USING SIMULATION FOR DECISION MAKING IN ZERO LATENCY ENTERPRISE PROJECTS

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ABSTRACT

The concept of Zero Latency Enterprise (ZLE) has received considerable attention through the last years. Many companies and organizations want to see the value of this kind of strategy before changing their IT infrastructure to implement ZLE solution. This paper proposes a new project methodology defining five main steps that should be followed to success in ZLE implementation projects. One of these steps, the Planning and Decision Making stage, is based on simulation techniques, allowing a comparison of the organization performance with and without ZLE strategies. Furthermore, in this work the different approaches for the ZLE simulation are examined and discussed.

INTRODUCTION

The competitiveness of current markets has lead many organizations to explore innovative strategies in order to enhance competitive differentiators. The Zero Latency Enterprise (ZLE) concept refers to a company in which business events recognized anywhere in the business can immediately trigger appropriate actions across the entire enterprise and beyond (White, 2001).

The ability to make decisions based on up-to-date information and to apply such decisions to reaction mechanisms clearly differentiates those companies that are capable of responding, acting, learning and adapting in real time (Ranavide, 1999).

Transforming an organization into a ZLE is a complex process that needs a detailed planning to achieve all the desired objectives with the required quality. The same data belonging to different applications and company departments use to be in different formats, to follow different rules and to be updated, modified and accessed through completely different processes. Therefore, ZLE projects are mainly related to integration and interoperability concepts.

The main contribution of this paper is the definition of a five steps methodology to implement ZLE strategies. One of the main problems during this implementation use to be the need of knowing the effects, costs, benefits and risks of this kind of strategy before making important decisions. ZLE implementation implies several challenges and difficulties and it is crucial for companies to know in advance the possible advantages and problems of the implementation.

This work proposes the use of simulation in the Decision Making step, providing a powerful mechanism to determine if ZLE is a profitable strategy for the company and to optimize its implementation if the project is finally carried out. Furthermore, a detailed analysis of the two main alternatives for this simulation, using monolithic or distributed models, are discussed to guide users in their ZLE projects.

The rest of this paper is organized as follows. Section 2 gives the theoretical background related t ZLE concepts and necessary to understand this work. Section 3 proposes the methodology for ZLE strategies implementation, and Section 4 analyzes the two main alternatives for simulation in the Decision Making step of the proposed methodology. Finally, Section 5, summarizes Conclusions and Future Work.

THEORETICAL BACKGROUND

Zero Latency Enterprise solutions allow applying real time concepts to business management. A ZLE strategy would be any strategy that exploits the immediate exchange of information across technical and organizational boundaries to achieve business benefit. ZLE describes organizations that can exchange information with employees, trading partners and customers in near real time, eliminating both internal and external latencies. In a ZLE organization, business events trigger system events that can post actions and send responses throughout the enterprise (Becker, 2001), (Hollar, 2003).

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ZLE implies that the company has minimized the latency of their operations so that the events related to any factor affecting the company immediately trigger the timely actions of those responsible. The possibility of reacting in real time will bring to the company a competitive advantage.

Therefore we can summarize by saying that ZLE implies the minimization of business processes latency and allows information systems integration, bringing real time corporate information management.

The benefits of implementing a ZLE strategy can be summarized as follows:

- Provide a real time view of the business. The user will have all the information available in real time to react to problems as soon as possible.
- Detect and remove potential dangers and threats for the organization before they become a real problem.
- Increase productivity of business processes: achieve greater efficiencies, responsiveness and profitability.
- Access to applications available for real time business management (data mining, CRM, balance scorecard, business intelligence).

But despite all these advantages, the current corporate environments present several barriers and difficulties in implementing such strategies:

- Subsystems based on black boxes that cannot be accessed or modified to allow the desired integration.
- Lack of compatibility among software/hardware systems from different vendors and developers.
- Information islands existing in different abstraction or technological levels.
- Excessive business processes latency.
- Organization rejection and people negative attitude in facing new information systems and processes.
- Ignorance and/or mistrust in concepts relative to real time.

The ZLE approach can be deployed in any environment where real time information is required. But depending on the industry or sector (retail, financial services, telecommunications, etc), the applications and the functionalities will be different.

Focusing for example in the retail industry, these would be some of the applications and functions covered by the ZLE approach: business intelligence, profitability forecasting, customer relationship management, supply chain management and marketing campaigns.

Technological Infrastructure for ZLE

One of the key factors necessary to implement a ZLE strategy is the software and network infrastructure that allows the systems integration, facilitates the business process latency reduction and provides real time information to corporate users.

