A mobility-based clustering approach to support mobility management and multicast routing in mobile ad-hoc wireless networks

International Journal of Network Management November 2001, ACM

Po Yu Chen

2002.11.29

Outline

- Introduction
- Purposed clustering algorithm
- Mobility-Based Clustering (MBC)
- Simulation result
- Conclusion

Introduction

Introduction

- A major challenge in ad-hoc networks is the ability to account for **location** management and **resource** management.
  - Routing/multicasting functions and
  - Bandwidth reservation or power consumption can be effectively placed on them.

Introduction

- Management functions, routing, multicasting, and scalability in ad-hoc networks present more complex problems than in wired or last-hop networks.
  - Random movement of nodes
  - Bandwidth and power limitation
  - The lack of fixed infrastructure
- In cellular networks (single-hop), the use of BS simplifies these problems.

Introduction

- Clustering
  - A method which attempts to organize unlabeled feature vectors into groups (clusters)
  - The clusterhead of a cluster can act as a BS to control the network.
  - Advantage
    - The efficient utilization of radio channel resources
    - The reduction of overhead [7]

Proposed clustering algorithm

Group (cluster) forming

- With clusterhead vs. without clusterhead
- Clustering Algorithm
  - The selection of the cluster head
    - The center of the group
    - The leader
    - A node with maximum power
    - …

Comparison

	Advantage	**Disadvantage**
With cluster head	■Simple and easy to management ■Less traffic generation	■Cluster head is broken ■Low error tolerance
Without cluster head	■More reliable ■High error tolerance	■High complexity ■More traffic generation

Lowest-ID algorithm [7]

- A node which only hears nodes with ID higher than itself is a **clusterhead (CH).**
- A node which can hear two or more clusterheads is a **gateway (GW).**
- Otherwise, a node is an ordinary node.

Lowest-ID algorithm [7]

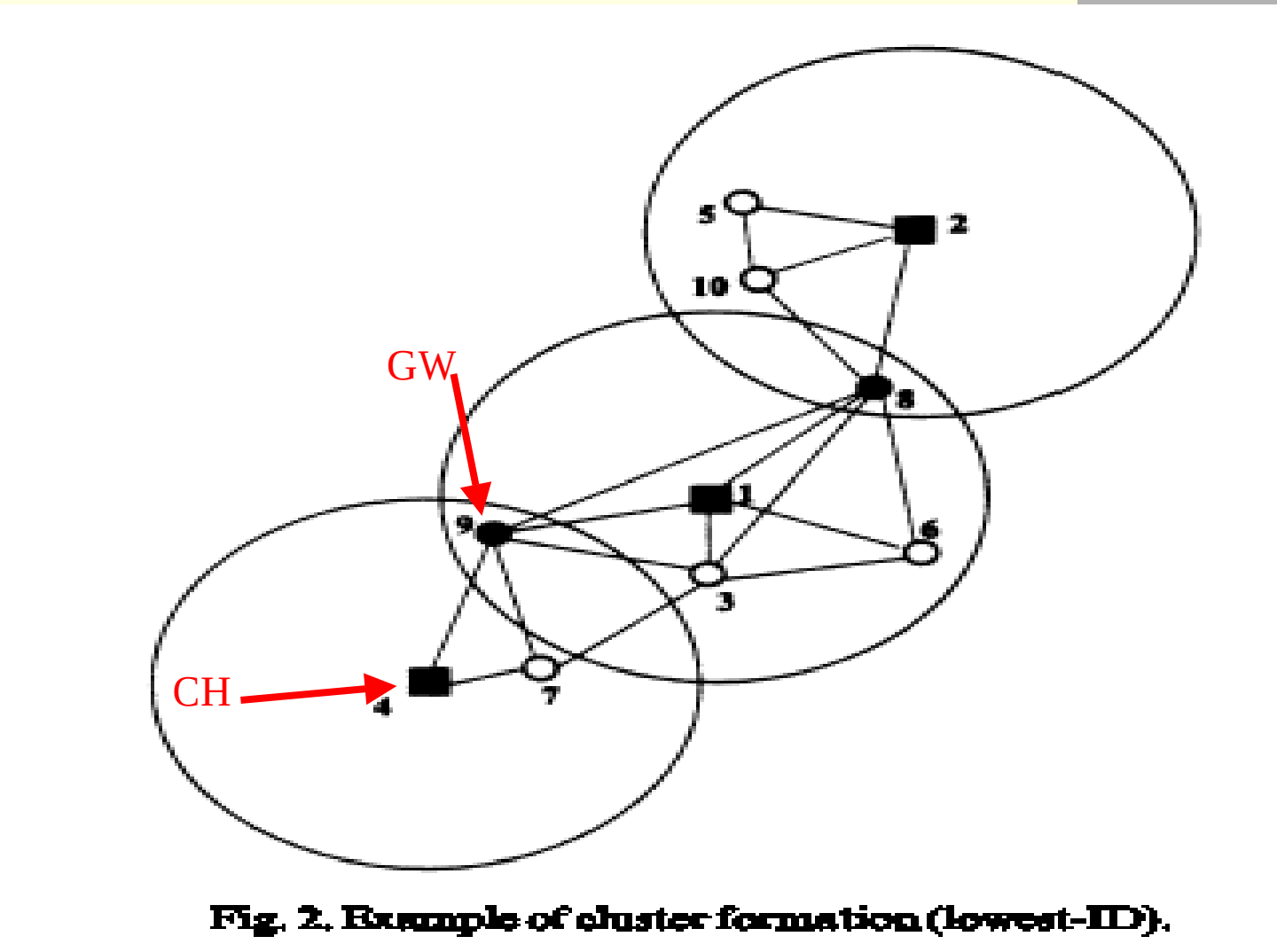


Fig. 2. Example of cluster formation (lowest-ID).

