CloudSim Plus

http://cloudsimplus.org

A Cloud Computing Simulation Framework Pursuing Software Engineering Principles for Improved Modularity, Extensibility and Correctness

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Agenda

- CloudSim Plus Introduction
- Architecture
  - Modules
  - Main Packages
- Main Exclusive Features
- Conclusions and Future Work

CloudSim Plus Introduction

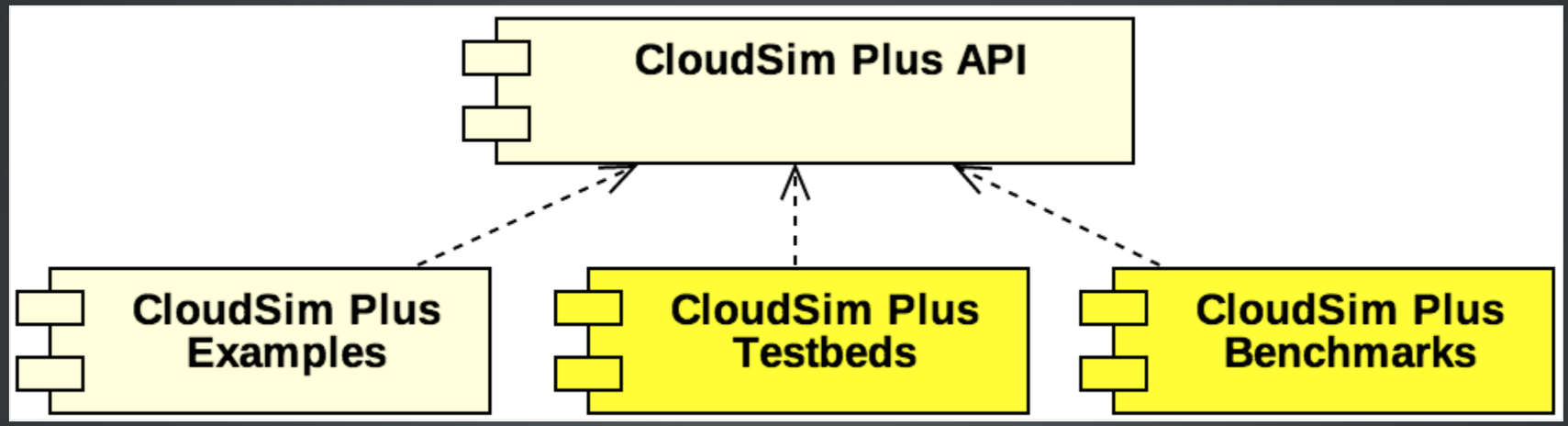
Java 8 independent CloudSim fork for Cloud Computing simulation

- Highly extensible, completely redesigned and refactored.
- Full-featured: more than 20 exclusive features.
- Design Patterns, SOLID principles, KISS, DRY and Clean Code practices.
- Reduced duplication, removed redundancy, simplified design (comparison).
- Less 30% code duplication, more 80% test coverage.

