

# A TABU SEARCH ALGORITHM FOR CLUSTER BUILDING IN WIRELESS SENSOR NETWORKS

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## Abstract

The main challenge in wireless sensor network deployment pertains to optimizing energy consumption when collecting data from sensor nodes. This paper proposes a new centralized clustering method for a data collection mechanism in wireless sensor networks, which is based on network energy maps and Quality-of-Service (QoS) requirements. The clustering problem is modelled as a hypergraph partitioning and its resolution is based on a tabu search heuristic. Our approach defines moves using largest size cliques in a feasibility cluster graph. Compared to other methods (CPLEX-based method, distributed method, simulated annealing-based method), the results show that our tabu search-based approach returns high-quality solutions in terms of cluster cost and execution time. As a result, this approach is suitable for handling network extensibility in a satisfactory manner.

The study specifies a new centralized clustering mechanism equipped with energy maps and constrained by Quality-of-Service (QoS) requirements. Such a clustering mechanism is used to collect data in sensor networks. The first original aspect of this investigation consists of adding these constraints to the clustering mechanism that helps the data collection algorithm in order to reduce energy consumption and provide applications with the information required without burdening them with unnecessary data.

Keywords: Wireless sensor network, Quality-of-Service (QoS), clustering.

## 1 Introduction

The main challenge when deploying sensor networks pertains to optimizing the energy consumption for data collection from sensor nodes. A new data collection mechanism based on a centralized clustering method distributed clustering method. It uses sensor network energy maps and applies QoS requirements in order to reduce energy consumption. They require the acquisition of data from the physical world in a reliable and automatic manner. This necessity implies the emergence of new kinds of networks, which are typically composed of low-capacity devices. Such devices, called sensors, make it possible to capture and measure specific elements from the physical world (e.g., temperature, pressure, humidity). Moreover, they run on small batteries with low energetic capacities. Consequently, their power consumption must be optimized in order to ensure increased

lifetime for those devices. During data collection, two mechanisms are used to reduce energy consumption: message aggregation and filtering of redundant data. These mechanisms generally use clustering methods in order to coordinate aggregation and filtering. Clustering methods belong to either one of two categories: distributed and centralized. The centralized approach assumes that the existence of a particular node is cognizant of the information pertaining to the other network nodes. Then, the problem is modeled as a graph partitioning problem with particular constraints that render this problem NP-hard. The central node determines clusters by solving this partitioning problem. However, the major drawbacks of this category are linked to additional costs engendered by communicating the network node information and the time required to solve an optimization problem.

## **CPLEX**

CPLEX also offers a network optimizer aimed at a special class of linear problem with network structures. CPLEX can optimize such problems as ordinary linear programs, but if CPLEX can extract all or part of the problem as a network, then it will apply its more efficient network optimizer to that part of your problem and use the partial solution it finds there to construct an advanced starting point to optimize the rest of the problem.

Specifically, it solves linearly or quadratically constrained optimization problems where the objective to be optimized can be expressed as a linear function or a convex quadratic function. The variables in the model may be declared as continuous or further constrained to take only integer values.

## **Simulated annealing**

It is a probabilistic algorithmic approach to solve optimization problems. It allows for a given optimization problem to accept solutions that degrade cost; even if later, such accepted solutions will be ignored when they fail to improve the best solution. Simulated annealing decides whether to reject or accept a solution that degrades costs randomly. The same query and topology were used to compare the results obtained by tabu search.

## **TAG Method**

Tiny Aggregation (TAG), a generic aggregation service for ad hoc networks of TinyOS motes. There are two essential attributes of this service. First, it provides a simple, declarative interface for data collection and aggregation, inspired by selection and aggregation facilities in database query languages. Second, it intelligently distributes and executes aggregation queries in the sensor network in a time and power-efficient manner, and is sensitive to the resource constraints and lossy communication properties of wireless sensor networks. TAG processes aggregates in the network by computing over the data as it flows through the sensors, discarding irrelevant data and combining relevant readings into more compact records when possible.

## **2 Proposed Scheme**

This paper proposes a new centralized clustering mechanism equipped with energy maps and constrained by Quality-of-Service (QoS) requirements. Such a clustering mechanism is used to collect data in sensor networks. The first original aspect of this investigation consists of adding these constraints to the clustering mechanism that helps the data collection algorithm in order to reduce energy consumption and provide applications with the information required without burdening them with unnecessary data. Centralized clustering is modeled as hypergraph partitioning. The novel method proposes the use of a tabu search heuristic to solve this problem. The existing centralized clustering methods cannot be used to solve this issue due to the fact that our approach to model the problem assumes that the numbers of clusters and cluster heads are unknown before clusters are created, which constitutes another major original facet of this paper.

### **2.1 Input data**

Simulation models are generated from a set of data taken from a stochastic system. It is necessary to check that the data is statistically valid by fitting a statistical distribution and then testing the significance of such a fit. Further, as with any modelling process, the input data's accuracy must be checked and any outliers must be removed.

## **2.2 Output data**

When a simulation has been completed, the data needs to be analysed. The simulation's output data will only produce a likely estimate of real-world events. Methods to increase the accuracy of output data include: repeatedly performing simulations and comparing results, dividing events into batches and processing them individually, and checking that the results of simulations conducted in adjacent time periods “connect” to produce a coherent holistic view of the system

The main idea is to partly implement HTTP, FTP and TCP protocols.

Routing is the process of selecting paths in a network along which to send network traffic. Routing is performed for many kinds of networks, including the telephone network (Circuit switching) , electronic data networks (such as the Internet), and transportation networks. This article is concerned primarily with routing in electronic data networks using packet switching technology.

In packet switching networks, routing directs packet forwarding, the transit of logically addressed packets from their source toward their ultimate destination through intermediate nodes, typically hardware devices called routers, bridges, gateways, firewalls, or switches. General-purpose computers can also forward packets and perform routing, though they are not specialized hardware and may suffer from limited performance. The routing process usually directs forwarding on the basis of routing tables which maintain a record of the routes to various network destinations. Thus, constructing routing tables, which are held in the router's memory, is very important for efficient routing. Most routing algorithms use only one network path at a time, but multipath routing techniques enable the use of multiple alternative paths.

Routing, in a more narrow sense of the term, is often contrasted with bridging in its assumption that network addresses are structured and that similar addresses imply proximity within the network. Because structured addresses allow a single routing table entry to represent the route to a group of devices, structured addressing (routing, in the narrow sense) outperforms unstructured addressing (bridging) in large networks, and has become the dominant form of addressing on the Internet, though bridging is still widely used within localized environments.

Routing schemes differ in their delivery semantics:

- unicast delivers a message to a single specified node;
- broadcast delivers a message to all nodes in the network;
- multicast delivers a message to a group of nodes that have expressed interest in receiving the message;

- anycast delivers a message to any one out of a group of nodes, typically the one nearest to the source.

### 2.3 Path selection

Path selection involves applying a routing metric to multiple routes, in order to select (or predict) the best route.

In the case of computer networking, the metric is computed by a routing algorithm, and can cover such information as bandwidth, network delay, hop count, path cost, load, MTU, reliability, and communication cost (see e.g. this survey for a list of proposed routing metrics). The routing table stores only the best possible routes, while link-state or topological databases may store all other information as well.

Because a routing metric is specific to a given routing protocol, multi-protocol routers must use some external heuristic in order to select between routes learned from different routing protocols. Cisco's routers. A local network administrator, in special cases, can set up host-specific routes to a particular machine which provides more control over network usage, permits testing and better overall security. This can come in handy when required to debug network connections or routing tables.

