Management of faults tolerance in the Ad hoc Networks based on Multi Agents System

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Abstract— *The ad hoc networks are distributed networks, self-organized does not require infrastructure. In such network, mobile infrastructures are subject of disconnections. This situation may concern a voluntary or involuntary disconnection of nodes caused by the high mobility in the ad hoc network. In these problems we are trying through this work to contribute to solving these problems in order to ensure continuous service by proposing our approach of faults tolerance based on MAS, which predicts a problem and decision making in relation to critical nodes.*

Our work contributes to study the prediction of voluntary and involuntary disconnections in the Ad-hoc network; therefore we propose our approach for faults tolerance that allows for effective distribution of information in the network by selecting some objects of the network to be a duplicates of information.

Index Terms—*Ad-hoc networks, faults tolerance, disconnection, group, replication, MAS.*

1. Introduction

1.1. Motivation

The mobile Ad-Hoc, usually called MANET, are wireless networks, mobile, spontaneous, composed of a set of nodes grouped dynamically and are usually connected by radio waves, not based on any existing infrastructure or centralized administration. The nodes are free to move randomly and organize themselves arbitrarily, thus, the topology of the wireless network may change rapidly and unpredictably. Such a network can operate in standalone mode, or can be connected to the Internet. An Ad hoc network may consist of several devices such as PDAs, laptops, etc. Each node can communicate directly with other nodes residing in its transmission range. To communicate with nodes that do not live around its radius, the node must use intermediate nodes to send the message per hop.

In wireless networks, especially ad hoc networks have coming new problems specific to mobile environments such as management of disconnections that result a loss of information, for that the fault tolerance by replication is a means to ensure continuity of service for data sharing in the network. The disconnections are voluntary or involuntary. The first disconnection decided by user from his mobile terminal. The latter are result of falling energy nodes; partition of the network, or the frequency of simultaneous failures of nodes.

1.2. Basic idea

The objective of this work is to build a service of fault tolerance by replication in Ad hoc network that incorporates the features necessary for improved data availability. Our solution is based on the formation of clusters to better manage the network, and each is managed by a leader node. This solution is mainly composed of four sub-services, namely, clustering, decision, replication, and consistency.

1.3. Organization of manuscript

The rest of the paper is organized as follows. After the literature review of the existing protocols of replication to ensure fault tolerance in the Ad hoc networks in Section 2, in Section 3, we specify our proposal service of fault tolerance by detailing these various sub -services. Then we present our various experiments conducted by our simulator developed in Java. Finally, we conclude and give perspectives of our work.

2. State of the Art

2.1. Mobile ad hoc networks

Mobile ad hoc networks are formed dynamically by an autonomous system of mobile nodes that are connected via wireless links without using an existing network infrastructure or centralized administration. The nodes are free to move randomly and organize themselves arbitrarily; thus, the network's wireless topology may change rapidly and unpredictably. Such a network may operate in a standalone fashion, or may be connected to the larger Internet. Mobile ad hoc networks are infrastructureless networks since they do not require any fixed infrastructure such as a base station for

their operation. In general, routes between nodes in an ad hoc network may include multiple hops and, hence, it is appropriate to call such networks « multihop wireless ad hoc networks ».
Figure 1.1 shows an example mobile ad hoc network and its communication topology. As shown in Figure 1.1, an ad hoc network might consist of several home computing devices, including notebooks, handheld PCs, and so on. Each node will be able to communicate directly with other nodes that reside within its transmission range. For communicating with nodes that reside beyond this range, the node needs to use intermediate nodes to relay messages hop by hop.

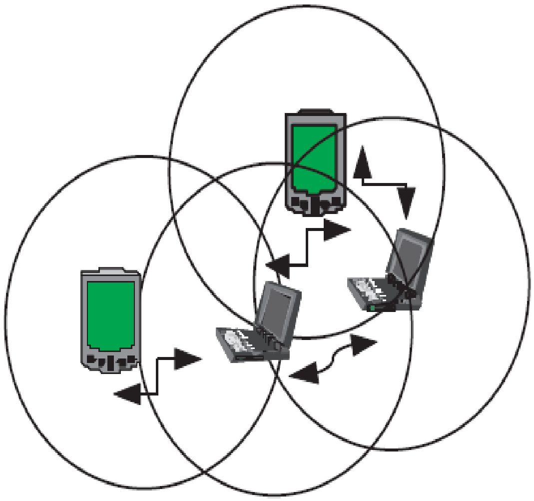

Fig. 1. Mobile ad hoc network

MANETs inherit common characteristics found in wireless networks in general, and add characteristics specific to ad hoc networking:

- **Wireless:** Nodes communicate wirelessly and share the same media (radio, infrared, etc.).
- **Mobility:** Each node is free to move about while communicating with other nodes. The topology of such an ad hoc network is dynamic in nature due to constant movement of the participating nodes.
- **Multihop routing:** No dedicated routers are necessary; every node acts as a router and forwards each others' packets to enable information sharing between mobile hosts.
- **Autonomous and infrastructureless:** MANET does not depend on any established infrastructure or centralized administration. Each node operates in distributed peer-to-peer mode, acts as an independent router.

2.2. Replication for fault tolerance

Replication is a fundamental technique used in distributed systems. It consists to store the same data or service in multiple nodes. The data or services are often replicated to improve availability, reliability, fault tolerance and performance. Replication can also improve data availability and service when the server crashes. Mobility or node failure can lead to network partitioning, where the network is divided into disjoint partitions, caused the possibility of inconsistent data.

Data replication has been extensively studied in distributed systems, particularly in wireline networks [1, 2]. In such systems, nodes that hold the database are more reliable and less to disconnect or fail. There is more than one replica to improve the query latency and cost update. They do not consider the availability of data as a major problem, since the failure of link and node is uncommon and a limited number of servers can provide the breeding of high data availability. The Ad hoc networks where nodes move freely and their batteries are rapidly diminishing, causing connection failures and frequent node failures. The failure of some links and nodes considered as criticism can split the network into several partitions. This greatly reduces the availability of data and causes no consistency. By replicating data to multiple nodes, data availability can be improved. In addition, data replication can also reduce the delay request, since the mobile nodes get the data replicates in some neighbors. In addition to problems of availability and performance that have been well discussed in the fixed network, data replication in Ad hoc networks must address the additional problems resulting from constraints imposed by environment of Ad hoc network. These problems are:

- **Problem of network partitioning:** by the partitions resulting in the Ad hoc networks, the chances of availability of data become low since mobile users may not be in the same partition as the node that owns the data. The replication of data in separate partitions before the occurrence of network partitioning can improve data availability. To do so, the replication protocol should determine the time when the network partitioning may occur and replicate data in advance.

- **Problem of energy consumption:** The mobile nodes operate with low battery power. A single server can serve many customers, causing the rapid depletion of its battery. To improve the availability of data, the replication protocol should replicate critical data on the nodes that can last for a long period. Moreover, it should also replicate data so that the power consumption of servers is reduced and balanced among all servers in the network.

- **Problem of scalability:** As the network size increases, a request sent by a client node can traverse a long path to reach the server node, increasing the cost and query latency. Moreover, the existence of a large number of customers request causes controversy over access channel, which significantly reduces the available bandwidth and increases the delay of access channel. The replication protocol should be designed so that its performance is not significantly affected if the number of nodes or the network size increases.

2.3. Related work

Hauspie et al. [3, 4] have proposed a new metric to detect partitioning in network without using GPS. The metric is based on finding a set of disjoints paths between a client node and a server node. A set of paths is a set of disjoints paths which have no common node except the client node and server node. The decision to replicate a service of data is taken when the connection between a client and a server gets worse in terms of sociability, bandwidth, delay, etc. Replicating the service or the data on one node that is the most nearest to the client node can increase the quality of connection between the client and server nodes.

Jorgic et al. [5] have proposed algorithms to detect localized nodes and critical links that could divide the network. A node *u* is called *k-critical* if the subgraph of its neighbors in *k* jumps, which we exclude *u* and the links that lead, is not connected. In a similar detection of critical links, a link *uv* is *k-critical* if a sets of neighbors in *k* jumps of *u* and *v* (built assuming that the link uv doesn't exist) are disjoint. If a link is critical in a comprehensive manner, it will be *k-critical* wherever *k> 1*.

The authors [6] have proposed a schema of replication, called the replication Expanding Ring Replication (ERR). The server of data measures the frequency of requests for each data. If it exceeds a threshold value, it replicates data on one or more nodes capable of its neighbors. The capacity function considers parameters such as available memory space, battery power remaining, and treatment capacity.

