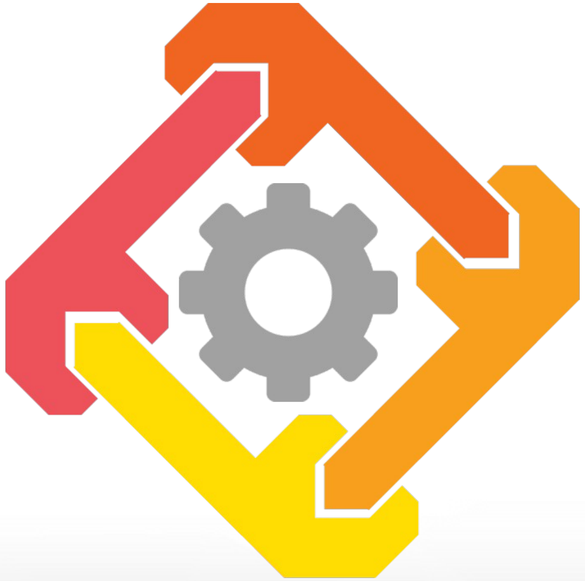


WRENCH

Workflow Management System Simulation Workbench

- *Accurate, scalable, and reproducible simulations*

http://wrench-project.org

Motivation

Scientific Workflows are key to advances in science and engineering

Their executions are complex:

- Workflow structures are large and can be configured in various ways
- Workflow Management Systems (WMS) are **large multi-component software systems** that employ ranges of decision making algorithms
- Workflow execution platforms are **heterogeneous** and diverse

We need a strong “**experimental science**” approach to study these complex systems in a view to optimizing workflow executions

