Cloud Simulators

Nelson Fonseca

CloudSim

- CloudSim is one of the most commonly used cloud simulators.
- CloudSim uses robotics simulator Gazebo and is based on an underlying toolkit called SimJava
- SimJava uses a discrete event simulator. It includes facilities for representing simulation objects as animated icons on screen.
- CloudSim supports adding elements dynamically and pausing/resuming the simulation

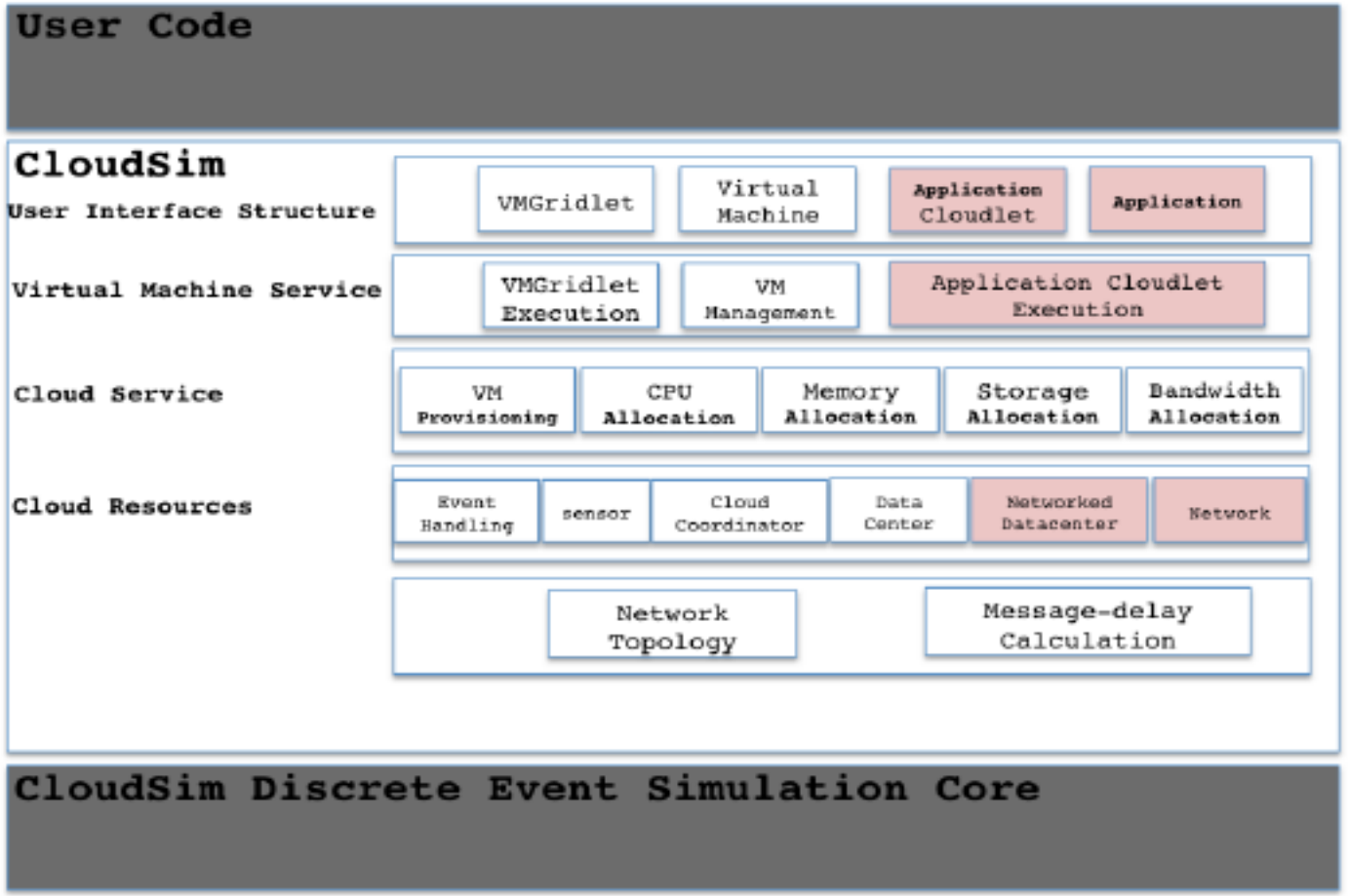
CloudSim

- CloudSim employs a set of classes to represent basic cloud functionality.
- The DataCenter class is a core class to the simulator functionality.
- DataCenter object instantiates a generalized resource provisioning component that implements a set of resource allocation policies
- Attributes of a data center include: Architecture, Operating system, List of machines, Allocation policy, Time or space-shared, and Resource price per time unit
- DatacenterBroker class. The broker’s responsibility is standing between service providers and cloud clients.

CloudSim

- User application in CloudSim is represented through Cloudlet class. Application size (complexity) is represented based on computational demands (instruction length).This is translated into two numbers: instruction length and amount of data transfer (both pre and post fetches totaled).
- CloudSim reads the data center topology using an input file in the BRITE format.

CloudSim


User Code
CloudSim
User Interface Structure
VMGridlet
Virtual Machine
Application Cloudlet
Application
Virtual Machine Service
VMGridlet Execution
VM Management
Application Cloudlet Execution
Cloud Service
VM Provisioning
CPU Allocation
Memory Allocation
Storage Allocation
Bandwidth Allocation
Cloud Resources
Event Handling
sensor
Cloud Coordinator
Data Center
Networked Datacenter
Network
Network Topology
Message-delay Calculation
CloudSim Discrete Event Simulation Core

