MOBILE INTELLIGENT SYSTEM (MIS) AND A MULTI-CRITERIA IN MPLS NETWORKS

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Abstract

In this paper, we introduce the original Mobile Intelligent System (MIS) in embeded FPGA architecture. This node will allow the construction of autonomous mobile network units which can move in unknowns, inaccessible or hostile environnement for human being, in order to collect data by various sensors and transmits them by routing to a unit of distant process.

In the sake of improving the performance of transmission, we propose multi-criteria approaches to enhance the routing process in MPLS networks. Dealing with distributed routing to select the best path between a MIS source and a MIS destination, we have included in our experiment the concept of multi-criteria which is more adapted to actual applications needs. Our proposition is fully based on the Distributed Multi Criteria Routing DMCR protocol.

A set of experiments was carried out to evaluate how the different value of time control packet affect the energy usage in MIS.

Keywords

Intelligent sensors, wireless sensor network, Quality of Service, energy efficiency, performance evaluation *and MPLS.*

1. Introduction

The sensors become necessary elements in all systems where information resulting from the external environment is necessary to evaluate and act. To have an exact and complete knowledge on the subject requires the deployment of several sensors, and possibly, to combine all retrieved information to have a better adjustment of each parameter's sensor.

A sensor network is composed of a large number of units called nodes. Each node is composed principally of one or several sensors, a processing unit and a module of communication, etc... These nodes communicate between each other according to the network topology and the existence or not of an infrastructure (access points) to forward the information to a control unit outside the zone of measure. All these features enable us to imagine an adaptive complex system built around several sensors in a wireless communication system. An original system has been designed and realized named MIS (Mobile Intelligent System) project, which allows integrating three main functions: acquisition, processing and routing of information around embedded architecture like FPGA.

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In this paper, we present the architecture of MIS and the study of improving the performance of transmission: select the best path between a MIS source and a MIS destination, using multi-criteria approaches to enhance the routing process in MPLS networks.

MIS are battery-powered. Energy consumption is therefore an important metric to improve, as it affects the overall performance of the MIS network. In this paper, we present also our work on energy-efficiency aspects into a MIS.

The paper is organized as follows: The first section is reserved for a general introduction. The second section presents the MIS System and its application; Section 3, present our work on energy-efficiency aspects into a MIS. Section 4, presents the concept of quality of service, MPLS and DMCR, the simulation and evaluation of performances is given using some criteria of interconnection between DMCR/MPLS and OSPF/MPLS.
We end with a conclusion and some perspectives.

2. MIS platform

In this section, we will present the MIS project and its experimental platform system previously introduced.

2.1 MIS presentation

MIS (Mobile Intelligent System) is a platform of prototyping of intelligent wireless sensors elaborated within Wireless Sensor Networks (WSN) group of the Laboratory Electronic and Communication (LEC) for topological applications of networks of communicating objects. This platform is based with various sensors (CO, resistive tape recorder...), of a routing and treatment unit, a module of wireless radio communication using standard BLUETOOTH or WIFI and a routing and treatment unit based on a microprocessor (IP software).

2.2 MIS applications

One of the main applications is the construction of mobile autonomous units' network capable of moving in unknown environnement, inaccessible, hostile for human being or in risk areas (fire, radiation, earthquake...) in order to optimize the human assistance. The aim is to provide ground information to establish a strategy of evolution according to the wished purpose. For example, we can locate victims during the rescue operations. This is possible thanks to small mobiles capable of infiltrating through rubble or others explore the watery funds, another application, and not the slightest, is the military exploitation. In this context, the use of sensors' networks allows the surveillance of the perimeters, to assist air or ground attacks and to lead operations of espionage. For that purpose, no element has to be indispensable for the functioning of the network. Such an Ad hoc architecture can maintain the network in activity after the loss of one or several elements and requires a routing module. (figure 1).

