Analysis of Modeling Techniques for Distributed Objects

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Abstract*: It can be noticed a deficiency in the way of correctly modeling the objects, that is, how to distribute the objects better, according to the application characteristics and the user needs, exploring more actively the advantages of this technology, and consequently reaching a better quality. So, with the purpose of searching a better organization of the objects, techniques which establish different modeling criterion for the distribution are presented here, based on the analysis and application of the objects. The aim of this work is to present the results of the utilization of modeling techniques utilization for distributed objects applied to the Satellite Simulator from INPE.*

1. Introduction

Nowadays, the methodologies viewing the distributed objects are concerned only with the distribution and do not present modeling techniques to design the distribution better and consequently organize these objects. Analyzing the behavior of the objects it is possible to design a way to distribute them more suitably in such a way that the modeling will benefit the application.

The aim is to create possibilities in order to obtain better results presented by the application as a consequence of this new organization of the objects.

Three ways of modeling to distribute the objects are experienced. These techniques are based in the object distribution by Use Case, Fault Tolerance and Random distribution. The characteristics of each technique of distribution are presented. The initiative does not have the objective of pointing which of the techniques to be used is the best, but to observe how they can influence the behavior of these objects.

The question about the granularity applied to each object is also approached. There is an interest in identifying which are the consequences in terms of performance resulting from the breaking of objects in smaller objects when utilizing each technique presented here.

The Satellite Simulator software from INPE is a tool which allows the creation of a realistic operational environment reproducing accurately each foreseen step of the life time of the

Satellite (Rozenfeld 1990) helping the development and validation of the operation procedures and control of the Satellite.

Transparence, flexibility, confiability, performance, availability, economy in the implantation cost and the expansion facility are the characteristics presented by distribution which eliminates the limitations previously found in the Satellite Simulator, since it was performing in centralized systems.

Viewing the achievement of improvement in these characteristics provided by the distribution, the three techniques of modeling for distributed objects are applied to the objects from the Satellite Simulator.

2. Application - The Satellite Simulator

The main objective of the Satellite Simulator is to allow the training of the operator to control and to track the Satellite and to provide a real environment which may be utilized for the elaboration of acceptance tests of the Satellite control system software [Rosenfeld 1990].

2.1. The Satellite Simulator Architecture

The satellite simulator is operated through the Interface Operator in an exclusive terminal where the Satellite Simulator is initialized, and from that point, the responsible for the simulation can follow the steps from the process, monitoring its state and interacting with the simulator in order to perform control actions or to cause failures. It is through the Configuration Editor that the System Data Base is edited. In this base the data are: identification items, password and user attributes, screens allowing to visualize and monitor current simulation states, parameters which define this state and the simulated failures. The architecture of the Satellite Simulator may be observed in Figure 1.

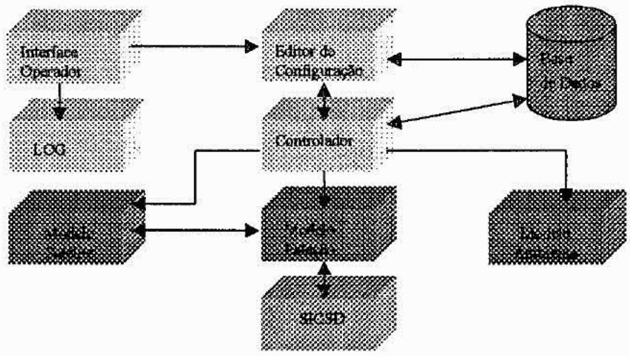


Figure 1. Satellite Simulator Architecture Adapted Source [Rozenfeld 1990].

The occurrences of important events are registered in a LOG file which may be consulted during the simulation process. The models: Satellite, Station and Environment are responsible for the simulation of the satellite subsystem functions.

3. Modeling Techniques

The satellite simulator acting in a centralized system presents some limitations, such as: failures in the availability, performance and fault tolerance. One of the objectives of this work is to utilize the resource of distributed computation through its innovator properties, applying them to the simulator, trying to eliminate the limitations presented. So, it is possible to obtain the following characteristics in the satellite simulator:

- The increase of availability of objects, independent of failures in the computers [Ferreira 2001].