Highest-connectivity algorithm [7]

- A node is elected as a clusterhead if it is the most highly connected node of all its uncovered neighbor nodes
- A node which has not elected its clusterhead yet is an uncovered node, otherwise it is a covered node.
- A node which has already elected another nodes as it clusterhead gives up its role as a clusterhead.

Highest-connectivity algorithm [7]

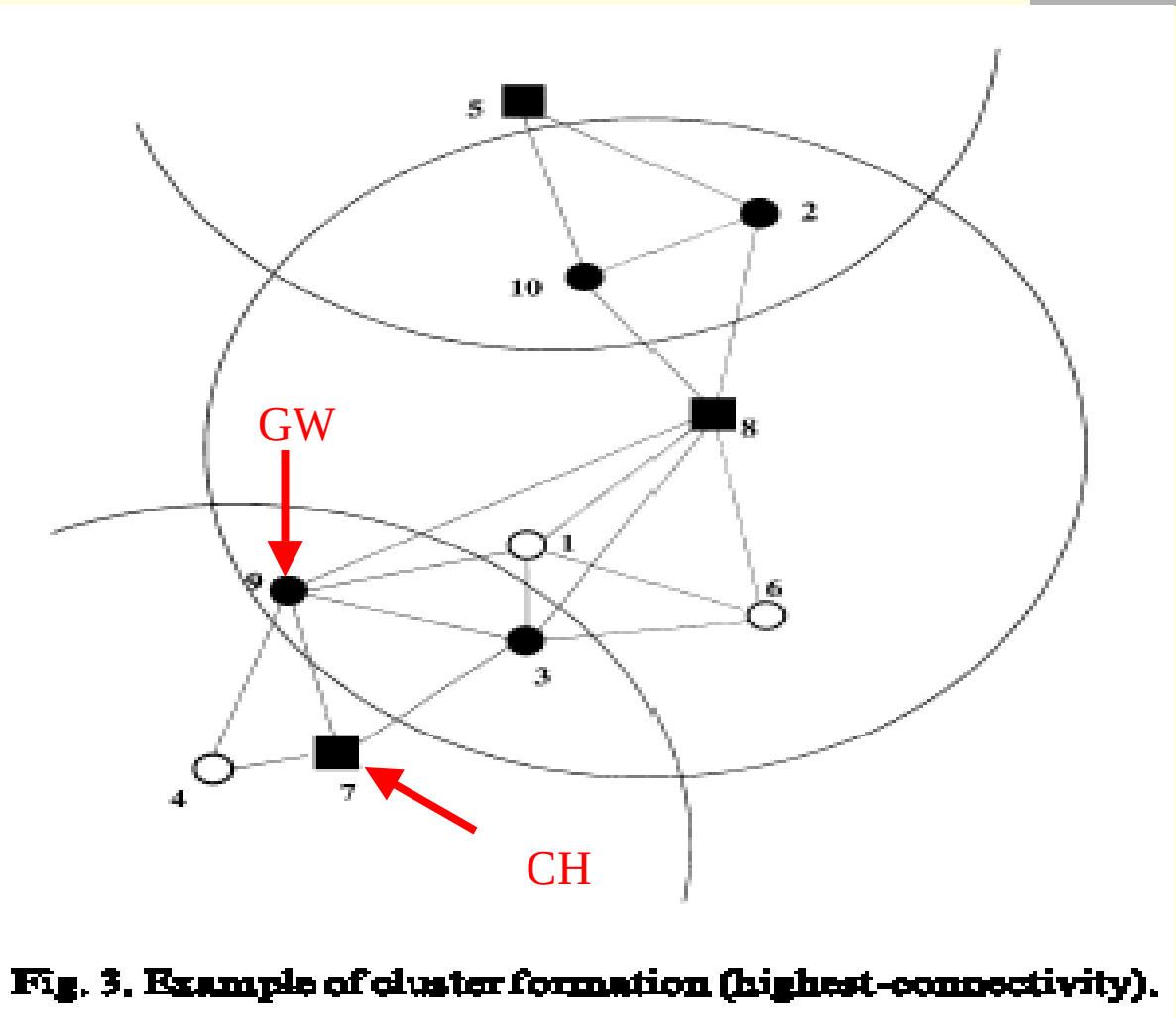


Fig. 3. Example of cluster formation (highest-connectivity).

Purposed clustering algorithm

- Properties of the two cluster algorithm:
  - Each node broadcasts the list of nodes that it can hear.
  - No clusterheads are directly linked.
  - In a cluster, any two nodes are at most **two-hops** away, since the clusterhead is directly linked to every other node in the cluster.
- Discussion
  - Single-hop
  - The coverage of a cluster is only two hops away.

Mobility-Based Clustering (MBC)

MBC

- The main idea is to combine both physical and logical partitions of the network.
- GPS will be mount in every mobile node.
- Hierarchical architecture
  - Can be applied in larger networks.
- A group may consist of clusters that present similar mobility characteristic.
- Several groups can be hierarchically merged into one group.

Definition

- Any two nodes in a cluster are at most L hops away.
- Velocity vector
  - *v* (m, t): the velocity of node m at time t
- Relative velocity
  - *v* (m, n, t): the relative velocity between m and n.