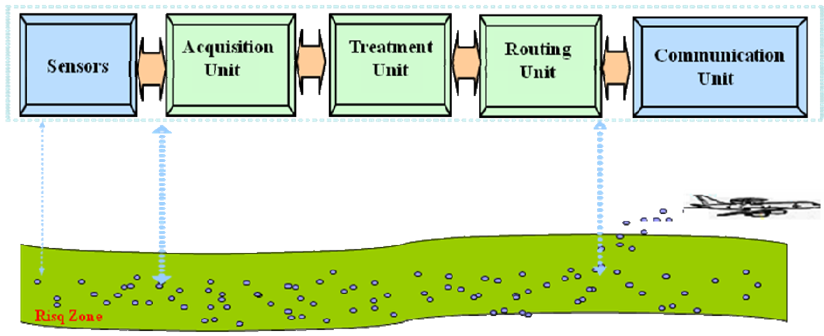

Figure 1: MIS in Risk Zone

*The next subsections, we are going to describe mainly our contribution as the "**Improving the performance of transmission between MIS system. : select the best path between a MIS source and a MIS destination",** subject of this paper.*

3. Minimizing Energy Consumption

One important aspect of MIS is energy efficiency. Thus, minimizing energy consumption is a major challenge. Every computation performed, and every packet (sent/received/forwarded) within unit routing drains this finite resource. Energy consumption is mainly used by transmission and reception of data packets and control packets, including naturally forwarding packets and updating broadcasts. For this reason a thorough investigation of average energy consumption have been considered by varying the times of control packets in Optimized Link State Protocol OLSR.

3.1 Optimized Link State Protocol (OLSR)

The information in this section concerning the Optimized Link State Protocol is taken from its RFC 3561.

Optimized Link State Protocol is a proactive routing protocol, so the routes are always immediately available when needed. OLSR is an optimization version of a pure link state protocol. So the topological changes cause the flooding of the topological information to all available hosts in the network. To reduce the possible overhead in the network protocol uses Multipoint Relays (MPR). The idea of MPR is to reduce flooding of broadcasts by reducing the same broadcast in some regions in the network, more details about MPR can be found later in this chapter. Another reduce is to provide the shortest path. The reducing the time interval for the control messages transmission can bring more reactivity to the topological changes.

OLSR uses two kinds of the control messages: Hello and Topology Control (TC). Hello messages are used for finding the information about the link status and the host's neighbors. With the Hello message the Multipoint Relay (MPR) Selector set is constructed which describes which neighbors has chosen this host to act as MPR and from this information the host can calculate its own set of the MPRs. the Hello messages are sent only one hop away but the TC messages are broadcasted throughout the entire network. TC messages are used for broadcasting information about own advertised neighbors which includes at least the MPR Selector list. The TC messages are broadcasted periodically and only the MPR hosts can forward the TC messages.

3.2 Experimental results

To study energy consumption, we simulate an ad hoc network using the network simulator NS2 (figure 2). (NS2: Network Simulator, TCL: Tool Command Language, NAM: Network AniMator, TR, Trace)

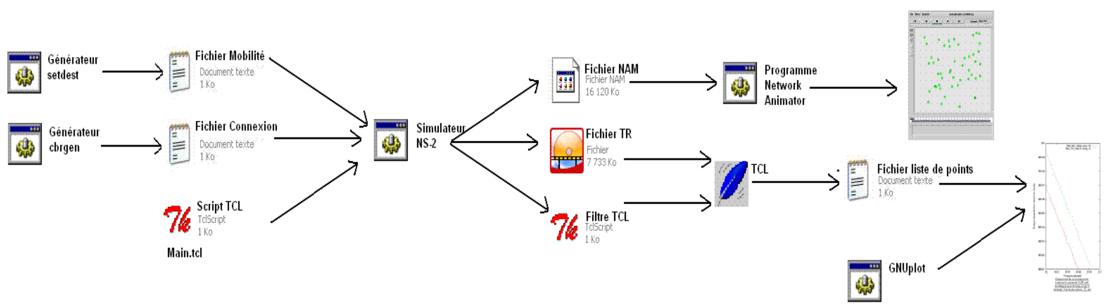

Figure 2: Methodologies of simulation

We use mobility models which reflect real MIS. We study the impact of different times of TC and HELLO modifications that aim to increase lifetime and network performance, and evaluate them under a range of different scenarios. A set of simulations was carried out, including different parameters: times TC and HELLO.

