Load balancing
in combined UMTS/GSM cellular systems

TECHNISCHE UNIVERSITÄT ILMENAU

Presentation

Presentation 10.11.2003

- Background
- Simulation
- Questions

Overview

- Background
- Simulation
- Questions

Background – CRRM

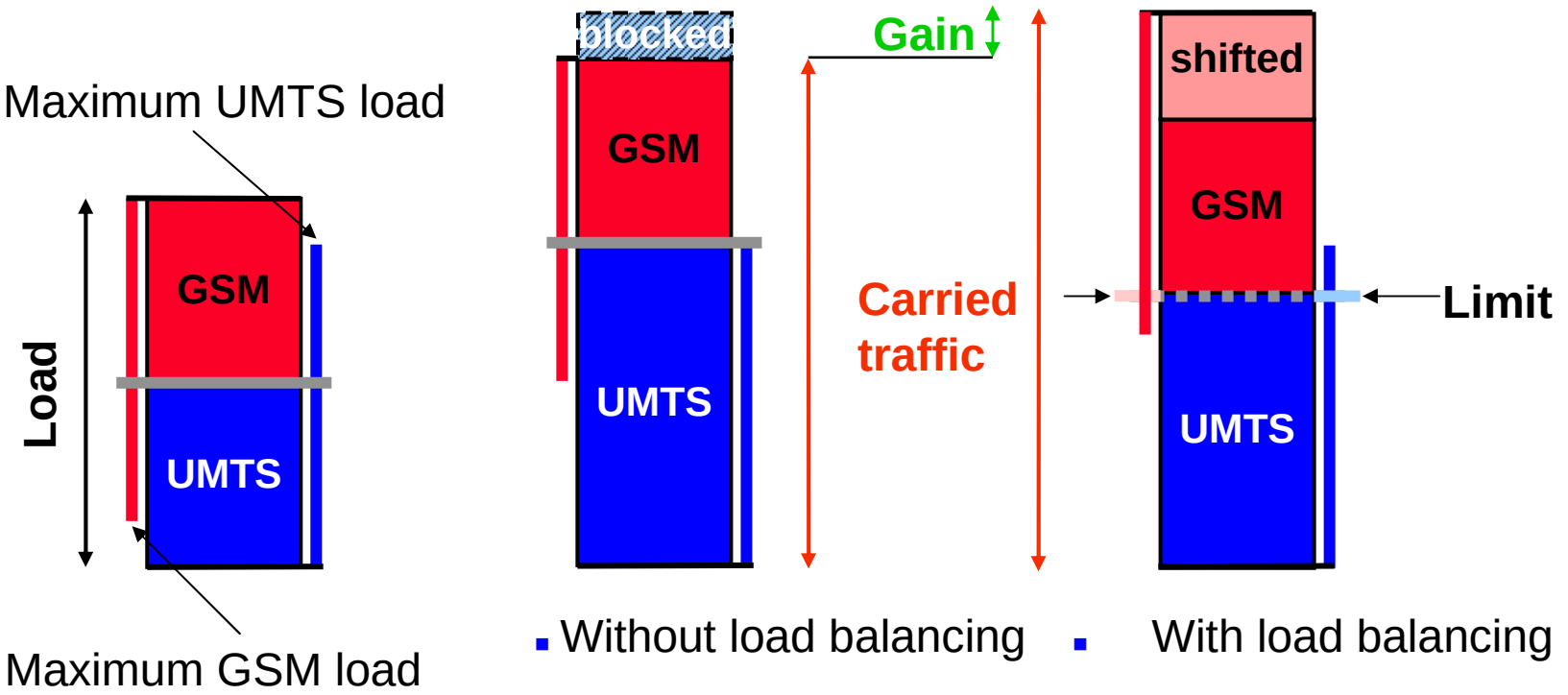
- In a multi-standard/layer mobile communication system an intelligent distribution of mobile users between the different systems and layers is required to
  - Prevent overload of a particular systems/layers
  - Guarantee the QoS requirements of all users
  - Reduce radio emissions and costs
- Algorithms which share that aim can be summarized under CRRM Algorithms
- An algorithm for UMTS – GSM load balancing was designed to prevent overload situations in these systems
  - its only choice of decision is migration

