Virtualization of Virtual Measurement Machines as component of Distributed Artificial Intelligence System

ANDREY ANGELOV ELENKOV
Faculty of Automatics
Technical University of Sofia
8, Kliment Ohridski st., Sofia-1000
BULGARIA
aelenkov@tu-sofia.bg http://www.tu-sofia.bg

Abstract: - The focus of Distributed Artificial Intelligence (DAI) is on the development of systems that emulate the intellectual abilities of a society of human beings. The approach in this paper corresponds to this focus – master, slave, hierarchy, centralized management. A low cost solution for High Availability and Disaster Recovery with hot site recovery strategy in SAN-oriented Virtual Measurement Systems, which are components of DAI System, is presented. It is based on cooperation and interaction between the intelligent agents (IAs). The agency is hierarchic and centralized, separated in branches formed of the IAs. Some of the branches are responsible for the measurements. The Virtual Measurement Machine (VM) is component of the IA. The IAs work as team. Each IA has a role but in case of disaster can play the role of the damaged IA because of implementation of VM live migration as virtualization technology.

Key-Words: - Distributed Artificial Intelligence, Virtual Measurement Machine, Disaster Recovery, Virtualization

1 Introduction
Information and Communication Technologies (ICT) are in the center of the contemporary human organization and it is logical that the ICT systems emulate the intellectual abilities of a society of human beings - Distributed Artificial Intelligence (DAI) System. A lot of organizations or enterprises have distributed ICT branches or ICT departments. The organization of the ICT infrastructure is hierarchic and the ICT management is centralized. The main problem is how to make the ICT systems more reliable. How to realize high availability and disaster recovery in real time at low cost? The virtualization and live migration of the virtual machines is the decision, but depending on the case the virtualization technologies vary.

In this paper the problem to be solved is focused on the building of a disaster recovery for a distributed measurement systems as part of an enterprise. The Recovery Point Objective (RPO) is close to the real time (less than 1 min as a goal) and the Recovery Time Objective (RTO) is close to zero. This means hot site recovery strategy.

Based on virtualization and live migration of virtual machines a low cost solution for High Availability and Disaster Recovery with hot site recovery strategy in SAN-oriented Virtual Measurement Systems, which are pieces of Distributed Artificial Intelligence (DAI) System, is presented.

2 Problem Formulation
2.1 Distributed Artificial Intelligence
In the mainstream of artificial intelligence, a new modern discipline has impressively evolved in the last years: distributed artificial intelligence (DAI).

Whereas the focus of artificial intelligence is on the development of systems that emulate the intellectual abilities of a single human being, e.g. speech recognition or solving general programming problems, e.g. neural networks [1, 2], or using math-modeling of a physical process [3], the focus of DAI is on the development of systems that emulate the intellectual abilities of a society of human beings. A typical artificial intelligence system exhibits some performances that roughly resemble the intellectual and interactive (in the case of robotic system [4]) performances of a human being, such as making diagnoses, proving theorems, allocating resources, scheduling activities, and planning and performing complex sequences of actions. On the other hand, the performances of a typical DAI system roughly
An agency is a unique machine. A multi-agent system is composed of intelligent agents that interact [6]. An intelligent agent (IA) is a (traditional) system of artificial intelligence, maybe performing inferential activities that can be implemented as a software program, as a dedicated computer, or as a robot. The IAs of a multi-agent system interacts together to organize their structure, assign tasks, and exchange knowledge. Competition and cooperation can be viewed as two extremes of a range of possible forms of interaction. From the designer’s perspective, there are two opposite approaches to develop a multi-agent system. According to the first approach, the designer has in mind a global goal to be accomplished and designs both the IAs and the interaction mechanism of the multi-agent system. In the second approach, the designer conceives and builds a set of self-interested IAs that are then left to evolve a stable interaction structure through the use of evolutionary and learning techniques.

An agency [7] is a multi-agent system in which the IAs and the interaction mechanism have been designed and built in order to achieve cooperation. The IAs of an agency cooperate together in order to achieve a global goal. For this reason, agency can be considered as the machine of cooperation. It is important to underline that, although it is composed of complex components like IAs, it is useful to consider an agency as a unique machine.