CloudSim

TABLE II
A SUMMARY OF CLOUDSIM FEATURES

Feature	Available?	Details
Ability to model user requests	Partially	Applications represented by a workload object that contains user workloads (by MIPS)
Ability to model inter-VM dependency	No	-
Ability to model multiple DCs	Yes	-
Ability to model servers	Yes	With fixed set of attributes
Ability to model network elements	limited	Data center network is modeled using BRITE" format but not used. Internal network not represented.
Ability to model VMs	Yes	Resource configuration and placement
Ability to model inter-VM connectivity	No	BW required by a VM is treated as a fixed commodity
Ability to model failures/recoveries	No	-
Ability to model energy power sources mix (24 hour source types	No	-
Ability to model power usage per VM, Server, Facility	Yes	Multiple power management methods are implemented Basic power usage statistics are available
Ability to model security measures (attacks, firewalls)?	No	-
Ability to model network flows?	No	-

NetworkcloudSim

- NetworkCloudSim is an extension of CloudSim that focuses on network capabilities. The major motive is enhancing CloudSim with complex application models such as message passing applications and workflows in addition to supporting a scalable network model for cloud data centers.
- the NetworkCloudlet class to represent a task executing in several phases/stages of communication and computation
- Each application contains several communicating elements (NetworkCloudlets). Each element runs in a VM and consists of stages where it either performs data exchange tasks (communicating) or computing tasks

NetworkCloudSim

TABLE VI
A SUMMARY OF NETWORKCLOUDSIM FEATURES

Feature	Available?	Details
Ability to model user requests	Yes	Can model communicating/dependent applications
Ability to model inter-VM dependency	Yes	-
Ability to model multiple DCs	Yes	-
Ability to model servers	Yes	With fixed set of attributes
Ability to model network elements	Yes	Internal DC network is modeled including switches
Ability to model VMs	Yes	Resource config and placement
Ability to model inter-VM connectivity	Yes	-
Ability to model failures/recoveries	No	-
Ability to model energy power sources mix (24 hour source types	No	-
Ability to model power usage per VM, Server, Facility	Yes	Multiple power management methods are implemented, basic power usage statistics are available
Ability to model security measures (attacks, firewalls)?	No	-
Ability to model network flows?	Yes	The designers chose flow model over packet model to send/receive data

TeachCloud

- TeachCloud was built for a specific purpose, namely education
- TeachCloud is an extension of CloudSim
- Architectures like VL2, BCube, Portland and Dcell are supported.
- Contains modules that monitor data center components, show the impact on system effectiveness and allow reconfiguration of the experiments.

CloudAnalyst

- CloudAnalyst is another extension of CloudSim.
- The motivation behind CloudAnalyst is analyzing and evaluating geographically distributed user workloads
- Data center configuration and user distribution/load parameters are supported.

TABLE X
CLOUDANALYST TEST PARAMETERS

Internet characteristics	User parameters
1-Region/region delay matrix : transmission delay between regions in (milliseconds) 2-Region/region bandwidth matrix (available bandwidth between regions)	1-User grouping factors in user bases (how many simultaneous users from the same base) 2-User grouping factors in data centers (how many simultaneous users on the same host) 3-Instruction length/ request (bytes) 4-Load balancing policies a-round robin b-equally spread current execution load c-throttled
Simulation configuration	**Data center configuration**
1-Simulation time 2-User bases: a-average number of users at peak time b-average number of users at off-peak time c-region d-request/user/hour and request size. e-daily peak hours 3-Broker service policy: a-closest data center b-optimize response time c-reconfigure dynamically	1-Region 2-Architecture 3-OS 4-VMM 5-VM cost 6-Storage cost 7-Data transfer cost 8-Physical hardware units 9-Server configuration: a-memory b-storage c-BW d-number of processors e-processor speed f-VM policy (time shared or space shared)

GreenCloud:

A Packet-level Simulator of Energy-aware Cloud Computing Data Centers

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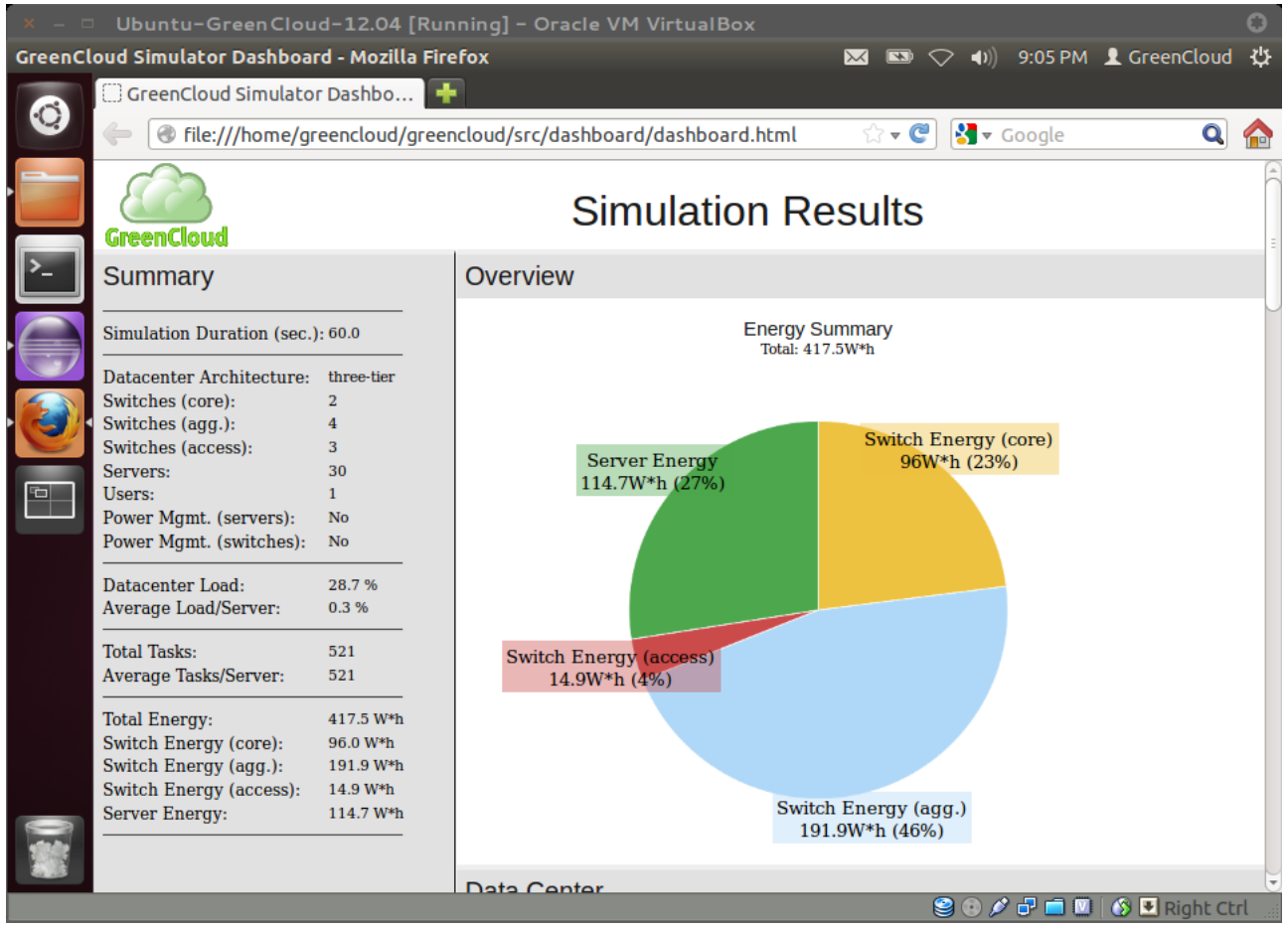
Cloud Computing Simulator

