Comparative Study of ARQ & HARQ Techniques in 4G LTE

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***Abstract:*-LTE technology is the most reliable mobile broadband technology to provide an excellent user experience. This paper do the comparative study of ARQ & HARQ type's mechanisms after simulation with Scilab, Paper gives short Introduction about ARQ and HARQ. It plays major role in Multipath MIMO and OFDM System also It is the core feature that provides robustness in LTE and Advance LTE networks.**

Keywords—ARQ,HARQ,MIMO,OFDM.

I. INTRODUCTION ARQ PROTOCOLS

Communications in wireless channels are designed to be highly reliable. However when there is only long-term CDIT (statistical information about the channel state), the selected data rate might produce outage events with a negative impact on the throughput of the system (defined as the average information bits transmitted over an interval of time). The throughput can be improved by allowing a notification from the receiver about the successful or unsuccessful of the received message. This scheme is named automatic repeat request (ARQ) protocol [1],[2]. There are three basic request modes: stop and wait (SW-ARQ), go back N (GBN-ARQ) and selective-repeat (SR-ARQ).

The SW-ARQ is the simplest one, where the transmitter sends a single packet and waits for the acknowledgment (ACK) in an idle state. Nevertheless, this mode has the worst throughput performance because during the idle state the transmitter does not transmit anything. GBN-ARQ assumes that the transmitter is capable of buffering N packets. When the transmitter is informed of an error in some packet, then the transmitter goes back to that packet and re-starts the transmission in that point. In this case the transmitter is always transmitting. Finally, the best scheme is the SR-ARQ because the transmitter only retransmits the specific packet for which the ACK is not received. Here the transmitter is also continuously transmitting and requires significant buffering in both the transmitter and the receiver.

Conventional ARQ protocols can be divided into two classes, pure ARQ and Hybrid ARQ protocols [3] depending on which information is retransmitted and how it is processed at the receiver. If a packet is wrongly decoded using pure ARQ, the received packet is discarded, a new transmission is performed and the decoder only considers the last received packet. In this work we define HARQ protocol when exist a combination between all the received packets. We define HARQ I (also named chase combining) if the packets are coherently combined. Furthermore, if the new transmissions are performed using different parts of the same codeword, the strategy is named H-ARQ II (also named code combining). In such a case, the codeword rate is decreased in each transmission, increasing the protection or coding gain. For instance, this can be done by using rate compatible punctured TC (RCPTC) with different orthogonal puncturing matrices. The benefits of the last protocol over the Pure ARQ, HARQ I and without retransmissions (only using FEC codes) over fading channels are shown in [1] and [2]. HARQ II can be considered as adaptive FEC that adapts to the instantaneous channel conditions thanks to the acknowledgment of the receiver..

II. ARQ IN DETAIL

The ARQ protocol considered here is based on the selective-repeat scheme [1]. Conventional ARQ protocols can be divided into two classes, Pure-ARQ and Hybrid ARQ protocols [1]. The difference between them is the task performed at the receiver and the type of the message transmitted. For the relay-assisted and direct transmission, only the destination informs to the source if it has decoded the packet correctly (ACK) or wrongly (NACK). In the sequel the process for the different ARQ methods is described:

- Pure-ARQ. If a packet is wrongly decoded, the destination requests a retransmission. The source transmits the same packet again. Then the destination discards the previous packet and tries to decode the new one.

- HARQ-I. This protocol considers all the received packets (the same packet) and combines them using the Maximal Ratio Combining (MRC) technique (chase combining). Therefore, the SNR of the packet to decode is increased in each retransmission.

- HARQ-II. When the source has to retransmit a packet, this protocol adds new redundancy (new parity bits) by changing the puncturing matrix (code combining) in each retransmission. The destination considers all the previous packets and builds a larger one with more redundancy. Then, the destination tries to decode this new packet. With this protocol the coding gain is increased in each retransmission. For example, let us assume that the source is transmitting a codeword of rate 1/2 (with N systematic bits and N parity bits). If the retransmission adds N new parity bits, the destination will try to decode a codeword of rate 1/3. In the case where some bits are transmitted again, then the MRC (Maximal Ratio Combining) technique has to be considered for those bits. In the previous example assume that the retransmission repeats N/2 parity bits and adds new N/2 parity bits. Therefore, the destination must perform the MRC of the N/2 repeated parity bits. Afterwards it will try to decode a codeword of rate 2/5.