Load balancing
in combined UMTS/GSM cellular systems

TECHNISCHE UNIVERSITÄT ILMENAU

Presentation

Background – Goal



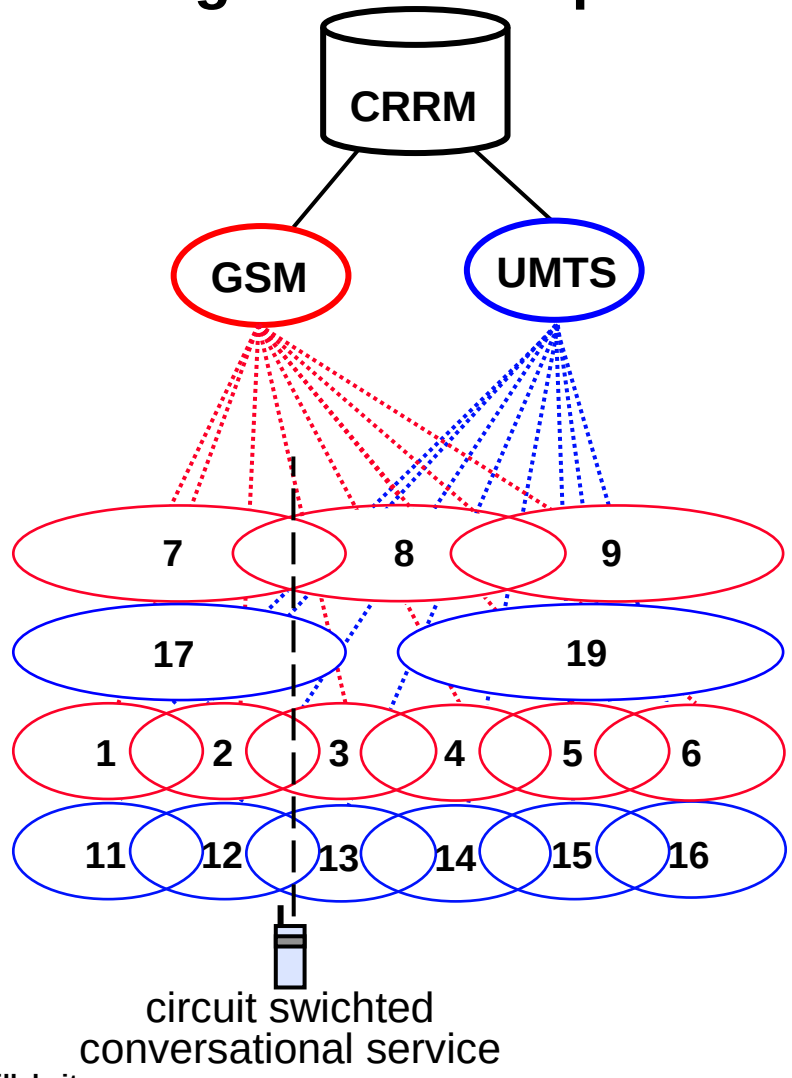
- Without load balancing
  - High outage
  - Low user satisfaction
  - Low total capacity
- With load balancing
  - Low outage
  - Higher user satisfaction
  - Higher total capacity