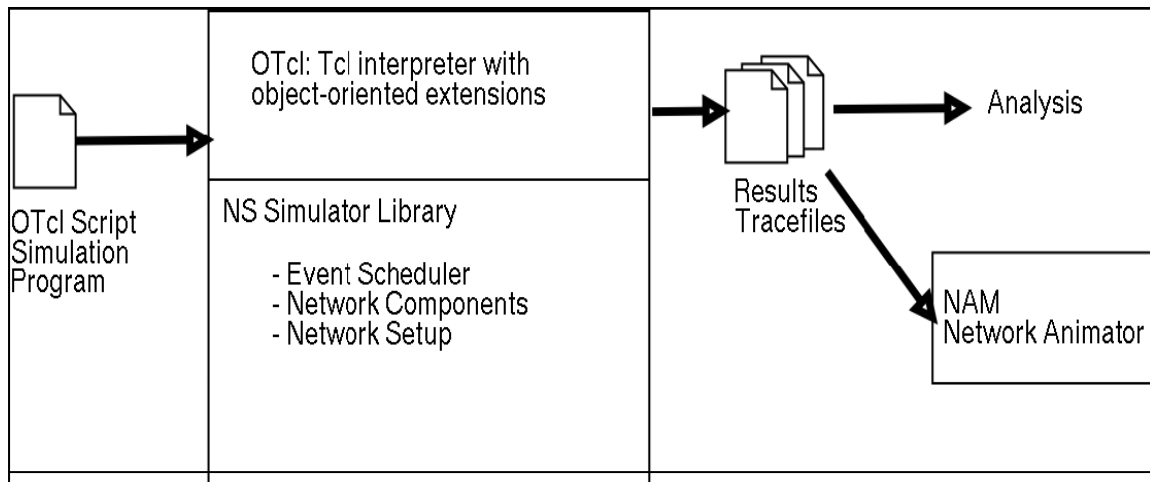
As the Internet and IP networks become mission critical business tools, there has been increased interest in techniques and methods to monitor the routing posture of networks. Incorrect routing or routing issues cause undesirable performance degradation, flapping and/or downtime. Monitoring routing in a network is achieved using Route analytics tools and techniques.

Protocols: TCP, UDP, HTTP, Routing algorithms etc

- Traffic Models: CBR, VBR, Web etc
- Error Models: Uniform, bursty etc
- Radio propagation, Mobility models
- Energy Models
- Topology Generation tools
- Visualization tools
- Extensibility

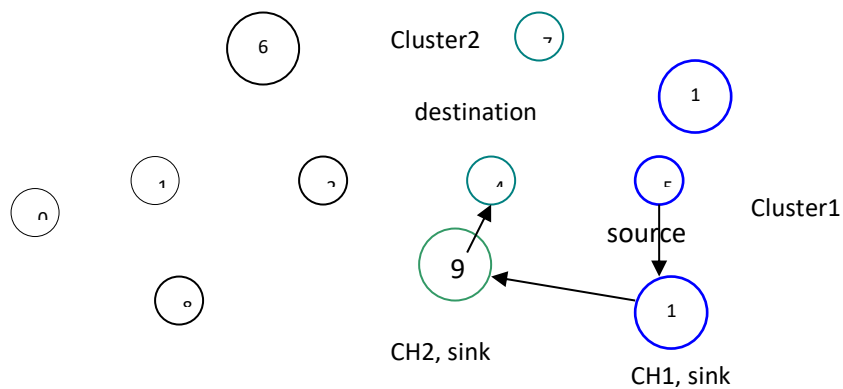
## 3. IMPLEMENTATION DETAILS

### 3.1 STRUCTURE OF NS2



**Fig** Simplified User's View of Ns

### 3.2 NODE CALIBARATION MODEL



**Fig** Reference Model for Node Deployment

The reference model for the node deployment is shown in the Fig. In this figure, nodes numbered as 1, 4, 6, 7, 8, 9,10,11 are common nodes and 5 is the source node, 10 is the cluster head, which acts as sink and receives message from source, then Cluster Head 1 sends the message to Cluster head 2, node number 9,

which received message and passes to destination 4. The initial step in the implementation is to create the nodes and configure it.

### 3.3 Tabu search heuristics algorithm

- Step: 1            Design an algorithm that returns an initial solution, which means sorting active nodes in the network
- Step: 2            Define neighborhood of a solution, here two types of moves are distinguished: the first move involves an ordinary node, i.e., a nonactive node, and the second move involves an active node. This is due to the fact that an active node could be a cluster head and thus build a new cluster.
- Step: 3            Determine the cluster head and cluster members
- Step: 4            Determine the content and size of tabu lists, that's arriving the clusters head and cluster members in the list
- Step: 5            Design intensification and diversification mechanisms, the approach consists of directing the search toward and away from selected boundaries of feasibility

### 3.4 Modules List:

- Deployment of Nodes
- Centralized Method
- Clustering Mechanism
- Data Collection Mechanism
- Diversification and Intensification

### 3.5 Module Description:

#### Deployment of Nodes

We consider a wireless sensor network with  $N$  nodes. Let  $N$  denote the set of all nodes in the network. The communication among all  $n$  nodes is based on a tree topology with the sink as the root. The tree is formed in the initial phase as follows. To transmit one data unit, the energy cost of the sender and receiver are  $e_{tr}$  and  $e_{re}$  respectively, and  $e_{tr}$  is also relevant to the distance between the sender and receiver. To simplify the problem, we set the length of each tree edge to one unit, which means that sensor nodes have a fixed transmission range and the energy cost of transferring data is only proportional to the data size.

#### Centralized Method

In which all data transferred from source will collected at one place which became act as centralized server. From the distribution of data to the destination will takes place to reduce the loss of data. This method is named as Clustering Method.

### Clustering Mechanism

The clustering mechanism that helps the data collection algorithm in order to reduce energy consumption and provide applications with the information required without burdening them with unnecessary data. Centralized clustering is modeled as hypergraph partitioning. The novel method proposes the use of a tabu search heuristic to solve this problem. The existing centralized clustering methods cannot be used to solve this issue due to the fact that our approach to model the problem assumes that the numbers of clusters and cluster heads are unknown before clusters are created.

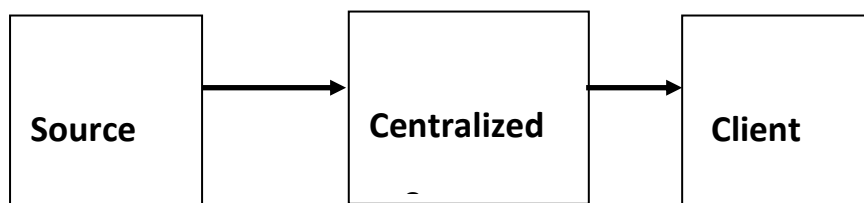
### Data Collection Mechanism

We propose a novel data collection approach for sensor networks that use energy maps and QoS requirements to reduce power consumption while increasing network coverage. The mechanism comprises two phases: during the first phase, the applications specify their QoS requirements regarding the data required by the applications. They send their requests to a particular node S, called the collector node, which receives the application query and obtains results from other nodes before returning them to the applications. The collector node builds the clusters, optimally using the QoS requirements and the energy map information. During the second phase, the cluster heads must provide the collector node with combined measurements for each period.

