Stretchable Architectures for Next Generation Cellular Networks

Presented By

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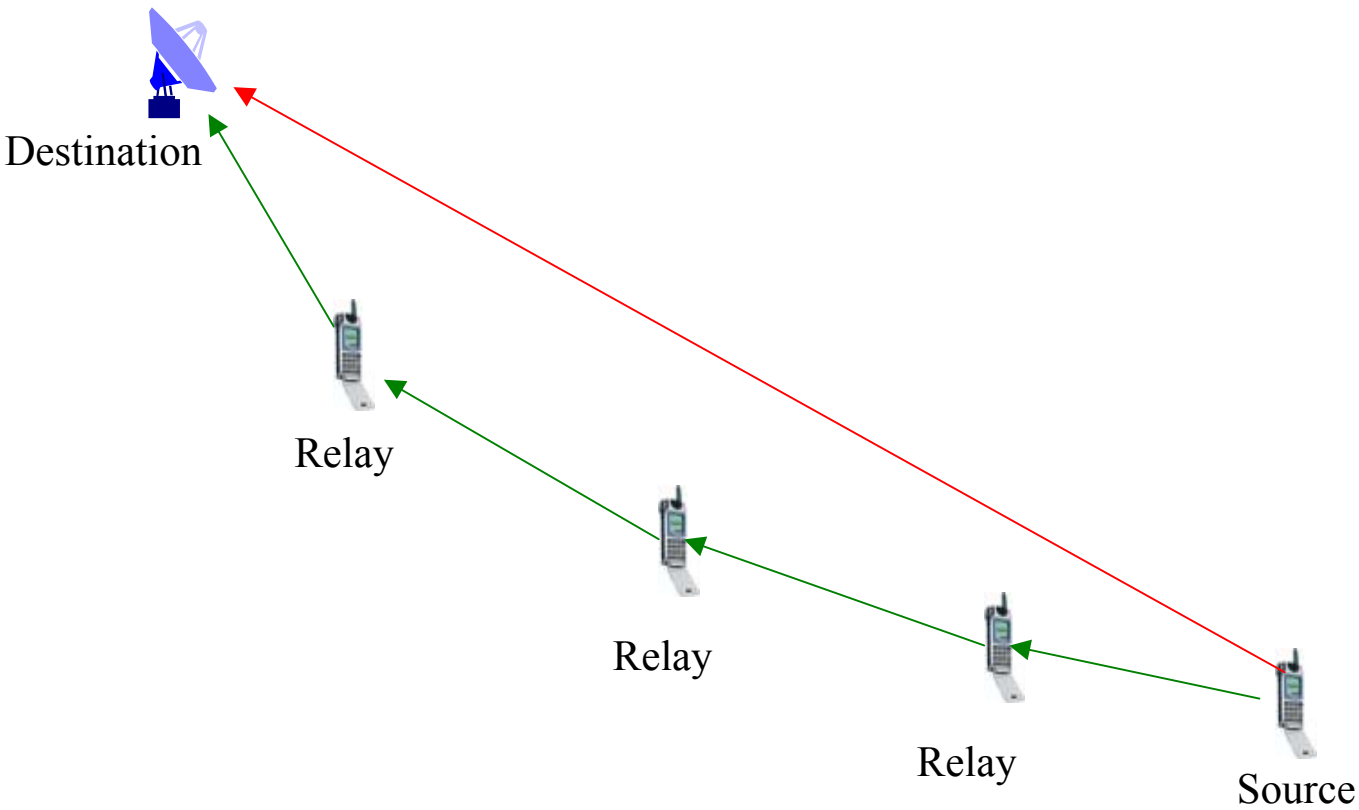
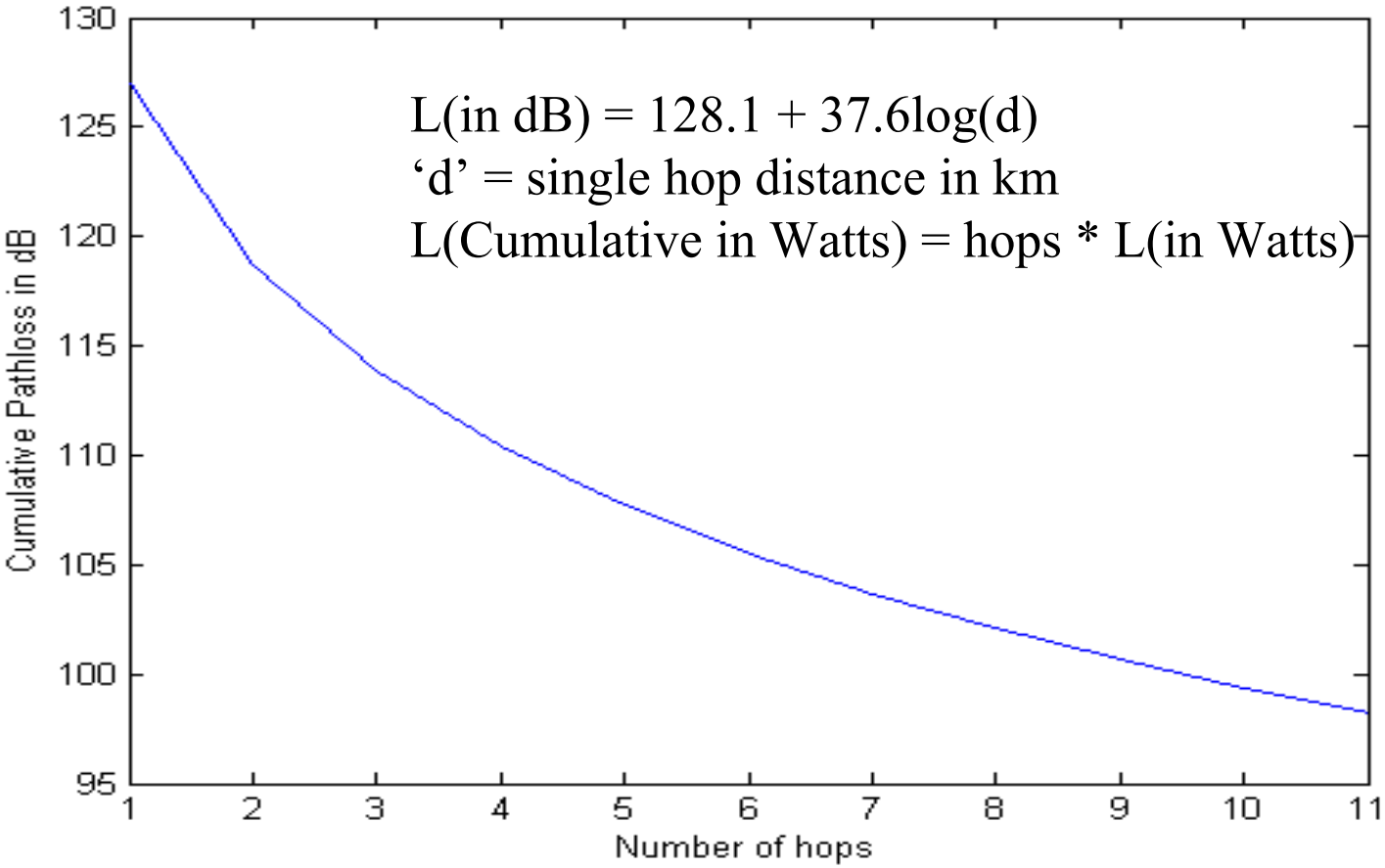
Relaying