➢ **Higher number of satisfied users (QoS requirements fulfilled)**

➢ **Needed: Identify suitable services (mobiles) for handover**

Load balancing in combined UMTS/GSM cellular systems

Background – Required basic structure

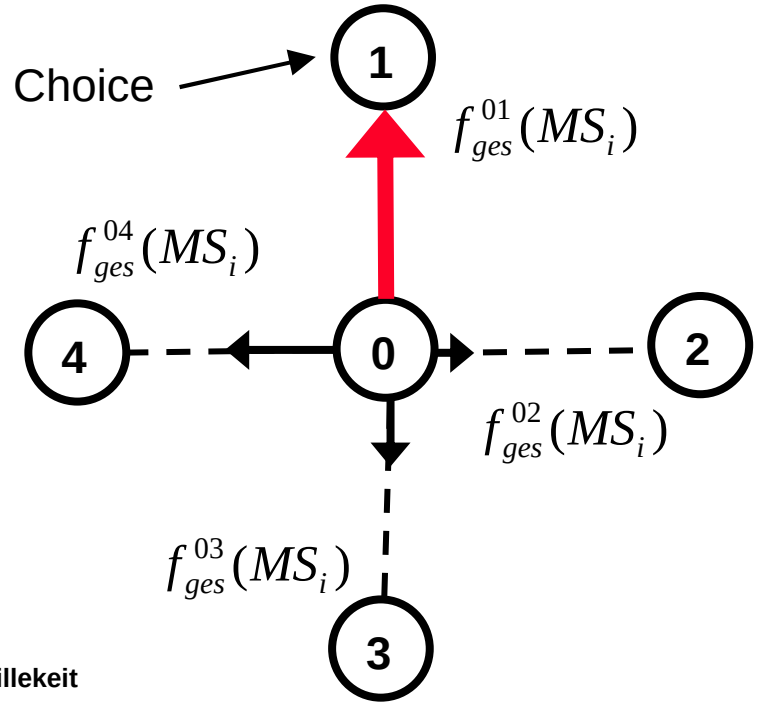


- Macro cells are more suitable for fast mobiles and mobiles with low data rates
- Micro/pico cells are more suitable for slow mobiles and mobiles with high data rates
- GSM more suitable for lower data rates and circuit switched services
- UMTS also suitable for higher data rates and higher other QoS requirements

Background – Force algorithm

- The choice of the appropriate target cell is based on superposition of different forces to target cell *k*

$$f_{ges}^{j->k}(MS_i) = c_L f_L^{j->k}(MS_i) + c_{QoS} f_{QoS}^{j->k}(MS_i) + \underbrace{c_{WK} f_{WK}^{j->k}(MS_i) + c_M f_M^{j->k}(MS_i)}_{\text{suppressing forces}}$$



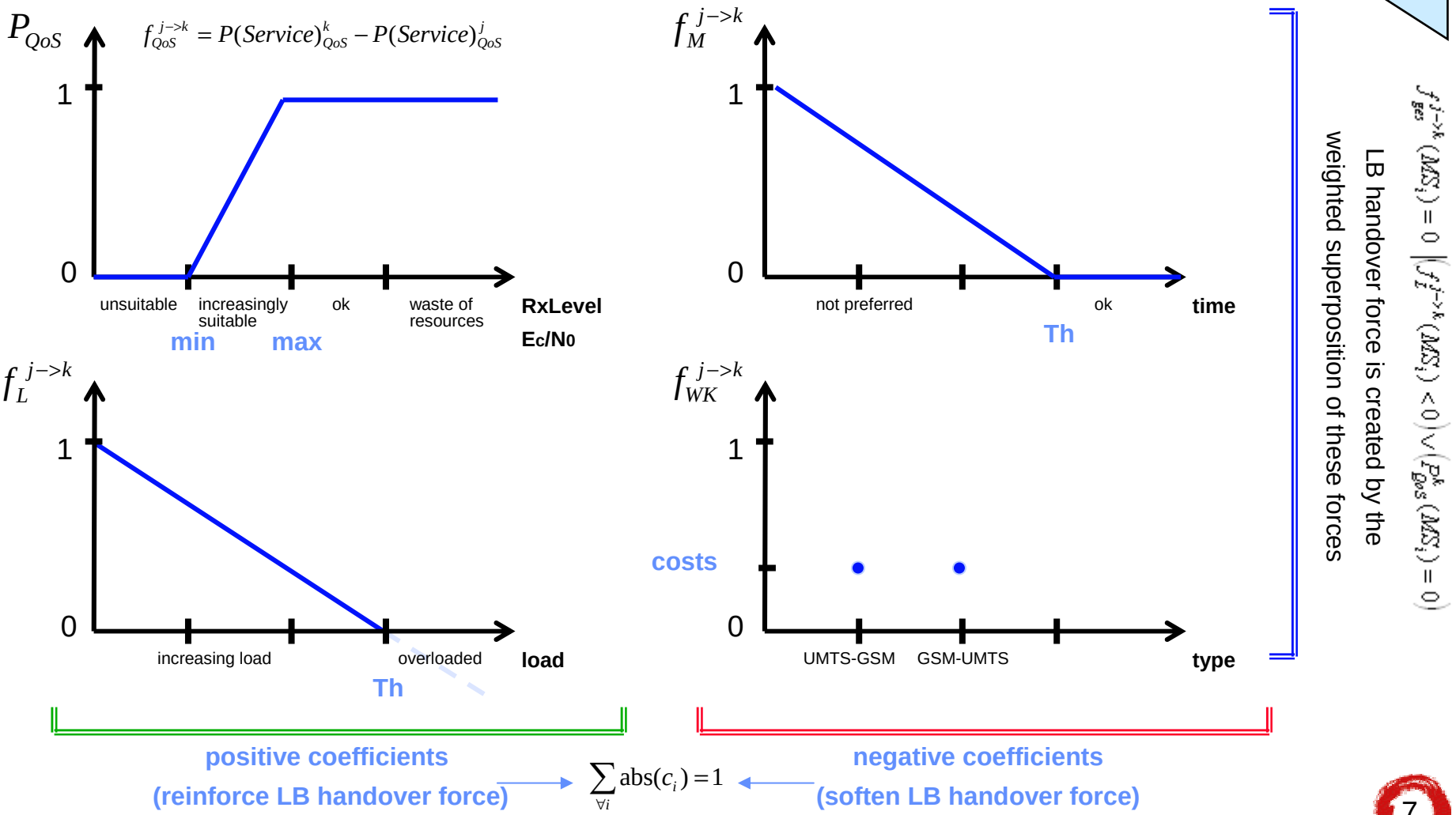
- f_L: load in target cell
- f_{QoS}: differences in QoS
- f_{WK}: handover costs
- f_M: time since previous performed LB handover