Architecture

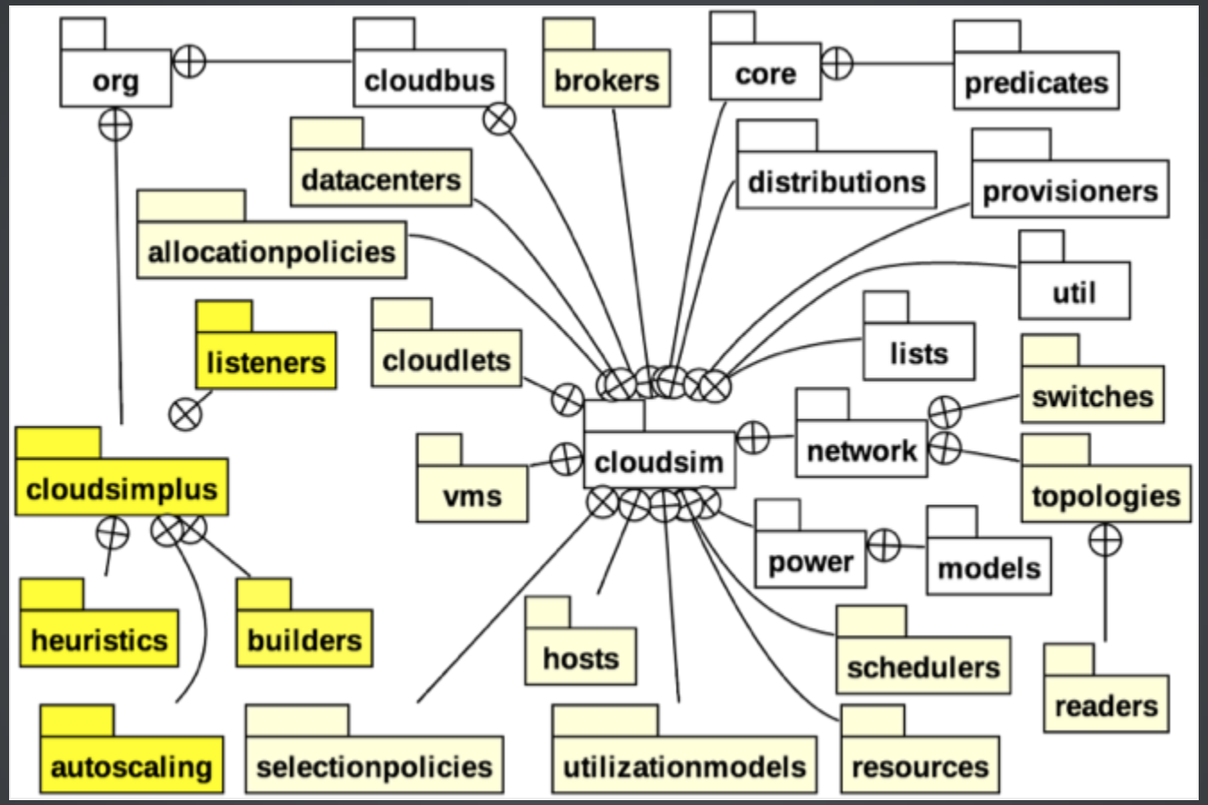
- Maven project available at Maven Central.
- Simplified module structure, new modules introduced.
- Totally re-organized and documented packages.
- New interfaces: increased abstraction, contracts for implementations.

Modules



- **API**: independent and single-required module for building simulations.
  - **Examples**: exclusive examples, refactored previous ones.
  - **Testbeds**: multiple-run simulations for scientifically valid data collection.
  - **Benchmarks**: performance assessment of features such as heuristics.

Main Packages



- **Dark yellow**: CloudSim Plus packages with exclusive features.
- **Light yellow**: new packages to better organize existing CloudSim classes.
- **White**: CloudSim existing packages.

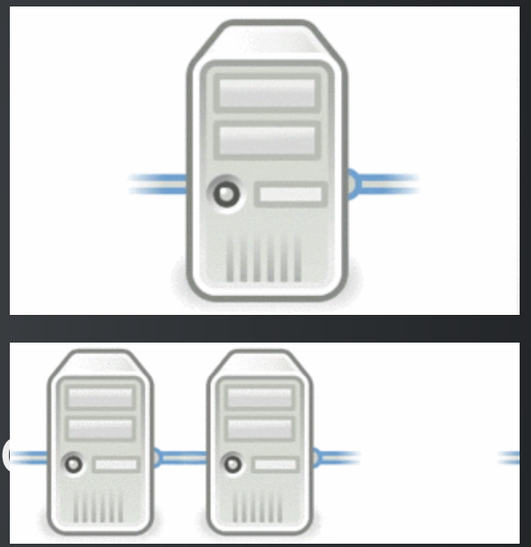
Main Exclusive Features

1. Vertical and Horizontal VM Scaling;
2. Parallel execution of simulations;
3. Dynamic creation of VMs and Cloudlets;
4. Delay creation of submitted VMs and Cloudlets;
5. Event Listeners
6. Strongly Object-oriented Framework;
7. Classes and Interfaces for Implementation of Heuristics;
8. Implementation of the Linux Completely Fair Scheduler;
9. Updated to Java 8 (Functional Programming, Lambda and Streams);
10. Functional `DatacenterBroker`;