Path loss reduction with Relaying



Relaying

- Multi-hop connection between source and destination
- Advantages
  - Longer battery life for the source mobile
  - Lower Node and System power
  - Increased capacity of cell
  - Higher system throughput (Energy per bit reduces)
  - Improves coverage in dead spots
    - path diversity
  - Propagation conditions can vary hop by hop.

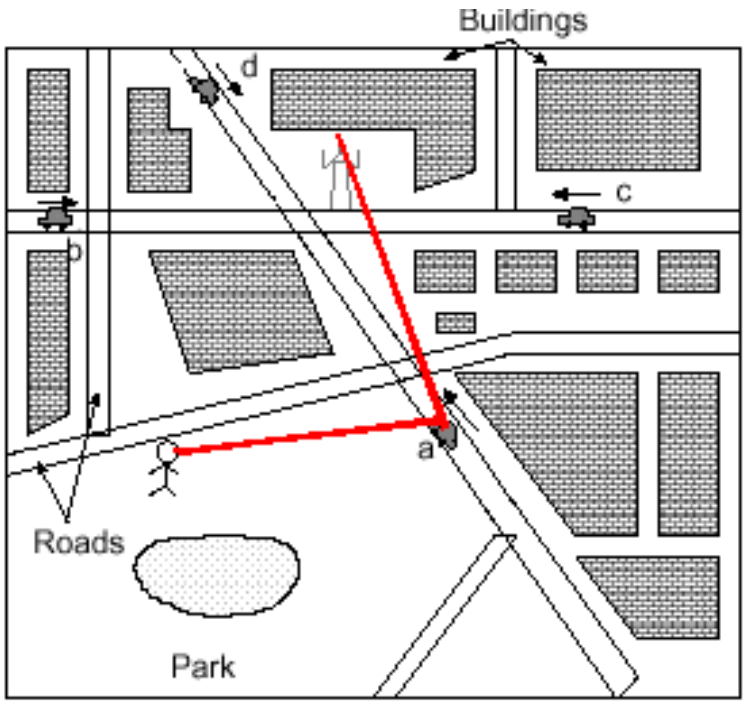
3G Issues

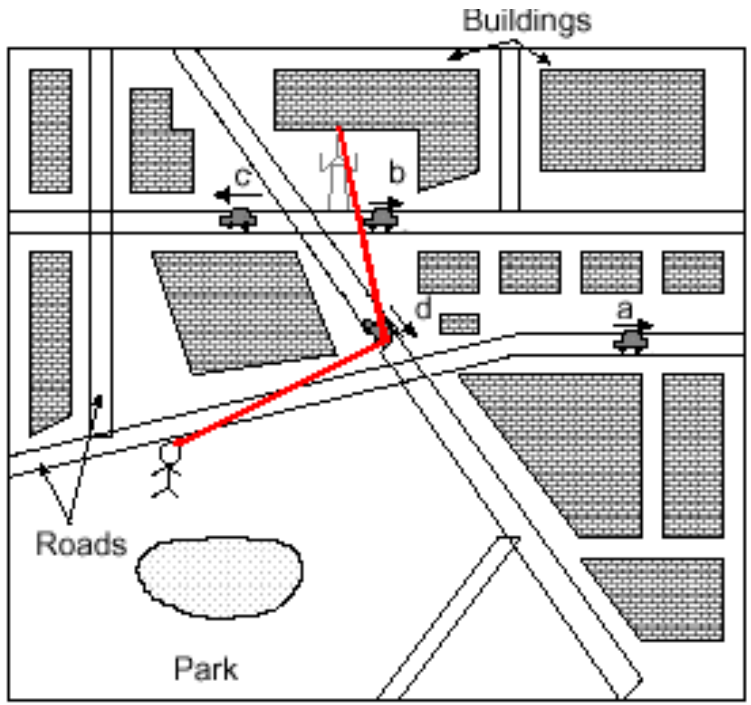
- Battery power utilized for benefit of others
- Mobile-to-Mobile communication
- Interference at relay's receiver
- Absence of diversity gain at the relay
- Security
- Handoffs between mobiles in multi-hop
