Purposeful Mobility, QoS and Security in Sensor Networks

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Ad-hoc Multi-hop CDMA Network Framework

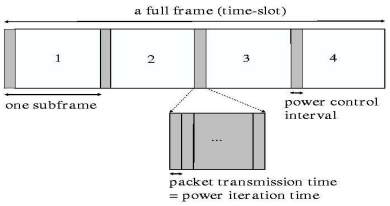
- CDMA MAC Layer:
  - Soft Capacity
  - No Packet Queuing Delay
  - Better Delay Performance
- A Framework for Integration of Link Scheduling, Routing and Power Control Based on Time Scales:
  - very fast: packet transmit time/power control iterations (time between two consecutive iterations)
  - fast: power control initiations
  - medium: routing/schedule dithering (periodical CBO refreshments)
  - slow: connection set-up/tear-down requiring incremental link scheduling

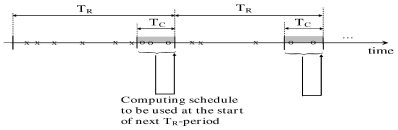
Distributed Power Control for Multi-hop CDMA Networks with Elastic Flows

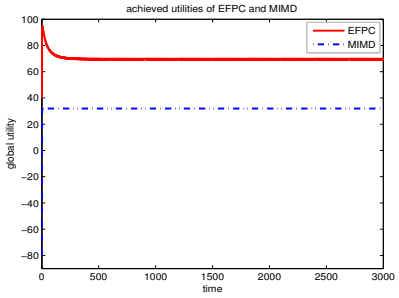
- Network maximizes a Global Utility:

$$v(\underline{P}) = \sum_{\varphi \in F} u^{\varphi}(\min_{i \in \tau(\varphi)} SINR^{\varphi}_{\upsilon(\varphi,i)}) - \sum_{i} \alpha_i \sum_{\varphi \in \tau^{-1}(i)} p_i^{\varphi}$$

- Motivation: QoS defined by bottleneck hops
- A cooperative Game:
  - Bottleneck nodes monitored by their interfering nodes
  - Transmission powers adjusted considering these bottlenecks
  - Maximizing local utilities leads to global (network-wide) utility
- Users announce desired QoS:
  - Network attempts to make best of them
  - No QoS guarantee







Simulation performed on a network with:
- 10 nodes uniformly distributed in a 10mx10m domain
- 7 fixed flows

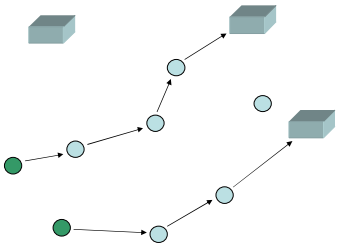
Purposeful Mobility in Sensor Networks

- Over time, expend energy for mobility of powerful logistical/relay nodes to conserve communication energy used by large numbers of energy-limited sensors
- That is, reduce their communication distance
- Distributed algorithm only using local information
- Greedy algorithm

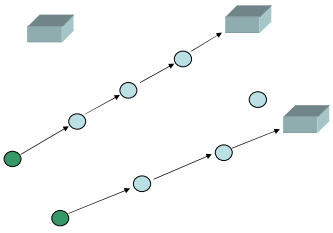
$$V((x_{-k}; z), R(x)) - V(x, R(x)) + c|z - x_k|/T$$
$$\equiv \Delta_k V(x, z) + c|z - x_k|/T$$

- Distributed Simulated Annealing algorithm randomly accepting "bad" moves to optimize in absence of global information:

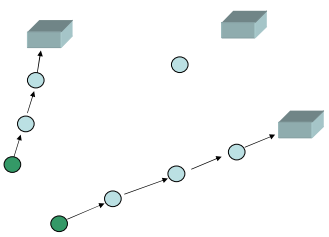
$$\bar{P}_{x,y} \equiv Q_{x,y} \min\{1, \exp(\beta[V(y, R(x)) - V(x, R(x)) + c||y - x||/T])\}$$



Sensor network before mobility algorithm

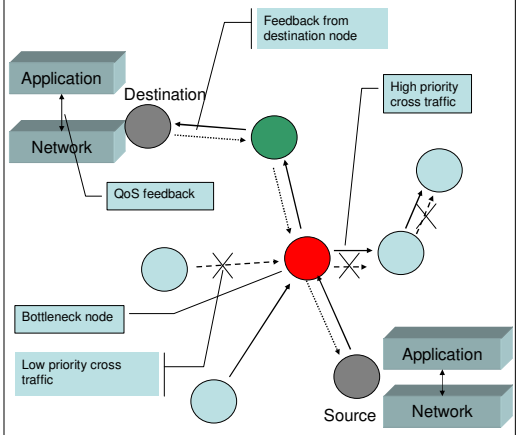


Greedy algorithm – Better node positions

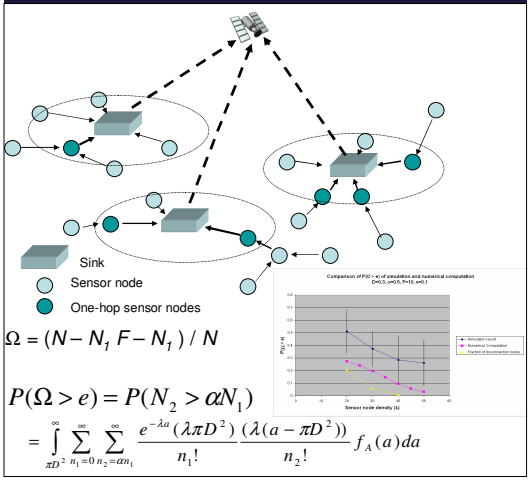


Distributed Simulated Annealing algorithm Best node positions

QoS



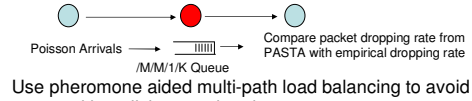
Capacity



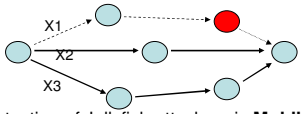
Jellyfish Attack

Detecting Malicious Packet Dropping (Jellyfish Attack) in Data Place

- Manipulate packet transmission times to detect malicious data loss in-transit at a trusted receiver



- Use pheromone aided multi-path load balancing to avoid routes with malicious packet droppers



- Detection of Jellyfish attackers in **Mobile** ad-hoc networking (MANET) context
- Cooperation incentive in commercial setting to encourage users to forward packets

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