

## **DISTRIBUTED SIMULATION MODELING: A COMPARISON OF HLA, CORBA, AND RMI**

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### **ABSTRACT**

The execution of distributed simulations has become increasingly important to the Department of Defense (DOD). This paper compares three architectures for supporting distributed computing, HLA, CORBA, and RMI. While the fundamental structure of each is similar, there are differences that can profoundly impact an application developer or the administrator of a distributed simulation exercise.

### **1 INTRODUCTION**

The design and execution of distributed simulation models has become increasingly important to the Department of Defense (DOD). In recent years, the DOD has invested considerable resources in infrastructures for distributed simulation modeling. The current focus is the High Level Architecture (HLA) spearheaded by the Defense Modeling and Simulation Office (DMSO) (US Department of Defense, 1998). The HLA benefits greatly from two earlier DOD efforts: the Distributed Interactive Simulation (DIS) protocol standards, and the Aggregate Level Simulation Protocol (ALSP). There have been several efforts in the commercial sector to enable distributed computing. Two of the most viable recent efforts are the Common Object Request Broker (CORBA), by the Object Management Group (OMG), and Remote Method Invocation (RMI), from Sunsoft's Java Development Kit (JDK).

There are many reasons why DOD has an interest in a common framework for performing distributed simulation. Declining defense budgets have increased the necessity for cost containment. Increased use of simulation for training, acquisition, and analysis promises to substantially reduce costs. A common architecture for distributed simulation enhances interoperability and reuse in various DOD simulation modeling efforts.

Each of these three architectures for distributed computing offers much to the problem of executing a distributed simulation model. Each has a fundamental world view that affects the structure of its architecture.

This paper will compare the features of these three important technologies with particular focus on their impact on distributed simulation. Naturally, it is impossible to cover all aspects of the architectures, so this paper will only touch briefly on the salient features of each, emphasizing those aspects impacting the simulator.

In the following section we will discuss the core elements of distributed architectures. Sections 3 through 5 will touch on the important features of HLA, CORBA, and RMI, respectively, followed by a brief discussion and comparison in Section 6. Section 7 will present conclusions and recommendations.

### **2 BASIC ELEMENTS OF DISTRIBUTED ARCHITECTURES**

We will focus our attention on three of the basic elements of distributed architectures: an object interface language, an object manager, and a naming service. In addition, we will consider issues such as the programming languages supported, the hardware and operating systems, and the network protocols used.

An object interface language is important for supporting distributed applications because they require a more abstract level of communications than ordinary applications. An object must make only minimal assumptions about the implementation of another object's method since that method could involve objects on another machine. In contrast to a class's definitions of methods, an interface is a contract for implementing objects and contains only a list of methods. Interfaces are therefore the ideal vehicle for providing interoperability between distributed objects. HLA and CORBA take a multilingual approach to distributed objects so they define their own separate interface specifications that are distinct from the implementing languages. RMI, on the other hand, is a language specific approach and thus uses the Java language interface for its interface specification. This considerably simplifies many design issues but limits the extent to which RMI can deal with distributed objects in other languages. Using interfaces is a critical factor for implementing

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1998 Winter Simulation Conference. Proceedings (Cat. No.98CH36274) , **1998 Winter Simulation Conference. Proceedings (Cat. No.98CH36274).** ,1998 1998 Winter Simulation Conference Proceedings John S. Carson,M. S. (eds.) Manivannan,Edward F. Watson,D. J. Medeiros,1998 **Handbooks in Operations Research and Management Science: Simulation** Shane G. Henderson,Barry L. Nelson,2006-09-02 This Handbook is a collection of chapters on key issues in the design and analysis of computer simulation experiments on models of stochastic systems The chapters are tightly focused and written by experts in each area For the purpose of this volume simulation refers to the analysis of stochastic processes through the generation of sample paths realization of the processes Attention focuses on design and analysis issues and the goal of this volume is to survey the concepts principles tools and techniques that underlie the theory and practice of stochastic simulation design and analysis Emphasis is placed on the ideas and methods that are likely to remain an intrinsic part of the foundation of the field for the foreseeable future The chapters provide up to date references for both the simulation researcher and the advanced simulation user but they do not constitute an introductory level how to guide Computer scientists financial analysts industrial engineers management scientists operations researchers and many other professionals use stochastic simulation to design understand and improve communications financial manufacturing logistics and service systems A theme that runs throughout these diverse applications is the need to evaluate system performance in the face of uncertainty including uncertainty in user load interest rates demand for product availability of goods cost of transportation and equipment failures Tightly focused chapters written by experts Surveys concepts principles tools and techniques that underlie the theory and practice of stochastic simulation design and analysis Provides an up to date reference for both simulation researchers and advanced simulation users Proceedings of the ... Winter Simulation Conference ,2002 **Index of Conference Proceedings** British Library. Document Supply Centre,2003 **Enterprise Information Systems** Joaquim Filipe,José Cordeiro,Jorge Cardoso,2008-10-20 This book contains the best papers of the 9th International Conference on Enterprise Information Systems ICEIS 2007 held in the city of Funchal Madeira Portugal organized by the Institute for Systems and Technologies of Information Control and Communication INSTICC and the University of Madeira in collaboration with ACM SIGMIS and AAAI Furthermore the conference was sponsored by the Portuguese Foundation for Science and Technology FCT ICEIS has become a major point of contact between research scientists engineers and practitioners in the area of business applications of information systems This year five simultaneous tracks were held covering different aspects related to enterprise computing including Databases and Information Systems Integration Artificial Intelligence and Decision Support Systems Information Systems Analysis and Specification Software Agents and Internet Computing and Human Computer Interaction All tracks focused on real world applications and highlighted benefits of information systems and technology for industry and services thus making a bridge between academia and enterprise