- Power Control between relay and MT
- QOS & Overhead
  - 3G standards shelves multi-hop protocol ODMA due to excessive overhead from signaling.

Our Proposal – Stretched Connection

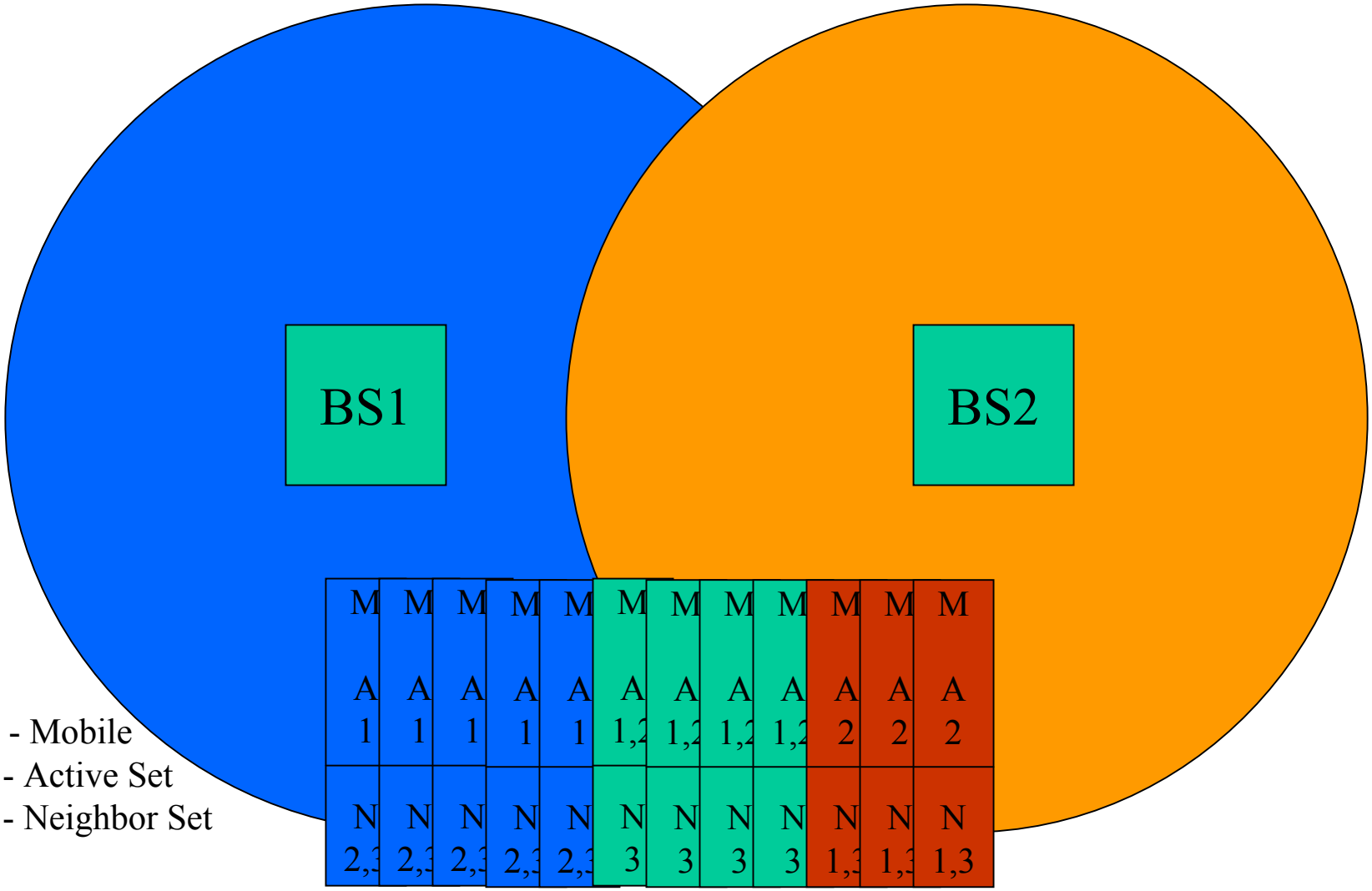
- Stretched Connection
  - AIM: To increase battery life of a Mobile Terminal using relaying in 3G systems.
  - Scenario: 2 hop relaying
    - Suitable for real time applications with less jitter.
    - Requires a “simple handoff/routing algorithm”
    - Appreciable “energy savings”.
    - Relay: A device with abundant power reserve – cars, full charged MTs
    - Relay is called “intermediary”
    - Relayed connection is a called “stretched connection”