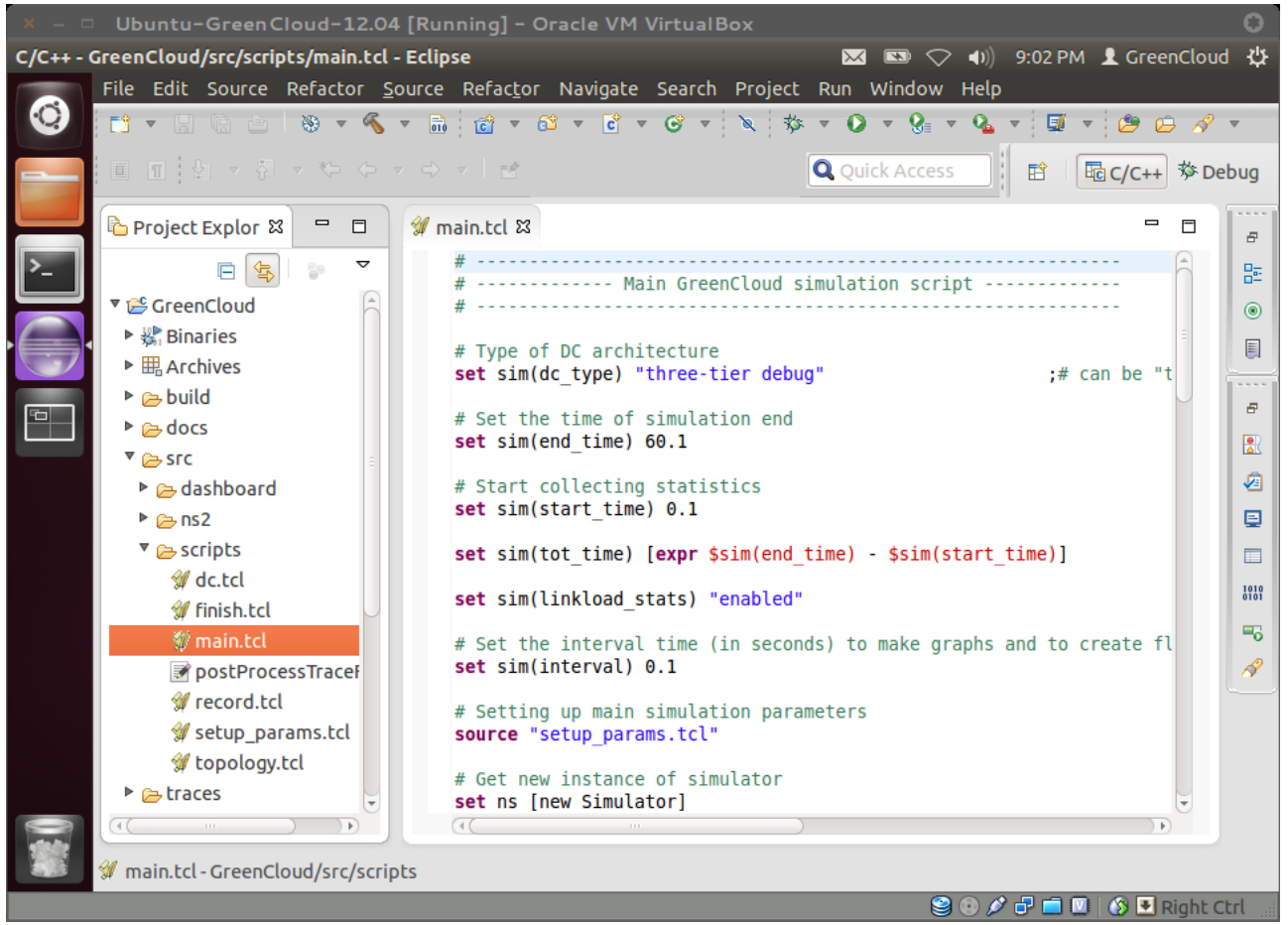
available at
http://greencloud.gforge.uni.lu

- Measures cloud performance and energy efficiency
- First to simulate cloud communications with packet-level precision
- Implements network-aware scheduling
- Implements complete TCP/IP protocol stack