Many more at http://cloudsimplus.org

1. VM Scaling

- Vertical VM Scaling
  - resize of VM resources to fit workload
  - RAM, CPU, Bandwidth and Storage
- Horizontal VM Scaling
  - creation and destruction of VMs for load balan



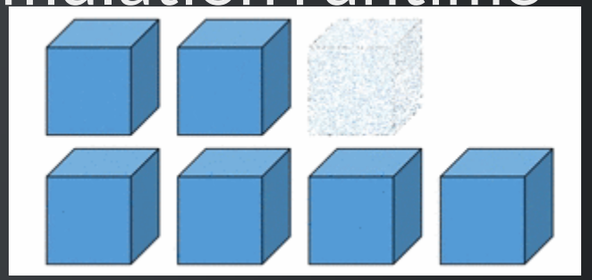
2. Parallel Execution of Simulations

- Parallel execution of multiple simulation runs
- Relies on Java 8 Parallel Streams mechanism
- As simple as calling a single line of code like

```
simulations.parallelStream().forEach(MySimulation::run);
```

3. Dynamic Creation of VMs and Cloudlets

- Enables creating objects after the simulation has started
- Doesn't require new DatacenterBrokers to be created at runtime
- Objects just have to be submitted to an existing broker at simulation runtime



4. Delay creation of submitted VMs and Cloudlets

- Creation of objects at a given time, before starting the simulation
- Used when the arrival times of objects to be create are known in advance
- A different way to simulate the dynamic creation of such objects

5. Event Listeners

- Enables simulation monitoring to:
  - collect resource utilization data
  - assess fulfillment of customer SLA
  - optimize resource allocation to avoid under/over resource provisioning
  - granular simulation execution feedback
- Listeners for events from Hosts, VMs, Cloudlets and more general ones.

6. Strongly Object-oriented Framework

- Objects are used to create actual relationships, instead of using integer IDs
- Fluent API, allowing direct chained calls such as `cloudlet.getVm().getHost().getDatacenter()`
- Uses Null Object Pattern to avoid NullPointerException.

7. Classes/Interfaces for Heuristics

- Specifies a contract to implement heuristics in some steps:
  - initial solution generation;
  - generation of neighbor solutions;
  - definition of an utility function to be minimized or maximized;
  - and then the solution finding stop criteria.
- Examples: Tabu Search, Simulated Annealing, Ant Colony Systems, etc;
- Includes a Simulated Annealing heuristic for mapping Cloudlets to VMs.

8. Implementation of the Linux Completely Fair Scheduler

- `CloudletScheduler`: how a Vm schedules the execution of Cloudlets
- Bad scheduling: starvation, wastage of CPU cycles, SLA violations
- Completely Fair Scheduler reduces these issues (needs improvements [Lozi et. al. 2016])
- Considers tasks priorities to define CPU time slices
- `CloudletSchedulerTimeShared`: simplistic; ignores task's priority; no actual preemption
- CloudletSchedulerCompletelyFair: more realistic implementation

10. Functional DatacenterBroker

- Enables changing, in runtime, the policies to select:
  - a DC to place waiting VMs;
  - a fallback DC when a previous one doesn't have a suitable Host for a VM;
  - and a VM to run each Cloudlet.
- Allows implementing new policies, without requiring new `DatacenterBroker` classes.

Conclusions and Future Work

- It is difficult to replicate a real system in simulation, mainly concerned in modelling the arrival of stochastic events such as workload bursts.
- To contribute for valid results, a simulation framework has to:
  - be well-designed and extensively test;
  - get away from code duplication to avoid code degeneration;
  - and provide classes following software engineering principles.
- CloudSim Plus is aligned with all these requirements.
- Proposed future work is available at the issues page.

Thanks

CloudSim Plus is developed through a partnership among the Systems, Security and Image Communication Lab of Instituto de Telecomunicações (IT, Portugal), the Universidade da Beira Interior (UBI, Portugal) and the Instituto Federal de Educação Ciência e Tecnologia do Tocantins (IFTO, Brazil). It is supported by the Brazilian CAPES (Proc. no 13585/13-4) and the Portuguese FCT (under the UID/EEA/50008/2013 Project) agencies.

Official Site/Presentation

http://cloudsimplus.org

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