SWINBURNE UNIVERSITY OF TECHNOLOGY

Inter-technology handoff in Next Generation Mobile Networks (NGMN)

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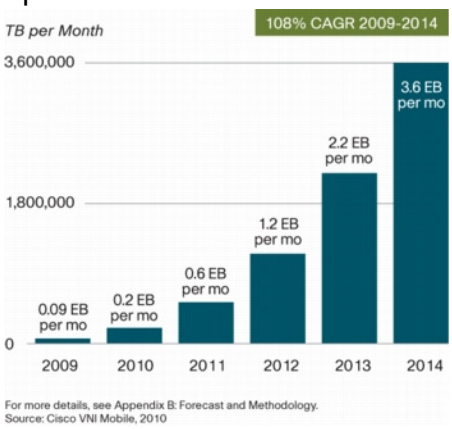
Outline

- Wireless technologies
- Handoff problem
- soft handoff approach
- Conservative soft handoff
- Some results, some analysis
- conclusion

Technologies

- 5.4 billion mobile users, 7.6 billion in 2015
- 3.6 exabytes per month mobile data in 2014

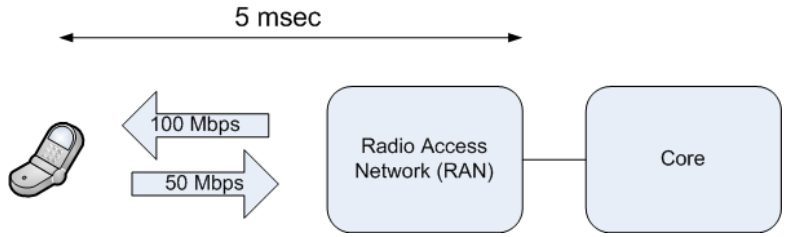


Technologies

- 3GPP technologies
  - GPRS, EDGE (2.5G, 2.75G)
  - UMTS, HSPA, HSPA+ (3G, 3.5G)
  - Long Term Evolution (LTE), LTE-Advanced
- IEEE technologies
  - WiMAX (mobile WiMAX, 802.16e)
  - WiMAX 2 (802.16m, to be released)
  - WiFi
- LTE-Advanced and WiMAX 2 submitted to ITU for IMT-Advanced

LTE: Introduction

- Released in Dec. 2008 by 3GPP.
- Currently 6 networks in service, 160 commitments



LTE: Field trial

- Ralf Irmer et al. describe two field trial in Dresden and Berlin, Germany [1]
- Dresden downtown trial focuses on PHY layer.
- Berlin trial is for evaluating applications

LTE: Field trial

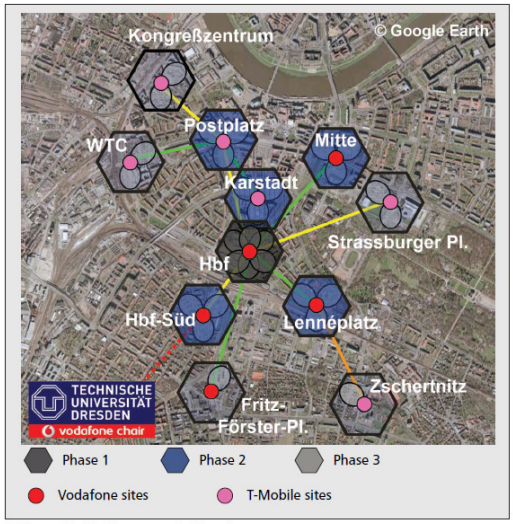


Figure 1. *Field test area in Dresden.*[1]

LTE: Field trial

Figure 2. *Test base station with antennas and microwave link at central site.* [1]

LTE: Field trial

Figure 3. *Signal coverage of the trial area based on drive tests.* [1]

