Mobility as a Network Control Primitive

Reza Omidi

Seminar: Ad Hoc Networks
Summer 2008
Christian Schindelhauer, Chia Ching Ooi,
Faisal Aslam

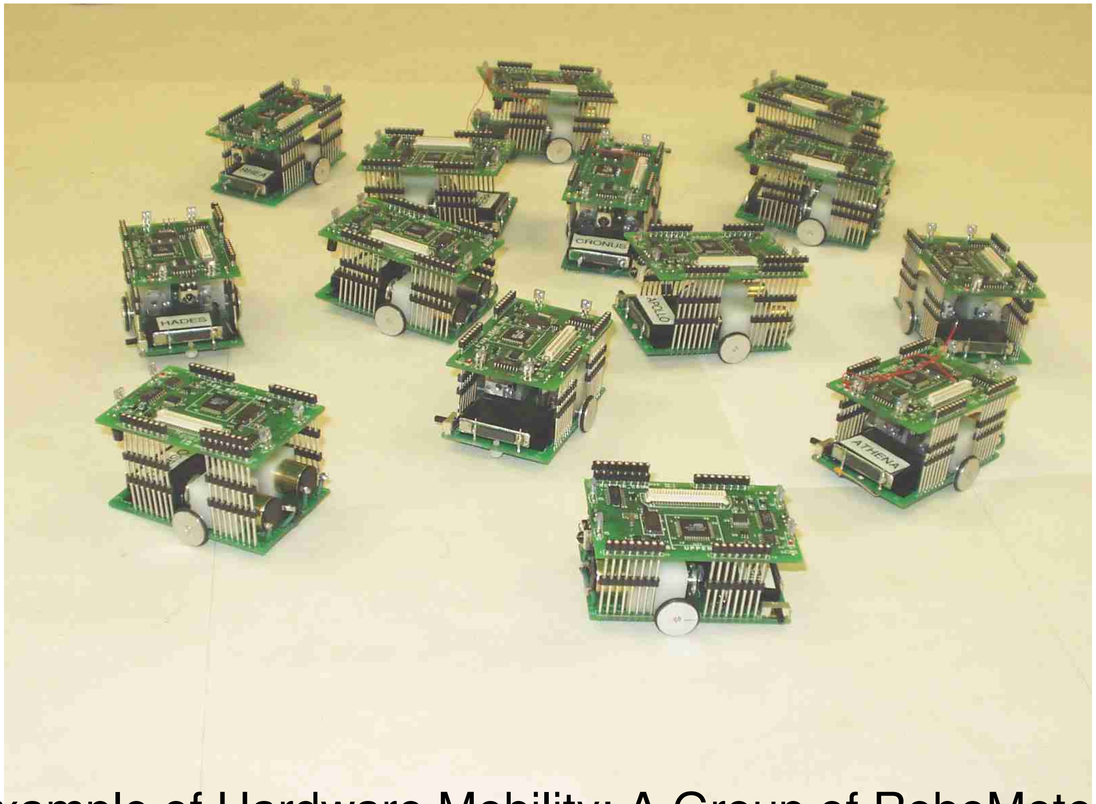
Table of Content

Introduction

- Large-scale networks needs wide rang of Sensing and Communication task
- Distributed, self adoptive, Local information
- Improve power efficiency on unicast flow, multiple unicast flow, many-to-one unicast flow

Example

- Example : term “bugging” deployment of self organization mobile sensors whose purpose is to intercept or record as much data as possible from a target as enemy communication tower or command center.



Example of Hardware Mobility: A Group of RoboMotes

The RoboMote: A platform for research in robotic sensor networks.

Credit: USC Robotic Embedded Systems Lab (PI: Prof. Gaurav S. Sukhatme)

Designing mobility control algorithm

1. The precise nature of any effective mobility control will be application dependent.
   - Will need to move differently under different traffic pattern
2. For scalability and robustness purpose, there should not be a central entity who computes the movement of all the nodes.
   - Totally distributed schema
3. The distributed mobility-control schema should be enable to self-organize the nodes to optimize a performance metric
   - Data reporting after target detection

Algorithms

- Distributed averaging algorithm
- Randezdous algorithm
  - All nodes in an arbitrary connected network coverage to a single point in space by using uniform, distributed, locally informed mobility control rules.