    = v (m, t) – v *(n, t)
- Relative mobility
  - $\mathbf{M}_{m, n, T}$:

$$\frac{1}{N} \sum_{i=1}^{N} \left| v\ (\ m\ ,\ n\ ,\ t_{i}\ ) \right|$$

Construct and maintain the clusters

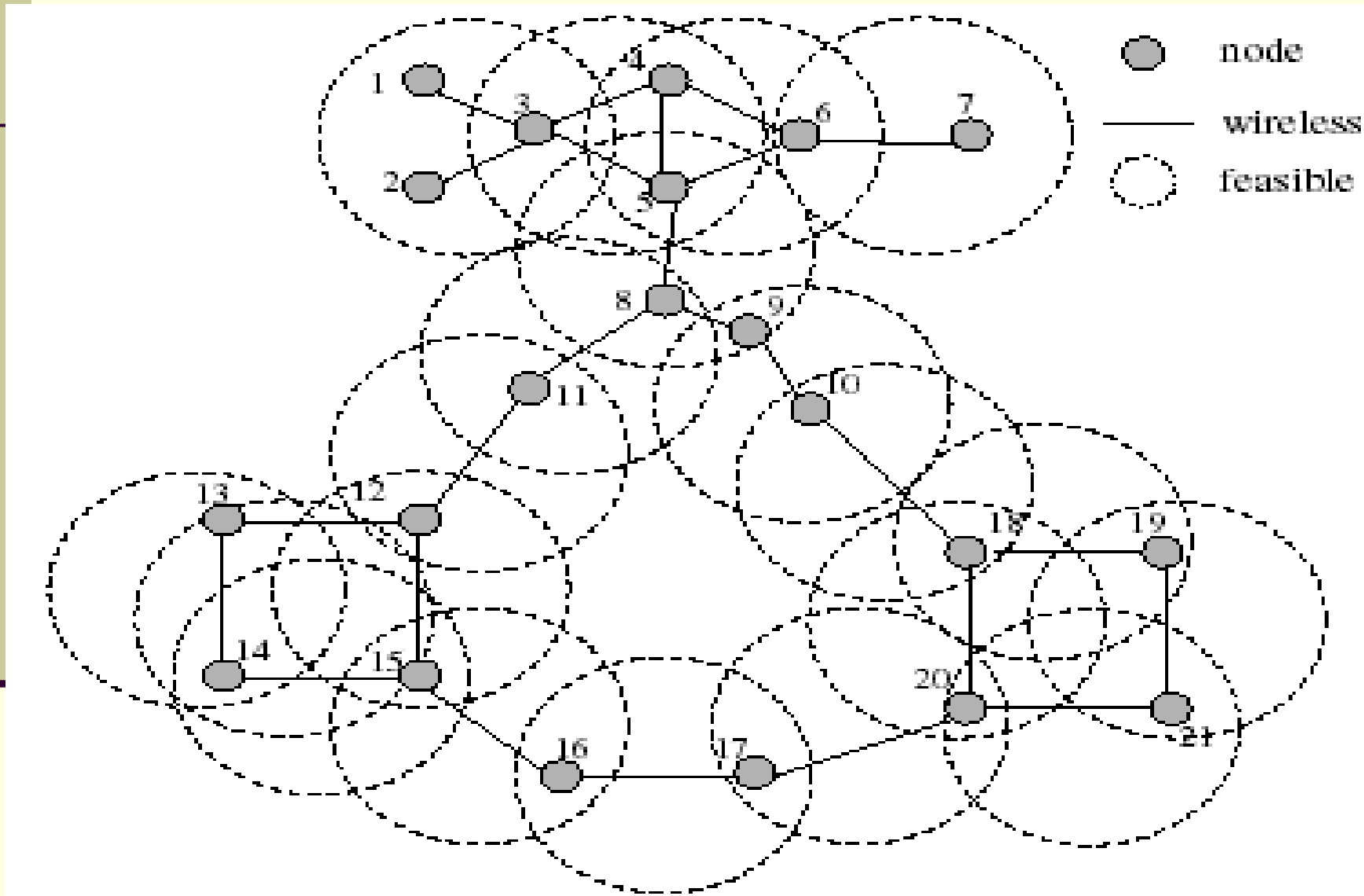
- Step1: Mobility Information Dissemination
  - Dissemination velocity information: v (n, t_i), t=1, 2, 3...
- Step2: Calculation of Mobility Metrics
  - Calculate relative velocity: ***v* (m, n, t)**
  - Calculate relative mobility: $\mathbf{M_{m, n, T}}$
- Step3: Initial (tentative) Cluster Construction
  - Tentative clusterhead (TCH)