LTE: Field trial – Border thoughput

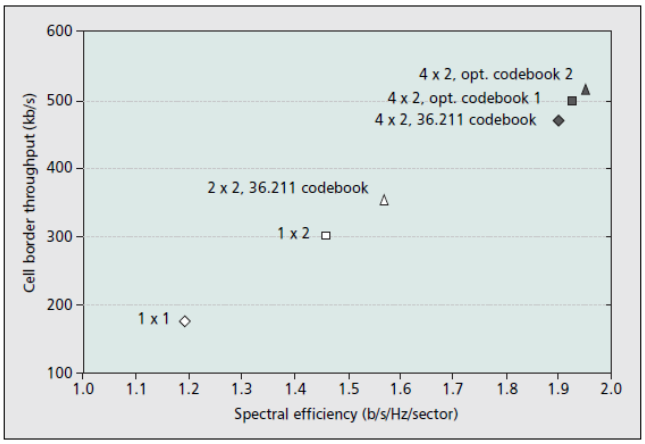
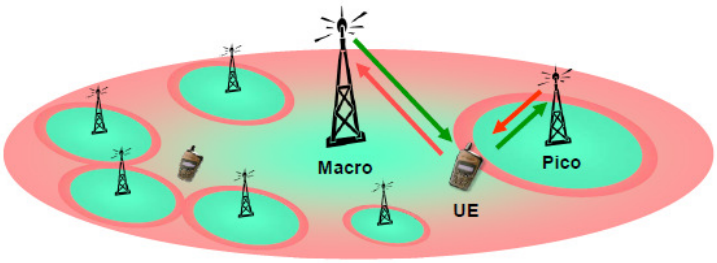


Figure 5. *Cell border throughput vs. system spectral efficiency for LTE DL with different antenna systems and precoding matrices.*

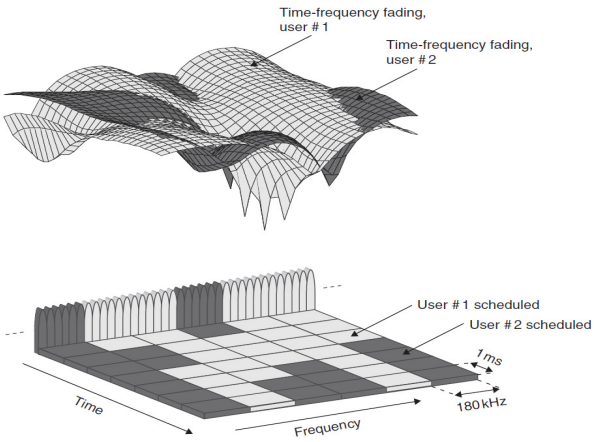
LTE: improvement techniques

- Heterogeneous networks [2]



LTE: improvement techniques

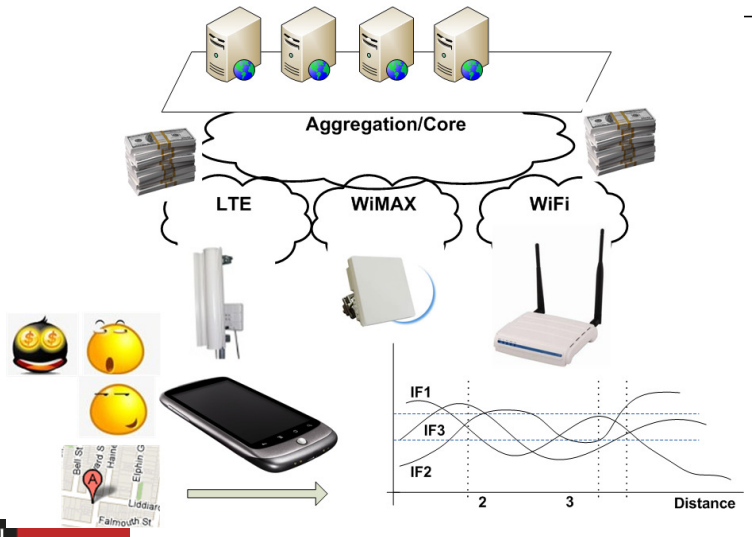
- Multiuser diversity [3]