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Parallel and Distributed Discrete Event Simulation Carl

Tropper,2002 Discrete event simulation has long been an integral part of the design process of complex engineering systems and the modelling of natural phenomena Many of the systems that we seek to understand or control can be modelled as digital systems In a digital model we view the system at discrete instants of time in effect taking snapshots of the system at these instants For example in a computer network simulation an event can be the sending of a message from one node to another node while in a VLSI logic simulation the arrival of a signal at a gate may be viewed as an event Digital systems such as computer systems are naturally susceptible to this approach However a variety of other systems may also be modelled this way These include transportation systems such as air traffic control systems epidemiological models such as the spreading of a virus and military war gaming models This book is representative of the advances in this field Discrete-Event Modeling and Simulation Gabriel A. Wainer,Pieter J. Mosterman,2018-09-03 Collecting the work of the foremost scientists in the field

Discrete Event Modeling and Simulation Theory and Applications presents the state of the art in modeling discrete event systems using the discrete event system specification DEVS approach It introduces the latest advances recent extensions of formal techniques and real world examples of various applications The book covers many topics that pertain to several layers of the modeling and simulation architecture It discusses DEVS model development support and the interaction of DEVS with other methodologies It describes different forms of simulation supported by DEVS the use of real time DEVS simulation the relationship between DEVS and graph transformation the influence of DEVS variants on simulation performance and interoperability and composability with emphasis on DEVS standardization The text also examines extensions to DEVS new formalisms and abstractions of DEVS models as well as the theory and analysis behind real world system identification and control To support the generation and search of optimal models of a system a framework is developed based on the system entity structure and its transformation to DEVS simulation models In addition the book explores numerous interesting examples that illustrate the use of DEVS to build successful applications including optical network on chip construction building design process control workflow systems and environmental models A one stop resource on advances in DEVS theory applications and methodology this volume offers a sampling of the best research in the area a broad picture of the DEVS landscape and trend setting applications enabled by the DEVS approach It provides the basis for future research discoveries and encourages the development of new applications **Industry 4.0 and People Analytics** Vinod Kumar

Shukla,Praveen Kulkarni,Deepika Gaur,Pradeep N,Jean Paolo G. Lacap,Amina Omrane,2024-07-05 Industry 4 0 is

revolutionizing the way companies do business by integrating new technologies into workplace practices and into production facilities and throughout their operations This new volume provides an insightful examination of the role of people analytics the data driven and goal focused method of studying people processes functions challenges and opportunities at work to elevate these systems and achieve sustainable business success in the era of Industry 4 0 It explores the use of AI and other technologies in analyzing cognition human potential and talent management for studying workplace diversity and inclusion in performance management and reward analytics to enhance emotional and social intelligence in decision making for employee training programs for employee wellness enhancement for leadership development and more Proceedings of the 1998 Winter Simulation Conference D. J. Medeiros,1998

**Netcentric System of Systems Engineering with DEVS Unified Process** Saurabh Mittal, José L. Risco Martín, 2018-09-03 In areas such as military security aerospace and disaster management the need for performance optimization and interoperability among heterogeneous systems is increasingly important Model driven engineering a paradigm in which the model becomes the actual software offers a promising approach toward systems of systems SoS engineering However model driven engineering has largely been unachieved in complex dynamical systems and netcentric SoS partly because modeling and simulation M S frameworks are stove piped and not designed for SoS composability Addressing this gap Netcentric System of Systems Engineering with DEVS Unified Process presents a methodology for realizing the model driven engineering vision and netcentric SoS using DEVS Unified Process DUNIP The authors draw on their experience with Discrete Event Systems Specification DEVS formalism System Entity Structure SES theory and applying model driven engineering in the context of a netcentric SoS They describe formal model driven engineering methods for netcentric M S using standards based approaches to develop and test complex dynamic models with DUNIP The book is organized into five sections Section I introduces undergraduate students and novices to the world of DEVS It covers systems and SoS M S as well as DEVS formalism software modeling language and DUNIP It also assesses DUNIP with the requirements of the Department of Defense s DoD Open Unified Technical Framework OpenUTF for netcentric Test and Evaluation T E Section II delves into M S based systems engineering for graduate students advanced practitioners and industry professionals It provides methodologies to apply M S principles to SoS design and reviews the development of executable architectures based on a framework such as the Department of Defense Architecture Framework DoDAF It also describes an approach for building netcentric knowledge based contingency driven systems Section III guides graduate students advanced DEVS users and industry professionals who are interested in building DEVS virtual machines and netcentric SoS It discusses modeling standardization the deployment of models and simulators in a netcentric environment event driven architectures and more Section IV explores real world case studies that realize many of the concepts defined in the previous chapters Section V outlines the next steps and looks at how the modeling of netcentric complex adaptive systems can be attempted using DEVS concepts It touches on the boundaries of DEVS formalism and the