- Fault Tolerance: the failure of a computer or object, in a distributed environment represents only a partial failure in the system, which can be overcome through new connections with objects which realize the same service.

- The increase of concurrence and performance: the capacity of instantiating copies of the same object in different machines provides a better performance to the attendance and request of multiple users. This factor must be taken in account to explore the concurrence resource in distributed systems, that is, two or more users can request the same service to the system, but be assisted by instantiated objects in different nodes.

- Flexibility to attend the different control situations: with the application of distributed objects in the satellite simulator control, parts of the simulation process can be distributed or even replicated completely in different machines.

- A software complex system, which presents quality, shows a harmony which makes it flexible to modification. This flexibility is obtained many times, through the utilization of some techniques already consecrated, such as, a modeling [Booch et al 1999].

In this context, the importance of carrying on a study focusing the modeling of distribution can be observed, that is, an attempt to establish techniques on how to improve the distribution of objects in order to increase the benefits acquired by the distribution.

Searching for a better organization of objects in the application, some important aspects must be analyzed such as:

- The function and behavior of the objects regarding its application;
- Individual factors of each object or factors when related to other objects;
- Determinant aspects of the application;
- Users necessity.

From this analysis on, the survey of some techniques can be idealized. The techniques here proposed (Distribution by Use case, by Fault Tolerance, and random way), establish criterion and different ways of modeling. The aim of the initiative is not to show which is the best technique to be utilized. The efforts will be concentrated only in studying the advantages and disadvantages of the presented techniques, exploring their qualitative and quantitative factors and classifying them according to the results obtained in a comparative study, which involves performance and availability. The three mentioned techniques are presented as follows:

3.1. Modeling Distribution based on Objects which Collaborate Between them to Realize a Use Case

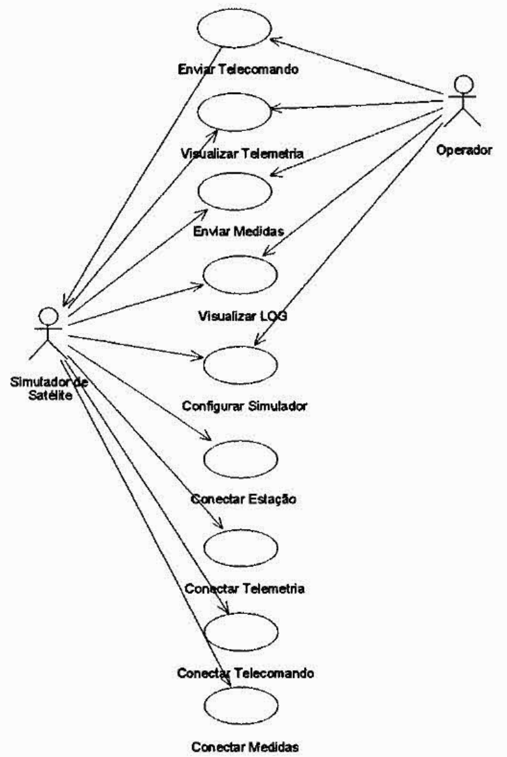


Figure2 – Use Case Diagram : Simulator Subsystem

In Figure 2 an Use Case diagram from the Satellite Simulator is observed. In many applications, in determined moments, an existent dependence among objects that must not be broken may be perceived. That is what happens with some objects observed in the satellite simulator, such as the telecommand and telemetry objects.

The Telecommand object represents messages which may be sent to the satellite, in order to correct or change key positions and turn sensors on and off. The object telemetry shows the internal state of the satellite, voltages, temperature, that is, the satellite equipment conditions. When a telecommand object is received from a client, while being treated it reflects almost immediately in the telemetry frame. It can be observed then, that frequently a telecommand object acts and affects the telemetry object, so, to let them working nearby or even in the same machine, may bring some advantages, when obeying to a determined criterion.

This criterion for object distribution can be obtained analyzing the subsystems of the satellite simulator and causing the objects which communicate more frequently among themselves to take part in the accomplishment of the same use case. These objects then, related by use case will be created in a same machine, diminishing then the relationships among the use case and consequently among the machines. This fact provides advantages, reduces the traffic in the net and obtains a higher availability. For example, if a failure in a determined object of a use case occurs, it will not harm a second case.