Yet real-world experiments are inherently limited

- Time- and resource-intensive
- Limited to existing configurations
- Require full-fledged implementations
- …

Objectives

Realize a **workflow execution simulation methodology** that has high simulation accuracy, low execution time, and low memory footprint

This framework is to be used:

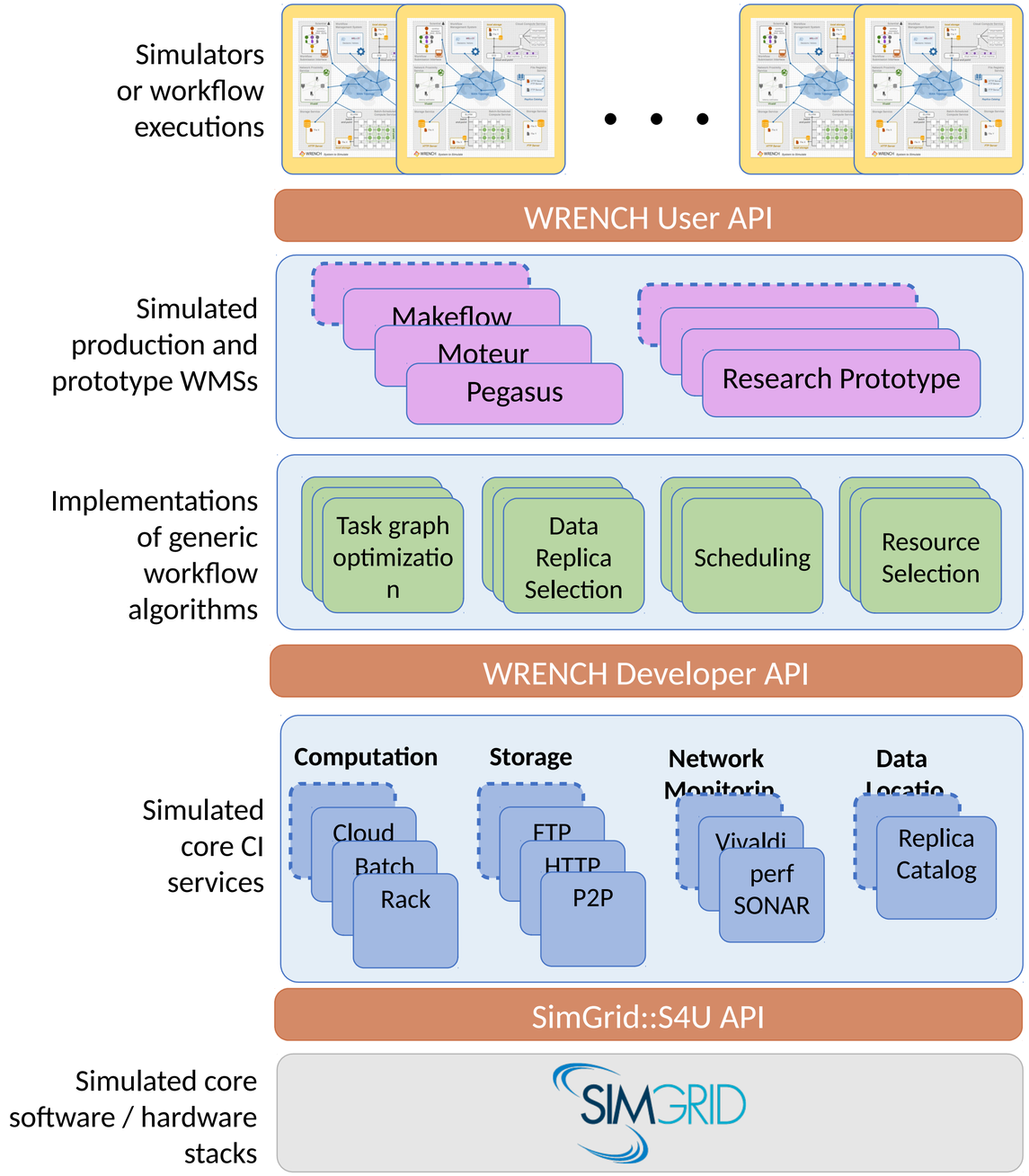
- By **workflow users** to study workflow executions
- By **WMS developers** to inform system and algorithm design decisions
- By **educators** to teach distributed computing in the context of workflows

