Seminar on Security of Self-Organizing Networks

An Inter-Cluster Communication Scheme for Self-Organized Transmission Power Control in MANET Clustering

Vaibhav Kasturia
M.Sc. ITIS
Leibniz Universität Hannover

Prof. Dr. Dieter Hogrefe
Department of Telematics
Georg-August Universität Göttingen

http://aqueducttech.com/wp-content/uploads/2013/05/network-security.jpg (28.01.2016)

Overview

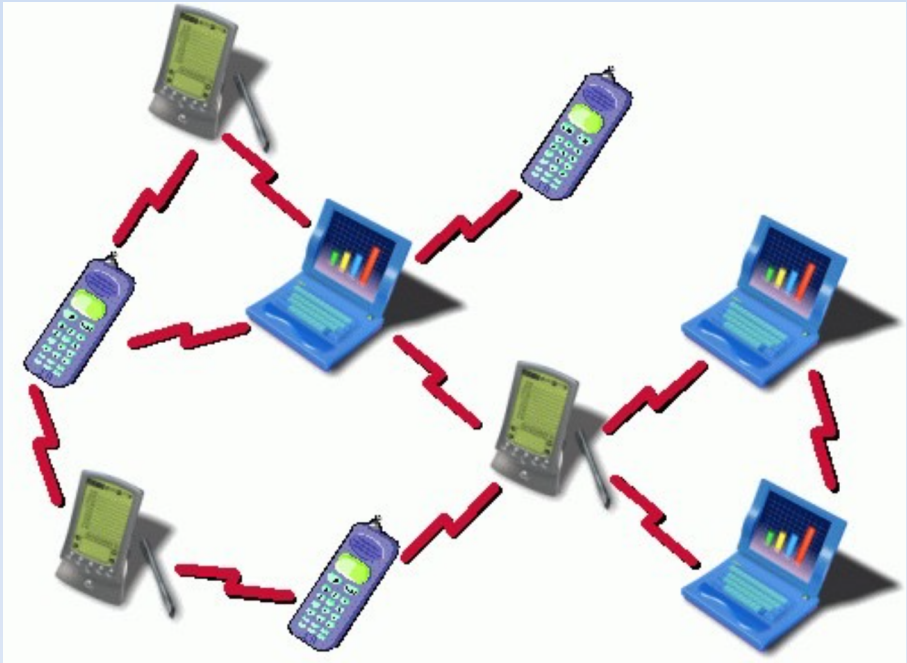
- Introduction
- Autonomous Clustering
- Self-Organized Transmission Power Control
- Proposed Scheme
- Simulation Experiments
- Discussion
- Conclusion

http://www.enersphere.com/mobile-network-operators/network.jpg (28.01.2016)

Introduction

Mobile Ad-Hoc Networks[1]:

- **Wireless mobile terminals: "Nodes"**
- **No fixed infrastructure**
- **Topology - Dynamically changing**
- **Battery life**
- **Transmission Power**



http://www.acorn.net.au/telecoms/adhocnetworks/adhocnet.gif (28.01.2016)

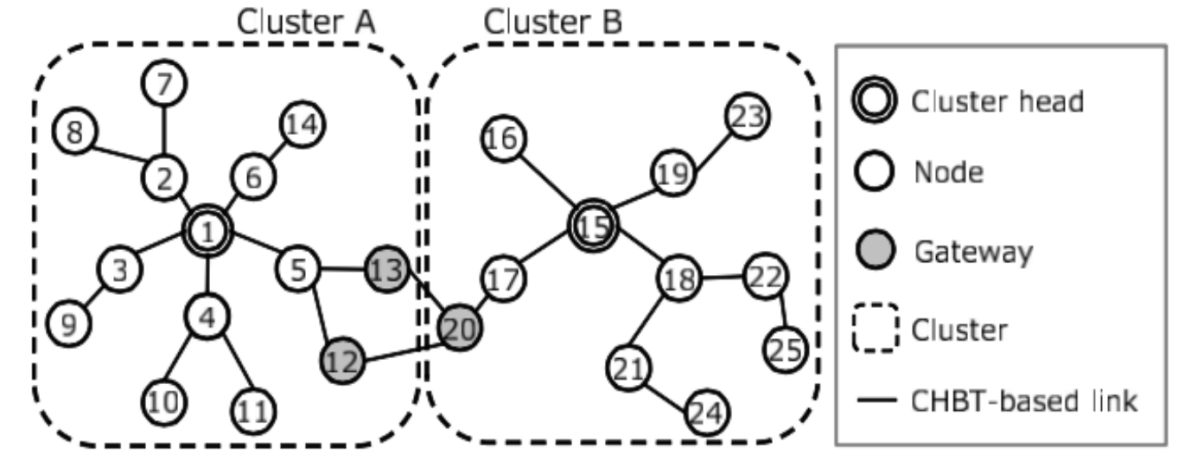
Autonomous Clustering

- **Connected node groups: “Clusters”**
- **Disjoint Clusters**
- **Hierarchical Routing Protocol (Hi-AODV)**
- **Intra-Cluster Routing and Inter-Cluster Routing**
- **Problems:**
  - **Rapidly changing node density**
  - **Possible radio interferences**
  - **All Clusters : Same transmission power**

Autonomous Clustering

Cluster Structure and Management:

- **One node acting as Cluster Head (CH)**
- **Member Nodes and Border Nodes (BNs)**



Cluster Configuration Example [2]

- **CH maintains Cluster by sending messages through Cluster Head Based Tree (CHBT)**
- **MEmber Packet (MEP) and Member Acknowledgement Packet (MAP)**

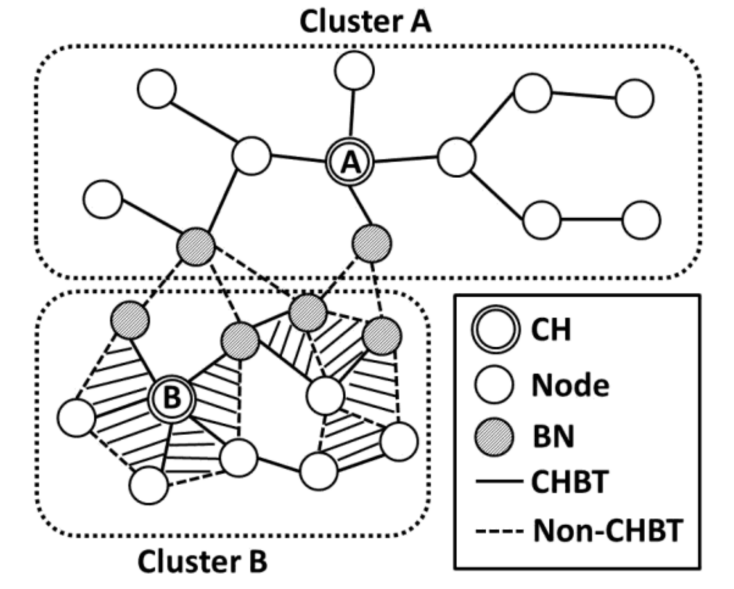
Autonomous Clustering

Cluster Size:

- **Need to keep Similar Cluster Size**
- **Fix Upper Bound and Lower Bound on Cluster Size**
- **Generally, Upper Bound = 2.5 * Lower Bound**
- **Cluster Size > Upper Bound : Split Cluster**
- **Cluster Size < Lower Bound : Merge two Clusters**
- **Lower Bound < Cluster Size < Upper Bound : No action necessary**

Self-Organized Transmission Power Control

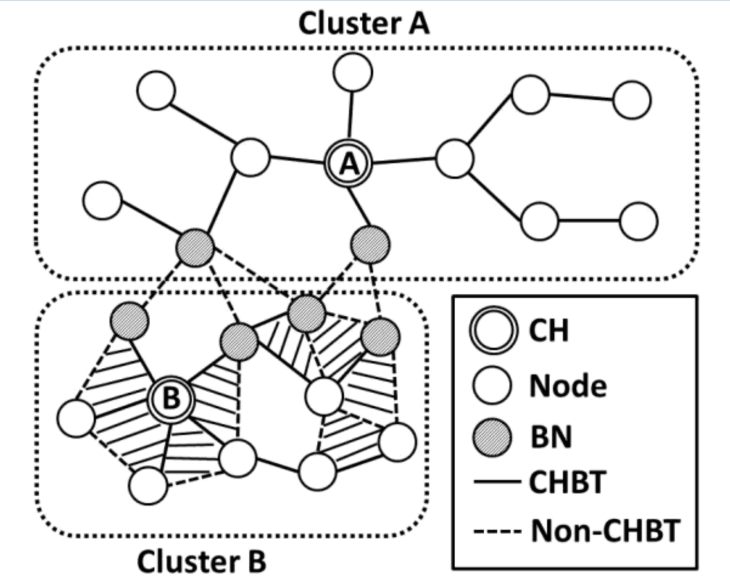
- **Node Density based Transmission Power**
- **Suitable for Intra-Cluster Communication**
- **Inter-Cluster Communication : One Way Communication Problem**



Cluster Size Estimation using Triangle Areas [3]

Inter Cluster Self-Organized Transmission Power Control Scheme

- Keep Transmission Power of Clusters based on Node Density
- Overcome problem of One-Way Inter Cluster Communication
- Possible Way: Increase Transmission Powers of BNs in a Cluster to those of Neighbouring Clusters
- Possibility of Radio Interferences within Same Cluster
- Selectively increase Transmission Power of those BNs of a Cluster connected to the maximum BNs of Neighbouring Clusters



Cluster Size Estimation using Triangle Areas [3]

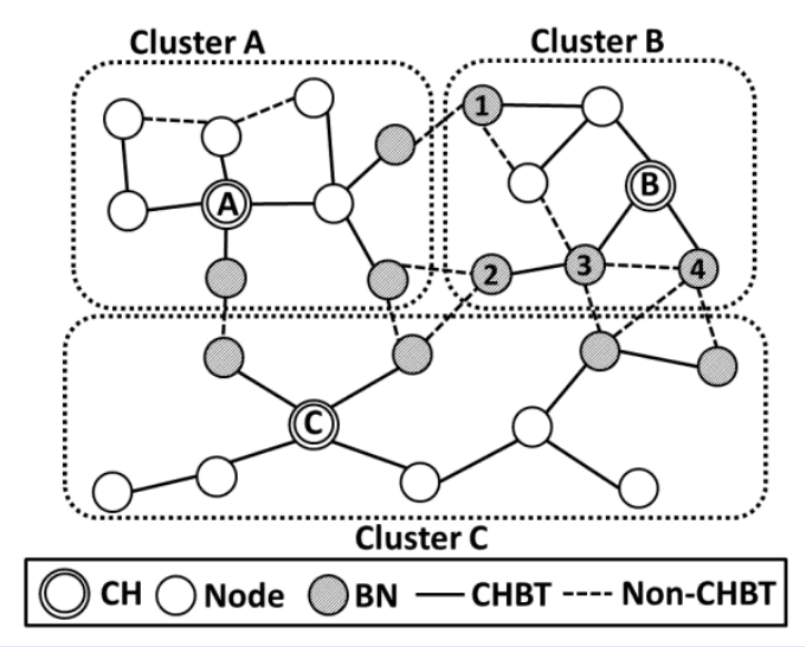
Proposed Scheme Algorithm

- **Step 1 : Select Cluster and choose a Neighbouring Cluster**
- **Step 2 : Check Transmission Power of Both Clusters**
- **Step 3 : CH selects BNs connected to maximum number of BNs of Neighbouring Cluster**
- **Step 4 : CH selects BN out of BNs which is minimum hops far**
- **Step 5 : Two or more BNs satisfying Step 4 - Random selection**
- **Step 6 : Transmission Power of selected BN increased to that of Neighbouring Cluster**

Proposed Scheme Algorithm

- **Step 7 : If same BN selected for two or more Neighbouring Clusters then Transmission Power of BN set to Neighbouring Cluster with Highest Transmission Power**

- **Step 8: CH selects next Neighbouring Cluster and goto Step 2. If no Neighbouring Cluster remains : Algorithm ends**

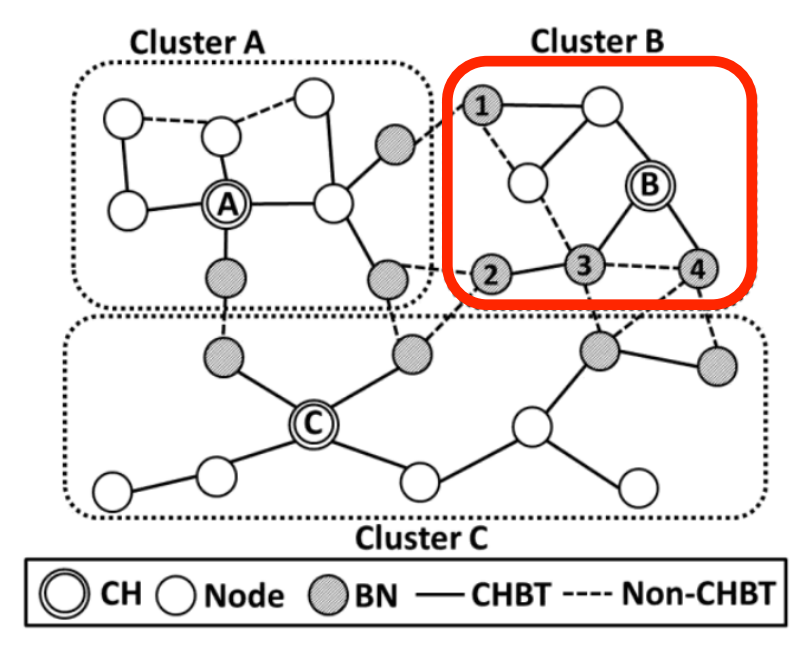


Proposed Scheme Example [3]

Proposed Scheme Algorithm

- **Step 7 : If same BN selected for two or more Neighbouring Clusters then Transmission Power of BN set to Neighbouring Cluster with Highest Transmission Power**

- **Step 8: CH selects next Neighbouring Cluster and goto Step 2. If no Neighbouring Cluster remains : Algorithm ends**

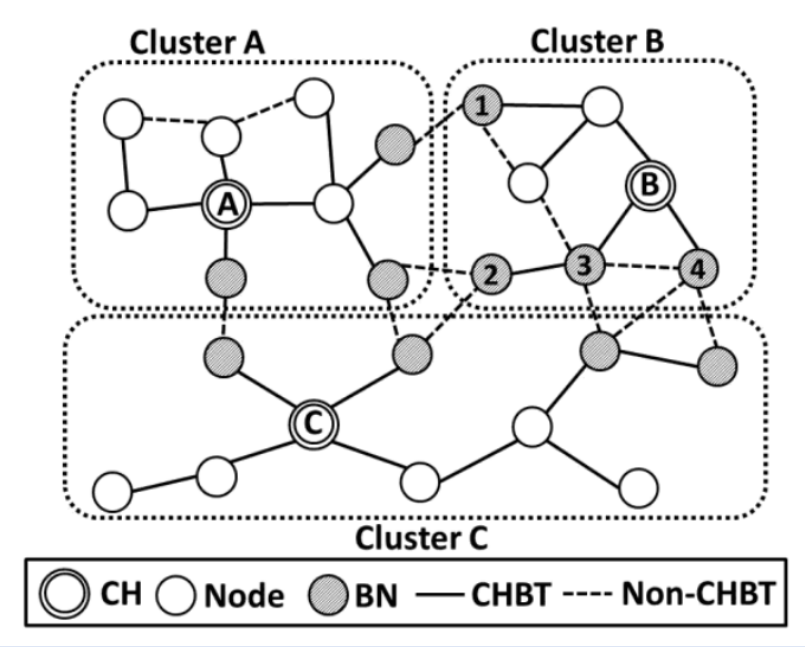


Proposed Scheme Example [3]

Proposed Scheme Algorithm

- **Step 7 : If same BN selected for two or more Neighbouring Clusters then Transmission Power of BN set to Neighbouring Cluster with Highest Transmission Power**

- **Step 8: CH selects next Neighbouring Cluster and goto Step 2. If no Neighbouring Cluster remains : Algorithm ends**

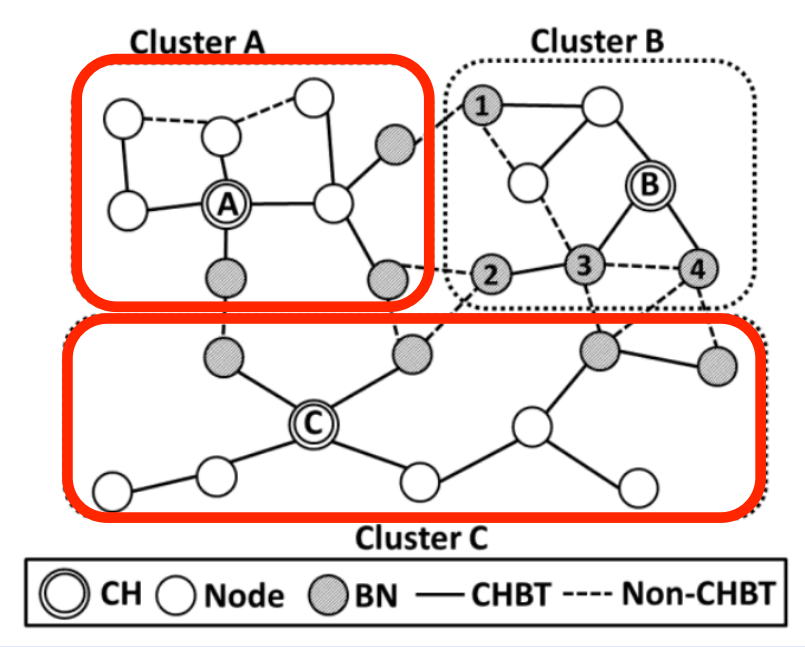


Proposed Scheme Example [3]

Proposed Scheme Algorithm

- **Step 7 : If same BN selected for two or more Neighbouring Clusters then Transmission Power of BN set to Neighbouring Cluster with Highest Transmission Power**

- **Step 8: CH selects next Neighbouring Cluster and goto Step 2. If no Neighbouring Cluster remains : Algorithm ends**

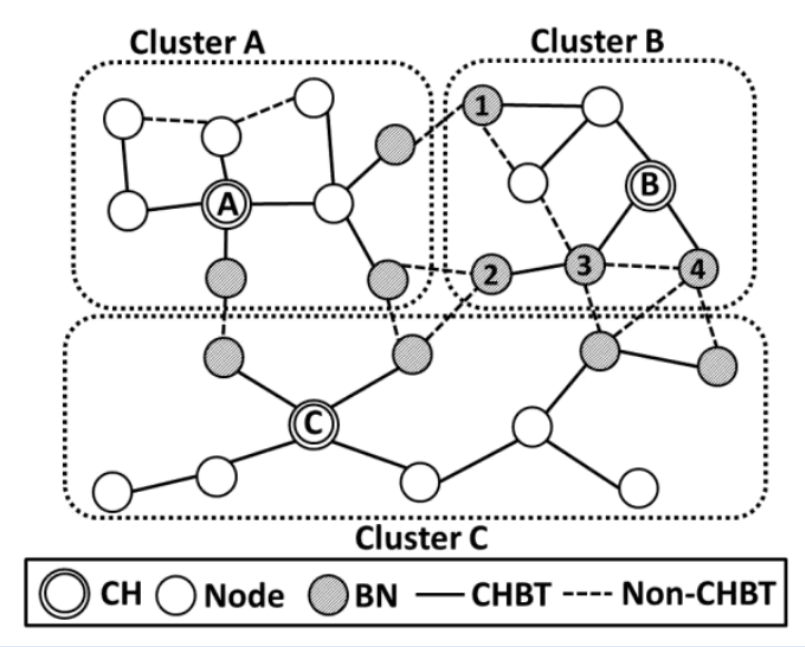


Proposed Scheme Example [3]

Proposed Scheme Algorithm

- **Step 7 : If same BN selected for two or more Neighbouring Clusters then Transmission Power of BN set to Neighbouring Cluster with Highest Transmission Power**

- **Step 8: CH selects next Neighbouring Cluster and goto Step 2. If no Neighbouring Cluster remains : Algorithm ends**

