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A review on scheduling strategy for real-time processes

Una revisión de la estrategia de programación a los procesos en tiempo real

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PALABRAS CLAVE:
Sistemas en tiempo real, entornos distribuidos, sistema integrado, tareas de programación.

RESUMEN

En este proyecto se implementó un algoritmo de programación de procesos en tiempo real, capaz de mejorar los resultados para la asignación de tareas en base a un consenso entre varios nodos de un sistema distribuido móvil. De tal forma que los datos de un dispositivo móvil se puedan transferir y ubicar en una red sin perder información, tenemos en cuenta la calidad del retraso. Este proyecto pretendía dar una visión de planificación y enrutamiento en tiempo real, que permitiera la obtención de buenos resultados sin pérdida de información, sin buscar mínimos locales. Asimismo, se propuso construir un algoritmo de enrutamiento para mantener y construir un planificador, considerando una compensación en línea de la distribución de cargas, además de optimizar la ruta de los mensajes, reduciendo el tiempo de comunicación en función del problema de enrutamiento.

KEYWORDS:
Real-time systems, distributed environments, embedded system, scheduling tasks

ABSTRACT

In this project, a real-time process scheduling algorithm was implemented, capable of improving the results for assigning tasks based on a consensus among several nodes of a mobile distributed system. In such a way that the data of a mobile device can be transferred and located in a network without losing information, we take into account the delay quality. This project was intended to give a real-time planning and routing vision, which allowed the obtaining of good results without loss of information, looking for no local minimums. Also, it was proposed to construct a routing algorithm to maintain and construct a scheduler, considering an online compensation the distribution of loads, in addition to optimizing the route of the messages, reducing the communication time based on the routing problem.

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1 INTRODUCTION

The importance of distributed systems is relevant in the computational sciences. Today they are found as a fundamental part in complex paradigms, for example in ubiquitous systems, pervasive systems, real-time systems, robotics, artificial intelligence, mobile computing, among others.

Real-time systems are heavily included and used in the latest generation of aircraft, spacecraft, robot control, wireless mobile device (WMD) communication, and etcetera. In WMDs, real-time algorithms must be capable of immediate response because they have restrictions regarding the use of their limited resources [1, 2, 3]. In a mobile distributed system (MDS), we have nodes (mobile devices) as a dynamic system, so it is necessary to perform the analysis of the metric to be used, which is the minimization of the sum of the weight weighted at determined times, based at a cost of sending a packet between two nodes. The metric is important since in the WMD, the difference of values is imparted on the complemented system [4]. This proposed metric is based on [5], where it compares different algorithms based on theorems of process planners on uniprocessors and multiprocessors by measuring the computation time required for the determination of a scheduler that satisfies partial order and resource constraints.

In an MDS, there is a single entity with three elements: sending node, receiving node, bridge node and router node. It can be viewed as a local state, depending on the requirements and constraints to make the communication. In an MDS, the nodes can communicate with neighboring nodes by means of an appropriate entity configuration, in a transmission range from a sender to a receiver in a neighborhood L. Communication in this MDS configuration neighborhood describes a dynamic topology, which makes it difficult to establish and maintain a communication path between the nodes $v_i \rightarrow v_j$, taking into account that $i \neq j$ and $v_i, v_j \in V$, where V is the set of nodes in a mobile network, presumably remote because of the unwillingness to communicate in a given time.

Routing algorithms in an MDS environment are based on message flooding, such as a route search mechanism in an L neighborhood, sending messages in the neighborhoods of nodes, using Ad Hoc SLR (Source Routing with Local Recovery) networks [5].

The analysis, design and implementation of a planning algorithm guaranteed the execution of periodic, aperiodic and sporadic tasks with appropriation to simulated dynamic environments, complying with deadline constraints, applied to a planned EDF (Earliest Deadline First) [6, 7, 8, 9].

The infrastructure analysis, as well as the tools required to design and implement the proposed algorithms and methods, were coupled to a software tool capable of measuring the times of process planners.

The scheduling algorithm was based on the consensus of CRA (consensus routing algorithm) tasks for MDS [10]. For this it was used in a multi-agent environment with uncertainty in the execution times [11, 12], based on the metric proposed previously for the planning of tasks a priori.

It is considered primarily to carry out the bibliographic study of mobile distributed systems, real-time systems and high-performance computing, as well as the application of hybrid routing algorithms [12], and reactive protocol algorithms, depending on the convenience of the application or applications. With all this abstraction it is decided to apply algorithms in a platform capable of executing them in real time, this chosen platform is a mobile device that plans the flight tasks of a drone. On the other hand, the simulated algorithms and methodologies are developed under a high-performance computing architecture, specifically in a supercomputer with adequate resources to perform the tests and obtain the desired results.