The development and deployment of this infrastructure can be done from scratch or using some kind of software reengineering such as EAI. And the selected strategy can be based on a customized product, specifically developed for the organization; on EAI commercial solutions such as SeeBeyond or TIBCO; or on the infrastructure developed by Hewlett-Packard, the only ZLE software in the market nowadays (HP, 2009).

In any case, all these approaches are usually based on two technological concepts: Hub-and-Spoke and Web Services.

Hub-and-Spoke are applications composed of a central data integration repository and of a messaging services motor that allows communication through different applications. The Hub-and-Spoke is also responsible for carrying out the ETL (Extract, Transform and Load) tasks.

The most widespread definition of a Web Service is *a software system designed to support interoperable machine-to-machine interaction over a network*.

Web services are frequently just Web APIs that can be accessed over a network (LAN or WAN) and executed on remote systems. Therefore, Web Services are components accessible from different applications, and based in standard protocols. These components are loosely coupled and their basic unit of communication is the message.

IMPLEMENTING A ZERO LATENCY ENTERPRISE STRATEGY

The implementation of a real time strategy will have an influence on almost all the divisions and departments within an organization, not only from a technological point of view (applications and data), but also from the viewpoint of innovation, processes or human resources, to name just some examples. The establishment of such a strategy requires a significant effort and in order to ensure success and a correct transition in the organization, a detailed methodology to develop the projects is needed. This work proposes a ZLE project roadmap composed of five different phases or stages:

1. Education and Communication.
2. State measurement and Benchmarking.
3. Information and Reporting.
4. Planning and Decision Making.
5. Implementation.

The first four stages should be always carried out in a ZLE project, but the fifth phase is performed only if in the Decision Making stage the cost/benefits analysis concludes that the ZLE strategy is a good option for the organization.

Next sections summarize these five stages proposed for the ZLE projects roadmap.

Education and Communication

The perception of the real time concept is often ambiguous or wrong. Two people talking about real time probably will talk about very different concepts. Therefore, for the success of the ZLE project, all the involved people must have a clear understanding, and more important, a common understanding of the concepts and technologies that are going to be handled.

This education is very important for other reasons, such as the involved departments' motivation, because without the cooperation and involvement of people working on the ZLE project, the achievement of the real time objectives will be impossible.

State measurement and Benchmarking

How prepared is the organization to ZLE?. To answer this question, all departments must examine in depth the current state of their IT infrastructures. This analysis will produce updated information about the qualitative and quantitative aspects that are important to the specific needs of the ZLE project. The state measurement can be performed within the organization or can be performed by external organizations or companies, in any case, an exhaustive benchmarking must be performed.

Information and Reporting

The data collected in the previous phase must be used to elaborate detailed information about the current organization applications, processes and information flows. Information about the available IT infrastructure and about the current organization resources must be elaborated too.

All this information must be reported to a ZLE project group responsible for performing the next step in the ZLE project roadmap: the Planning and Decision Making. Therefore, this group should be composed of people from all relevant departments and divisions of the organization.

Planning and Decision Making

After the reporting phase, the best ZLE strategy for the organization can be designed. In particular, the following aspects can be discerned: the processes and applications that will be needed to obtain a real time strategy, the departments necessarily involved in the ZLE strategy and the information flows between these departments.

Afterwards, a cost-benefit analysis must be performed to decide if it is profitable to carry out the project, taking into account the costs, the risks and the benefits of the ZLE implementation.

There are not analytical solutions for this evaluation because it is a too complex system, and qualitative aspects are not enough to take robust decisions because they not help in identifying the critical aspects for the project success.

A variety of simulation techniques have been previously applied to software development projects (Kellner et al., 1999). In this kind of work, simulation has demonstrated to be useful in predicting the costs and benefits of software projects (Donzelli and Iazeolla, 2001), (Host et al., 2001), (Raffo and Wakeland, 2003).

In this work simulation techniques are recommended as a tool to reach a decision in ZLE projects. A simulation of the performance of the company with and without ZLE can easily determine if it is a profitable strategy.

To improve decision making at this stage, simulation can be complemented with other techniques to determine more specific aspects, for example, about the low level technological details of the project or about specific applications.

But the simulation of the "virtual organization" should be the main decision mechanism on a project of this complexity. Furthermore, if it is decided to go ahead with the project, this simulation can really help in finding the optimal ZLE strategy for the organization.

These are the main questions that should be answered from simulation results:

- What would be the costs, benefits and risks associated with implementing ZLE?.
- How would the ZLE solution contribute to the company competitiveness?.
- What would be the impact of considering certain processes, applications or departments in the ZLE strategy?.

