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)

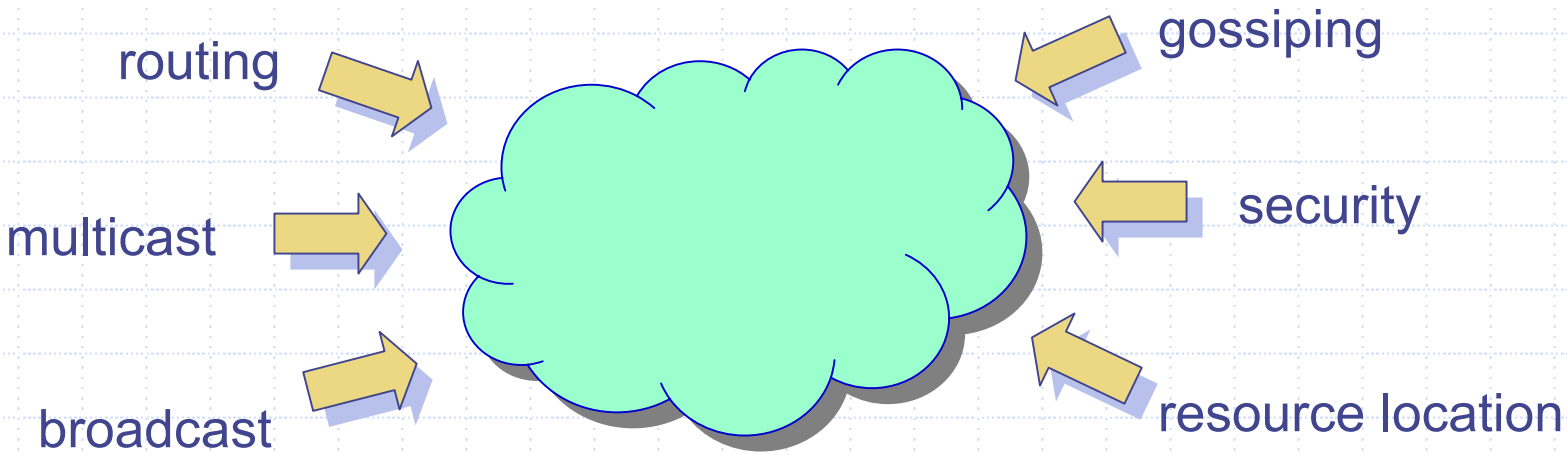
Multipoint Communications, 2

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



Inside the Cloud

- 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 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

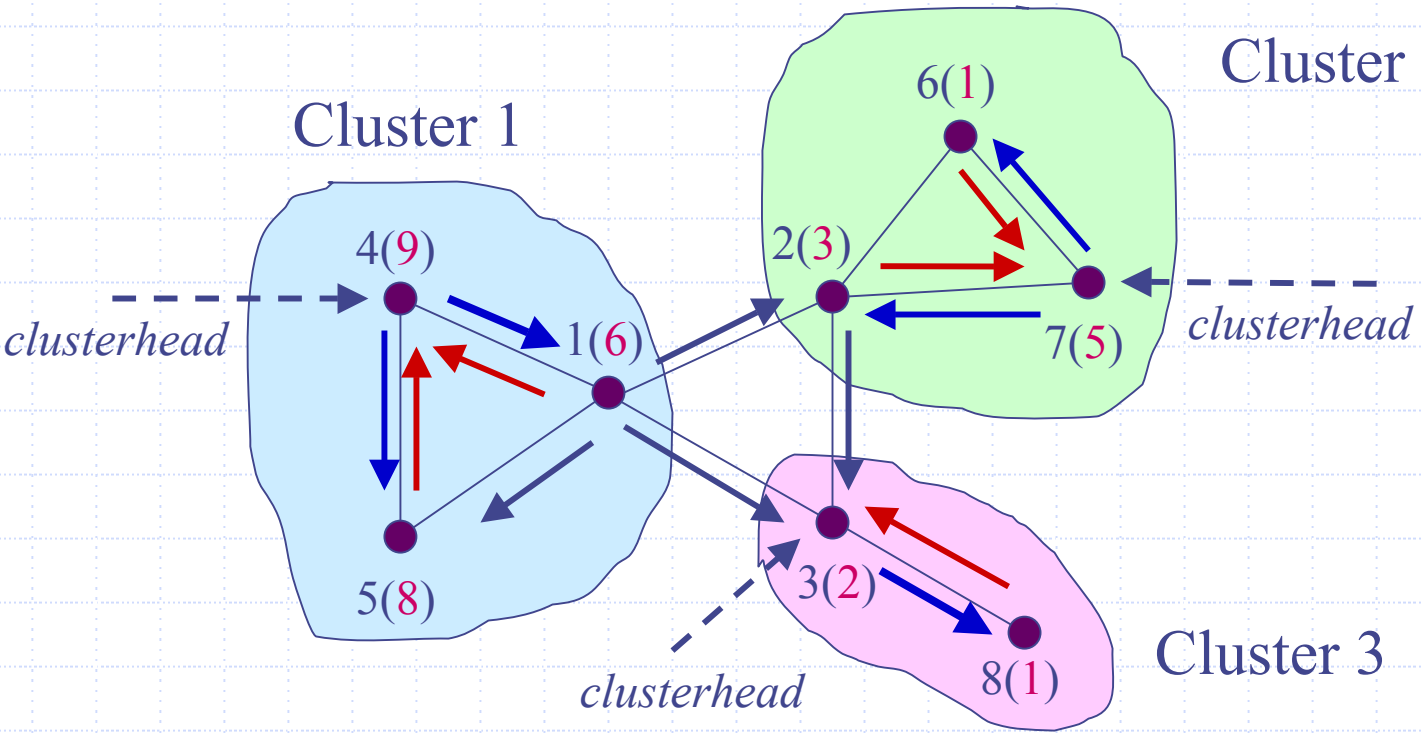
DCA: Distributed Clustering Algorithm, 1

- 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)
  - OnReceivingCH(v), OnReceivingJOIN(u,v) (message triggered)

Example



I Step II Step III Step IV Step V Step

DCA: Provable Properties

- Consider

$$\tau: V \rightarrow \{1,2,3, \ldots , 2k\}$$

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 (<= 2n)

A Note on the Average Time Complexity

- We notice that

$$k <= \alpha(G)$$

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

- We see the network as a *random graph*, for which

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

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