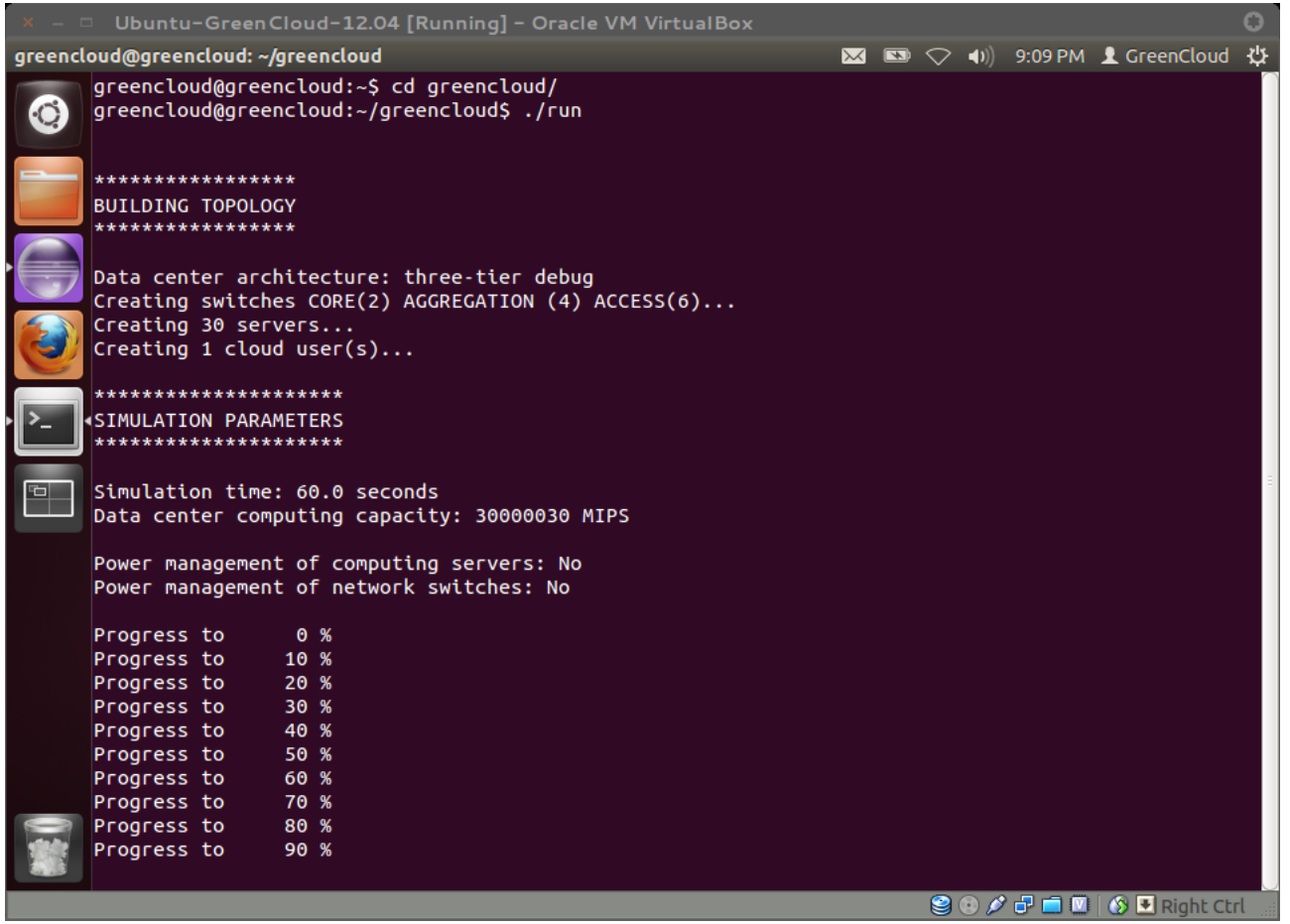
GreenCloud: Screenshots



GreenCloud: Screenshots



GreenCloud: Screenshots



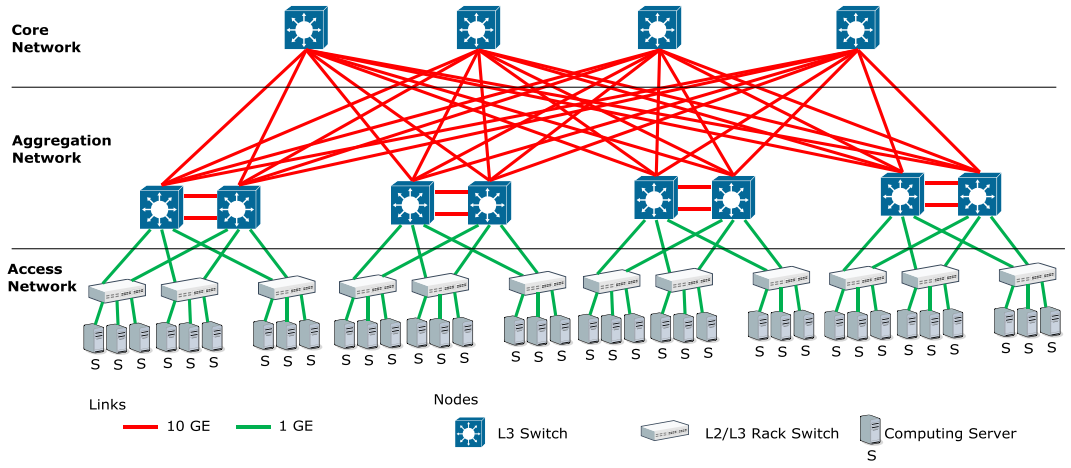
GreenCloud: Data Center Architectures

- Three-tier data center architecture

Access, aggregation, and core layers

Scales to over 10,000 servers

8-way ECMP load balancing



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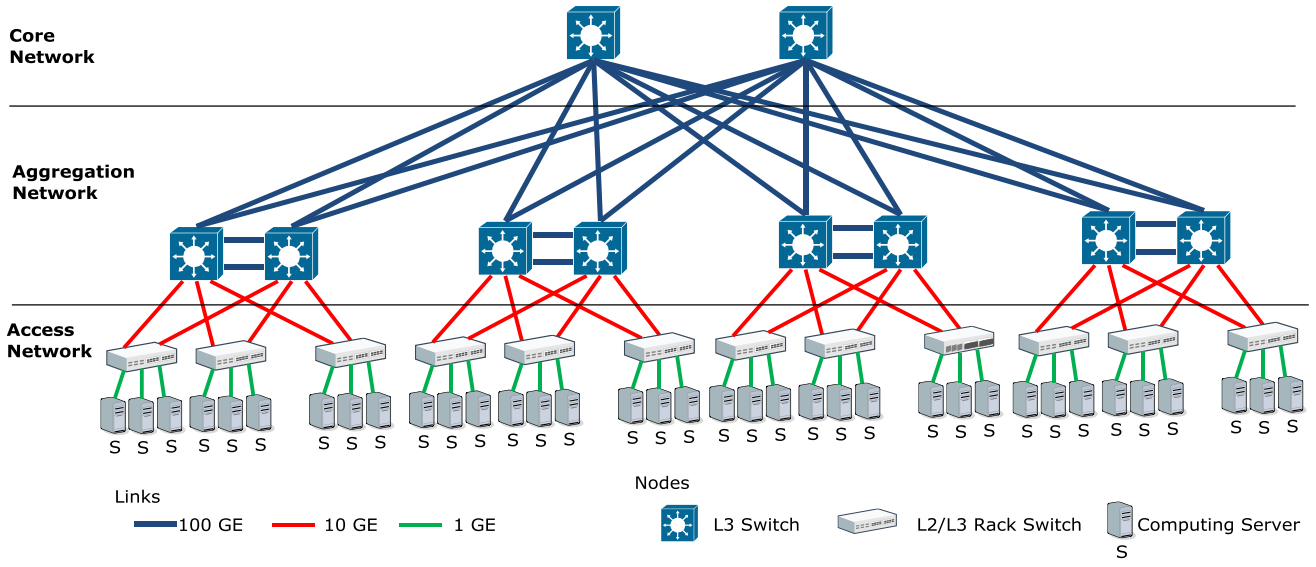
GreenCloud: Data Center Architectures