What is WRENCH?

WRENCH enables novel avenues for scientific workflow use, **research**, **development**, and **education** in the context of large-scale scientific computations and data analyses

WRENCH is an **open-source library** for developing simulators

WRENCH exposes several high-level simulation abstractions to provide high-level **building blocks** for developing custom simulators



Why SimGrid?

http://simgrid.gforge.inria.fr

SimGrid is a **research project**

Development of **simulation models** of hardware/software stacks

Models are **accurate** (validated/invalidated) and **scalable** (low computational complexity, low memory footprint)

SimGrid is **open source usable software**

Provides different APIs for a range of simulation needs, e.g.:

S4U: General simulation of Concurrent Sequential Processes

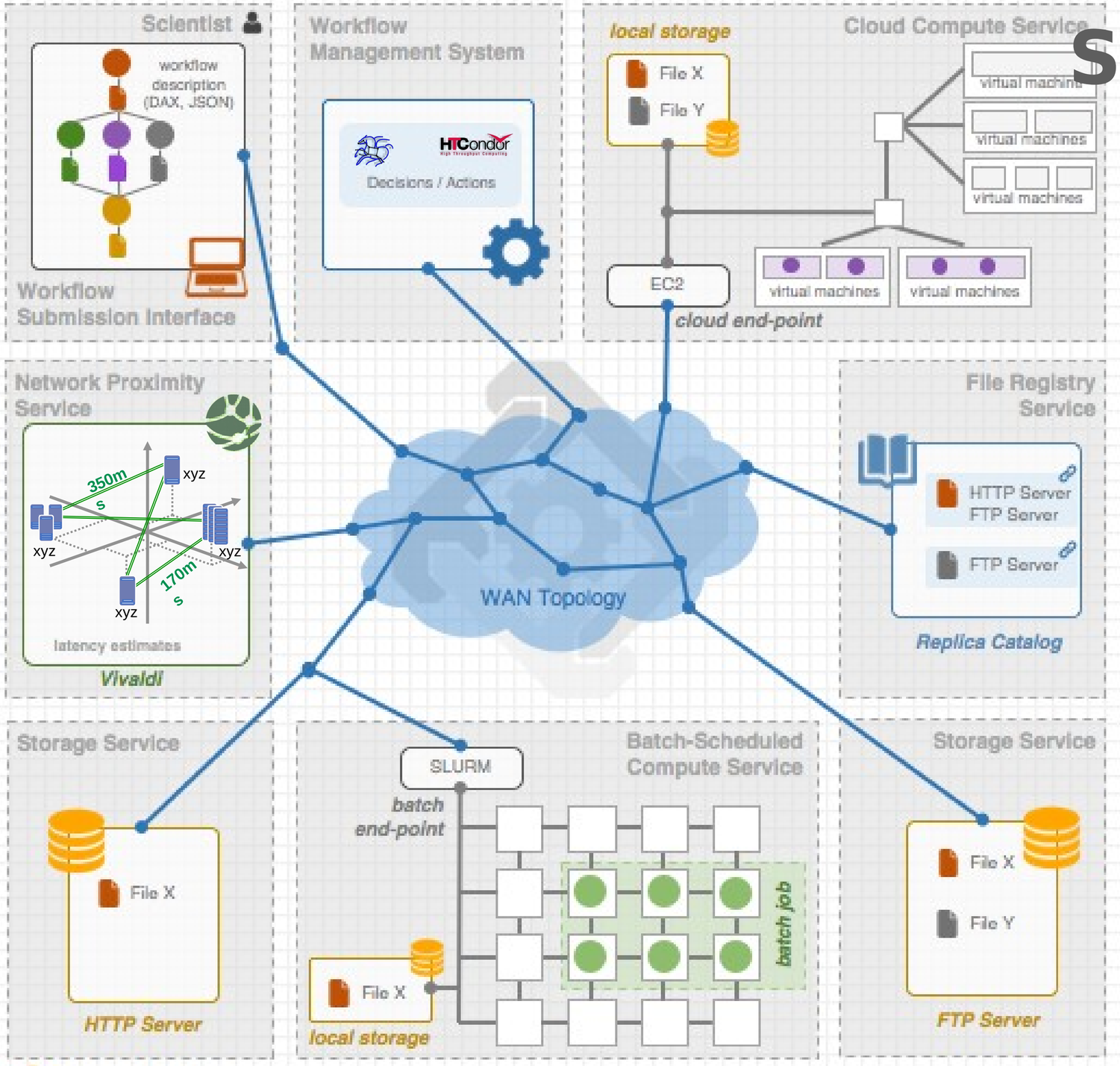
SMPI: Fine-grained simulation of MPI applications

SimGrid is **versatile scientific instrument**

Used for (combinations of) **Grid**, **HPC**, **Peer-to-Peer**, **Cloud**, **Fog** simulation projects

First developed in 2000, latest release: v3.21 (September 2018)

System to Simulate



Compute Services

- Bare-metal servers
- Cloud platforms
- Virtualized Cluster platforms
- Batch-scheduled clusters

Storage Services

- Including scratch spaces

File Registry Services

- Replica catalog (key-value pairs)

Network Proximity Services

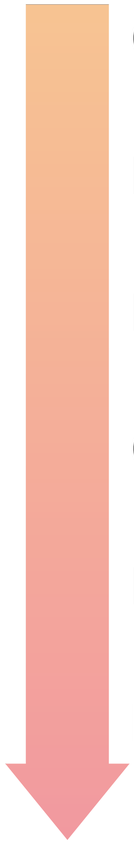
- Database of host-to-host network distances (Vivaldi)

Workflow Management Systems

- Decision-making for optimizing various objectives (static and dynamic)
- Pilot Jobs

