The 5th Annual Mediterranean Ad Hoc Networking Workshop

Relay Devices in UMTS Networks

Effects on Application Performance

Women's Postgraduate College for Internet Technologies

Martina Umlauft
Women's Postgraduate College for Internet Technologies
Institute of Software Technology and Interactive Systems
Vienna University of Technology
umlauft@wit.tuwien.ac.at, http://wit.tuwien.ac.at

Technische Universität Wien
Vienna University of Technology

Overview

Motivation

- High data rates can be achieved by small cell sizes but the introduction of many radio cells is expensive.
- Relays can mitigate this situation but increase the number of hops which may hurt interactive traffic like, e.g. Web traffic.

Goals

- To investigate the effect of relays on the performance of Web traffic taking into account the whole network stack.

Contribution

Evaluation taking a holistic view, showing

- the gain achievable at the physical layer,
- the impact at the transport layer (TCP),
- and on the application layer for Web traffic.

Scenario

- Cell extended by 6 low-cost, dedicated relays.
- Position at 2/3^{rds} of the cell radius.
- Connection to Node B with highly directive antenna, using separate carrier freqency.
- Connection to MTs with omni-directional antenna.

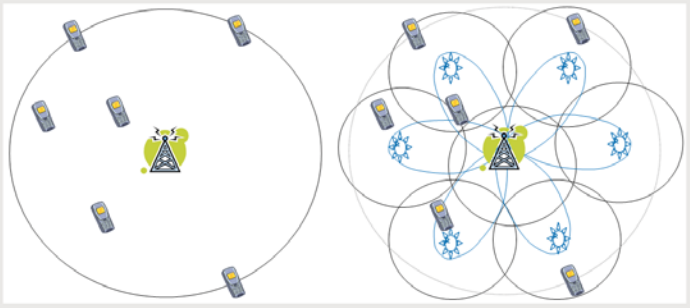


Fig. 1. *Single cell coverage.* (a) without, (b) with relays.

Simulation Parameters

- Developed in ns-2, based on EURANE Seacorn project [1].
- Improved physical model for DCH traffic: computes SIR for all packets received in the same TTI:

$$SIR = \frac{P_T L G f^2 m^2}{P_N + I_{EXT} + I_{INT}}$$

Eq. 1. *SIR Computation [2].*

- Simple model for inner loop power control.
- Micro cell with 1 km radius.
- Single cell with 1 Node-B.
- Consider one sector of cell only (1 relay).
- One mobile under test (MuT) at far edge of cell with Web Traffic [3].
- 0, 1, 2, 4 interfering mobiles near to MuT with CBR traffic (300kbit/s).
- DCH, RLC AM.
- 3600 s (1 h) of simulation time.

References

[1] *EURANE Extension to ns-2 Simulator* [Online]. SEACORN IST-Project No. IST-2001-34900. Available: http://www.ti-wmc.nl/eurane/ (last visited: 2006-04-12).

[2] H. Holma and A. Toskala, Eds., *WCDMA for UMTS*. Wiley, 2004.

[3] P. Barford and M. E. Crovella, „Generating Representative Workloads for Network and Server Performance Evaluation", in *Proc. ACM Sigmetrics 98*, 1998, pp. 151-160.

Results

Fig. 2. *Average Power necessary to reach Mobile under Test.* Power is controlled to reach a target SIR of 6 dB.

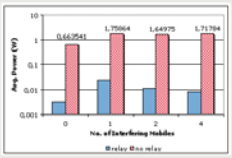


Fig. 3. *Average Number of Errors experienced by RLC Layer causing RLC retransmissions.*

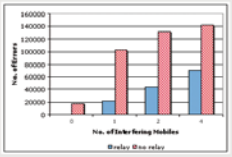


Fig. 4. *Average TCP Packet Delay.* End-to-end.

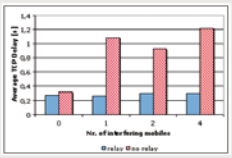


Fig. 5. *Web Response Time CDF.* Page response time is an important criterion for user satisfaction.

Results for the relay case are better than for the standard cell case in the user-relevant area of < 10 s.

However, since the distribution of Web page sizes is heavy-tailed raw response times are not necessarily a good indicator.

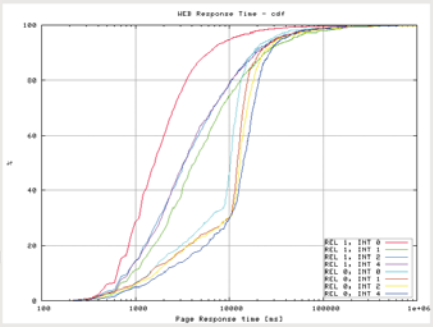
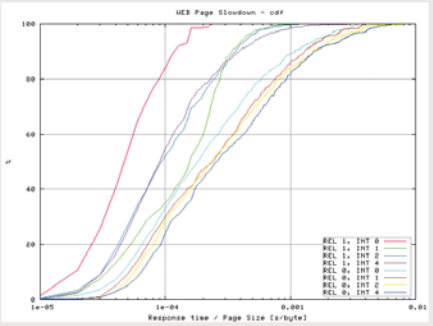


Fig. 6. *Web Slowdown CDF.* Page response time normalized to page size.

Results for the relay case are better than for the standard cell case.



Conclusion & Future Work

Relays lead to

- Reduced transmission power thus lower interference.
- Less RLC retransmissions.
- Lower average TCP packet delay.
- Improved Web page response time and Web page slowdown.

Future Work

- Investigate complete cell with full set of relays.
- Determine optimal number and placement.
- Compare several physical layer models
- Influence on other application layer traffic; e.g. mobile VoIP.
- Relays for adaptive modulation schemes (e.g. HSDPA)

Acknowledgement

This research has been funded in part by the Austrian Federal Ministry for Education, Science, and Culture, and the European Social Fund (ESF) under grant 31.963/46-VII/9/2002 and partly by the Austrian K*plus* competence center program.