Empowered by Innovation NEC

Network Initiated handovers Simulation results

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A two-steps approach

1. NIHO studied as a general concept and compared to scenarios where MIHO-only is applied:
   - No signaling study
   - Aiming at
     - quantifying the benefit of the approach
     - Identifying conditions affecting relevance of NIHO support
   - Consider user mobility patterns and wireless overlapping
   - WLAN propagation model used for simplicity
2. NIHO studied from a signaling/mobility point of view:
   - IEEE 802.21 based signaling design
   - Network controlled and Network Initiated
   - Impact of signaling on terminal mobility

Step one

- Customized simulator (results averaged over 30 simulation runs)
- Simplified setup by considering single technology and regular cells placement
- 6 access points in hexagonal grid (see next slides)
- Nodes' birth/death follow Poisson distribution
- Random way point model is used (different speeds accounted)
- Uniform distribution of users:
  - First, simulations have been performed in scenarios where only MIHO is used. This provides reference results.
  - In a second stage, the simulations combine both MIHO and NIHO techniques, and are then compared with the previous reference results.
- Change the scenario with not evenly distributed users

Metrics

Performance study accounts for the following metrics:

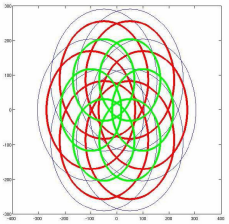
- Mean number of users in the system
- Probability of Rejection at first connection.
- Probability of Rejection while performing handover.
- Decrement in the number of Handovers (Mobile Initiated) between MIHO and MIHO plus NIHO.
- Ratio between Mobile Initiated Handovers and Network Initiated Handovers in the MIHO plus NIHO case.

Compared against the following variables:

- Degree of wireless overlapping area
- System load
- How often NIHO is triggered

Different overlapping coverage areas

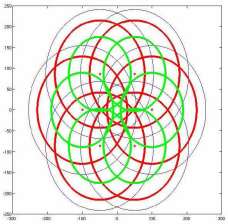
Overlapping 1



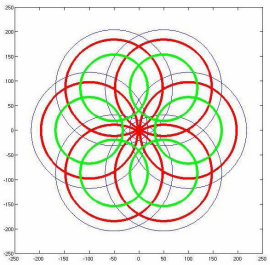
Black line : sensitivity threshold
Red Line: MIHO threshold trigger
Green Line: NIHO threshold trigger