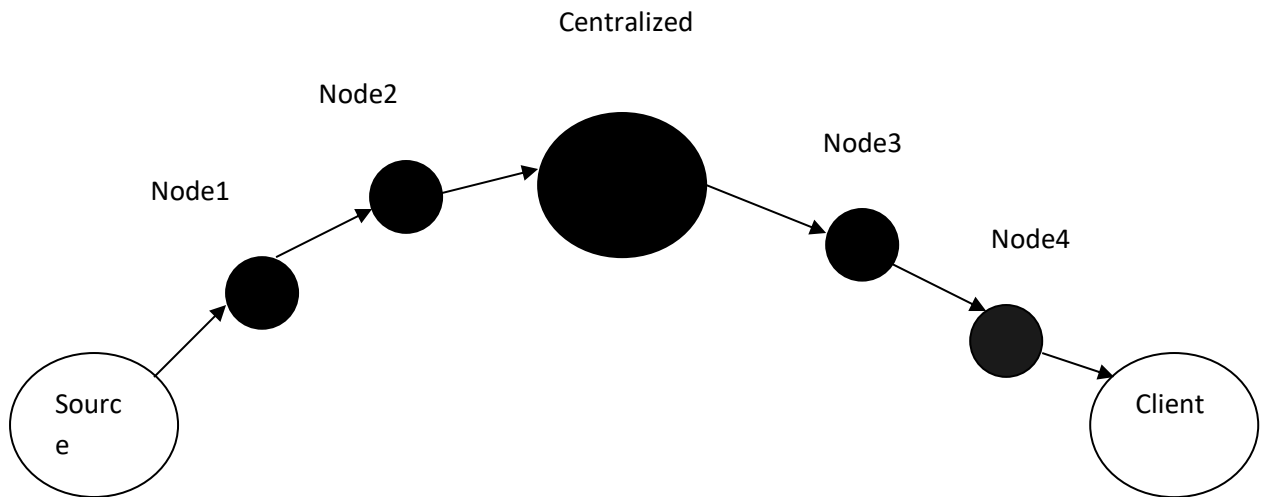
### Diversification and Intensification

Diversification and Intensification are two mechanisms that make it possible to improve tabu search methods. They start by analyzing the appropriate solutions visited and obtain their common properties in order to be able to intensify the search in another neighborhood or to diversify the searches. In tabu searches, this mechanism is called long-term memory. Our proposal uses a technique called the shifting penalty tactic, which is an instance of a procedure called strategic oscillation, representing one of the basic diversification approaches for tabu searches.

