\, \tau_{(E_1 \rightleftarrows E_{2,4})} = (\lambda^{c(k)}_{Z_i} + \lambda^{c(k)}_{Z_i}.\mathbb{P}(W_1 > W_i))(\tfrac{b^k_{1i}}{N^k_{PRB}} + 1).(\tfrac{n^k_{1i}}{n^k_0} + 1).\tfrac{1}{\Delta_{c(k)}} \quad s.q/ \begin{cases} b_i & = & B_i \\ \sum_{j=1}^{m}(b_{1j} + N^k_{PRB}) & \leq & B^{uc}_1 \\ n_i & = & N_i \\ \sum_{j=1}^{m}(n_{1j} + n^k_0) & \leq & N^{uc}_1 \end{cases}$$

$$\checkmark\, \tau_{(E_1 \rightleftarrows E_{2,5})} = (\lambda^{c(k)}_{Z_i} + \lambda^{c(k)}_{Z_i}.\mathbb{P}(W_1 > W_i))(\tfrac{b^k_{1i}}{N^k_{PRB}}.\tfrac{n^k_{1i}}{n^k_0}).\tfrac{1}{\Delta_{c(k)}} \quad s.q/ \begin{cases} b_i & = & B_i \\ b^k_{1i} & \geq & N^k_{PRB} \\ n_i & = & N_i \\ n^k_{1i} & \geq & n^k_0 \end{cases}$$

$$\checkmark\, \tau_{(E_2 \rightleftarrows E_{3,7})} = (\lambda^{c(k)}_{Z_i} + \lambda^{c(k)}_{Z_i}.\mathbb{P}(W_1 > W_i))(b^k_i + 1).(\tfrac{n^k_i}{n^k_0} + 1).\tfrac{1}{\Delta_{c(k)}} \quad s.q/ \begin{cases} b_i & \leq & B_i \\ \sum_{j=1}^{m}(b_{1j} + N^k_{PRB}) & = & B^{uc}_1 \\ n_i & \leq & N_i \\ \sum_{j=1}^{m}(n_{1j} + n^k_0) & = & N^{mc}_1 \end{cases}$$

$$\checkmark\, \tau_{(E_2 \rightleftarrows E_{3,8})} = (\lambda^{c(k)}_{Z_i} + \lambda^{c(k)}_{Z_i}.\mathbb{P}(W_1 > W_i))(b^k_i).(\tfrac{n^k_i}{n^k_0}).\tfrac{1}{\Delta_{c(k)}} \quad s.q/ \begin{cases} b^k_i & \geq & 1 \\ \sum_{j=1}^{m}(b_{1j} + N^k_{PRB}) & = & B^{uc}_1 \\ n^k_i & \geq & n^k_0 \\ \sum_{j=1}^{m}(n_{1j} + n^k_0) & = & N^{mc}_1 \end{cases}$$

$$\checkmark \tau_{(E_3 \rightleftarrows E_{4,10})} = (\frac{b_{11}^k}{N_{PRB}^k}+1)(\frac{n_{11}^k}{n_0^k}+1)(\frac{b_{1i}^k}{N_{PRB}^k})(\frac{n_{1i}^k}{n_0^k}).\tau_{Z_0>Z_i}^{H(k)} \quad s.q/ \begin{cases} b_i & = & B_i \\ \sum_{j=1}^{m}(b_{1j}+N_{PRB}^k) & \leq & B_1^{uc} \\ b_{1i}^k & \geq & N_{PRB}^k \\ n_i & = & N_i \\ \sum_{j=1}^{m}(n_{1j}+n_0^k) & \leq & N_1^{mc} \\ n_{1i}^k & = & n_0^k \end{cases}$$

$$\checkmark \tau_{(E_3 \rightleftarrows E_{4,11})} = (\frac{b_{11}^k}{N_{PRB}^k})(\frac{n_{11}^k}{n_0^k})(\frac{b_{1i}^k}{N_{PRB}^k}+1)(\frac{n_{1i}^k}{n_0^k}+1).\tau_{Z_i>Z_0}^{H(k)} \quad s.q/ \begin{cases} b_i & = & B_i \\ \sum_{j=1}^{m}(b_{1j}+N_{PRB}^k) & \leq & B_1^{uc} \\ b_{11}^k & \geq & N_{PRB}^k \\ n_i & = & N_i \\ \sum_{j=1}^{m}(n_{1j}+n_0^k) & = & N_1^{mc} \\ n_{11}^k & = & n_0^k \end{cases}$$