Finally, any complex and articulated measurement system should be conceived as perceptive agency [5].

In this paper the virtual measurement machine is a component of the IA and the IA is a component of departments or cells building the measurement systems, which are components of the agency (enterprise).

2.2 Disaster Recovery Planning
Disaster Recovery (DR) planning is the process of preparing for recovery or continuation of ICT processing tasks that support critical business processes in the event of a threat to the ICT infrastructure. In some cases, ICT infrastructure would be recovered in a process that could take days (or weeks) while in other cases processing will continue immediately (or within minutes) at a remote site away from the threat.

The DR planning and testing process is not generally regarded by ICT teams as the most exciting task to be involved in, and most would prefer to keep busy with 'cooler' projects such as virtualization or some new Web 2.0 technology. But business continuity and DR planning is critical for an organization and when the worst actually happens, there is always plenty of excitement to go around.

The Recovery Point Objective (RPO) is a measure of how much data can be lost when a disaster occurs. This is effectively the difference in time between when the disaster happens and when the last backup occurred.

Essentially the Recovery Time Objective (RTO) is the measurement of how long the business can survive without the systems being in place to run the specific business process. This may vary from zero (e.g. the underlying systems always need to be available) or could run as long as days or weeks (if there are sufficient manual processes in place for the process to continue for this length of time without the systems).

After the determination of the RPO and RTO for all systems the strategy for recovery must be selected. A common way to look at the primary strategies for disaster recovery is based on definitions of the primary off-site recovery centre facilities that these strategies use.

A cold site recovery site would provide the most basic of infrastructure at the recovery site with no actual systems. For example, the cold site may have air-conditioning, computer cabling, raised floor, etc - but there will be no systems permanently available at that site. When a disaster occurs, new systems need to be delivered to the site and only then can recovery start. Obviously the time to recover will be relatively long (days or weeks - depending on how long it takes to for backup systems to be delivered to the site) and therefore this strategy is seldom used and is not recommended.

A warm site recovery site would provide the most basic of infrastructure at the recovery site with no actual systems. For example, the cold site may have air-conditioning, computer cabling, raised floor, etc - but there will be no systems permanently available at that site. When a disaster occurs, new systems need to be delivered to the site and only then can recovery start. Obviously the time to recover will be relatively long (days or weeks - depending on how long it takes to for backup systems to be delivered to the site) and therefore this strategy is seldom used and is not recommended.

A hot site recovery facility contains dedicated hardware that can be ready to take over production system processing immediately, within minutes or within a few hours at most. With hot site recovery the data required to continue operations is generally replicated to the recovery site and so is available.
virtually immediately. A hot site recovery strategy is fairly expensive but is the only acceptable strategy for very low (or near zero) RTO and RPO objectives.

Preparing for DR is an on-going task and it’s not easy. The initial step in formulating a successful DR plan is to look at the company’s reliance on critical data functions. Below, is a list of questions to ask when deciding if a DR plan is essential for the business [8]:

- How far behind the competition would the company fall without access to its stored data for a day? A week? A month?
- What would be the financial impact of an interruption in computer-to-storage operations?
- Do the day-to-day business functions of the company rely on the computer’s stored database?
- Does the business have a substantial customer base relying on E-commerce?
- Is the managed data used to directly generate income for the company?
- Are there legal liabilities or penalties incurred if the company is unable to meet obligations? Even if the company is not a bank or doing business in another regulated industry, the corporate officers can be held personally liable for many business losses, including failure to take adequate precautions to protect against business interruptions.
- What is the impact on customer service and goodwill if data cannot be accessed and the company cannot provide timely information?
- Is the computer controlling or storing quality assurance data? What quantity of the company’s products would be rendered useless without that data or the computer-controlled measurement systems?

The questions were posed to the enterprise involved in this project. In this paper the task is to solve the problem coming from the last question – low cost hot site recovery strategy for computer-controlled measurement system (virtual measurement machine) as part of this enterprise.