### 3.6 System Architecture

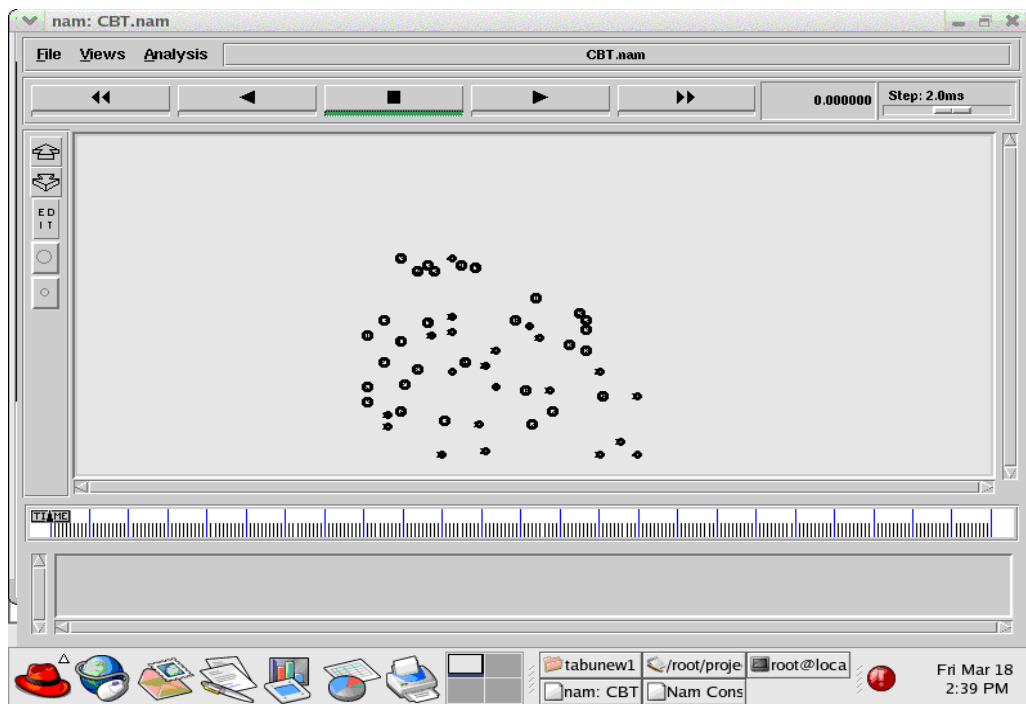


### Data Flow Diagram



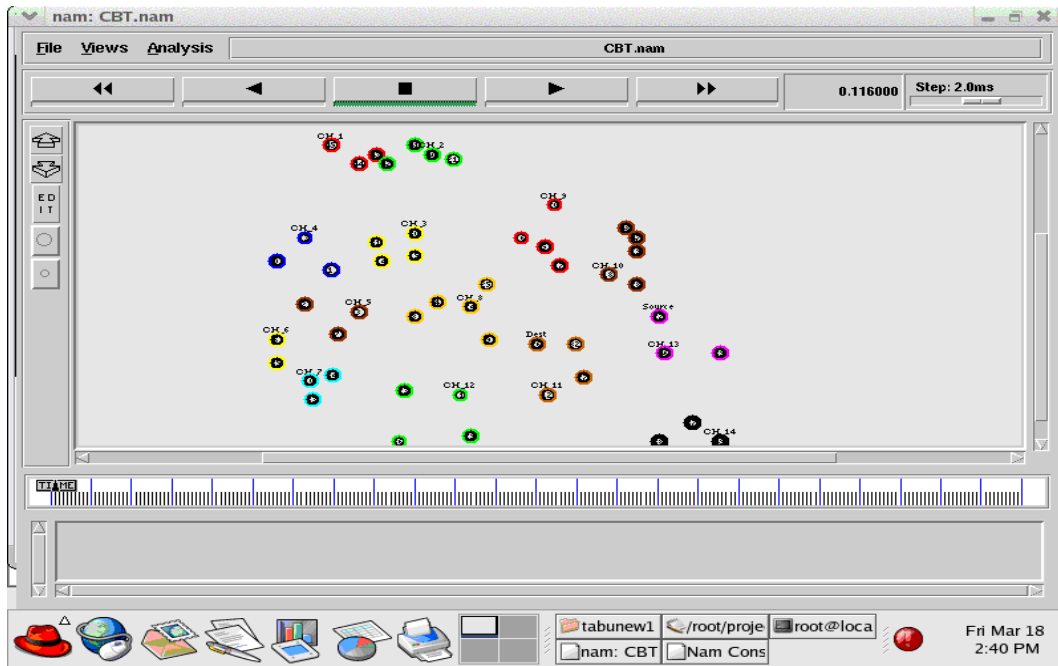
## 4 Result Analysis and Discussion

### Deployment of Nodes

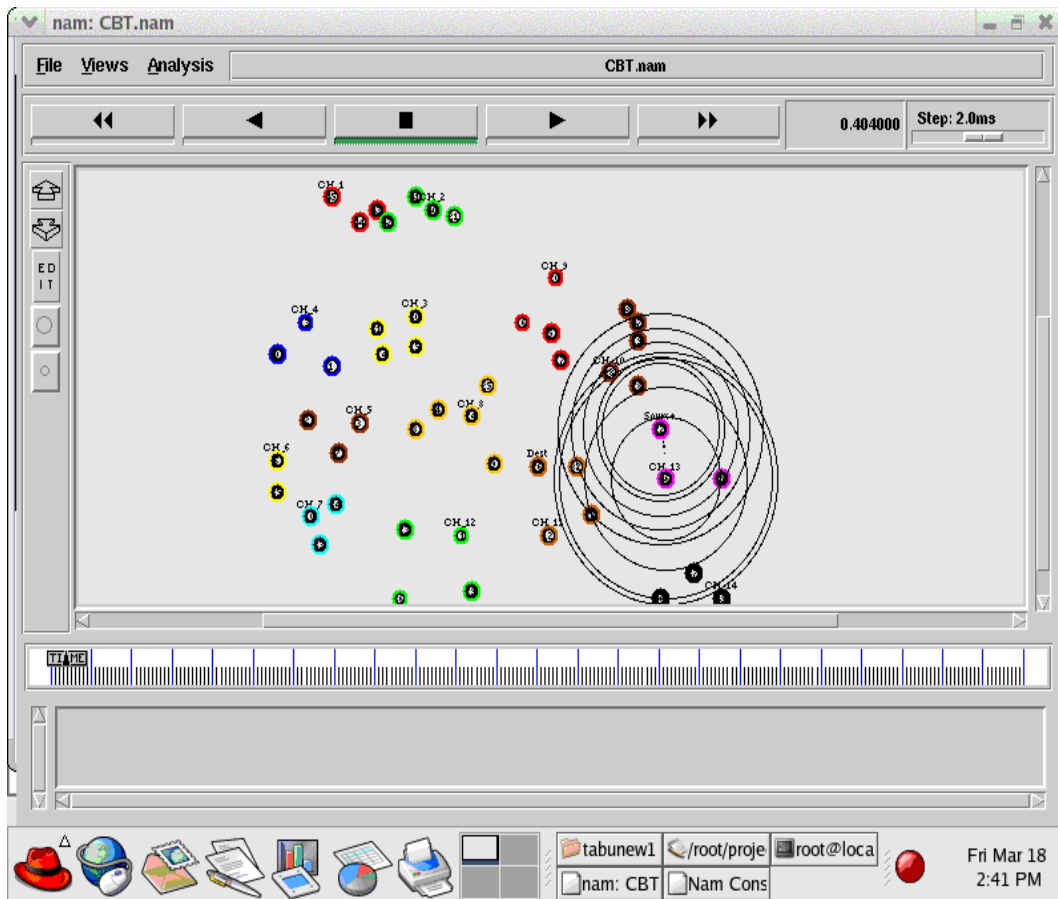




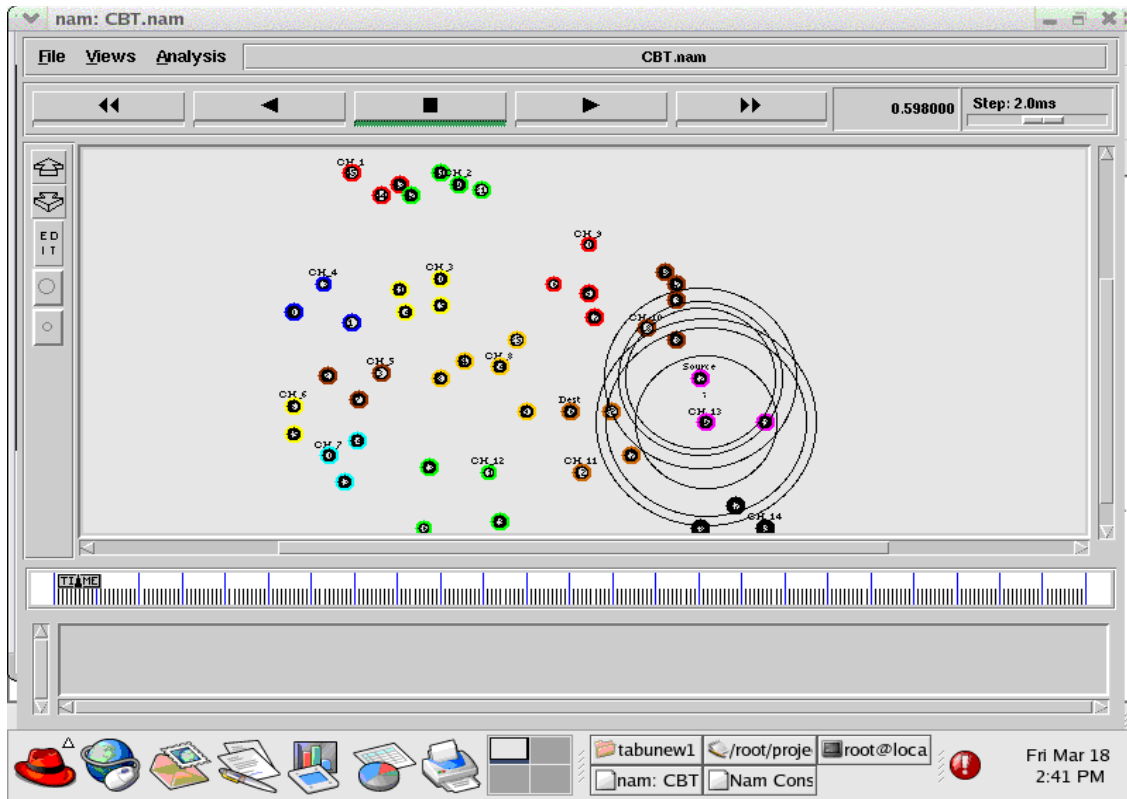