3. PROPOSAL

The proposed approach for fault tolerance in the Ad hoc networks is composed of four sub services, which are presented in Figure 1. The service fault tolerance is built in an architecture based on clusters that are identified by a particular node called the leader and is assigned to each leader a leader agent who handles himself launched three other agents to cooperate together: recording, replication and consistency in groups with the aim of cooperation. The model is based essentially on the concept of replication after predicting of eventual disconnections or partition of an object s to be critical in the network.

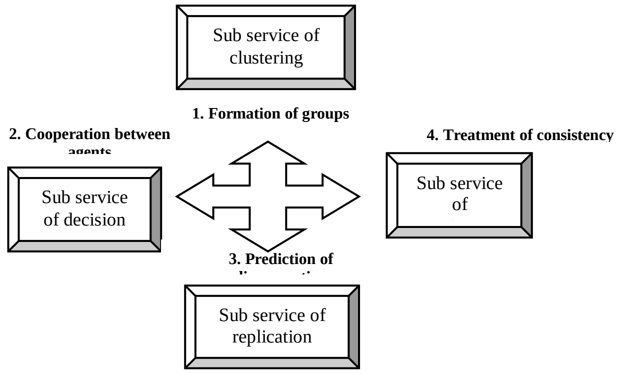

Fig. 2. Service of faults tolerance

3.1. Sub service of clustering

The clustering is a virtual division of network in groups of nodes near geographically. These groups are called clusters. To form clusters, we use a distributed algorithm based on the distance between nodes and the energy level. The clustering algorithm illustrates the pseudo code for the construction of the various clusters that make up the network (see Algorithm 1).

Algorithm of Clustering

for all node n_i de G_k **do**
  K←0;
  Somme_distance←0;
  for all node de G_k (j≠i) **do**
  Distance←Distance+ $\sqrt{(x_j - x_i)^2 + (y_j - y_i)^2}$
   K←K+1;
  end for
  Moy_distance[i] ←Distance/K;
end for
Calculate (Min_distance);
/*Moy_distance[m] this minimum*/
Elect n_m leader of group;
if ∃ two or several **then**
  Elect the node which has the most energy;
  /*one leader is elected by group*/
end if
The leader diffuses his identifier, his co-ordinates and his energy in his group;

3.2. Sub service of decision:

After the construction of clusters in network, we have cooperated a set of agents with intelligent behavior, coordinate their goals and action plans to solve a problem. In our work, we implemented several agents while being inspired from the contract-net protocol presented in figure 2.

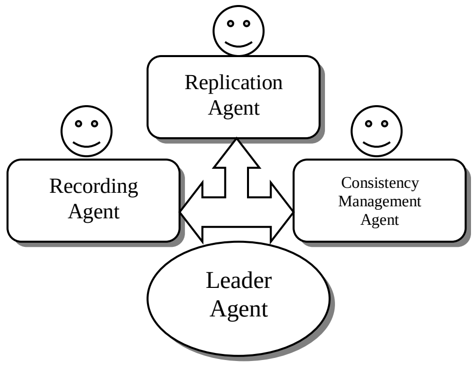

Fig. 3. Different agents implemented

The leader agent is the manager agent in the group that launches three agents, the recording agent have charge of registering the nodes forming the group and the new nodes and those who leave the group, replication agent which ensures the control of number of replicas in the group following the detection of a possible disconnection in the network and the consistency agent that initiates the update propagation to nodes. The generic agent responsible for managing all groups, it is a super agent, agent reserved to gather information's of all leaders in network, whether a leader fails, and then the generic agent may substitute him to accomplish its tasks. Figure 3 shows the diagram of class UML of the various entities comprising in the system.

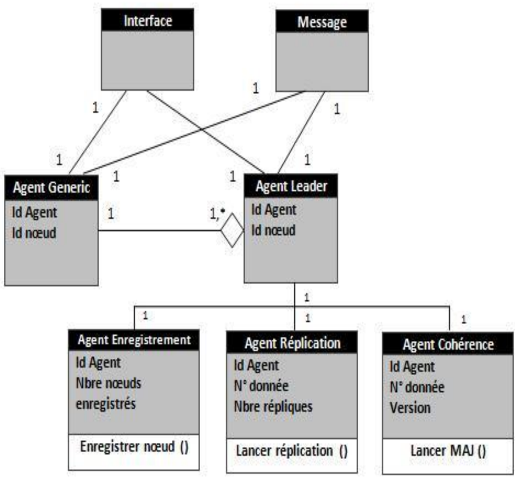

Fig. 4. Diagram of class of the phase of decision

3.3. Sub service of prediction and replication

The main function of this phase is to predict a possible failure or disconnection of the network by establishing a list of critical items (sensitive). Each leader can know the current status of all nodes of the cluster. To assess the criticality, the sub service can detect several types of critical items: energy, articulation point, Isthmus, frequency of breakdowns.

