Optimizing the Combination of MBSFN and PTM Transmissions in LTE Systems

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***Abstract*— The 3rd Generation Partnership Project (3GPP) has introduced the evolved Multimedia Broadcast/Multicast Service (e-MBMS) feature for cellular systems as an evolution to the existing MBMS service. To support e-MBMS in Long Term Evolution (LTE) systems, 3GPP recommends the use of Point-to-Multipoint (PTM) transmissions and MBMS over a Single Frequency Network (MBSFN). MBSFN is a new feature where a time-synchronized common waveform is transmitted from multiple cells. In this paper we investigate the provision of MBMS service over a combination of MBSFN and PTM transmission methods. A cost analysis of the MBMS service is presented based on the transmission cost over all the interfaces and nodes of the LTE architecture. We evaluate the performance of this transmission scheme from telecommunication cost perspective and we compare it with other transmission schemes. The performance evaluation has been performed with the aid of a new simulation tool that estimates the cost for the MBMS provision under different network topologies, MBSFN deployments and user distributions.**

Keywords- ***long term evolution; multimedia broadcast and multicast; single frequency network; point-to-multipoint; cost analysis;***

I. INTRODUCTION

The evolved Multimedia Broadcast and Multicast Services (e-MBMS) feature constitutes the evolutionary successor of MBMS for Long Term Evolution (LTE) systems. The key motivation for integrating multicast and broadcast extensions into mobile communication systems is to enable efficient group related data distribution services, especially on the radio interface [1].

Point-to-Multipoint (PTM) transmission method has been proposed by the 3rd Generation Partnership Project (3GPP) and allows data to be transmitted from a single source entity to multiple recipients [1]. It improves the scalability of broadcast and multicast in cellular networks by utilizing a common channel to send the same data to multiple receivers, and thus minimizes the usage of network resources. However, its performance is still restricted, mainly because the performance of User Equipments (UEs) at the overlapping cellular regions could be affected by destructive interferences, i.e., Inter-Symbol Interference (ISI).

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Furthermore, the performance of a UE gradually degrades as it moves away from the transmitting base station. However, the fact that cells broadcast the media to all users without requiring synchronization with adjacent cells indicates that PTM transmissions may result in low cost.

To improve the multimedia data delivery, LTE has exploited the Orthogonal Frequency-Division Multiplexing (OFDM) radio interface to transmit MBMS data as a multicell transmission over a synchronized Single Frequency Network (MBSFN). MBSFN transmission enables a more efficient operation of the MBMS service, allowing over-the-air combining of multi-cell transmissions towards the UEs [1].

It is important to mention that several previous research works examine the performance of PTM and MBSFN transmissions. More specifically, an end-to-end cost analysis model for the evaluation of different one-to-many packet delivery schemes in Universal Mobile Telecommunication System (UMTS) is presented in research works [2] and [3]. In these works, the authors consider different transport channels for the transmission of the MBMS data over UMTS systems. However, both these approaches focus on UMTS networks and cannot be applied in next generation LTE networks. Research work [4] examines how many neighboring cell rings should be included in the same MBSFN area with the cells that actually contain users. In order to estimate the ideal number of assisting rings, only the air interface cost - in terms of spectral efficiency - and not the total telecommunication cost is taken into account. Finally, the work presented in [5], proposes an analytical approach to evaluate and validate the performance of an MBSFN-enabled LTE network. However, none of these works examine the provision of MBMS service over a combination of MBSFN and PTM transmission schemes.

The goal achieved by this work is twofold. At a first level, the proposed mechanism extends the above research works by evaluating the performance of a MBMS provision scheme that combines MBSFN with PTM transmissions. At a second level, the end-to-end cost-based evaluation approach has not yet been studied and it is our belief that this approach contributes to more sophisticated results than other approaches that investigate only the efficiency over the air interface. During the evaluation we take into account the total transmission cost that consists of the packet delivery cost at the network nodes and interfaces and the cost for control procedures. Contrary to previous works (like [4] and [5]), we suppose a linear change of the resource efficiency when transiting between different numbers of assisting rings instead of the flat one. This results in a more realistic estimation of the air interface cost. For the experimental evaluation we have designed and implemented a simulation tool that examines the various LTE system configurations and makes an optimal selection of the transmission method (MBSFN or PTM) over each cell of the LTE network in order to minimize the total telecommunication cost.