Simulator	NS2
Routing Protocols	OLSR
Mobility Model	RWP
Simulation Time (sec)	100
Pause Time (sec)	0
Simulation Area (m)	670x 670m²
Number of nodes	50
Transmission Range	2,5 s
Maximum speed (m/s)	140km/h
Traffic Rate (pkts/sec)	CBR
Data Payload (Bytes)	512 octet

TABLE I. SIMULATION PARAMETERS

The effect of variation times TC and HELLO is shown in figure 3:

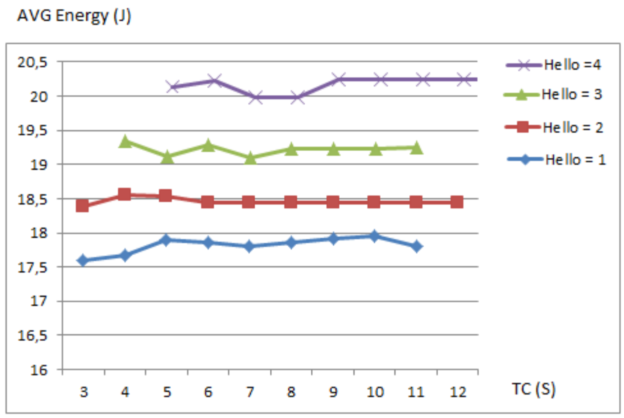

Figure 3: Energy consumption as a function of time TC and a time HELLO

Observation:
This experiment indicates that the average energy consumption decreases when the value of time HELLO decreases. But is not significant with the variations of times TC.

Interpretation:
Increase in mobility speed leads to increase in broken routes. This results in the generation of HELLO messages for route establishment from source node to destination node which dramatically increases the overhead in the MIS network. For this reason, choosing the value of time HELLO affect the average energy of the MIS variable speed

Conclusion:
For using less energy in MIS, we must choose the good value time HELLO.

4. QoS improvement over MIS/MPLS network

Improving the performance of transmission between MIS system in Risk Zone, can be considered as a first step in the study of enhancing QoS in MPLS networks. (figure 4).

To route information between nodes MIS that are found in very remote areas of risk we use the MPLS.

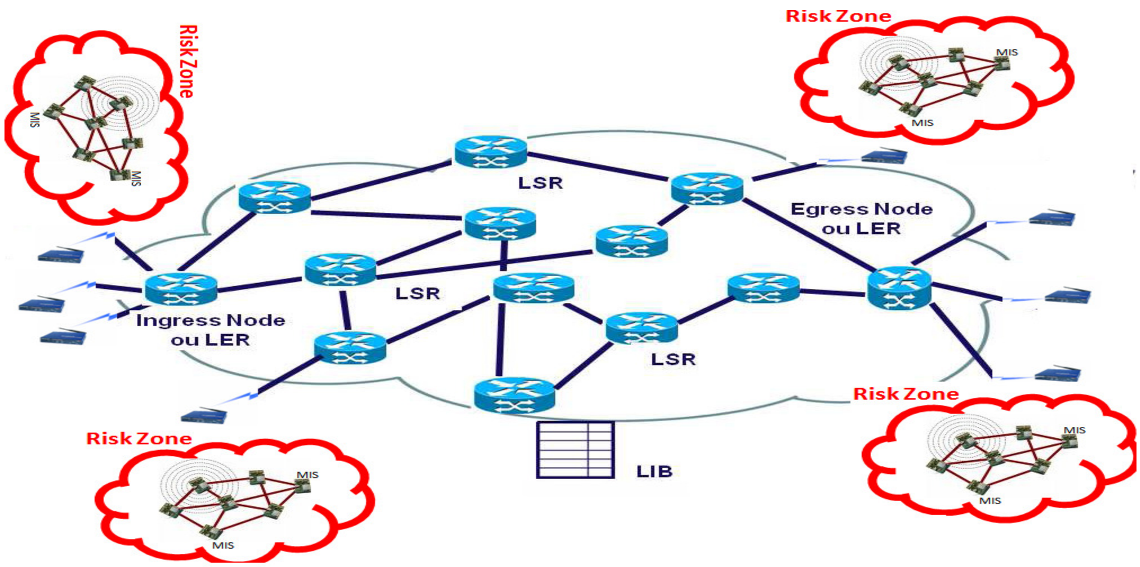

Figure 4: Simulation Architecture

4.1 Quality of service

According to the recommendation E.800 CCITT, the quality of service is "the general effect of the performance of a service, which determines the degree of satisfaction of a user of the service" [1]. This definition is subjective and reflects the perception of the quality of service seen by a user. More technically, the quality of service is the ability to obtain a certain level of insurance so that traffic flow and/or services required are best satisfied, which allows you to share equitably and according to the needs required applications, all of the resources available in order to provide, wherever possible, each user quality he needs. Generally, this quality is focused on bandwidth, the delay and packet loss.