Replication makes it possible to create a copy (or several) full of an object or a fragment of an object, it is a basic method which allows the reliability and continuity of service. When the leader agent detects a possible failure or disconnection in his group, he launched the replication agent; his role is to replicate the data of the critical object detected in the node that has the most energy.

3.4. Sub service of consistency

This phase can manage the consistency management between replicas. The consistency management must provide copies of their mutual consistency; all copies of data are identical. In this work, we focus on the strong consistency among replicas, the consistency agent is responsible for the propagation of updated when a node makes a write request by the dynamic quorum who allows to write on the majority of the counterparts in each cluster and reading on half of the counterparts.

4. EXPERIMENTATIONS AND RESULTS

The software is a simulator of Ad hoc developed in Java. It is proposed to simulate the mobility aspect of the real world. The model contains partitions, clusters and nodes. The partition is a set of connected nodes (which can communicate). Each partition is divided into a set of clusters. Nodes in cluster move in the area of simulation with a given speed. The nodes can form links with other nodes, from which they can communicate.

4.1. Accepted requests

In this first series of experiments, we measured the number of accepted and lost requests. This simulation was conducted with the parameters of simulation as follows: 50 nodes, 20 data, given the size of 100MB, bandwidth 11 Mb / s, surface of simulation 700mx700m, the range 200m, time of simulation 60s, the results of this simulation are shown in Figure 4.

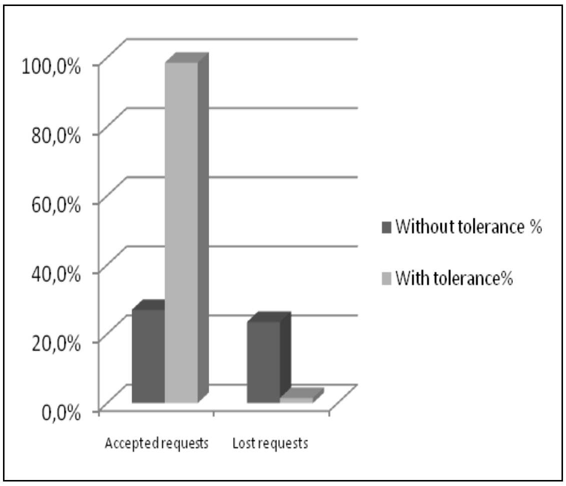

Fig. 5. Accepted and lost requests

We can see that the results of our proposal are very significant, and that the number of lost requests decreases by using our service of faults tolerance.

4.2. Life in Network

In this second series of experiments, we measured the number of nodes alive and failed. This simulation was conducted with the following simulation parameters: 50 nodes, 20 data, given the size of 100MB, bandwidth 11 Mb / s, surface of simulation 700mx700m, the range is 200m, time of simulation 60s, and number of requests 200, the simulation results are shown in Figure 5.

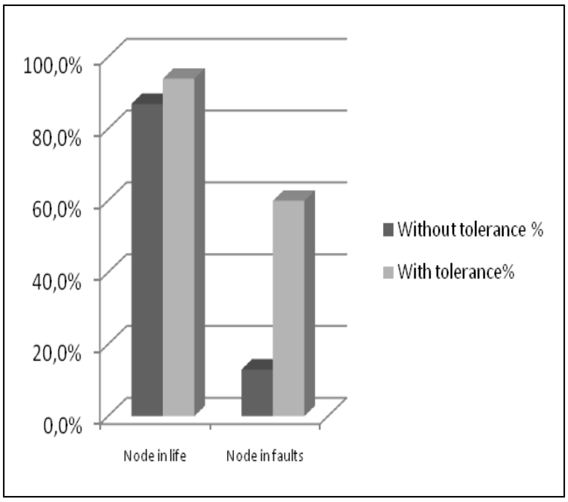

Fig.6. Life of the network

We can see that the results of our proposal are very significant, and that the number of nodes alife increases by using our service of faults tolerance.

