Graphical Analysis for monitoring in a sensor network (WSN). Simulator : OMNET++

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Abstract —The wireless sensor networks are attracting more attention from the research community. And simulation is a frequently used approach to test and validate approaches, simulation environments must be able to support different models of wireless sensor networks.

Our paper focuses specifically on a case-monitoring sensor networks. The protocol tested is based on the reconfiguration of nodes with the principle of redundancy to keep coverage of the area and ensure a long life of the network.

The validation of the approach is considered with the use of the simulator OMNeT + + as the results have shown that the concept of the approach in terms of fault tolerance (the principle of awakening the nodes asleep in case of failure or exhaustion of energy from one active node) to ensures proper operation and longevity the network.

Keywords — Wireless sensor network, monitoring, redundancy, reconfiguration, Simulation, OMNeT + +, Castalia

1 Introduction

The concept of wireless sensor networks is growing very rapidly in the areas of communications and computing Because of progress made in recent decades in the micro Electrical, micromechanics and communication technologies wireless have produced at a reasonable cost of components of a few cubic millimeters in size. As a result, a cost-attractive and easy to deploy has created for remote monitoring of complex environments distribution known as the "Wireless Sensor Networks."

The wireless sensor networks are considered as type of ad hoc networks. The nodes are usually deployed randomly throughout a geographic area. Each node is a very small size that consists of a radio transmission, reception and a source energy (battery).

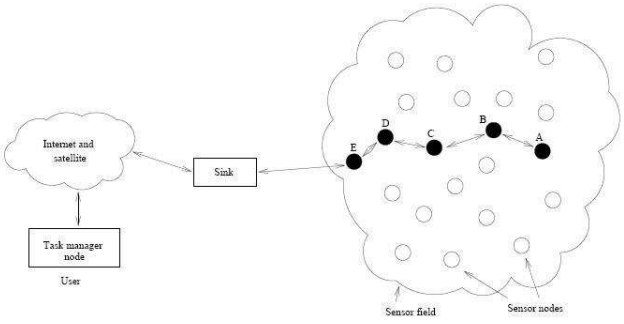

Figure 1: Architecture of wireless sensor networks

The failure of a node can lead to the loss of this information that causes the destruction of the network. In this context, the approach simulated in this paper is a remedy to this problem based on the concept of redundant nodes.

In a network of wireless sensor, nodes are deployed in an adventurous manner, thus the neighboring nodes may appear useless if they have the ability to collect the same data when the approach is to detect redundant nodes .

Simulation is a key step in this case study knowing that many approaches in Wireless sensor networks simulators are evaluated by discret-researchers . In recent years are more attracted by OMNeT + + simulator Despite that lack of direct support and a concise chain by ad-hoc communication.This two are provided by Castalia.

2 Earlier Work

In 'SELF ORGANIZED SENSOR "[TLG05], the author designed its monitoring protocol based on the construction of a hierarchical tree by using the mathematical model such that the theory of graphs or a Voronoi diagram that apply to a wide area due to the use of communication and multi-hop data could be aggregated at intermediate nodes.

The protocol EEP proposed by SAYAD MAYA [SAM] brings improvements such as increased duration of operation of the network and reducing the delay of transmission. Therefore it There's energy savings because the creation of roads is dynamic and is based on a function of cost that takes into account the energy level of nodes and their distance from a base station.

All these approaches are centralized which leads to major disadvantages - Failure of the monitoring station causes the disfunction
of the network.
- Overload of network nodes by the control messages.
From this basis the researchers turned to the decentralized approaches.

The authors [BAN10] have studied the monitoring using multicriteria decision by formulating specific that are trust members, the
limited resources in terms load and capacity of storage and computation, and the absence fixed infrastructure (mobility), connectivity, and distance between the sensors to deal with bad behavior that can target it.

Samira ALLAM into [SAL09] focuses on the routing protocol based on a distributed approach with a multi-agent based on self-organization to ensure the reduction of energy consumed.