Load balancing
in combined UMTS/GSM cellular systems

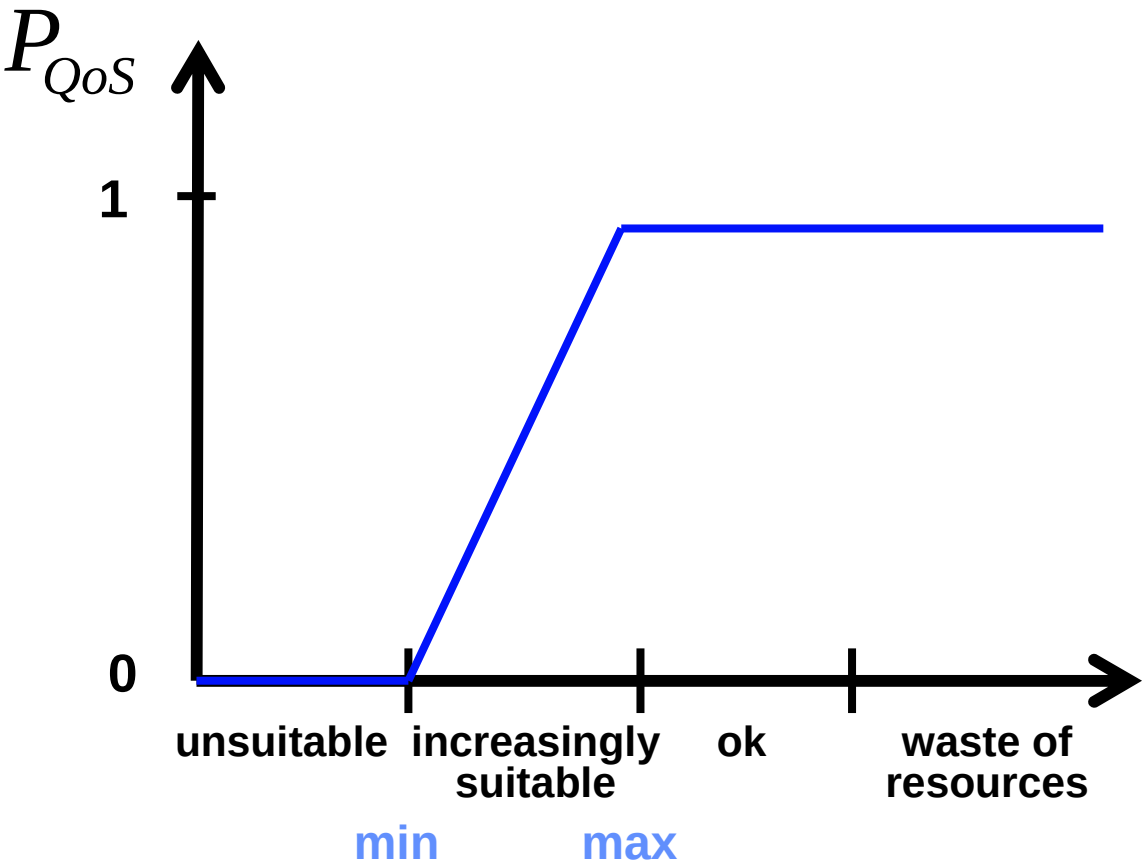
TECHNISCHE UNIVERSITÄT ILMENAU

Presentation

Background – Force algorithm, overview



Background – Force algorithm, example QoS force



$$P_{QoS}^{k} = \frac{\sum_{\forall types} c_{QoS,type} \cdot P_{QoS,type}^{k}}{\sum_{\forall types} c_{QoS,type}}$$

- Overall potential of QoS in cell k

Background – Force algorithm, example QoS force

$$f_{QoS}^{j->k} = P(Service)_{QoS}^{k} - P(Service)_{QoS}^{j}$$

- Negative if source cell j is more suitable than target cell k
- Positive if target cell k is more suitable than source cell j

Background - Indices