- Three-tier High-Speed architecture

Increased core network bandwidth

2-way ECMP load balancing

100 GE standard (IEEE 802.3ba)



GreenCloud: Data Center Architectures

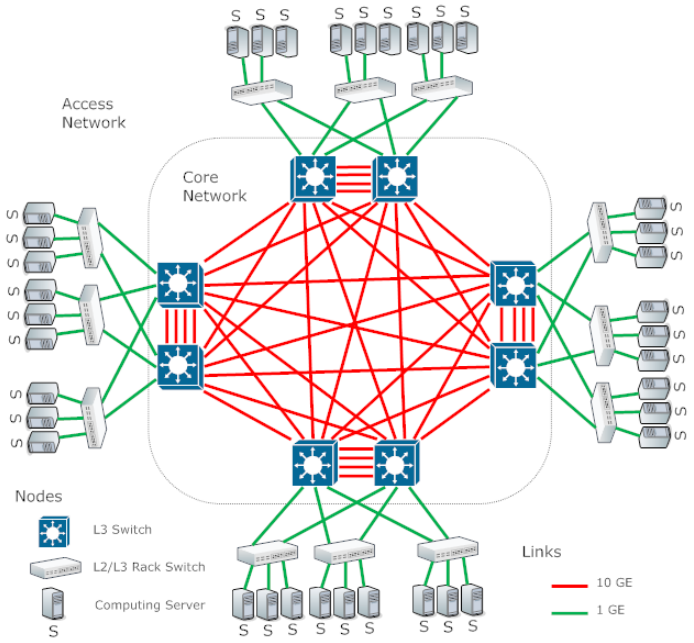
- Two-tier data center architecture

Access and Core layers

Load balancing using ICMP

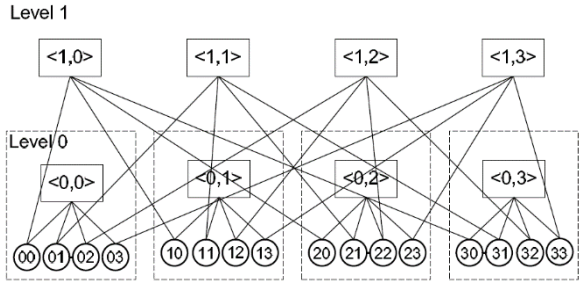
Full mesh core network

1 GE and 10 GE links

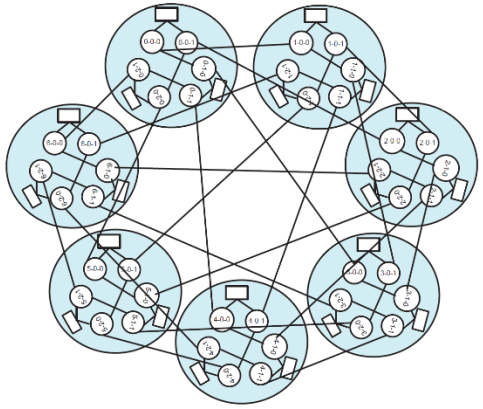