## Cluster Building



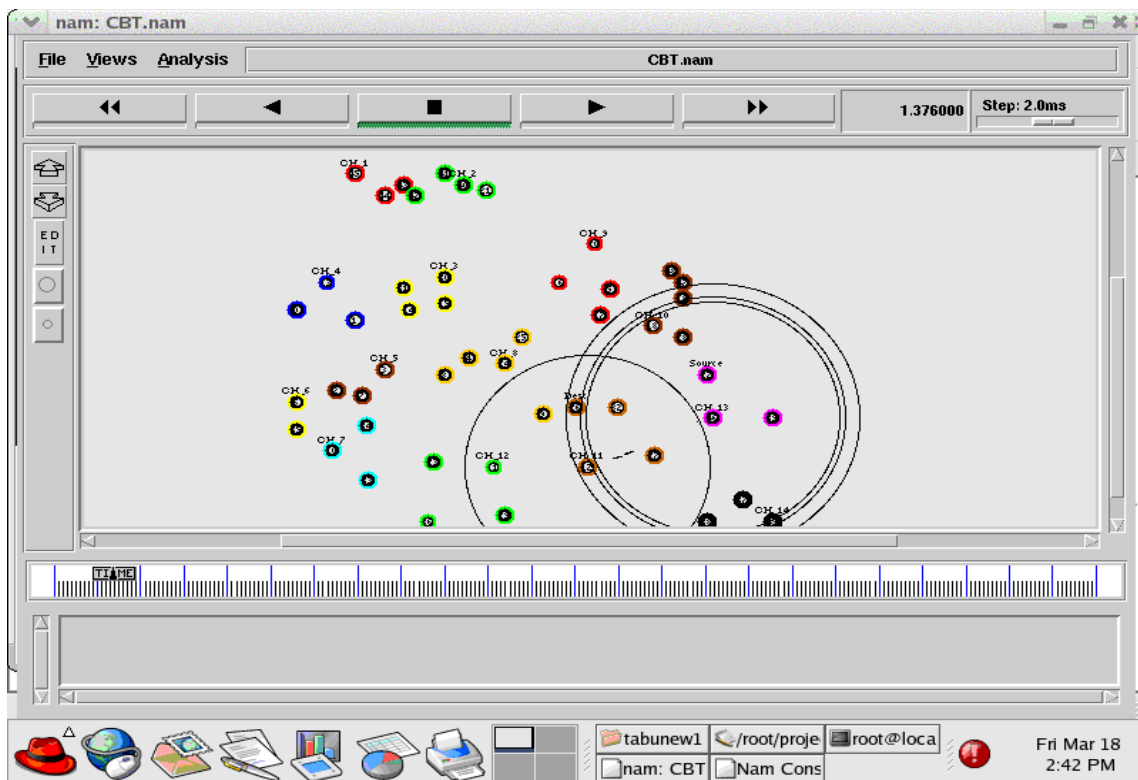
## Message from Source to cluster head



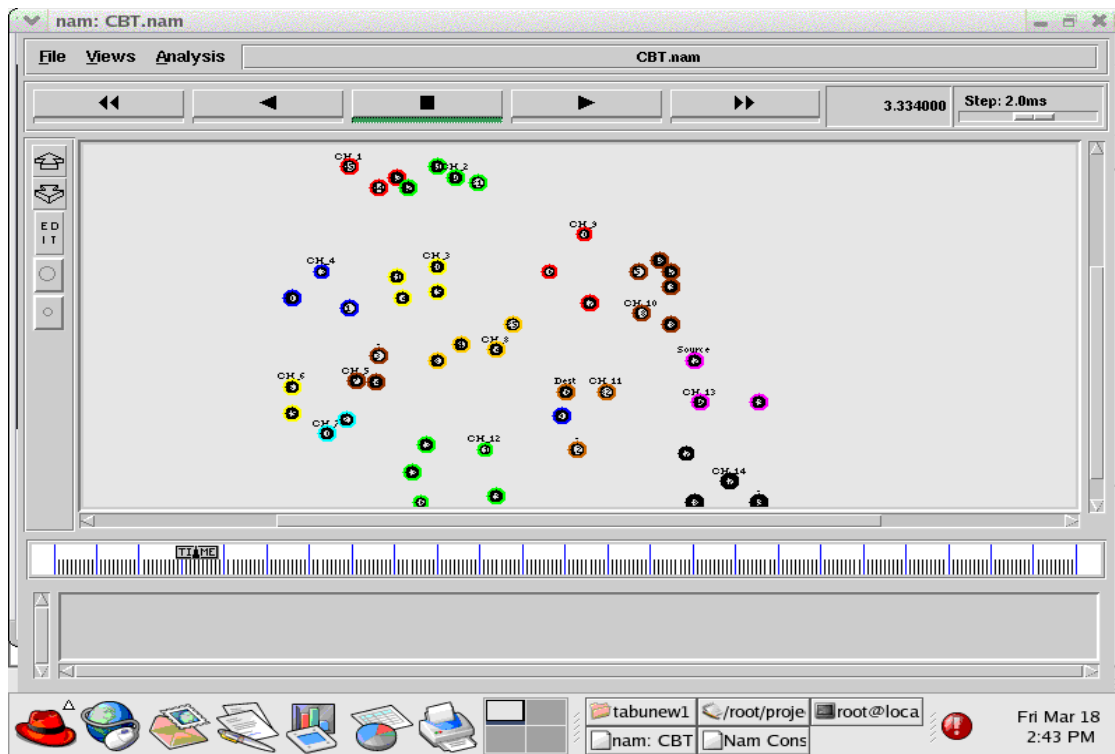
### Message from Source to cluster head



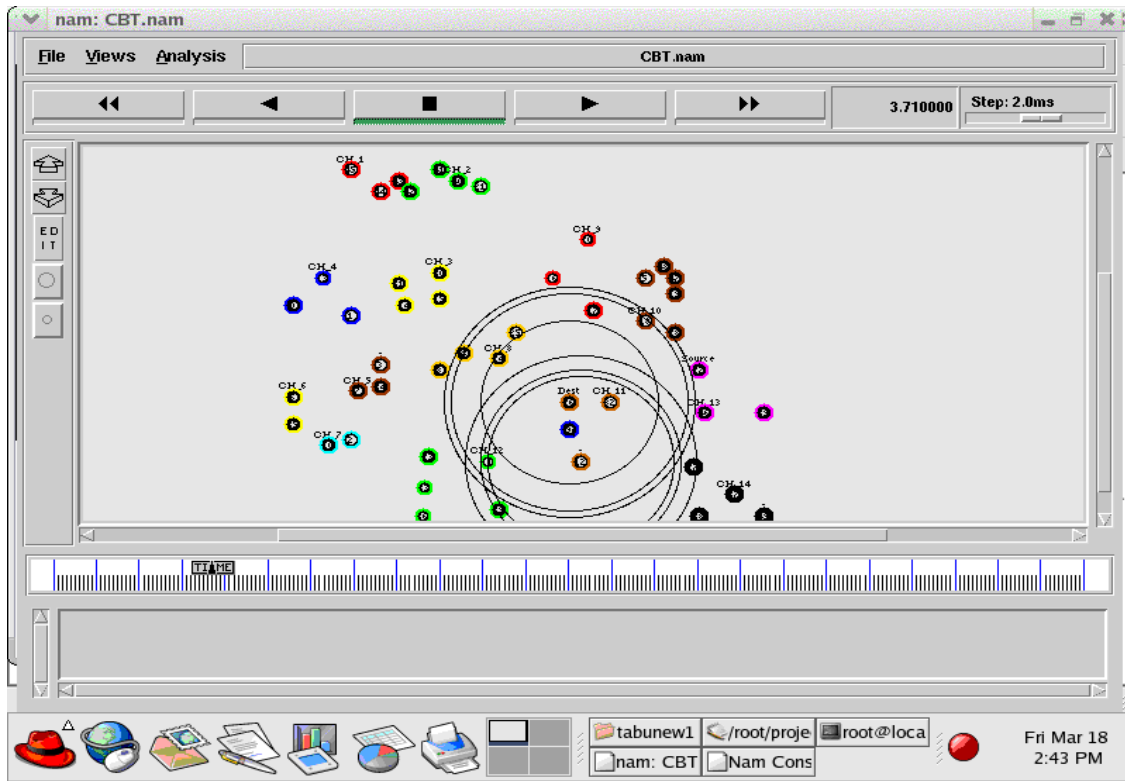
### Message from cluster head to next Cluster Head