In Figure 3, the objects which collaborate among themselves to realize a use case may be observed. The dotted ellipse is indicating this collaboration. The equivalent colors characterize the instance of a same object.

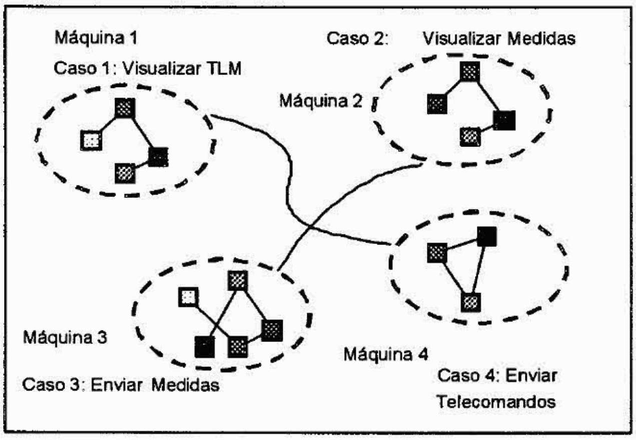


Figure 3 – Objects distributed by modeling based on objects which collaborate among themselves to realize a use case.

There is no impeachment in having duplicity of use cases in different machines, because, being the copy of a use case, the set of objects will provide the same characteristics as the first original one.

3.2. Modeling of the Distribution based on Fault Tolerance

A second aspect to be approached in an attempting to find modeling options for a better distribution, is to provide fault tolerance to the object failure. Focalizing this property, the established criterion is to replicate the objects, independent from the kind of service executed in every machine existing in the system. In this case, the machines overload becomes unavoidable, but the availability of a determined object is strongly assured. Figure 4 shows how this system is presented.

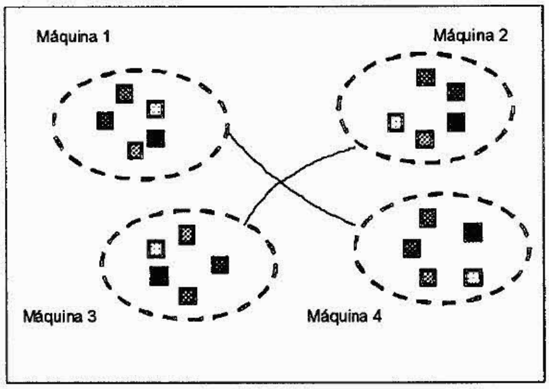


Figure 4 – Objects distributed based on Fault Tolerance

3.3. Modeling of the Distribution based in the Random Way

The third way presented here consists of the random modeling. This technique is equivalent to the traditional method, except because it obeys to an only criteria imposed by the modeling, which establishes the existence of at least one copy of a same object in the system. Figure 5 illustrates this distribution as follows:

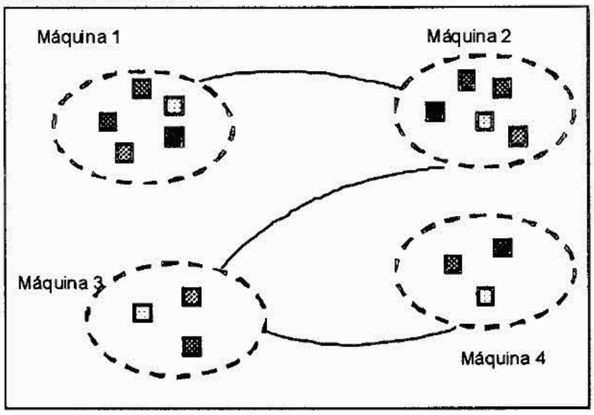


Figure 5 – Object distributed by modeling based in the Random Way

4. Result

At first, the results about the elimination of the simulator software limitations are shown. Later a quantitative analysis about the three techniques presented here is approached.