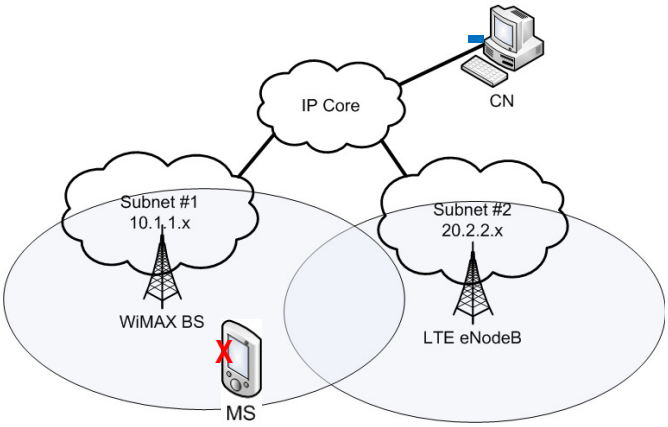
LTE: improvement techniques

- Multiuser diversity [3]
  - For K users the capacity gain is *O(log (log (K)))*
- If shadow fading is also considered the gain is O(√log(k)) [4]

Inter-technology Hanodoff



Mobility and Seamless Handoff



Mobility and Seamless Handoff

- Handoff process:
  - Scanning
  - Network selection
  - Authentication and Authorization
  - IP address configuration
  - Routing information update
- Handoff can be too time consuming
- Soft handoff (SHO) can be used

Mobility and Seamless Handoff

- Soft Handoff (SHO) approach
  - Two active interfaces
  - Duplicated data packets are received

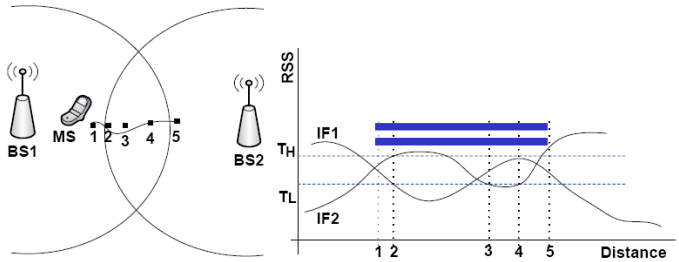


Figure 1. MS movement from RAN1 to RAN2

Soft handoff methods

- Soft handoff in the application layer: mSIP [5]
- Transport layer: MMSP [6]
  - Adds FEC to packets

Soft handoff methods

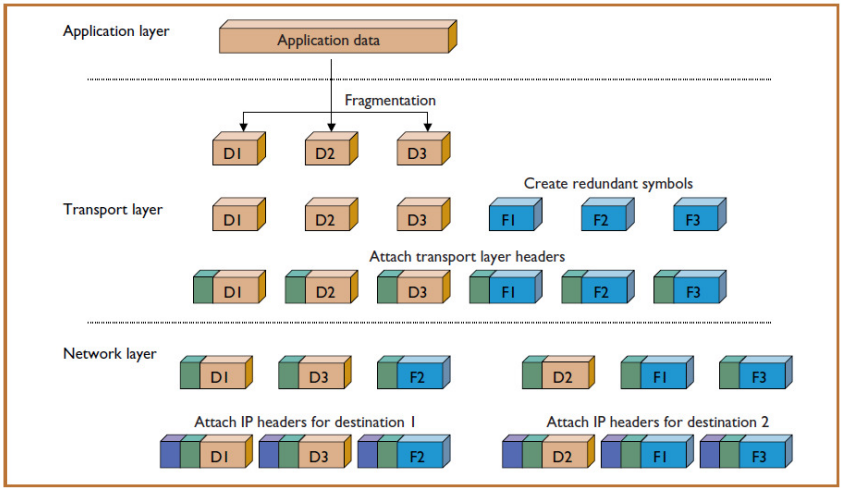


Figure from [6]