Stretched Connection





Soft Handoff

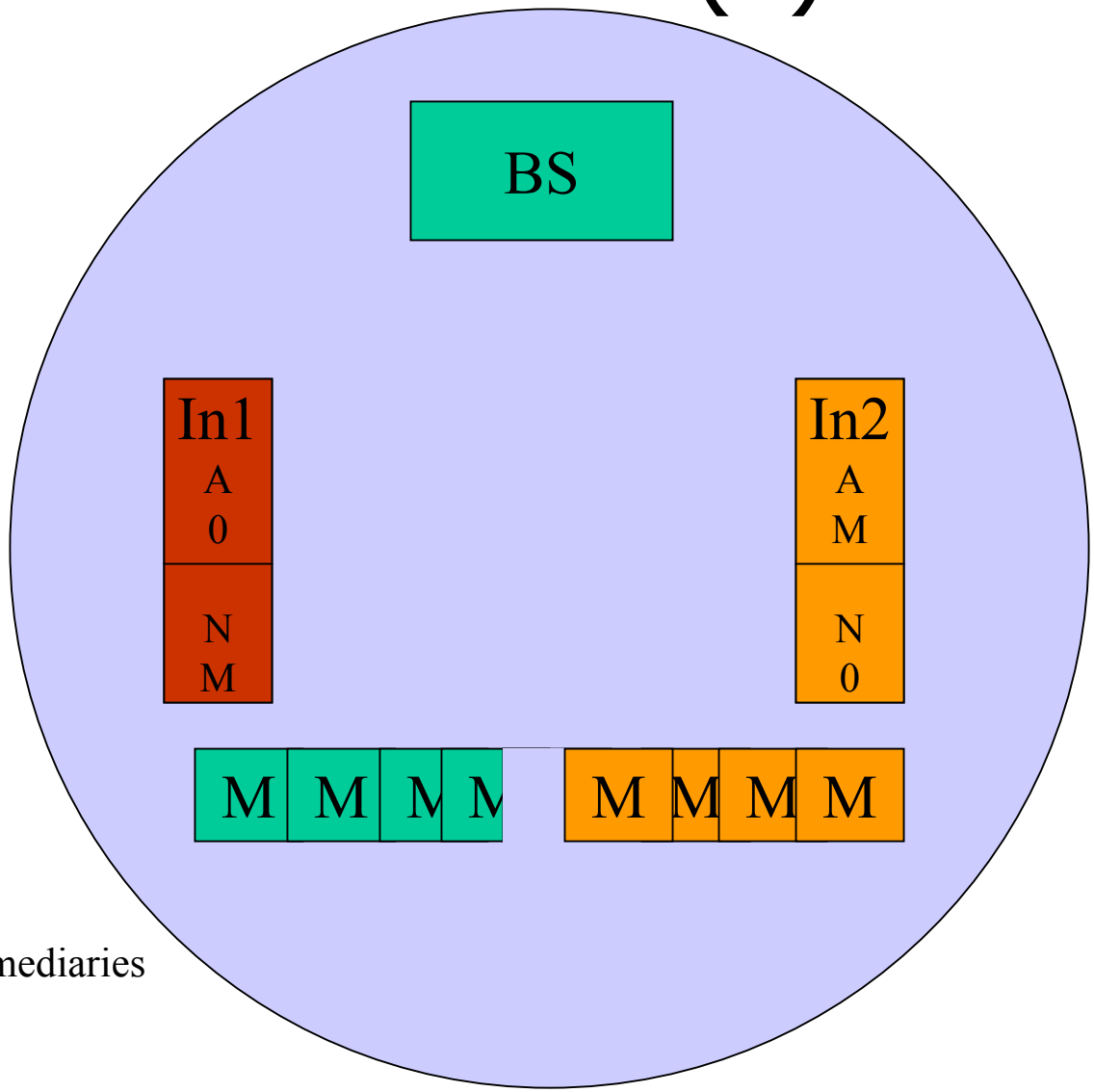


M - Mobile
A - Active Set
N - Neighbor Set

Intermediary Initiated Soft Handoff (1)

- Handoff is initiated by intermediaries and assisted by BS.
- BS assist candidate intermediaries by passing location of MT, system parameters of the mobile
- Relays listen promiscuously to MT's transmissions, assuming some changes to uplink (ODMA specifications)
- Relays maintain 3 sets - active, neighbor and candidate sets of MTs in its vicinity: similar to Soft Handoff mechanism.
- BS selects the best intermediary.
- Note: For multihop scenario, BS cannot choose all the intermediaries – not scalable.
  - Use of adhoc networking protocol, with metric being SIR at the intermediary.