Building a Simulator

Blueprint for a WRENCH-based simulator



Create and initialize a simulation

Instantiate a simulated platform

Instantiate services on the platform

Create at least one workflow

Instantiate at least one WMS per workflow

Launch the simulation

Process simulation output

WRENCH + SimGrid internals

Agent: some code, some private data, running on a given host

Task: amount of work to do and of data to exchange

Host: location on which agents execute

Mailbox: Rendez-vous points between agents

You can send ‘data' to a mailbox; you receive ‘data' from a mailbox

Communication time between sender/receiver is accounted (**payload**) and depends on the network traffic

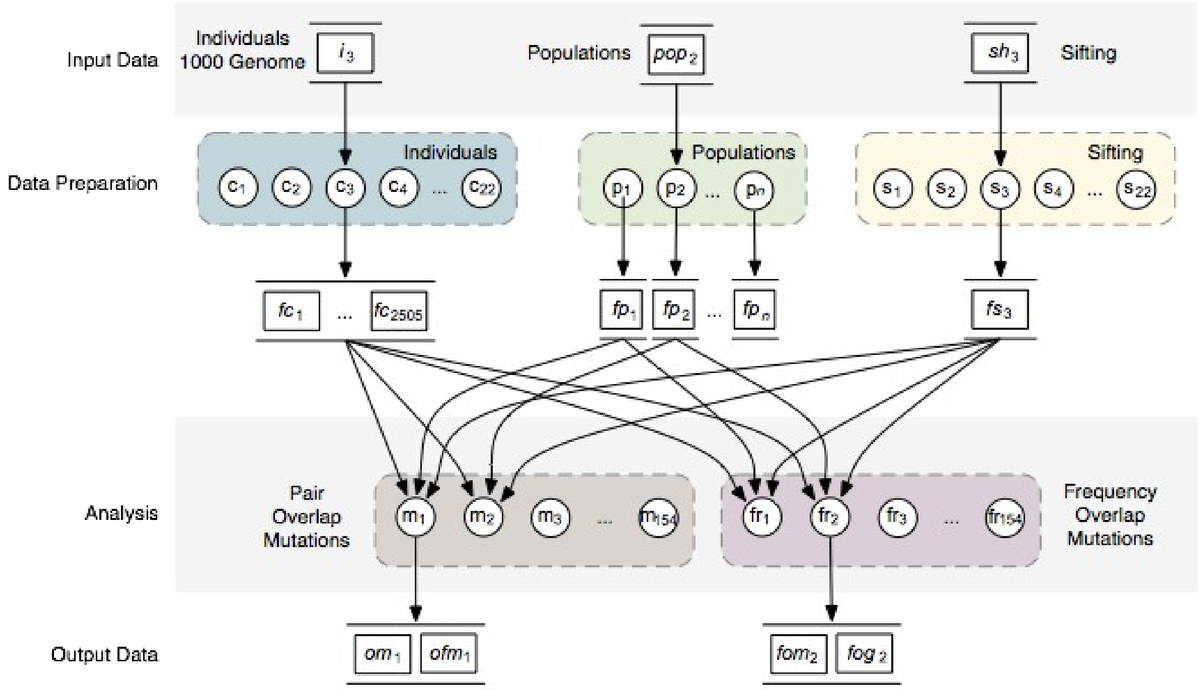
Preliminary Results

Scientific Workflow Application

1000 Genome Sequencing Analysis Workflow

Identifies mutational overlaps using data from the 1000 genomes project

22 Individual tasks, 7 Population tasks, 22 Sifting tasks, 154 Pair Overlap Mutations tasks, and 154 Frequency Overlap Mutations tasks (**Total 359 tasks**)