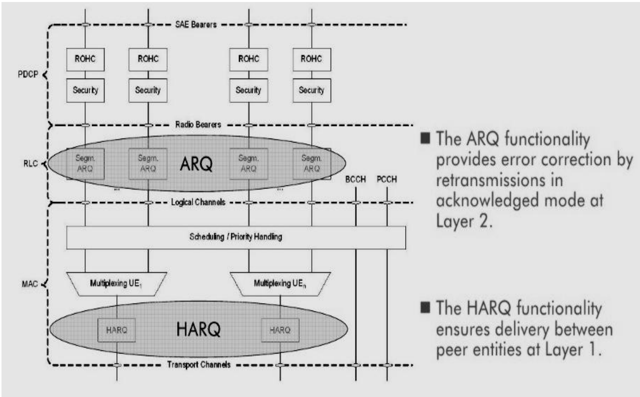
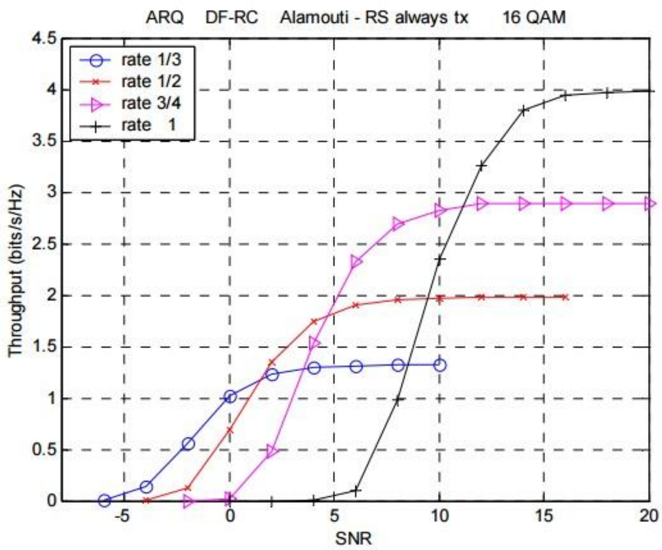
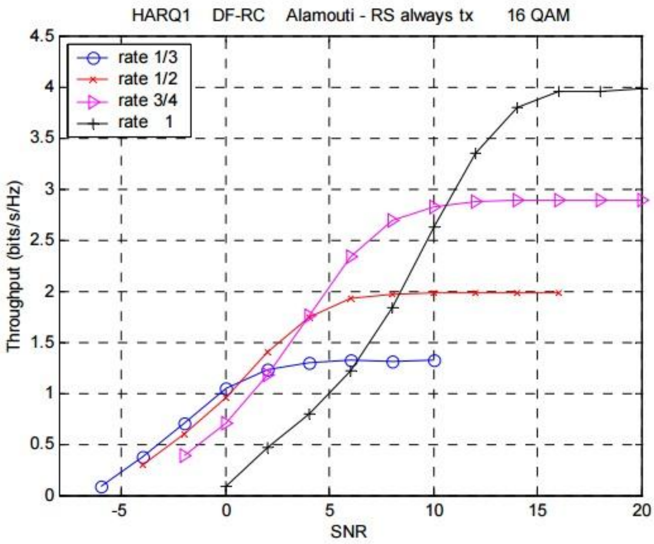


Fig 1.ARQ and HARQ in a System

II. EFFECT OF ARQ IN RELAY-DF

We present the throughput performance for the relay-DF strategy under different ARQ protocols. In Figure, the throughput obtained for the relay-DF (relay always transmit, persistent transmission) is depicted for the different ARQ protocols. Different codeword rate has been selected (from 1 (encoded) to 1/3). It is shown that for a given codeword rate, see for instance 3/4 (right-triangle), the worst performance (at low SNR) is obtained for Pure-ARQ. The HARQ-I improves throughput and the best operation (though the gains are not really significant) is obtained for HARQ-II. Additionally, for the HARQ-II protocol the throughput can be improved by decreasing the length of the retransmissions, because it can efficiently adapt to the channel state, see Figure 2. Note that for a SNR of 10 dB and code rate 1, there is an improvement of 0.9 bit/s/Hz between partial (Figure 2 -right) and full slot retransmission (Figure 2), and for SNR=4 dB and code rate 3/4 the difference is about 0.3 bit/s/Hz. It is important to remark the effect obtained at low SNR, where the full-slot retransmission is better than partial slot option because of the fixed number of transmissions. The reason for this behavior is the following: given the same number of transmissions the full slot option can transmit more symbols (systematic or parity) than the partial slot mode.