$$TCH = Least_{i \in S_m} \left\{ ID \middle| M_{m,i,T} < th_{mob} \right\}$$

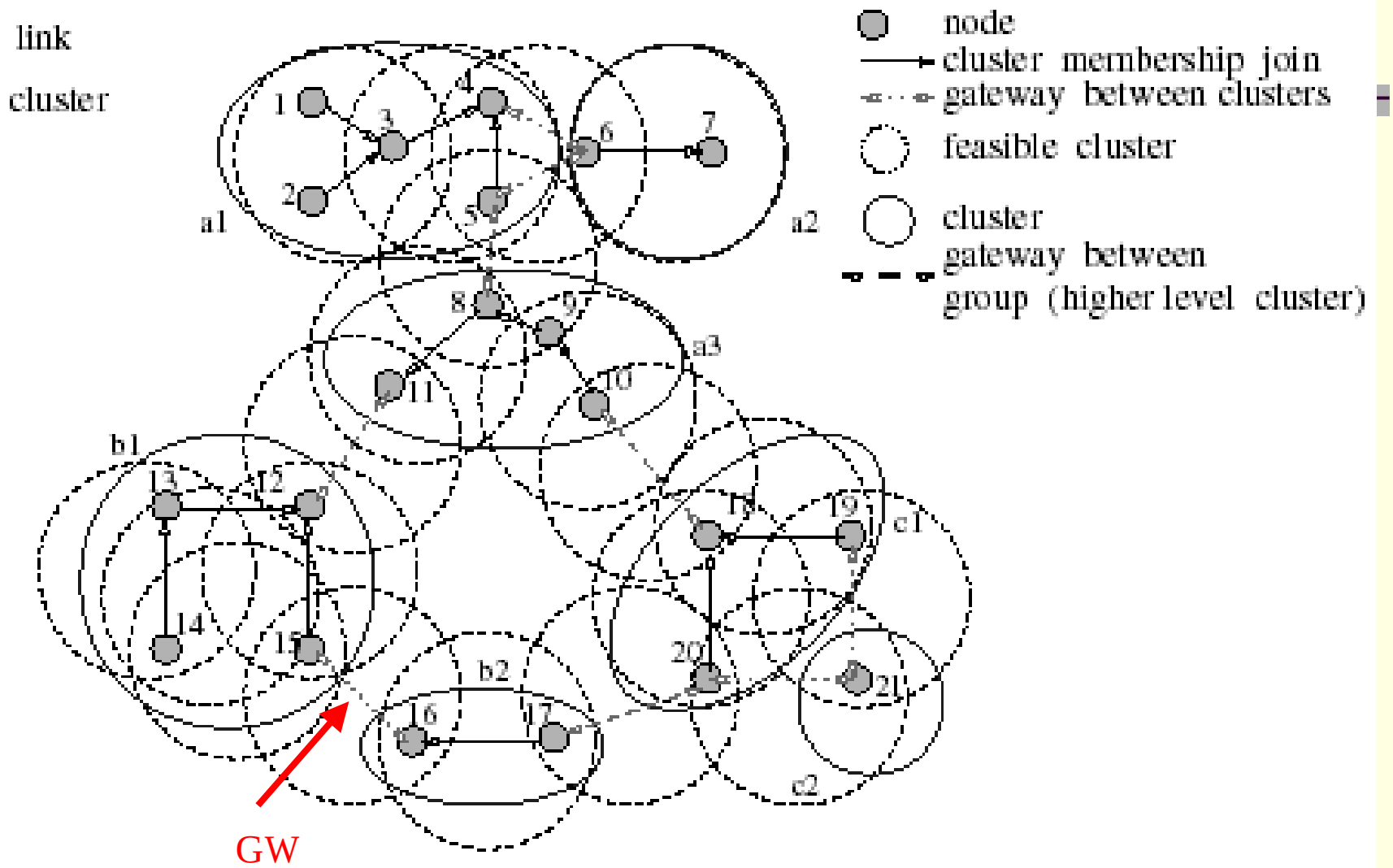
  - Th_{mob}: mobility threshold

Construct and maintain the clusters

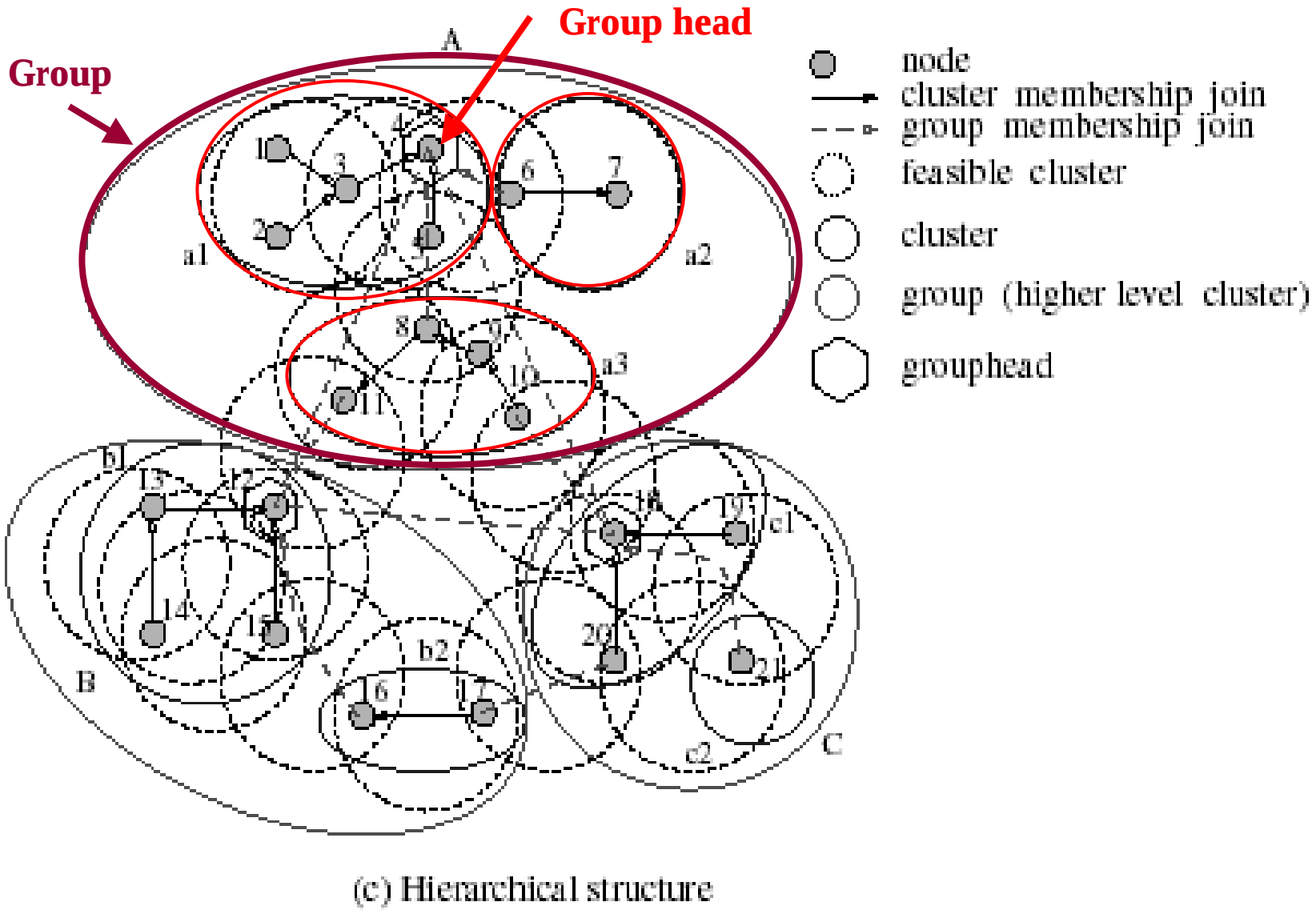
- A node with high relative mobility should not be elected as clusterhead.
- Step4: Cluster Merging
  - If clusterhead (TCH1) is included in cluster TCH2, then the TCH1 joins into TCH2
  - Upper bound: L hops
- Step5: Cluster Maintenance/Reconstruction
  - When a node m in Ci moves into cluster Cj,