Preliminary Results

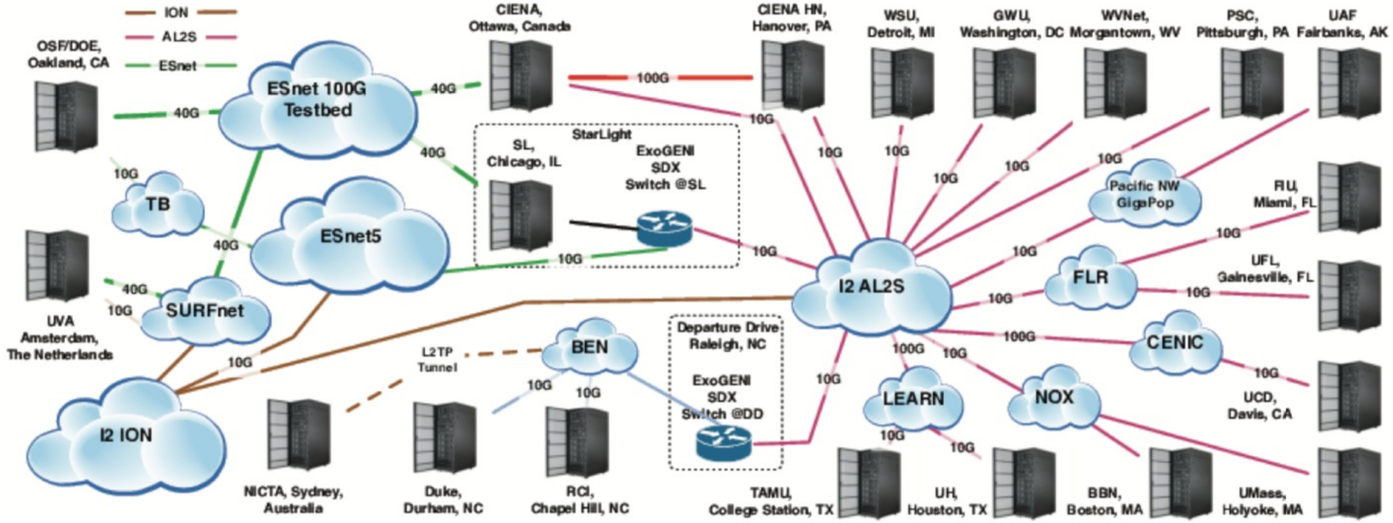
Experiment Configuration

Simulation based on a real Computing Infrastructure

ExoGENI testbed

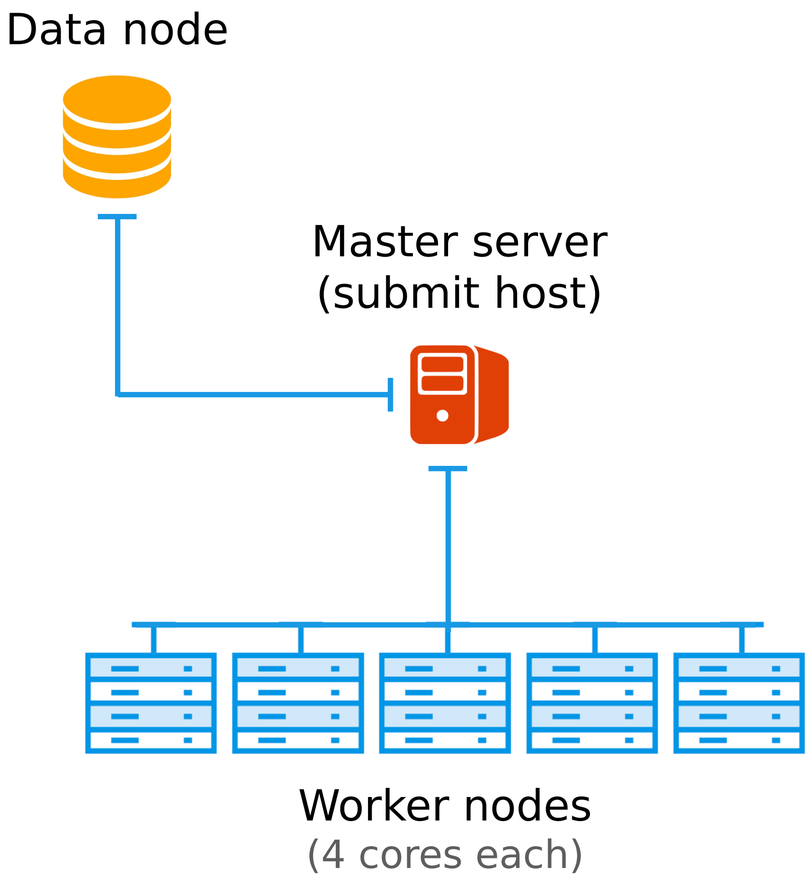
Network IaaS national testbed powered by the ORCA (Open Resource Control Architecture) control software used for GENI