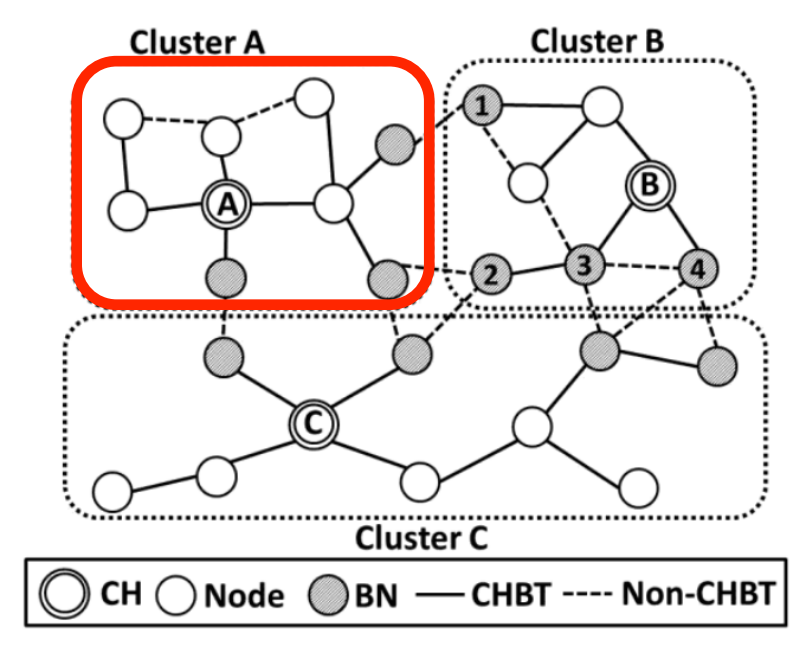


Proposed Scheme Example [3]

Proposed Scheme Algorithm

- **Step 7 : If same BN selected for two or more Neighbouring Clusters then Transmission Power of BN set to Neighbouring Cluster with Highest Transmission Power**

- **Step 8: CH selects next Neighbouring Cluster and goto Step 2. If no Neighbouring Cluster remains : Algorithm ends**

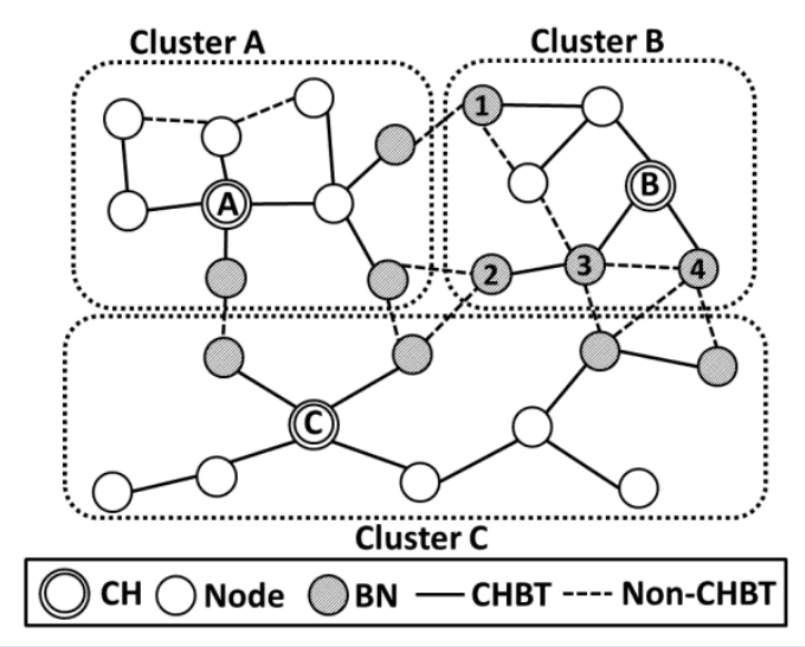


Proposed Scheme Example [3]

Proposed Scheme Algorithm

- **Step 7 : If same BN selected for two or more Neighbouring Clusters then Transmission Power of BN set to Neighbouring Cluster with Highest Transmission Power**

- **Step 8: CH selects next Neighbouring Cluster and goto Step 2. If no Neighbouring Cluster remains : Algorithm ends**

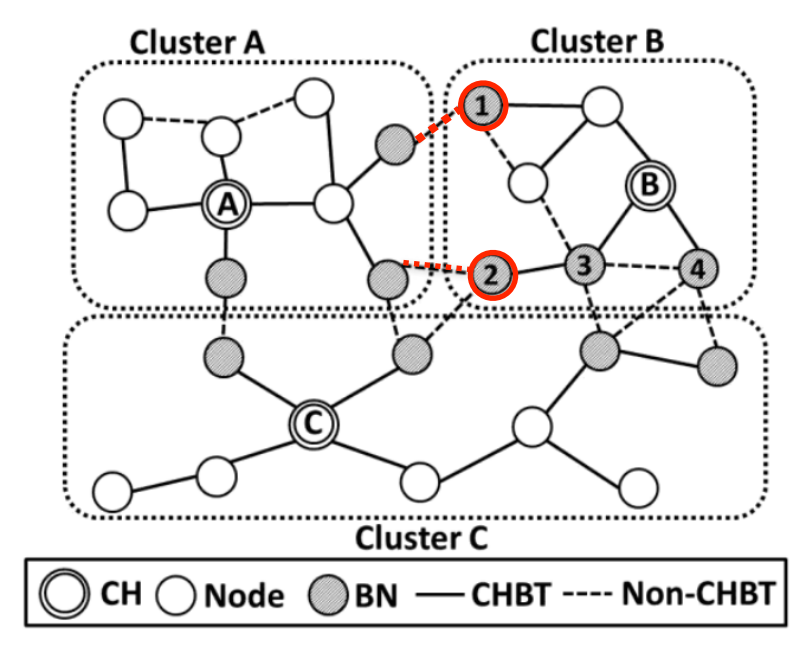


Proposed Scheme Example [3]

Proposed Scheme Algorithm

- **Step 7 : If same BN selected for two or more Neighbouring Clusters then Transmission Power of BN set to Neighbouring Cluster with Highest Transmission Power**

- **Step 8: CH selects next Neighbouring Cluster and goto Step 2. If no Neighbouring Cluster remains : Algorithm ends**

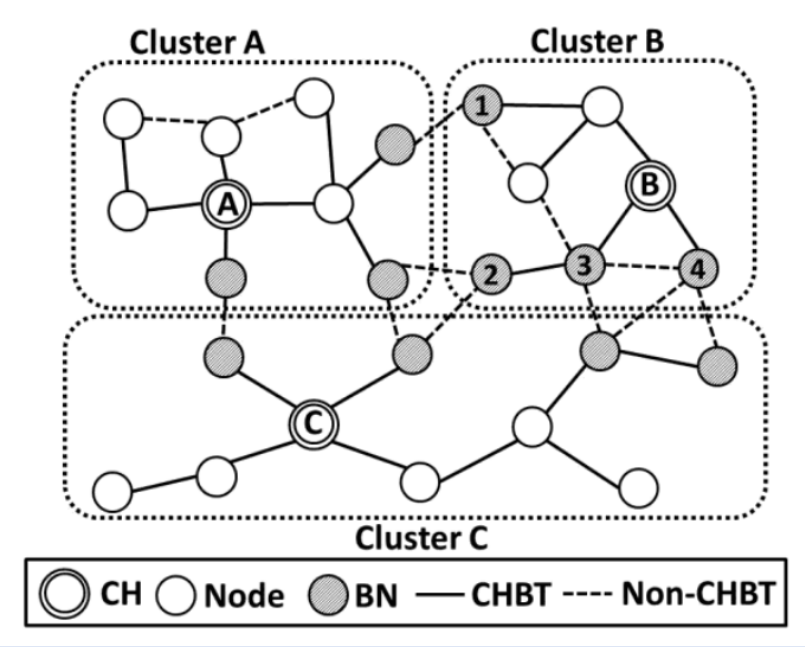


Proposed Scheme Example [3]

Proposed Scheme Algorithm

- **Step 7 : If same BN selected for two or more Neighbouring Clusters then Transmission Power of BN set to Neighbouring Cluster with Highest Transmission Power**

- **Step 8: CH selects next Neighbouring Cluster and goto Step 2. If no Neighbouring Cluster remains : Algorithm ends**

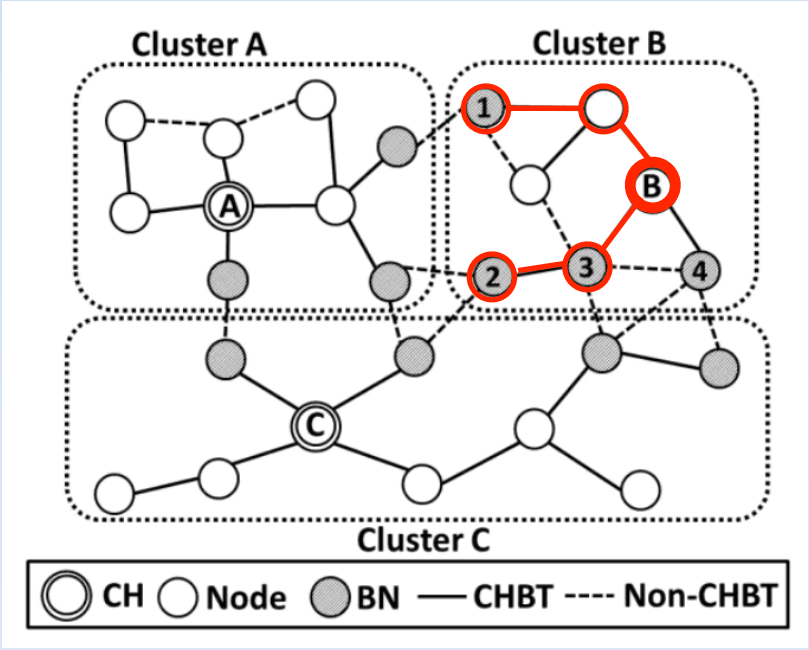


Proposed Scheme Example [3]

Proposed Scheme Algorithm

- **<u>Step 7</u> : If same BN selected for two or more Neighbouring Clusters then Transmission Power of BN set to Neighbouring Cluster with Highest Transmission Power**

- **<u>Step 8</u>: CH selects next Neighbouring Cluster and goto Step 2. If no Neighbouring Cluster remains : Algorithm ends**

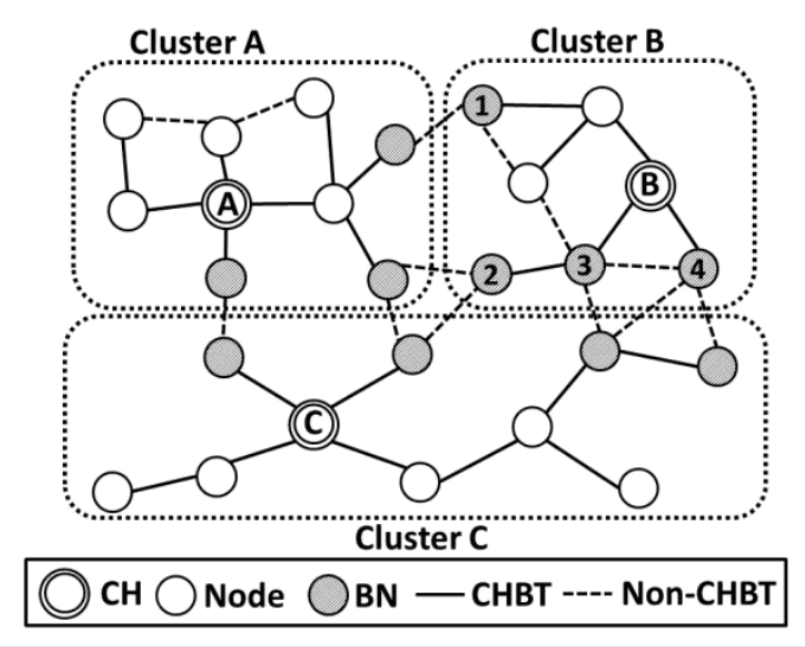


Proposed Scheme Example [3]

Proposed Scheme Algorithm

- **Step 7 : If same BN selected for two or more Neighbouring Clusters then Transmission Power of BN set to Neighbouring Cluster with Highest Transmission Power**

- **Step 8: CH selects next Neighbouring Cluster and goto Step 2. If no Neighbouring Cluster remains : Algorithm ends**

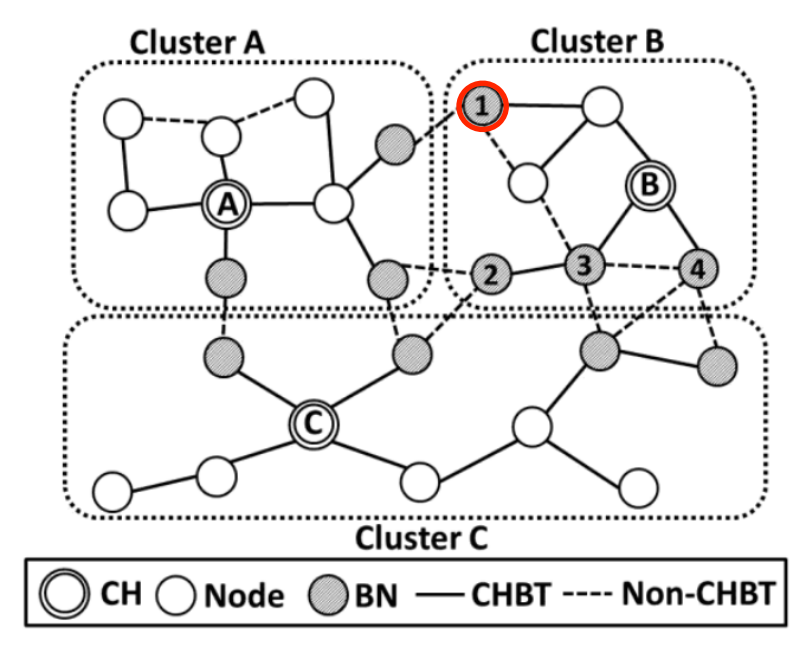


Proposed Scheme Example [3]

Proposed Scheme Algorithm

- **Step 7 : If same BN selected for two or more Neighbouring Clusters then Transmission Power of BN set to Neighbouring Cluster with Highest Transmission Power**

- **Step 8: CH selects next Neighbouring Cluster and goto Step 2. If no Neighbouring Cluster remains : Algorithm ends**

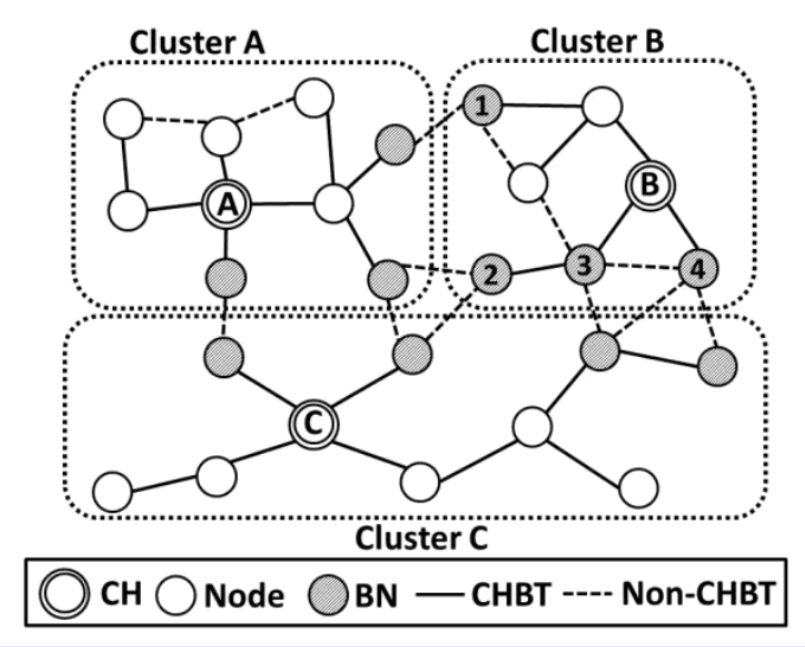


Proposed Scheme Example [3]

Proposed Scheme Algorithm

- **Step 7 : If same BN selected for two or more Neighbouring Clusters then Transmission Power of BN set to Neighbouring Cluster with Highest Transmission Power**

- **Step 8: CH selects next Neighbouring Cluster and goto Step 2. If no Neighbouring Cluster remains : Algorithm ends**

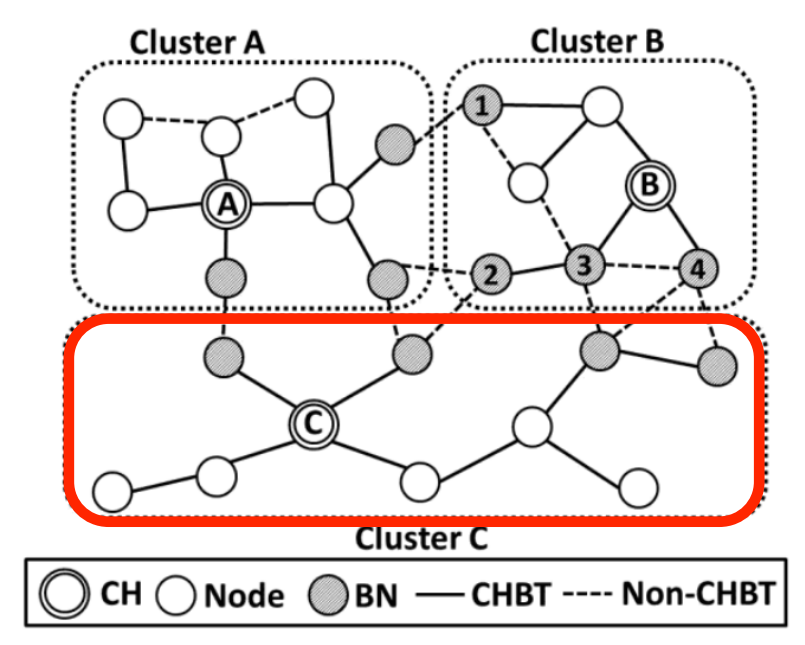


Proposed Scheme Example [3]

Proposed Scheme Algorithm

- **Step 7 : If same BN selected for two or more Neighbouring Clusters then Transmission Power of BN set to Neighbouring Cluster with Highest Transmission Power**

- **Step 8: CH selects next Neighbouring Cluster and goto Step 2. If no Neighbouring Cluster remains : Algorithm ends**

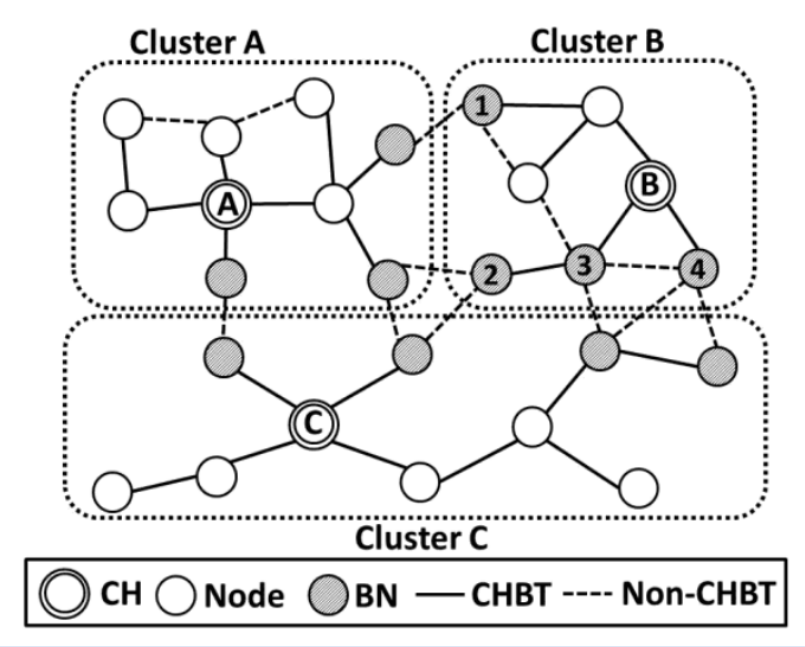


Proposed Scheme Example [3]

Proposed Scheme Algorithm

- **Step 7 : If same BN selected for two or more Neighbouring Clusters then Transmission Power of BN set to Neighbouring Cluster with Highest Transmission Power**

- **Step 8: CH selects next Neighbouring Cluster and goto Step 2. If no Neighbouring Cluster remains : Algorithm ends**