$$\checkmark \tau_{(E_4 \rightleftarrows E_{5,13})} = (b_i^k)(\frac{n_i^k}{n_0^k})(\frac{b_{11}^k}{N_{PRB}^k}+1)(\frac{n_{11}^k}{n_0^k}+1).\tau_{Z_i>Z_0}^{V(k)} \quad s.q/ \begin{cases} b_i^k & \geq & 1 \\ \sum_{j=1}^{m}(b_{1j}+N_{PRB}^k) & \leq & B_1^{uc} \\ n_i^k & \geq & n_0^k \\ \sum_{j=1}^{m}(n_{1j}+n_0^k) & = & N_1^{mc} \end{cases}$$

$$\checkmark \tau_{(E_4 \rightleftarrows E_{5,14})} = (b_i^k+1)(\frac{n_i^k}{n_0^k}+1)(\frac{b_{11}^k}{N_{PRB}^k})(\frac{n_{11}^k}{n_0^k}).\tau_{Z_0>Z_i}^{V(k)} \quad s.q/ \begin{cases} b_i & < & B_i \\ b_{1i}^k & \geq & N_{PRB}^k \\ n_i & < & N_i \\ n_{1i}^k & \geq & n_0^k \end{cases}$$

$$\checkmark \tau_{(E_5 \rightleftarrows E_{6,16})} = (\frac{b_{1i}^k}{N_{PRB}^k}+1)(\frac{n_{1i}^k}{n_0^k}+1)(b_i^k)(\frac{n_i^k}{n_0^k}) \quad s.q/ \begin{cases} b_i^k & \geq & 1 \\ \sum_{j=1}^{m}(b_{1j}+N_{PRB}^k) & \leq & B_1^{uc} \\ n_i^k & \geq & n_0^k \\ \sum_{j=1}^{m}(n_{1j}+n_0^k) & \leq & N_1^{mc} \end{cases}$$

$$\checkmark\,\tau_{(E_5 \rightleftarrows E_{6,17})} = (\frac{b_{1i}^k}{N_{PRB}^k})(\frac{n_{1i}^k}{n_0^k})(b_i^k + 1)(\frac{n_i^k}{n_0^k} + 1) \quad s.q/ \begin{cases} b_{1i}^k & \geq & N_{PRB}^k \\ b_i & \leq & B_i \\ n_{1i}^k & \geq & n_0^k \\ n_i & \leq & N_i \end{cases}$$

8. The Metrics of System Performances

We calculate the selection technique performances of a network based on the SINR in terms of blocking probability and the connections quality.

8.1 System SINR in a Sub-zone Z_i

The signal quality value SINR received in a sub-zone Z_i from the network W_1 is in function of the number of units bandwidth present in networks W_1 and W_i. By denoting $SINR_1^{avg}(E)$ the average capacity of signal received from network and $\mathbb{P}(E)$ the probability of balance state of the system then the total average value of SINR received in a zone Z_i from the network $W_1^{avg}(E)$ is given by:

$$SINR_{W_1}^{tot} = \sum_{k=1}^{s}(\lambda_{Z_i}^{c(k)} + \mathbb{P}(Z_i > Z_1)).\mathbb{P}(E)SINR_1^{avg}(E) \tag{9}$$

$$s.q/ \begin{cases} \sum_{j=1}^{m}(b_{1j} + N_{PRB}^k) & \leq & B_1^{uc} \\ \sum_{j=1}^{m}(n_{1j} + n_0^k) & \leq & N_1^{mc} \end{cases}$$

Where from we have:

$$SINR_1^{avg}(E) = SINR_1^{avg}.(1 - \Omega\sqrt{\frac{\sum_{j=1}^{m}(b_{1j} + b_j)}{B_1^{uc} + B_i}\frac{\sum_{j=1}^{m}(n_{1j} + n_j)}{N_1^{mc} + N_i}})$$

With

$$SINR_1^{avg} = \frac{P_1^{max}g_1.\mid x\mid^{-\alpha_1}}{\sum_{j=1}^{Q}P_{I(j)}^{max}.h_{nj}\mid Y_{nj}\mid^{-\alpha_j} + \sigma} \tag{10}$$

Where from:

- ☒ $\mid x \mid$ is the user's distance to the BS;
- ☒ P_1^{max} the maximal power transmitted by BS;
- ☒ g_1 exponential distribution of the channel power in average unity stemming from BS;
- ☒ α_1 is loss of the channel route stemming from BS;
- ☒ $\mid Y_{nj} \mid$ is distance from the source j to the user n is;
- ☒ $P_{I(j)}^{max}$ is the maximal power stemming from the interference source;
- ☒ h_{nj} is the exponential distribution of the channel power in average unit stemming from the interference source j;
- ☒ α_j is route loss of the channel from the interference source j is;

Then we have:

$$\overline{SINR}_{Z_{1i}} = \frac{SINR_{W_1}^{tot}}{\eta_{Z_i}^{c(k)}} \tag{11}$$

8.2 Blocking Probability and Connection Loss in a Sub-zone Z_i

By means of the probability balance states of the system $\mathbb{P}(E)$, we determined the blocking probability of the connections in a zone Z_i. Indeed, we added the probability of the system states where the number of units of busy bandwidth exceeds that available in the network W_1 as follows:

$$\mathbb{P}^B_{W_1} = \sum_{k=1}^{s} (\lambda^{c(k)}_{W_i} + \mathbb{P}(Z_i > Z_1)).\mathbb{P}(E).\mathbb{P}^B_1(E) \tag{12}$$

$$s.q/ \begin{cases} \sum_{j=1}^{m} (b_{1j} + N^k_{PRB}) & > & B^{uc}_1 \\ \sum_{j=1}^{m} (n_{1j} + n^k_0) & > & N^k_1 \end{cases}$$

With

$$\mathbb{P}^B_1(E) = \mathbb{P}^B_{Z_i}.(1 - \Theta.\sqrt{\frac{\sum_{j=2}^{m}(b_{1j} + b_j)}{B^{uc}_1 + B_i} \frac{\sum_{j=2}^{m}(n_{1j} + n_j)}{N^{mc}_1 + N_i}})$$

Where from we have:

$$\mathbb{P}^B_{Z_i} = \sum_{k=1}^{s} (\frac{\lambda^{c(k)}_{Z_i}.\mathbb{P}^{B(k)}_{Z_i}}{\lambda^c_{Z_i}}) \tag{13}$$

With $\mathbb{P}^{B(k)}_{Z_i}$ is the probability that a user is blocked to a service k in the zone Z_i.

9. Simulation and Critical Analysis Results

To test our results, we reduced our study frame to a cell Z_1 covered by the network W_1 (LTE) in which we implanted a wireless W_2(WIFI) in sub-cell Z_2 of Z_1.

Table 1. Simulation parameters

Parameters	Data
Average access rate to a service	70%
Average handover rate	60%
Average state balance rate	80%
Bandwidth Units in Lte	60
Noise power	-174 dBm/Hz
Signal power	400 dBm
Services number	2 services unicast
Cell radius	600m Z_1, 200m Z_2
Distance between area center	300m

With the simulator (NS3, 2006) and based on the parameters above we managed to obtain satisfactory results as gives evidence the obtained curves.

We estimated the average SINR value $SINR^{tot}_{W_1}$ obtained by a user n_0 in her sub-zone Z_2. As the selection technique of a network is directly related to the best SINR between networks W_1 and W_2 which overlap in sub-zone Z_2, then user choses the one which has the best quality of service that is the one of highest SINR. The results which we obtained, showed that a low modification of the signal quality occurs because of the congestion of the network. The factor Ω realizes this change as indicates figure 3 when the SINR is estimated in function of the interference. So more we increase the interference sources more the signal quality decreases in sub-zone Z_2. Nevertheless we calculated the signal quality in function of the bandwidth occupied rate as illustrate by figure 4. It also depends on the sensitivity factor Ω. We define the bandwidth occupied rate as the product of the fraction number of units occupied bandwidth on the number of units of bandwidth available on the initial of the network and the number of users occupying these units of bandwidth on the minimal number of users being able to occupy these units of bandwidth to the initial state.

