HO Policies for Combined WLAN/UMTS Networks

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Project Overview

- Project partners
  - Uni Würzburg,
    - Lehrstuhl für verteilte Systeme (Prof. Tran-Gia),
    - Rastin Pries, Dr. Dirk Staehle,
    - Simulative and analytical performance evaluation of UMTS and WLAN,
  - TU Berlin,
    - Fachgebiet Telekommunikationsnetze (Prof. Wolisz),
    - Sven Wiethölter,
    - Performance evaluation of WLAN in combination with perceived QoS,
- Goal:

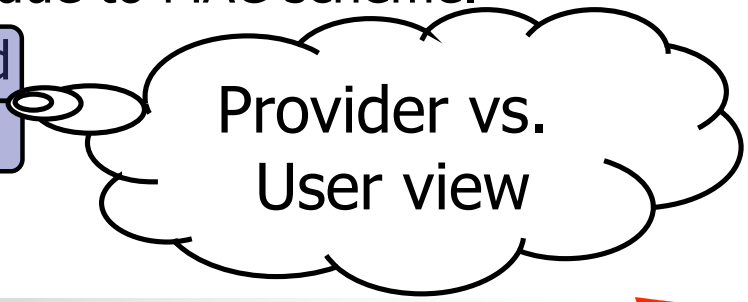
  Design and investigation of policies for handovers in heterogeneous networks (UMTS/WLAN).

Overview

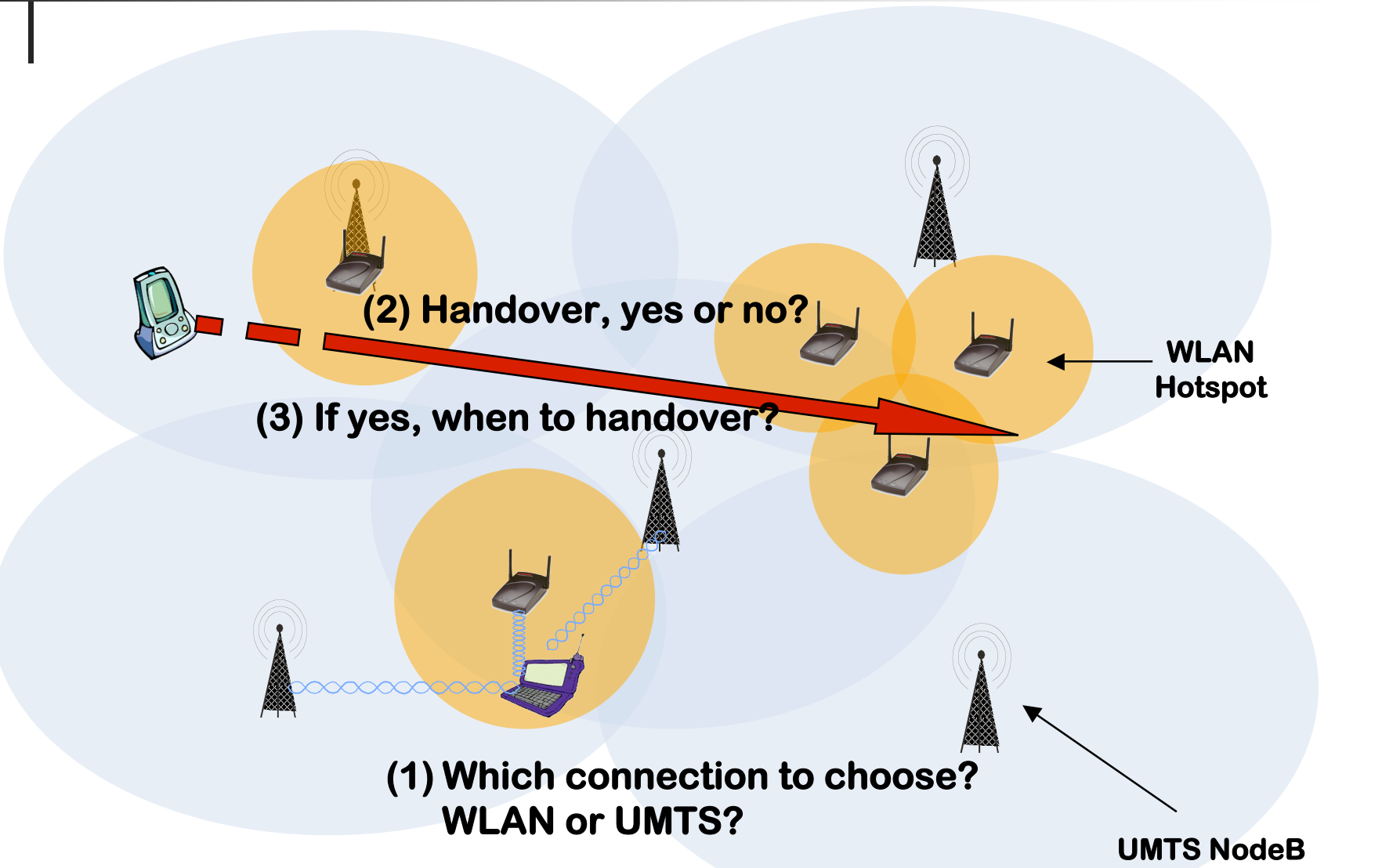
- Introduction:
  - Motivation
  - Issues for handover policies
  - Evaluation criterion – basic idea
- Evaluation criterion for
  - WLAN
  - UMTS
- VHO policy framework
- Summary
- Outlook

Motivation

- Common approaches for handover decision:
  - Based on single threshold, e.g., dependent on
    - RX power level,
    - Number of retransmissions,
  - Loss of connectivity.
- Issue: When should a mobile be served by which technology, if and when to handover? Depends on
  - Characteristics of each technology:
    - Available resources vs. supported degree of mobility,
    - Weaknesses, e.g., overhead due to MAC scheme.
  - Radio resource management, and
  - Perceived quality of user.