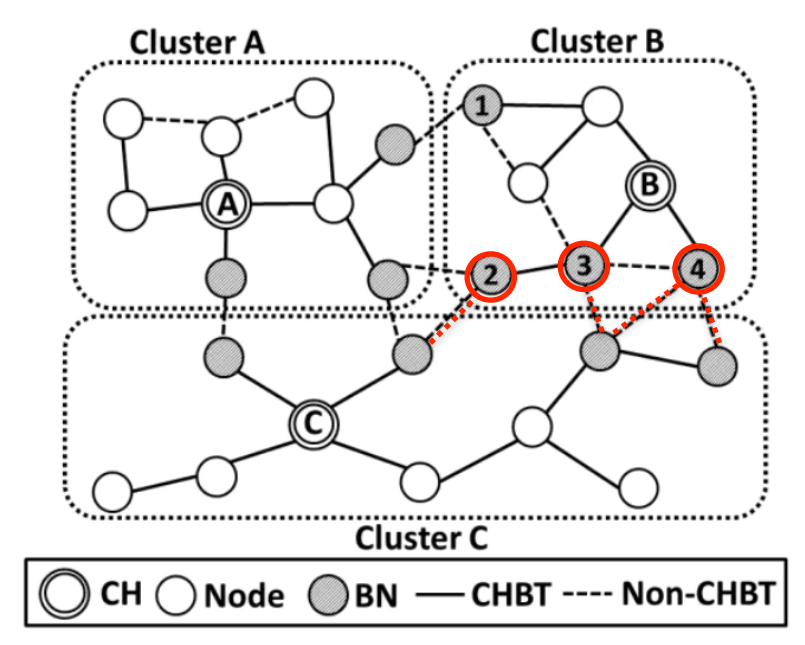


Proposed Scheme Example [3]

Proposed Scheme Algorithm

- **Step 7 : If same BN selected for two or more Neighbouring Clusters then Transmission Power of BN set to Neighbouring Cluster with Highest Transmission Power**

- **Step 8: CH selects next Neighbouring Cluster and goto Step 2. If no Neighbouring Cluster remains : Algorithm ends**

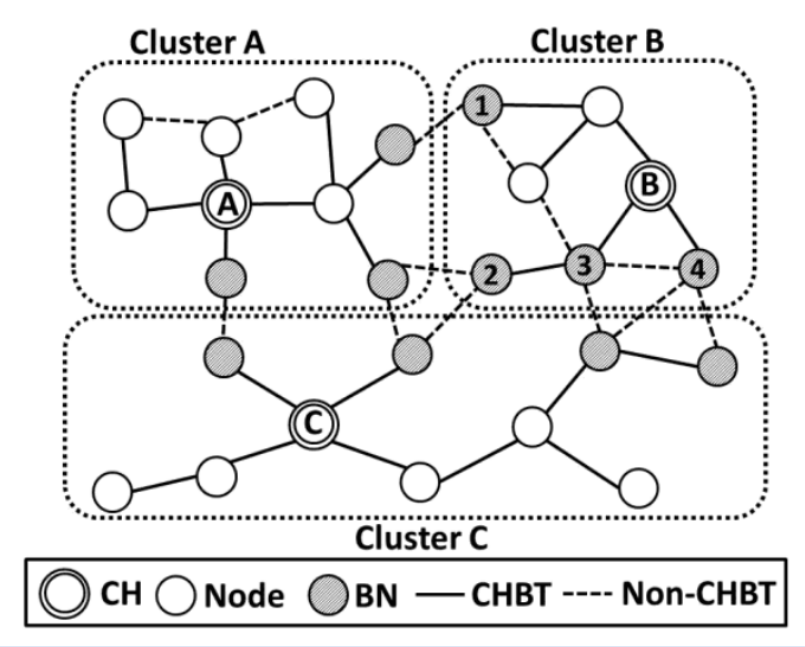


Proposed Scheme Example [3]

Proposed Scheme Algorithm

- **Step 7 : If same BN selected for two or more Neighbouring Clusters then Transmission Power of BN set to Neighbouring Cluster with Highest Transmission Power**

- **Step 8: CH selects next Neighbouring Cluster and goto Step 2. If no Neighbouring Cluster remains : Algorithm ends**

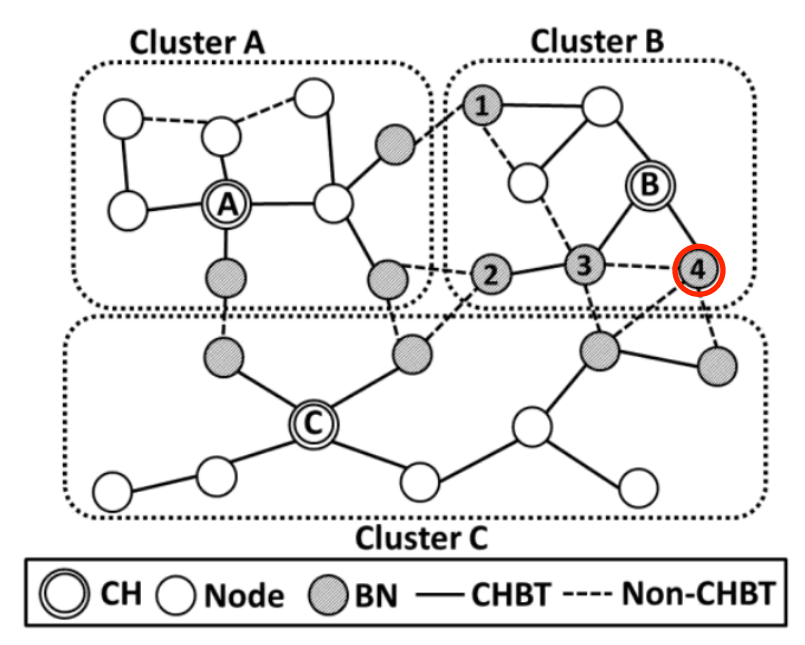


Proposed Scheme Example [3]

Proposed Scheme Algorithm

- **Step 7 : If same BN selected for two or more Neighbouring Clusters then Transmission Power of BN set to Neighbouring Cluster with Highest Transmission Power**

- **Step 8: CH selects next Neighbouring Cluster and goto Step 2. If no Neighbouring Cluster remains : Algorithm ends**

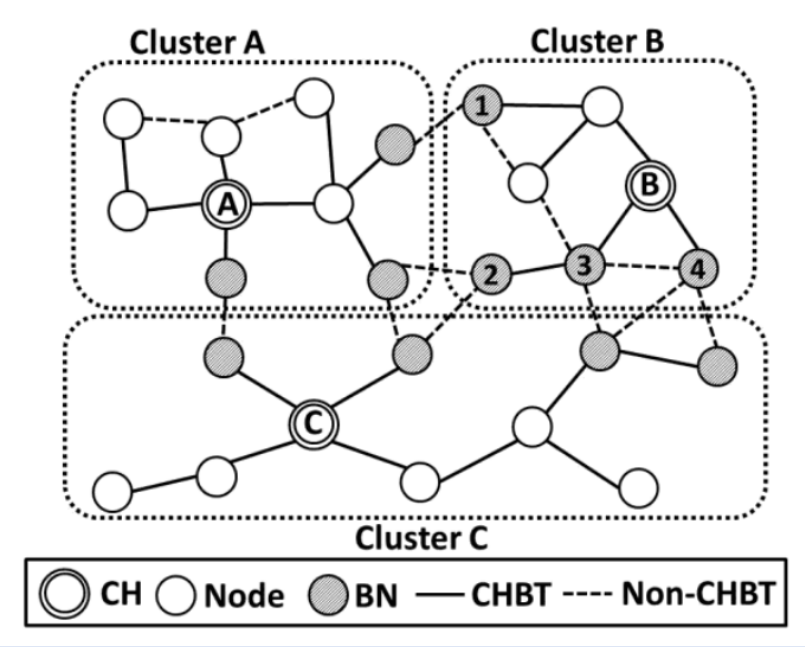


Proposed Scheme Example [3]

Proposed Scheme Algorithm

- **Step 7 : If same BN selected for two or more Neighbouring Clusters then Transmission Power of BN set to Neighbouring Cluster with Highest Transmission Power**

- **Step 8: CH selects next Neighbouring Cluster and goto Step 2. If no Neighbouring Cluster remains : Algorithm ends**



Proposed Scheme Example [3]

Simulation Experiments

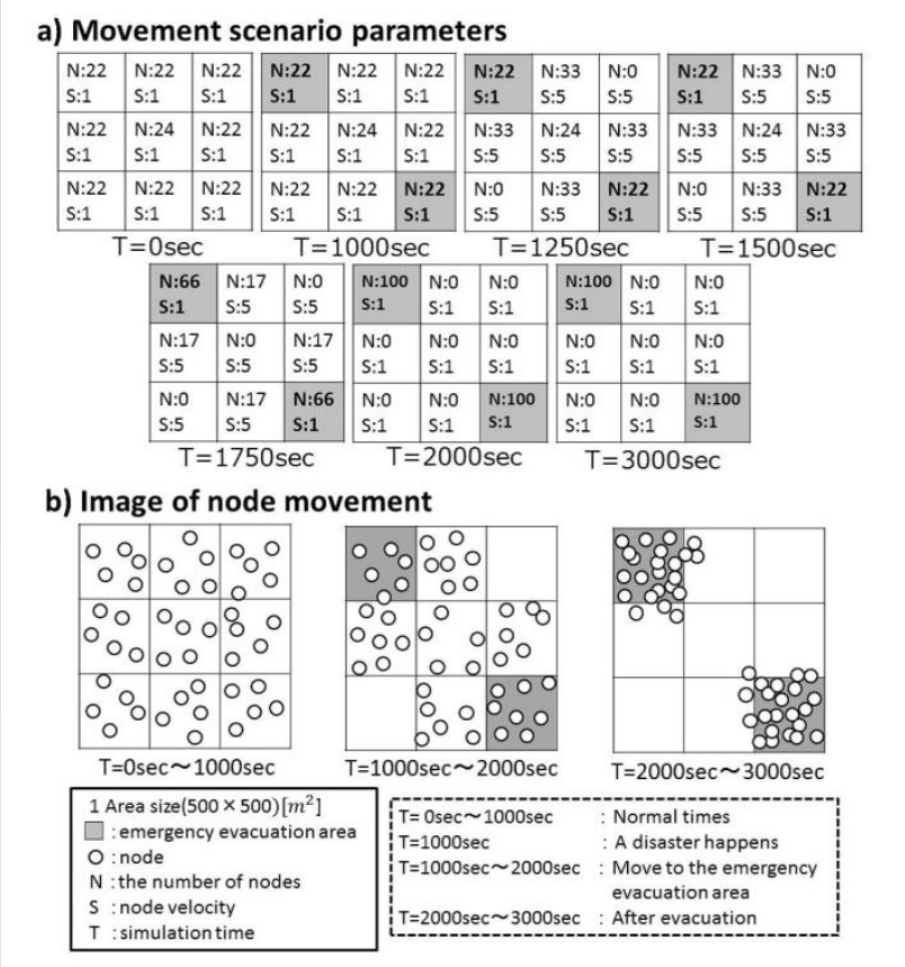
Evaluation Metrics:

- **Total Energy Consumption**
- **Data Packet Reachability = $\frac{\text{Data Packets Received}}{\text{Data Packets Transmitted}}$**
- **Total Packet Size = Data Packet Size + Control Packet Size**

Simulation Experiments

Simulation Model and Parameters[4]:

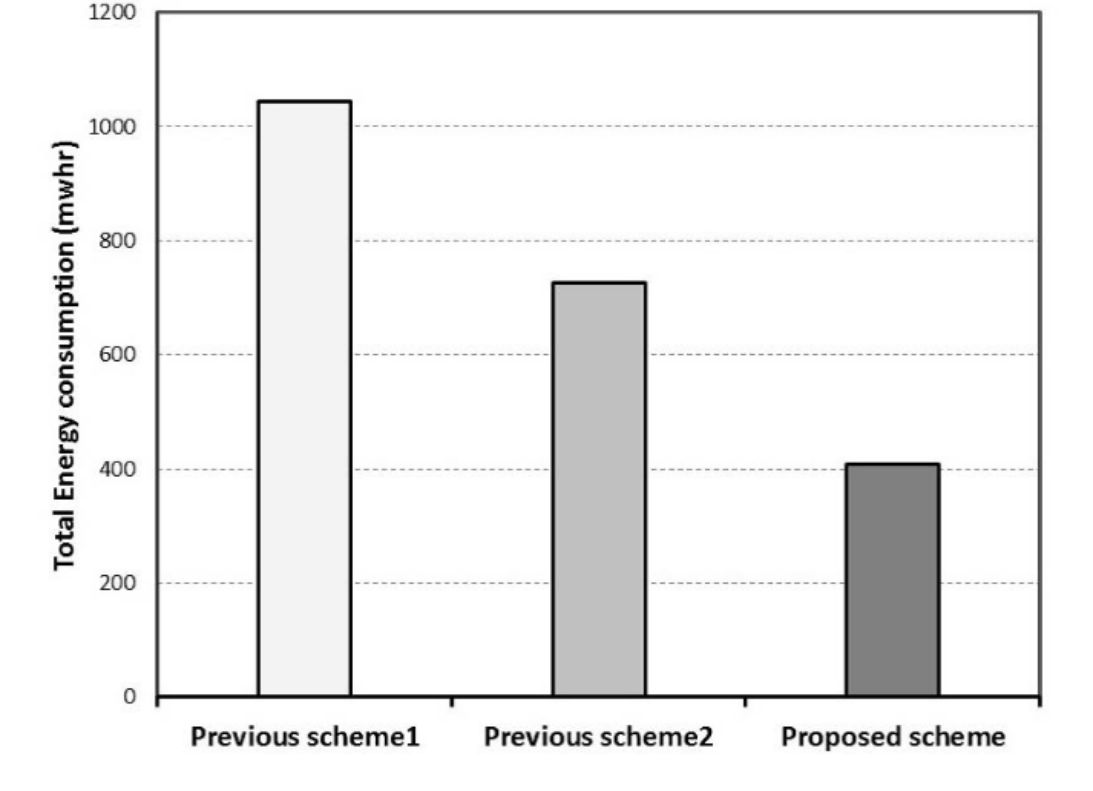
- **Mobility Model**
- **Change in Nodes and Velocity**
- **Time Interval t = 0 to 3000 sec**
- **Disaster at t=1000 sec**



Node Movement Scenario [3]

Simulation Experiments

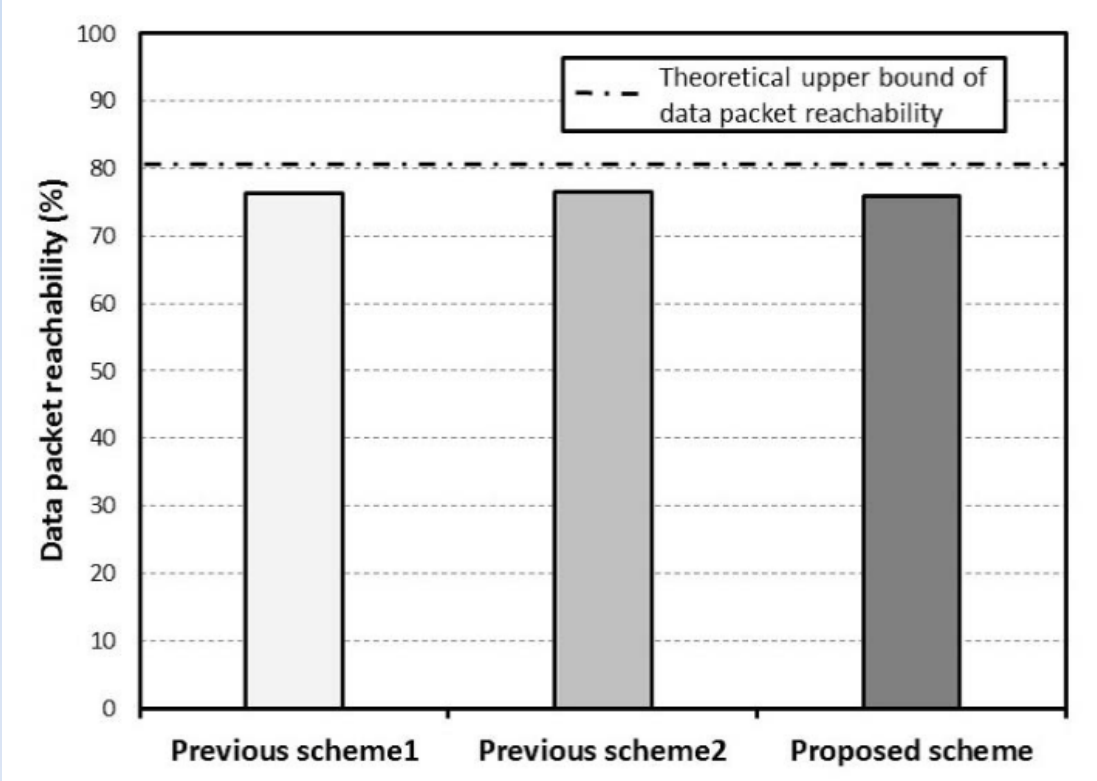
Results Obtained:



Total Energy Consumption [3]

Simulation Experiments

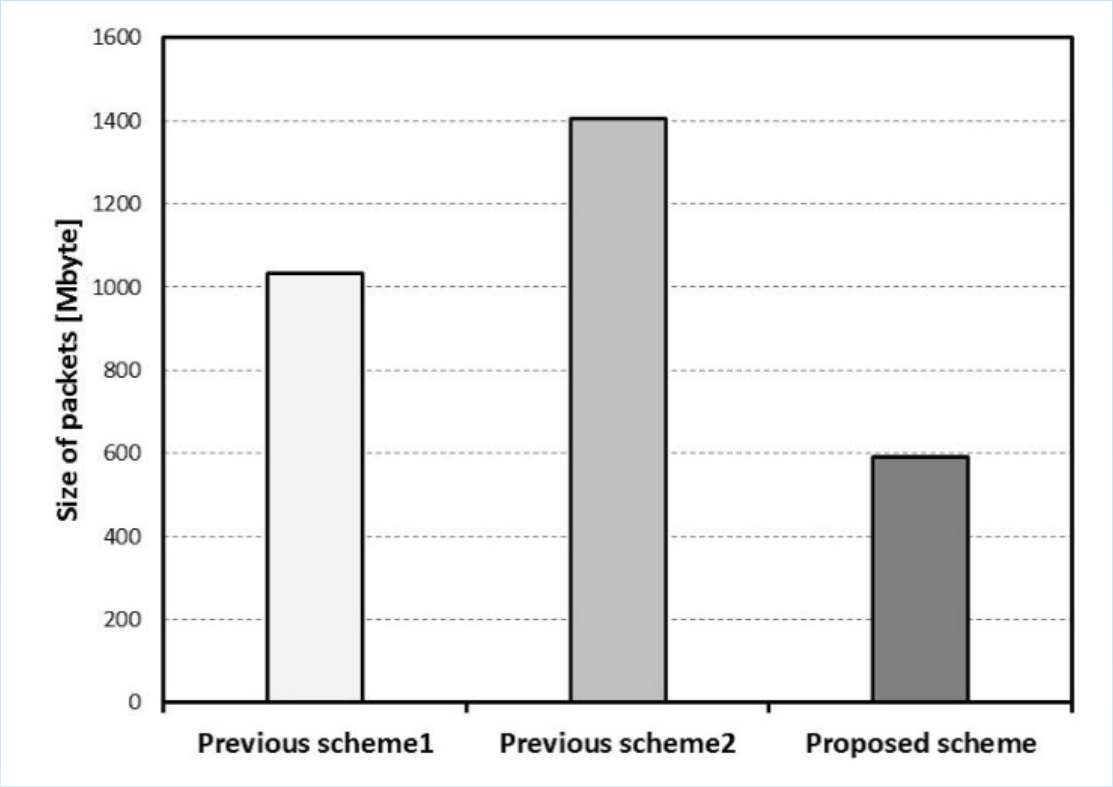
Results Obtained:



Data Packet Reachability [3]

Simulation Experiments

Results Obtained:

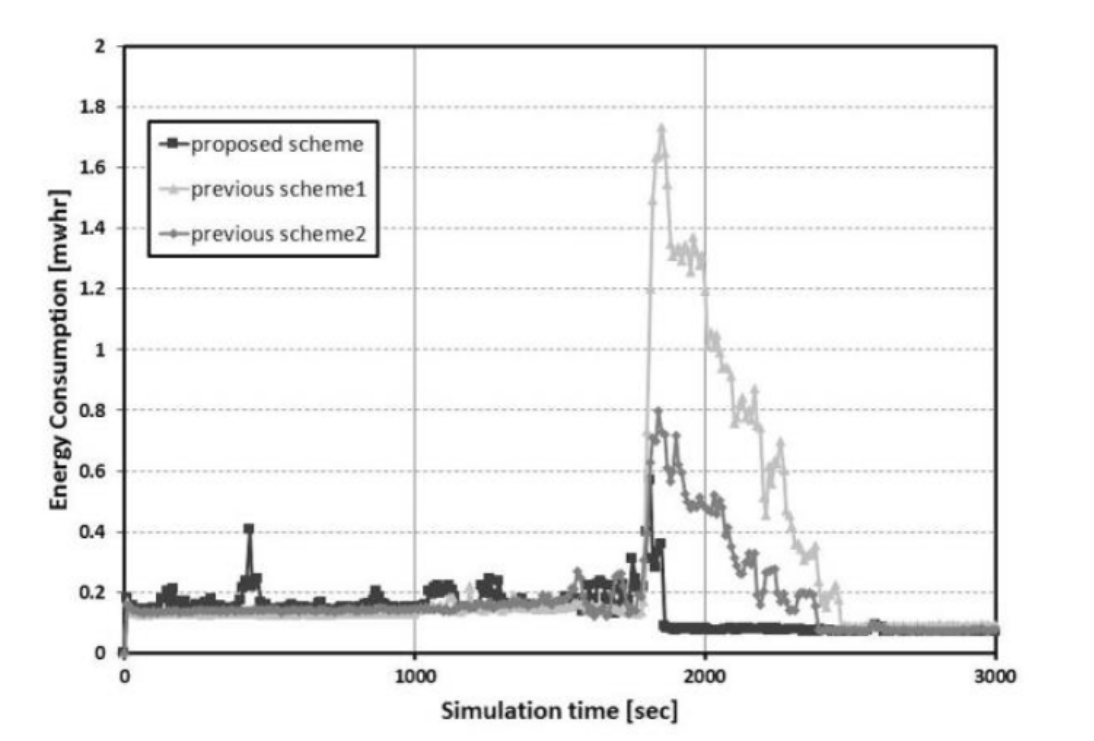


Total Packet Size [3]

Simulation Experiments

Results Obtained:

- Energy Distribution almost equal till t=1800 sec
- Sharp increase at t=1800 sec
- Proposed Scheme: Decrease afterwards is sharp
- Previous Schemes: Decrease afterwards is gradual



Energy Consumption per unit time [3]

Discussion

Ways to decrease Energy Consumption in MANETs[6]:

- **Energy Efficient Routing: Avoid Nodes with Low Battery remaining**
- **Scheduling Sleep Modes to avoid Battery Wastage**
- **Energy Conservation by changing Network Topology**
- **Methods like Aggregation for reducing Information to be delivered**

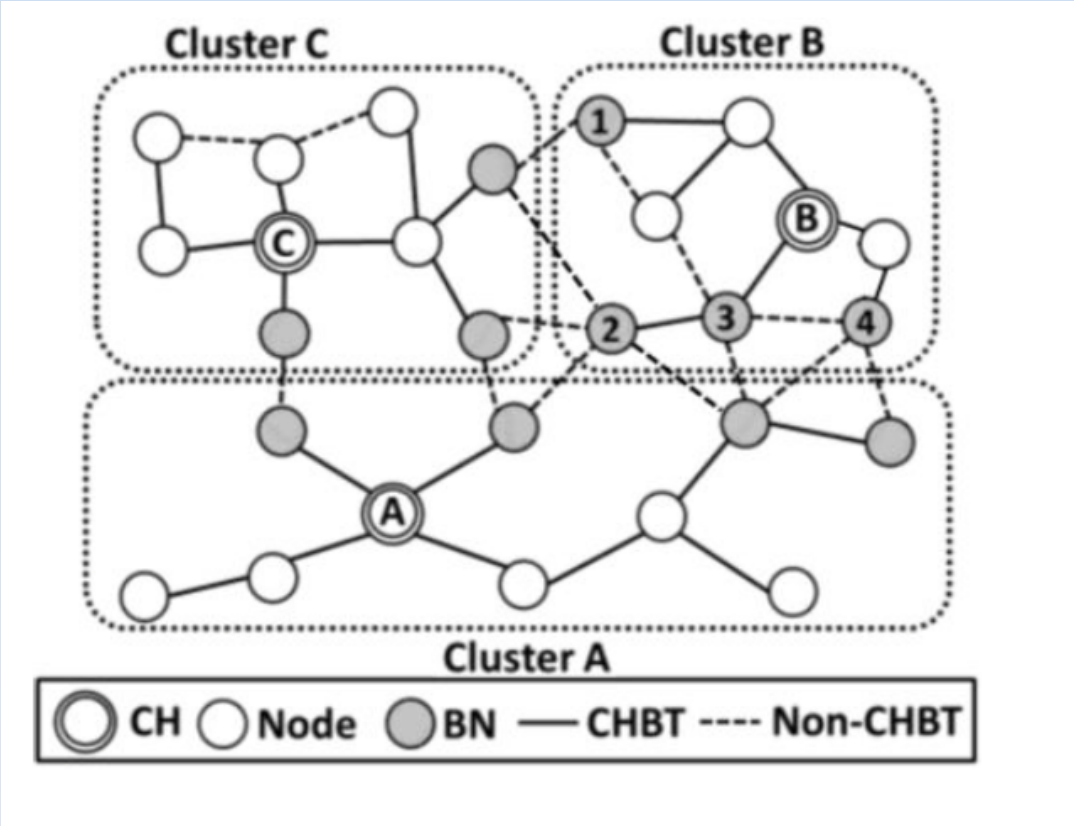
Discussion

Possible Improvement:

- **Combine Energy Efficient Routing with Proposed Scheme**
- **Choose node with more battery remaining instead of randomly choosing among similar nodes at Step 5 of Proposed Scheme**
- **May not cause decrease in Energy Consumption but may increase life of Network**
- **Battery information included in MAPs sent to CH**

Discussion

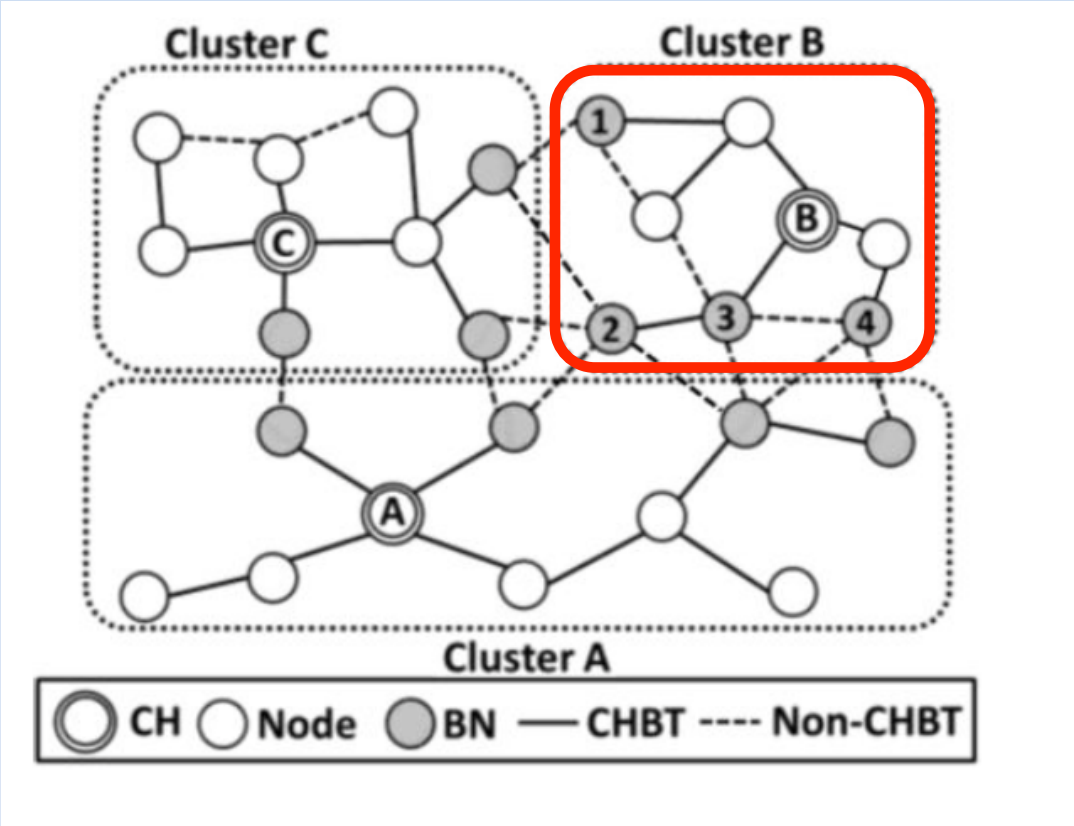
Possible Improvement Example:



Example Network for Application of New Scheme

Discussion

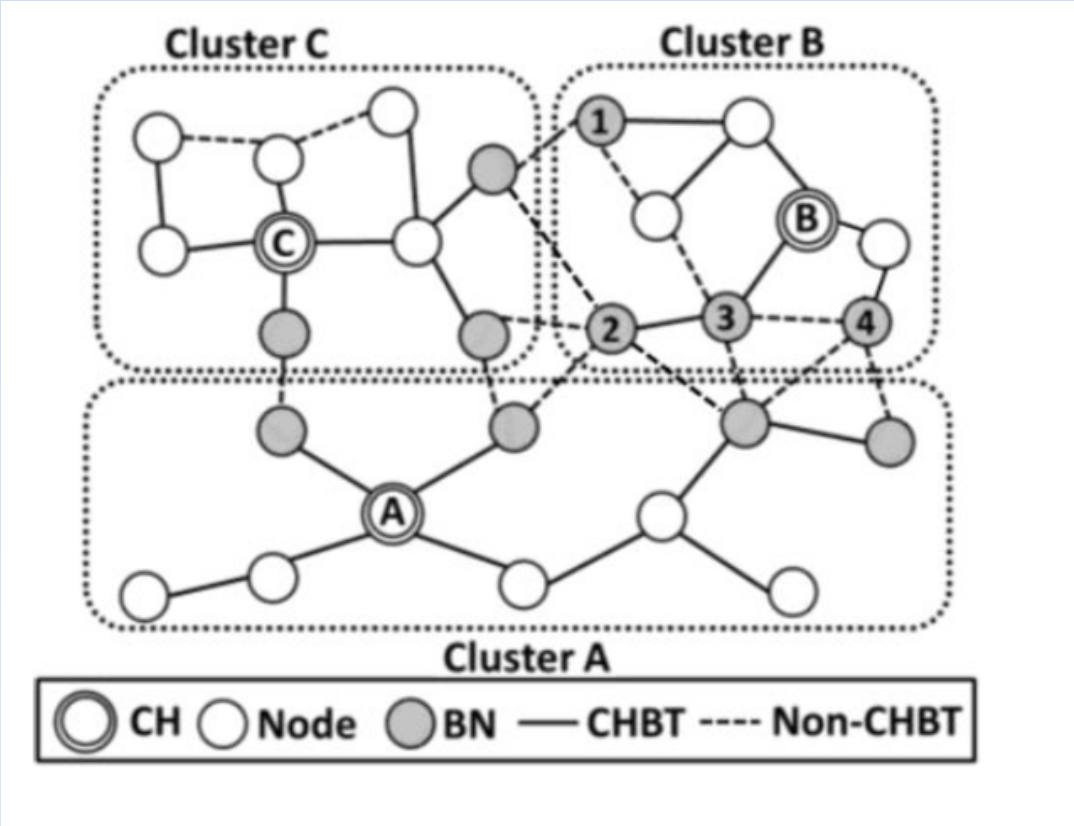
Possible Improvement Example:



Example Network for Application of New Scheme

Discussion

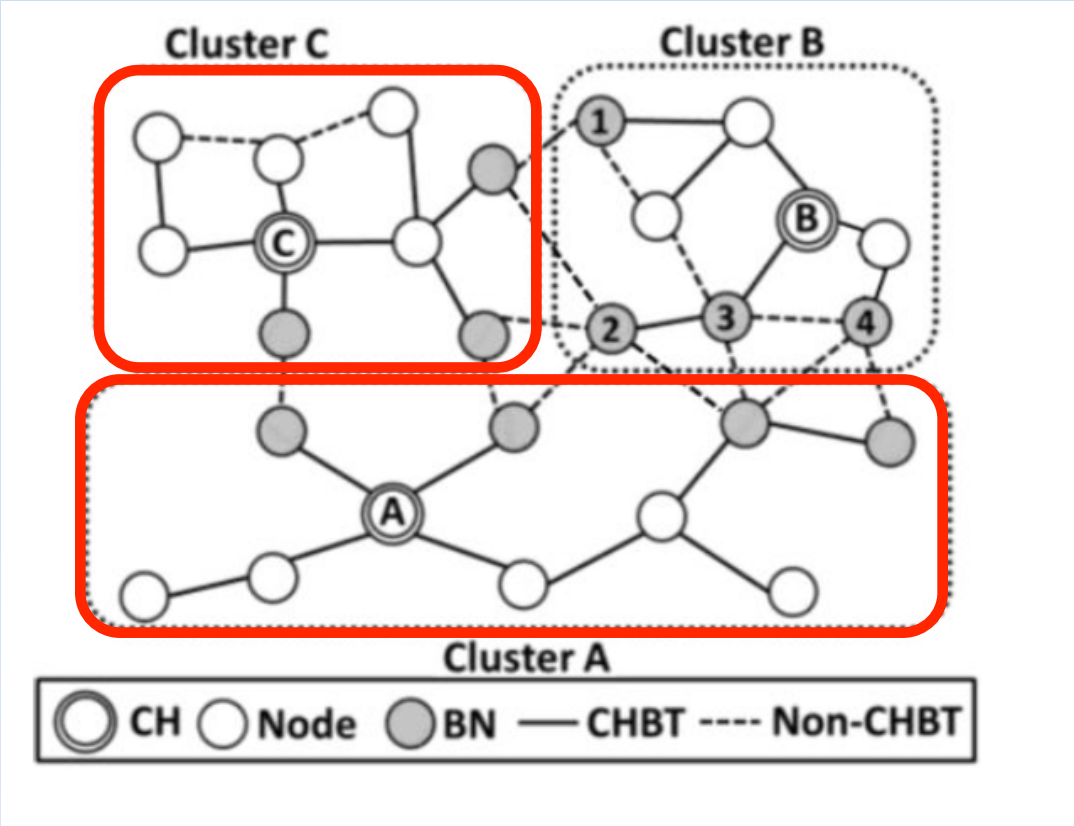
Possible Improvement Example:



Example Network for Application of New Scheme

Discussion

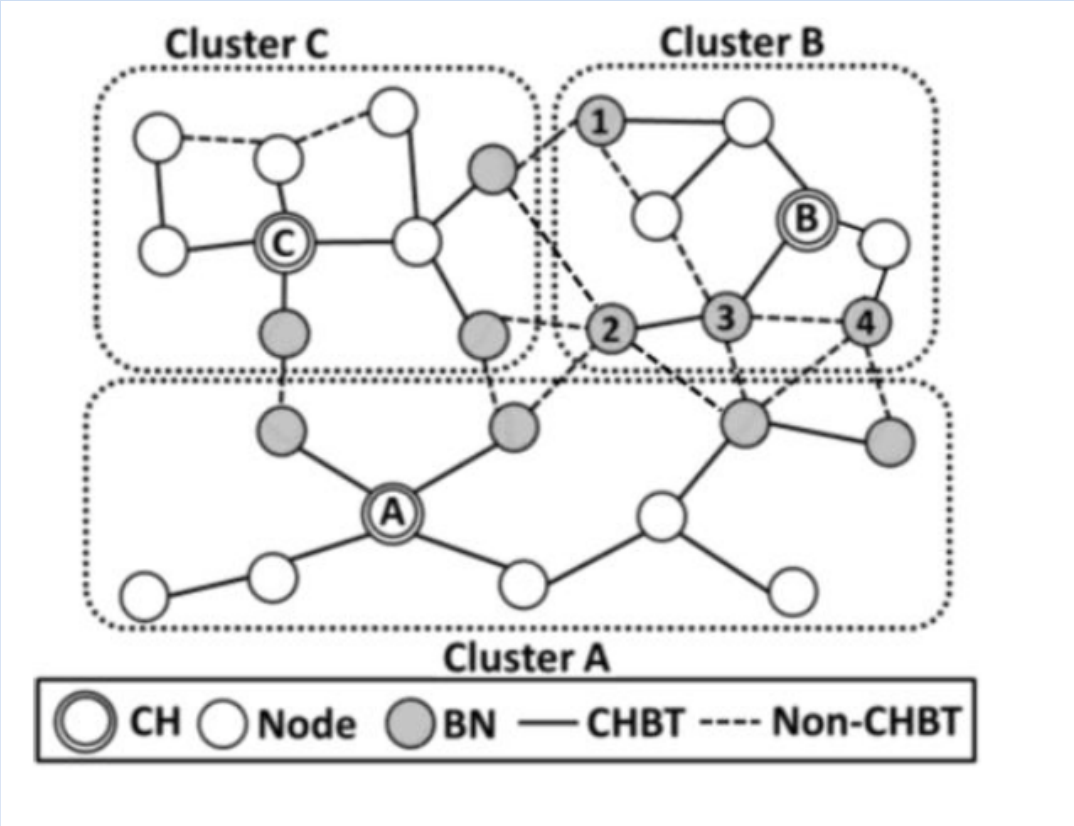
Possible Improvement Example:



Example Network for Application of New Scheme

Discussion

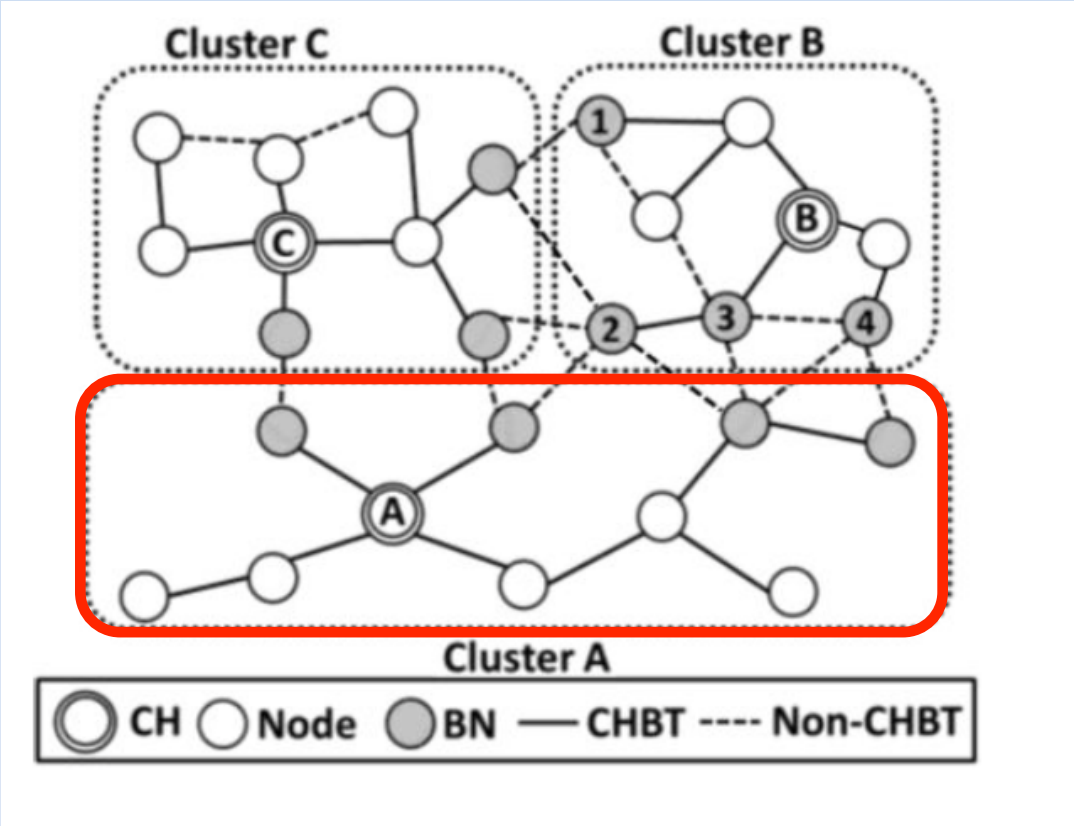
Possible Improvement Example:



Example Network for Application of New Scheme

Discussion

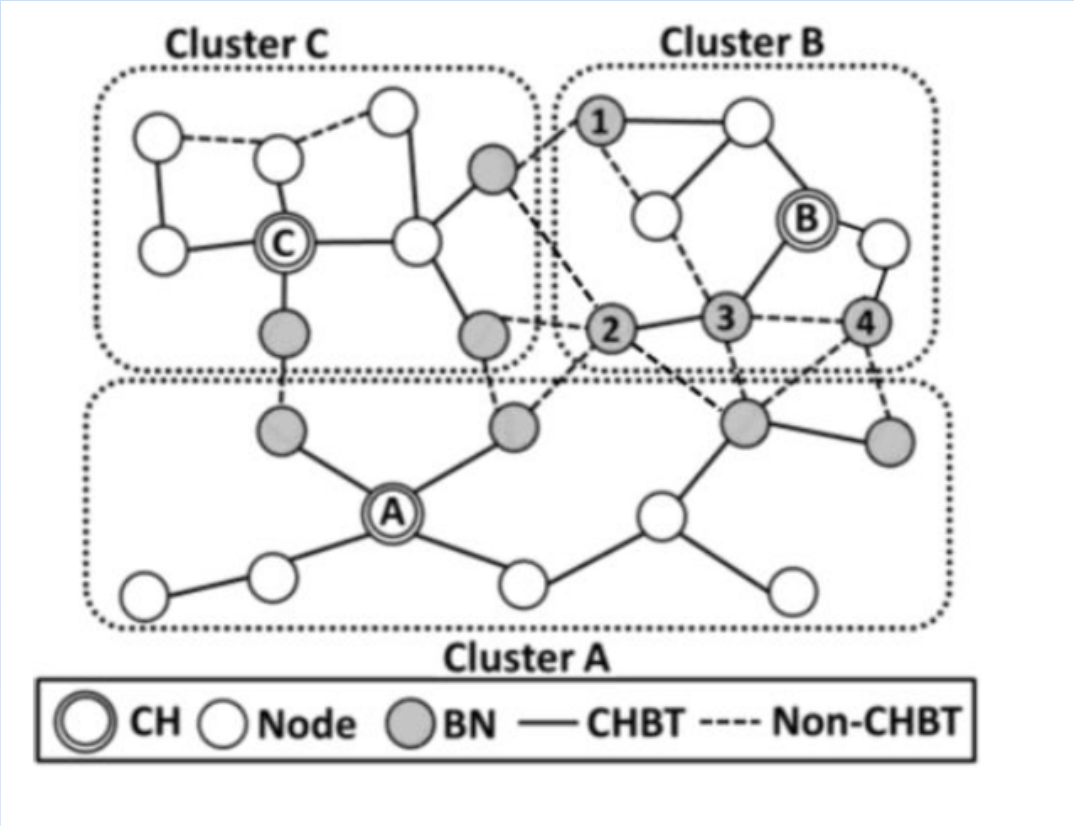
Possible Improvement Example:



Example Network for Application of New Scheme

Discussion

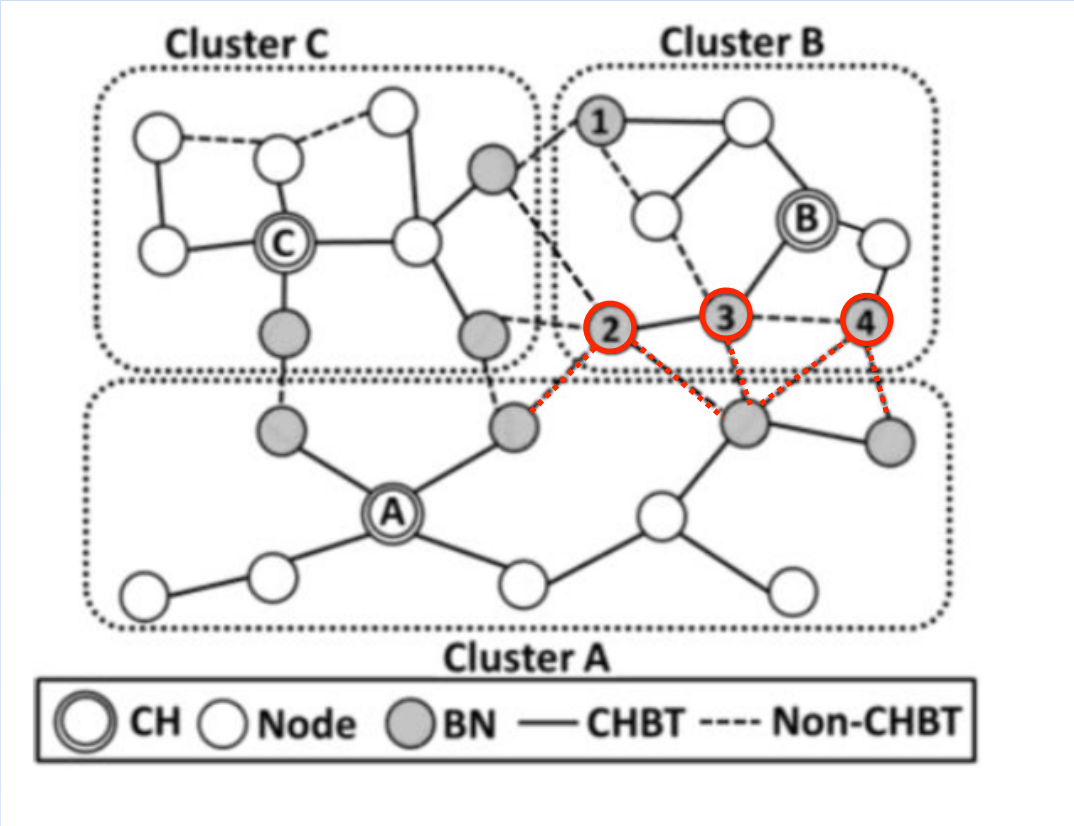
Possible Improvement Example:



Example Network for Application of New Scheme

Discussion

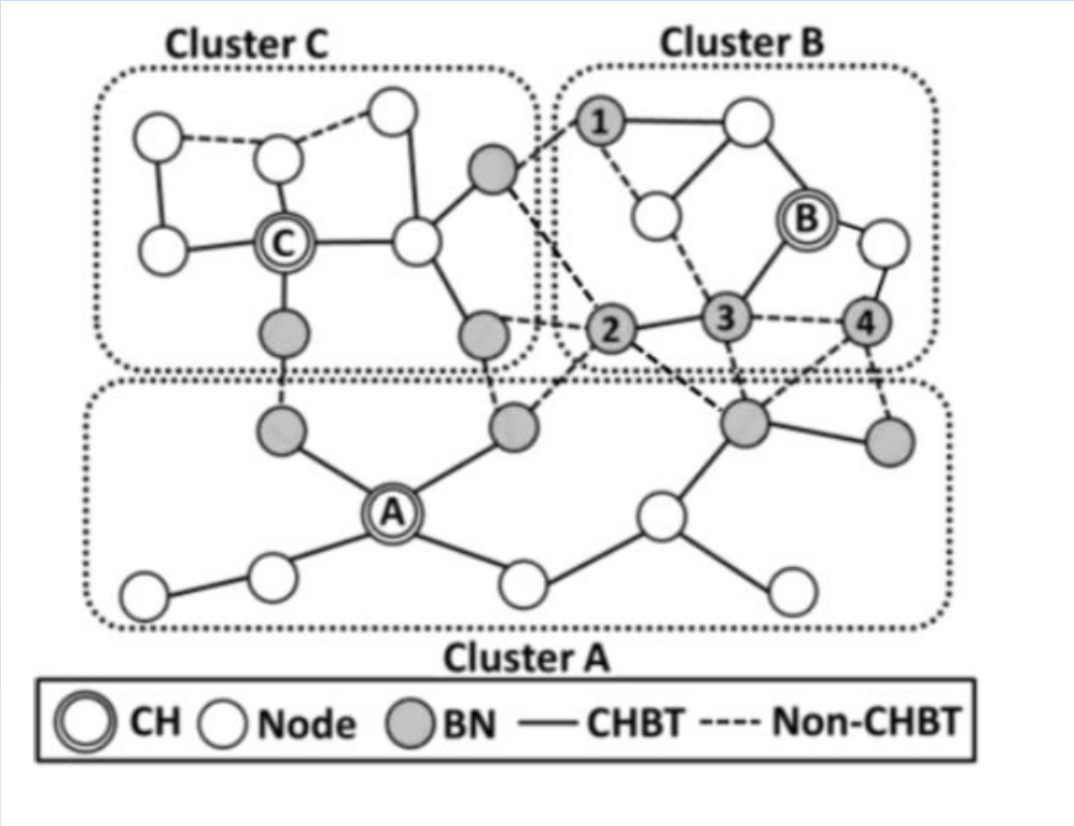
Possible Improvement Example:



Example Network for Application of New Scheme

Discussion

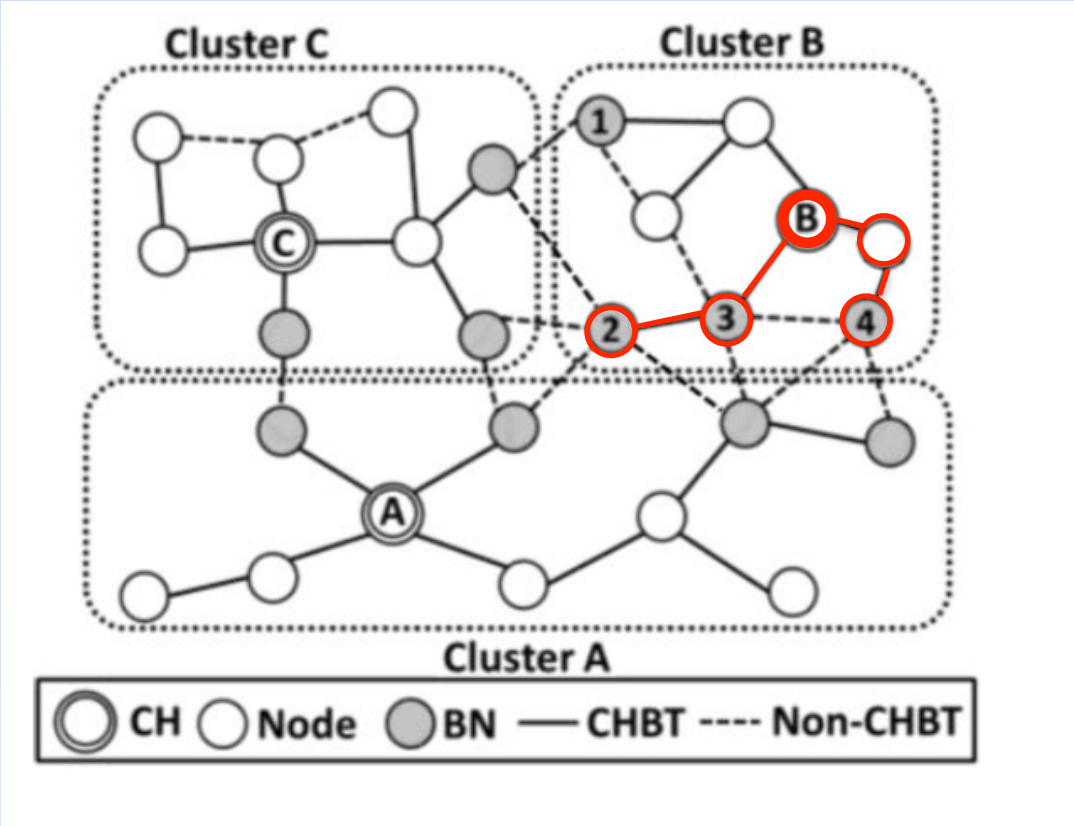
Possible Improvement Example:



Example Network for Application of New Scheme

Discussion

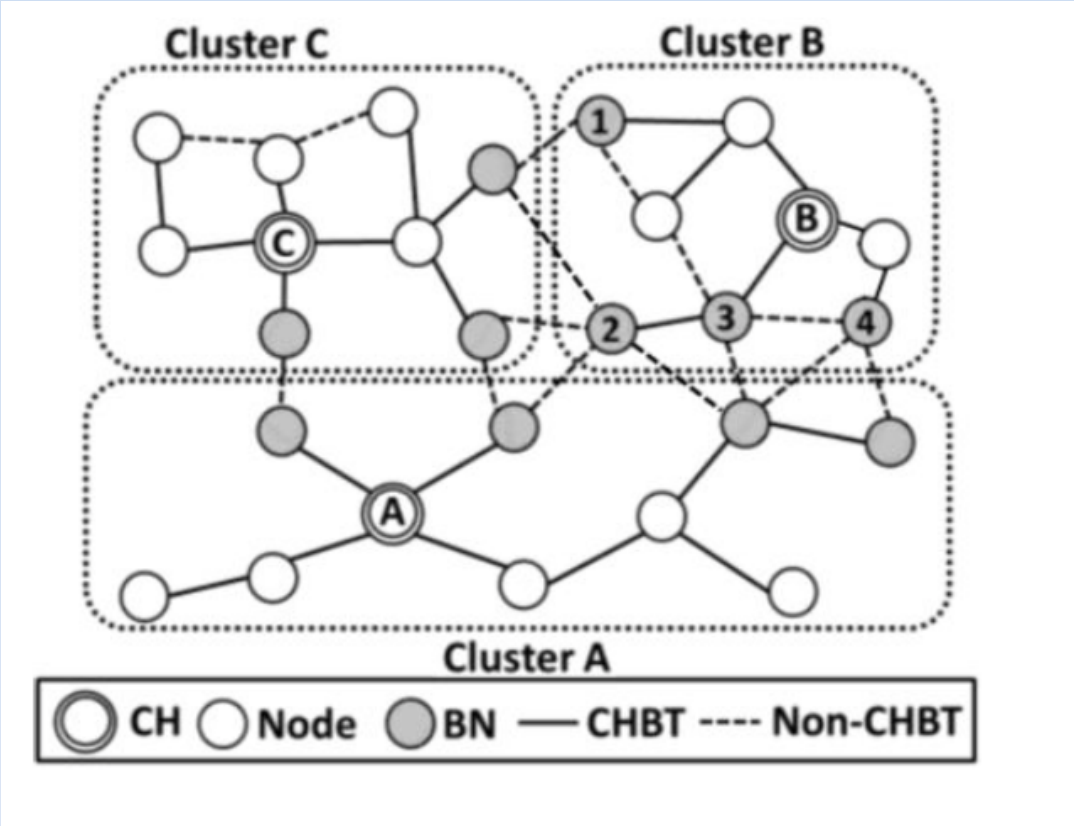
Possible Improvement Example:



Example Network for Application of New Scheme

Discussion

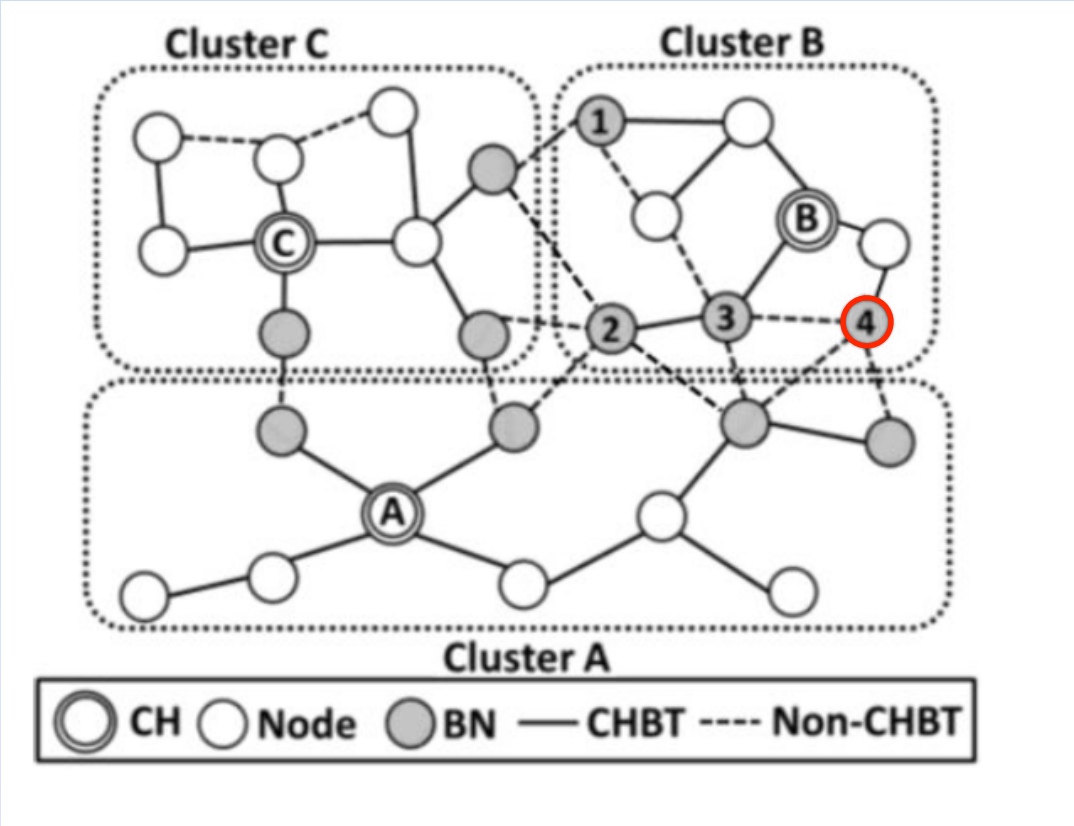
Possible Improvement Example:



Example Network for Application of New Scheme

Discussion

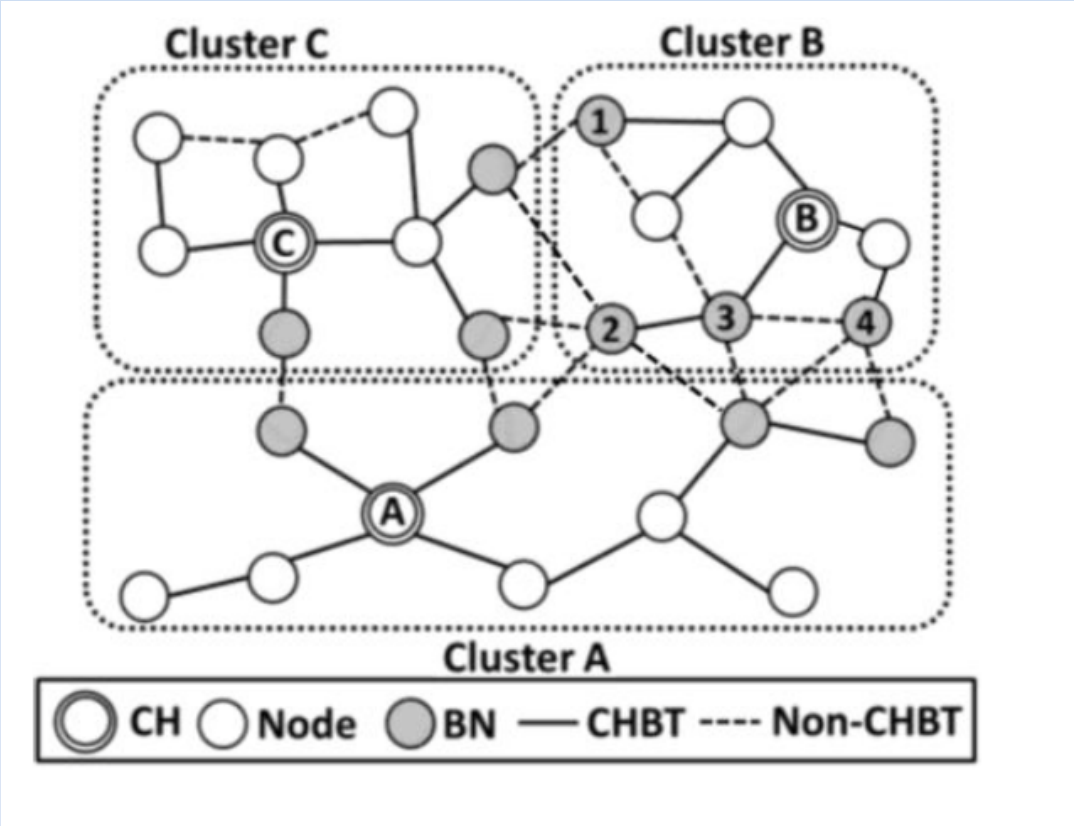
Possible Improvement Example:



Example Network for Application of New Scheme

Discussion

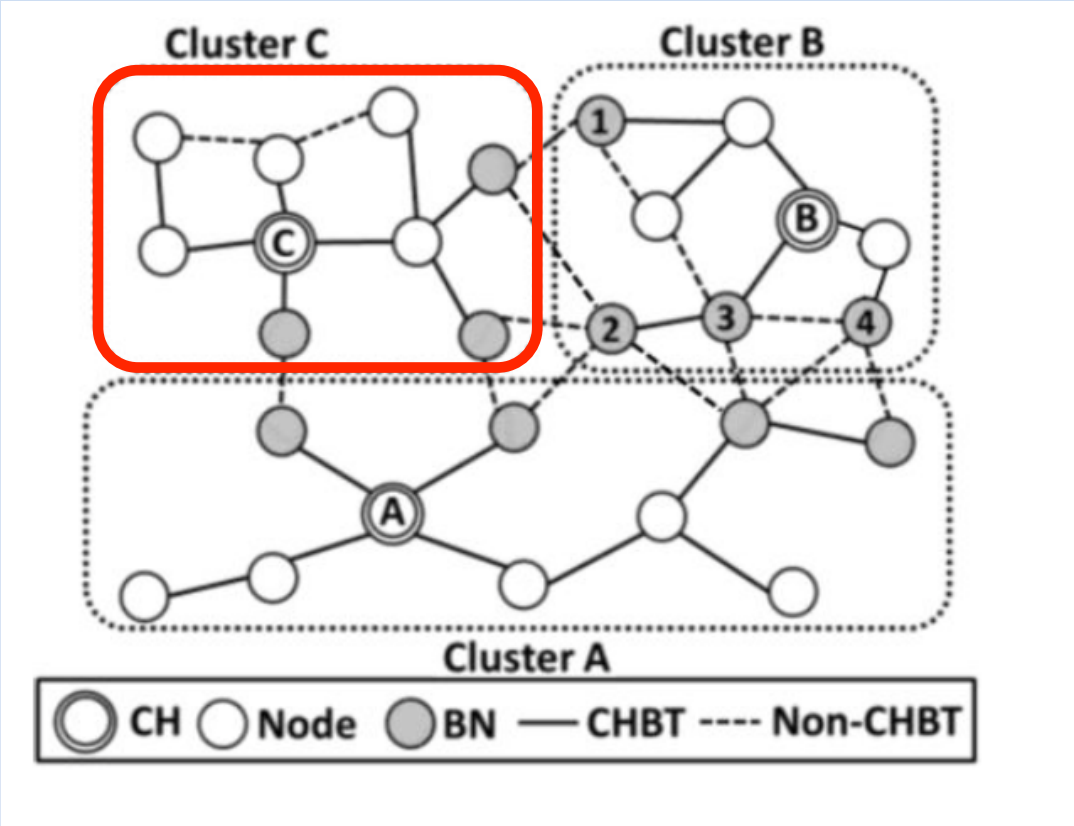
Possible Improvement Example:



Example Network for Application of New Scheme

Discussion

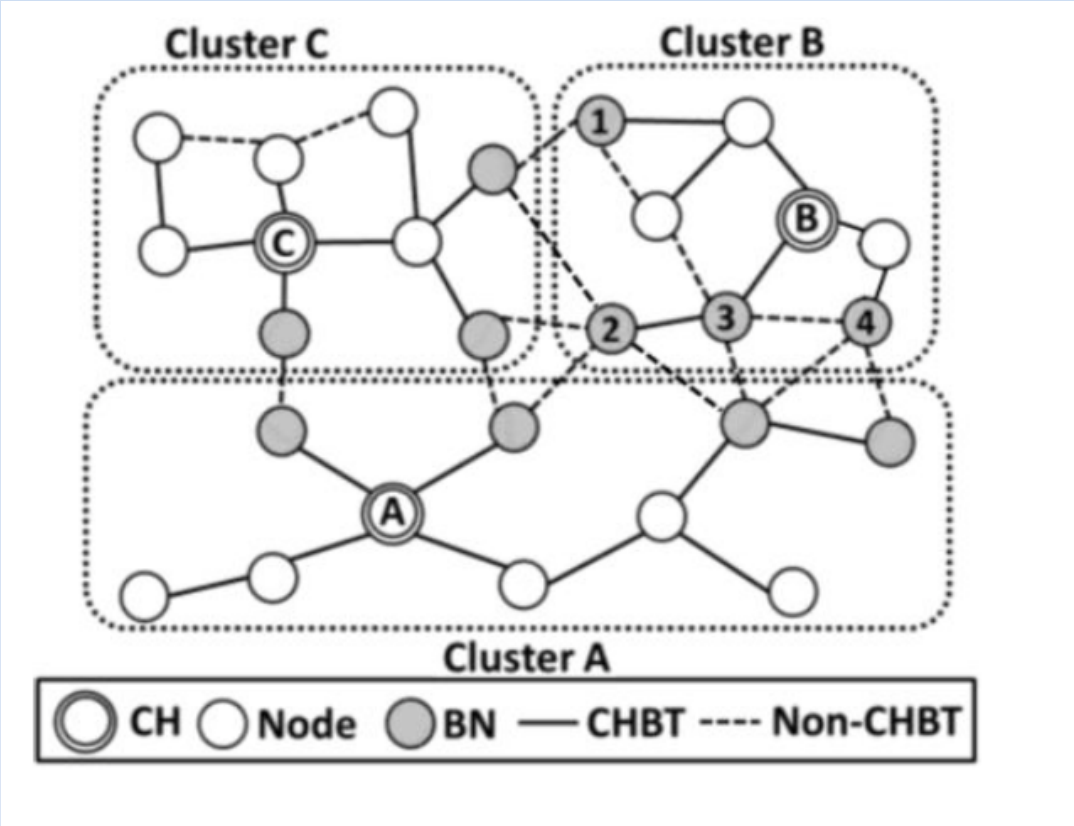
Possible Improvement Example:



Example Network for Application of New Scheme

Discussion

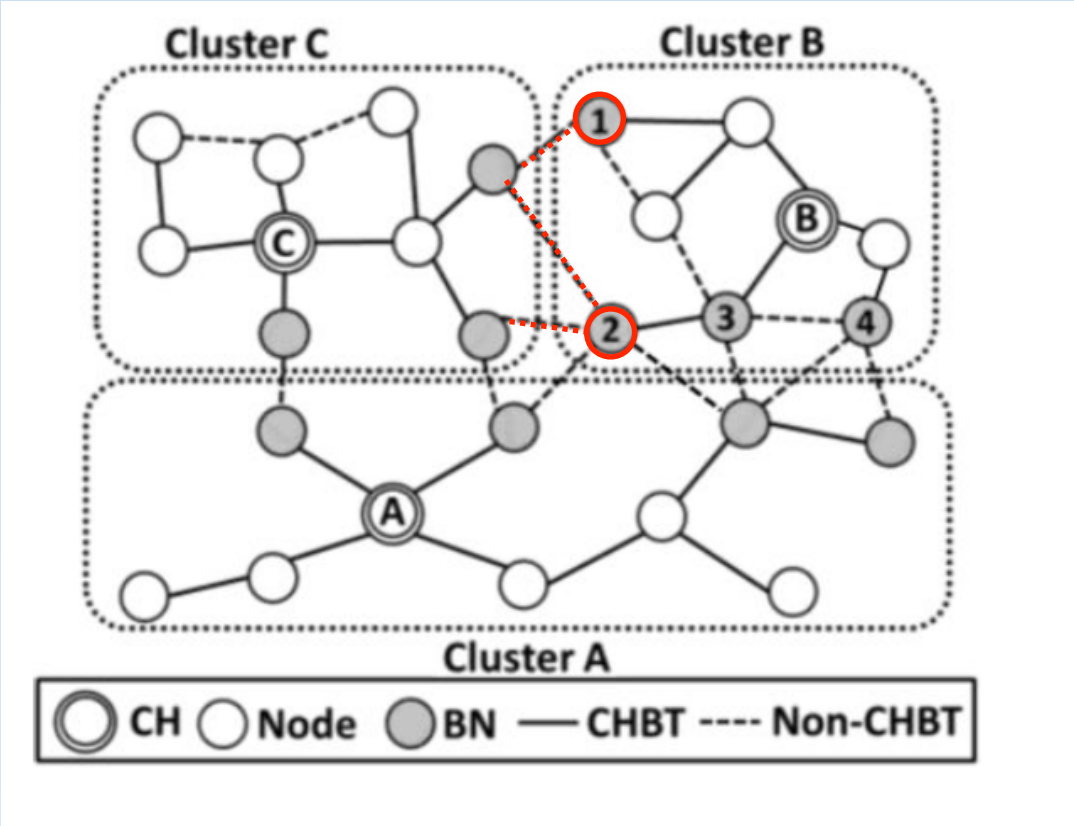
Possible Improvement Example:



Example Network for Application of New Scheme

Discussion

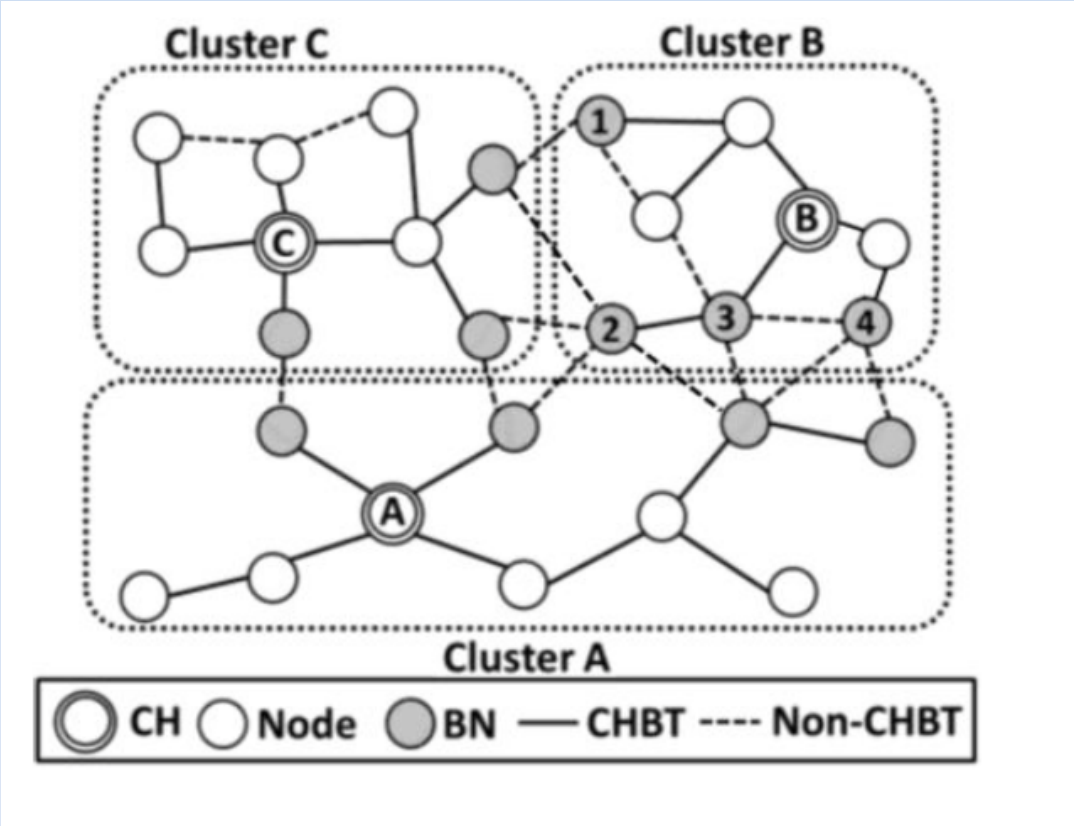
Possible Improvement Example:



Example Network for Application of New Scheme

Discussion

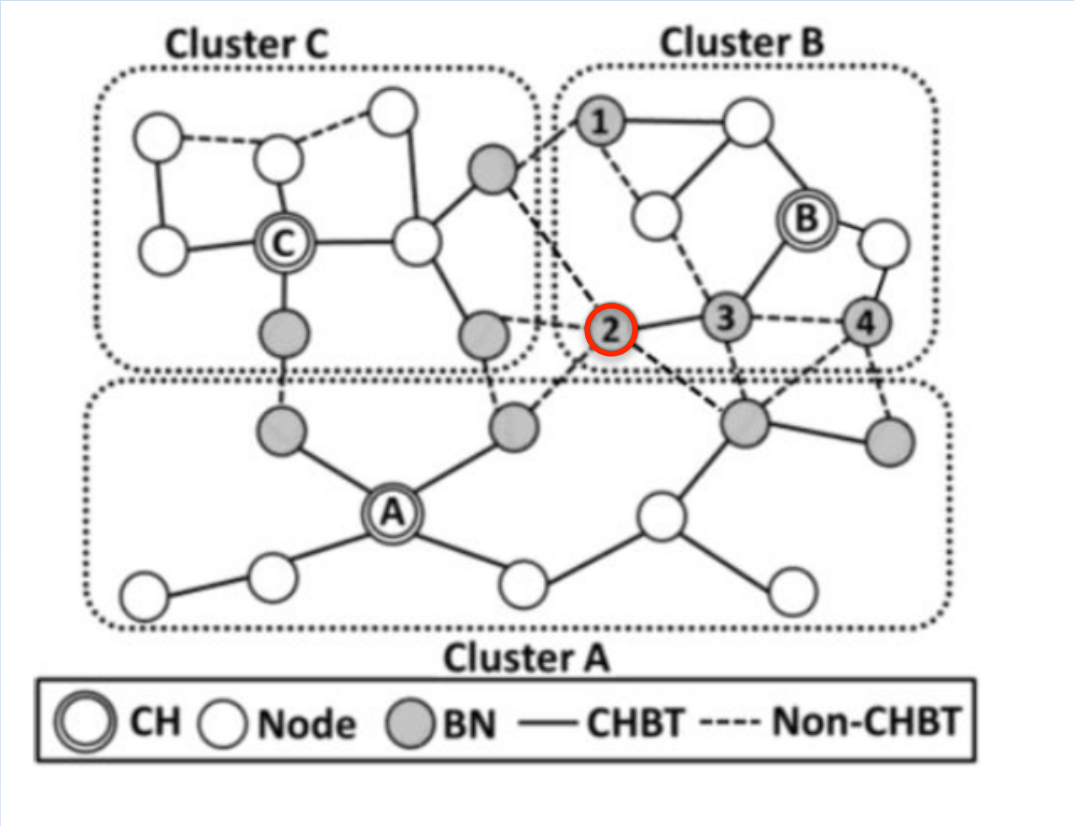
Possible Improvement Example:



Example Network for Application of New Scheme

Discussion

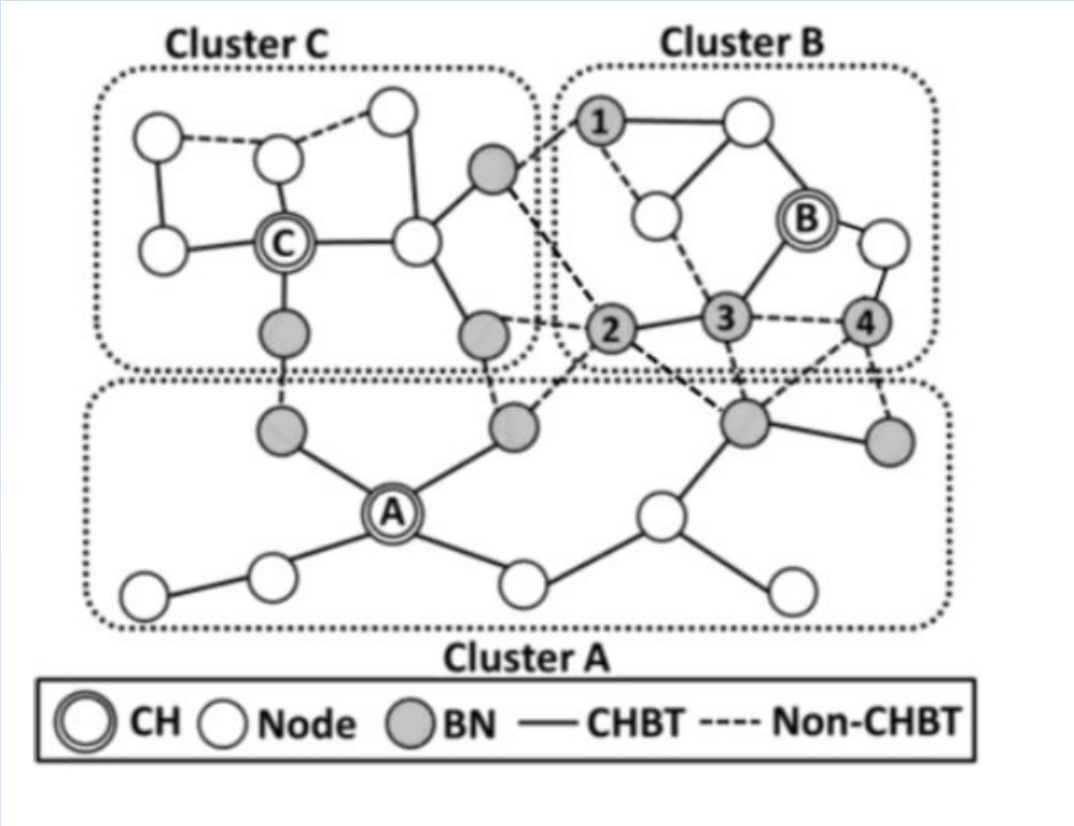
Possible Improvement Example:



Example Network for Application of New Scheme

Discussion

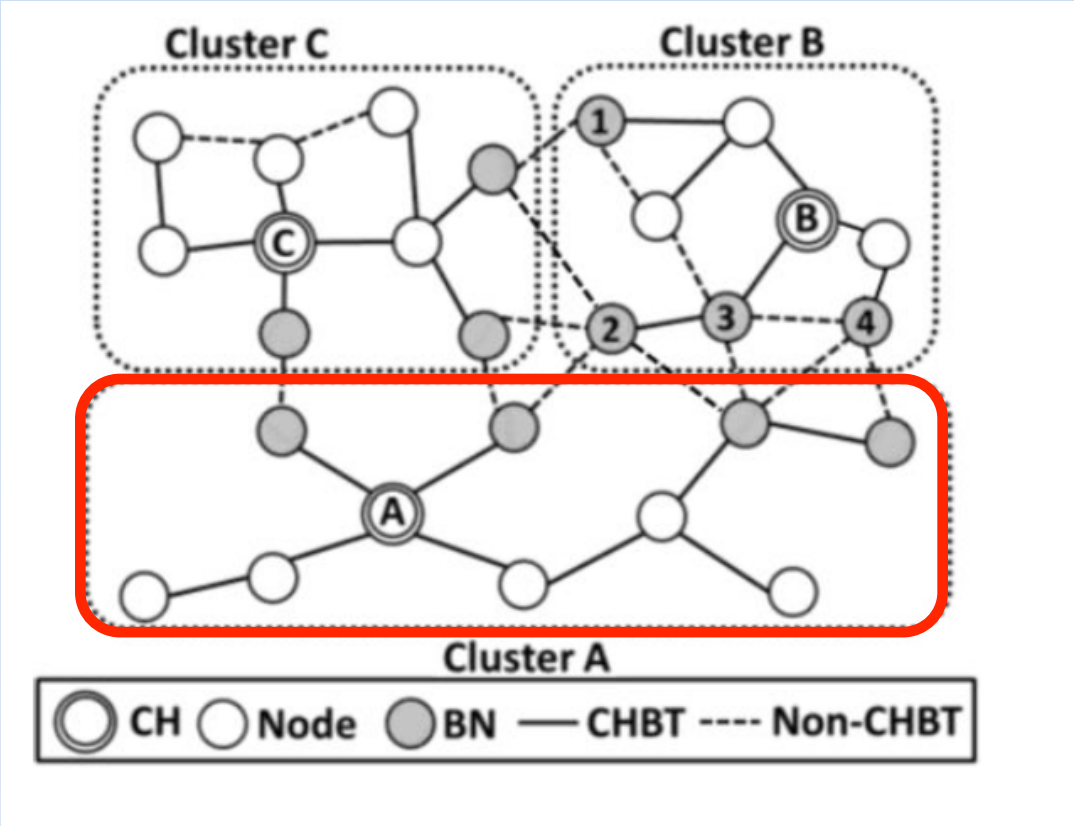
Possible Improvement Example:



