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INVESTIGATING CLOUD-BASED ARCHITECTURE FOR DISTRIBUTED SIMULATION (DS) IN OPERATIONAL REASEARCH (OR)

Nura T. Abubakar

Modeling & Simulation Group
Department of Computer Science
Brunel University London
Uxbridge, UB8 3PH, United Kingdom

ABSTRACT

For decades, Modeling & Simulation (M&S) have been the choice for Operations Research and Management Science (OR/MS) to analyze systems behaviors. The evolution of M&S brings the Distributed Simulation (DS) - High-Level Architecture (HLA), used mainly by defense applications, thus allowing researchers to compose models which run on different processors. As cloud computing grows, its capabilities upgraded many applications, including M&S having the elasticity needed for DS to speed up simulation by bringing reusable models together with interoperability. This paper presents a proposed cloud-based DS deployment architecture and development framework for OR analysts.

1 INTRODUCTION

The need for a faster way to compose and reuse models has attracted researchers to extends the M&S boundaries. Notably, the M&S has evolved from running a single model on a single computer by a single analyst to parallel and distributed methods. These new methods enable modelers to compose models or divide the large model into smaller sub-models that run on separate processors for speedy experiments. Since it is advent, cloud computing offers remote access to high-performance computing resources without having to manage them on-premises. DS executes a simulation over computing platforms that span a much broader geographic extent than parallel computers (Fujimoto 2015). In theory, when combined with HLA (IEEE-1516), the cloud can be used to compose models in a distributed fashion with runtime infrastructure (RTI) technology.

2 METHOD

From the literature, there are many tried-and-true methods used in OR/MS and engineering, including DSEEP to run local or networked DS simulation projects. Distributed Simulation Engineering and Execution Process (DSEEP) is a generalized framework that can be adapted to meet individual DS needs (Anastasia and Simon 2017). The framework presented here leverages the cloud infrastructure with DS components where we use open source resources; RePAST Symphony simulator and poRTIco RTI implementation of IEEE-1516. The experimented framework was deployed to CloudSigma, Amazon Web Services' EC2, Scaleway, Google Cloud Computing and DigitalOcean public clouds. We deploy Ubuntu 18.04 LTS instances and run the federation with a shell script which executes the models headless and output results in CSV format.

The process starts by running one federate (model) which creates the 'federation,' initialize the environment, publish and waits for others to join based on fulfilled specifications. When the simulation starts, the Ambulance federate (see Case Study section) takes data file as input and

simulate according to parameter file instructions. The result is then output a directory close to the model. This hybrid simulation experiment combined Type A.1 (entity transfer) and Type C (shared event) interoperability reference models (IRMs) (Taylor *et al.* 2009) as standardized by Simulation Interoperability Standard Organization (SISO). This combination facilitates the interaction between the two paradigms used in the study; Ambulance Service (ambulance model) being Agent-Based Simulation and a few Accident & Emergency Departments (hospital models) which are Discrete Event Simulation.

3 CASE STUDY

This research featured a case study – Emergency Medical Service (EMS), which combined the two paradigms (ABS and DES) as published by Anastasia and Simon 2017b) and Nouman *et al.* 2013. EMS systems consist of an ambulance service and several accidents and emergency (A&E) departments. The A&Es are located in the regional hospitals of the ambulance cover area. We, therefore, need several heterogeneous models to communicate with each other. That is the ambulance service model and several A&E models in the area of coverage. The ambulance service entities interact enormously with each other and their environment. Depending on some parameters, they have to decide to allocate the appropriate ambulance for an incident, decide whether there is a need for transfer to an A&E, and find the most suitable hospital. On the other hand, A&E departments are mainly process-oriented. The entities, e.g., patients, do not make decisions but rather are driven by hospital events. For this scenario, the ambulance service is modeled using ABS, and the A&E departments are modeled using DES techniques.

4 CONCLUSION

The use of cloud resources and RTI middleware enable and promotes model re-usability. Conversely, the experiments show a longer execution time when running DS over different cloud infrastructures. We presented a cloud-based DS deployment architecture and development framework to where the IRMs made possible the running of ABS-DES to analyze a single OR system (EMS) over the cloud. The cloud performance is used to evaluate the proposed contribution presented in this work.

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