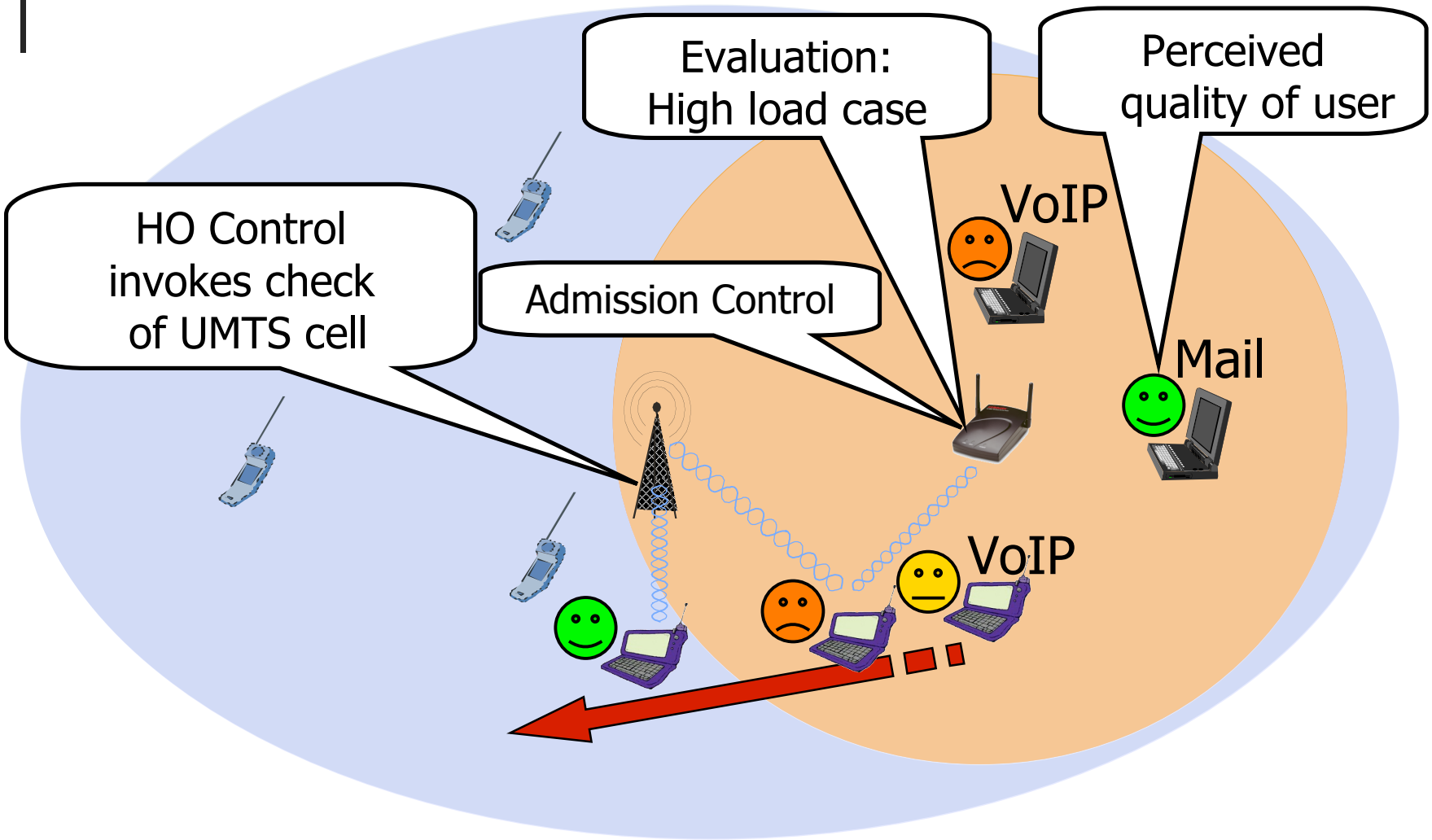
Issues for Handover Policies



WLAN or UMTS?

- Decision requires knowledge of current situation in WLAN and UMTS ➔ evaluation of situation
- Evaluation criterion for each technology must
  - Reflect current situation, and
  - Allow a predictive investigation of networks`behaviors.
- Evaluation functions
  - For Admission Control in each network, as well as
  - For Handover Control, most probably at different place.
- Investigations for evaluation criterion include:
  - For WLAN
    - CSMA/CA-specific behavior:
      - Inter-frame spaces,
      - (Post)backoff,
    - Rate adaptation.
  - For UMTS
    - Limitations due to interferences / maximum transmit power, and
    - Allocation of channelization codes.