The rest of the paper is structured as follows: Section II describes the e-MBMS LTE architecture. A cost analysis for the examined transmission methods is presented in Section III. Section IV describes our simulation experiments and the obtained results. Finally, in Section V we draw conclusions and propose ideas for future work.

II. E-MBMS LTE Architecture

The e-MBMS architecture is illustrated in Figure 1. Within evolved Universal Terrestrial Radio Access Network (e-UTRAN), the evolved Node Bs (e-NBs) or base stations are the collectors of the information that has to be transmitted to users over the air-interface. The Multicell/multicast Coordination Entity (MCE) is the responsible node for the allocation of time and frequency resources for multi-cell MBMS transmission. When MBSFN is used, MCE is also responsible for coordinating the transmission of synchronized signals from different e-NBs. The e-MBMS Gateway (e-MBMS GW) is physically located between the evolved Broadcast Multicast Service Centre (e-BM-SC) and e-NBs and its principal functionality is to forward the MBMS packets to each e-NB transmitting the service. Furthermore, e-MBMS GW performs MBMS Session Control Signaling (Session start/stop) towards the e-UTRAN via Mobility Management Entity (MME). The e-MBMS GW is logically split into two domains. Likewise, two distinct interfaces have been defined between e-MBMS GW and e-UTRAN namely M1 for user plane and M3 for control plane. M1 interface makes use of IP multicast protocol for the delivery of packets to e-NBs. M3 interface supports the MBMS session control signaling, e.g. for session initiation and termination [1], [6].

The e-BM-SC is the entity in charge of introducing multimedia content into the network. For that purpose, the e-BM-SC serves as an entry point for content providers or any other external broadcast/multicast source. An e-BM-SC serves all the e-MBMS GWs in a network.

Regarding the air (or LTE-Uu) interface, both PTM and MBSFN transmission methods use two downlink logical channels, namely Multicast Traffic Channel (MTCH) and Multicast Control Channel (MCCH). MTCH is a PTM channel for transmitting data traffic to the UEs residing to the service area. On the other hand, MCCH is a PTM downlink channel used for transmitting MBMS control information from the network to UEs and is associated to one or several MTCHs. MCCH and MTCH are only used by UEs that receive MBMS traffic [1], [7].

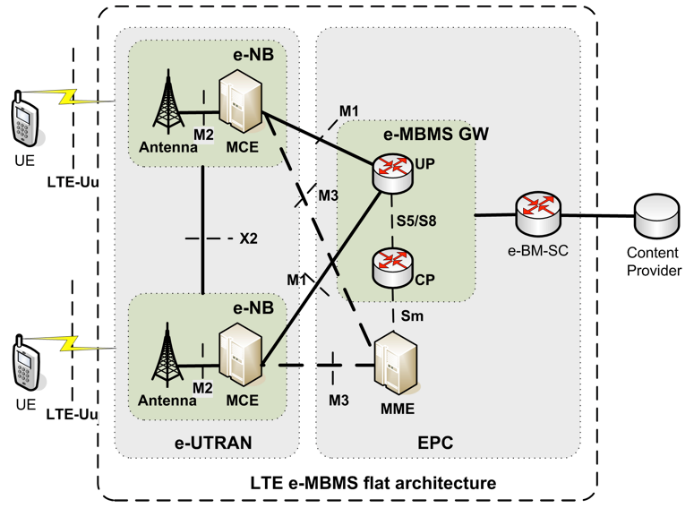

Figure 1. e-MBMS flat architecture.

III. Cost Analysis

In this section, we present a cost analysis of PTM and MBSFN transmission schemes. The evaluation of the performance of each transmission scheme and the selection of the optimal system configuration is based on this cost analysis. The performance metric for the evaluation is the total telecommunication cost for both packet deliveries and control signal transmissions [8]. For the analysis, we apply the notations presented in Table I.