Intermediary Initiated Soft Handoff (2)

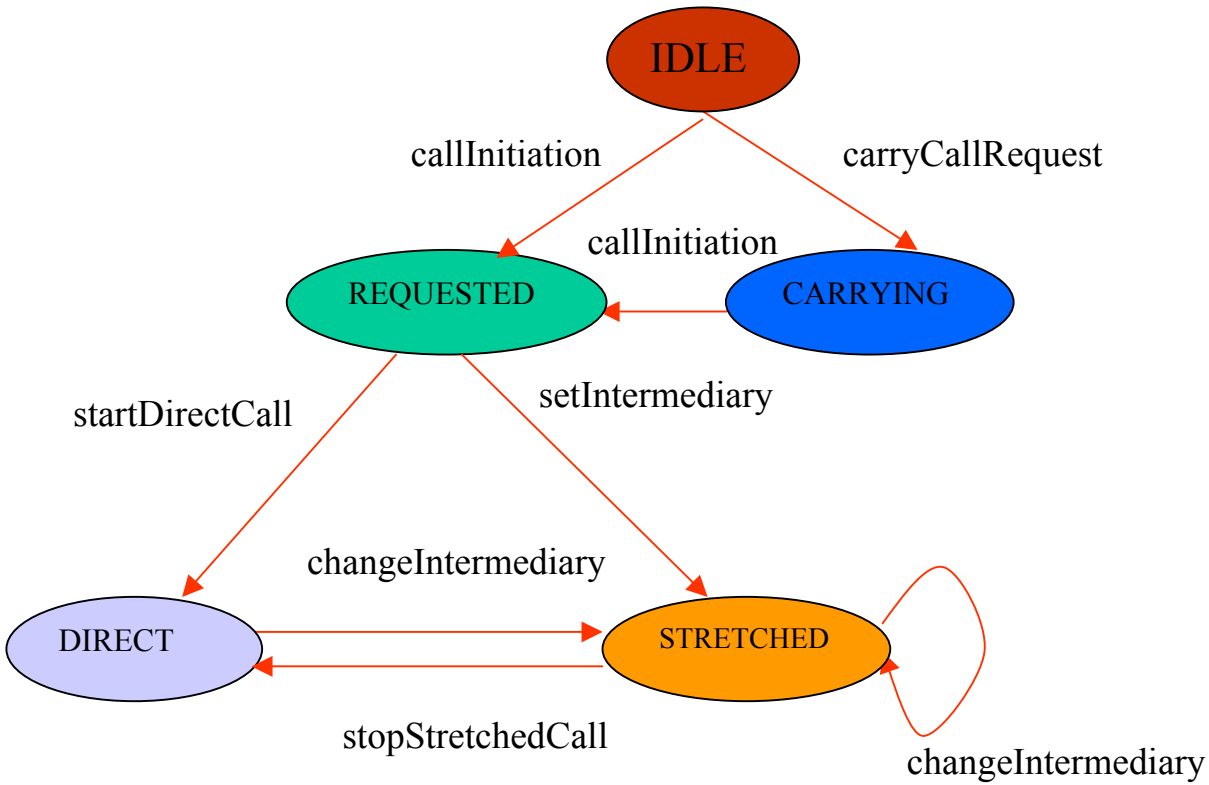


In1, In2 – Intermediaries
M - Mobile

Advantages of Intermediary Initiated Soft Handoff

- Receiver centric
  - The intermediary knows about its "Interference temperature" better than the sender.
- Neighbor discovery and maintenance is done at intermediary
  - Reduced overhead for the MT.
- (MT need not know the identity of the intermediary)
  - Signals from 2 intermediaries is considered as multipath
  - During intermediary soft handoff, MT's parameters for the connection remain unchanged – unlike soft handoff