2.1 Virtualization with live migration - low cost Disaster Recovery and High Availability

Virtualization is one of the fastest-growing trends within enterprise data centers. It allows multiple operating systems in virtual machines to execute concurrently on the same computer system. Virtual machines execute within special boundaries called partitions, which have different levels of access to various hardware components. Partitions can be provided with virtualized hardware, share a piece of physical hardware among themselves, or be the sole “owner” of a particular hardware component.

A special-purpose virtual machine (VM) provides management functionality and is sufficiently privileged to create and manipulate other virtual machines. The software that allows the multiplexing of virtual machines on a single physical machine is called the virtual machine monitor (VMM) or hypervisor. Because it creates a standard virtual hardware platform regardless of the underlying physical system, virtualization technology further enables the migration of virtual machines from one physical system to another. When migrations can be performed without interrupting the execution of the guest OS on the virtual machine, they are referred to as live migrations. The benefits of live migrations are considerable: Being able to dynamically relocate operating systems in response to performance needs, systems management events, or data center scale-out requirements could change the way data centers are designed and used.

Virtualization with live migration because of no interrupting time could solve the problem of low cost hot site recovery strategy for the defined problem.

3 Problem Solution

The agency could be separated in branches or cells. Each branch is a multi-agent system composed with intelligent agents (in the following simply called agents). Some of the branches are responsible for the measurements. The enterprise (agency) is hierarchic and centralized. To ensure high availability (HA) and disaster recovery (DR) the enterprise (agency) needs at minimum 3 agents in every branch or cell teaming in two levels.

Figure 1 shows this three-agent on a two level approach. Two agents, Agent 1 and Agent 2, work as team and following the custom one is master and the other one is slave. The same is in the real agency with people staff, e.g. two colleagues. On the next level is situated the Agent 3 who stores the info (data) and is responsible for the communication with the higher level. This means Agent 3 is responsible and for the management and the monitoring, e.g. with the help of Agent 3 the system could be managed remotely from other agency’s cell.

The solution from Fig.1 with three agents on two levels corresponds on Storage Area Networking (SAN) -oriented virtualization architecture, where Agent 1 and Agent 2 are two servers working in cluster and Agent 3 (server 3) is a storage and communication server. Based on the process of virtualization different virtual machines (VMs) could be started on each agent, e.g. as shown on Fig.1 – VM1 and VM2. On the other hand each VM could
be virtualized with live migration and could be migrated from one agent to another. To ensure low cost virtualization each VM controls different measurement group (MG). Every MG is connected to servers physically with one and the same ports following Fig.1 VM1 to port X (PX) and VM2 to port Y (PY). It means VM1 is bundled with PX and MG1. On the other hand VM2 is bundled with PY and MG2. With the help of virtualization technology it is not a problem to do the live migration of the VMs from one server to another. The virtualization is on software level only and the migration is only for the VMs. The system could be easily tested and the HA and DR could be attained at low cost because of the lack of hardware virtualization.

Virtual machines VM1 and VM2 could use different graphical programming languages. Into the test system LabVIEW has been started on the two machines. LabVIEW has subsequently become the de-facto standard for graphical development environments in the technical information technology sector [9]. VM1 and VM2 together with measurement groups MG1 and MG2 form Virtual Measurement Instruments which could be called Virtual Measurement Machines (VMMs). The migration is live migration of VMM1 or VMM2 from one server (agent) to another and the result is virtualization of VMMs.

To test this solution a test system was built with two servers in cluster and a storage server, built as iSCSI SAN, with 10GB Ethernet switch for the connections between the servers. As result the migration time of the VMMs was less than 50ms and the VMMs were bundled with the physical ports.

4 Conclusion
Virtualization has rapidly become a standard technology for use in software development and test, and server consolidation scenarios. A growing trend is for organizations to further leverage virtualization to achieve superior disaster planning and recovery operations.

On the other hand the focus of DAI is on the development of systems that emulate the intellectual abilities of a society of human beings. The approach in this paper corresponds to this focus – master, slave, hierarchy and centralized management.

Virtualization gives a low cost HA and DR for the branches with real measurement systems in real time. The solution could be easily involved in each agency’s cell or branch. On the other hand the proposed solution could be easily tested and introduced step by step, department by department, cell by cell.

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