Principle of Evaluation Function



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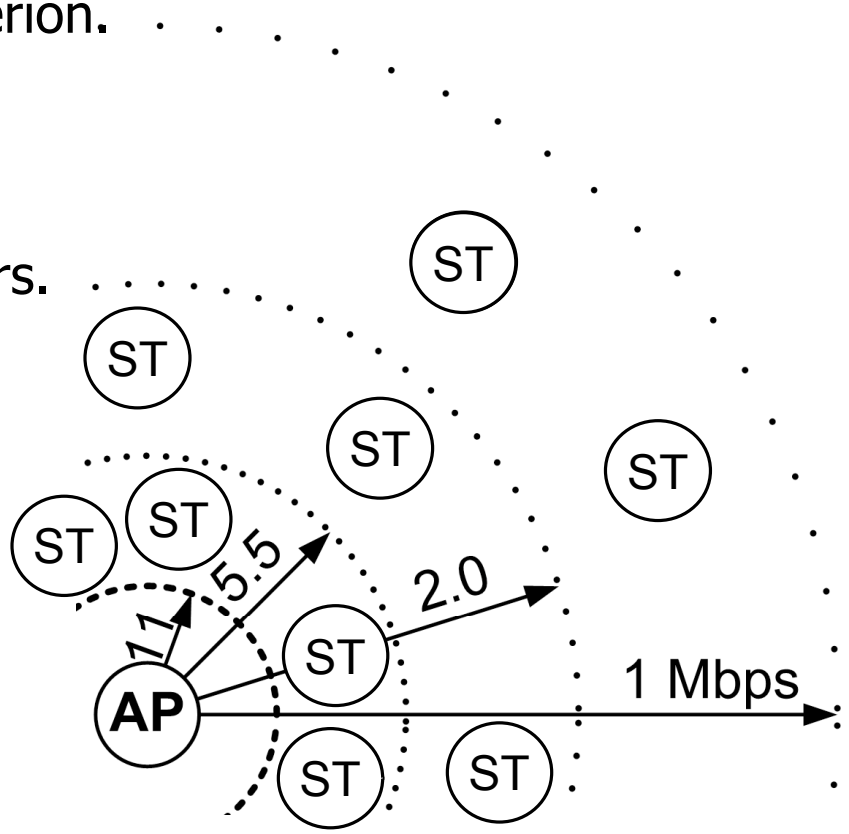
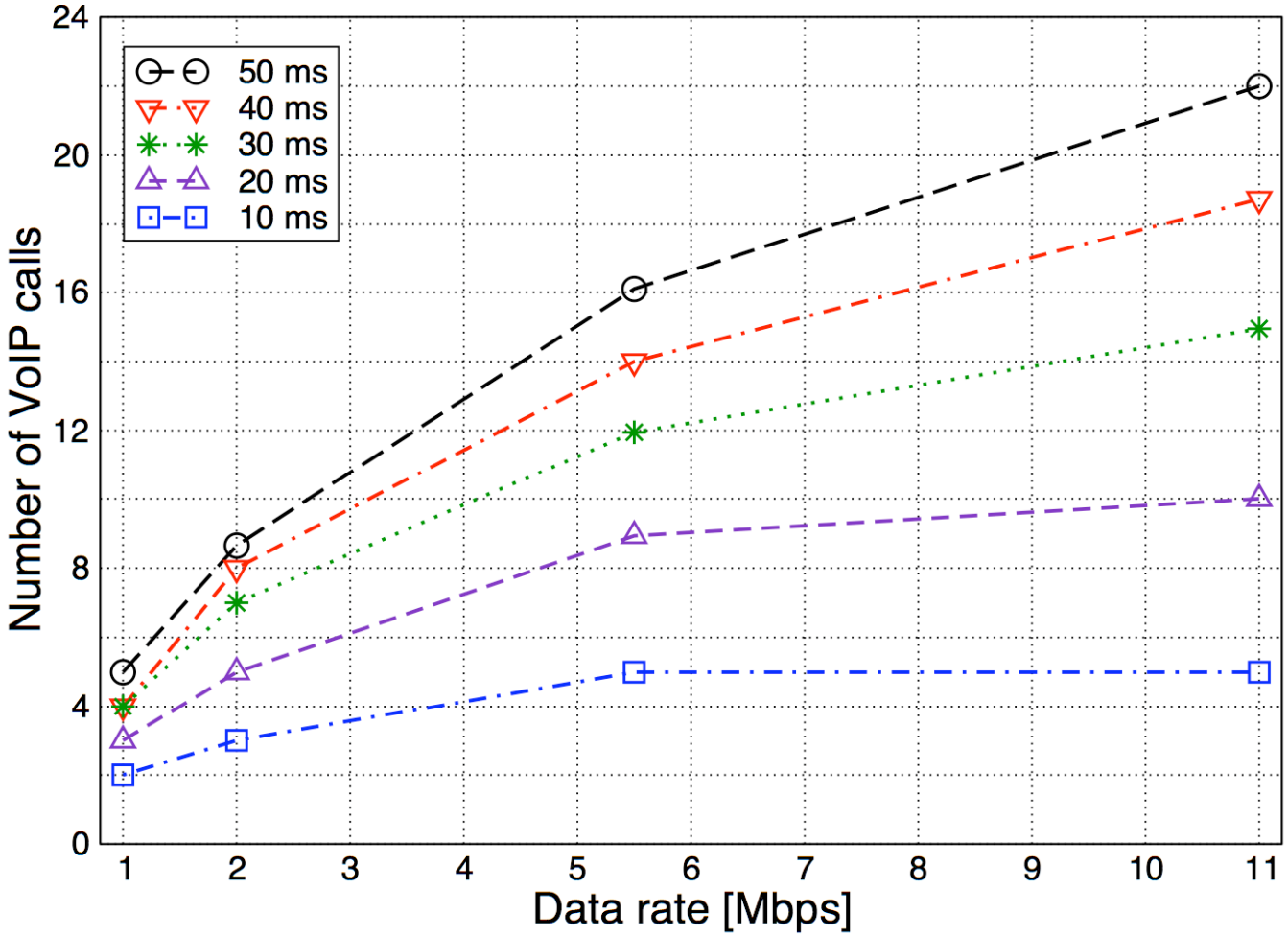
WLAN – Simulation Scenario

- Goals:
  - Identification of costs due to low-rate transmissions,
  - Derivation of Evaluation criterion.
- Two investigations:
  - Maximum capacity, and
  - Degradation by low-rate users.
- VoIP traffic in 802.11b:
  - Bi-directional CBR streams,
  - ITU-T G711-codec, 64kbps,
  - Various packetizations,
  - Call has lousy quality, if:
    - 5 percent packet loss,
    - Including packets with a one-way delay > 150ms.