Maximum load per AP 10 stations
RSSI and load for handover decision

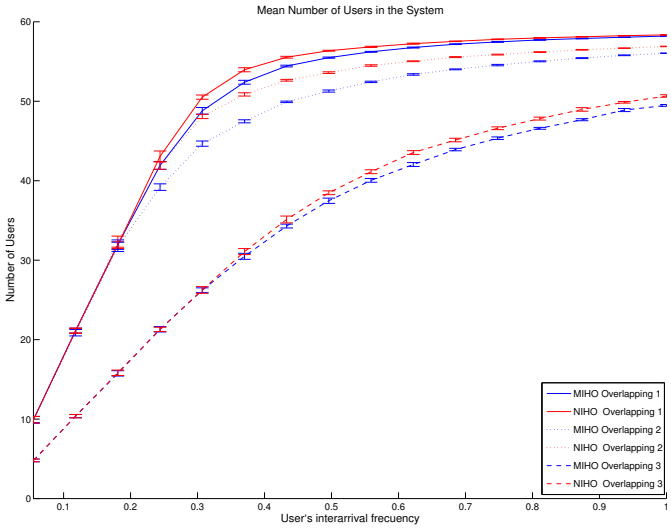
Overlapping 2

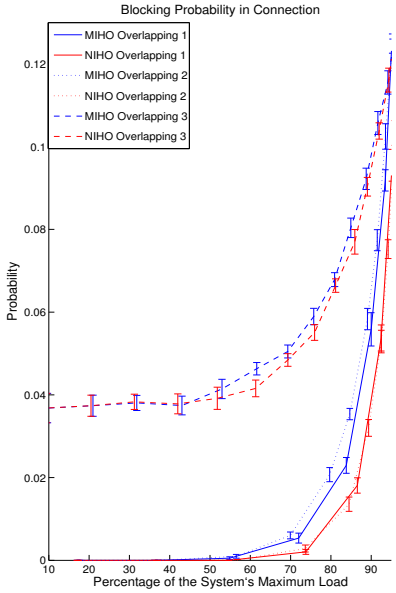


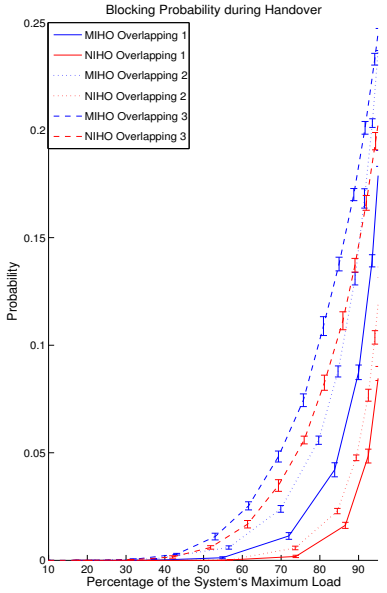
Overlapping 3

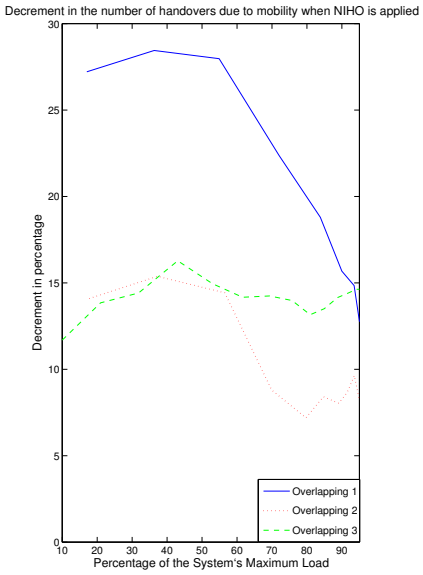


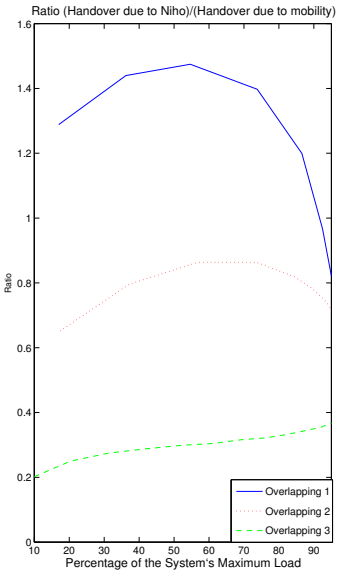
Mean Number of Users




Blocking Probability in Connection
MIHO Overlapping 1
NIHO Overlapping 1
MIHO Overlapping 2
NIHO Overlapping 2
MIHO Overlapping 3
NIHO Overlapping 3
Probability
Percentage of the System's Maximum Load


Blocking Probability during Handover
MIHO Overlapping 1
NIHO Overlapping 1
MIHO Overlapping 2
NIHO Overlapping 2
MIHO Overlapping 3
NIHO Overlapping 3
Probability
Percentage of the System's Maximum Load


Decrement in the number of handovers due to mobility when NIHO is applied
Decrement in percentage
Overlapping 1
Overlapping 2
Overlapping 3
Percentage of the System's Maximum Load


Ratio (Handover due to Niho)/(Handover due to mobility)
Ratio
Overlapping 1
Overlapping 2
Overlapping 3
Percentage of the System's Maximum Load

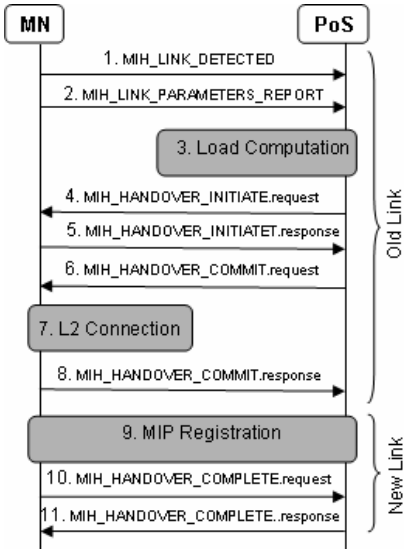
Considerations not evenly distributed users

Consider scenarios where users are concentrated in one portion of the network (e.g. hotspots, shopping malls, airports)

Table I. Metrics values for different network loads (lambda)

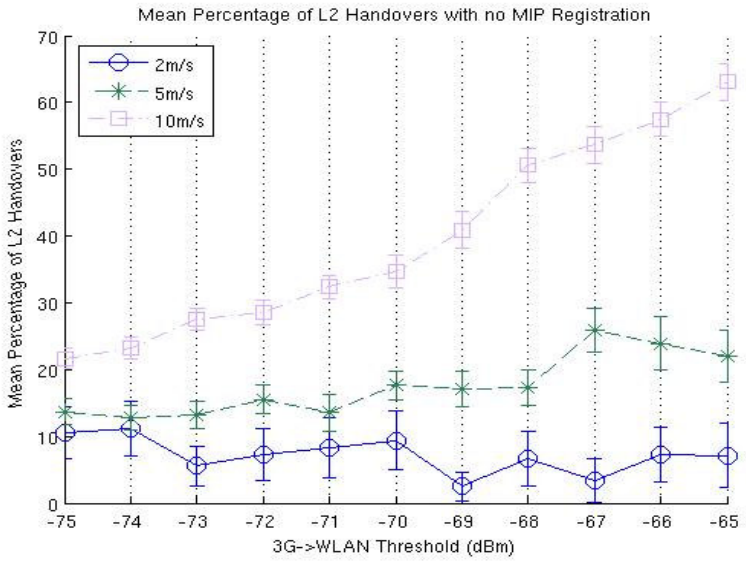
λ	NumberUsers	RejectHOProb	RejectConnProb	NumberHO	Load
0.04	9.53%	83.2%	86.78%	14.16%	50.52%
0.06	7.64%	85.57%	85.6%	16.57%	63.9%
0.12	24.9%	64.73%	55.04%	84.8%	84.7%
0.31	30.52%	28.12%	44.8%	14.93%	92%
1	31.15%	9%	21.8%	56.13%	100%