GreenCloud: Data Center Architectures

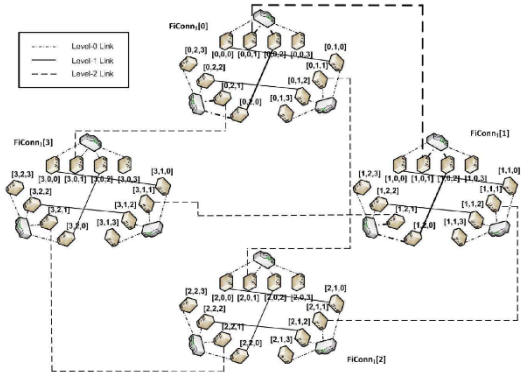
- Modular data center architectures



DCell



BCube



FiConn

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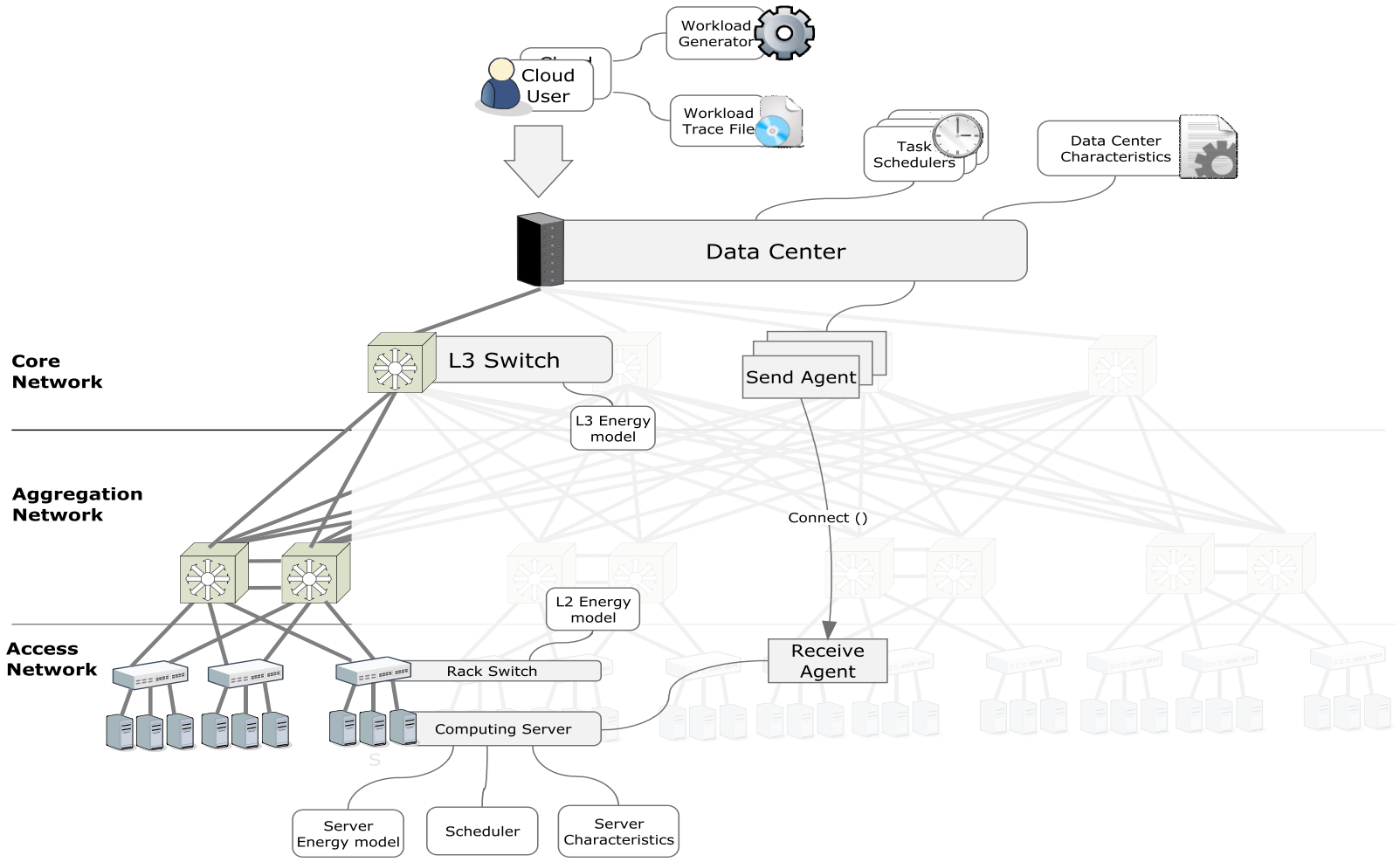
GreenCloud Architecture



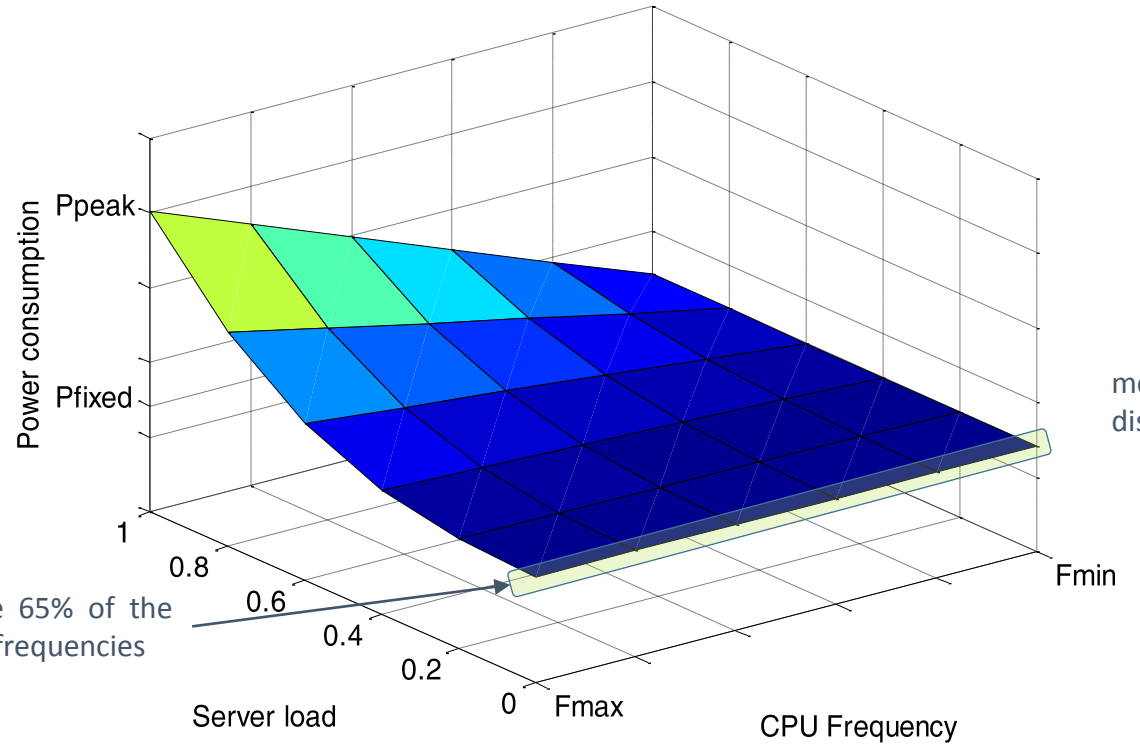
GreenCloud: Simulator Components

- Servers
  - Responsible for task execution
  - Single-core nodes
  - Preset processing limit in MIPS or FLOPS