- UMTS and GSM are heterogeneous systems, therefore all metrics must be designed in a way making these systems comparable.
  - Easy for quality of service, because of similar service requirements in both systems
    - Delay, jitter, throughput, reliability
  - More difficult for load index, due to different radio access technologies
    - GSM: FDMA & TDMA (limited by the number of available frequency channels and timeslots)
    - UMTS: CDMA (limited by the interference situation and code usage)

Background – Load index and model

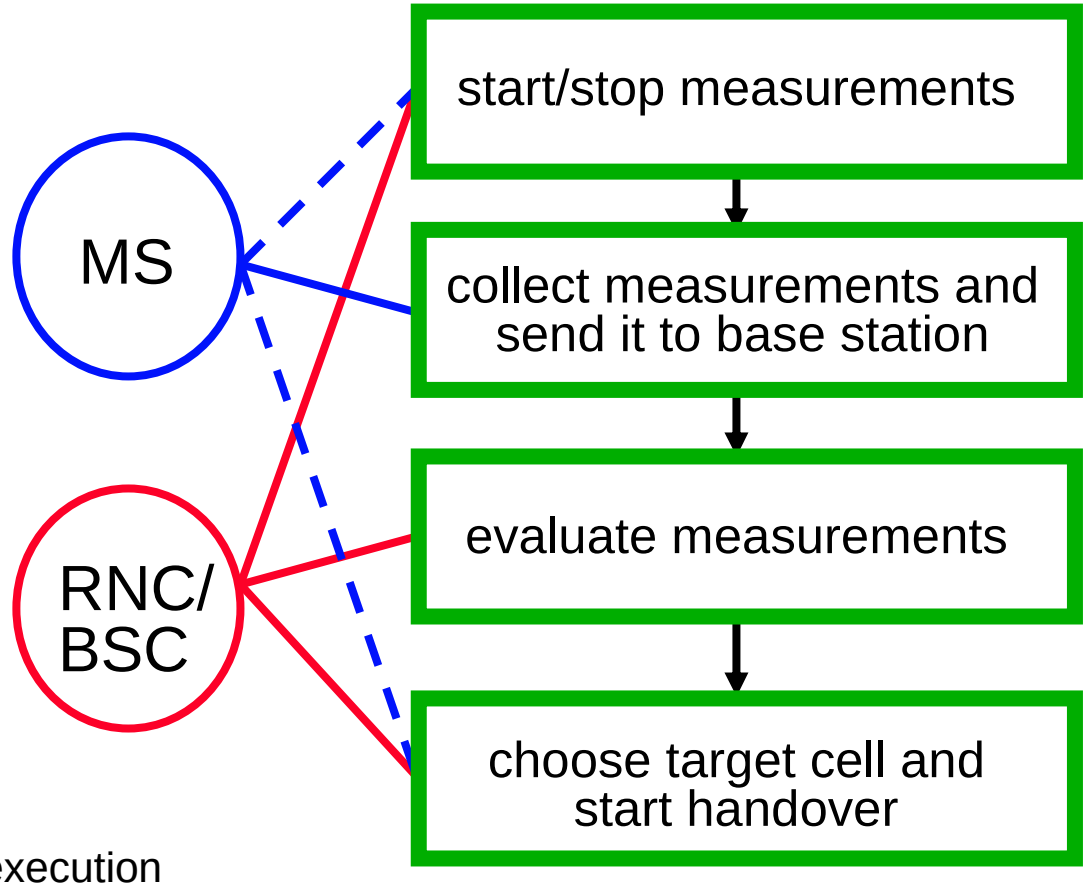
- The load index η_{System} is calculated by the sum of each service's resource consumption α_{MS} in the cell (1 is 100%)