(a) Feasible clusters with L=1



(b) Mobility-based clusters with L<3



(c) Hierarchical structure

Simulation result

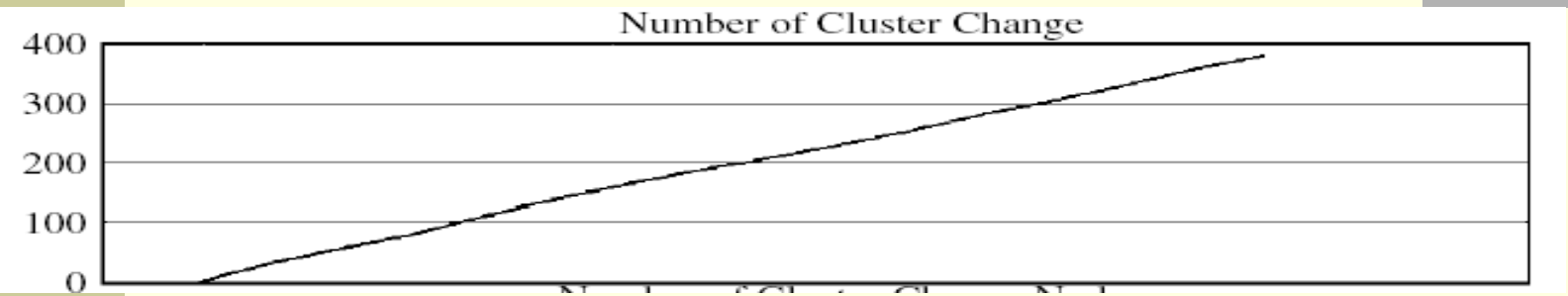
Performance evaluation

- Using the OPNET
- 200 nodes
- Rectangular region: 10km * 10km
- Constant radio range: 1000m
- Compare with lowest-ID and highest-connectivity algorithm.

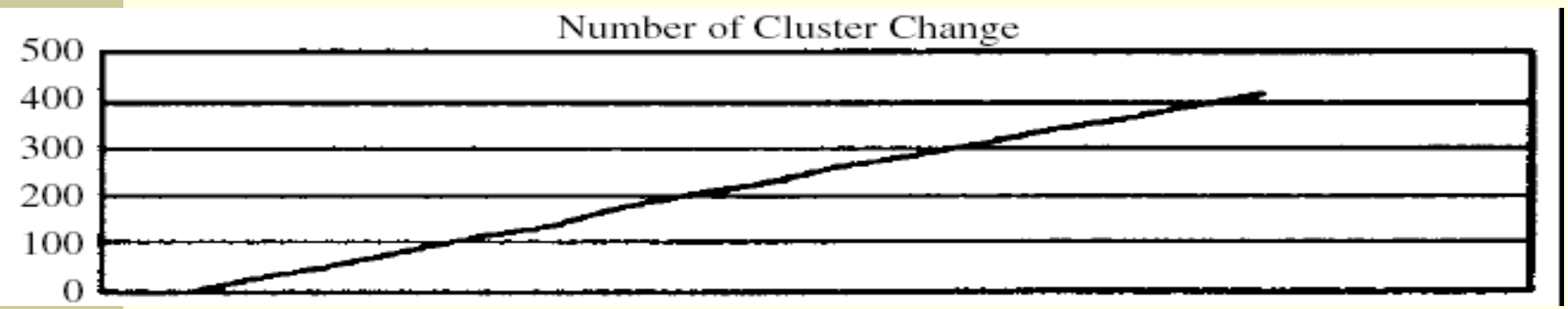
Two mobility scenarios

- Mobility 1:
  - The speed and the direction of each move are uniformly distributed, with speed range [0, 72km/h] and direction range [0, 2 pi]
- Mobility 2: (group based)
  - The speed and the direction of each group are selected randomly.