For maximum reliability, QoS requires the cooperation of all segments in the active network, as well as each network element, from the beginning to the end. The different management policies are adopted to ensure QoS, depending where it is placed in OSI layers. To improve QoS in a MIS/MPLS/DiffServ networks, we need to address the IP layer.

4.2 MPLS Protocol

MPLS is a new technology, developed and standardized by the IETF, using switching mechanisms in order to reduce the cost of routing in the network layer while giving it better performance, greater scalability and greater flexibility in the restoration services [2-3]. This technology is easily integrated with others such as DiffServ and InterServ.

The increased flow of information passing over networks, particularly the Internet, has spawned a need for bandwidth consumption growing in recent years. This demand has encouraged the evolution of these different networks which at the same time increased the complexity of managing them.

In terms of improvements, MPLS allows better management in routing (switching) and transfer packages, through networks [4]. But that's not because MPLS is able to solve many problems outlined above by improving four major aspects [4]:

- Possibility to define in advance the path that will take data or types of data sent over the network (Traffic Engineering).
- Ease of creating tunnels and IP VPNs (Virtual Private Network) level including Internet service providers, and solving problems related to the multiplication of them.
- Independence of layers 2 and 3 protocols with a support of IPv6, IPv4 layer 3, and Ethernet, Token Ring, FDDI, ATM, Frame Relay and PPP layer 2.
- Interaction and cohabitation with existing routing protocols such as OSPF (Open Shortest Path First) and BGP (Border Gateway Protocol).

The MPLS architecture is based on switching labels mechanisms linking Layer 2 of the OSI model (switching) with the layer 3 of the OSI model (routing). Moreover, switching conducted layer 2 is independent of the technology used.

The networks now analyses IP headers to make routing decisions but MPLS based its decision on two distinct components: the control plan and data plane.

- The data plan can be used to transmit data packets based on labels that are maintained in a database distributed on all intermediate routers.
- The control plan maintains information transmission labels to groups of switches labels.

Philips and all [5] limits the role of MPLS in the satisfaction of users requirements to differentiate and secure packets in the network.

Nagao and all [6] presents MPLS as a mechanism to administer routes by using optical networks, in order to achieve greater flexibility and change without interruption using secondary LSPs.

Haci and all [7] deals with the benefits of coupling DiffServ and MPLS to give several options for routing and increase the capacity of network resources to meet various needs of the users.

MPLS allows the network administrator to specify how to aggregate DiffServ (DiffServ Aggregates Behavior: BAs) with allocated LSPs. In fact, the question is how to allocate a set of BA to a set of LSPs. When packets arrive in the Ingress MPLS domain, the DSCP field is added to the header which corresponds to Aggregate Behavior (BA).

At each crossed node, the DSCP field will allow to select the right PHB (Per Hop Behavior), that defines the process scheduling (class of priority, WFQ.), and the probability of rejection. This mapping between MPLS classes and DiffServ PHB opens the door for interconnecting these different QoS mechanisms.

In order to improve the MPLS operating, and to update rapidly its data plan and its control plan, we must provide intelligent routing protocols [8] that give the right priority to the right application.

We believe that integrating a multi-criteria approach in MPLS, rather than using traditional protocols, will enhance its task.

In this paper, we particularly try to use the protocol DMCR to achieve better operation in MPLS.

4.3 Distributed Multi Criteria Routing

Distributed Multiple Criteria Routing is a new algorithm that creates routing tables based on several collected criteria. In DMCR, each router forwards packets by using routing tables annotated by special constraints for each Multi next hop (adjacent routers). These tables are used by the router to get a composite routing table. Examination of several criteria in such a distributed manner can be beneficial for routing applications demanding QoS with traffic differentiation.. The DMCR is an application of multipath routing based on multiple constraints, "distributed" means the routing algorithm used, is a distance vector (DV). To adapt MCR to DV, each node is able to store multiple criteria tables. Each table represents a given QoS parameter. Each node also stores the weight given to criteria NWF (normalized weighting function) [9] assigned to each application and/or user.