Soft handoff methods

- SNR for MPEG4 video

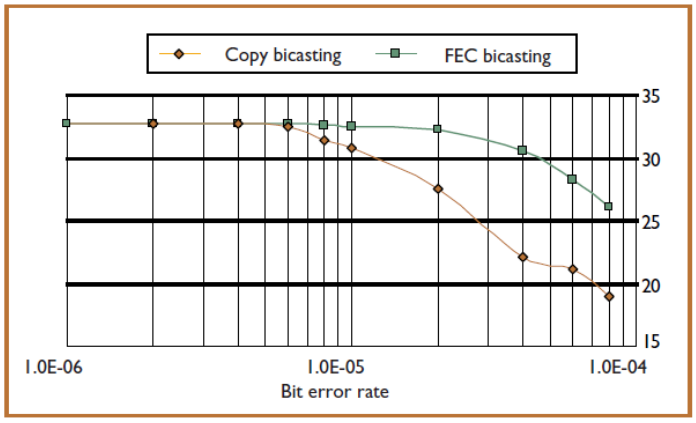


Figure from [6]

Soft handoff methods

- IP layer SHO: look at [7] for an example

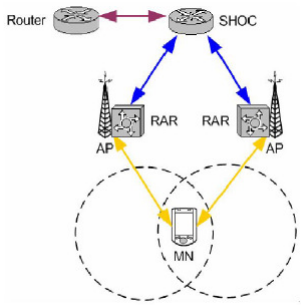


Figure 2. ISHO network structure

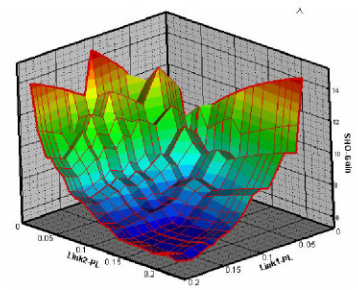


Figure 7. PDG of IP layer Soft Handover

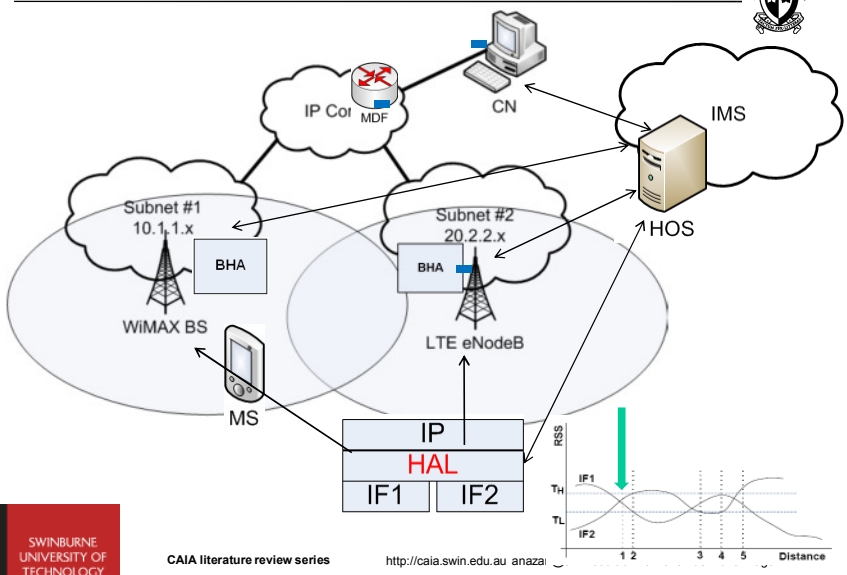
Soft handoff drawbacks

- The mobile station (MS) should have multiple radio interface
- Excessive power usage
- Consumption of radio resource usage
- Cell-edge capacity problem.
  - Handoff usually happens in cells edge
- In some cases soft handoff is used only for signaling