TABLE I. Notations for Cost Analysis

Abbreviation	Explanation
D_{Uu_PTM}	Transmission cost of single packet over air for PTM
D_{Uu_MBSFN}	Transmission cost of single packet over air for MBSFN
C_{Uu_PTM}	Total transmission cost over Uu (air) interface for PTM
C_{Uu_MBSFN}	Total transmission cost over Uu (air) interface for MBSFN
C_{M1_PTM}	Total transmission cost over M1 interface for PTM
C_{M1_MBSFN}	Total transmission cost over M1 interface for MBSFN
N_{eNB_PTM}	Number of e-NBs that participate in PTM (cells with users)
N_{eNB_MBSFN}	Number of e-NBs that participate in MBSFN
N_{cell_PTM}	Total number of e-NBs in the topology for PTM
N_{cell_MBSFN}	Total number of e-NBs in the topology for MBSFN
D_{M1}	Transmission cost of single packet over M1 interface
D_{M2}	Transmission cost of single packet over M2 interface
N_p	Total number of packets of the MBSFN session
N_{p_burst}	Mean number of packets in each packet burst
C_{SYNC}	Total cost for synchronization
C_{PTM}	Total telecommunication cost of the PTM transmission
C_{MBSFN}	Total telecommunication cost of the MBSFN transmission
C_{TOTAL}	Total telecommunication cost of the whole session

Before presenting in detail the above parameters, some information on the properties of the MBSFN area is presented.

A. MBSFN Area Configuration

In Figure 2 we present an example of a topology that transmits over a synchronized waveform using the MBSFN transmission scheme. The MBSFN area consists of the cells marked with blue or cyan color. The users are located in the blue cells. The external cells of the center blue area assist the service and transmit the same MBSFN data. These are called assisting cells formulating assisting rings and are painted with cyan color. Finally, red color is used for the cells where for

PTM transmission scheme is used. The same convention is used through all this work.

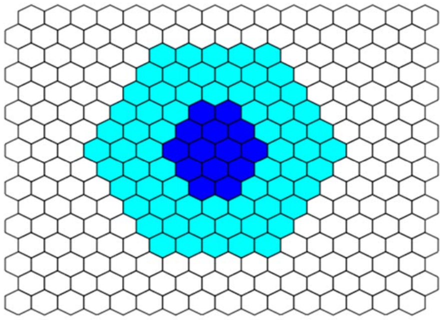

Figure 2. MBSFN area consisting of the centre cells and three assisting rings.

The reason for MBSFN transmission in the assisting cells is that the performance of the MBSFN transmission scheme increases rapidly when assisting cells that transmit the same MBSFN data are added to the topology. More specifically according to [9] and [10], even the presence of one assisting ring can significantly increase the overall spectral efficiency and decrease the total telecommunication cost. Moreover, we assume that a maximum of 3 neighboring rings outside the center cells can transmit in the same frequency and broadcast the same MBSFN data (assisting rings), since additional rings do not offer any significant additional gain in the MBSFN transmission [9], [10].

Below is presented an analysis of each cost that is taken into account for the calculation of the total telecommunication cost. The analysis is based on the e-MBMS LTE architecture that was presented in Section II (Figure 1).

B. Polling Cost

In order to determine which cells contain users interested in receiving the MBMS service, we assume that a polling procedure is taking place. It should be noted that we differentiate the cost for MBMS polling from the cost for packet deliveries. In contrast to the counting procedure used for the provision of MBMS in UMTS systems, where the exact number of MBMS users was determined, polling just determines if the cell contains at least one user interested for the given service. The polling cost is independent and stable compared to the other parts of the total cost. Moreover, this cost is too small in comparison to the other parts of the total cost.

The e-NB receives the feedback from the UEs in the form of signature sequence. This information (packet) is sent to the MCE over M2 interface, which estimates which cells contain MBMS users interested for the given MBMS service [11].

$$\begin{aligned} C_{Polling} &= C_{Polling\_air} + C_{Polling\_core} = \\ & D_{p\_eNB\_PTM} \cdot N_{cell\_PTM} + D_{p\_eNB\_PTM} \cdot N_{cell\_MBSFN} + \\ & D_{M2} \cdot (N_{eNB\_PTM} + N_{eNB\_MBSFN}) \end{aligned} \tag{1}$$

The total cost associated to the polling procedure is derived from equation (1), where N_{cell_PTM} and N_{cell_MBSFN} is the number of e-NBs in the topology for PTM and MBSFN transmission schemes (since all e-NBs send a UE feedback request message), N_{eNB_MBSFN} represents the number of e-NBs that participate in MBSFN transmission and N_{eNB_PTM} those that participate in PTM transmission. Also the terms Dp_eNB_PTM and $D_{p\_eNB\_MBSFN}$ represent the cost of polling procedure at each e-NB (equal to D_{Uu_PTM} and D_{Uu_MBSFN} respectively) and *DM2* is the cost of the delivery of a single packet over the M2 interface (see Figure 1).