4.1 - Qualitative Results:

Availability and Fault tolerance: an increase in the availability in the distributed Simulator Software Prototype may be verified. It can be observed that when causing a failure in an object of the Simulator, such as the telemetry, the other subsystems of the simulator software related to other objects such as range and telecommand are still available. This fact shows that a failure in a certain software object does not cause unavailability of other services. So, the existence of a fault tolerance in the distributed simulator software can be observed: when a failure is provoked in one of the objects, such as failure in the telecommand object, it is not possible to utilize any of the commands related to this object but it is possible to establish a new connection with an object equivalent to the telecommand object in another machine. Then, at the moment when this object is instantiated, the services related to the telecommand object which were inoperable to this moment, become available.

Concurrence and Flexibility- A higher flexibility to attend different control situations is observed. It is possible to replicate totally the simulator software in another machine attending to possible needs of one or more users, where it is possible to instantiate all the objects simultaneously in more than one machine, allowing then to replicate totally the Simulator Software.

4.2. Quantitative Results

Experiments in order to obtain qualitative results about this modeling techniques presented in this work were carried on. These experiments were done in order to compare the time consumed by each way of distribution presented here, that is, by distribution techniques by use case, fault tolerance and Random way. Before detailing the process carried on to obtain the values of the performance measures it is necessary a short explanation about the granularity. Related to objects, granularity means the breaking of objects in smaller objects in such a way that the union of these smaller objects form the object which has originated them. This set of smaller objects should maintain as well the same functionality presented by the original object.

The necessity of granularizing the objects in this work appeared in the execution of the practical tests in the Simulator Software. Observing the results, it was seen that the objects which collaborate among themselves to execute a use case showed different performances when locally and remotely allocated and this performance varied even more when the random modeling technique was utilized, where the objects were found scattered by the net. It appeared then an interest in observing how these objects would behave increasing their granularity and distributing them according to the techniques of modeling approached here. Figure 6 shows the mentioned idea.

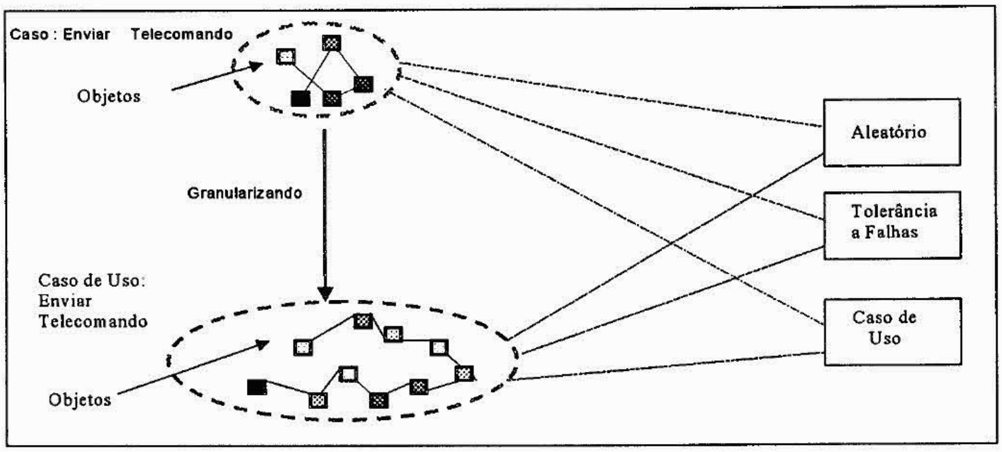


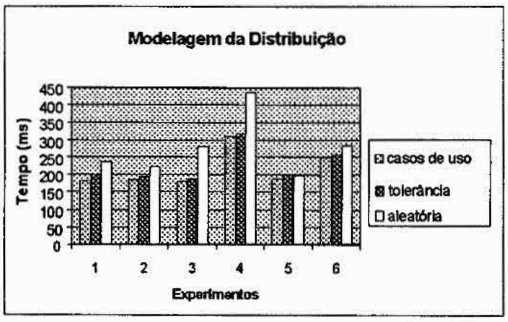
Figura 6. Granularizing objects

Figure 6 illustrates objects which collaborate between themselves to execute the Use Case "Send Telecommand". To these objects it is possible to apply the granularity, that is, to break these objects in smaller objects, but keeping the same functionality. So, a bigger set of objects to collaborate among themselves in the accomplishment of the same Use Case "Send Telecommand" is obtained.