ORCA allows users to create mutually **isolated slices** of interconnected infrastructure from multiple independent providers (**compute**, **network**, and **storage**) and commodity infrastructure



Preliminary Results

Simulated Platform



Modeled as a bare metal system

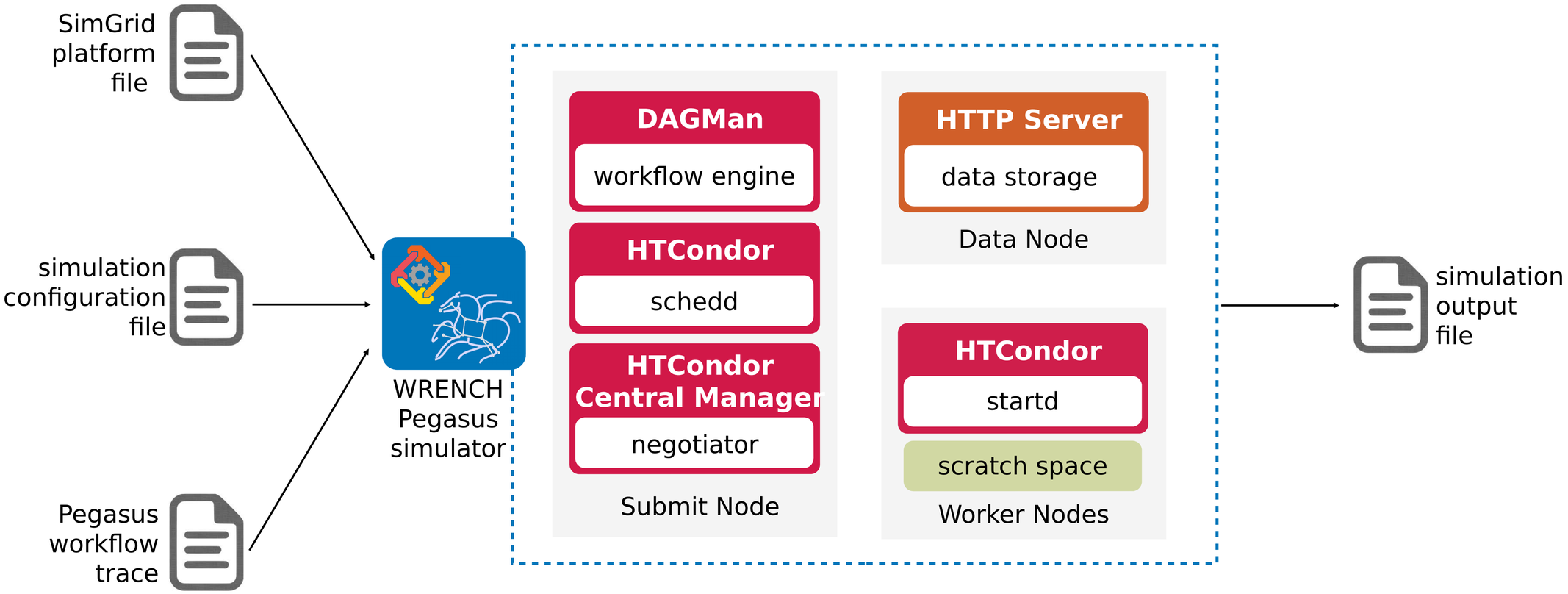
```
<?xml version='1.0'?>
<!DOCTYPE platform SYSTEM "http://simgrid.gforge.inria.fr/simgrid/simgrid.dtd">
<platform version="4.1">
   <zone id="AS0" routing="Full">
      <host id="master" speed="1f" core="4"/>
      <host id="data" speed="1f" core="1"/>
      <host id="workers1-2" speed="1f" core="4"/>
      <host id="workers1-0" speed="1f" core="4"/>
      <host id="workers1-3" speed="1f" core="4"/>
      <host id="workers1-1" speed="1f" core="4"/>
      <host id="workers1-4" speed="1f" core="4"/>
      <link id="1" bandwidth="125MBps" latency="100us"/>
      <link id="2" bandwidth="55MBps" latency="100us"/>
      <route src="master" dst="workers1-2">
         <link_ctn id="1"/>
      </route>
      <route src="master" dst="workers1-0">
         <link_ctn id="1"/>
      </route>
      <route src="master" dst="workers1-3">
         <link_ctn id="1"/>
      </route>
      <route src="master" dst="workers1-1">
         <link_ctn id="1"/>
      </route>
      <route src="master" dst="workers1-4">
         <link_ctn id="1"/>
      </route>
      <route src="data" dst="master">
         <link_ctn id="2"/>
      </route>
   </zone>
</platform>
```