$$\eta_{System} = \sum_{\forall MS} \alpha_{MS}$$

- Used load model is static and includes only quantitative views.
  - no change of model when load changes
  - no consideration of priorities
- Load model makes possible to estimate the load after handover.

$$\tilde{\eta}_{i+1} = \eta_i \pm \tilde{\alpha}_{MS}$$

Background – Simplified model of LB algorithm



Overview

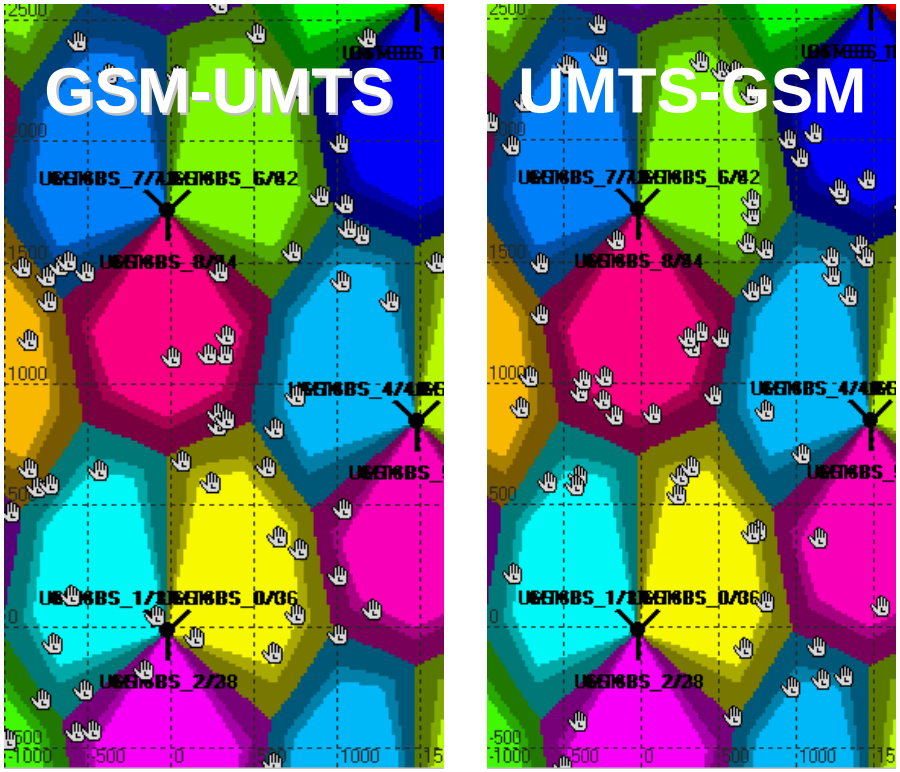
- Background
- Simulation
- Questions

Simulation – Environment

- 12 base stations with 3 sector cells each for both UMTS and GSM
- Cells are co-located
- Each GSM cell uses 3 TRX, each UMTS cell uses 5 Mhz
- Cell size 1000 m
- Mobiles use one conversational service

