Cloud-Enabled Infrastructure for Simulation as a Service

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Project Introduction

- Cloud computing infrastructure allows for convenient on-demand access to a shared pool of computational resources
- This enables consumers to utilise large amounts of computational power without having to pay the expensive upfront costs associated with setting up such infrastructure
- This is especially useful for computer simulation, which is becoming an increasingly popular tool used in the design and analysis of complex systems
- Simulation of a complex system often requires computationally intensive solving of mathematical models or the exploration of a large state space
- Cloud computing infrastructure provides on demand access to computing resources required to run computer simulations with the ability to scale to meet complexity requirements
- Dynamically scaling computer resources as required allows users to pay only for what they need
- In addition to this, having a shared centralised cloud computing infrastructure allows for more efficient utilisation of computing resources

Project Objectives

- Research and develop a system that is able to provide Simulation as a Service (SIMaaS) for Docker images by utilising various web and cloud computing technologies
- The system should allow users to remotely access a shared computational platform that manages the deployment, configuration and execution of simulations and the gathering and analysis of results

Proposed Solution

- A system architecture with a strong emphasis on modularity for the Infrastructure as a Service (IaaS) back-end. This allows various IaaS providers to be used such as Amazon Elastic Compute Cloud (EC2), OpenStack and Google Compute Engine
- Apache jclouds™, a Java API for abstracting the interaction with back-end IaaS platforms
- A front-end browser interface to remotely access the computational platform
- Simulations are provided as Docker images stored in Docker Hub. The back-end pulls the simulations directly from Docker Hub as directed by the user through the front-end

SIMaaS System Architecture

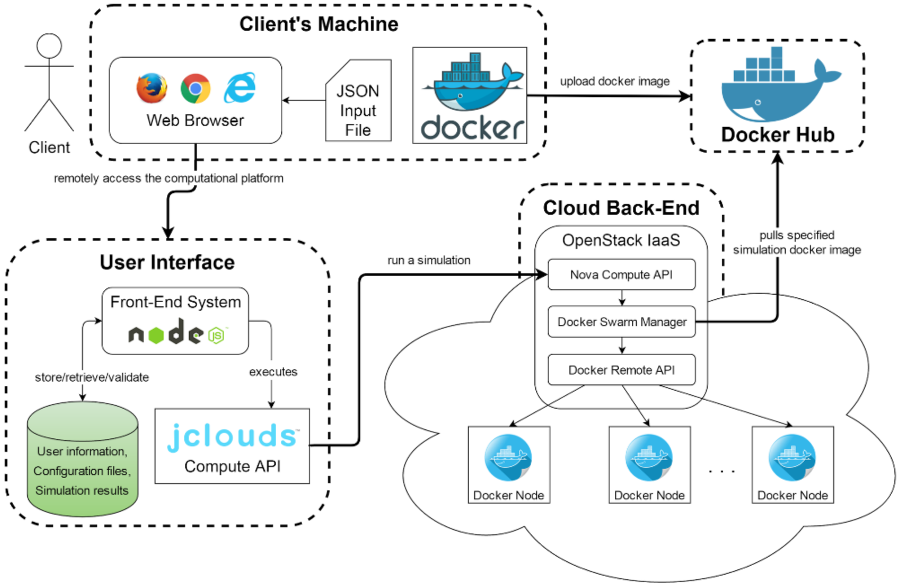

Figure 1 - Proposed system architecture for cloud-enabled infrastructure for simulation as a service

System Front-end

- Web interface allows ease of use and system compatibility with a wide range of devices
- Figure 2 shows a basic workflow of the web interface accessing the shared computational platform remotely
- A full user management system is provided and cloud access can be controlled per user
- A variety of modern web technologies are utilised, including:
  - The MEAN stack (MongoDB, Express.js, Angular.js, Node.js)
  - Twitter Bootstrap
  - Many Node modules, including Mongoose, Jade/Pug, Dockerode, and node-ssh
- Apache jclouds™ is used to interact with the cloud services, and is invoked via the Node.js application as Java executables
- This allows for a number of popular cloud services to be used with ease due to the abstractions provided by the jclouds API
- A secure interface is implemented using the Passport Node module and other technologies
- Simulation images are managed through the well known Docker tools

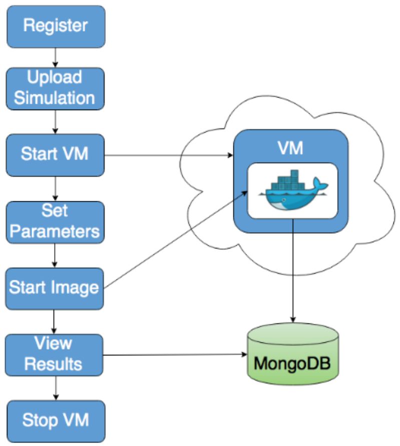

Figure 2 - Basic workflow of the web interface

System Back-end

- The IaaS back-end was implemented using an OpenStack server provided by the University of Adelaide
- Apache jclouds™ allows for various cloud IaaS implementations to be used due to the abstractions mad by the Compute API and thus, the system can be easily configured to use Amazon EC2 or other service
- Simulations are packaged as Docker images and thus, are restricted to Linux software environments
- Docker containers wrap a piece of software into a complete filesystem which contains everything necessary to run the code such as runtime, system tools, system libraries, etc. This ensures that simulations will always run the same regardless of the environment [1]
- Docker containers are more portable and lightweight when compared to virtual machines as the operating system kernel is shared for every machine running the Docker engine. This is demonstrated by Figure 3 [1] shown on the right

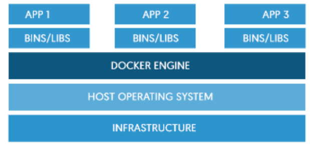

Figure 3 - Docker node architecture

- The back-end of the system is capable of running Docker containers on a single Docker node or multiple via a Docker Swarm as configured by the user
- This is useful for simulations that need to be run across a large input state space. Multiple Docker containers can be run simultaneously with the Docker Swarm taking care of allocation to compute nodes

[1] - Docker, 2016, *What is Docker?*, Available at: https://www.docker.com/what-docker]

Advantages

- Money is saved by not having to set up expensive infrastructure and instead, paying only for what is used
- Having a centralised system allows for more cost effective maintenance and efficient utilisation of computing resources
- Allows convenient and simple execution of simulations on a cloud system by abstracting complex communications between client and server

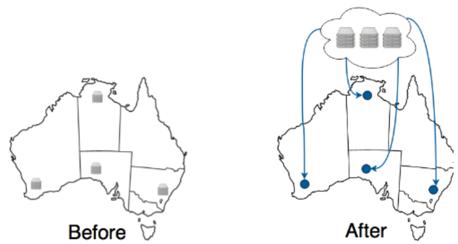

Figure 4 - Comparison of traditional servers vs cloud-enabled infrastructure for simulation as a service

- Modular system design allows for a variety of popular cloud IaaS providers to be used such as OpenStack, Amazon EC2, Google Compute Engine and more
- Features full user management, allowing cloud and simulation access to be managed on a per-user bas

Limitations

- Docker images are not compatible with Windows software environments. However, Docker support for Windows is currently in development
- A fully operating billing model has not yet been implemented
- Simulations must be provided as Docker Images, and uploaded directly onto Docker Hub

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