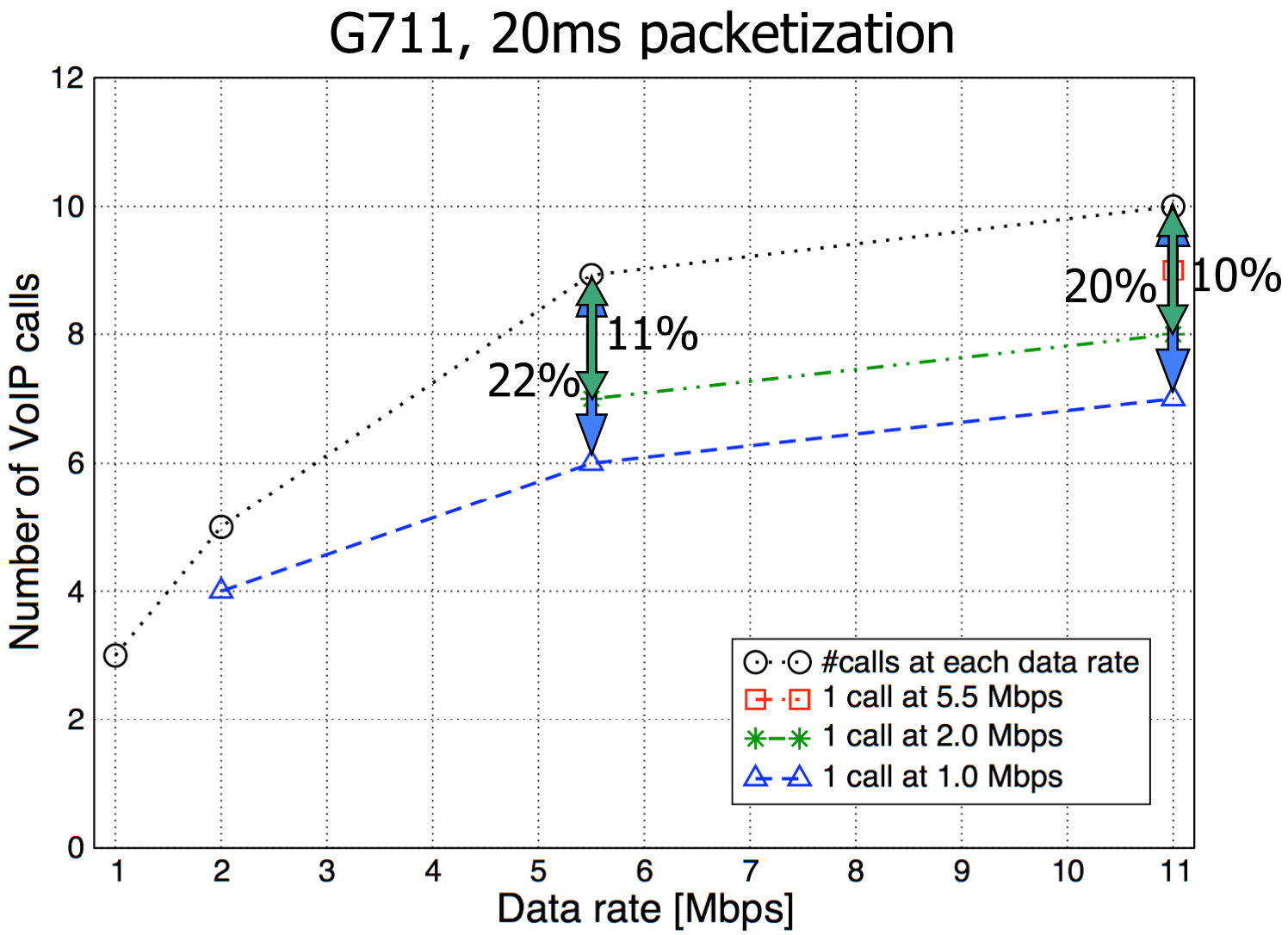


WLAN – Capacity at homogeneous rates

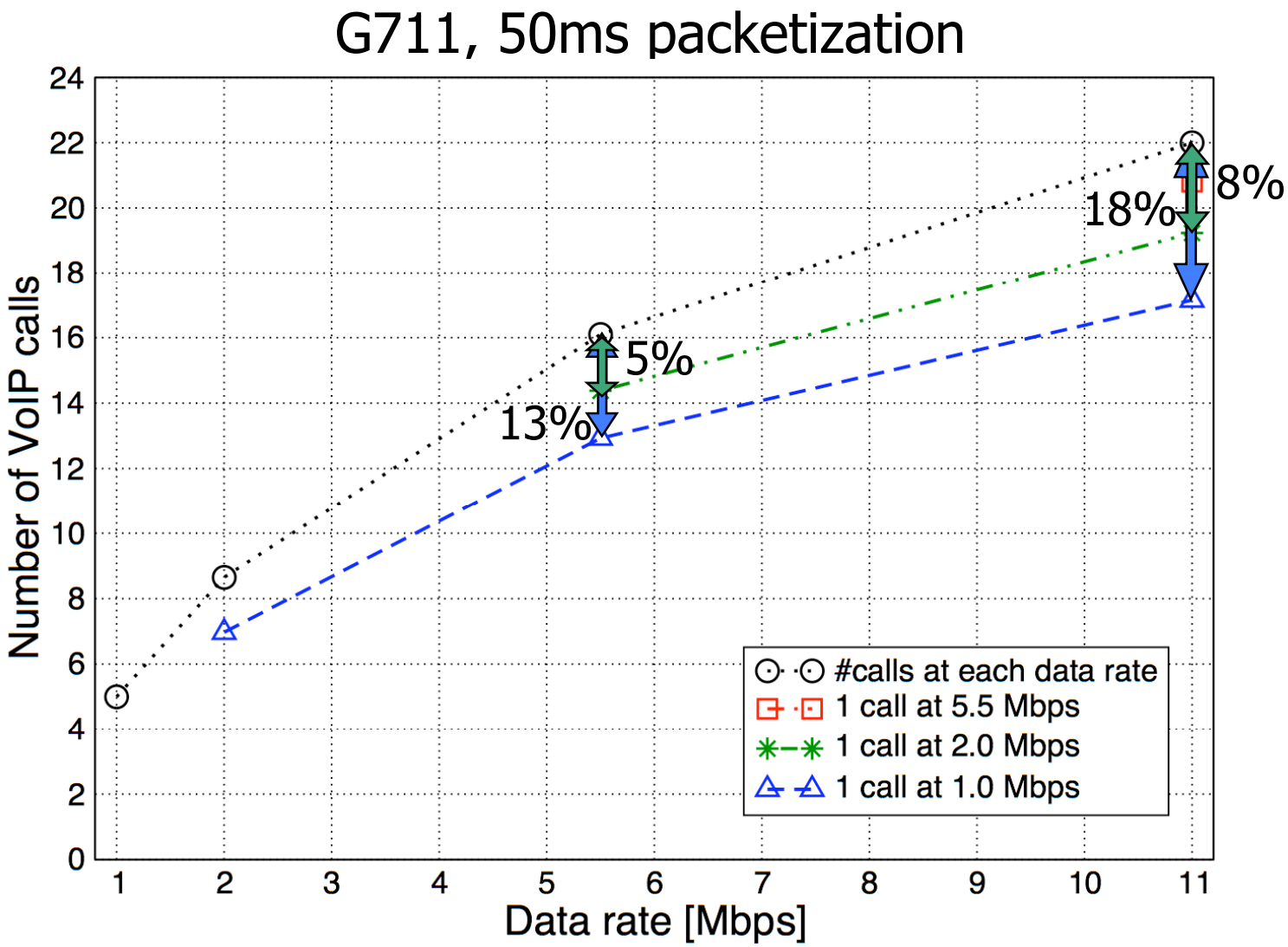
G711, packetizations ranging from 10 to 50 ms



WLAN – Mixed Data Rate Environment I

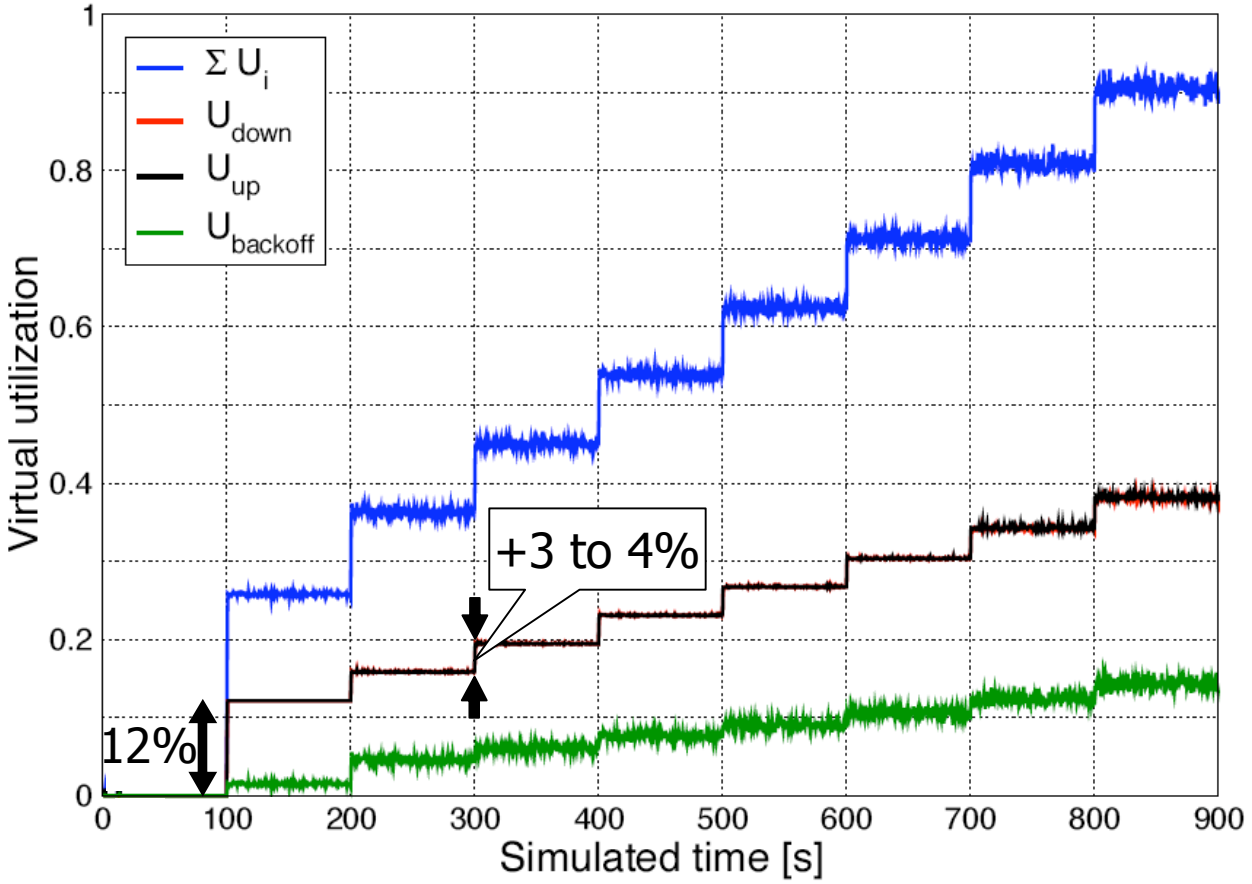


WLAN – Mixed Data Rate Environment II



WLAN – Virtual Utilization

- Occupancy time for each transmission, including packet headers, inter-frame spaces, immediate ACK, (post)backoff
- Virtual Utilization at AP (i.e., at bottleneck):



