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# RECAP SIMULATOR: SIMULATION OF CLOUD/EDGE/FOG COMPUTING SCENARIOS

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## ABSTRACT

With the increasing trend towards edge and fog computing, the aim of the RECAP simulator is to simulate large scale scenarios in the cloud, fog and edge computing space in order to provide decision and control support for application and data center resource administration. This will be accomplished through the simulation of applications and application subsystems, simulation of infrastructure resources and resource management systems, and experimentation and validation of simulation results. The RECAP simulator and associated models will provide support for understanding and predicting impact on resources, workloads and quality of service (QoS) metrics as well as trade-offs for energy efficiency and cost within cloud, edge and fog computing scenarios, while maintaining the service level agreements (SLAs) of users.

## 1 INTRODUCTION

Large-scale computing systems are today built as distributed systems, where components and services are distributed and accessed remotely through clients and devices for reasons of scale, heterogeneity, cost and energy efficiency. In some systems, in particular latency-sensitive or high availability systems, components are also placed closer to end-users in order to increase reliability and reduce latency, a style of computing often referred to as edge or fog computing. However, while recent years have seen significant advances in system instrumentation as well as data center energy efficiency and automation, computational resources and network capacity are often provisioned using best-effort models and coarse-grained QoS mechanisms, even in state-of-the-art data centers. These limitations are seen as a major hindrance in the face of the coming evolution of the Internet of Things (IoT) and the networked society, which are projected to significantly increase the load on networks and data centers (Östberg et. al, 2017).

In order to tackle such limitations, the RECAP simulator is being developed within the umbrella of the RECAP project (RECAP Consortium, 2017), a €4.7 million European Union funded project the aim of which is to develop the next generation of cloud/edge/fog computing capacity provisioning and remediation via targeted research advances in cloud infrastructure optimization, simulation and automation. The RECAP project will define and implement a novel architecture in order to realize ideas relating to resource management, data analytics and intelligent automation. As a result RECAP will produce a number of distinct tools designed to operate together, including the RECAP data collector and analyzer, the RECAP application modeler, the RECAP workload modeler, the RECAP optimizer and the RECAP simulator. These are described in further detail in Östberg et. al (2017).

## 2 THE RECAP SIMULATOR

The RECAP simulator will allow for reproducible and controllable experimentation, aiding in identifying targets for components deployment and solving them optimally prior to the actual deployment in a real cloud environment. Such simulation technologies will be extensively employed in RECAP, to both simu-

late the interactions of distributed cloud application behaviors, and to emulate data center and connectivity networks systems. The complexity and size of the systems addressed are in themselves prohibitive for full-scale deployment, and will be studied at several levels in simulation. The RECAP simulator will assist the RECAP optimizer in the evaluation of different deployment and infrastructure management alternatives in terms of cost, energy, resource allocation and utilization, before actuating on real application deployments. This will require accurate output through the monitoring of the status of data center infrastructure in order to provide an effective decision support instrument. This joint operation is of particular importance for understanding and managing trade-offs in edge and fog computing scenarios.

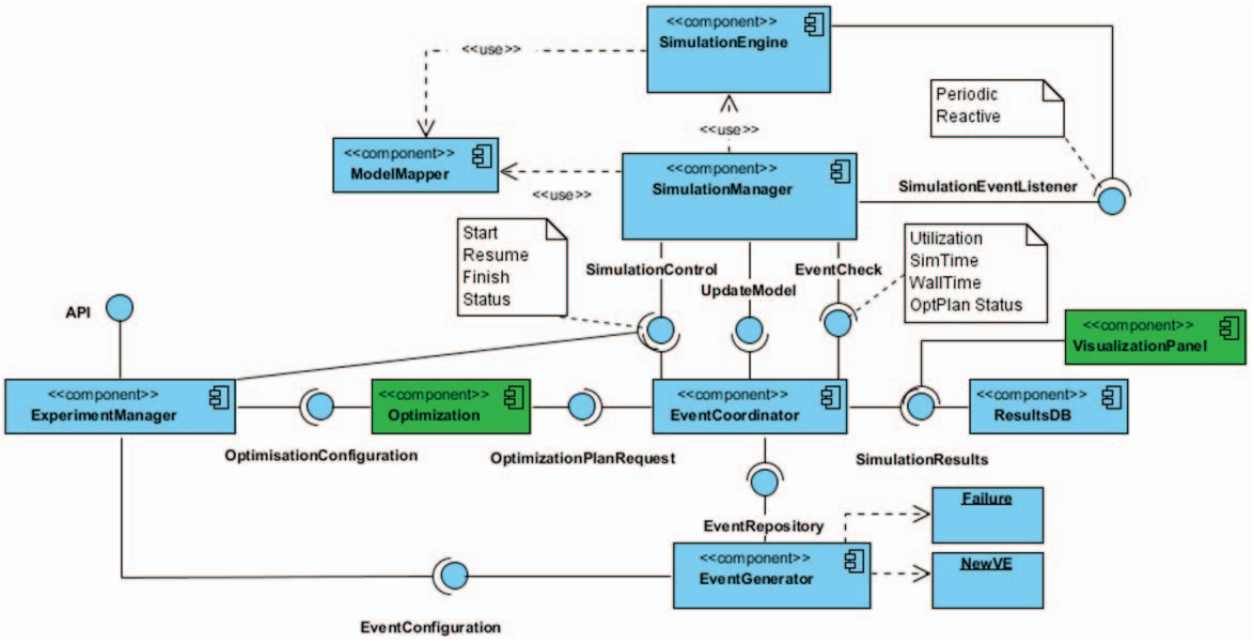


Figure 1. RECAP simulator high level component diagram.

Referring to Figure 1, the RECAP simulator is made up of the following components:

- ExperimentManager - polls optimization, simulation, and event generator for available options and launches simulation instance with the listed parameters. Its main purpose is to gather all models and system configuration settings for the simulation experiment.
- SimulationManager - controls the simulation cycle using the ModelMapper to link RECAP Infrastructure Models (RIM) and simulation engine model elements.
- EventCoordinator - is responsible for simulation results serialization to a database storage and administration of optimization and failure events.
- EventGenerator - creates a distribution of failures or new Virtual Entity (VE) arrivals for the duration of simulation. It can also be extended to inject other types of events into simulation routine.

## REFERENCES

Östberg, P-O, Byrne, J., Casari, P., Eardley, P., Anta, A. F., Forsman, J., Kennedy J. et al. "Reliable capacity provisioning for distributed cloud/edge/fog computing applications." In *Networks and Communications (EuCNC), 2017 European Conference on*, pp. 1-6. IEEE, 2017.

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