- What need to be done to ensure that the full benefits of ZLE are achieved?.

Implementation

If the Decision Making stage leads to the ZLE implementation, the old IT infrastructure is gradually replaced by the new, allowing real time. This transition must be a dynamic process in which the ZLE project group is responsible for avoiding unnecessary costs and latencies, and for ensuring that the specified quality is achieved and the project objectives are satisfied.

In a realistic environment, this implementation stage is almost always iterative, implementing the ZLE solution in small steps until the real-time objectives are met. In each of the iterations, the simulation can help to achieve the project goals faster and with less costs and risks.

ALTERNATIVES FOR THE SIMULATION IN THE DECISION MAKING STAGE

As it has been stated in the previous section, one of the most important steps in implementing a ZLE strategy is the simulation of the operation of the company before and after its implementation.

This stage allows estimating the costs and benefits involved in the ZLE project and making decisions not only with qualitative information. However, this stage can be expensive in time and resources, since it involves simulating the operation of different processes, applications and departments composing the organization, as well as information flows between them.

This may involve the simulation of models of manufacturing plants and infrastructures (production planning, flow of raw materials, resource consumption, production strategies), logistics and supply chain (suppliers behavior, demand, stocks) or different kind of business processes (business development, marketing, training).

In this section we analyze the two different approaches that can be used for this "virtual organization" simulation: the use of a monolithic model of the company created for the ZLE project or the use of a distributed simulation by exploiting the different models previously coded and used in the organization for other purposes.

Monolithic model

In this case, once the processes, systems and departments that are involved in the ZLE strategy are determined, a model of joint behavior of all of them is created from scratch to simulate their operation without and with ZLE.

To integrate into a single model so many heterogeneous subsystems, almost always it is necessary to create this model with a general purpose language such as Java, Fortran or C++. Only in certain simple cases COTS simulation packages such as Arena, Extend, FlexSim or Simul8 can be used to create the monolithic model for the Decision Making stage in the ZLE project roadmap.

Such a model can be very complex to obtain, and the modeler could greatly benefit from a design philosophy based on modularity, simplifying the process using libraries of re-usable modules. Although such libraries are common in the lower end of the simulation (mechanical and electrical systems or manufacturing processes, for example), unfortunately they are not yet widespread in the higher levels (business processes, for example). Therefore, it may be difficult to find pre-defined building blocks to model certain parts of the organization.

Documentation and execution of a single monolithic model are, in general, easy to perform. But this kind of model makes difficult the reuse of existing simulations; requires the people involved in the project to understand the low-level details of the company's operation; and the model updating whenever there is a change in the company will have a great cost. The disappearance, modification or addition of a subsystem in the organization make necessary to revise completely the monolithic model.

As a conclusion, this alternative is profitable only in small projects that either are located in small organizations, or involve only a small part of larger companies. The creation of a single monolithic model for more complex projects would be too expensive in time and resources, hard to maintain and furthermore, would reduce the quality of simulation results due to the simplifications that should be made to obtain it.

Distributed model

The use of simulation in business environments has become a *de facto standard*. When a company decides to deal with the implementation of a ZLE strategy, almost always exist in the organization models and simulators of different subsystems previously implemented.

The approach of distributed modelling tries to exploit these existing models in the company, but there are no tools to integrate heterogeneous models from arbitrary packages or programming languages automatically.

Building a distributed simulation is much more complex than building a monolithic model, since it involves many new concepts: integration of all models at run time, time synchronization, representation of the data to be exchanged, data and objects ownership management, etc. The simulation software used to model and predict the behavior of the manufacturing process or of the scheduling methodologies do not use the same data formats as the systems used to simulate the new products design or to re.-engineer the production system, for example.

It can be very difficult to solve all these new problems, and if the modeler is not familiar with distributed simulation this difficulties can lead to semantic inconsistencies in the simulation. It is not enough to possess good knowledge in modelling and programming to complete a project of this type and the simulation results may suffer in terms of quality and performance.

The modelling phase is usually easy to perform because previously coded models can be used and if new models are needed, they can be coded separately, taking advantage of the best package or programming language for each subsystem and of building blocks libraries. But the documentation and execution are complicated, just the opposite of the monolithic model. A monolithic model simulation performs faster than a collection of coupled models, because there is no need for explicit time synchronization, for example.

Also unlike the monolithic model, the updating is much simpler, being the scalability one of the big advantages of distributed simulation.

When an organization needs to integrate different models, low-level technologies such as WinSock, COM or CORBA, have been traditionally used. But humans still play an important role in operating these systems and this kind of integration suffers from the typical disadvantages of customized solutions.