- Supported power management modes
  - DVFS: Dynamic Voltage/Frequency Scaling
  - DNS: Dynamic Shutdown (or stand-by)
  - Both: DNS if server is idle, DVFS otherwise

GreenCloud: Simulator Components

- Energy Model for Hosts



Idle servers consume 65% of the peak load for all CPU frequencies

$$P = P_{\text{fixed}} + P_f \cdot f^3$$

memory modules, disks, I/O resources

CPU

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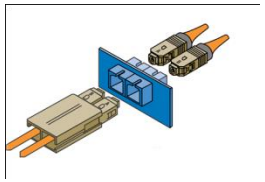
GreenCloud: Simulator Components

- Switches
  - Most common Top-of-Rack (ToR) switches typically operate at Layer-2 interconnecting gigabit links in the access network
  - Aggregation and core networks host Layer-3 switches operating at 10 GE (or 100 GE)

- Links
  - Transceivers' power consumption depends on the quality of signal transmission in cables and is proportional to their cost
  - 1 GE links: 0.4W for 100 meter transmissions over twisted pair
  - 10 GE links: 1W for 300 meter transmission over optical fiber



- Supported power management modes
  - DVFS, DNS, or both

GreenCloud: Simulator Components

- Energy model for a network switch

$$P_{switch} = P_{chasis} + n_{linecards} \cdot P_{linecard} + \sum_{i=0}^{R} n_{ports.r} \cdot P_r$$

Chassis
~ 36%

Linecards
~ 53%

Port transceivers
~ 11%

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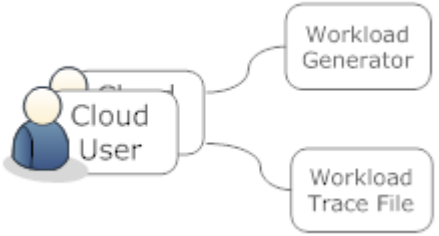
GreenCloud: Simulator Components

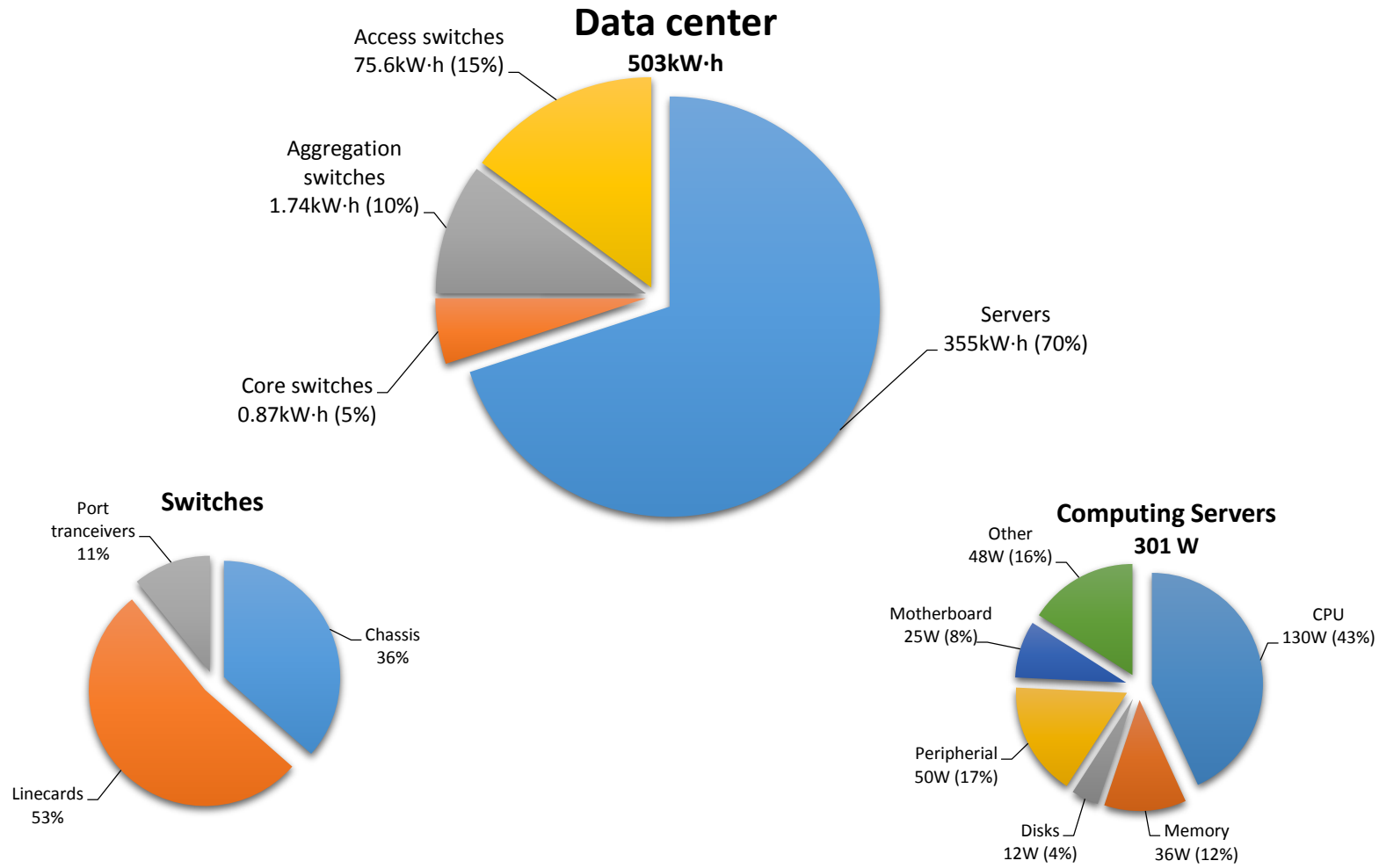
- Workloads
  - Model cloud user applications (social networking, instant messaging, content distribution, etc.)