4.3. Variation of number of nodes/ #lost requests

The third set of simulation results show the effect of variation in the number of nodes on the average results of lost requests. For this simulation, we vary the number of node from 50 to 300 in step of 50, with the number of requests = 200. By varying number of node, the figure *Fig. 6* described as graphic variation of the suggested service of faults tolerance. We can see that the results of our proposal are very significant, and that the number of lost requests decreases by using our service of faults tolerances (see table Tab1).

#node	Without Tolerance	With Tolerance
50	27,5	1
100	30	0
150	25,5	0
200	28	1
250	28	0
300	29	0

Tab1. Variation of lost requests /#number of nodes

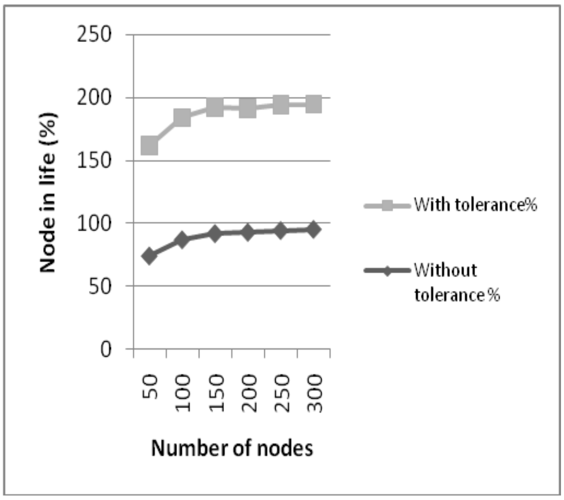

Fig.7. Variation of lost request/#number of nodes

4.4. Variation of number of nodes/ #lost requests

The fourth set of simulation results show the effect of variation in the number of nodes on the average results of the remainder nodes en life. For this simulation, we vary the number of node from 50 to 300 in step of 50, with the number of requests = 200. By varying number of node, the figure *Fig. 7* described as graphic variation of the suggested service of faults tolerance. We can see that the results of our proposal are very significant, and that the number of nodes in life increases by using our service of faults tolerances (see table Tab2).

#node	Without Tolerance	With Tolerance
50	27,5	1
100	30	0
150	25,5	0
200	28	1
250	28	0
300	29	0

Tab2. Variation of nodes in life / #number of nodes

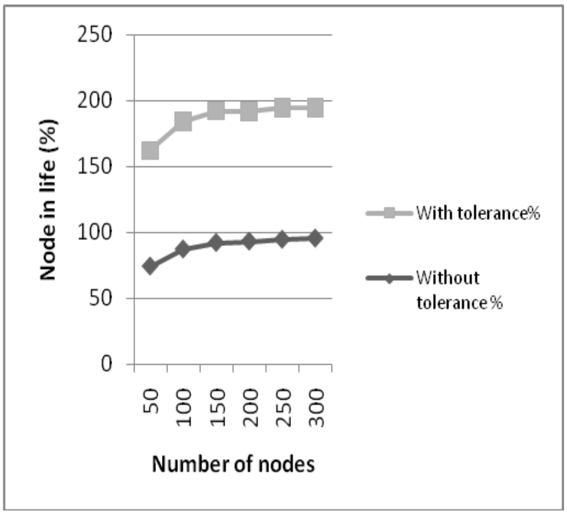

Fig.8. Variation of nodes in life/ #number of nodes

5. CONCLUSION AND FUTURES WORKS

Fault tolerance in the Ad hoc networks is a difficult problem to solve. We have presented in this paper a service of fault tolerance that includes an algorithm of modeling in group in the Ad hoc networks and then apply the fault tolerance by replication of data of nodes that are critical, which is essentially based on the prediction.

The algorithm defined form groups based on geographical criteria and energy nodes. The network after clustering has a hierarchical structure of level two with a leader for each group and super leader for the totality of network. The groups are open, dynamic, mutually exclusive, explicit, allowing point to point communication and group.

The service fault tolerance applied consists of four sub services namely (clustering, decision, replication and consistency management) to better manage the network and incorporates the features necessary for improved data availability. Our contribution takes into account the characteristics of minimize the loss of information. For perspective: we want to integrate in our simulator different protocols of routing in Ad hoc network and implement our service of fault tolerance in a real simulator for Ad hoc network as NS-2 or GloMoSim.

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