An Improved Error Correction Algorithm for Multicasting over LTE Networks

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Abstract – Multicasting in LTE environments poses several challenges if it is to be reliably implemented. Neither retransmission schemes nor Forward Error Correction (FEC), the traditional error-correction approaches, can be readily applied to this system of communication if bandwidth and resources are to be used efficiently. This paper details current work in progress aiming to develop an algorithm to select the best error-correction scheme for such a multicast network.

Index Terms—Long-Term Evolution, MBSFN, multicasting, error correction

I. Introduction

The most likely candidate to achieve the realisation of 4th generation (4G) radio technologies is the 3rd Generation Partnership Project's (3GPP) Long-Term Evolution (LTE) system. With LTE's improvements in speed and capacity over its predecessors, multicast communication has been supported from the first release of its specifications in the form of a Single Frequency Network (SFN) [1]. This method of communication can greatly increase bandwidth efficiency and is particularly suitable for the delivery of multimedia content to a group of mobile receivers. It turns out, however, that error-free multicasting poses several implementation challenges [2]. It is this area that this research in progress seeks to address.

The remainder of this paper includes a background and elaboration on the aforementioned technologies in Section II. The proposed research is presented in Section III, followed by a summarized methodology (Section IV). Section V concludes this document.

II. Background

A. Multicasting in LTE Environments

The 3GPP's application of multicast technology to cellular networks has been termed the MBMS, or Multimedia Broadcast/Multicast Service. For LTE systems this specification has been further enhanced to the evolved-MBMS (e-MBMS) [3]. Currently e-MBMS includes two types of multicast transmission, namely single-cell transmission and multi-cell transmission. As the terms imply, the former can only distribute multicast data within a single cell of coverage, while the latter uses a number of different, highly synchronized cells to transmit the multicast data [4].

Of the services described by e-MBMS, it is the multi-cell transmission which is envisioned to be employed on large scale to support the distribution of multimedia content (such as mobile television) [1]. In LTE environments this type of transmission is also known as MBMS Single Frequency Network (MBSFN). Its operation is based on a set of base stations transmitting the same signal at the same time and in the same frequency channel to a group of multicast user equipment (UE). From the viewpoint of the user equipment, the combined signal from the different locations will appear as if coming from a single base station, but being subject to severe multipath propagation [4]. MBSFN allows for over-the-air signal combining and other technology to change the destructive interference of multiple signals to a constructive signal resulting in a much higher Signal-to-Interference plus Noise-Ratio (SINR) compared to single-cell transmission [1]. An in-depth discussion of the physical operation of MBSFN falls beyond the scope of this document. A more complete analysis is given in [1], [2], [3], [4], and [5].

B. Error Correction in MBSFN

Two traditional approaches to error-correction in communication systems are retransmission schemes and forward error-correction (FEC). Retransmission schemes, specifically the automatic repeat request (ARQ) process, rely on feedback from the receiver to the source to ensure error-free communication. Lost or corrupt packages are simply retransmitted by the source. In FEC, redundant data, sent from source to receiver, allows the receiver to both *detect* and/or *correct* possible errors in communication.

It should be clear that ARQ on its own is not an effective method to establish error-free multicast communication. The authors of [2] name three drawbacks of ARQ in an MBSFN system. The most important problem with this approach is known as *feedback implosion*. Since ARQ relies on feedback from individual receivers for its operation, it is possible (even probable, with multiple receivers) that a large number of retransmission requests may occur simultaneously, placing a heavy burden on network resources. Spectrum efficiency is also reduced if a large number of retransmitted messages congest the downlink network channel. Furthermore, the bursty nature of traffic in both the uplink and downlink channels has a detrimental effect on network scalability and efficiency. A fourth drawback, mentioned by the same authors in [6], is that the feedback channel in LTE (and any wireless network) consumes valuable power and is expensive to implement.

An apparent solution to the shortcomings of ARQ in an MBSFN is to make exclusive use of FEC techniques. Since all data necessary for error correction is transmitted in the downlink channel, the need for a feedback channel is greatly reduced. This eliminates the possibility of feedback implosion. Also, independent errors at different receivers have no effect on the error correction operation, allowing for network scalability [7].

Since FEC introduces a fixed amount of overhead into the system, there are, however, certain conditions under which FEC might be a less desirable approach than ARQ [6]. If a low number of users have subscribed to the multicast service, for example, ARQ could be more effective. In a reliable network, if packet loss is low, ARQ might also be the more practical option [2]. It seems therefore that a combination of the two schemes might be necessary. In fact, a vast number of network parameters and topology variables need to be considered before an appropriate error correction scheme can be drawn up for an MBSFN system. It is out of this observation that our problem statement has been formulated.

III. Proposed Research

The proposed research aims to develop an algorithm to improve error correction techniques in MBSFN systems. Recent research ([2], [5], [8]), published in 2011 and the first quarter of 2012, has investigated the efficiency of different ARQ and FEC techniques in MBSFN systems . Several researchers have quantified the effect of a number of network parameters on the efficiency of error correction techniques (and their associated network costs). However, no effort has yet been made to unify these studies into a systematic approach that could help with the selection of the most effective technique given certain network conditions.

The algorithm will take a broad spectrum of network parameters as input conditions. These may include network topology, number of users, density of user equipment and many others. As output, the developed algorithm would provide an idea of what error correction scheme will be most effective for the network at hand. It could, for example, help with the selection of an appropriate Raptor code for FEC under dynamic conditions. It should be noted that the goal is overall *improvement* and not mathematical *optimization* of error correction techniques – the latter requiring rigorous mathematical proofs.

IV. Methodology

An *initial literature study* on LTE, MBSFN and error-correction techniques was done to identify a gap in current knowledge and define the area of contribution for this research project.

An *in-depth literature study* will follow, covering all aspects of LTE environments with regards to multicasting. Network parameters that might affect reliability of communication and error correction schemes will be identified in this step.

A *simulated LTE environment*, using a software packet such as OMNet++, will be created. This will be used to *develop and analyse* an error-correction algorithm for MBSFN systems. It will serve as a model of interaction from which the algorithm can be evaluated.

Finally, the results will be *validated and verified* by comparing experimentation results to real life results. For this research project, a special step of validation will investigate and propose new areas to practically implement error-free multicasting in LTE environments.

V. Conclusion

This paper introduced the problem of creating an algorithm to select the most efficient error-correction scheme given a set of network conditions for multicast systems in LTE environments. Background on the aforementioned was given. Future work entails the development and analysis of such an algorithm in the context of a simulated LTE network. The expected output is a *systematic, quantified approach* to select the best error-correction scheme given a specific LTE multicast application.

VI. References

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