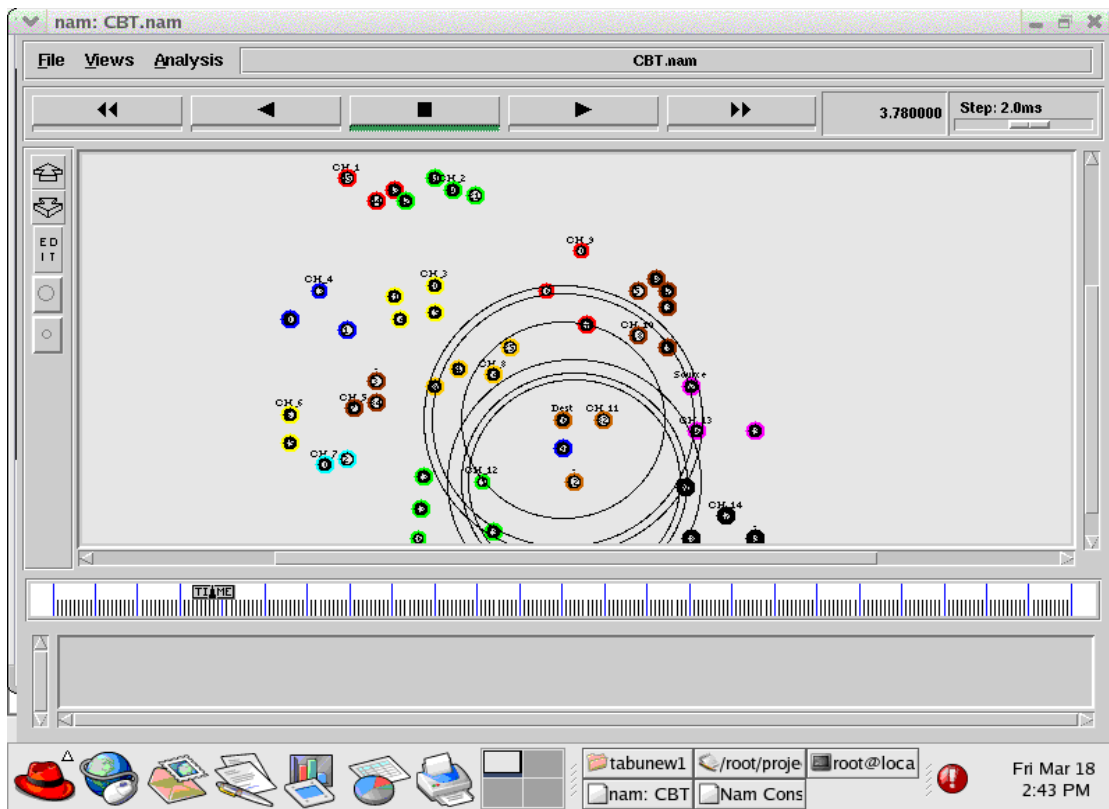
### Message from second cluster head to destination

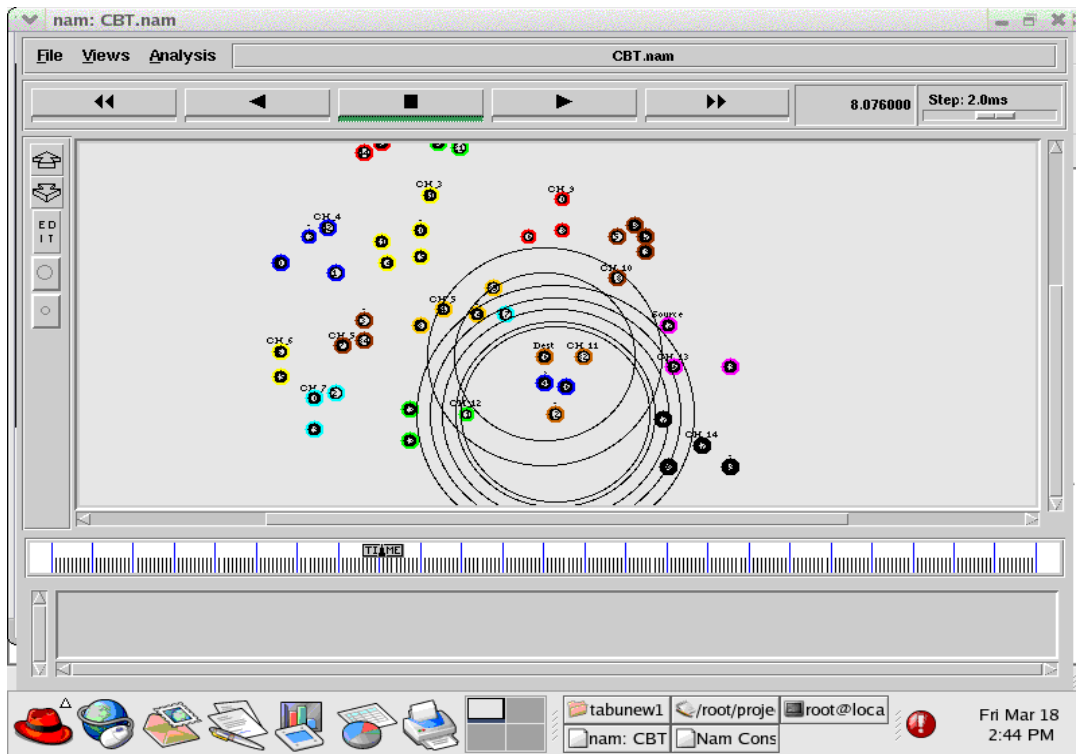
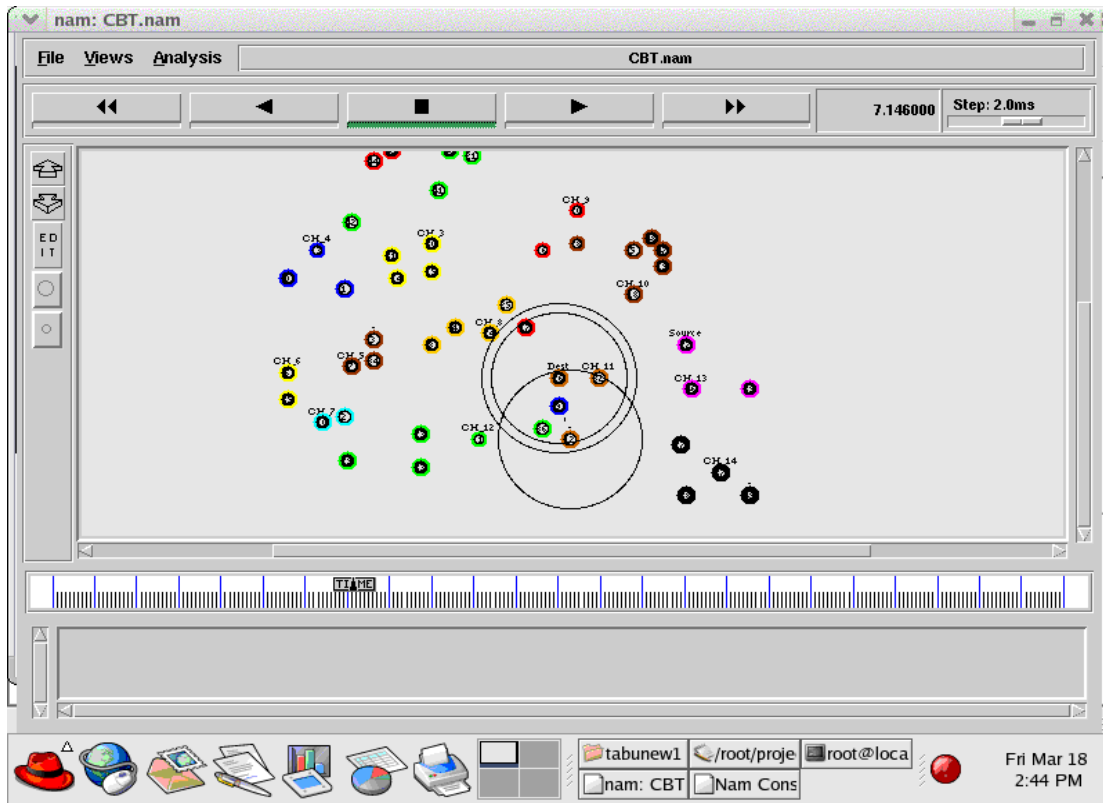