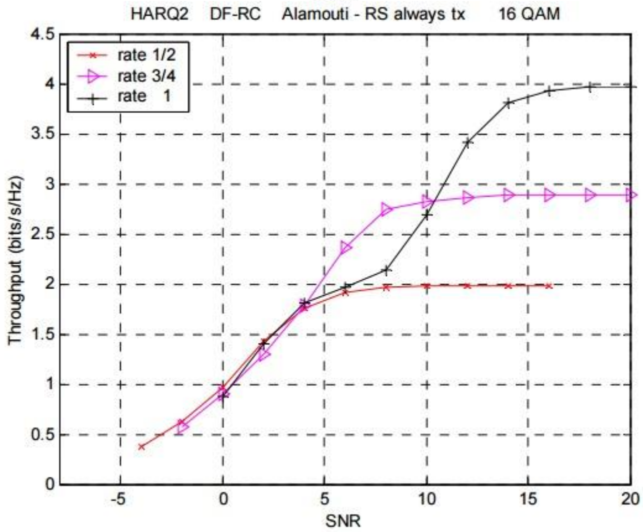
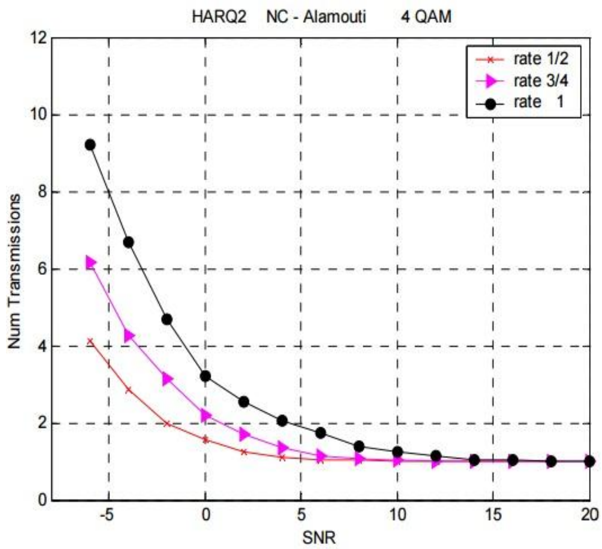


Figure 2.- Throughput performance for different Pure-ARQ , HARQ-I and HARQ-II with persistent transmission. 16-QAM.

III. DIRECT MIMO TRANSMISSION



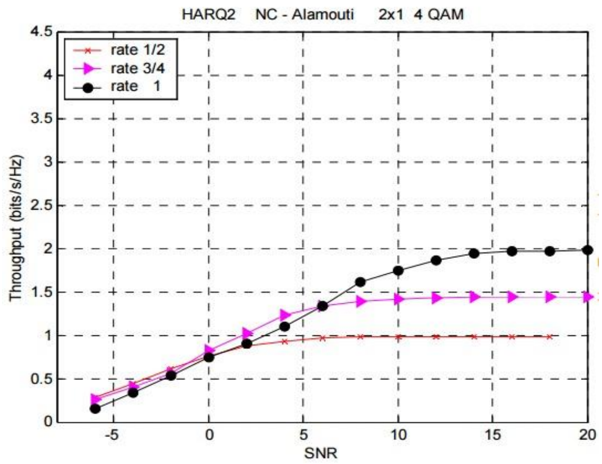


Fig 3 Throughput (left) and average number of transmissions (right) for direct transmission using HARQ-II and RCPT codes with rates {1/2,3/4,1}, 4 QAM. ZF-receiver.

Fig shows the performance in terms of throughput and average number of transmissions (ANT) when the Alamouti ST code has been selected for the direct (MISO) transmission. The selected retransmission scheme is the HARQ-II, because it was shown in the previous sub-section to be the best one in terms of throughput. Direct transmission throughput results will be taken as relevant reference for the relay-assisted case presented in the following sections (let us recall that the source is using ns=2 antennas and the destination is equipped with only nd=1 antenna)

IV. LINEAR VS NON-LINEAR RECEIVERS

Finally, in this section a comparison between linear (zero forcing, ZF) and non-linear (list-SD) decoders is presented. Figure 4 shows the different performance of the receivers when a non-orthogonal STC (VBLAST in this case) is considered. It can be seen a difference around 4 dB at 2.5 bits/s/Hz. Therefore, the use of non-linear receivers is recommended for nonorthogonal STC.

