CloudNetSim++: A Toolkit for Data Center Simulations in OMNET++

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Outline

- Introduction
- Related Work
- Motivation
- CloudNetSim++ Features
- CloudNetSim++ Architecture
- Performance Evaluation
- Conclusion
Cloud computing services have become increasingly popular

“Market Tends” estimates that cloud-based SaaS will increase from US $13.4 billion in 2011 to $32.2 billion in 2016 *

Similarly, in IaaS and PaaS markets are estimated growth from $7.6 billion in 2011 to $35.5 billion in 2016 *

Require massive infrastructure to support this enormous growth

Large geographically distributed data centers requires considerable amount of energy

High power consumption generates heat and requires an accompanying cooling system that costs in a range of $2 to $5 million per year

Introduction

- Failure to keep data center temperature within operational ranges drastically decreases hardware reliability
- The techniques, Dynamic Voltage and Frequency Scaling (DVFS) and Dynamic Power Management (DPM) is widely adopted
- Idle server may consume about 2/3 of the peak load*
- Workload of data center fluctuates on the hourly basis
- Average load account only 30% of data center resources**
- This allow putting rest 70% into a sleep mode for most of the time
- To achieve this, central coordination and energy-aware scheduling is required

## Related Work

<table>
<thead>
<tr>
<th>Simulator</th>
<th>Available</th>
<th>Language</th>
<th>GUI</th>
<th>Comm. Model</th>
<th>Energy Model</th>
<th>Simulation Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>CloudSim</td>
<td>Open Source</td>
<td>Java</td>
<td>No</td>
<td>Limited</td>
<td>Yes</td>
<td>Second</td>
</tr>
<tr>
<td>NetworkCloudSim</td>
<td>Open Source</td>
<td>Java</td>
<td>No</td>
<td>Full</td>
<td>No</td>
<td>Second</td>
</tr>
<tr>
<td>iCanCloud</td>
<td>Open Source</td>
<td>C++</td>
<td>Yes</td>
<td>Full</td>
<td>No</td>
<td>Second</td>
</tr>
<tr>
<td>DCSim+</td>
<td>Open Source</td>
<td>Java</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Minutes</td>
</tr>
<tr>
<td>GreenCloud</td>
<td>Open Source</td>
<td>C++, oTcl</td>
<td></td>
<td>Limited</td>
<td>Full</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Motivation

- To build a comprehensive Cloud simulator that facilitate
  - Students
  - Researchers
  - Industry
CloudNetSim++: Features

- Support Service Level Agreement (SLA)
- Support various scheduling algorithms
- Distributed data centers
- Configurable number of data centers
- Configurable number of racks and servers
- Configurable physical link properties
- Energy Module
- Support multiple users
CloudNetSim++: High Level Architecture

Multiple Client

Data center-I

Data center-II

Centralize Scheduler

INET

OMNeT++
CloudNetSim++: Node Level Architecture

Compute Node
- App Module
- Energy Module
- Queue Module
- Communication Module

Router/Switches
- Energy Module
- Communication Module
Energy Computation

Flexible data center model, compute energy utilization of following components

- Servers
- Data center architecture, router and switches

Power management, Dynamic Voltage Frequency Scaling (DVFS) technique

\[ V^2 \times F \]

The average power consumption is stated as below

\[ P = P_c + CPU_f \times f \]

- \( P_c \): power consumed not scale to frequency
- \( CPU_f \times f \): represent frequency depended power consumption
Power consumption of switches stated as:

\[ P_{\text{switch}} = P_{\text{chassis}} + n_{\text{linecard}} \cdot P_{\text{linecard}} + \sum_{i=0}^{R} n_{\text{port},r} \cdot P_r \]

- \( P_{\text{chassis}} \): Power consumed by switch hardware
- \( P_{\text{linecard}} \): Power consumed by a line card
- \( P_r \): Power consumed by a port operating at rate \( r \)
CloudNetSim++: Graphical User Interface
CloudNetSim++: Performance Evaluation