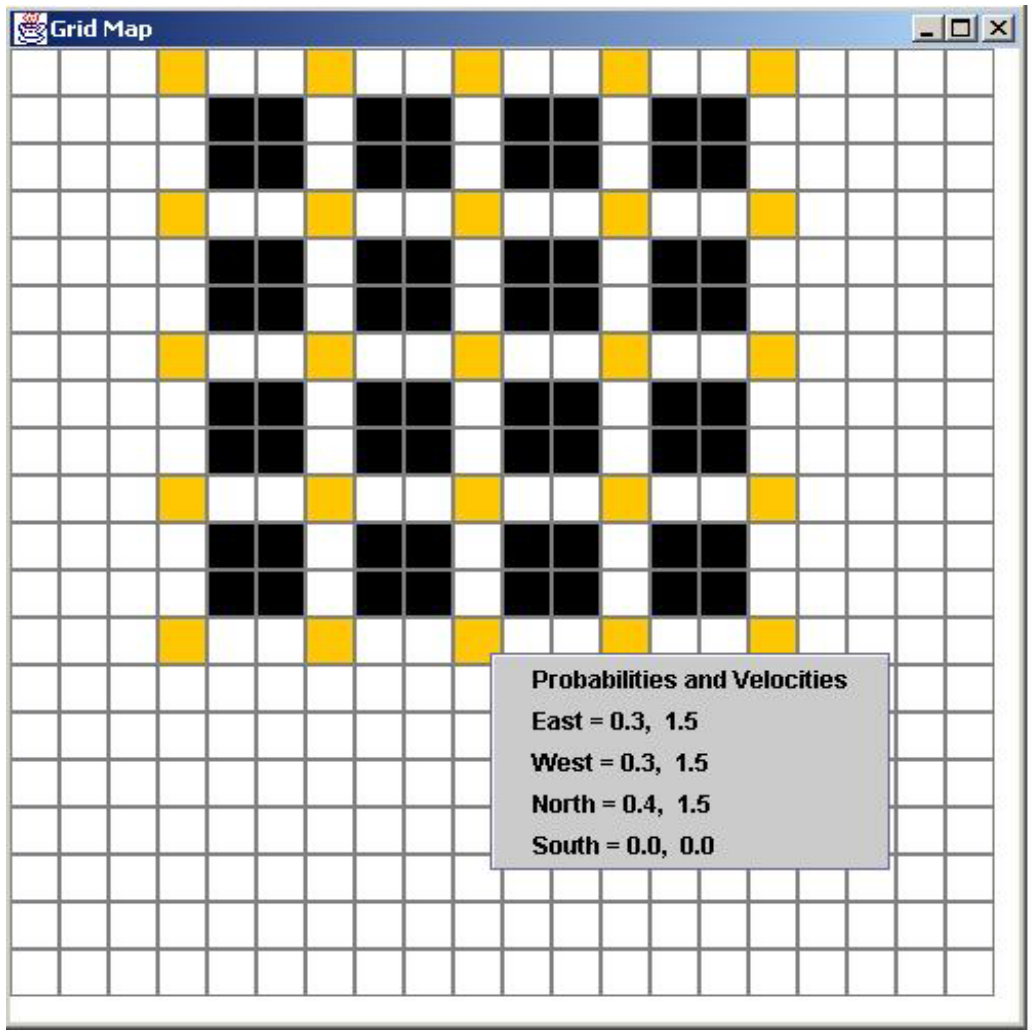
FSM of Node in Simulation



Simulation Setup

- Discrete Event simulation
  - Recursive path loss formula for Pedestrian and vehicular radio channel in a Manhattan type terrain (UMTS 30.03 Selection Procedures)
  - Block size = 20 meters
  - Frequency = 1.9Ghz
  - Poisson call arrival (Call rate = 1,2 per hour)
  - All nodes moving with velocity 1.5m/s
  - Stretched connection pathloss is always less than direct connection.