C. Air Interface Cost

The transmission cost over the air interface is defined for different network topologies, user distributions and deployments. In Figure 1 the air interface is the interface Uu that connects the UE and the base station.

In order to estimate the telecommunication cost over the air interface, we define the term resource efficiency percentage (*RE_percentage*). This is the fraction of the current deployment resource efficiency to the maximum resource efficiency that can be achieved for the given user distribution and indicates the quality of the resource efficiency achieved by the examined deployment [4]. Then, we define the cost of packet delivery over the air interface (DUu) as the inverse of *RE_percentage*. This means that as the resource efficiency of a cell increases, the *RE_percentage* increases too. Thus, the cost of packet delivery over the air interface decreases. In [4] the maximum resource efficiency achieved 2.4 bps/Hz (infinity topology with AAA MBSFN deployment). According to this, we define the cost of a single packet delivery over the air interface (DUu) as follows:

$$D_{Uu} = \frac{2.4}{RE\_percentage} \tag{2}$$

Finally, the total cost for the transmission of the data packets over Uu (air) interface is derived from the following equation:

$$C_{Uu} = C_{Uu\_PTM} + C_{Uu\_MBSFN} \tag{3}$$

The above definition includes the air interface costs for both PTM and MBSFN transmission schemes. In order to make it explicit, we express the equation (4) for PTM transmission scheme:

$$C_{Uu\_PTM} = D_{Uu\_PTM} \cdot N_p \cdot N_{eNB\_PTM} \tag{4}$$

The term N_{eNB_PTM} represents the number of e-NBs that participate in PTM transmission; N_p the total number of packets of the session and D_{Uu_PTM} is the cost of the delivery of a single packet over the air interface.

Similarly in equation (5) the equivalent terms are defined for the MBSFN transmission scheme.

$$C_{Uu\_MBSFN} = D_{Uu\_MBSFN} \cdot N_p \cdot N_{eNB\_MBSFN} \tag{5}$$

D. Core Interface Cost

The cost over M1 interface is indicated as the core telecommunication cost. M1 interface uses IP multicast protocol for the delivery of packets to e-NBs. The total cost for the transmission of the data packets over M1 interface for PTM and MBSFN transmission schemes is derived from equations 6 and 7. The term DM1 is the cost of the delivery of a single packet over M1 interface. It is obvious that this cost depends on the number of e-NBs that participate in the PTM and MBSFN transmission respectively.

$$C_{M1\_PTM} = D_{M1} \cdot N_P \cdot N_{eNB\_PTM} \quad (6)$$

$$C_{M1\_MBSFN} = D_{M1} \cdot N_P \cdot N_{eNB\_MBSFN} \quad (7)$$

The term DM1 depends on the number of hops between the nodes connected by M1 interface and the profile of the M1 interface in terms of link capacity [5]. Generally, a high link capacity corresponds to a low packet delivery cost over M1 and a small number of hops, corresponds to a low packet delivery cost.

E. Synchronization Cost

The synchronization cost appears only in the case of MBSFN transmission scheme. The overall user plane architecture for content synchronization is depicted in Figure 3.

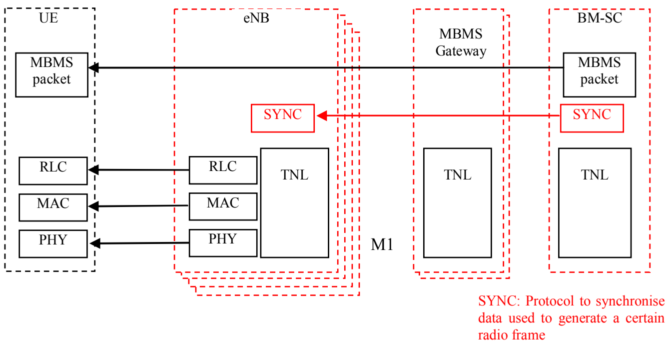

Figure 3. Content synchronization in MBSFN.