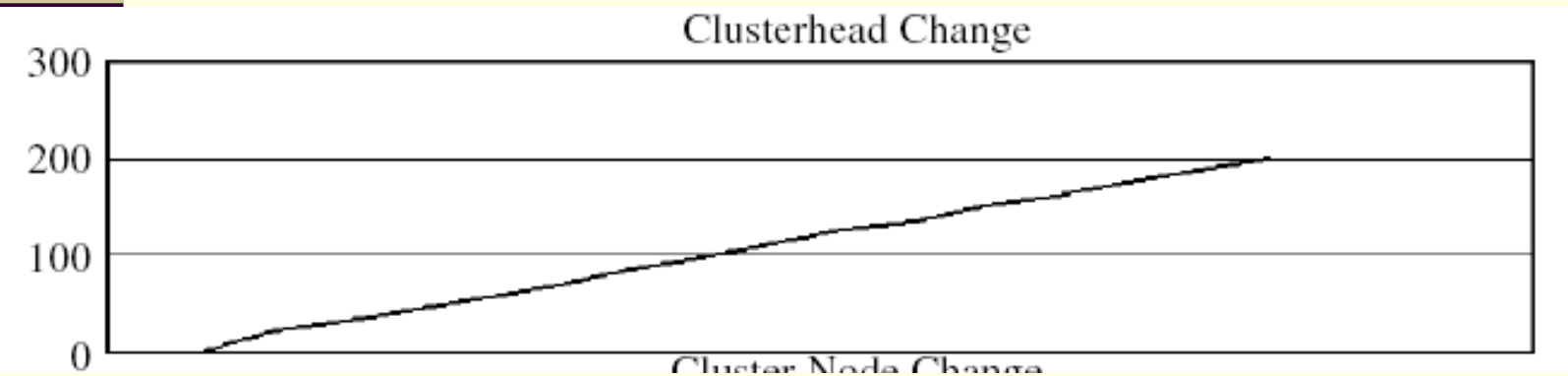
Mobility 1 – number of cluster change



Lowest-ID

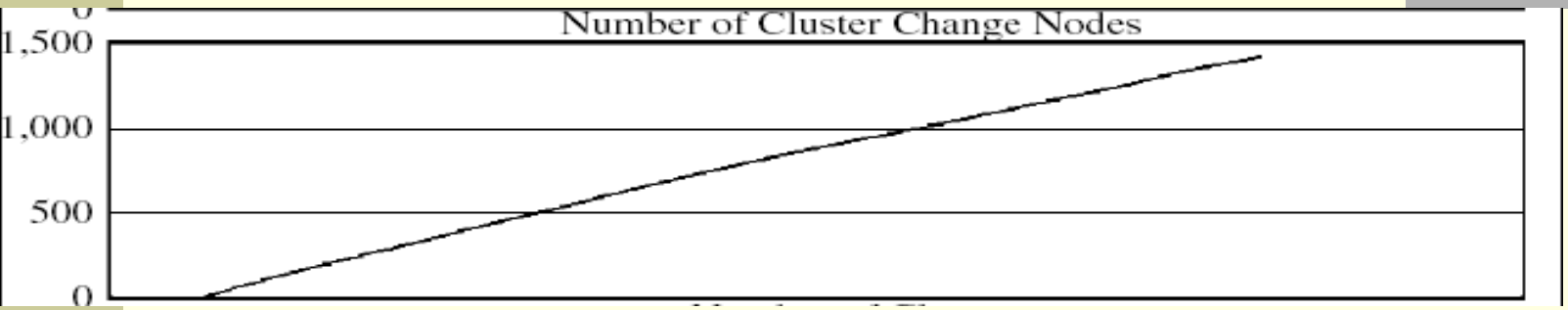


Highest-connectivity

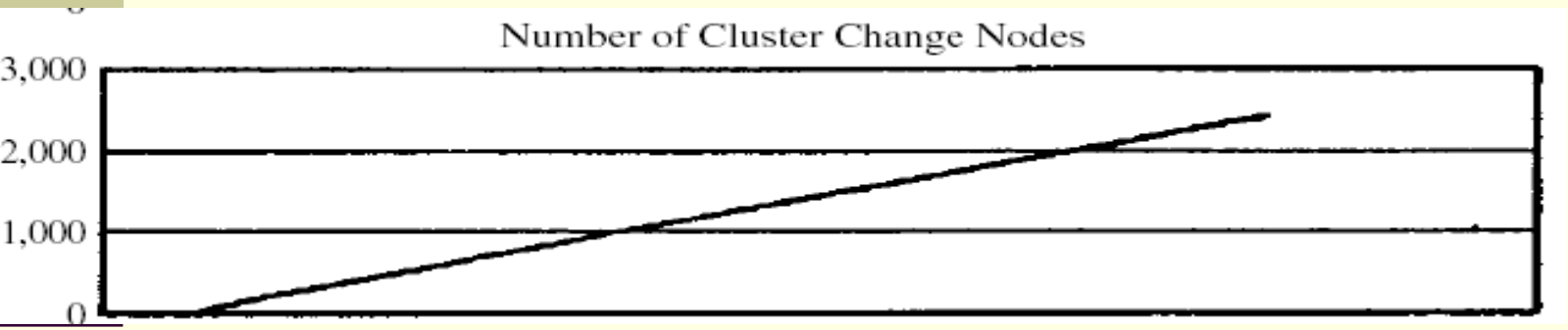


MBC

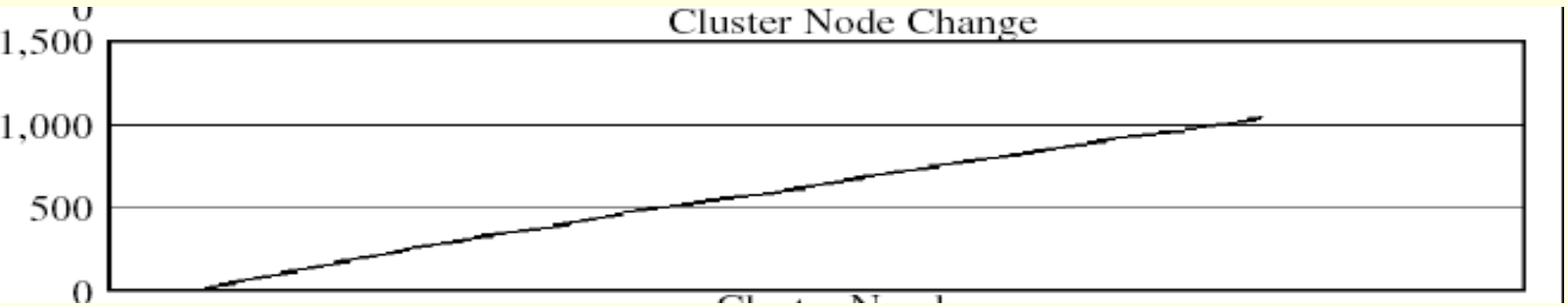
Mobility 1 – cluster node change



Lowest-ID

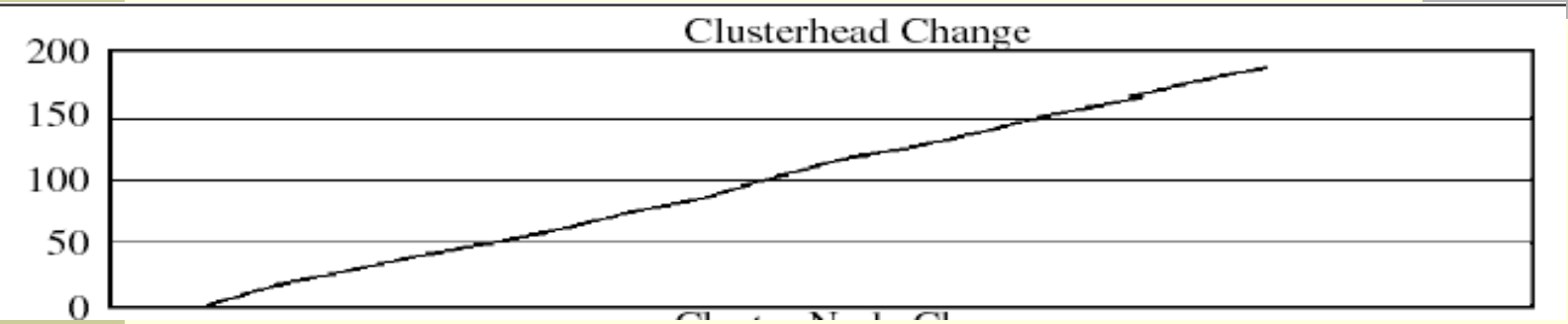