On the other hand, we calculated the performances based on the total average blocking probability and connections losses to the services in sub-cell Z_2. The sensitivity factor Ω plays a fundamental role in the congestion and de-congestion of the network as illustrate by figures 5 and 6. We noticed, for the sensitivity factors $\Omega \in \{1; 0.7; 0.4\}$,

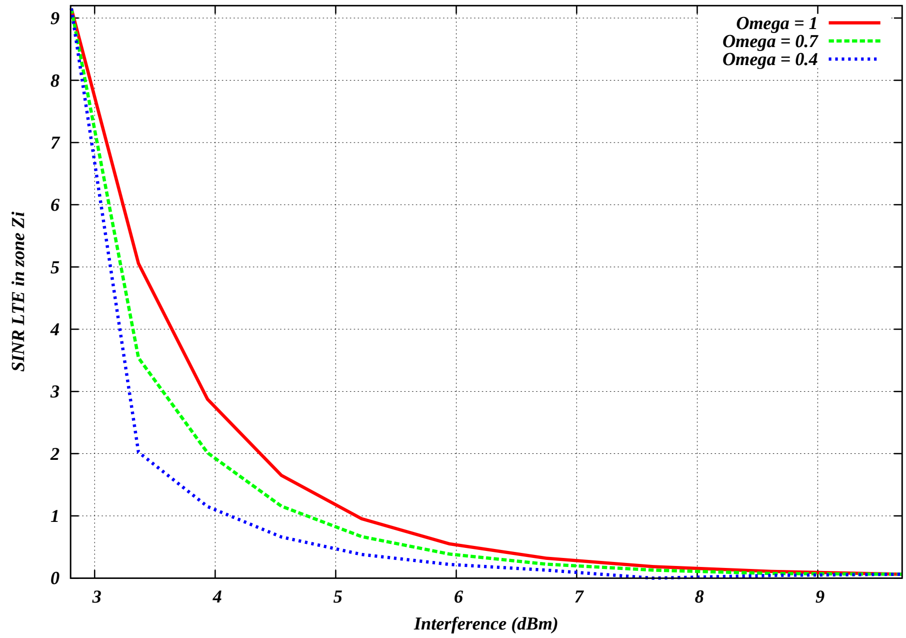

Figure 3. Average SINR of the network W_1 in the zone Z_2 in function of the interference.

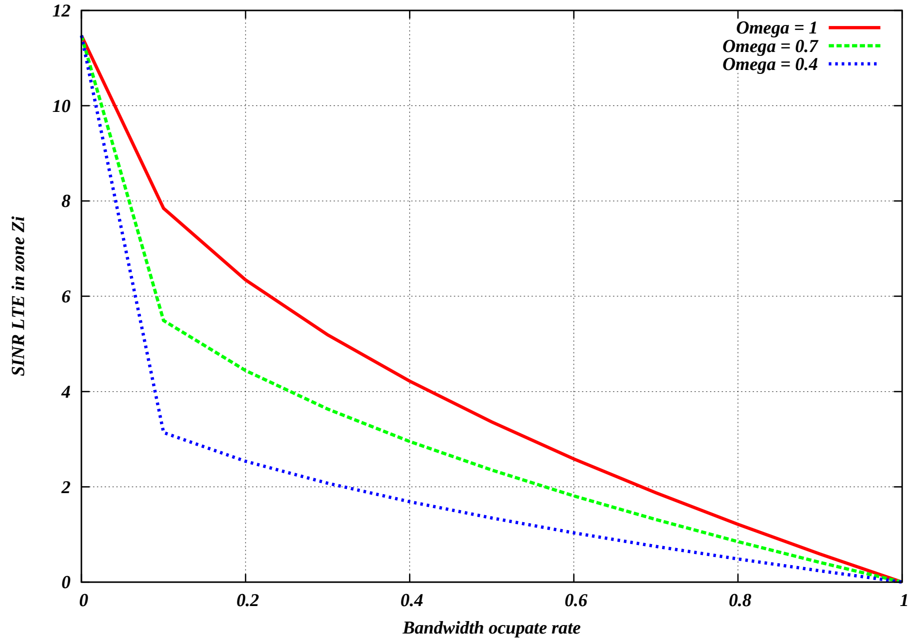

Figure 4. Average SINR of the network W_1 in the zone Z_2 in function of the busy bandwidth rate.

the blocking probability and connections losses in the zone Z_2 for the network W_1 are lower the 40% bar when they are determined in function of the occupation bandwidth rate as indicates figure 5. They also remain lower than the 50% bar in sub-cell zone Z_2 when we estimate them in function of the offered load by the traffic for any given sensitivity factor. This situation is understandable by a strong congestion of the heterogeneous networks system.