An MDS is developed by applying a network connection based on p2p nodes. Once this result is obtained, the planning algorithm is designed and implemented in order to observe the delay quality.

2 STATE OF THE ART

In [13] describes the approach to the problem of consensus and agreement: "The agreement between processes in a distributed system is a fundamental requirement for a wide range of applications. Many forms of coordination require processes to exchange information, which is used to negotiate processes with processes and reach a common understanding, before taking specific actions of the application".

In [14] it is discussed the application of the results for the problem of consensus based on multi-agent systems, where two algorithms based on the Laplacian matrix of the network G graph are proposed that achieves the consensus in a finite time using functions Lyapunov. In this way, a special distributed map is proposed for the class of non-directed graphs. These maps are used in [15], where we propose a comprehensive analysis and design of co-operative strategies for consensus, another contribution is the introduction to the necessary and sufficient conditions for two discontinuous distributed algorithms that achieve minimum and maximum knowledge in time finite and asymptotically. As proposed in this work of thesis research, the use of Ad Hoc networks is proposed, for this reason we contemplate these works mentioned above, to validate their results in networks with intercommunication topologies and dynamic changes. Another work with novel approaches to consensus algorithms is [16], in this paper we re-addressed the concomitant problem for distributed non-linear multi-agent systems and apply a controller to directed and non-directed graphs. In addition, this control allows you to work on fixed and changeable topologies. The application of consensuses and agreements in multi-agents in distributed environments and design of observers can be found in [17], this work is based on neighborhood rules L for the coordination of multi-agents. In the search for an active leader, we describe the agent dynamics to be followed with interactive control inputs.

An example of mobile distributed systems (MDS) applications can be found in [18, 19 and 20], this paper focuses on the problem of determining an optimal route, through a route discovery algorithm. The AEC is applied to an SD environment using an adjacency matrix, then the numerical distance is used to apply the consensus for the mobile topology case study expressed in equation (1).

$$y_i^k = \frac{\sum_{k=1}^{m} w\left(i,J_i^h\right) f_{\left(i,J_i^h\right)}^k(\rho)}{\sum_{k=1}^{m} w_{\left(i,J_i^h\right)}} \qquad (1)$$

where:

y_i^k It is the winner of the consensus with the interaction i.

$w\left(i,J_i^h\right)$ It is the level of agreement with respect to the input pairs.

$f_{\left(i,J_i^h\right)}^k(\rho)$ Availability function of the neighbors of i.

For example, in [21], we can observe the application of fuzzy control based on Takagi-Sugeno's theory. In this experiment they were based on commercial platforms, applying the Takagi-Sugeno methodology for diffuse logic control. Both quadcopter and helicopter set three dimming points: $\theta = -45^o$, $\theta = 0^o$ y $\theta = 45^o$. These conditions are important for obtaining the desired quantifications, although they are limited to only three sets of them.

Other research work that emphasizes the analysis and design of control systems in NCS networks is found in [19], here we experience a LQR (Linear-Quadratic Regulator) control applied to delays in a real-time system that is in an NCS.

A comparison of the work in [15], in [16] a modeling is presented using Euler-Lagrange for the helicopter in 2DoF. Based on this model, an FF-LQR (Feed Forward-Linear Quadratic Regulator) control is applied to control a helicopter by regulating the axis at an angle pitch with FF. The FF + LQR + I control uses an integrator in the feedback loop to reduce steady state error. Using the FF and proportional integral velocity (PIV) the pitch angle is regulated and only the angle of yaw is controlled with the PIV.

The LQR control effectively adjusts the frequency set without the calculation of the control law and the reconfiguration itself impacting the transition. It should be noted that this latter reconfiguration decreases the performance index caused by a network utilization outside its bandwidth or due to low sampling of transmission outside the planning region at angles and speeds in pitch and yaw, is say, respectively.

The research work is presented in [20], where a proposal for the control of the helicopter is presented. The objective is to maintain the desired angle of pitch and yaw, through two propellers with two motors as actuators, in addition to other use cases like the simulation of a magnetic levitation system, with an electromagnet as actuator, and two sensors that measure the position of a steel ball and the current of the electromagnet.

To show the application of the design of an NCS, the loss of packets in a remote communication between computers or mobile devices, based on the UDP (User Datagram Protocol) protocol, is presented.

The fuzzy control designed is applied to both case studies, using the fuzzy model designed and the imperfections model. Feedback matrices are designed for each discrete sub-model through an LQR design [21].

