"Mobility increases the capacity of ad hoc wireless networks"

Authors: M. Grossglauser and D. Tse

Presented by: Ştefan Istrate

University of Cambridge

February 24, 2011

Introduction: ad hoc wireless networks

The problem: **channel strength varies over time**

Causes:

- multipath fading
- path loss via distance attenuation
- shadowing by obstacles
- interference from other users

Some solutions:

- combine multipaths by using different signal frequencies
- add more antennas or base stations
- tolerate delays and benefit from the user mobility

Previous approaches for communication in mobile networks

Gupta and Kumar developed a model for fixed ad hoc networks:

- randomly located, but immobile nodes
- each node is source, destination and relay
- each source wants to communicate to a random destination

Results:

- excessive interference
- throughput per source-to-destination of $O(1/\sqrt{n})$
- the average number of hops: $\sqrt{n}$
- most communication occur between nearest neighbors (distances of order $1/\sqrt{n}$)

Conclusion: pessimistic result on the scalability

Current approach

This paper

- studies a model of an ad hoc network with mobile nodes and random communication
- exploits a form of multiuser diversity via packet relaying
- examines the per-session throughput (direct communication vs. communication using relays)

Suitable for asynchronous application that can tolerate end-to-end delays:

- e-mail
- database synchronization between a mobile terminal and a central database
- certain types of event notification

Current approach (cont.)

The strategy:

- each source node splits its packet stream to many different nodes
- these relays hand the packets off to the final destination
- the probability for a node to get close to the destination is significant
- the packet goes through at most one relay => high throughput

Model

- n nodes lying in the disk of unit area ($radius = 1/\sqrt{\pi}$)
- $X_i(t)$ = location of the ith user at time t
- nodes are mobile
- independent and identically distributed trajectories
- each node is source and destination
- each node has an infinite stream of packets to send to its destination
- each node has an infinite buffer to store relayed packets

Transmission model

- $P_i(t)$ = the transmit power of node i
- $\gamma_{ij}(t)$ = channel gain from node i to node j
- the received power at node j is $P_i(t)\gamma_{ij}$
- at time t, node i transmits data at rate R *packets/sec* to node j if

$$\frac{P_i(t)\gamma_{ij}(t)}{N_0 + \frac{1}{L}\sum_{k\neq i} P_k(t)\gamma_{kj}(t))} > \beta$$

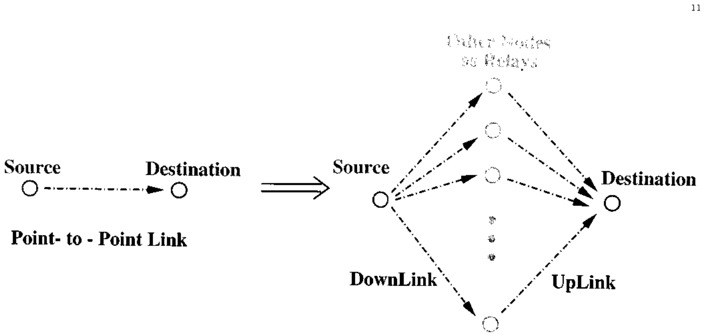
- β = signal-to-interference ratio requirement for successful communication
- N_0 = the background noise power
- L = the processing gain of the system
- $\gamma_{ij}(t) = \frac{1}{|X_i(t) - X_j(t)|^\alpha}$, where $\alpha > 2$

The idea: at any time t, a scheduler chooses the sources, the packets and power level $P_i(t)$

Comparison of different approaches

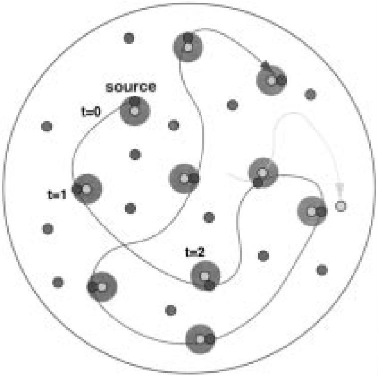
A. Fixed nodes: throughput of $O(1/\sqrt{n})$

B. Mobile nodes without relaying: throughput of $O(1/\sqrt[1+\alpha/2]{n})$

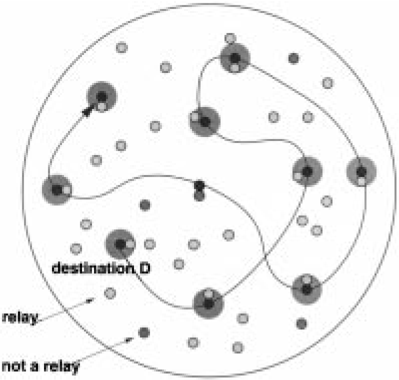


C. Mobile nodes with relaying: throughput of $O(1)$

Comparison of different approaches (cont.)



Phase 1



Phase 2

Conclusions

1. Mobility helps
2. Best performance when using relays
3. Very scalable model, since the throughput is $O(1)$
4. Suitable for delay tolerant applications
5. Not very relevant to real-time applications

Questions / Comments?