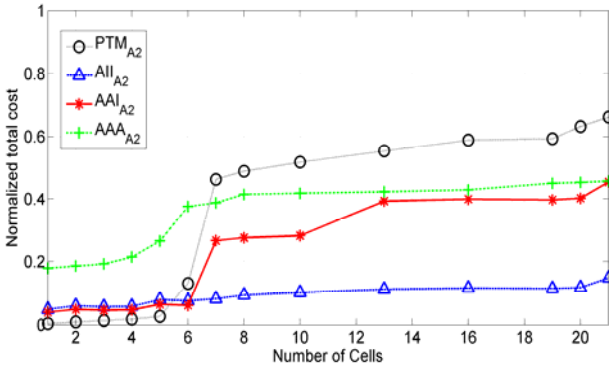


Figure 7. Total cost for Approach 2 (Prefixed Overhead).

As far as Figure 7 is concerned, PTM transmission scheme seems to be more cost efficient than the others, only for a small number of cells (1-5). For larger number of cells, the corresponding cost increases radically due to the fact that the prefixed number of FEC coding has been consumed and also retransmission of repair symbols is necessary. Deployment AII shows similar behavior with AAI for a small number of cells (1-6) but for larger number of cells cost for AAI increases rapidly. The overall conclusion is that AII shows generally a stable and cost efficient behavior.

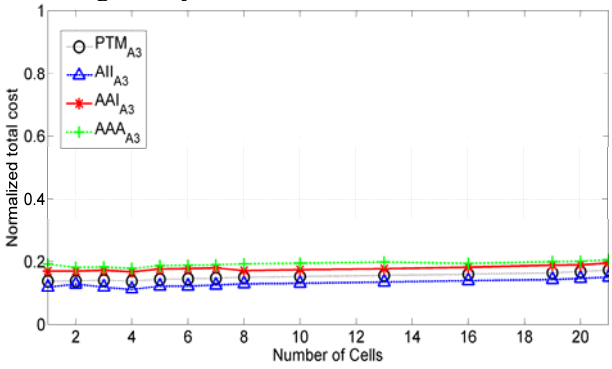


Figure 8. Total cost for Approach 3 (Redundant Symbols).

Finally, by observing Figure 8 we notice that Approach 3 proves a stable behavior for all the concerning deployments and results in low cost independently of the number of cells.

The three figures depicted above, can be compared to draw some general results. None of the file repair approaches can be considered optimal for all the network configurations. It is interesting to observe that for a small number of cells retransmission and the approach that uses prefixed overhead seems to have better results compared to Approach 3. So, depending on the network configuration and the file transmission scheme we can choose the optimal file repair scheme.

## V. Conclusions and Future Work

In this paper, we have presented a complete evaluation study on the provision of reliable MBMS service through MBSFN and PTM transmissions. The error recovery schemes that we have examined include the approaches standardized by 3GPP and a proposed one that employs exclusively FEC for the file repair. The evaluation of the different transmission schemes, MBSFN deployments and error recovery methods, has been performed using a metric that reflects the total telecommunication cost for the MBMS service provision. The conducted experiments have led to some important results concerning the reliable multicast data delivery over MBSFN and PTM transmission schemes. We have observed that the total telecommunication cost is strongly related with the network configuration in terms of transmission scheme, MBSFN deployment and error recovery method. Our quantitative analysis can define the optimal network configuration that minimizes the total cost based on the multicast user distribution.

The step that follows this work could be the investigation of the proposed file repair approach and the modeling and implementation of a mechanism that makes efficient Raptor code selection for LTE networks. This mechanism could monitor the network conditions and use them as input to decide on the appropriate amount of redundant symbols for FEC encoding.

## References

[1] 3GPP TS 36.300, V9.1.0. "Technical Specification Group Radio Access Network; E-UTRA and E-UTRAN; Overall description; Stage 2 (Release 9)", 2009.

[2] Alexiou A., Bouras C., and Papazois A., "Adopting Forward Error Correction for Multicasting over Cellular Networks", in Proc. EW 2010.

[3] Luby M., Gasiba T., Stockhammer T. and Watson M., "Reliable Multimedia Download Delivery in Cellular Broadcast Networks", IEEE Trans. on Broadcasting, 53 (2), 2007, pp. 235-246.

[4] Luby M., Watson M., Gasiba T., Stockhammer T., and Xu W., "Raptor codes for reliable download delivery in wireless broadcast systems", in Proc. CCNC 2006, pp. 192-197

[5] 3GPP TS 23.246 V9.0.0, "Technical Specification Group Services and System Aspects; MBMS; Architecture and functional description (Release 9)", 2008.

[6] Rong L., Haddada O., and Elayoubi S., "Analytical Analysis of the Coverage of a MBSFN OFDMA Network", in Proc. of IEEE Global Communications Conference (GLOBECOM 2008), 2008.

[7] 3GPP TSG RAN WG1 R1-070051, "Performance of MBMS Transmission Configurations", 2007.

[8] Rummler R, Chung Y, Aghvami H. "Modeling and Analysis of an Efficient Multicast Mechanism for UMTS", IEEE Transactions on Vehicular Technology; 54(1), pp. 350-365, 2005.

[9] 3GPP TS 26.346 V7.8.0, "Technical Specification Group Services and System Aspects; MBMS; Protocols and codecs (Release 7)", 2008.

[10] Alexiou A., Bouras C., Kokkinos V. and Tsichrintzis G. "Communication Cost Analysis of MBSFN in LTE", in Proc. of the 21th Annual IEEE International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC'10), Istanbul, Turkey, 2010.

[11] Holma H, Toskala A. "LTE for UMTS - OFDMA and SC-FDMA Based Radio Access", JohnWiley & Sons: Chichester, 2009. ISBN 9780470994016.

[12] 3GPP TS 36.201, V8.3.0. "Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); LTE Physical Layer - General Description (Release 8)", 2009.