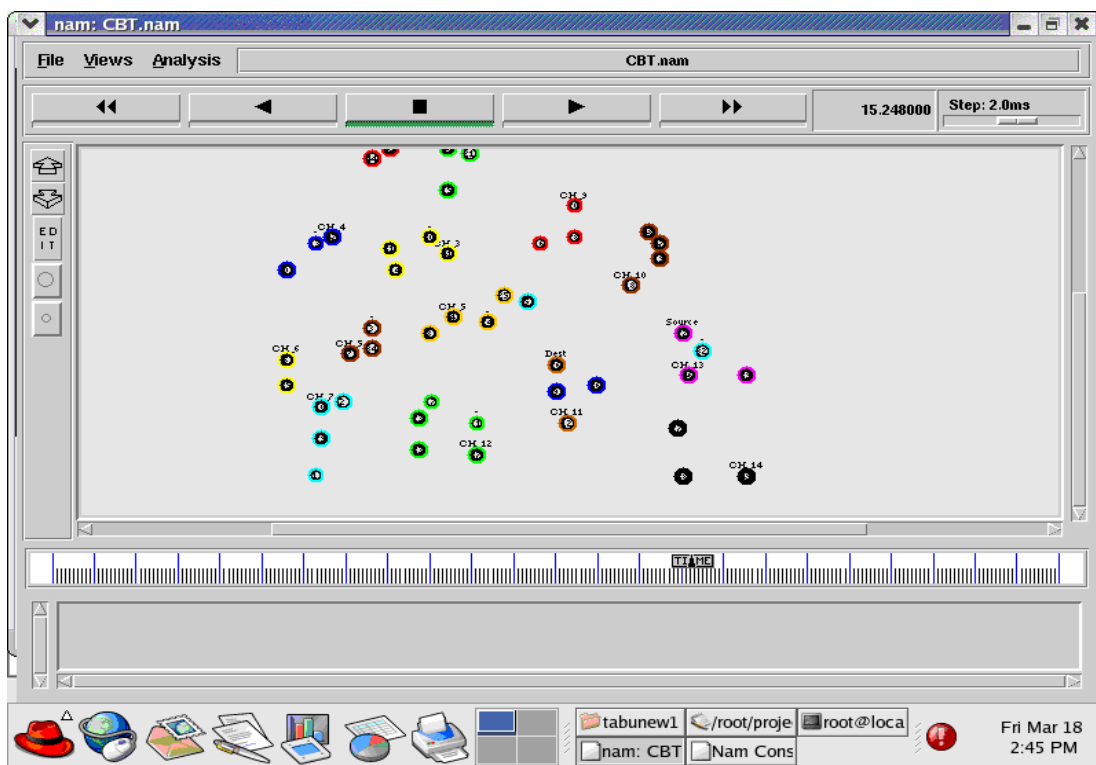
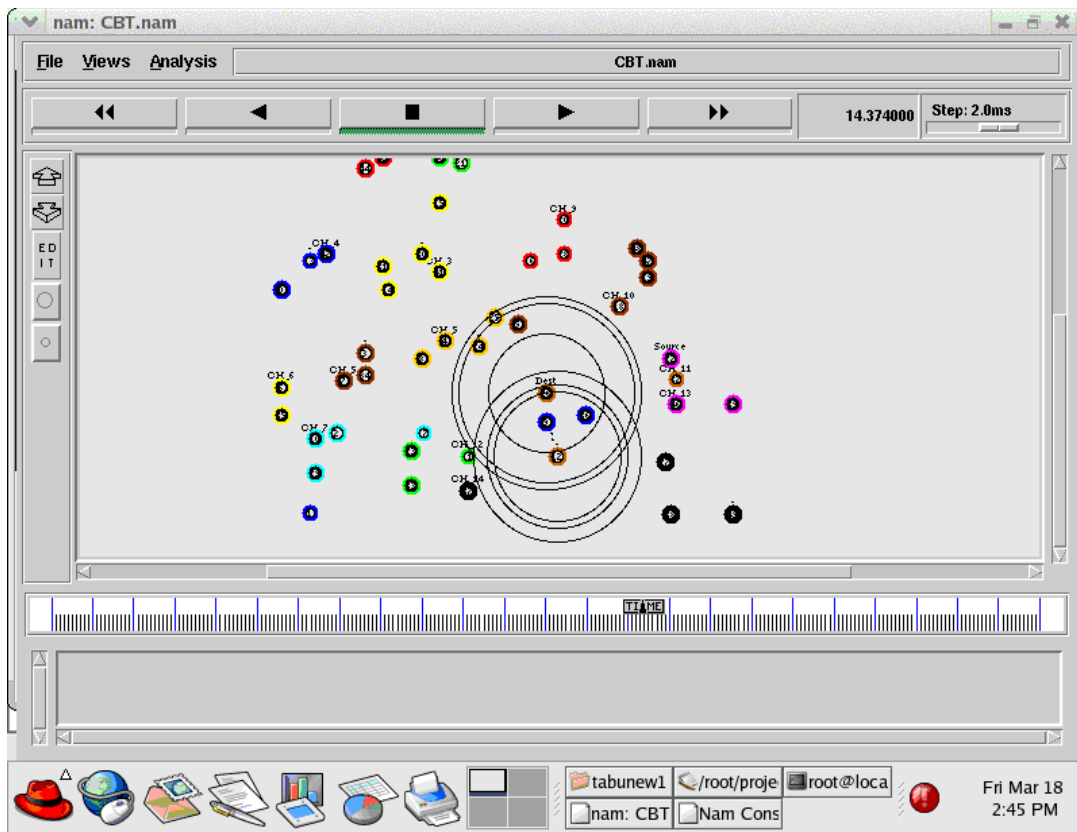
### Message from second cluster head to destination