future work needed to utilize advanced concepts like weak and strong emergence self organization scale free systems run time modularity and event interoperability This groundbreaking work details how DUNIP offers a well structured platform independent methodology for the modeling and simulation of netcentric system of systems

**Gaming and Simulations: Concepts, Methodologies, Tools and Applications** Management Association, Information Resources,2010-11-30 This book set unites fundamental research on the history current directions and implications of gaming at individual and organizational levels exploring all facets of game design and application and describing how this emerging discipline informs and is informed by society and culture Provided by publisher

*Engineering Principles of Combat Modeling and Distributed Simulation* Andreas Tolk,2012-03-20 Explore the military and combat applications of modeling and simulation Engineering Principles of Combat Modeling and Distributed Simulation is the first book of its kind to address the three perspectives that simulation engineers must master for successful military and defense related modeling the operational view what needs to be modeled the conceptual view how to do combat modeling and the technical view how to conduct distributed simulation Through methods from the fields of operations research computer science and engineering readers are guided through the history current training practices and modern methodology related to combat modeling and distributed simulation systems Comprised of contributions from leading international researchers and practitioners this book provides a comprehensive overview of the engineering principles and state of the art methods needed to address the many facets of combat modeling and distributed simulation and features the following four sections Foundations introduces relevant topics and recommended practices providing the needed basis for understanding the challenges associated with combat modeling and distributed simulation Combat Modeling focuses on the challenges in human social cultural and behavioral modeling such as the core processes of move shoot look and communicate within a synthetic environment and also equips readers with the knowledge to fully understand the related concepts and limitations Distributed Simulation introduces the main challenges of advanced distributed simulation outlines the basics of validation and verification and exhibits how these systems can support the operational environment of the warfighter Advanced Topics highlights new and developing special topic areas including mathematical applications fo combat modeling combat modeling with high level architecture and base object models and virtual and interactive digital worlds Featuring practical examples and applications relevant to industrial and government audiences Engineering Principles of Combat Modeling and Distributed Simulation is an excellent resource for researchers and practitioners in the fields of operations research military modeling simulation and computer science Extensively classroom tested the book is also ideal for courses on modeling and simulation systems engineering and combat modeling at the graduate level

**Conceptual Modeling for Discrete-Event Simulation** Stewart Robinson,Roger Brooks,Kathy Kotiadis,Durk-Jouke Van Der Zee,2010-08-02 Bringing together an international group of researchers involved in military business and health modeling and simulation Conceptual Modeling for Discrete Event Simulation presents a comprehensive

view of the current state of the art in the field The book addresses a host of issues including What is a conceptual model How is conceptual modelin      **Advances in Computing, Informatics, Networking and Cybersecurity** Petros

Nicopolitidis,Sudip Misra,Laurence T. Yang,Bernard Zeigler,Zhaolng Ning,2022-03-03 This book presents new research contributions in the above mentioned fields Information and communication technologies ICT have an integral role in today s society Four major driving pillars in the field are computing which nowadays enables data processing in unprecedented speeds informatics which derives information stemming for processed data to feed relevant applications networking which interconnects the various computing infrastructures and cybersecurity for addressing the growing concern for secure and lawful use of the ICT infrastructure and services Its intended readership covers senior undergraduate and graduate students in Computer Science and Engineering and Electrical Engineering as well as researchers scientists engineers ICT managers working in the relevant fields and industries      *Managing Complexity: Insights, Concepts, Applications* Dirk

Helbing,2007-10-13 Each chapter in Managing Complexity focuses on analyzing real world complex systems and transferring knowledge from the complex systems sciences to applications in business industry and society The interdisciplinary contributions range from markets and production through logistics traffic control and critical infrastructures up to network design information systems social conflicts and building consensus They serve to raise readers awareness concerning the often counter intuitive behavior of complex systems and to help them integrate insights gained in complexity research into everyday planning decision making strategic optimization and policy Intended for a broad readership the contributions have been kept largely non technical and address a general scientifically literate audience involved in corporate academic and public institutions      **Simulation and Modeling: Current Technologies and Applications** El Sheikh, Asim,Al Ajeeli,

Abid Thyab,Abu-Taieh, Evon,2007-08-31 This book offers insight into the computer science aspect of simulation and modeling while integrating the business practices of SM It includes current issues related to simulation such as Web based simulation virtual reality augmented reality and artificial intelligence combining different methods views theories and applications of simulations in one volume Provided by publisher

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