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Title: Performance of Hybrid ARQ for Low Bitrates in TDD Mode

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1. Introduction

The throughput of Hybrid ARQ Types I and II-III is investigated for a low bitrate NRT service. In an earlier paper, it was shown that Type II-III outperforms Type I at high bitrates [1]. Now, the low bitrate problem is attacked. Simulation results are presented for UDD 8kbit/s downlink traffic in the Micro environment for various code-rates and interleaving schemes. In this paper, we emphasise differences between Types I and II and consider Types II and III as minor variants of the same scheme which we will call "Type II-III" for the purpose at hand.

Hybrid ARQ Type II-III outperforms Type I for all NRT services between 8kb/s and 2Mb/s.

2. Traffic Model for Low Bitrate

For a general description of the working assumptions, we refer to the earlier presented high bitrate comparison paper [1]. The high bitrate simulations were carried out with the “UMTS 30.03” traffic model [3]. For low bitrate services, we use a slightly modified traffic model which is based on internet investigations (Web browsing). The following parameters differ from the model in [3]:

Description	Parameter	Used value	ETSI model for Web browsing at 8kbps
Mean interarrival time between packets	**Dd**	**0.1365s**	**0.5s**
Minimum Packet Size	**Pareto-k**	**20 byte**	**81.5 byte**

These parameters result in a mean packet size of μ=131 byte which is considerably lower than the 480 byte of the original ETSI model. Due to the changed mean interarrival time between packets, the overall bitrate is still 8 kbit/s.

We motivate the lower mean packet size with user behavior in response to the low bitrate: For avoiding long loading times, the user will enjoy primarily text browsing (possibly with low-quality images included). A Web user at low bitrate will change the preferences of his browser such that images are not loaded automatically.

3. Simulated Retransmission Schemes

Type I and II-III simulations were carried out with varying parameter settings. This section summarises selected parameter combinations for which results are shown in the following sections.

The following table displays parameter combinations chosen for Type I simulations presented here.

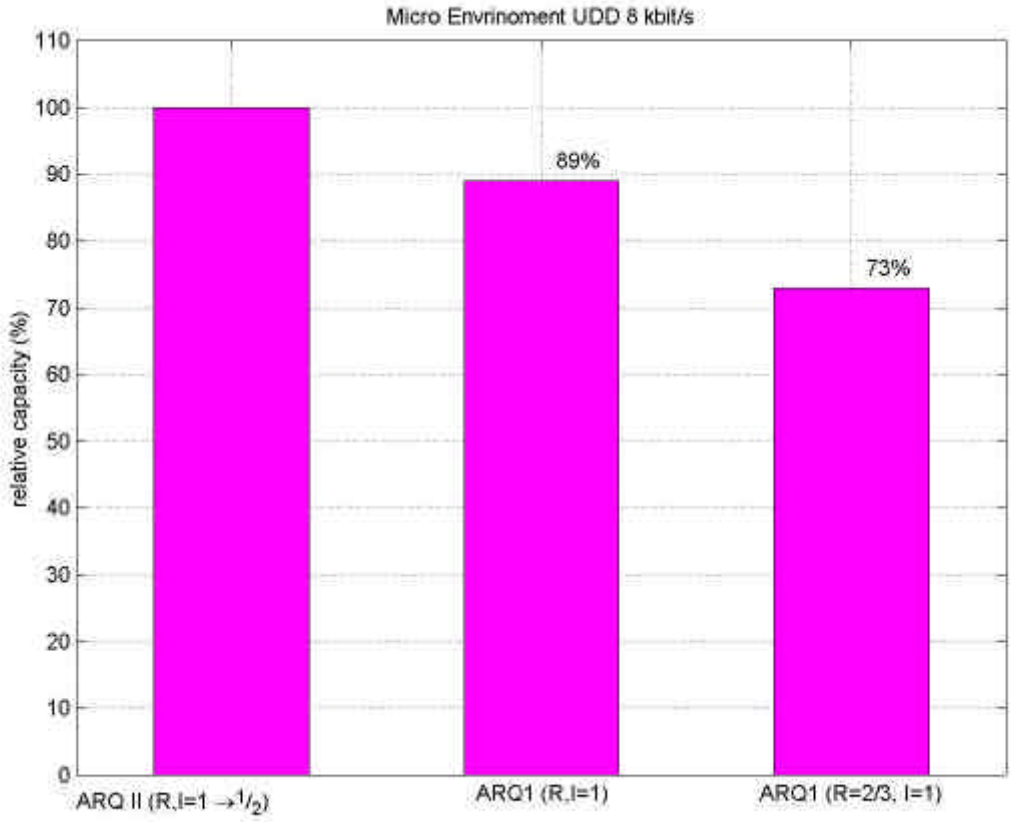
Code-Rate *R*	Interleaving factor *I*	Naming convention in plots
1/1	1	ARQ1 (*R, I* = 1)
2/3	1	ARQ1 (*R* = $^2/_3$, *I* = 1)

