G 364: Mobile and Wireless Networking

CLASS 8, Mon. Feb. 2 2004
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M-W, 11:40am-1:20pm, 109 Rob
Technical Challenges for the Ad Hoc Architecture

- Given **node mobility**: Every node in the network can move unpredictably and independently, at variable speed.
- Given **a very large number of nodes**: For supporting pervasive computing, sensing of large geographic areas, etc.
- Given the nodes’ **limited resources**

  - Network protocols need to be **robust**, **reliable** and **scalable** (which makes the network such).
Multipoint Communications, 1

The most general form of communication. It includes:

- One-to-one (routing)
- One-to-many (multicast)
- One-to-all (broadcast)
- Many-to-many (gossiping)
Multipoint Communications, 2

Previous approaches:
- Focus on a single communication problems
- Several diverse techniques (not efficiently “reusable”)
- Have to maintain communication information at each node (state information)
- Devote lots of resources to control traffic
A Unifying Approach

An architectural concept that implements network services and communication protocols without maintaining communication information at the nodes.

- routing
- gossiping
- multicast
- security
- broadcast
- resource location
A:

- Fast and simple
- Resource efficient
- Mobility adaptive
- Node-status dependent

node selection mechanism to efficiently select and maintain ONLY a small subset of nodes for implementing network services and protocols
How to Select the Best Nodes

- Independence of the clusterheads
- Dominance of the clusterheads
- Possibility to express “preferences”
- Distributed operations
- Fast and simple implementation
Previous Approaches

- **Heuristics based on Independent Sets**
  - Minimum ID approach (Gerla & al.)
  - Maximum degree (Ephremides & al.)

- **Heuristics based on Dominating Sets**
  - The concept of “spine”
  - Minimum connected dominating set
Previous Approaches: Drawbacks

- No preferences
- Clustering “set up” differs from clustering maintenance
- One and two hops neighbors have to be known at each node
- Problems with nodes mobility
- No analytical results
MWIS-Based Clustering

- MWIS = Maximal Weight Independent Set
- Clustering selection based on generic weights (real numbers > 0)
  - Mobility/node related parameters
  - Generalizes previous “Independent Set” solutions
Two Protocols

- **Distributed Clustering Algorithm (DCA)**
  - Quasi-mobile networks, periodical reclustering. Allow complexity analysis, fast and simple

- **Distributed and Mobility-Adaptive Clustering (DMAC) Algorithm**
  - Same rules/procedures for clustering set up and maintenance, adaptive to nodes mobility and node/link failures
DCA: Distributed Clustering Algorithm, 1

Assumptions

- Knowledge of IDs and weights of one-hop neighbors
- Broadcast transmission of a packet in finite time (a “step”)
- Nodes do not move during clustering
DCA, 2

(Only) Two messages:
- \( CH(v) \): Sent by a clusterhead \( v \)
- \( JOIN(u,t) \): Sent by ordinary node \( u \) when it joins the cluster of clusterhead \( t \)

Three (simple) procedures:
- Init (start up)
- OnReceiving\(CH(v)\), OnReceiving\(JOIN(u,v)\) (message triggered)
Example

Cluster 1

Cluster 2

Cluster 3

I Step

II Step

III Step

IV Step

V Step
DCA: Provable Properties

Consider

\[ \tau: V \to \{1,2,3, \ldots, 2k\} \]

\( V = \) set of network nodes, \( k = \) number of clusters

**Proposition:** Each node \( v \) in \( V \) sends exactly one message by \( \tau(v) \) steps

**Corollary 1:** DCA message complexity is \( n = |V| \)

**Corollary 2:** DCA terminates correctly in at most \( 2k \) steps (\( \leq 2n \))
A Note on the Average Time Complexity

We notice that

\[ k \leq \alpha(G) \]

\( G \) = topology graph, \( \alpha(G) \) = \( G \)'s stability number

We see the network as a random graph, for which

\( 2k \leq 2 \alpha(G) = \text{circa } O(\log n) \)

Log’s base is a function of \( n \) and the number of the network links
Assignments

- Read the paper for HMW # 2
- Updated information on the class web page:

  www.ece.neu.edu/courses/eceg364/2004sp