The SYNC protocol layer is defined on transport network layer to support content synchronization. It carries additional information that enables e-NBs to identify the timing for radio frame transmission and detect packet loss. The SYNC protocol operates between e-BM-SC and e-NB. As a result, synchronization ensures that the same content is sent over the air to all UEs [1].

The total telecommunication cost for the transmission of the synchronization packets is derived from the following equation where DM1 is the cost of the delivery of a single packet over the M1 interface and N_{p_burst} is the mean value of the number of packets transmitted each time in the sequential bursts of the MBSFN session [11].

$$C_{SYNC} = \frac{N_{P\_MBSFN}}{N_{P\_burst}} \cdot D_{M1} \cdot N_{eNB\_MBSFN} \quad (8)$$

F. Total Telecommunication Cost

It is quite important to define the term telecommunication cost, which is a metric that takes into account the number of transmitted packets and all the properties of the interfaces and intermediate nodes. The total telecommunication cost for the transmission is the combination of PTM, MBSFN and polling costs.

$$C_{TOTAL} = C_{PTM} + C_{MBSFN} + C_{Polling} \quad (9)$$

According to the detailed analysis presented above, the total cost for the MBSFN transmission is the following:

$$C_{MBSFN} = C_{Uu\_MBSFN} + C_{M1\_MBSFN} + C_{SYNC} \quad (10)$$

The estimation of the PTM cost takes into account the air interface and core network telecommunication cost. The equation below shows the total cost for PTM transmission scheme:

$$C_{PTM} = C_{Uu\_PTM} + C_{M1\_PTM} \quad (11)$$

IV. EXPERIMENTAL RESULTS

Based on the above cost analysis we examine the total telecommunication cost for several transmission schemes (PTM, MBSFN with or without assisting cells and their combination). We consider different multicast users distributions in the LTE network and determine the minimal cost among the estimated ones. Our goal is to investigate how the optimal MBSFN deployment and the corresponding minimal cost vary for the simulation scenarios that we examine. By the term optimal MBSFN deployment we mean that we determine the cells that should be assigned to an MBSFN area, while the rest of the cells with multicast users are served through PTM transmissions, in a way that minimizes the total telecommunication cost. For the performance evaluation we have designed and implemented a simulation tool that is able to estimate the total telecommunication cost for different deployments and user distributions as well as the optimal deployment for a given user distribution. The tool is available at [12].

A. Simulation Scheme

The pseudocode that summarizes our mechanism for the selection of the optimal network configuration for any given user distribution is presented below. The main idea is to sequentially compare the intermediate calculated costs until we find the minimum total one. More specifically, the grid subroutine constructs the environment where we carry out our experiments. The evaluate subroutine calculates the total cost for each cell and then returns the cost of the system. The mutate subroutine randomly enables and disables MBSFN cells and returns the changes it recently made. The demutate subroutine can undo those changes later if the evaluation of the grid shows a decrease in the cost of the system topology because of those changes.

```
% Telecommunication Cost Optimization Algorithm

grid = create_grid( )
create_rings(grid, number_of_assisting_rings)
cost = evaluate(grid)
best = cost
output("Initial Cost: ", best)
While (not user_break)
        mutations = mutate(grid)
        cost = evaluate(grid)
        if cost < best then
                best = cost
                output("Current cost: ", best)
                export_grid_to_file(grid)
        elseif cost == best then
                best = cost
        else
                demutate(grid, mutations)
        end
end
```

The system simulation parameters that we take into account during our simulation experiments are presented in Table II.

The typical evaluation scenario used for LTE, is macro Case 1 with bandwidth equal to 1.4 MHz and low UE mobility. The propagation models for macro-cell scenario are based on the Okamura-Hata model [4].

In our simulation experiments, we examine how the optimal MBSFN area deployment varies with respect to the estimated telecommunication cost. In addition, we compare this optimal cost with the cost that corresponds to the following configurations that have been defined and analyzed in [4]:

- MBSFN area deployment with AII (one assisting ring and two interfering rings),
- MBSFN area deployment with AAI (two assisting rings and one interfering),
- MBSFN area deployment with AAA (three assisting rings),
- PTM only transmission (no MBSFN is used).

The estimated costs for the above configurations are compared to the optimal ones selected by our simulation tool (combination of MBSFN and PTM transmission schemes).