Multi-criteria distributed methods have been designed to help avoiding a wide variety of problems in many different applications such as streaming, real time, transportation, etc. In this work we based MPLS enhancements on one particular Multi-criteria distributed method which is the Normalized Weighted Function (NWF).

However, other complex variant methods can be used. The NWF method is based on normalizing criteria (QoS parameter) values and using some weights of importance that varies between 0 and 1, with the sum of weight equal to one. NWF is used as a means of evaluation criteria, while considering the needs of users and application preferences. This function allows us to have a standardized cost between 0 and 1.

In this work, we consider three criteria: Energy, Delay, and Bit Error Rate (Quality).

4.4 Simulation Scenario and results

Simulation

Using ns-2 packet simulations, we compare the performance of DMCR/MPLS with an open shortest path first routing (OSPF/MPLS). Our implementation differs from the comparable related work on multipath routing performance evaluation which does not implement important properties like the relaxed best path criteria, or uses unrealistically simple architecture and application models.

As far as a realistic topology is concerned, we have chosen the backbone topology as sketched in Fig. 4. In our scenarios, we have abstracted 13 nodes MPLS and 16 backbone links from this topology with 4 sender Stations (or MIS) and 4 receiver stations (or MIS). Each station sends, simultaneously and during 35s, a CBR (Constant Bit Rate) flow on the UDP transport level. In our work, we made 2 kinds of simulations, the first with OSPF/MPLS routing already developed in NS2, and the second which refers to our developed solution DMCR/MPLS.

Results

In this section, we will compare between these simulations based on bandwidth and drop rate packets.

Bandwidth:

Figures 5 and 6 show the throughput results of our ns-2 simulations, OSPF/MPLS and DMCR/MPLS. In the OSPF/MPLS case (figure 5), we notice the increase of the throughput (flows cbr0 and cbr3), and some flows deterioration (flows cbr1 and cbr2), that signifies charging the network and more link occupation.

This decreases the quality of service. In our DMCR/MPLS case (figure 6), we notice a middle increase of the throughput and a good distribution of flows according to the capacity of the network without congestion. These figures show the best results of our proposal.