- Workload properties
  - Computational: MIPS, duration
  - Communicational: workload size, internal and external communications

- Generation
  - Trace-driven
  - Using random distribution (Exp, Pareto, etc.)

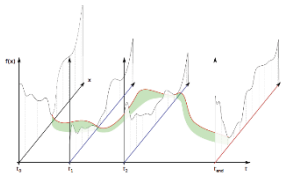
GreenCloud: Simulation Results



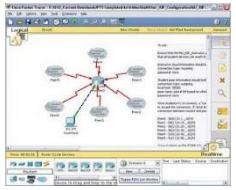
GreenCloud Usage and Benefits

- GreenCloud tools cover complete optimization workflow

1: Client data center analysis



2: Applying optimization solutions



3: Verification and proof of the concept

- Can be used to
  - Optimize existing data centers
  - Guide capacity extension decisions
  - Help to design future data center facilities

GreenCloud

TABLE VIII
A SUMMARY OF GREENCLOUD FEATURES

Feature	Available?	Details
Ability to model user requests	yes	CIWs,DIWs,BWs
Ability to model inter-VM dependency	no	Can configure Tasks to communicate with a random server
Ability to model multiple DCs	no	-
Ability to model servers	Yes	With fixed set of attributes
Ability to model network elements	yes	3 different topologies available switches and links modeled packets sent over the network
Ability to model VMs	Yes	Resource configuration and placement
Ability to model inter-VM connectivity	yes	Can configure Tasks to communicate with a random server
Ability to model failures/recoveries	No	No mention of recovery in their documentation
Ability to model energy power sources mix (24 hour source types	No	
Ability to model power usage per VM, Server, Facility	Yes	Multiple power management methods are included Basic power usage statistics are available
Ability to model security measures (attacks, firewalls)?	No	-
Ability to model network flows?	Yes	It is based on NS2, TCP/IP enabled.

GreenCloud

TABLE VII
TYPES OF WORKLOADS/TASKS AT GREENCLOUD

	Computationally Intensive Workloads (CIWs)	**Data-Intensive Workloads (DIWs)**	**Balanced Workloads (BWs)**
Real life Application Modeled	High-Performance Computing (HPC) applications that solve advanced computational problems	Applications like video sharing (for each request there is a streaming process.)	Applications with computing communication requirements (geographic information systems)
Computational vs. network load	high computing load, low network load	no computing load, high network load	load the computing servers and communication links proportionally.
Scheduling central point	Server energy efficiency is critical (server consolidation)	No network congestions	Network becomes the bottleneck Constant exchanged feedback is a must-Both computational and network portions.

iCanCloud

- Distributed experiments are also supported as iCanCloud can run an experiment on multiple machines .
- Cloudbrokering options are included using a hypervisor feature.
- Storage a special attention in iCanCloud as it supports models for local or remote storage systems as well as parallel storage and RAID designs.

Comparison

TABLE XI
A SUMMARY OF THE CLOUD SIMULATORS FEATURES: EXTERNAL VIEW

Feature/ parameter	Underlying toolkit/ platform	Programming language	Availability	Simulation time (estimate)
CloudSim	SimJava	Java	Open Source	Seconds
GreenCloud	NS2	C++/TCL	Open Source	Minutes /tens of minutes
iCanCloud	OMNET, MPI	C++	Open Source	Seconds
MDCsim	CSIM	C++/Java	Commercial	Seconds
NetworkCloudSim	CloudSim	Java	Open source	Seconds
CloudAnalyst	CloudSim	Java	Open source	Seconds
GroudSim	SimEngine	Java	Academic	Seconds
TeachCloud	CloudSim	Java	Open source	Seconds
CDOSim	CloudSim	Java	Academic	Minutes
GDCSim	BlueSim	Java/XML	Academic	Minutes

Comparison

TABLE XII
A SUMMARY OF THE CLOUD SIMULATORS FEATURES: STRENGTHS AND LIMITATIONS

Simulator / Parameter	Focus/ strength	Limitations
CloudSim	Most commonly used (many extension projects) Supports large scale problems Inclusive support for DCs, VMs and resource provisioning techniques.	Communication model on the packet level is not supported directly
GreenCloud	Focus on power management and energy consumption techniques testing Packet level communication supported	Runtime Detailed brokering model
iCanCloud	Trade-off between costs and performance. Full GUI Parallel execution of 1 experiment over several machines	Cost policies focus is on pay-as-you-go policies No focus on energy consumption No full network model
MDCsim	General purpose functionalities available	Commercial No full network model
GDCSim	Focus on low level power saving methods and cooling	Unproven for general purposes and on large scales
CloudAnalyst	Has a full GUI Focus on geographical factors	Focus on Specific Purpose. No full network model
GroudSim	Works for Grid and cloud systems. Works for large scale problems (high number of requirements) General features available	Basic Network functionalities Basic power consumption optimization functionalities
TeachCloud	For Educational purposes. Simple to use GUI	Basic features Only for academic purposes
CDOSim	Focus on Deployment Options Extension of CloudSim	Unproven for general purposes and on a large scale
NetworkCloud -Sim	Extension of CloudSim Extra communication features like message passing Full application model	No networking on packet level. Less focus on power/cost models Issues of CloudSim apply