- Used two different traffic scenarios
  - Many-to-one model
  - Many-to-many model
<table>
<thead>
<tr>
<th>S.No</th>
<th>Parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Inter-Data Center (DC) topology</td>
<td>Star/Mesh</td>
</tr>
<tr>
<td>2</td>
<td>Intra-DC topology</td>
<td>three-tier</td>
</tr>
<tr>
<td>3</td>
<td>Inter-DC link</td>
<td>100-Gbps</td>
</tr>
<tr>
<td>4</td>
<td>Data center to data center link (Bit Error Rate)</td>
<td>$10^{-12}$</td>
</tr>
<tr>
<td>5</td>
<td>Core to aggregate link</td>
<td>10 Gbps</td>
</tr>
<tr>
<td>6</td>
<td>Aggregate to access link</td>
<td>1 Gbps</td>
</tr>
<tr>
<td>7</td>
<td>Access to servers link</td>
<td>1 Gbps</td>
</tr>
<tr>
<td>8</td>
<td>Core to aggregate link (BER)</td>
<td>$10^{-12}$</td>
</tr>
<tr>
<td>9</td>
<td>Aggregate to access link (BER)</td>
<td>$10^{-12}$</td>
</tr>
<tr>
<td>10</td>
<td>Access link to computing servers link (BER)</td>
<td>$10^{-5}$</td>
</tr>
<tr>
<td>11</td>
<td>Packet size</td>
<td>1500 bytes</td>
</tr>
<tr>
<td>12</td>
<td>Core nodes</td>
<td>8</td>
</tr>
<tr>
<td>13</td>
<td>Aggregate nodes</td>
<td>16</td>
</tr>
<tr>
<td>14</td>
<td>Access nodes</td>
<td>256</td>
</tr>
<tr>
<td>15</td>
<td>Computing server</td>
<td>2200 - 9000</td>
</tr>
</tbody>
</table>
### CloudNetSim++: Performance Evaluation

<table>
<thead>
<tr>
<th>DC-East (kWh)</th>
<th>DC-West (kWh)</th>
<th>DC-South (kWh)</th>
<th>DC-North (kWh)</th>
<th>Core Switch (kWh)</th>
<th>Aggregate Switch (kWh)</th>
<th>Access Switch (kWh)</th>
<th>Server (kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>156</td>
<td>45</td>
<td>200</td>
<td>98</td>
<td>4.086</td>
<td>16.218</td>
<td>9.21</td>
<td>70.633</td>
</tr>
</tbody>
</table>
CloudNetSim++: Performance Evaluation
CloudNetSim++: Performance Evaluation

Graph showing the relationship between computing nodes and delay for different topologies. The x-axis represents the number of computing nodes, while the y-axis represents delay in seconds. Two lines are shown: one for Star Topology and another for Mesh Topology.
CloudNetSim++: Performance Evaluation

The diagram illustrates the throughput (Mbps) as a function of the number of computing nodes for two topologies: Star and Mesh. The throughput decreases as the number of computing nodes increases, with the Mesh topology showing a more gradual decrease compared to the Star topology.
CloudNetSim++: Available download

- Available for download at
- http://cloudnetsim.seecs.edu.pk/
CloudNetSim++, a modeling and simulation toolkit to facilitate simulation of distributed datacenter architectures, energy models, and high speed data centers' communication network. The CloudNetSim++ is designed to allow researchers to incorporate their custom protocols and, applications, to analyze under realistic data center architectures with network traffic patterns.

CloudNetSim++ is the first cloud computing simulator that uses real network physical characteristics to model distributed datacenters. CloudNetSim++ provides a generic framework that allows users to define SLA policy, scheduling algorithms, and modules for different components of datacenters without worrying about low level details with ease and minimum effort.
Conclusion

- Designed to facilitate students, researchers and industry requirement
- Provide rich Graphical User Interface – GUI
- Modular approach, new modules can easily be incorporated
- Configurable architecture
- Open source, available to download
CloudNetSim++
cloudnetsim.seecs.edu.pk

Thank You!


References