$$U_{uplink} = \frac{t_{busy,uplink}}{\Delta t_{average}}$$

$$U_{downlink} = \frac{t_{busy,downlink}}{\Delta t_{average}}$$

$$U_{backoff} = \frac{t_{busy,overhead}}{\Delta t_{average}}$$

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UMTS – Characteristics

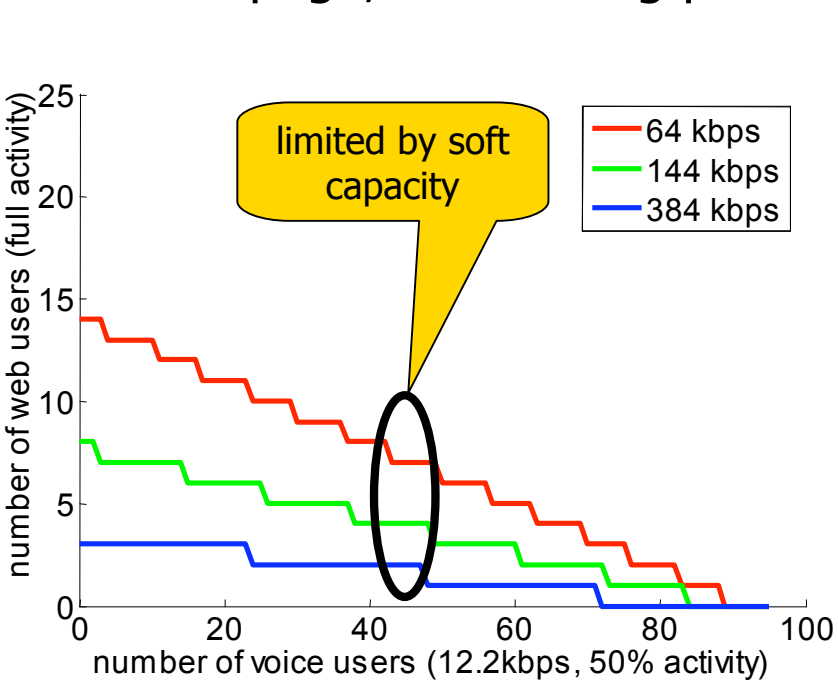
- Our current focus:
  - UMTS FDD
  - Dedicated channels on uplink and downlink
  - QoS is supported for real-time applications
  - Slow rate control/adaptation for best-effort applications
- Future focus:
  - High Speed Downlink Packet Access (HSDPA)
  - Enhanced Uplink with E-DCH
- Characteristics of UMTS
  - Wideband CDMA as multiple access technology
  - Users share the same frequency band at the same time
  - Signals are separated by using different codes
  - Signals interfere with each other
  - Capacity is interference limited

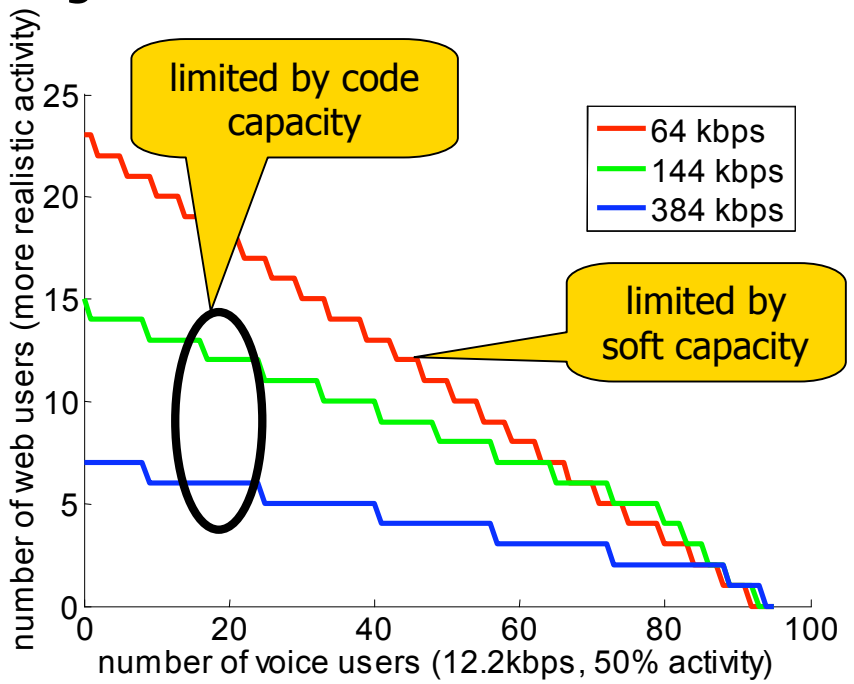
UMTS – Capacity, Admission Control, and QoS