Highest-connectivity

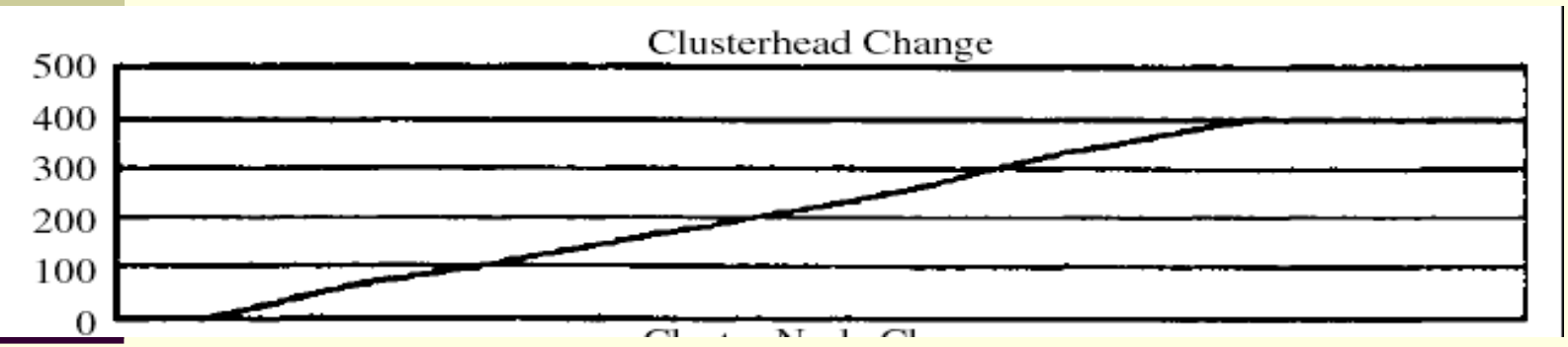


MBC

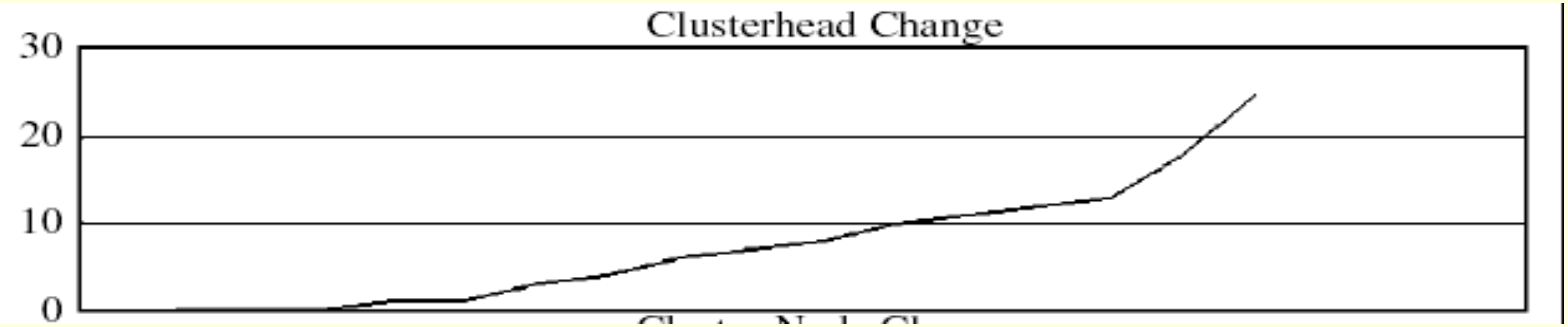
Mobility 2 – number of cluster change



Lowest-ID

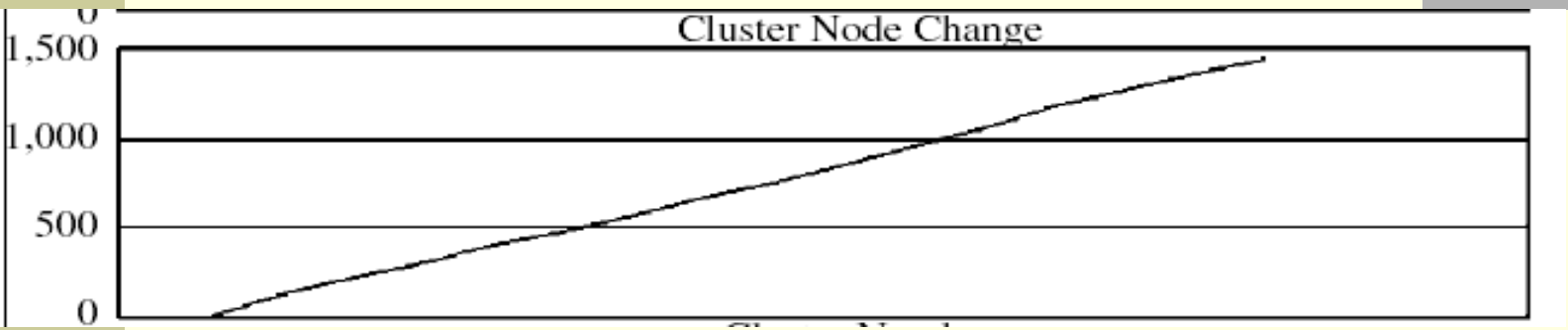


Highest-connectivity

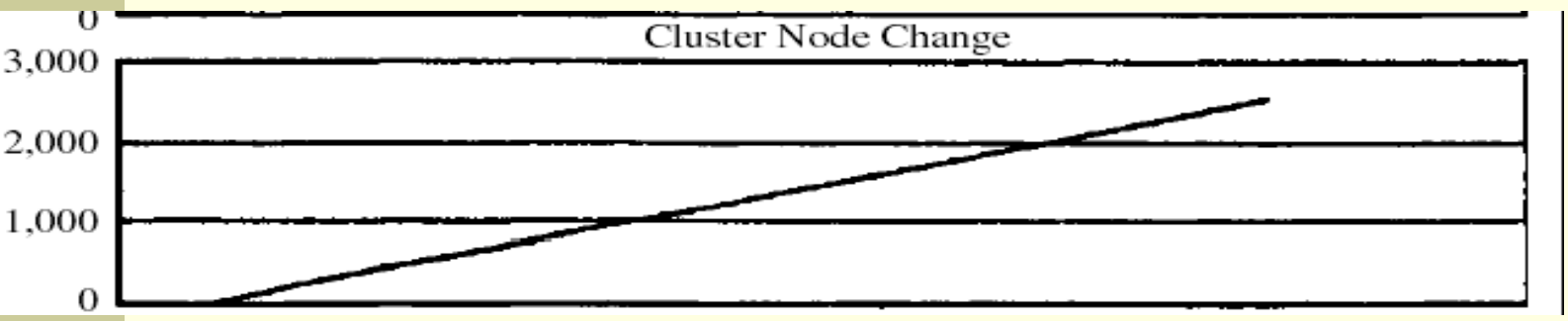


MBC

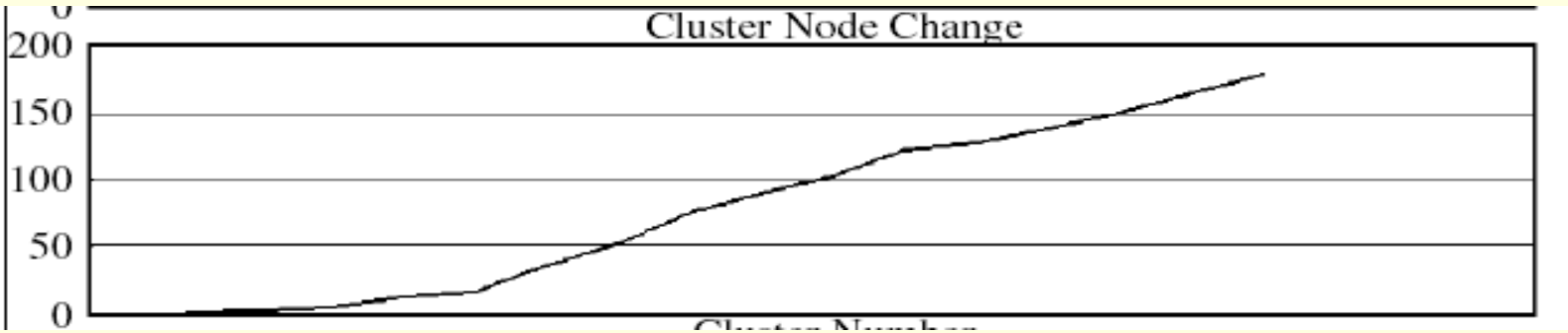
Mobility 2 – cluster node change



Lowest-ID



Highest-connectivity



MBC

Conclusion

- The MBC uses a combination of both physical (geographic proximity) and logical partition (functional relation between nodes).
- The mobility threshold, Th_{mob}, can control and affect the stability of the generated clusters.
- Discussion
  - Partition problem
  - Routing