Apply to different scenario

- 10 kbps voice stream data flow
- 1 km long greedy routed multihop
- Node capable of moving around 0.1 m/s
- In under a minute to guide to optimal routing configuration (50 %)
- Cost of mobility, total energy saving realized after 5 min

Related Work

- Random movement of the user
- Predict user movement
- Mobility improve accuracy of network localization
- Realistic mobility model with obstacles [2]

- Combine Randezvous & generalized averaging schema
- Power optimization configuration & connectivity coverage

Algorithm for Single Flow

- Use Greedy routing
- Relay nodes : nodes between source & destination
- Connected : if distance < radios (r)
- Assume Source & Destination will not move

Communication Cost

- Without coverage constraints communication cost is

  power $P(d) = \min \{ w/S(w,d)\}$

$S(w,d)$ = success rate associated with transmitting a message with Power(w) and distance (d)

Theorem 1

- Energy cost function P(d) is non-decreasing convex function.
- So optimal position must lie entirely between the source and destination

Mobility control : synchronous scheme

▷ x_i: current position of node i.
▷ x_{i-1} and x_{i+1}: positions of nodes $i-1$ and $i+1$.
▷ $g \in (0,1]$: damping factor.

repeat
    send x_i to neighbors $i-1$ and $i+1$
    receive x_{i-1} and x_{i+1}
    set $x'_i = (x_{i-1} + x_{i+1})/2$
    move to $x_i + g \cdot (x'_i - x_i)$
until (convergence)

Figure 1: The distributed, synchronous mobility-control algorithm at relay node i. Node $i-1$ and $i+1$ are its neighbors on the routing path.

Figure Ref [1]

Theorem 2

- Connectivity between communication neighbors is not lost in the synchronous algorithm

Theorem 3

- Using distributed synchronous algorithm, all nodes will equally distributed on the line between the source and destination

Mobility control in Asynchronous schema

- The asynchronous protocol is deadlock free, if messages are not dropped and it can reliably transmitted.

Theorem 4

- Connectivity between communication neighbors is not lost in the asynchronous algorithm.

Theorem 5

- All nodes will finally spaced between the source and destination (there is an upper bound on the time it takes for the node to move to its target point)

Mobility connectivity for non-communicating Neighbors

- Its possible that node during moving to its optimal position become disconnected from non-communicating neighbors.
- We can apply a constraint to guaranty the connectivity of all nodes (either communicating or not)

Constraint Vs. Unconstraint

- With the constraint of having connectivity is called Constraint mobility and without that is called Unconstraint mobility.

Simulation

- Generate nodes uniformly at random
- Randomly chooses a source and destination
- Run greedy geographic routing protocol to locate routing path
- Decrease energy usage using synchronous mobility control

- Communication cost model
- $P(d) = a + bd^\alpha$
- $2 < \alpha < 6$, a & b are constant
- Mobility cost
- $Pm(d) = kd$

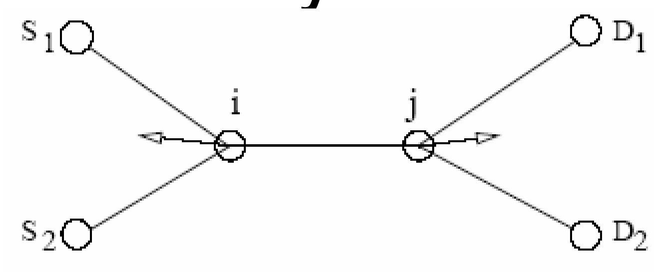
Mobility control for Multiple flow

- Relay node will move to the average position of its two neighbors

- Junction node: in position of routing path

Applying averaging algorithm on Multiple Flow

- Junction node may become disconnected



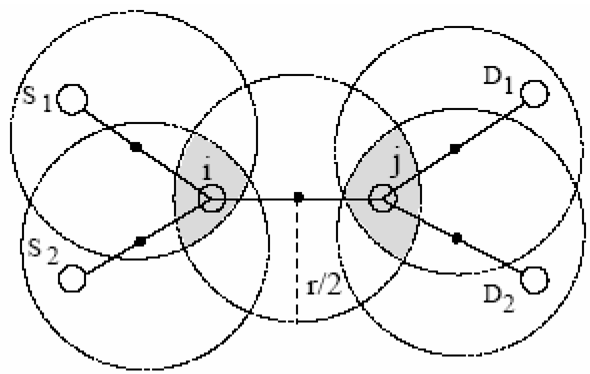
- Optimal position of junction node may not be average
- Single link may be on any number of paths

Solution

- For general cost function and number of neighbors use descent direction algorithm instead of averaging algorithm
- Descent direction is calculated by local information

Solution

- Pairwise constraint



- If the pairwise constraint is satisfied, communicating neighbors will not become disconnected

Figure Ref [1]

Concast networks

- Destination of all flows is a single sink node.
- Easier because of single direction of traffic flow

References

- [1] **Towards Mobility as a Network Control Primitive,** David K. Goldenberg, Jie Lin, A. Stephen Morse, Brad E. Rosen, Y. Richard Yang (Yale university)

- [2] **Towards Realistic Mobility Models for Mobile Ad hoc Networks** Amit Jardosh, Elizabeth M. BeldingRoyer,Kevin C. Almeroth,Subhash Suri (Department of Computer ScienceUniversity of California at Santa Barbara)

Thanks for attention.

Any Question ?