Our Conservative SHO (cSHO)

- Only one active interface at a time
- The radio interface with lowest PER is active

Conservative Soft Handoff (cSHO)



Our Conservative SHO (cSHO)

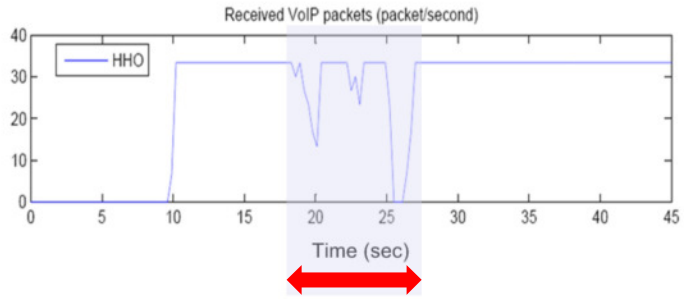
- Only one active connection ➔ Less resource consumption
- We can use shadow fading to improve capacity
- There is a signaling cost for feedback
  - We use IEEE802.21 ➔ Large packets
- More complexity due to buffering and forwarding
  - Much less than Cooperative Multipoint Transmission (CoMP)
- Some battery consumption for running the algorithm and monitoring interfaces

Our Conservative SHO (cSHO)

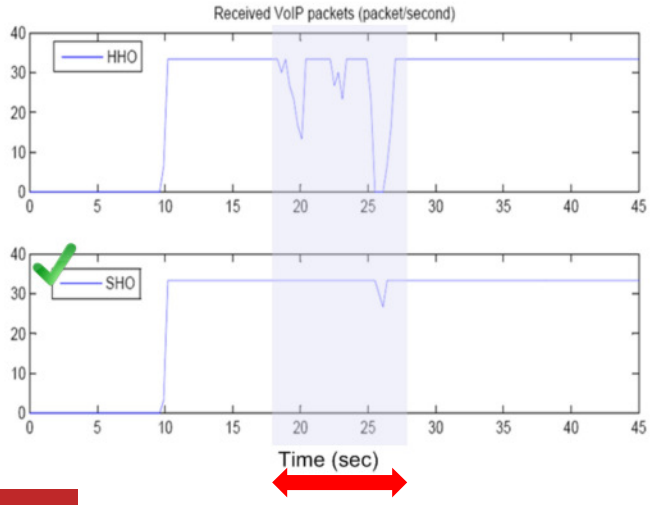
- More packet loss compare to SHO
  - We need to evaluate the performance of cSHO and SHO

Simulation Results

- Received VoIP packets per second



Simulation Results



Simulation Results

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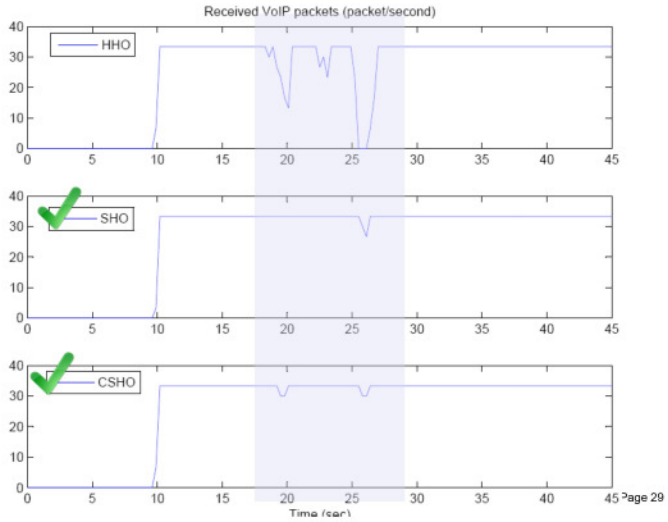