In the simulation environment that we have constructed, we create different topologies and calculate the total normalized telecommunication costs. It is worth mentioning that for the term normalized we assume a value that varies between 0 and 1 and equals to the current cost divided by the corresponding maximum one.

TABLE II. SIMULATION PARAMETERS

Parameter	Units	Value
Cellular layout		Hexagonal grid, 19 cell sites
Inter Site Distance (ISD)	m	500
Carrier frequency	MHz	2000
System bandwidth	MHz	1.4
Channel model		3GPP Typical Urban
Path loss	dB	Okumura-Hata
BS transmit power	dBm	46
BS # antennas		1
UE # Rx antennas		2
UE speed	Km/h	3

B. Cost for Typical User Distributions

The first part of our simulation experiments determines the optimal telecommunication cost and compares it with the costs that correspond to the configurations presented above for some indicative typical examples of user distribution.

Figure 4 illustrates the four examined scenarios of this part of our simulation experiment. The first user distribution (a) considers that all multicast users are located in a set of adjacent cells in a way that a single area with multicast users is formulated. The second one (b) considers that the majority of the multicast users are located in a set of adjacent cells formulating a primary area, while a small minority roams to a single-cell area. The third scenario (c), considers the case where the multicast user population is distributed sparsely among the grid. The last distribution (d) includes a random MBSFN area and a small area of adjacent cells that are joined with assisting cells.

The configurations depicted in Figure 4 are the optimal ones selected by our simulation tool. Based on the above description of the figures' colour layout, the multicast users are located on the cells with blue color (MBSFN UE drop location cells) and in the cell with red color (cells served by PTM transmission). The cyan cells transmitting with MBSFN transmission scheme for assisting purposes and are selected to be used only in the (d) scenario where the primary and secondary areas have been connected with assisting rings in a way that a single MBSFN area has been formulated.

For each topology presented in Figure 4 and each configuration presented above, we calculate the normalized total telecommunication costs. We present the comparison of the results in Figure 5. This figure reveals the total telecommunication cost for each examined case for the user distributions (a) to (d). The bars that correspond to the "MBSFN + PTM" transmission scheme refer to the optimal configuration selected by our simulation tools. This does not necessarily mean that both MBSFN and PTM transmission are always used for the provision of MBMS service. There are cases where the optimal configuration dictates that only MBSFN or only PTM transmission achieves the lowest cost.

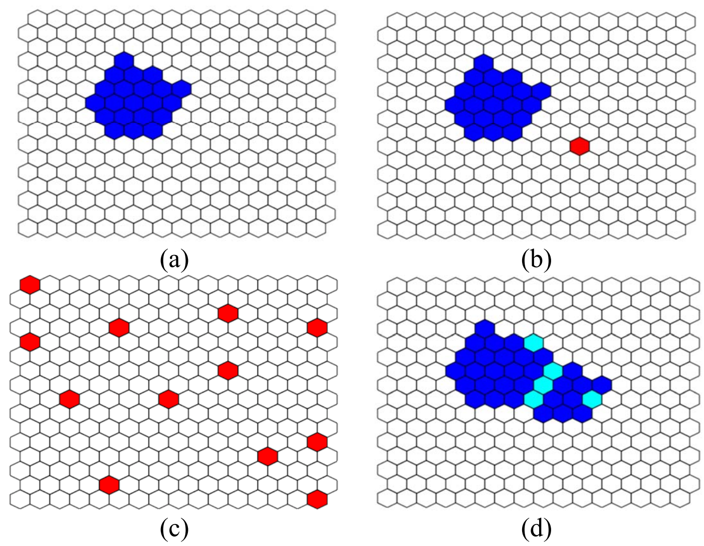

Figure 4. Optimal configuration for typical user distributions.

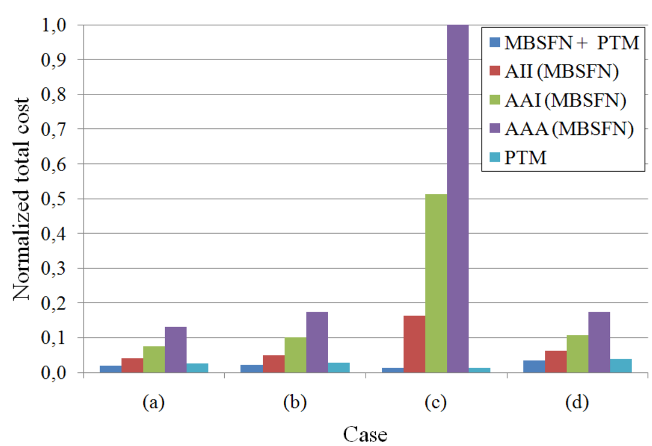

Figure 5. Normalized total telecommunication for each case from (a) to (d).