In [BER09]the author proposed a descentralized model for monitoring a WSN using a staff simulator designed with C + + for the validation of tests.

After work, we tested a method of descentralized monitoring based on Auto-configuration with a tolerance fault while relying on some optimization concepts of energy.To maintain the

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life of the network, this approach is based on the principle of a multi-agent system where each node has a specific role. The network clusters currency supervised by a node of type "Representative", This node is the responsable on the network configuration
given that the communication inter cluster nodes is done by "Link"
While nodes are simply capture the physical phenomene on the network. By and once the network is organized, it operates the principle of redundancy of some actifve node when the others in "SLEEP" to optimize the use Efficiency Energy. Following this approach, we validate our approach simulator with a robust platform : OMNeT++ and Castalia (Simulator dedicated to sensor networks).

3 Monitoring WSN

A WSN[1] consists of a set of autonomous nodes with a battery so limited power capacity. This type of network allows the deployment of a wide range of applications.

A monitoring system allow the detection of failures observing the evolution of system, then to diagnosis. the diagnostic is determination of the presence of defaults. to ensure this function, it is
essential to distinguish between normal and abnormal situations.

Two nodes are considered redundant if they are close on the other. When the deployment is random, there may be a high redundancy between nodes and a common approach is used to define a subset of nodes that are active while others are inactive.

4 Overview of the distributed approach

The approach is to define a sensor network wirelessly with the principle of agents: different roles of nodes to form groups (clusters or zones), this same algorithm is used to reorganize the network if failure by using the principle of redundancy with the theory the graph.

4.1 Definition of roles

- **Representative node :** This is the node that manages communications within the group of sensor.
- **Link Node :** It is responsible for communications between regions.
- **Simple Node :** It captures the information requested and to communicate to the Sink via his representative.
- **Sink:** This is the main station that can communicate with all the nodes in order to collect the information.

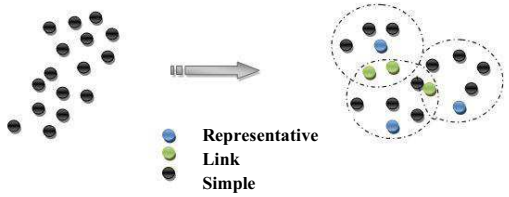

Figure 2: Allocation of roles in a WSN.

[1] Wireless Sensor Network

4.2 Routing protocol

Principle:

The routing protocol is based on the principle role assignment knowing that the nodes of the system interact by sending messages as follows:

- The detection of the neighborhood;
- Changing roles;
- Detection of neighboring groups;
- Resolution of conflicts between representatives;
- Management of redundancy;
- Mechanism for detecting faults.

1. The detection of the neighborhood:
   Each sensor broadcasts a message says "HELLO Message" (at the nodes of a single jump).

Type	Src	Dest	NHop

   Each node receiving this message (HELLO) responds message to a destination.

Type	Src	Dest	Role	Grp	Pos	NHop

   [BER09]

2. **Changing roles:**
   Upon detection of a change in the neighbor table by a node. It sends a message "ChangeRole" each node receiving this message will be obliged to executed the algorithm for allocating roles.

Type	Src	Dest	Role	Grp

   [BER09]

Figure 3: Allocation of roles in a WSN.

3. **Checking the consistency groups :**
   This problem can be caused if and only if there are two disjoint groups.
   The moment a node detects inconsistencies,
   it spreads a message "VerifCoherence" which consists of:

Type	Src	Dest	Role	Grp	GrpNeigh

   [BER09]

4. **Resolving conflicts between representatives:**

Type	Src	Dest	Grp

   [BER09]

   is used in cases of conflicts between groups in which two representatives can become neighbors.