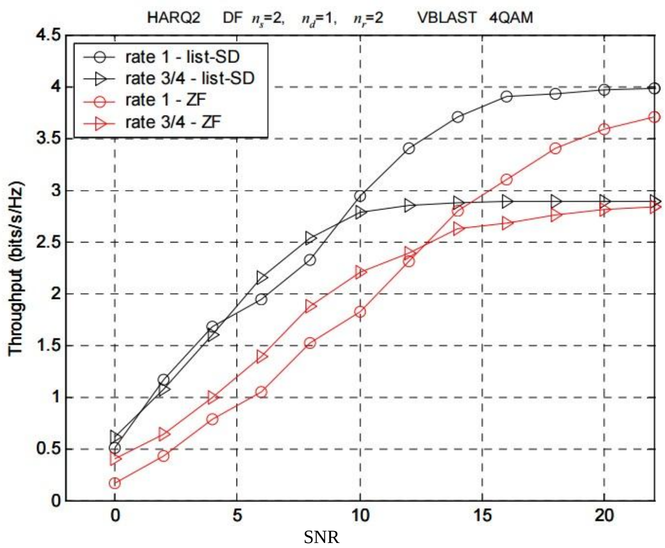


Fig 4 Throughput for C-DF schemes with HARQ-II with RCPTC of rates {3/4,1} using VBLAST with the list-SD and the ZF receiver.

CONCLUSION

The relay-assisted transmission applied in the downlink of a TDMA system has been investigated, using different schemes that combine ARQ, STC and turbo codes to achieve results close to the true capacity of the system. It has been shown that relay-assisted transmission outperforms the direct transmission in terms of throughput for a high reuse (K>>1) of the relay slot (assuming all the destinations with similar configuration). Additionally, different . ARQ protocols have been considered and hybrid protocols have shown better performance than Pure ARQ. For medium to high SNR values, the HARQ-II with partial slot retransmission seems to be needed to achieve better throughput results.

The following conclusions may be drawn: It has been shown that relay-DF (relay decodes the received data) is the best relay assisted strategy in terms of throughput.

- For low SNR values a strategy exploiting the diversity gain (Alamouti) is the best, and hence, the selection of the rate for the STC seems to be a useful strategy.
- For the symmetric scenario (and since we have only considered the channel uses between source and destination) the use of selective transmission does not seem to offer significant gains, that is, transmissions from the relay always seem to be rewarding even when some errors are encountered.
- Whereas for medium and high SNR values, strategies using the STC rate gain with distributed space-time codes (RC, UC or Mixed relay-DF) are better in terms of throughput than the direct transmission, the relay-DF-UC is the best. It has shown that a suitable selection of the STC depending on the channel state is beneficial to improve the throughput.
- Additionally, the analysis for the AF also has been considered. Slight SNR losses are observed with respect to relay-DF, but there are two points to worth noticing, it only uses 1 antenna at the relay (in the DF nr=2 are required) and the symmetric configuration (equal average SNR in all links) is slightly penalizing its performance. Moreover, if other scenarios are considered (asymmetric) the relay-AF can achieve better throughput results than the relay-DF, see Figure 5.14. Therefore, this strategy shows a good compromise between the performance and the complexity at relay.
- Finally, a comparison between linear (ZF) and non-linear (list-SD) receivers has analyzed. Differences around 4 dB have been found when non-orthogonal STC are considered. Therefore, the use of non-linear receivers seems to be required for the cases where the non-orthogonal STC are used.
- The extension for other antenna configuration requires the use of space-time codes designed for such configuration.

REFERENCES

[1] E.Malkamäki, H.Leib, "Performance of truncated type-II hybrid ARQ schemes with noisy feedback over block fading channels", in IEEENumber Trans. on Communications, vol.48, no. 9, pp. 1477-1487

[2] D.N. Rowitch, L.B. Milstein, "On the performance of Hybrid FEC/ARQ systems using rate compatible Punctured Turbo (RCPT) Codes", in IEEE Trans. on Communications, vol.48, no.6, pp. 948-959, June 2000.

[3] B. Classon, et al, "Efficient OFDM-HARQ System Evaluation Using a Recursive EESM Link Error Prediction", in Proc. IEEE Wireless Communications and Networking Conference (WCNC-2006), April 2006

[4] D.J.Costello, J.Hagenauer, H.Imai, S.B.Wicker, "Applications of error-control coding", in IEEE Trans. Information Theory, vol.44, no.6, pp.2531-2560, Oct.1998.

[5] S. Lin, D.J.Costello, Error Control Coding, Fundamentals and Applications, Prentice Hall, Inc. Englewood Cliffs, New Jersey 07632, 1983.