For Type II-III, the interleaving factor *I* = 1 was chosen to be constant and the joint code-rate changes for the retransmissions. Here, a scheme was chosen where the initial transmission is almost uncoded ($R_1 \approx 1$) and all subsequent retransmission have the smaller joint code-rate $R_2 = ½$. Beginning with the 3rd transmission (i.e. the 2nd retransmission), the burst with weakest CIR is repeated and maximum-ratio combined with the previously received corrupted copy.

Code-Rates R_1,R_2	Interleaving factor I	Naming convention in plots
1/1, 1/2	1	ARQ II (R,I=1→1/2)

4. Relative Capacity Results

The following bar graph in Error! Unknown switch argument. compares capacities (bitrates per bandwidth per cell) relative to the maximum obtained capacity for various ARQ schemes implementing the UDD 8 service in the Micro environment. The bars give percentages of capacity. This approach was adopted for avoiding confusion with results presented in [4] which are not easily comparable. We have optimised over code-rate/interleaving parameters for Hybrid ARQ Type II-III and show the best obtained result in the left bar of Error! Unknown switch argument.**.** The three other bars show highest capacity results for Hybrid ARQ Type I with various combinations of code rate *R* and interleaving factor *I.* We have not found any parameter combination for Type I that can compete with Type II-III. However, it is admitted that the benefits of using Type II-III over Type I are smaller than for UDD 384 in Micro environment, cf. Ref. [1].



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5. Conclusions

It is shown that Hybrid ARQ Type II-III outperforms Type I for "UDD 8 Micro" in terms of capacity. Together with the earlier presented results for “UDD 2M Pico” and “UDD 384 Micro” in [1], we conclude that Type II-III outperforms Type I for all UDD bearer types. The difference in throughput between Type II-III and Type I is higher for high bitrates, but it is still significant at low bitrates. Therefore, the Layer 2 signalling protocol must support both Hybrid ARQ Type I and Type II-III protocols.

6. References

[1] ETSI Tdoc SMG2 UMTS-L23 436/98, *Comparison of Hybrid ARQ Types I and II-III for TDD Mode*, Source: Siemens, ETSI/STC/SMG2 UMTS L23 #28, Paris, France, Nov 12-13, 1998.

[2] Seppo Hämäläinen, Peter Slanina, Magnus Hartman, Antti Lappeteläinen, Harri Holma, Oscar Salonaho, *A Novel Interface Between Link and System Level Simulations,* Acts Mobile Communications Summit '97, pp. 599-604, Aalborg/Denmark, Oct 7-10, 1997.

[3] ETSI TR 101 112, *Selection procedures for the choice of radio transmission technologies of the Universal Mobile Telecommunications System UMTS* (UMTS 30.03), version 3.2.0, April 1998.

[4] ETSI Tdoc SMG2 306/98*, UTRA TDD Link Level and System Level Simulation Results for ITU Submission*, Source: Siemens, Helsinki, Sep 8-11, 1998.