- Uplink Capacity
  - Soft capacity: limited by multiple access interference (MAI)
- Downlink capacity
  - Soft capacity: limited by multiple access interference (available Node B transmit power)
  - Code capacity: limited by available channelization codes per sector/cell
- Admission control (AC)
  - Uplink: threshold on measured noise-rise
  - Downlink: threshold on measured Node B transmit power and occupied channelization codes
- QoS
  - Bearer defines net bit rate and target FER
  - Rate of best-effort services is slowly adapted to interference, Node B transmit power, and code situation

UMTS – Web vs. Voice on the Downlink

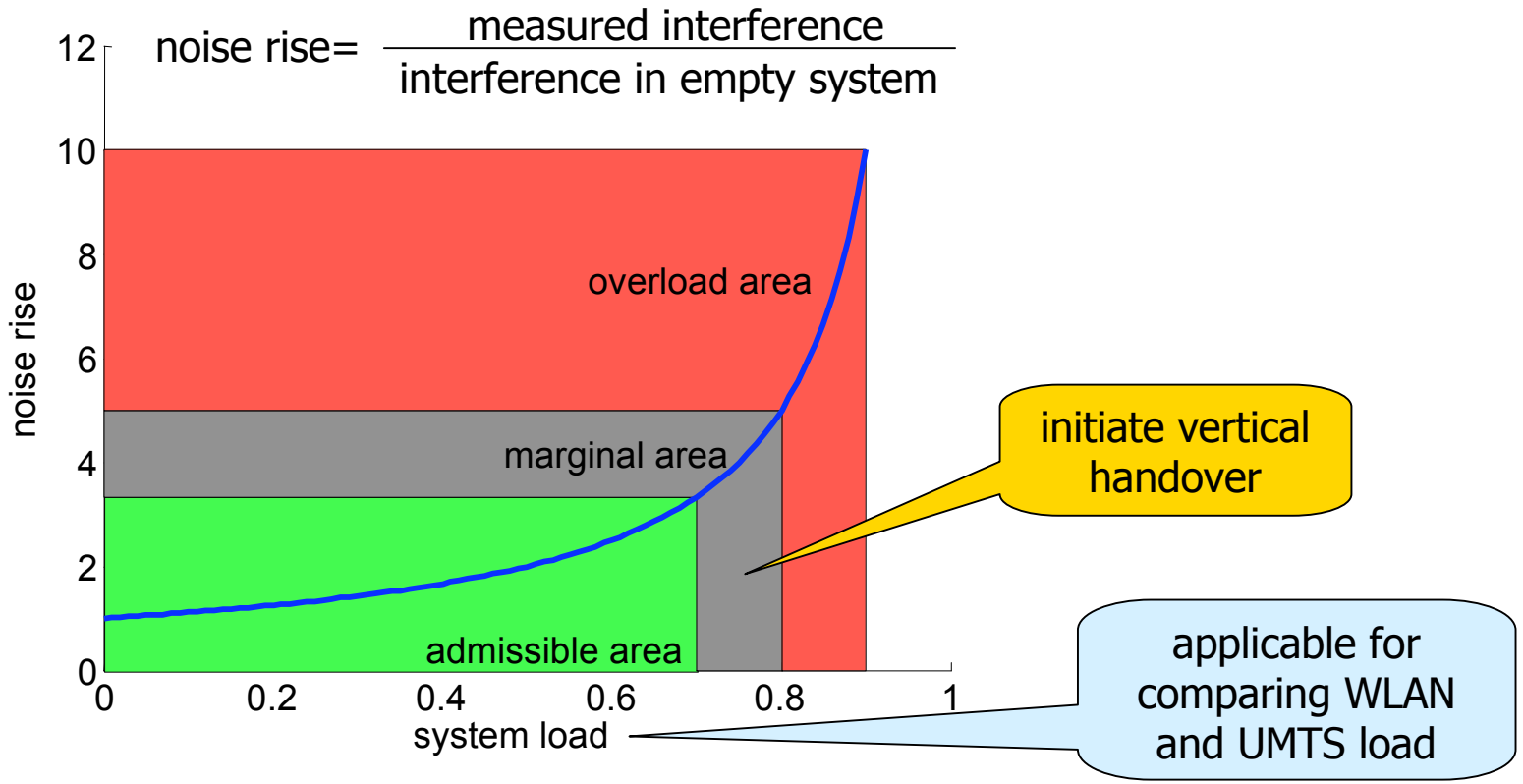
- Voice: AMR codec with 12.2 kbps bearer, 50% activity
- Web with adaptive bearer:
  - bit rate: 64kbps, 144kbps, 384 kbps
  - „realistic" activity: 62.5%, 27.7%, 10% with 100kB web page, 20s loading plus viewing time