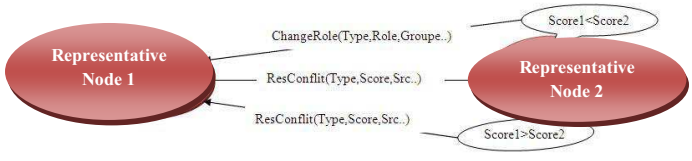

Figure 4: Conflict resolution between representatives .

4.3 Redundancy management:

A node is said redundant if and only if there is another node with the same role to ensure the same tasks as condidat node. This process is applied on Simple and Link nodes as follows:

- **SIMPLE NODE:** Using the property of Gabriel, Simple node "S1" is said redundant if there is another Simple node "S2" in the same group as S1 such as:

  $Redondant(S\ 1)/S1 \in G_i \Rightarrow \exists S2 \in G_i \text{ and } S1 \in Cercle(S2, R_i)$

- **LINK NODE :**A node link L1 is considered redundant if and only if there is another link node L2 as representatives Ri covered by the node L1 are included or equal to the set of nodes Representatives covered by L2. We can formulate this as follows:

  $Redondant(L1)/L1 \in G_i \Rightarrow \exists L2 \in G_i / Grp(L1) \subseteq Grp(L2)$

4.3.1 The approach taken to manage the redundancy :

The redundancy of the nodes is managed by the exchange of messages. Knowing that only the representative has the ability to change the state of a node that is part of the group based a message "ChangeState" that is sent to a specific node to either wake or sleep.

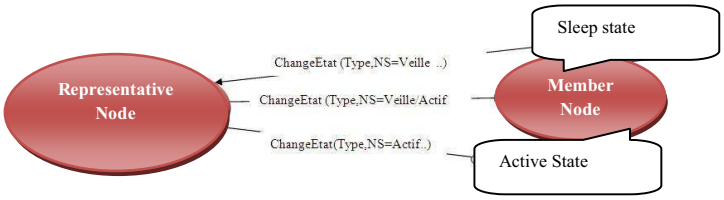

Figure 5: Change state of a node.

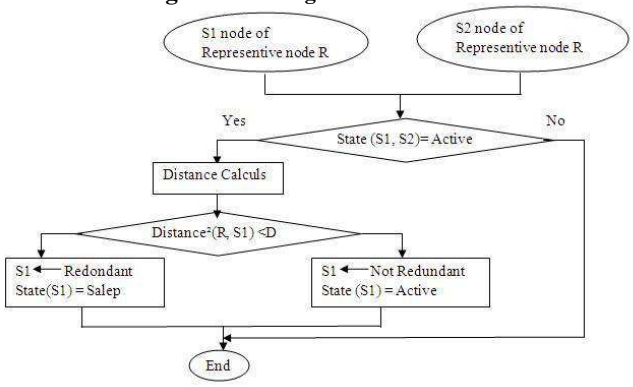

Figure 6: Organizational redundancy of simples nodes.

4.3.2 Failure detection mechanism

The principle can be described in these points:

- The representative node periodically broadcasts the "HELLO" message to the active nodes.
- All nodes receiving this message responds with the "HELLORep" message.
- The node does not respond, is considered faulty by Representative, it awakens all neighboring nodes and starts the process of assigning roles in disseminating the "ChangeState" message.

5 Simulation Environment

There are several network simulators such as: NS2, OPNET, GLOMOSIM, JSIM ... etc.. Another popular discrete event simulator : OMNeT++ [HOV09].
This is not a simulator for WSN, but a rich platform simulation in which independent groups can build their own simulators[HOV09]. OMNeT++ is built from components called modules:

- Module is a simple basic unit of execution and is written in C.+ +.
- Module compound consists of a set of modules (simple or compound) which are connected by connections.

The modules communicate via messages that are sent via connections. The network topology is defined using a declarative language called NED. Scenarios and parameters simulation are defined in the INI files, and are therefore separated from the models and topology [HOV09].
OMNeT++ includes an integrated development environment (IDE) that allows C programming and debugging modules simple and graphic and text file editing NED.