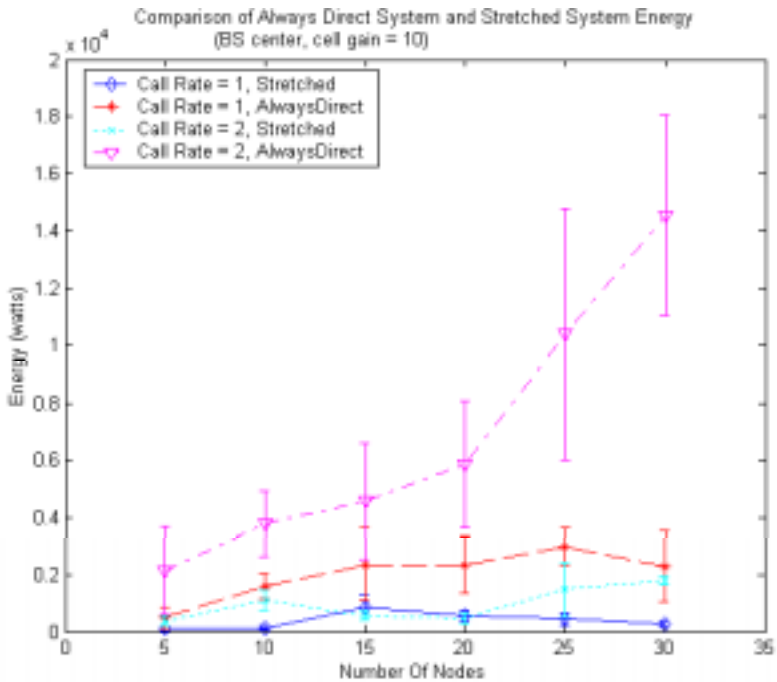
Terrain Map

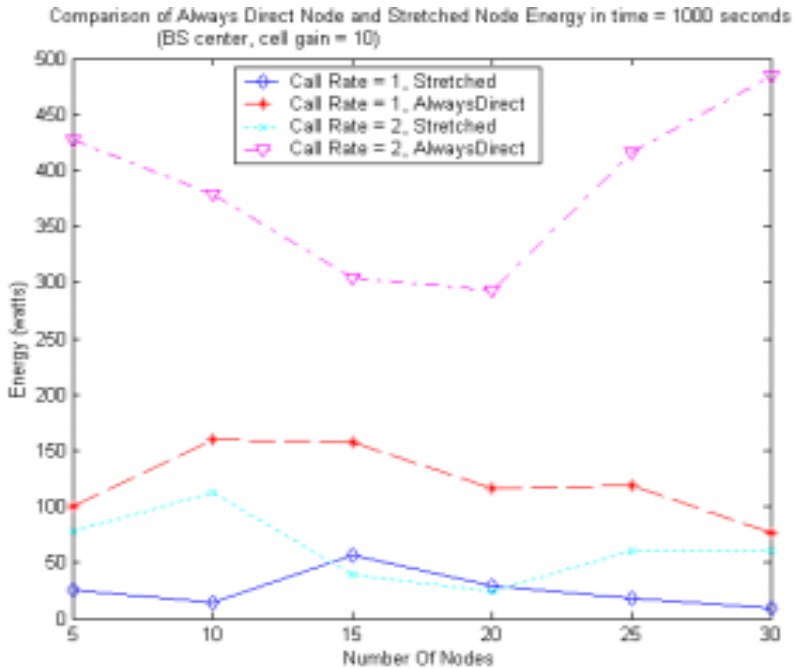

Grid Map
Probabilities and Velocities
East = 0.3, 1.5
West = 0.3, 1.5
North = 0.4, 1.5
South = 0.0, 0.0

Experimental Setup

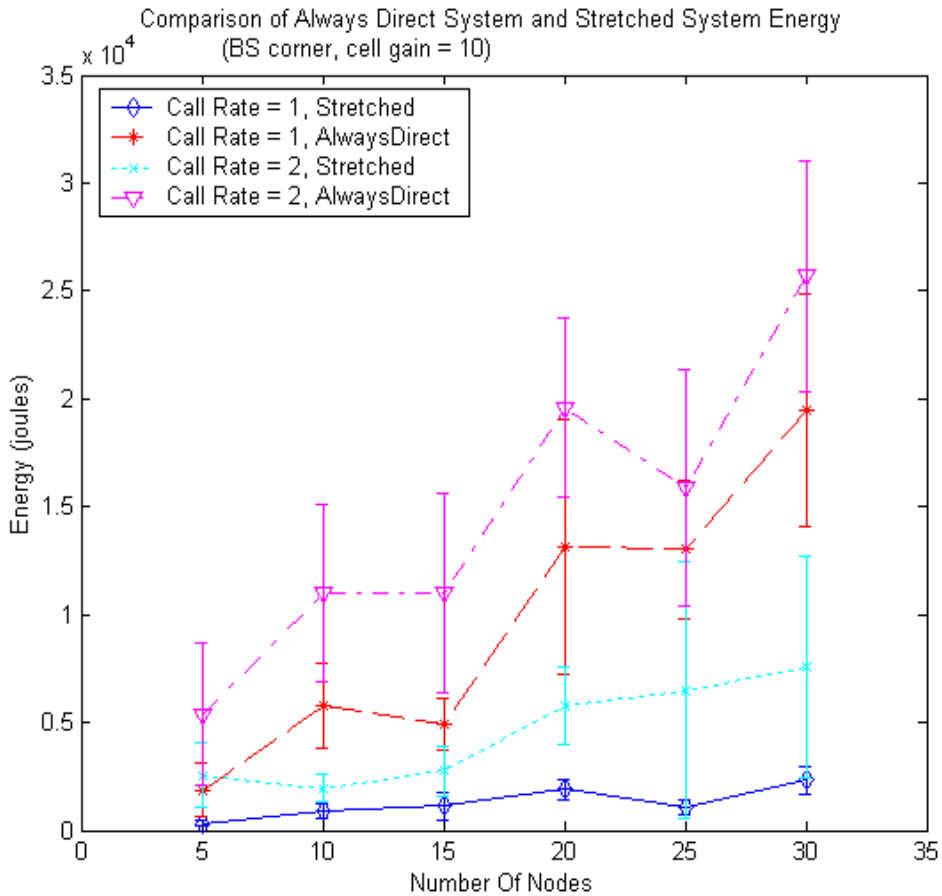
- Metrics chosen: Energy, # of handoffs, Time spent in relaying
- Factors chosen: Number of nodes and location of BS
- 1000 sec per run, with 10 repetitions
- Mean and 90% confidence interval plotted
- Diversity gain only between Intermediary and BS
- Pair-wise comparison between stretched and direct connections
- Selection of intermediary based on greedy method