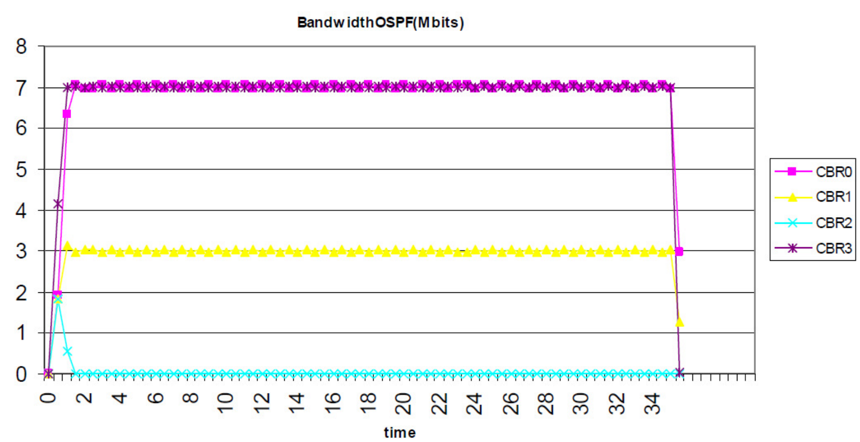

Figure 5: Bandwidth (Mbits/s) evolution over a OSPF/MPLS network

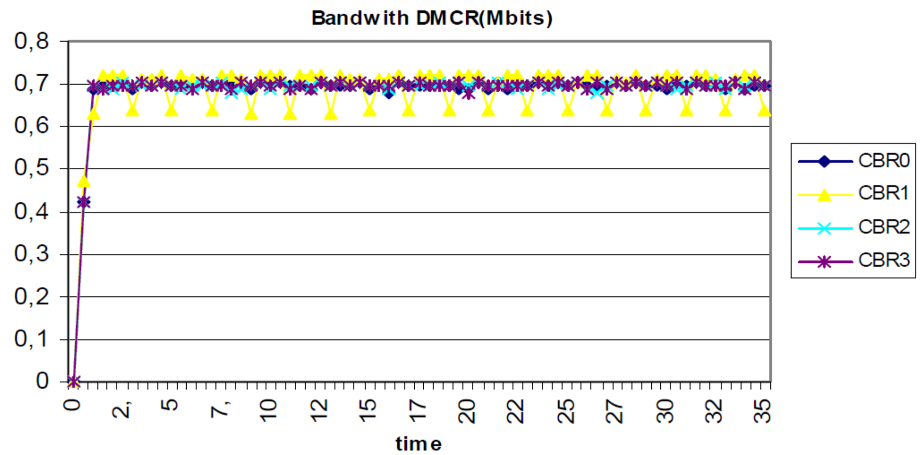

Figure 6: Bandwidth (Mbits/s) evolution over a DMCR/MPLS network

Rate of loss:

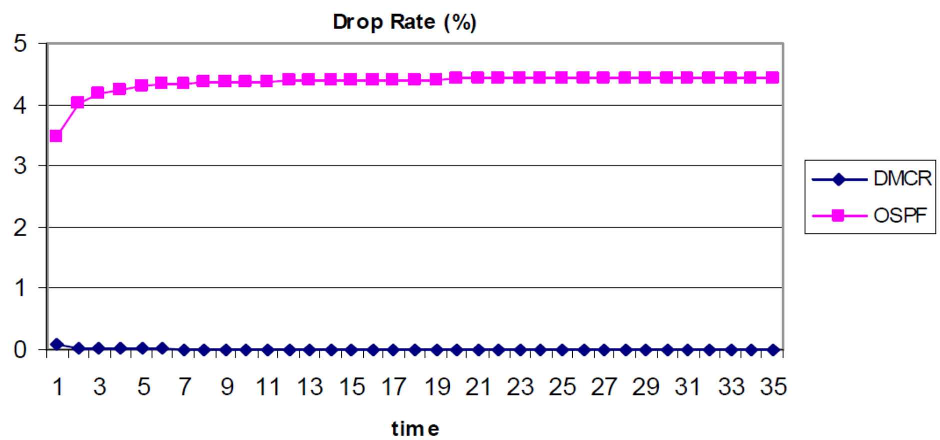

Figure 7: Drop rate evolution over a OSPF/MPLS and DMCR/MPLS network

The figure 7 shows the evolution of loss rate, the blue curve represents the modified implementation, its value tends to 0, by cons OSPF (red curve) increases the loss and time during the transmission, this will lead to failure. Our approach gives an 4,4% of enhancements. The interpretations and the operating principles above is an expected result given the method of creating DV way that is compatible with an extensive and dynamic process, and also our protocol DMCR which collects all of the criteria and assigned way with rapid notification of fault.

5. Conclusions

In this paper, we have introduced the architecture of an intelligent beacon for ad-hoc wireless sensor networks named MIS (Mobile Intelligent System) and its first implementation on the platform. This beacon may acquire environmental data of the environment and detect possible defaults (great variations). When some alarm is triggered, data are sent on a wireless network such as Bluetooth or Wifi.

In this paper, we have also seen that times TC and HELLO affect clearly energy consumption in unit routing of MIS. At the same time, not all modifications are equally beneficial. In particular, changing time of TC, is not promising under of the studied scenarios.

In this work we have also to look for improving the performance of transmission between MIS system. It can be considered as a first step in the study of enhancing QoS in MPLS networks to select the best path between a MIS source and a MIS destination.

We aim to propose a protocol for finding the best Path in MPLS, by using the Multi-criteria and Distance Vector Method to make effective use of MPLS mechanisms to administer large IP networks. We combine the DMCR algorithm within MPLS networks to enhance its performance and reliability. Our approach is able to provide multi-routing priority to applications requiring a specific service and to combine multi-criteria (delay, loss rate, energy) to select the best path in order to fit to a specific QoS need. In the future works, we propose to explore other combined QoS parameters.

The interest of such a work has a big impact for the applications related to the networks of wireless mobile sensors, in particular those dedicated to the military domain.

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