Performance evaluation

- Performance criteria:
  - Packet Error Rate (PER)
  - Probability of outage
  - Handoff accuracy; Matching Rate
  - Handoff delay; signaling delay
- Cost analysis:
  - Signaling cost
  - Complexity: network modifications, protocol stack modifications

Performance evaluation

- Cost analysis (cont.)
  - Radio resource consumption & battery consumption
  - Backhaul link capacity usage

Performance evaluation: Packet loss

- PER1 and PER2: packet error rate of interface 1 and 2.
- SHO PER = PER1 * PER2
- HHO PER = PER1 or PER2
- cSHO PER = min{PER1, PER2}
- cSHO Gain: $G_{cSHO} = \frac{PER\,of\,HHO}{PER\,cSHO}$
- SHO Gain [7]

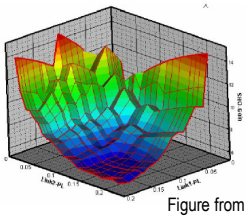
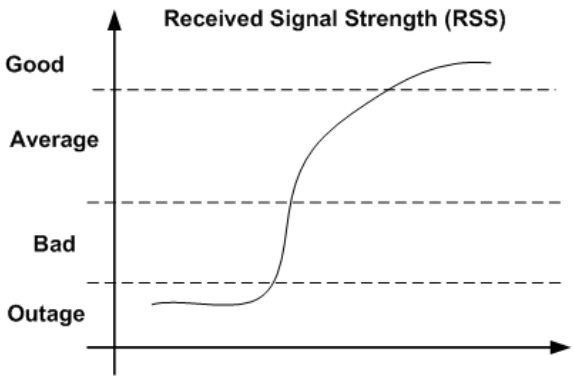


Figure from [7]

Figure 7. PDG of IP layer Soft Handover

Performance evaluation: Packet loss

- Radio channel with shadow fading:



Performance evaluation: Packet loss

- HHO with hysteresis: do handoff if current RSS is less than average and target RSS is above average
- SHO and cSHO don't need hysteresis
- We need to use Markov State Model for the radio channel
  - Find the probability of being in each state
  - Find the probability of using each interface in each state
  - Find the gain in each state assuming using each interface
  - Find the average gain

Some ideas

- cSHO with multi-interfaces, multi base stations
  - All base stations have packet datas
  - BS with the best conditions sends the packet
- Dynamic Auction in packet forwarding
  - The cheapest BS sends the data

Conclusion

- With HHO it is hard to achieve seamless handoff
- SHO provides seamless handoff with the best packet delivery performance
- SHO causes capacity problems
- cSHO provides good packet delivery ratio while saving some resources
- cSHO adds more complexity to networks.

References

[1] Irmer, R.; Mayer, H.-p.; Weber, A.; Braun, V.; Schmidt, M.; Ohm, M.; Ahr, N.; Zoch, Jandura, C.; Marsch, P.; Fettweis, G.; "Multisite field trial for LTE and advanced concepts ", 2009

[2] *Avneesh Agrawal,Sr VP, Technology, Qualcomm,* "Heterogeneous NetworksA new paradigm for increasing cellular capacity", 2009

[3] J. S. P. B. Erik Dahlman, Stefan Parkvall, "3G EVOLUTION: HSPA and LTE for Mobile Broadband." Elsevier, second edition ed., 2008.

[4] Wan Choi; Andrews, J.G. "The Capacity Gain from Base Station Cooperative Scheduling in a MIMO DPC Cellular System ", 2006

[5] Seok Joo Koh; Wook Hyun, "mSIP: Extension of SIP for Soft Handover with Bicasting", 2008

[6] Matsuoka, H.; Yoshimura, M.; Ohya, T.; "A robust method for soft IP Handover ", 2003

[7] Jianwen Huang; Ruijun Feng; Yana Bi; Wu, J.; Mei Song; "A IP Layer Soft-handover Approach for All-IP Wireless Networks", 2005

Questions??