SimGrid Platform description file

Preliminary Results

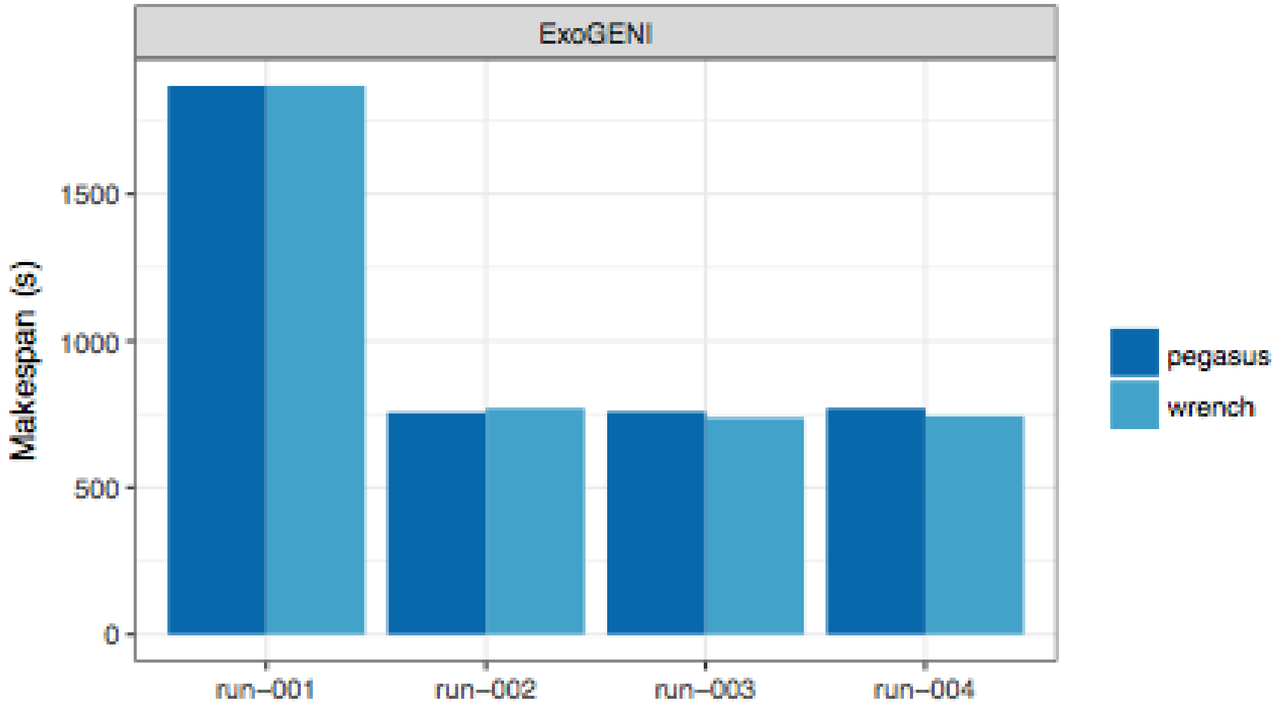
https://github.com/wrench-project/pegasus