A general result applicable to all the examined user distributions is that the case of the MBSFN area with three assisting rings (AAA), results in the highest cost. Especially in case (c) where the optimal selection indicates that MBMS is provided with PTM transmission scheme in all the cells where users are located, the cost reaches the maximum value. On the other hand, the cases of MBSFN transmission with one assisting ring (AII), two assisting rings (AAI), and PTM transmission scheme show flat cost behavior. The optimal deployment selected by our simulation tool combines MBSFN and PTM transmission schemes. This deployment results in the lower telecommunication cost and appears the most efficient scheme for the provision of MBMS service. It should be noted that in some cases the proposed transmission scheme can coincide with one of the configurations borrowed by [4] and used for benchmarking purposes. For instance, the optimal selection for case (c) coincides with the plain PTM transmission scheme.

C. *Cost for Moving Users Located in Single Cell*

The second part of our simulation experiments attempts to estimate how the optimal MBSFN deployment varies as the multicast user distribution changes. In the following experiments the estimated optimal cost is compared with the cost estimated for the four typical configurations that we examine (MBSFN-AII, MBSFN-AAI, MBSFN-AAA, and PTM only).

First, we consider a set of adjacent cells where the multicast users are located in a way that a primary area with multicast users is formed. The next step is to define a cell where multicast users exist and to see how the optimal MBSFN deployment varies as the position of this cell recedes from the primary multicast users' area. We call each step of the procedure "hop". The procedure is described step by step in Figure 6. The case where we define zero number of hops is shown in Figure 4 (a), so in Figure 6 we start from the case where the moving cell borders with the primary area of the examined topology.

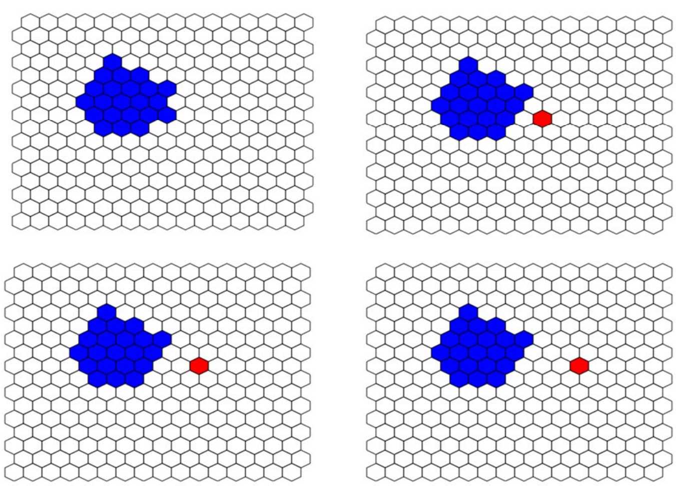

Figure 6. Cell moving one to four hops away from the starting topology.

In Figure 7 we observe that the cost increases as the users are moving away from the initial topology. In the case where the cell (where multicast user(s) exist) has moved four hops far from the primary MBSFN area, the cost has the highest value. Also the curve in Figure 7 that represents the case of MBSFN area with the three assisting rings (AAA) appears to be the most cost inefficient method.

Another interesting observation in this figure is that the optimal scheme (combination of MBSFN and PTM) ensures the lowest cost and proves a stable behavior when network condition changes occur.

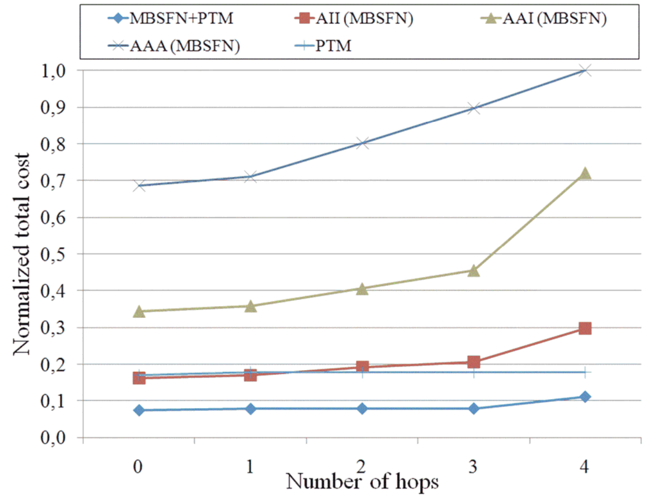

Figure 7. Normalized cost vs. number of hops.