Energy for BS at center

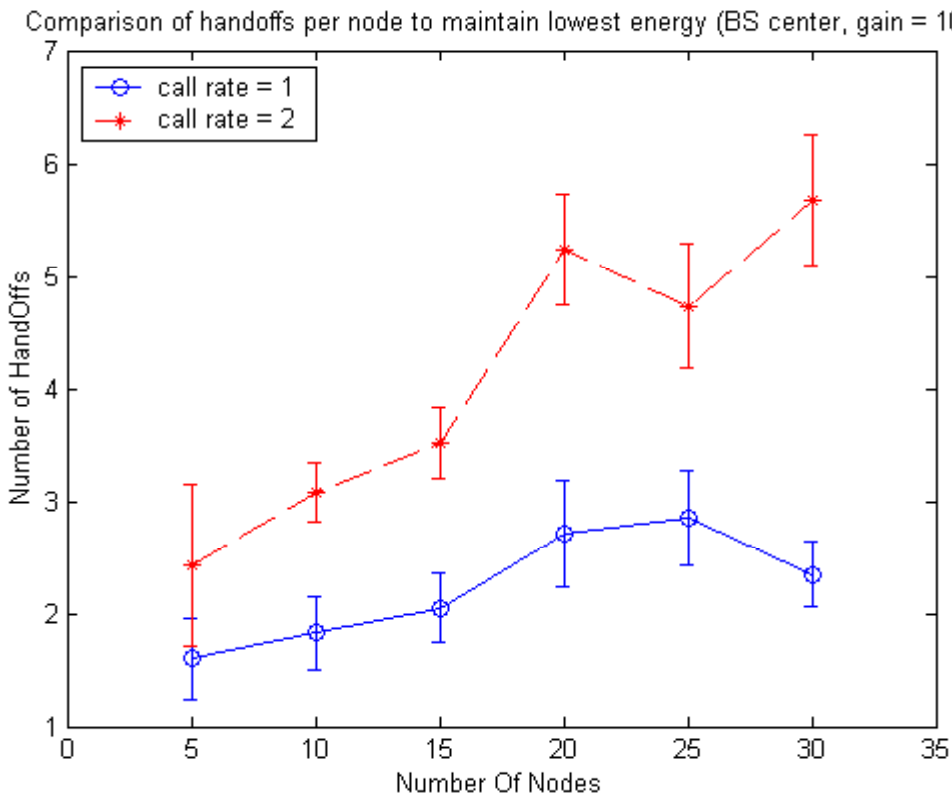




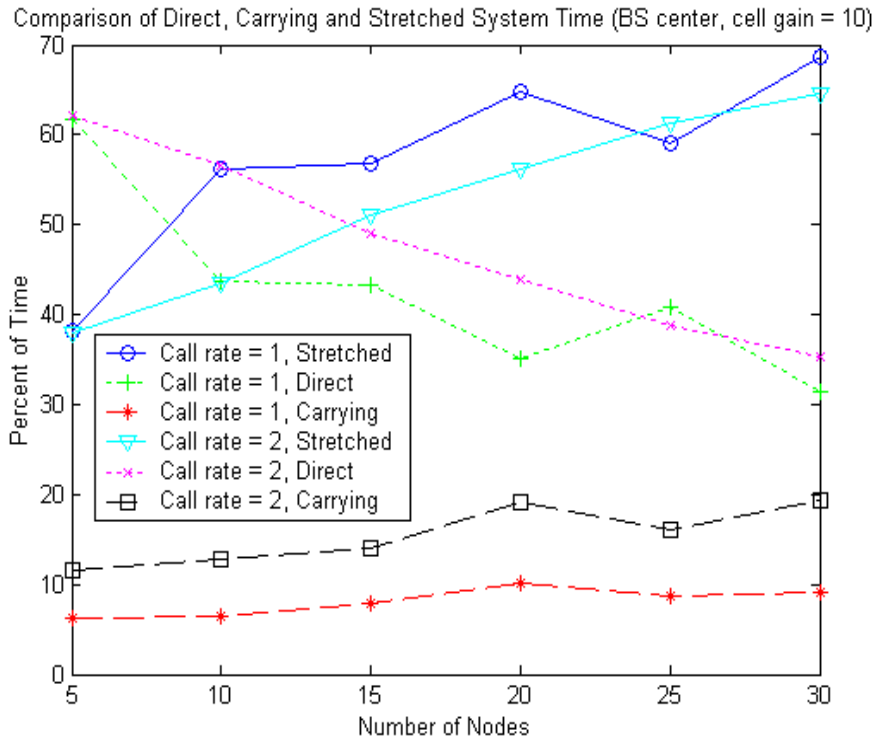
Energy for BS at Corner



Handoff


Comparison of handoffs per node to maintain lowest energy (BS center, gain = 10)
call rate = 1
call rate = 2
Number of HandOffs
Number Of Nodes
1
2
3
4
5
6
7
0
5
10
15
20
25
30
35

Time spent in stretched connection by MT



Related Work

- ODMA & Intelligent Relaying: Multihop relaying
- Integrated Cellular & Ad hoc Relaying Systems (iCAR)
  - Relay stations at strategic locations
  - To enable rerouting of congested traffic
  - Increase capacity
  - Uses 802.11 between MTs and relays, and cellular between relays and BS
- Mobility Increases the Capacity of Ad hoc Wireless Networks.
  - Multi-user diversity: Relays "carry" traffic from source to destination.
  - Non-real time applications
  - 2 hop
  - Advantage: O(1) throughput, independent of number of users.

Conclusions

- A 2-hop stretched connection yield significant power savings between 3X – 7X!!!!
- The amount of time spent in relaying is 10-15% of idle time – not a significant overhead!!!!
- Handoffs increase linearly with number of nodes
  - Intermediary initiated handoff reduces overhead for MT.
  - No overhead of ad-hoc networking protocol for 2-hop stretched connection.
- 2-hop stretched connection suitable for real time applications

Future Work

- Implementing intermediary based soft handoff.
- Capacity and throughput analysis.
- Developing optimizations to choose the best intermediaries