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Exploring impact of time management services on HLA-based Petri Nets Simulation Engine

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Abstract

We describe a HLA-based Stochastic Petri Nets (SPN) Simulation Engine that has been developed in order to study distributed behaviour of SPN. We simulate a Federation constituted from SPN (sub) models. Two approaches are considered: (1) a single Petri Nets (PN) is decomposed into subnets which are executed on different heterogeneously connected computers (2) different PN which model different processes are combined into a single distributed simulation. We use a sender/receiver SPN-model to illustrate these approaches and to explore the impact of time management services applied in the implementation of the SPN distributed simulation engine. © 2001 Elsevier Science B.V. All rights reserved.

Keywords: (S)PN; HLA-RTI; Time management; Distributed simulation; Federation

1. Introduction

Distributed simulation of Stochastic Petri Nets (SPN) has been considered for years as an attractive idea for increasing the effectiveness of execution of complex models. SPN concept exhibits an inherent parallelism and it was expected that exploiting this property will result in a remarkable gain in speedup. The research

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has focused on methods for partitioning a single model in order to distribute submodels over several nodes and on algorithms of controlling communication between submodels as well [1,6,7,23,27]. However, the results were rather not encouraging in terms of obtained speedup due to the overhead introduced by the controlling algorithms. Moreover comparisons of algorithms, independent from simulation platforms and communication methods used, were very difficult because of the lack of appropriate metrics of speedup.

New technologies (fast networking, WEB) however put the task of distributed simulation of SPN again on the list of attractive research topics. This time the aim of distributed execution has changed a little bit. The emphasis is no longer on speedup (although still important), rather on the possibility of the construction and execution of complex models from heterogeneous components developed and run on different servers.

We have developed a Simulation Engine for SPN using the new technology offered by High Level Architecture (HLA). We are interested in studying the impact of HLA on the effectiveness of distributed simulation. We also believe, that the primary importance of HLA could be in using it as a reference platform for the comparison of algorithms for partitioning models and distributing them among the network.

Generally the main difficulties in the area of distributed simulation [9,10,21] are to be found in both the management of events without causality violation and communication between the distributed components which compose the simulation model. To cope with these difficulties among others, the HLA concept has been developed by the Defence Modelling and Simulation Office (DMSO) of the Department of Defence (DoD). The main aim of HLA is to support interoperability [26] between simulations and reusability of components. HLA is a component integration standard for distributed simulation and now an Institute of Electrical and Electronics Engineers (IEEE) standard No. P1516 by the Simulation Interoperability Standards Organization (SISO) since October 21, 2000.

Petri Nets (PN) are a graphical and mathematical modelling technique for formal description of systems whose dynamical behaviour have properties such as concurrency, synchronization, conflicts and mutual exclusion, which are seen as typical features of distributed environments. Since PN models have an intrinsic parallelism, they are an excellent candidate when being simulated in a distributed way. We use a type of PN called SPN, which are derived from time augmented PN by assigning negative exponential (memoryless) randomly distributed firing time to the transitions. SPN models are characterized by the fact that their qualitative behaviour is identical to that of their underlying PN model without any temporal specifications, so that the reachability and structural analysis results obtained from the PN model are valid also for the SPN.

For distributed simulation of SPN we consider two approaches: (1) a single SPN model is decomposed into subnets which can be executed on different heterogeneously connected computers and (2) different SPN which model different processes are combined into a single distributed simulation. In the second case the modeller has to establish a connection between these Nets on the modelling level. The task

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