Example Network for Application of New Scheme

Discussion

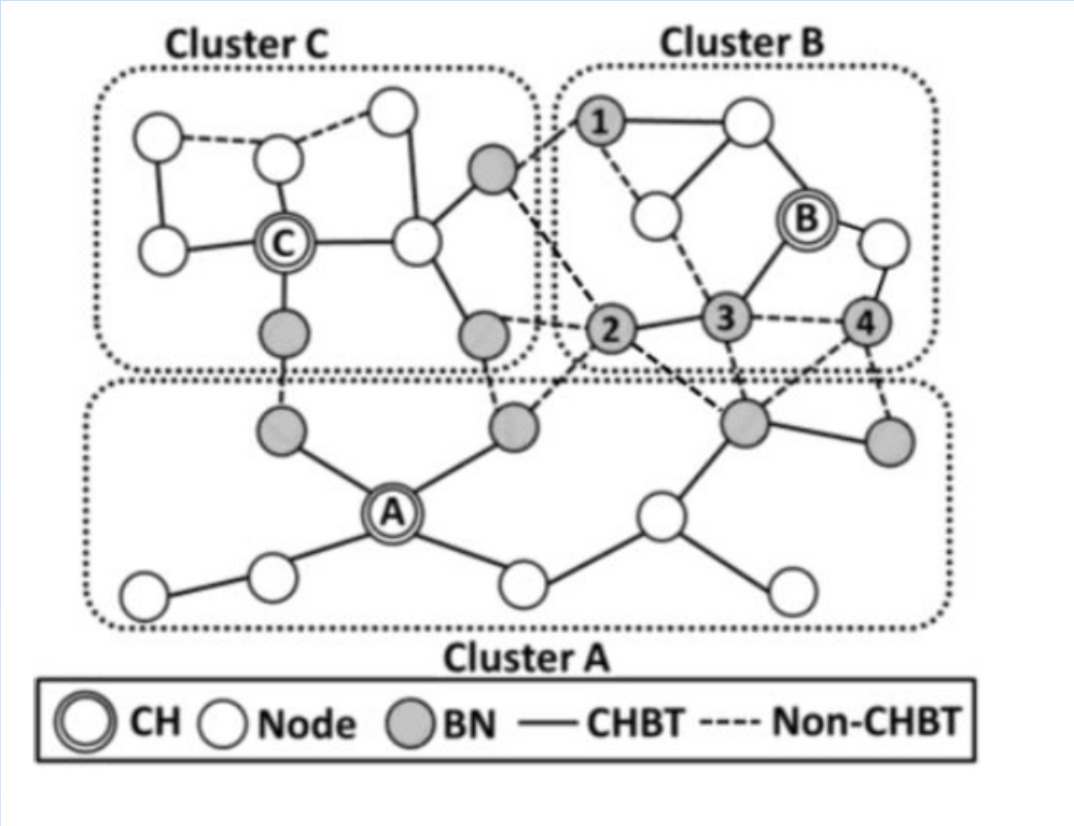
Possible Improvement Example:



Example Network for Application of New Scheme

Discussion

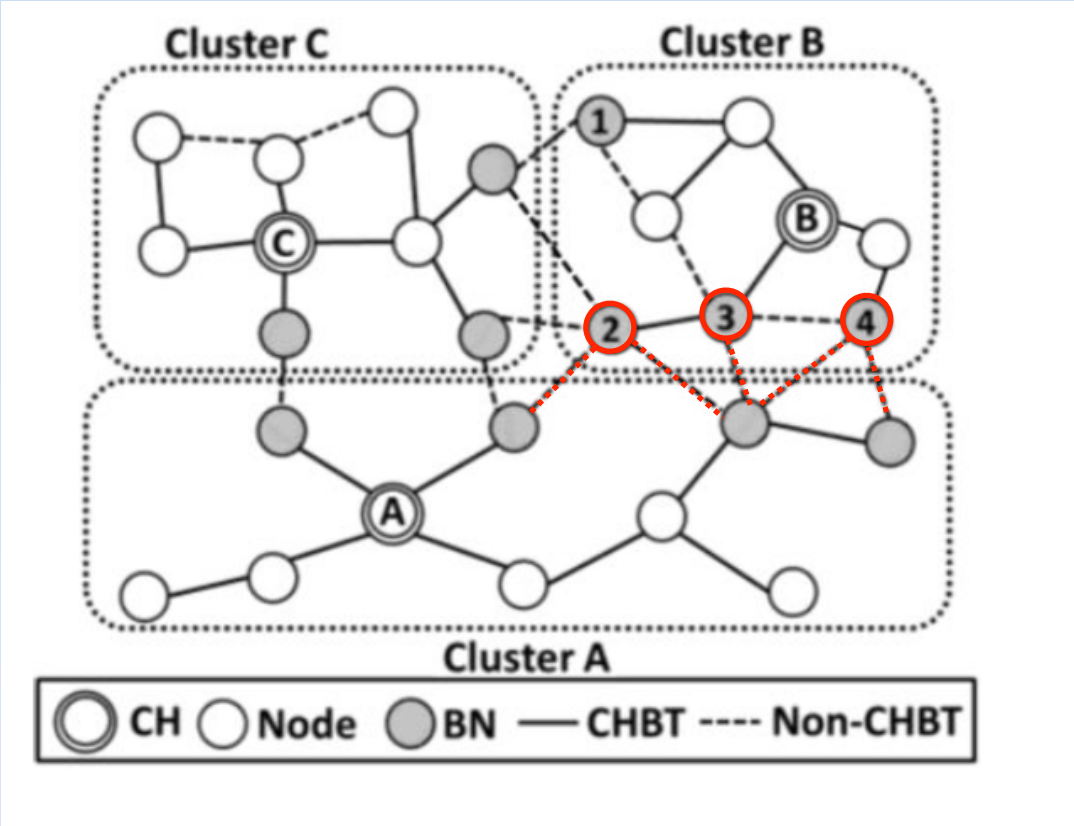
Possible Improvement Example:



Example Network for Application of New Scheme

Discussion

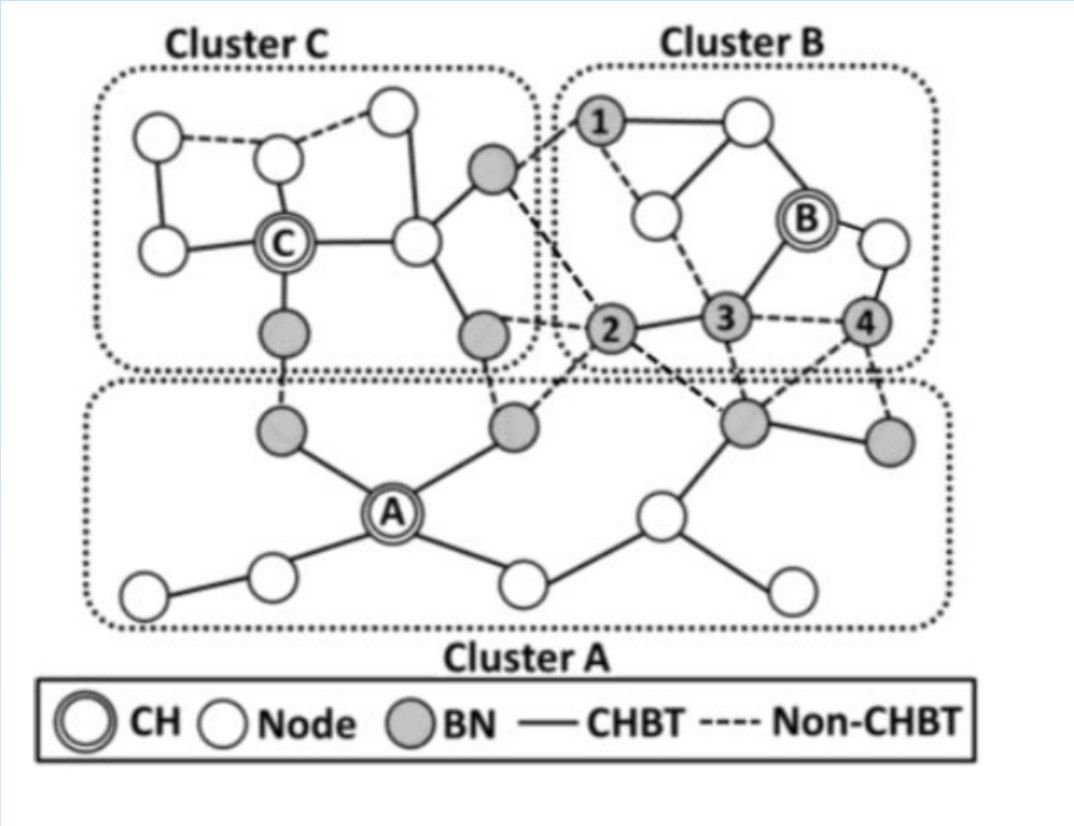
Possible Improvement Example:



Example Network for Application of New Scheme

Discussion

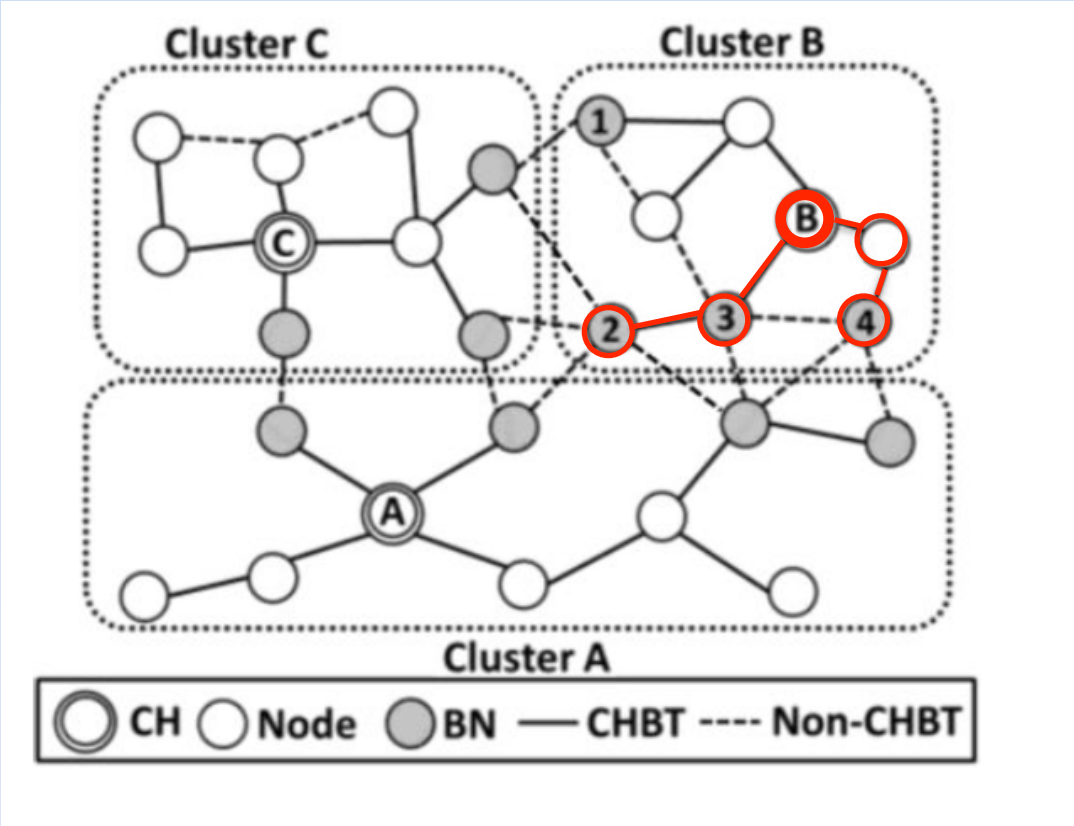
Possible Improvement Example:



Example Network for Application of New Scheme

Discussion

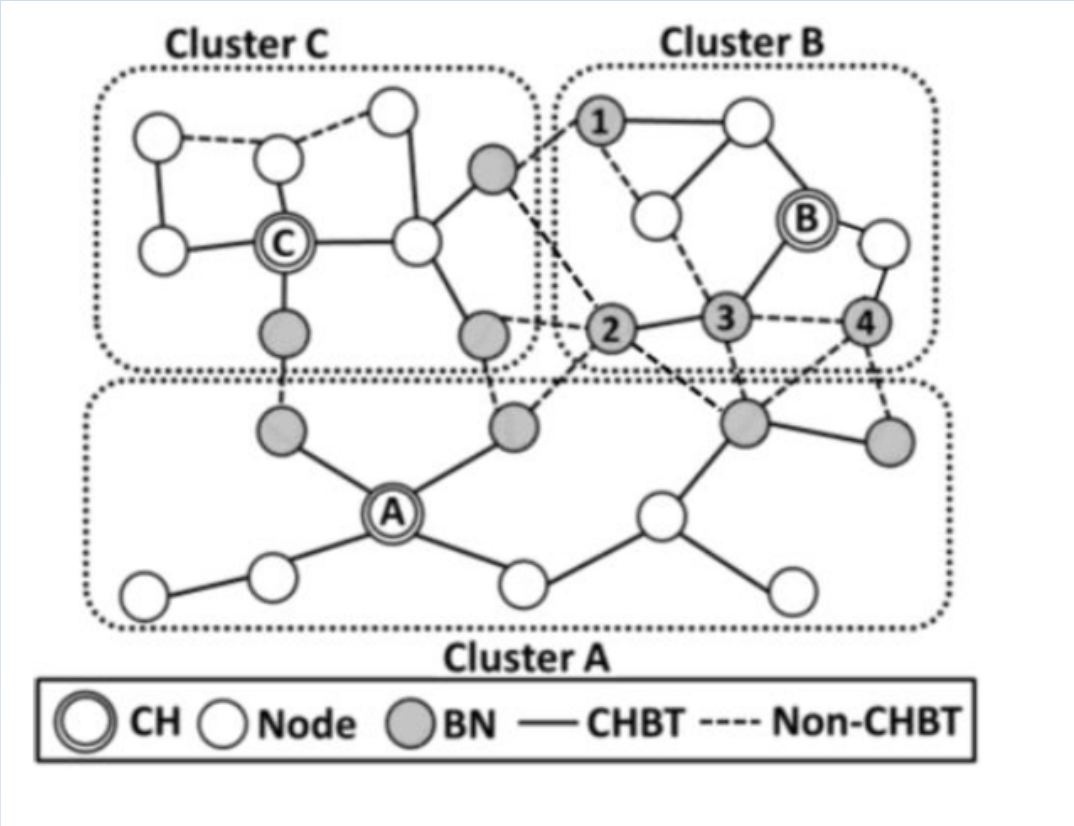
Possible Improvement Example:



Example Network for Application of New Scheme

Discussion

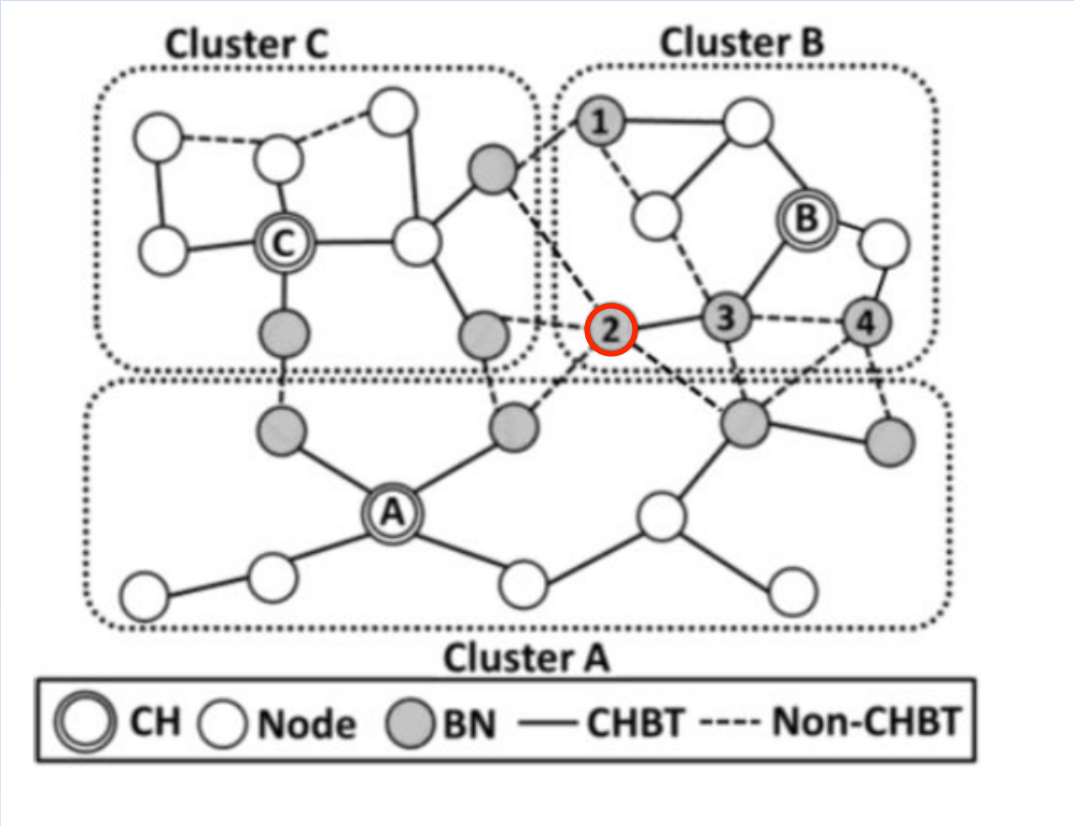
Possible Improvement Example:



Example Network for Application of New Scheme

Discussion

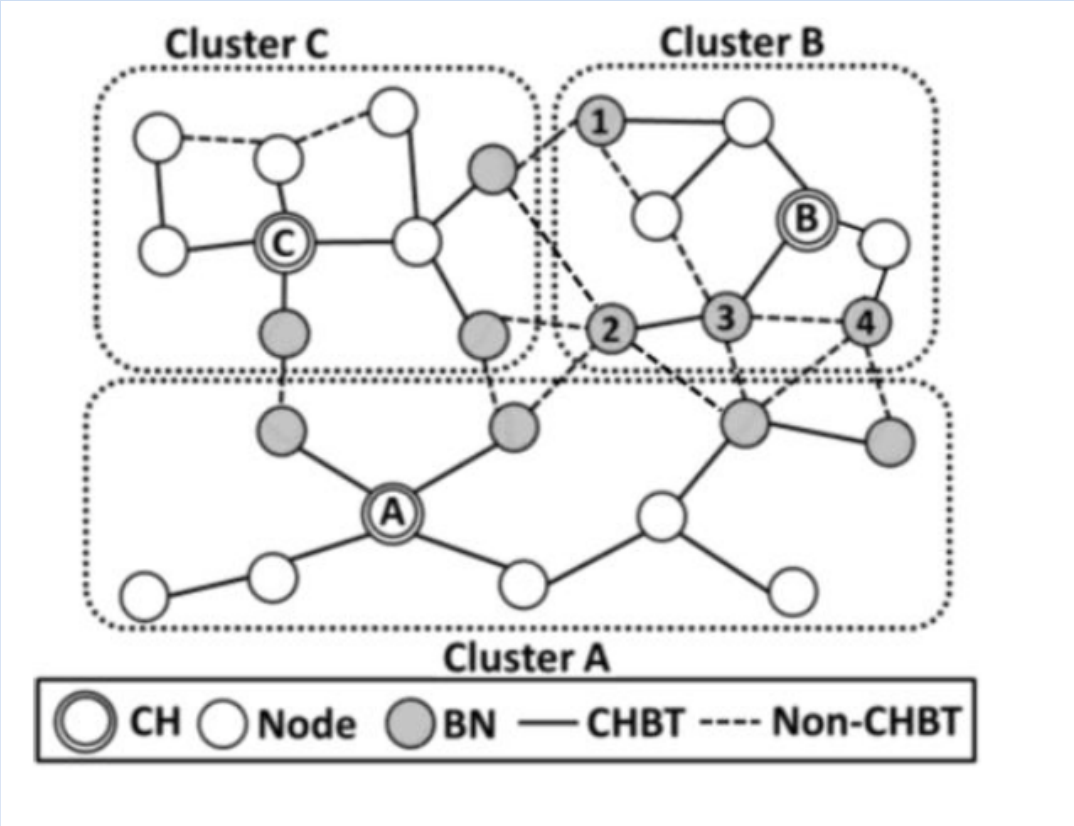
Possible Improvement Example:



Example Network for Application of New Scheme

Discussion

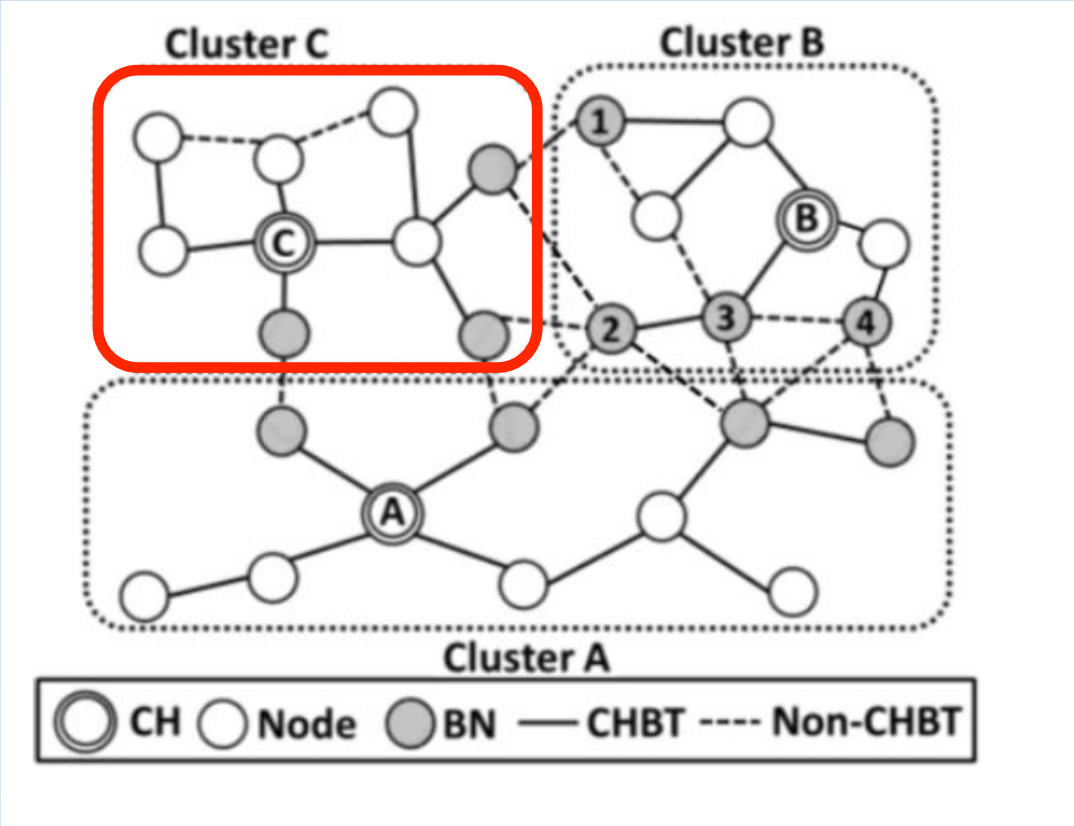
Possible Improvement Example:



Example Network for Application of New Scheme

Discussion

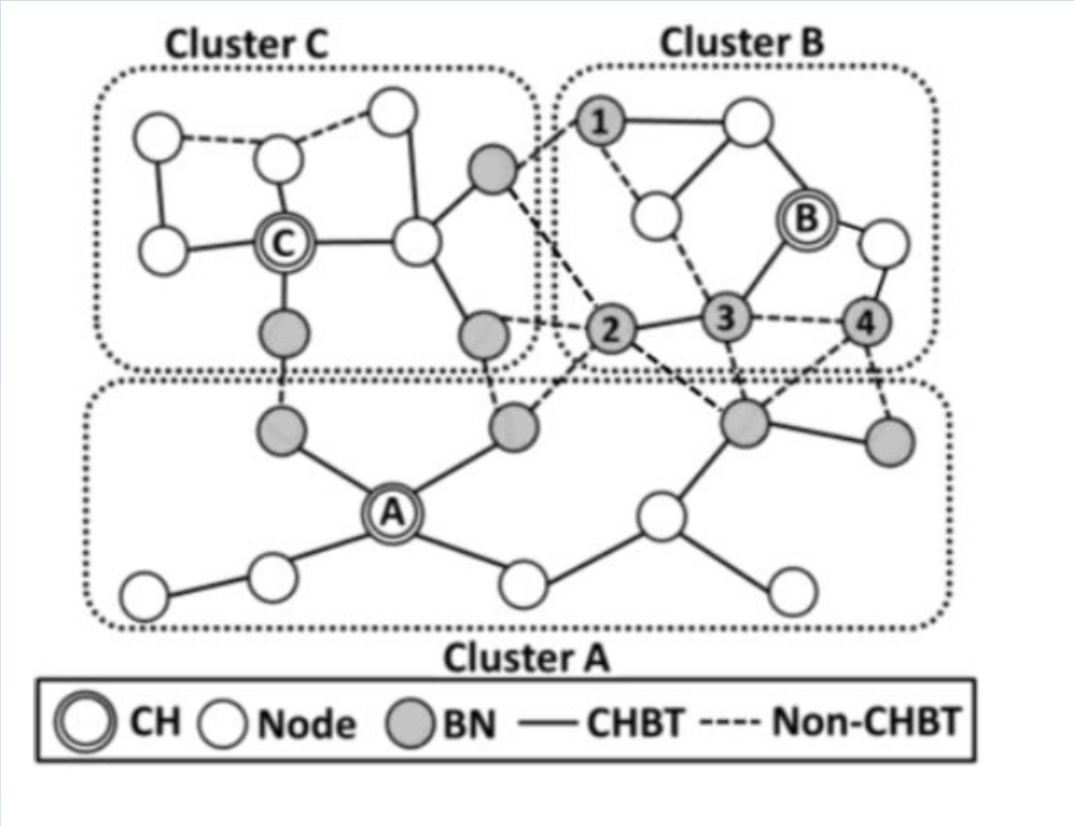
Possible Improvement Example:



Example Network for Application of New Scheme

Discussion

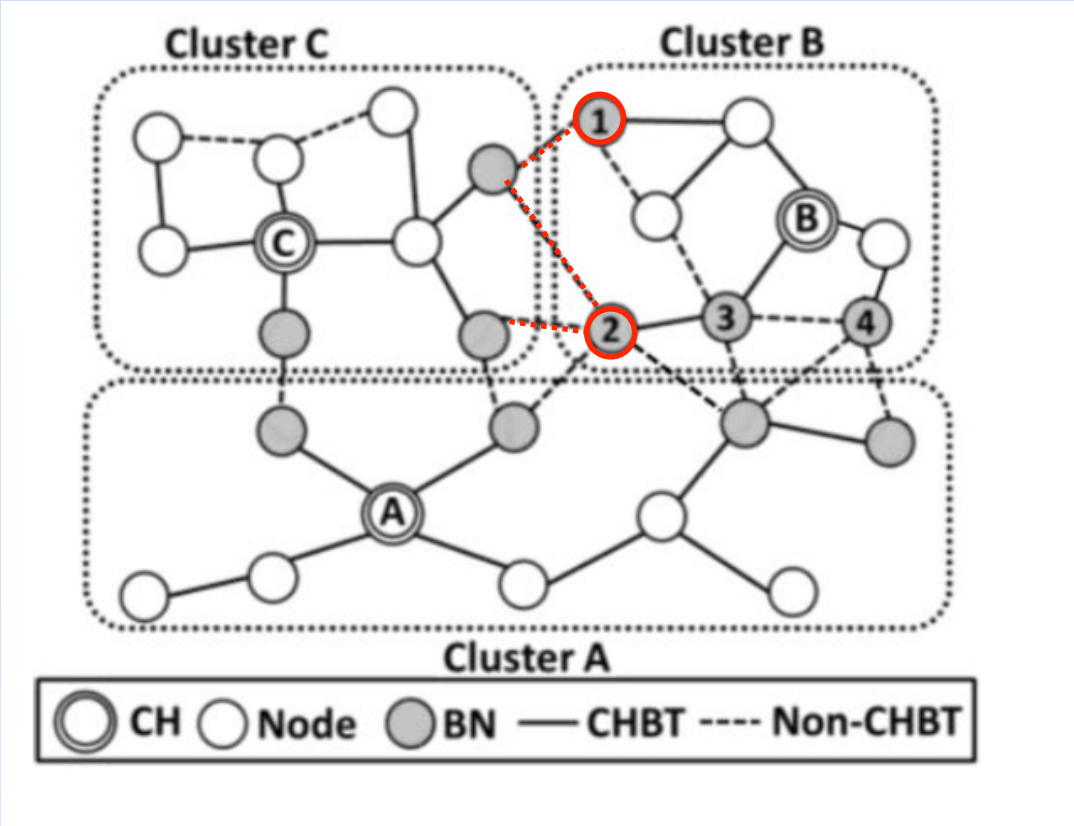
Possible Improvement Example:



Example Network for Application of New Scheme

Discussion

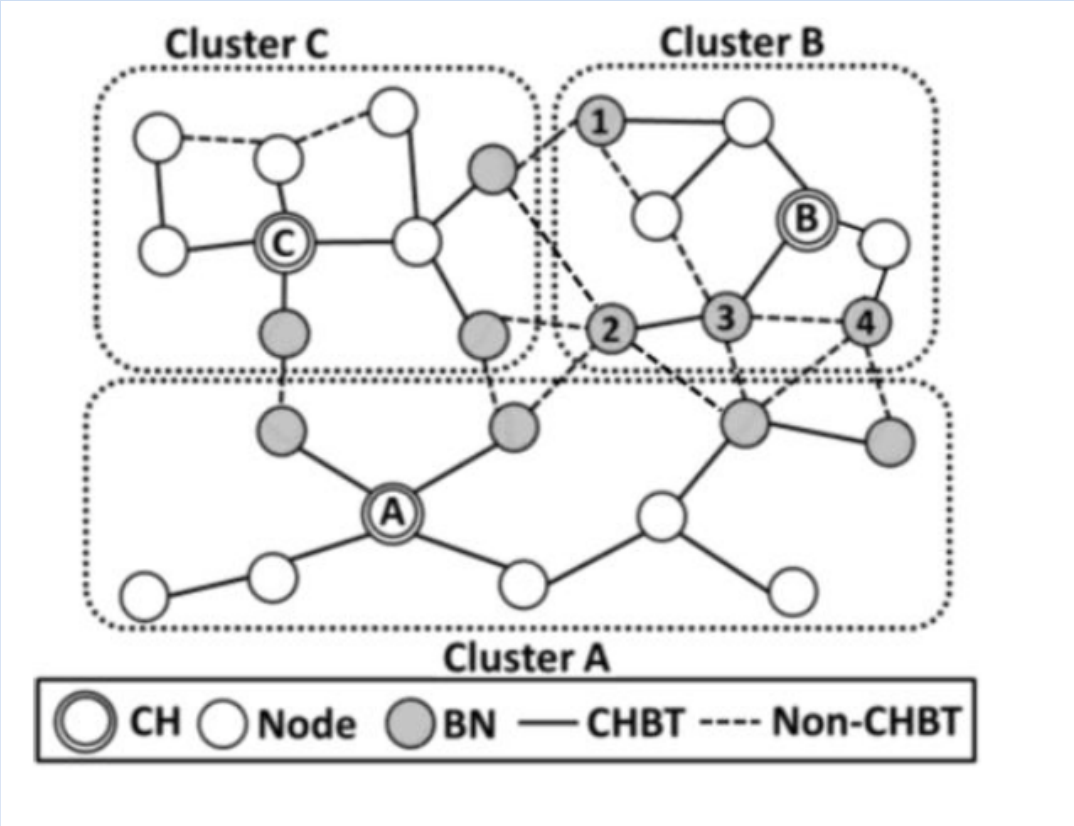
Possible Improvement Example:



Example Network for Application of New Scheme

Discussion

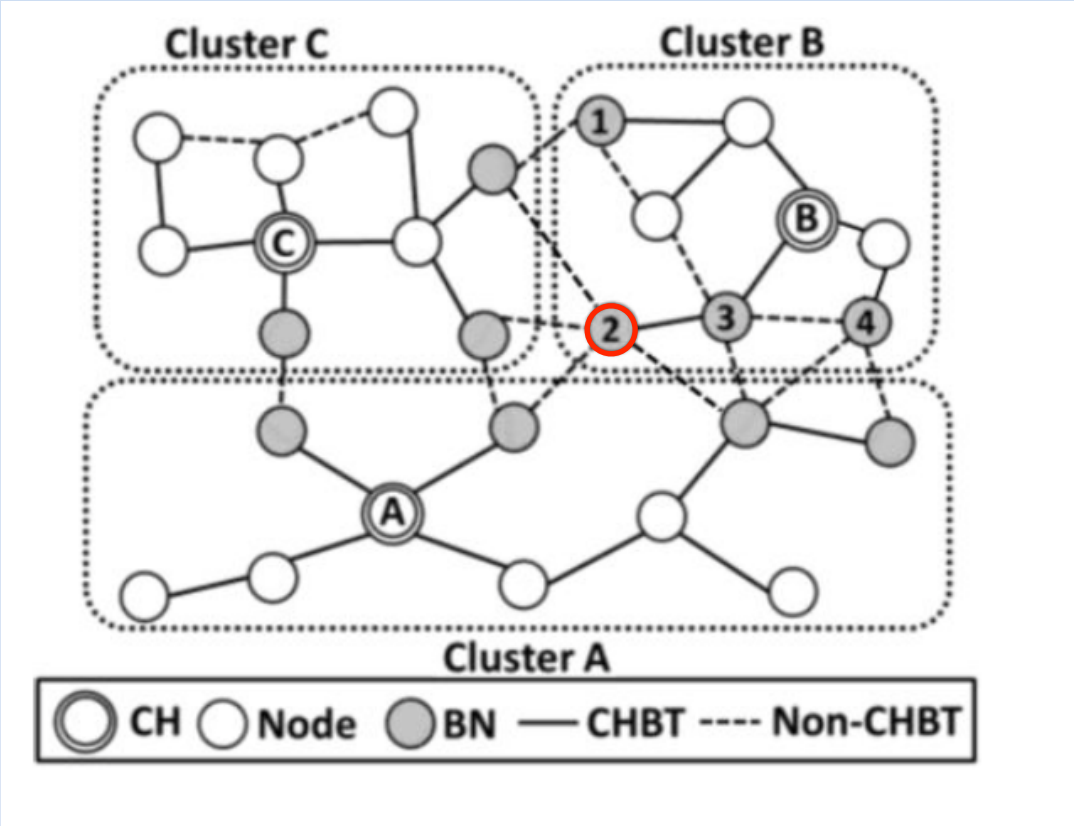
Possible Improvement Example:



Example Network for Application of New Scheme

Discussion

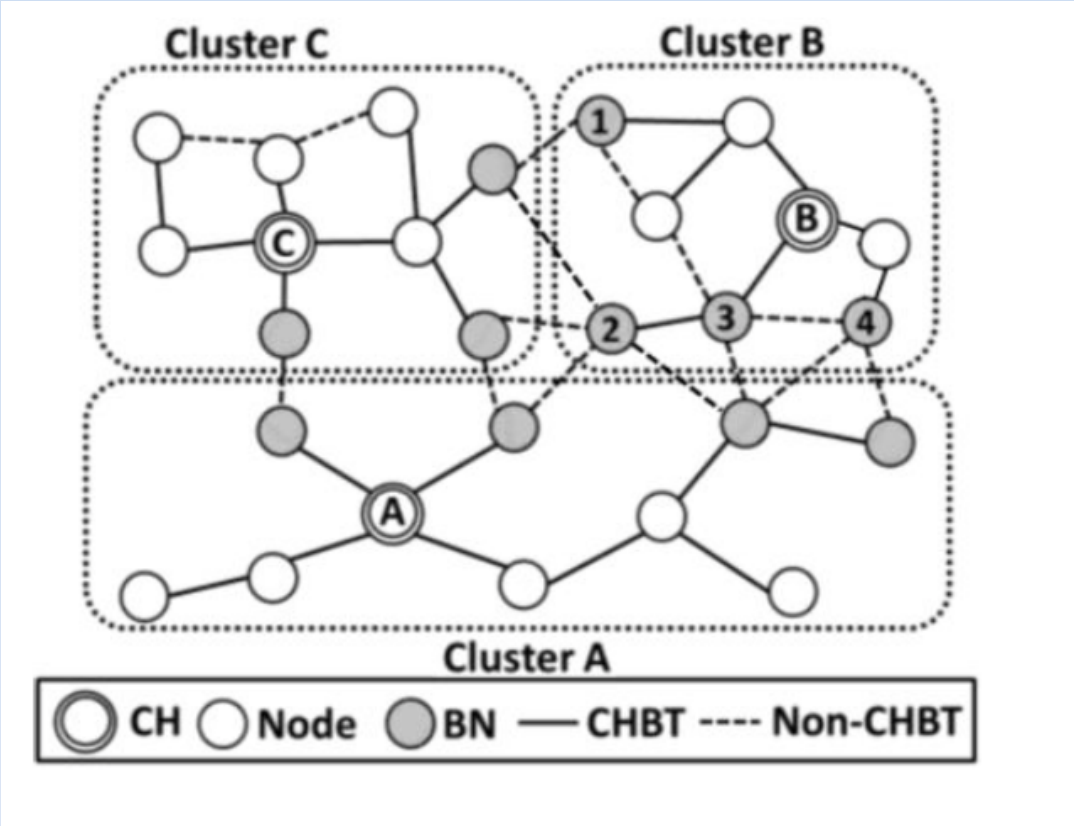
Possible Improvement Example:



Example Network for Application of New Scheme

Discussion

Possible Improvement Example:



Example Network for Application of New Scheme

Conclusion

- **Autonomous Clustering : No Energy Distribution based on Node Density**
- **Self Organised Transmission Control Scheme: One-way Inter Cluster communication problem**
- **Proposed Scheme: Energy Consumption Reduction without affecting Data Reachability**
- **Further enhancement possible by combining Proposed Scheme with methods like Energy Efficient Routing**
- **Reduced Energy Consumption methods foreseeable in future**

References

[1] Yoshiaki Kakuda, Tomoyuki Ohta, and Miroslaw Malek,"Self- Organizing Real-Time Services in Mobile Ad Hoc Networks",Self- Organization in Embedded Real-Time Systems, Chapter 3, pp. 55-74, 2013.

[2] Kenji Yui, Shinji Inoue and Yoshiaki Kakuda,"A self-organized clustering for transmission power control adapting to change of node density in MANETs",Proc. First International Symposium on Computing and Networking (CANDAR'13), 6th International Workshop on Autonomous Self-Organizing Networks (ASON'13), pp.454-460, Ehime, Japan, Dec. 2013, doi:10.1109/CANDAR.2013.80

[3] Keita Kobayashi, Yoshiaki Kakuda, "An Inter-Cluster Communication Scheme for Self-Organized Transmission Power Control in MANET Clustering", 2015 IEEE 18th International Symposium on Real-Time Distributed Computing Workshops, pp.95-102, doi:10.1109/ISORCW.2015.49

[4] Hiroki Matsukane and Yoshiaki Kakuda, "Network model for changing node mobility and density in mobile ad hoc networks", Proc. IEEE 11th International Symposium on Autonomous Decentralised Systems (ISADS 2013), 5th International Workshop on Ad Hoc.,Sensor,P2P Networks, pp.199-205, 2013.of the IEEE Computer and Communications, IEEE Societies, vol.2, Apr. 2003, pp. 1312-1321

[5] Scalable Network Technologies Inc., "Qualnet network simulator by scalable net-work technologies" ,www.scalable-networks.com,(2015-01- 18)

[6] Soaucene Mahfoudh and Pascale Minet, "Survey of Energy Efficient Strategies in Wireless Ad Hoc and Sensor Networks", IEEE Seventh International Conference on Networking, pp.1-7, 2008.

Q & A