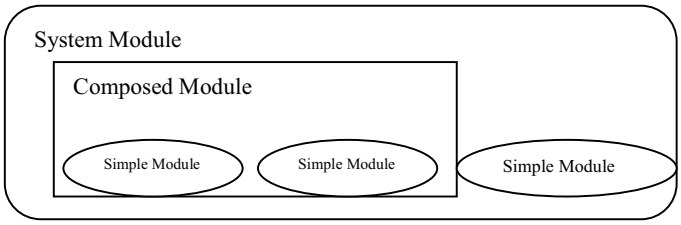

Figure 7: Modular architecture of the simulator Omnet++.

Example of a WSN simulator built on top of OMNeT + + is Castalia [BOA].This is a generic simulator for the validation of the prime high-level algorithms before moving on to a specific sensors platform.
In Castalia, sensor nodes are implemented as modules composed of sub-modules that represent, for example, layers of the network stack. The nodes are connected the wireless channel modules and physical process modules[BOA].

6 Choice of the simulator

OMNeT + + is a simulation environment to discrete events based on C + +, an open source application and under the GNU. It is fully programmable, configurable and with its flexible and generic modular architecture, it has been used successfully in various fields. OMNeT + + & Castalia is our simulation environment, thanks to its architecture modular, it will extend the simulator by implementing a new specific model to sensor networks.

6.1 Design of a node

For our simulation, the first thing we should be modeled is node module with its various sub modules (the protocol stack).
For better view, the graphic file ".Ned" illustrates the used modules.

Figure 8: Graphics ".Ned" file.

In addition to these modules as there are in the following modules:

"Battery" : means a network of sensor is necessarily modeled by a battery in each sensor.
"mobility": To define the network topology and to know the position
of each sensor.

6.2 Structure des Messages

In OMNeT + + messages can be stated in a ".msg" File. The message is used as follows:

```
message Hello {
    int srcAdress;
    int destAdress;
    int HopCount;
}
```

```
cplusplus {{
#include "Hello_m.h"
}}
message Hello;

//
// TODO generated message class
//
message HelloRep extends Hello{
    int Role;
    int Group;
    int Position;
}
```

Figure 9: structure of the Hello and HelloRep message

```
cplusplus {{
#include "PassRep_m.h"
}}
message PassRep;

//
// TODO generated message class
//
message VerifCoherence extends PassRep {
    int Role;
    int GroupN;
}
```

```
cplusplus {{
#include "PassRep_m.h"
}}
message PassRep;

//
// TODO generated message class
//
message ChangeRole extends PassRep {
    int role;
}
```

Figure 10: The structure of the message "Verification of consistency" and "Change Role"

```
message PassRep {
    int srcAdress;
    int destAdress;
    int Group;
}
```

```
message ResConflitRep {
    int srcAdress;
    int destAdress;
    double Score;
}
```

Figure 11: The structure of the message "Pass Representative" and "Conflict Resolution"

6.3 Overview of Sources

1. **Periodic sending of HELLO**
   This message is sent periodically depending on the configuration user
   as follows:

```
void WsnSurvey :: Sendhello()
{WsnHello *msg=new
WsnHello("WsnHello",NETWORK_LAYER_PACKET );
msg ->setSrcAdress(SELF_NETWORK_ADDRESS);
msg->setDestAdress(BROADCAST_NETWORK_ADDRESS);
msg->setHelloKind(HELLO);
scheduleAt(simTime(),msg);
toMacLayer(msg,BROADCAST_MAC_ADDRESS);
}
```

2. **Neighbourhood Table**
   Each node sends a neighbor HELLO_REP message and updated its neighbor table as:

```
Void WsnSurvey ::updatetable(string s,string d,int r)
{int role =1;
            NTable::iterator pos; pos = table.find(s);
            if (pos == table.end())
             { Neighbor newEntry;
            newEntry.Address=d;
             newEntry.source=s;
            newEntry.srcRole=r;
            nbvois=nbvois+1;
            table.insert(make_pair(s,newEntry));  }
             role =RoleAttribute();
```