Now, it is possible to observe how the objects behave, applying to them, before and after the granularization the distribution techniques presented in this work. In this way, as the figure shows, the modeling techniques based in Use Cases, Fault Tolerance and Random are also applied to this new set of granularized objects. The objective is to observe how the breaking of objects together with the way in which they are distributed, can influence the performance of a determined task.

Several measurements were done in order to obtain enough information to make possible to execute a quantitative analysis, expressing through graphics the obtained results.

Six methods were selected (1 – send telecommand, 2 – Visualize Telemetry, 3 – Send range, 4 connect range, connect telemetry, connect telecommand) of the satellite simulator software. The objects were distributed according to each technique and measurements of the time necessary to the conclusion of a certain method invocated were done. This measurements were repeated for invocations of the six methods. However the invocation of the same six methods for all the techniques of distribution utilized was repeated. The measurements were redone granularizing the original objects in 10 objects, a number empirically chosen and then once more, the measurements with increase in the traffic in the utilized net were repeated so that the traffic influences in the performance of the objects could be observed. The graphic in figure one shows the result only for original objects, that is, without granularity. The mean may be verified as follows:



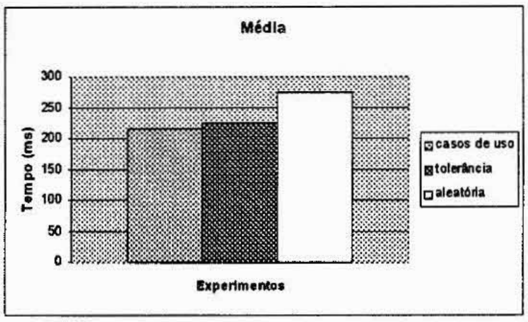
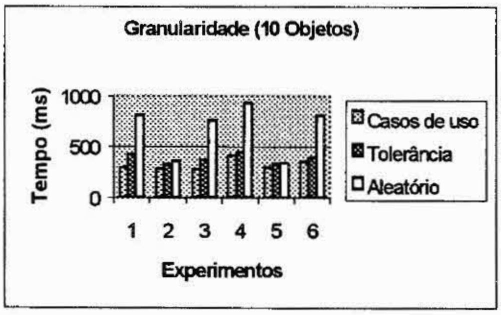


Figure 7. Models of distribution and Mean

Next it can be observed in Figure 8, the graphics of the results glanularizing the original objects in 10 objects and the graphic of the mean.



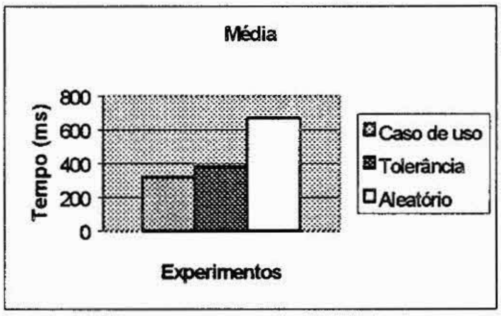


Figure 8. Glanularity in 10 objects and Mean with traffic

The graphic in Figure 9 shows the results obtained with traffic increase, only for the original objects, that is, without granularity

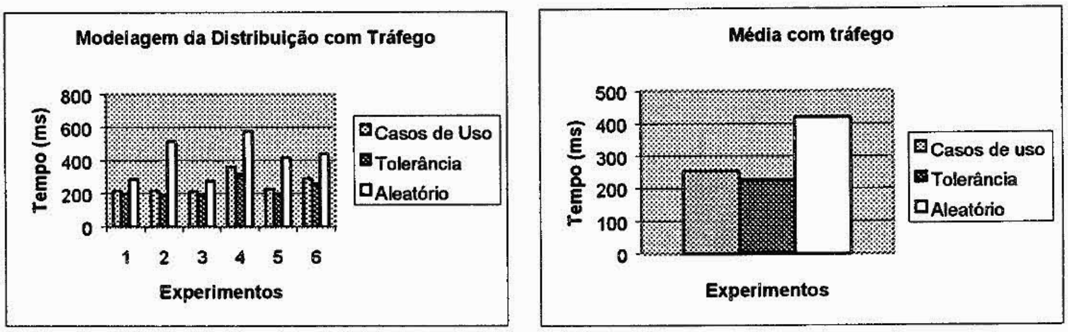


Figura 9. Models of distribution and Mean with traffic.