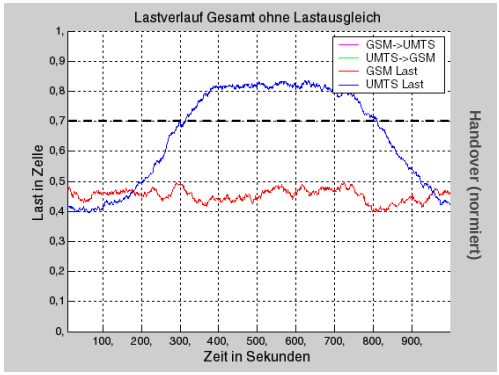
Simulation – Impact of sorting

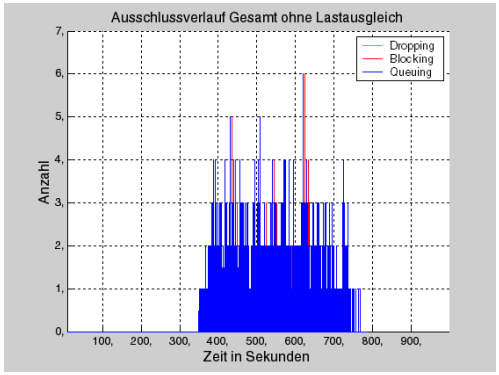
- LB handovers mostly at the border of cells
  - More resource consumption at the borders of cells in UMTS due to higher interference and higher distance
  - Statistical saving of GSM handovers is obvious

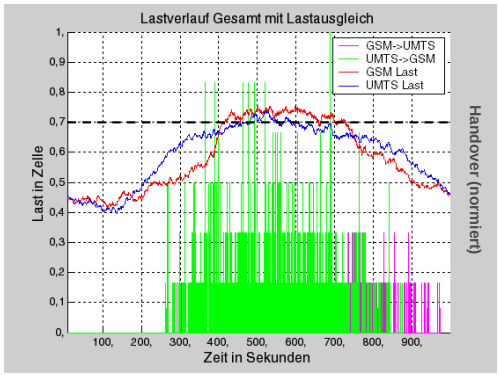


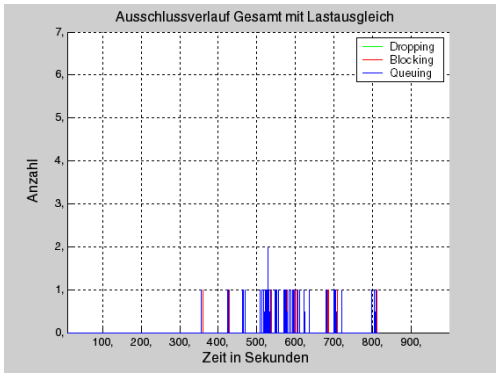
Simulation – Overall results

- Enables the transfer of load in an overload situation (overload at 350s)
- Less blocking, dropping, queuing (14.4% to 1.7%)
  - Slight increase of outage and queuing in GSM system.
- Increasing number of handovers due to LB Handovers (+24%)
- Longer high load in UMTS due to GSM-UMTS LB handover