3. **Attribution Roles**

```
Int WsnSurvey ::RoleAttribute()
{
              int nbLiaison=0;int nbRep=0;intnbSimple=0;
            for(NTable::iterator
            pos=table.begin();pos!=table.end();++pos)
             {
            Neighbor aNeighbor= pos->second;
            if(aNeighbor.srcRole == 3)
            {
             nbRep++;}
            if (aNeighbor.srcRole == 2) nbLiaison++;
              if (aNeighbor.srcRole == 1) nbSimple++;}
            if(nbRep == 0) IchRole = 3;//noeud de liaison
            else {  if(nbLiaison== 0) IchRole=2;//représentant
             else
            {
if          (nbRep > 1) IchRole = 1; //noeud simple          }
            }
}
```

4. **Managing Redundancy**

Once roles were assigned, the node representative takes over and begins the process to nodes redandants on sleep state.
The following algorithm is as follows:

```
Void WsnSurvey :: redondant()

{          if(IchRole==3) {

 for(NTable::iterator pos=table.begin();pos!=table.end();++pos)

                { Neighbor aNeighbor = pos->second;
                //string* des=pos->second.Address;
                //string* des=pos->second.Address;
                if ((aNeighbor.srcRole == 1)&&(nbRep!=0))
                { state = new cPacket("state",STATE);
                toMacLayer(state,resolveNetworkAddress(des));
                 if ((aNeighbor.srcRole == 1)&&(nbSimple!=0))
                { state = new cPacket("state",STATE)
toMacLayer(state,resolveNetworkAddress(des));
```

7 results

7.1 Consumed Energy

We did the simulation on a number of different node which is in the same network. The parameters of our simulation are listed in this Table:

- Area of 100 * 100,
- Energy of 5 dB,
- Number of nodes: 20, 50 up to 100

These results based on the comparison of networks with and without management supervision.

1. **20 Nodes :**

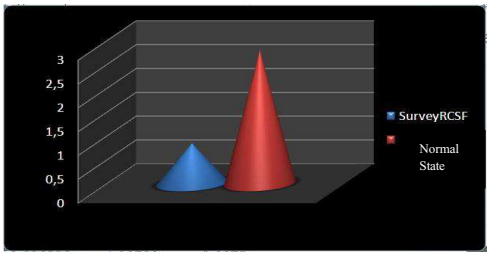

Figure 12: Consumed Energy in the two methods

2. **50 Nodes :**

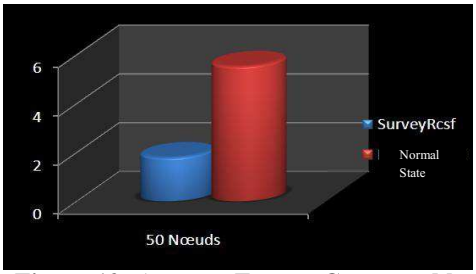

Figure 13: Average Energy Consumed by 50 Nodes

3. **100 Nodes :**

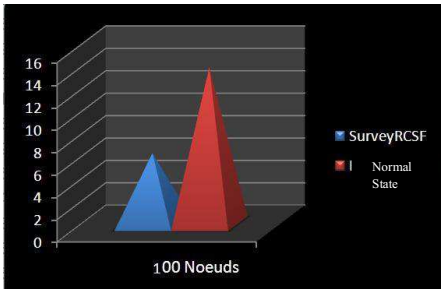

Figure 14: Average Energy Consumed by 100 Nodes

Note that the energy level of a network without redundancy is higher than in the case of a network with monitoring.

7.2 Energy consumed while along the simulation

Both results provide an overview on the consumption energy at some nodes from which one can conclude the network "With Monitoring" is much more optimal than the If "No Monitoring".