D. *Cost for Variable MBSFN Area*

Last but not least, we examine how the optimal MBSFN deployment varies, when the number of cells that consist the remote area increases. For this purpose, we consider that a remote (secondary) area initially consisting of one cell is located near to the central (primary) area with multicast users. In the experiment that we carry out, we monitor the telecommunication cost when the number of cells that consist the secondary area increases. The estimation of the telecommunication cost is performed for the five configurations that have also been considered in the previous experiments.

In more detail, in this case we have a random MBSFN topology and we start to construct cell-by-cell another one close to this. The final result is similar to the topology presented in Figure 4 (d). This construction is done in nine steps. Therefore, eventually the remote area is consisted of nine cells. For each step of the experiment we calculate the total telecommunication cost that occurs for each topology.

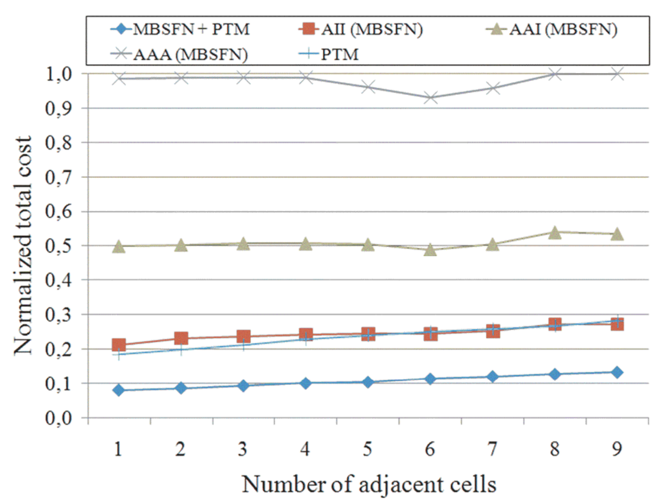

Figure 8. Normalized telecommunication cost vs. number of adjacent cells.

In Figure 8 we present the impact of the number of the adjacent cells inserted in the secondary area, on the total telecommunication cost. The main observation is that AAA case produces the highest cost value. The selected combination of MBSFN and PTM is always the most cost efficient and increases linearly as we increase the number of cells. Another interesting observation is that the cost of MBSFN transmission scheme with one assisting ring has almost equal values to the cost estimated for the plain PTM scheme. Finally, an important point is that when we increase the number of cells in the remote area, the cost also increases. The only exception to this occasion is when there are 6 cells in the remote area. Then, the cost slightly reduces in cases AAA and AAI. This happens due to the fact that the existing assisting cells cover the needs for the MBSFN transmissions and there is no other need for additional rings to assist the central MBSFN area.

V. CONCLUSIONS AND FUTURE WORK

In this paper, we have presented a complete evaluation study of the MBMS service provision through MBSFN and PTM transmission methods. Our evaluation has been performed using a metric that reflects the telecommunication cost for the MBMS service provision. We have presented a novel analysis of the telecommunication cost for MBSFN and PTM transmission methods that concerns, the various processes for the MBMS data delivery, the packet transmission costs over the various LTE network interfaces and the cost for control procedures and signaling. All the simulation results have shown that our selection mechanism is able to provide a cost efficient transmission session through a combination of MBSFN and PTM transmission schemes in comparison with the other examined methods.

This research work is one step towards the specification of a mechanism that makes an optimal MBSFN area selection in LTE systems. This field is expected to become of extreme interest since in the next releases of the LTE systems the MBSFN area deployment will be dynamically determined contrary to the current 3GPP standard that specifies static MBSFN area configuration defined by the network operator. A possible future step is the enhancement of the simulation tool in order to support different cell properties (e.g., cell sizes). This will enable the application of the existing analytical model to real mobile network deployments in order to draw more real-life conclusions.

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