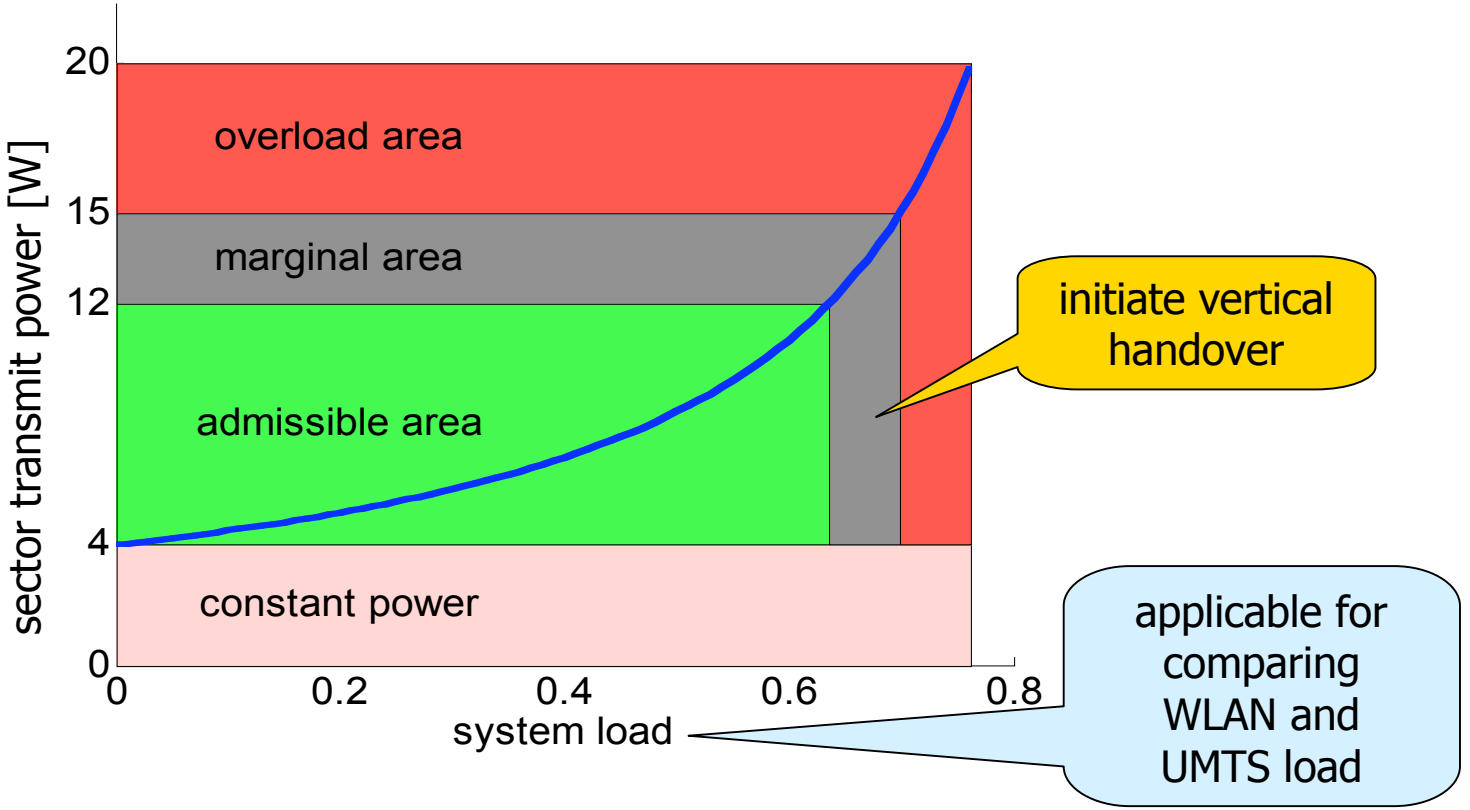
UMTS – Uplink AC and System Load

- AC
  - Measures noise rise,
  - Translates noise rise to system load, and
  - Estimates system load increase by new user.



UMTS – Downlink AC and System Load

- AC
  - Measures sector transmit power, and
  - Estimates sector transmit power increase by new user.



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VHO Policy Framework I

- Utilization-based criterion each technology
  - Reflects current situation,
  - Will enable a predictive evaluation, and
  - Is a basis for the evaluation function.
- Utilization Margins:
  - Specify an upper level of cell utilization,
  - For perceived quality of different applications,
  - Rescue Margins
    - For non-preventable handovers,
    - Depend on (vertical) neighbor cell and their users.
- Place for HO control
  - Centralized rendezvous entity
    - Signaling delay determines requirements on prediction,
  - But collection of distributed pieces of information among
    - Mobile,
    - RNC, and AP.

VHO Policy Framework II

- Information service:
  - Between UMTS / WLAN networks: status information exchange
    - Enables HO management functionality (e.g., adaptation of rescue margins)
  - Between mobile and WLAN / UMTS networks:
    - Results in information about (vertical) neighbor cells,
    - Enables pre-configuration of devices + higher layer settings,
    - Allows vague prediction of handovers.
- Policies:
  - Costs of each user identified
    - By evaluation criterion including technology-specific weaknesses
    - In Combination with perceived quality metrics.
  - Perform Handover, if
    - In WLAN: low goodput, high virtual utilization, low perceived QoS, high influence on perceived QoS of other users,
    - IN UMTS: system load (up-, downlink, code) in marginal area, low level of perceived QoS for best effort users.

Summary

- Goal: Design of Policies for the decision
  - when a mobile should be served by which technology, and
  - If and when a VHO should be performed.
- Evaluation of situation in each technology:
  - WLAN:
    - VoIP simulations show great impact of
      - Overhead due to MAC specific behavior,
      - Users with lower rates and identify their provoked costs.
    - Motivation for virtual utilization at bottleneck,
      separation into Up, Downlink and overhead part
      allows fine-grained Admission / HO control.
  - UMTS:
    - Evaluation criterion for load situation of sector/cell (UMTS FDD) that is applicable in vertical handover decision
- WLAN/UMTS policy framework
  - Utilization criterion for both technologies combined with perceived quality metrics,
  - Utility margins for HO decisions.

Outlook

- WLAN:
  - Investigation of VoIP / web-traffic mixes with respect to virtual utilization and perceived QoS,
  - Short-term predictive investigation of virtual utilization.
- UMTS:
  - Measure for best-effort users' level of perceived quality,
  - Extension to HSDPA and Enhanced Uplink.
- Combined WLAN/UMTS networks:
  - Place of HO decision, including bounds of signaling delay,
  - Simulative investigation of WLAN/UMTS evaluation criteria and handover function,
  - Identification of "best" user to handover.

Thanks for your attention.

Questions?