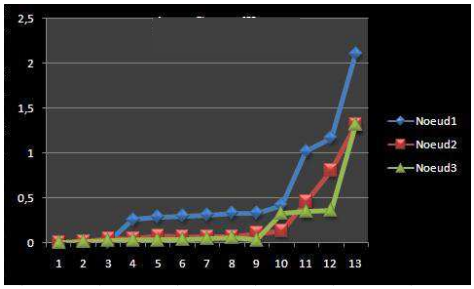

Figure 15: Consumed Energy With Monitoring.

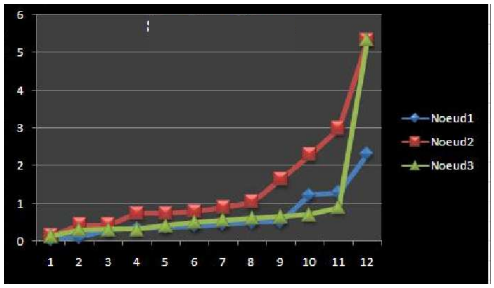

Figure 16: Consumed Energy Without supervision.

7.3 Representative Energy

More precisely, and meadows we collected the results Representative of a node where it is noted that the energy is less consumed in the new approach due to the small radius of transmission (Inter Cluster) and the few active nodes.

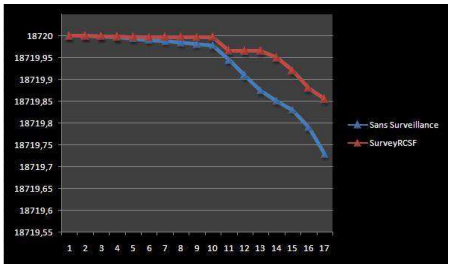

Figure 17: The remaining energy level of a Representative node.

7.4 Number of Packets

This curve has an average of packets sent and received by different nodes according to their roles that summarize the representing the nodes have an average higher as they responsible for the organization of the network.

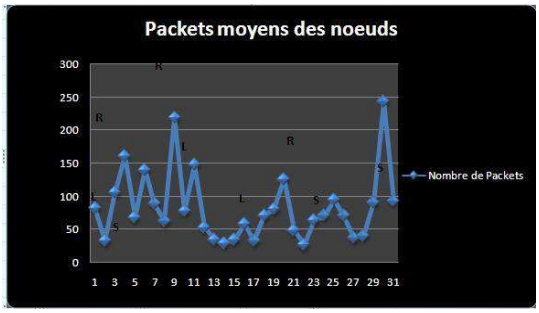

Figure 18: Means packets sent and received by nodes.

7.5 Influence of the nodes Mobility

7.5.1 Average Energy

the average energy in a network with mobility boucoup higher than in a network without mobility is mainly due due to the reconfiguration of the network and sending messages for the discovery of new neighborhood until stability the network.

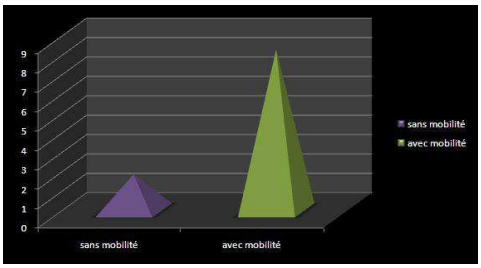

Figure 19: Influence of mobility compared to the Average-energy.

8 Conclusion

In this paper, our goal was to test the performance approach with surveillance under the base: Managing Redundancy nodes distributed in a manner designed to expand longevity of the network by optimizing energy consumption. Following the use of a robust simulator OMNeT + + as Castalia stinks and we show that the results were satisfactory both in the organization of the network that level of consumption ENERGITE and we had the OPPORTUNITY added to an approach at the basic approaches present in Castalia. After graduation, we want to compare this approach with the new distributed approach and to work more with the team for OMNeT to propose a new concepts designed in a basic simulator.

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