To overcome these limitations, a standard solution has been developed for distributed simulation: High Level Architecture (HLA). This standard was developed by the US Department of Defense in 1995 to solve the problem of distributed simulation by allowing different independent and heterogeneous models to interact in a federation (Morse et al., 2006).

A federated model can exchange data with the rest of models in the federation via a Run Time (RTI) implemented over a network in a time synchronized manner. This is achieved by separating the data model and architecture of the methods and functions used for the information exchange between models. The HLA specification consists of:

- **HLA Framework and Rules (standard IEEE 1516):** Define ten rules to specify the responsibilities of the federated simulators and federations to ensure a proper interaction between them.

- **HLA Federate Interface Specification (standard IEEE 1516.1):** Specifies the services and interfaces of the RTI (Runtime Infrastructure) that is used to communicate a federation, using a data network and tools for time synchronization between models.

- **HLA Object Model Template (standard IEEE 1516.2):** Provides the templates for the objects used to achieve interoperability between simulators, the Simulation Object Model (SOM) and the Federation Object Model (FOM).

Initially, there were only a few simulation projects in industrial environments in which the HLA standard was applied. This is mainly due to all the HLA features, important to military environments but not very useful for the industry simulation. These features add a great complexity to projects, unnecessarily, and the industry is not interested in technology but in obtaining results as quickly as possible and with as little investment as possible. Furthermore, the HLA specification presented certain ambiguities, making it difficult to integrate this standard with the typical COTS packages (Attila et al., 2006), (Attila et al., 2006), (Attila et al., 2008).

The main solution for these initial problems with HLA and industry has been the SISO CSPI PDG standard definition (Strassburger, 2006). It defines Interoperability Reference Models (IRM), to identify in a clear, simple and precise way the cases in which typical COTS packages should use HLA to federate two or more models in industrial environments. There are four types of IRM (Taylor et al., 2007):

- Type A: Entity transfer.
- Type B: Shared resource.
- Type C: Shared event.
- Type D: Shared data structure.

Their definition has enabled all COTS packages to build in HLA interfaces for distributed simulation, all of them integrating the HLA standard in the same way. Therefore, the federation of models encoded with COTS packages is much easier today thanks to the use of HLA and IRMs.

The difficulty is still in the integration of models coded with other packages or programming languages, due to lack of maturity of the HLA standard in industrial and business environments.

The evolution of technologies such as WebServices and of SOA programming philosophies (Banks et al., 2003) suggests that the future of distributed simulation will be in making simulations available through networks.

In the long term, an end user will be able to compose a federation through his browser, since the simulations of different models will reside in the LAN or WAN as web services. The latest versions of HLA already supports this kind of solution and there are a few works that go in this direction (Wu et al., 2007), (Zhang et al., 2008), but we are still far from achieving distributed simulations where the interoperability between heterogeneous models is transparent to the user to this point.

CONCLUSIONS AND FUTURE WORK

Today it is more crucial than ever for a company to be up to date and not miss time and/or resources in unnecessary latencies. This leads to a strong need of having business information in real time and to become a Zero Latency Enterprise.

The implementation of this kind of strategy use to involve many different processes, systems and departments of an organization, hence, ZLE projects must follow a clear an detailed methodology, considering both the costs and the benefits of the ZLE transition.

In this paper, a 5-steps methodology has been proposed, using simulation techniques in the 4th stage, Planning and Decision Making, to decide if the ZLE strategy implementation is profitable to the company. In authors' opinion, firms will not blindly adopt this kind of solution and will want to see its tangible benefits in the mean and long term. Therefore, simulation is a perfect solution for the Decision Making in ZLE projects, providing a robust tool to optimize the later ZLE strategy implementation.

The two main alternatives for the simulation stage have been examined in this work, discussing the advantages and drawbacks of using a monolithic and distributed models.

The bigger and more complex the project, the bigger the benefits from cutting it up into small subprojects. Distributed simulation reduces complexity by cutting things up into independent domains although it adds some new complexity introducing new concepts and problems that must be solved. HLA and IRMs can help to solve these aspects, but there is still a lot of work to do in this area.

Complexity and project size are, therefore, the main drivers to decide the best option for the simulation in the Decision Making stage of projects.

We are now working in the definition of new IRMs capable of defining typical situations in ZLE projects at a higher level than the IRMs currently available. A very interesting line for future research would be creating a library of re-usable models and simulation blocks with the more common models in ZLE projects. And exploring the possible solutions for making these models accessible from Internet to allow users composing distributed simulations through the network.

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