Next, it can be observed in Figure 10 the graphic of the result, with an increase in the traffic, glanularizing the objects in 10 objects.

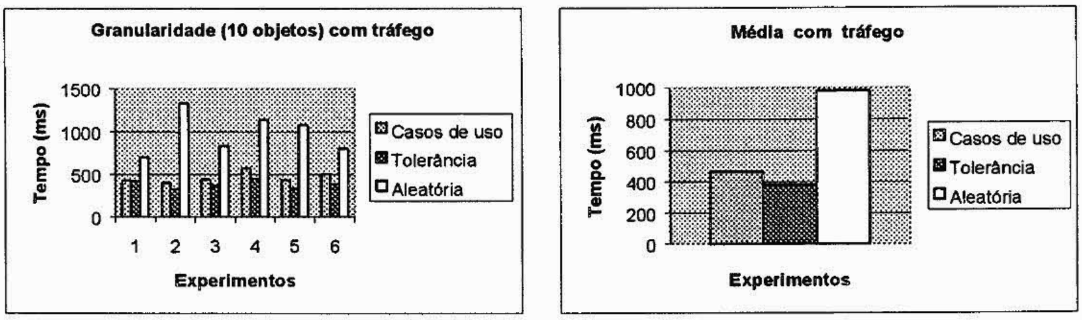


Figure 10. Granularity in 10 objects and mean with traffic

5 – Conclusions

Through the result presented it is possible to notice that when the project needs a better performance, a good choice could be the modeling of the objects which collaborate among themselves to realize use cases. It is also noticed that the utilization of this technique allows a smaller latency of communication among the objects which are interacting with a higher frequency, because it creates a strong coupled among them, bringing them nearer from each other, avoiding then excessive remote access. However, when the concern is availability, the modeling by fault tolerance appears as the best choice.

This technique guarantees the availability of the objects since they are instantiated in all the machines. It can be noticed through the results obtained that, with this technique the performance of the machines may be affected due to the overload of instantiated objects in the machines, but even harmed, the performance appears better than when the random modeling technique is utilized. The random modeling appeared as the worst option in every case. As the objects are

more scattered through the net, more remote accesses are necessary than when using other techniques of modeling, increasing then the net traffic harming unavoidably the performance of the enrolled machines.
Through the graphics obtained, it is possible to observe that the results follow these same tendencies too, when the glanularity of the objects is increased, that is, in the mean, the technique of the objects which collaborate among themselves to realize use cases continues presenting the best performances. The random modeling presents even worse results when realizing the breaking of the objects in smaller objects, considering that the quantity of objects distributed by the net increases. So, the consequences of the increase of granularity reflect more expressively when the accesses are remote.
The deficiency found in how to distribute the objects of an application, motivated the creation of distributed modeling techniques. These techniques may be considered as a help to obtain improvement in the characteristics of the distribution, considering that the results presented by the experiences carried on prove that such a modeling, influences right on system characteristics such as performance and availability.
In terms of limitations of the Simulator Software it is possible to notice that the same were satisfactory eliminated with the application of the objects distributed in the system.
Question like availability, fault tolerance, concurrence and flexibility were solved with the use of technology of distribution.
It is possible to perceive then that "how to distribute" the objects of an application is an activity which must be considered when deciding to work with distributed objects.

References

Booch, G.; Rumbaugh, J.; Jacobson, I. (1999) "The Unified Modeling Language User Guide". Reading, Massachusetts: Rational Software.

Ferreira, M. G. V.(2001) "Uma arquitetura flexível e dinâmica para objetos distribuídos aplicada ao Software de Controle de Satélites", INPE, São José dos Campos.

Rozenfeld, P; Miguez, R; Orlando, V. (1990) "Proposta de um Simulador para o Satélite SCD1", INPE.

Burgareli,L.A.. (2003) "Abordagens de Objetos Distribuídos Aplicados no Simulador de Satélites do INPE", INPE, São José dos Campos.