3 IMPLEMENTATION OF THE CALLED FAN ALGORITHM WITH PROCESSES

The algorithm developed is shown in algorithm 1, and highlights the handling, creation and scaling of processes with a specific deadline. The processes fulfill the task of sending messages in a certain time, creating a process by message, in this way the metric based on the time is obtained. Each process was identified by an identifier, if the value is different from zero, then the child processes creation is expanded, and fan planning is enhanced. If this is not the case, the processes are put on hold.

```
Create.SocketUDP(host,port)
repeat
    for i=0 to NumProcess do
        Create main process
        If ID=0 then
            sendMessage();
            create.Process();
    else if ID==0 then
                wait();
            end if
    end for
until Dispatch all processes
```

Algorithm 1. Algorithm proposed named Fan.

The executions were performed on a node assigned by the LNS-BUAP supercomputer lab, using instances of the reduced operating system with a micro-kernel called Minix version 3.

The micro-kernel has basic resources of an operating system, being ideal for the execution of the algorithms of planning. These instances were carried out with a tool for the administration of the cloud of computation. The tool called OpenStack allowed the execution of a considerable number of Minix instances, several tests were performed with at least 1,000 instances and a handling of 1,000 processes.

The third line of algorithm 1 represents the execution of cycle of processes that send messages by means of the remote communication protocol Socket UDP.

4 RESULT

The idea behind the algorithm proposed here is to launch all of the processes with a certain deadline set up apriority, as if a fan was unfolded (that is the reason for its name), with the hope that all of the processes reach their goal [22].

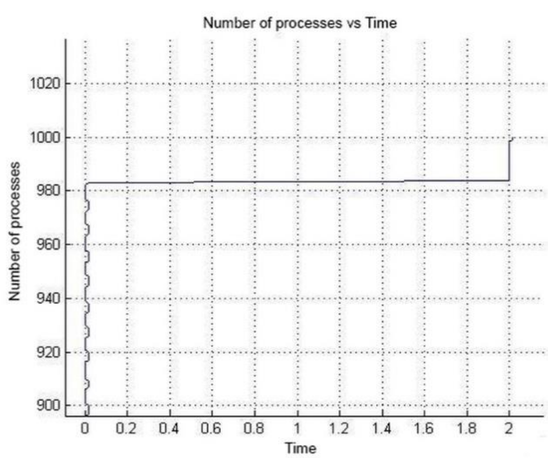

Figure 1. Processes with deadline.

During the performed tests, once all the processes were launched, the time to reach their deadline was measured. As an example of these tests, in Fig. 1 is shown that 92% of the processes reached their a priori deadline in less than a minute, whereas the remaining processes reached their deadline in the lapse of two hours.

More tests need to be executed to confirm that this is an average behavior and to analyze what happens when the number of processes and resources are increased. Nevertheless, the proposed algorithm generated results that can be used to compare them with the results of other similar algorithms in order to determine whether or not it reduces the time for the processes scheduling.

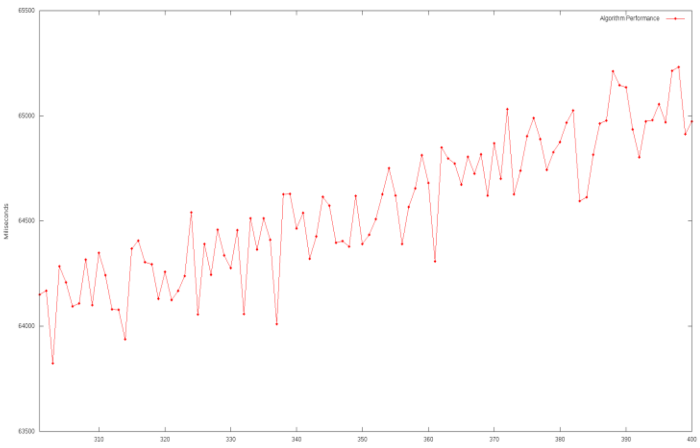

Figure 2. Measured in seconds.

Figure 2, we show the processes measured in seconds and it is possible to appreciate the results obtained by the tests carried out in the LNS laboratory node. It should be noted that 92% of the processes achieved their deadline established a priori. From 980 processes, a constant with respect to time is observed. The interpretation of this statement indicates that the scheduler has a brief improvement with respect to the deadline of the processes. After a processing time, 98.9% of processes reaching out their deadline are achieved. The remaining 8% achieved a considerable improvement in the range of 1.8s to 2 seconds. And it keeps up with this behavior. Finally improvements are expected to this proposed algorithm increasing the number of processes and resources.

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