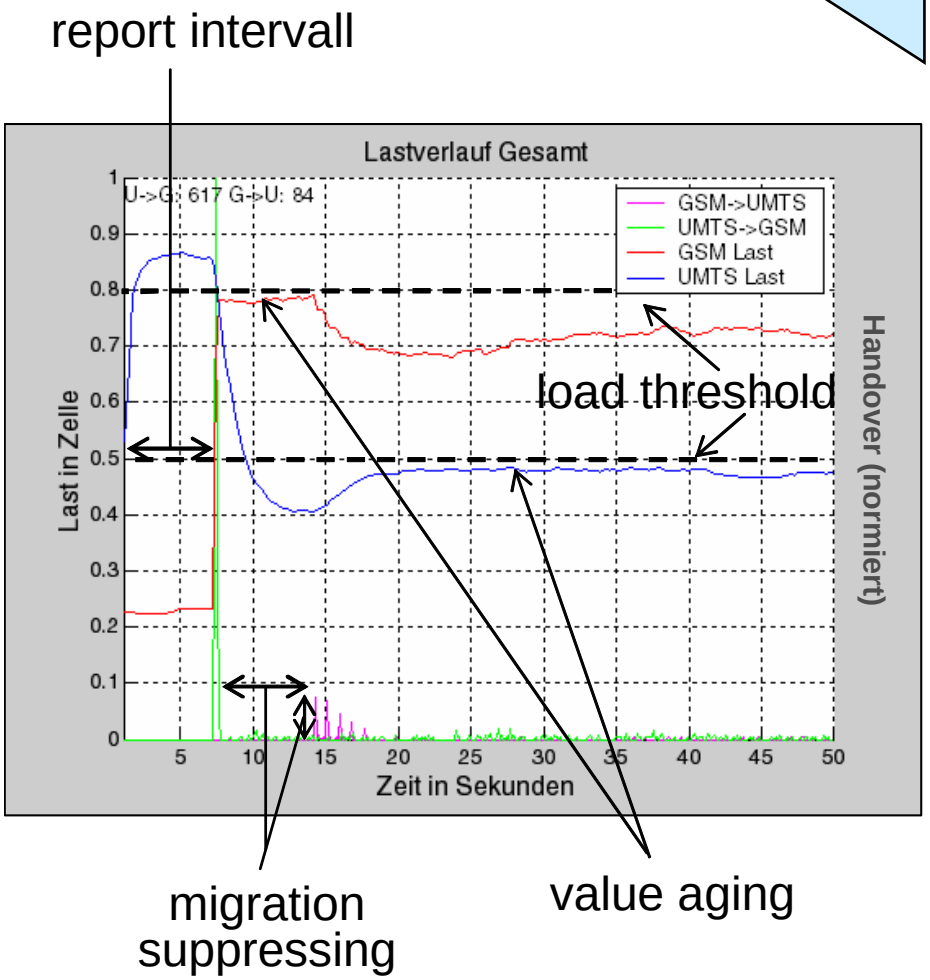




Load balancing
in combined UMTS/GSM cellular systems

Simulation – Impact of parameters

- Robust to parameter changes
- Even long report intervals were suitable for fast load changes
- GSM to UMTS handovers not needed to increase carried traffic if GSM has enough capacity
- High values of the value aging parameter lead to higher resource consumption



- Time for Questions

Thank you very much
for your attention!

Bibliography

- M. Mouly, M.-B. Pautet, “The GSM System for Mobile Communications”, 1. Aufl, Cell&Sys, 1992
- H. Kaaranen, “UMTS Networks - Architecture, Mobility and Services”, John Wiley & Sons LTD, 2001
- J. Mueckenheim, U. Bernhard, “On Load Control in 3rd Generation CDMA networks”, Technical Report Lucent Technologies, Juni 2001
- G. Quadros, E. Monteiro, F. Boavida, “A QoS Metric for Packet Networks”, in Proceedings of SPIES's symposium on Voice, Video, and Data Communications conference on Quality of Service Issues Related to Internet, Boston, MA, USA, November 2-5, 1998.
- Edmundo Monteiro, Gonçalo Quadros, Fernando Boavida, "A Scheme for the Quantification of Congestion in Communication Services and Systems", In Proceedings of the third International Workshop on Services in Distributed and Networked Envirnoments, IEEE ComSoc, Macau, 3-4 Juni 1996.
- Sabata B., Chatterjee S., Davis M., Sydir J., Lawrence T., "Taxonomy for QoS Specifications," Proceedings of Workshop on Object-oriented Real-time Dependable Systems (WORDS 97), Februar 1997.
- Bouch A., Sasse M., DeMeer H. G., “Of Packets and People: A User-Centered Approach to Quality of Service”, in Proceedings of IWQoS'00, Juni 2000.
- A. Campbell, C. Aurrecoechea, and L. Hauw. “A review of QoS Architectures”. ACM Multimedia Systems Journal, 1996.
- J.M. Köhn, “Kooperatives Management der Funkressourcen bei Multistandard/Multiband - Mobilkommunikationssystemen”, Diplomarbeit Lucent Technologies, Nürnberg, 2001
- Andreas Pillekeit, “Lastverteilung in Multistandard/Multibandsystemen (UMTS/GSM)”, Diplomarbeit Lucent Technologies, Nürnberg, 2003
- Heiss, Prozessorzuteilung in Parallelrechnern, 1. Aufl., BI-Wissenschaftsverlag, 1994
- Livny, Melman, „Load balancing in homogeneous broadcast distributed systems”, Proceedings of the Computer Network Performance Symposium, 1982
- Eager, Lazowska, Zahorjan, „A comparision of Receiver-initiated and Sender-initiated adaptive load sharing”, Conference on Measurement and Modeling of Computer Systems, 1985
- A. Leon Garcia, „Probability and random processes for electrical engineering”, Addison-Wesley, 1989
- ETSI TS 122 105 V 5.2.0 “UMTS Services and Service capabilities”
- ETSI TS 122 129 V 3.2.0 “Handover Requirements between UMTS and GSM or other Radio Systems”
- ETSI TS 101 113 V 7.4.0 “GPRS Service description” Stage 1
- ETSI TS 101 344 V 7.9.0 “GPRS Service description” Stage 2