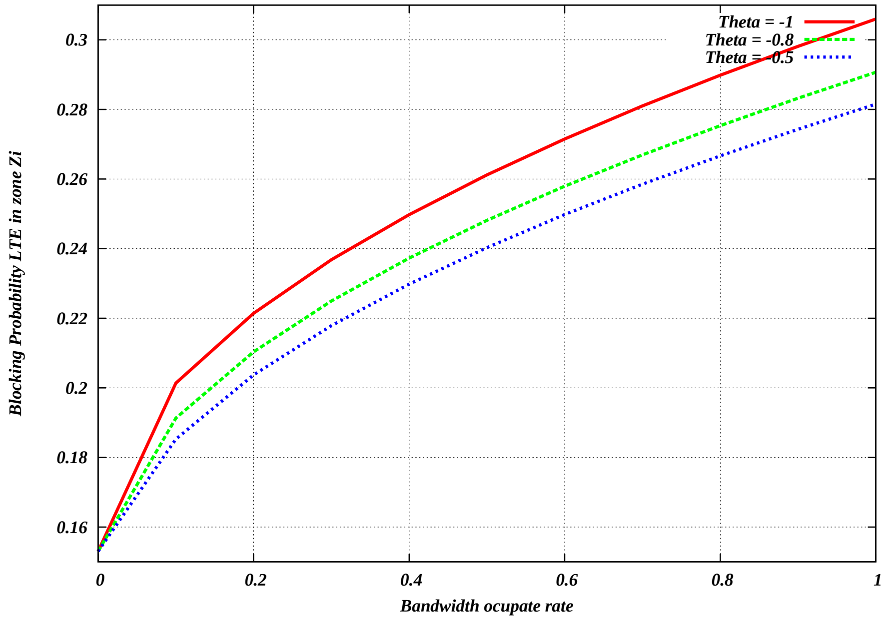

Figure 5. Blocking probability in the zone Z_2 in function of the busy bandwidth rate.

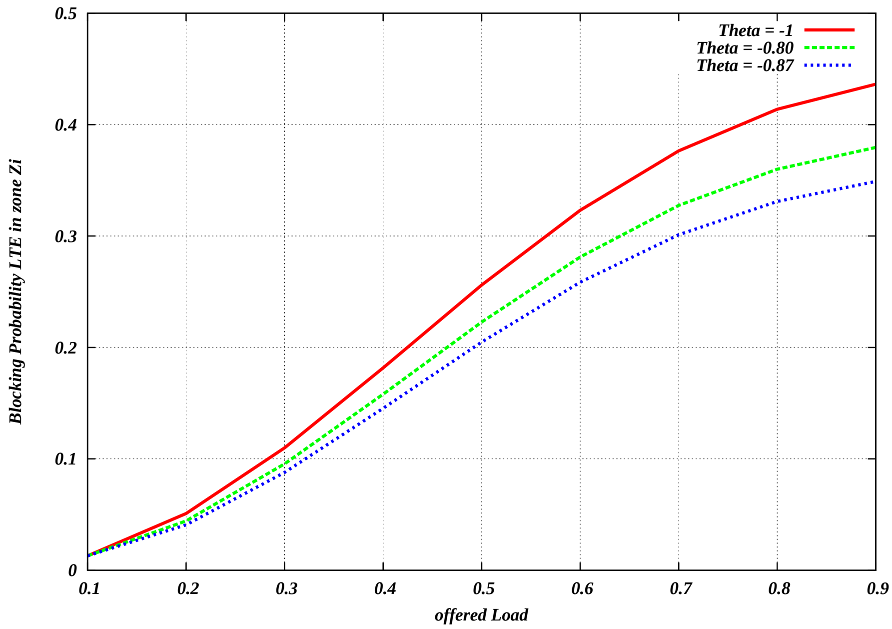

Figure 6. Blocking probability in the zone Z_2 in function of the offered load rate.

10. Conclusion

In this paper, we considered a network selection technique based on the value of the highest SINR received by a user in a system compound of networks LTE and WIFI. At the end of our study on the optimal performances of integration system of wireless and new generations mobile networks, we discovered a factor which remains very sensitive to the variations of the SINR calculated in function of the interference. Besides, this factor remains so determining for the blocking probability theory in a sub-zone Z_i by means of the rate of busy bandwidth or the rate of offered load traffic. The satisfactory results obtained on the performances of a system of wireless and mobile networks such the LTE and the Wi-Fi based on the signal power emitted by down-ling voice, allowed us to discover the dynamic evolutions of the system related to the SINR. The parameters related to the SINR such as the blocking probability are estimated with rates approaching the 40% bar. As future works, we plan to estimate the same sensitivity factor when we consider the performances of the system related to the bit rate.

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