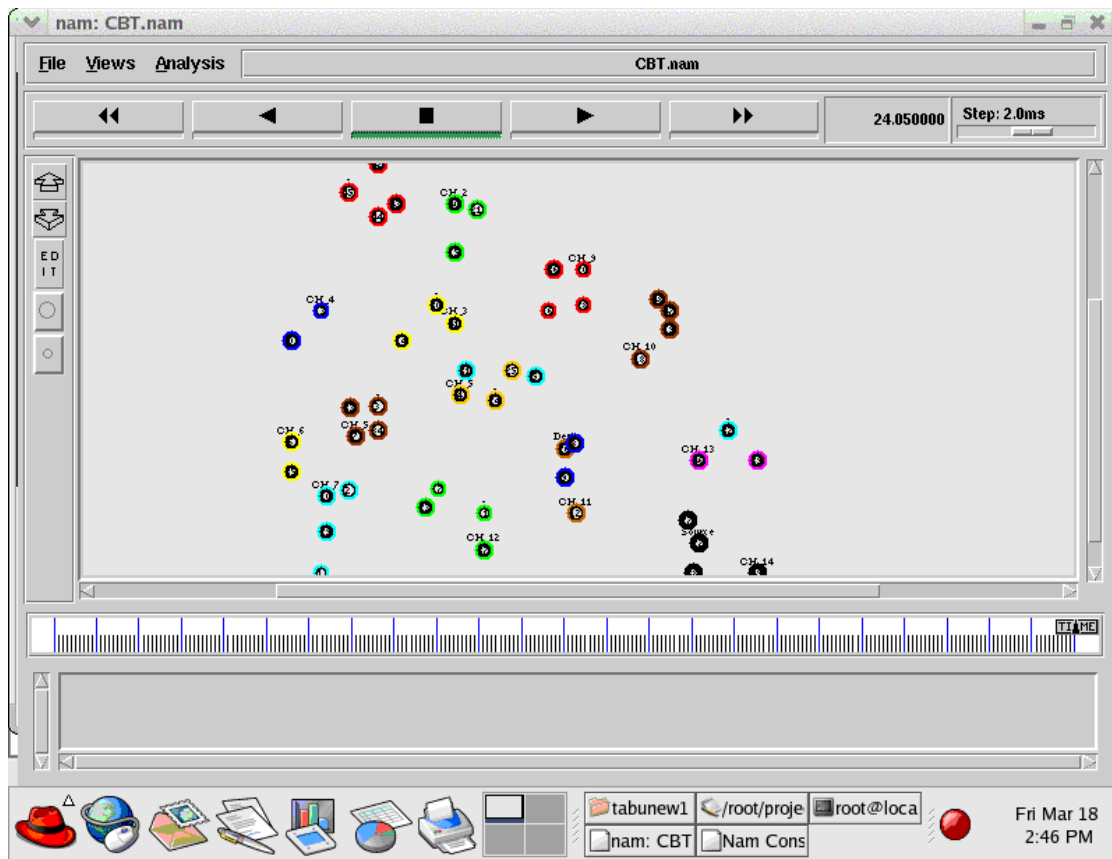
### Message from second cluster head to destination



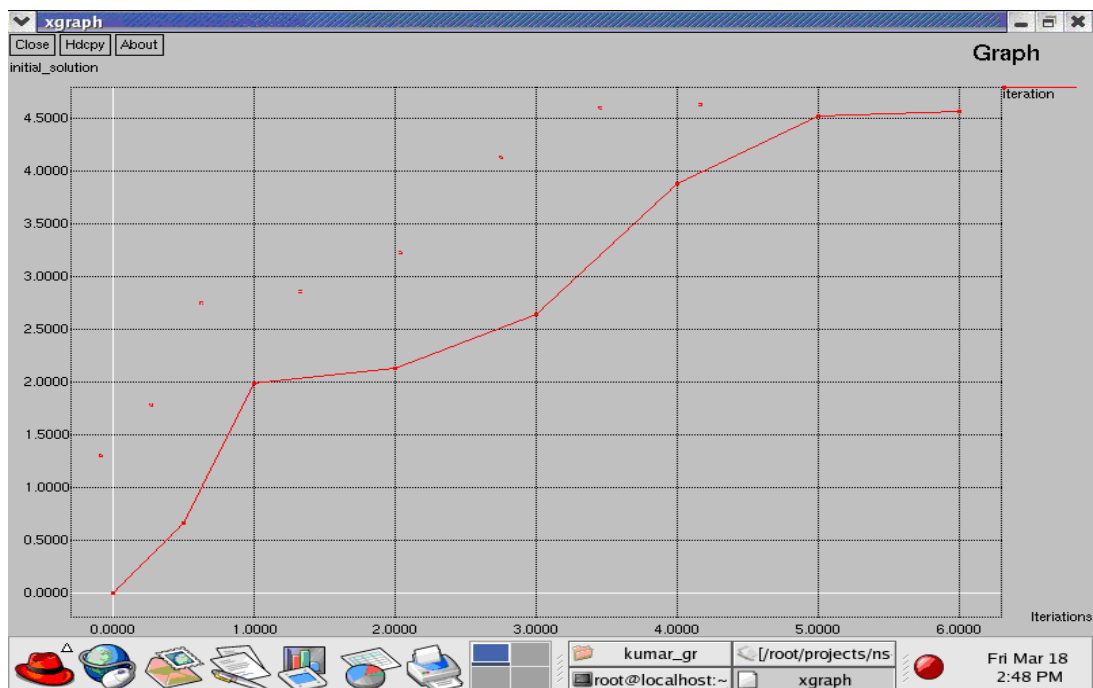




## Cluster Building



## Iteration Value



## 5 Conclusion

This paper has presented a heuristic approach based on a tabu search to solve clustering problems where the numbers of clusters and cluster heads are unknown beforehand. To our knowledge, this is the first time that the clustering problem is modelled and resolved with these constraints. The tabu search adaptation consists of defining three types of moves that allow reassigning nodes to clusters, selecting cluster heads, and removing existing clusters. Such moves use the largest size clique in a feasibility cluster graph, which facilitates the analysis of several solutions and makes it possible to compare them using a gain function. The Tabu search based resolution method provides quality solutions in terms of cluster cost and execution time. It also behaves well with network extensibility.

## References

1. Olutayo Boyinbode, Hanh Le and Makoto Takizawa, "A survey on clustering algorithms for wireless sensor networks" *International Journal of Space-Based and Situated Computing*, Vol. 1, No. 2-3, pp 130-136, May 25,2011.
2. Shio Kumar Sing, M P Singh , and D K Singh, "Energy Efficient Homogenous Clustering Algorithm for Wireless Sensor Networks", *International Journal of Wireless & Mobile Networks ( IJWMN )*, Vol.2, No.3, August 2010 DOI : 10.5121/ijwmn.2010.2304 49
3. P.K. Agarwal and C.M. Procopiuc, "Exact and Approximatio Algorithms for Clustering," *Algorithmica*, vol. 33, no. 2, pp. 201- 226, June 2002.
4. P. Basu and J. Redi, "Effect of Overhearing Transmissions on Energy Efficiency in Dense Sensor Networks," *Proc. Third Int'l Symp. Information Processing in Sensor Networks (IPSN '04)*, pp. 196- 204, Apr. 2004.
5. A. El Rhazi and S. Pierre, "A Data Collection Algorithm Using Energy Maps in Sensor Networks," *Proc. Third IEEE Int'l Conf. Wireless and Mobile Computing, Networking, and Comm. WiMob '07*,2007.
6. S. Ghiasi, A. Srivastava, X. Yang, and M. Sarrafzadeh, "Optimal Energy Aware Clustering in Sensor Networks,"*Sensors*,pp.258-269,2002.
7. F. Glover, E. Taillard, and D. Werra, "A User's Guide to Tabu Search," *Annals of Operations Research*, vol. 41, no. 14, pp. 3-28, May 1993.
8. S. V. Manikanthan and T. Padmapriya, "An efficient cluster head selection and routing in mobile WSN," *Int. J. Interact. Mob. Technol.*, vol. 13, no. 10, pp. 56–70, 2019, doi: 10.3991/ijim.v13i10.11303.
9. K. N. Dattatraya and K. R. Rao, "Hybrid based cluster head selection for maximizing network lifetime and energy efficiency in WSN," *J. King Saud Univ. - Comput. Inf. Sci.*, no. xxxx, 2019, doi: 10.1016/j.jksuci.2019.04.003.
10. P. L. Rajarajeswari and N. K. Karthikeyan, "Hyper-geometric energy factor based semi-Markov prediction mechanism for effective cluster head election in WSNs," *J. Intell. Fuzzy Syst.*, vol. 32, no. 4, pp. 3111–3120, 2017, doi: 10.3233/JIFS-169254.