Step two

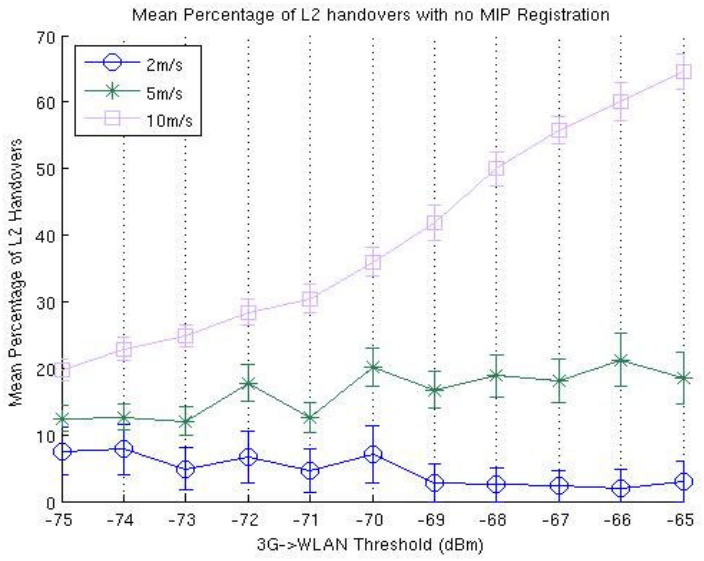


- Terminal design based on [1]
- WLAN hotspots and full 3G coverage
- WLAN→3G and 3G→WLAN handovers
- Omnet++ simulation environment
- Results obtained with and without load control
- Several metrics considered:
  - Mean percentage of L2 handover without MIP registration
  - Mean number of 3G → WLAN handovers
  - Mean number of WLAN → 3G handovers
  - Mean wireless utilization time

No load control



Load control applied



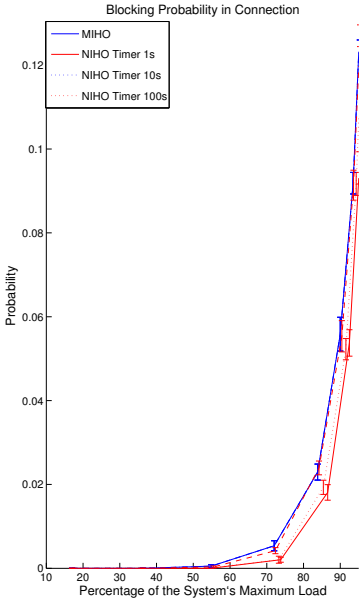
Considerations on 802.21 signaling

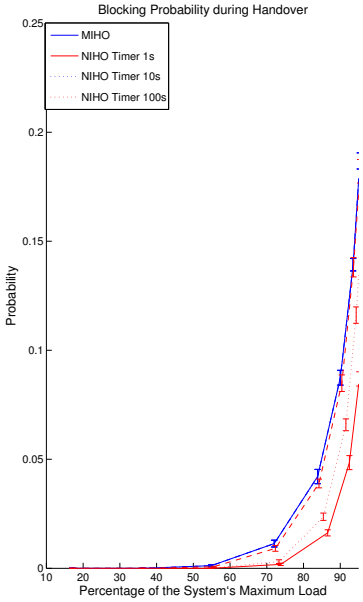
- Out of cell implementation is required to not impact the metrics
- The location (Report message with AP AMC) is sufficiently accurate
- It is possible to achieve comparable results with and without load balancing
- Optimal threshold configuration allows 0 packet loss
- Wireless utilization time is till not too much affected
- Framework handles race conditions
- RTT impact is not visible
- We did analyze the system at 50% load capacity
  - More to be studied

References

[1] T. Melia et al, *"Analysis of the effect of mobile terminal speed on WLAN/3G vertical handovers",* In proceedings Globecom 2006, Wireless Communications Symposium

[2] T. Melia et al. *"Network Initiated handovers: challenges and possibilities"*, Submitted to Special issue on seamless handover, Personal Wireless Communication, Springer


Blocking Probability in Connection
MIHO
NIHO Timer 1s
NIHO Timer 10s
NIHO Timer 100s
Probability
0
0.02
0.04
0.06
0.08
0.1
0.12
10
20
30
40
50
60
70
80
90
Percentage of the System's Maximum Load


Blocking Probability during Handover
MIHO
NIHO Timer 1s
NIHO Timer 10s
NIHO Timer 100s
Probability
0
0.05
0.1
0.15
0.2
0.25
10
20
30
40
50
60
70
80
90
Percentage of the System's Maximum Load