Simulated Workflow Management System



Preliminary Results

Simulation Results and Accuracy



>98% workflow makespan accuracy

Simulated **compute** and **data transfer** tasks

includes simulation of auxiliary tasks (e.g., create_dir, cleanup, and registration), and PRE and POST script jobs

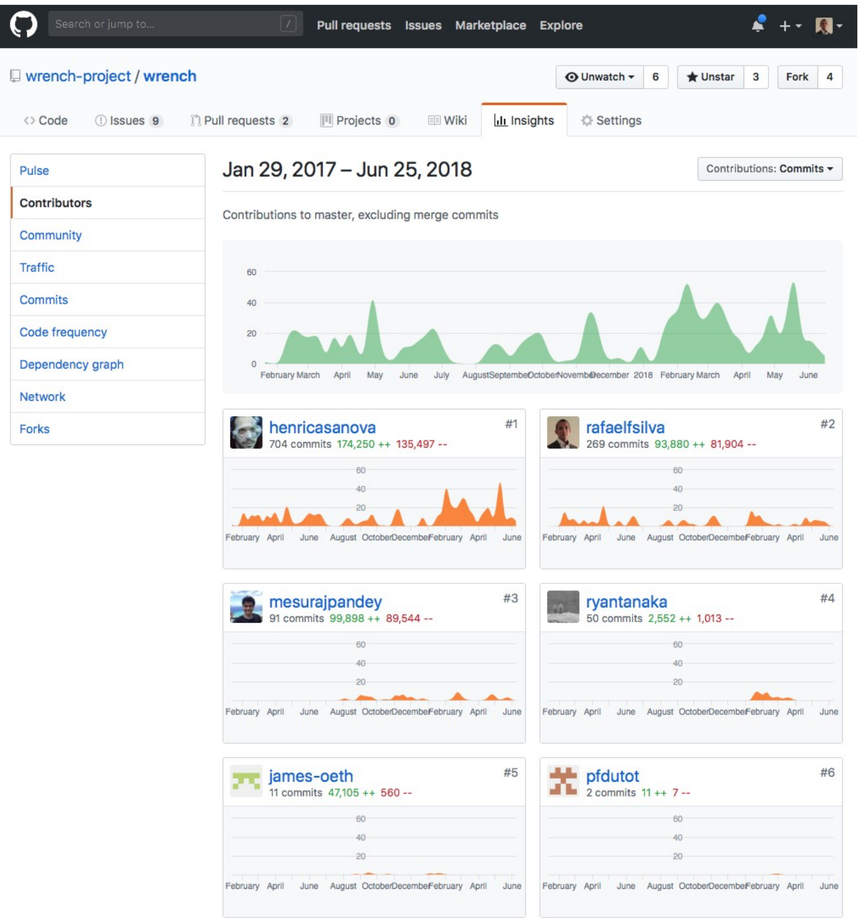
Simulates delays on both DAGMan and HTCondor daemons

Software Availability

Code Repository, Releases, Software Engineering Process

Open-source repository

https://github.com/wrench-project/wrench



Releases

1.0	**(June 16, 2018)**
1.0-beta	(April 15, 2018)
1.0-alpha	(December 1, 2017)

Upcoming releases (estimated)

1.0.1	(August 2018)
1.1	(September 2018)

Continuous Integration

https://travis-ci.org/wrench-project/wrench

Travis CI build passing

Tests Coverage

https://coveralls.io/github/wrench-project/wrench

COVERALLS coverage 89%

Code Review

https://sonarcloud.io/dashboard?id=wrench

sonarcloud lines of code 15k code quality A

Education

http://wrench-project.org/wrench-pedagogic-modules

WRENCH Stand-alone Pedagogical Module

It is crucial to teach undergraduate students parallel and distributed computing

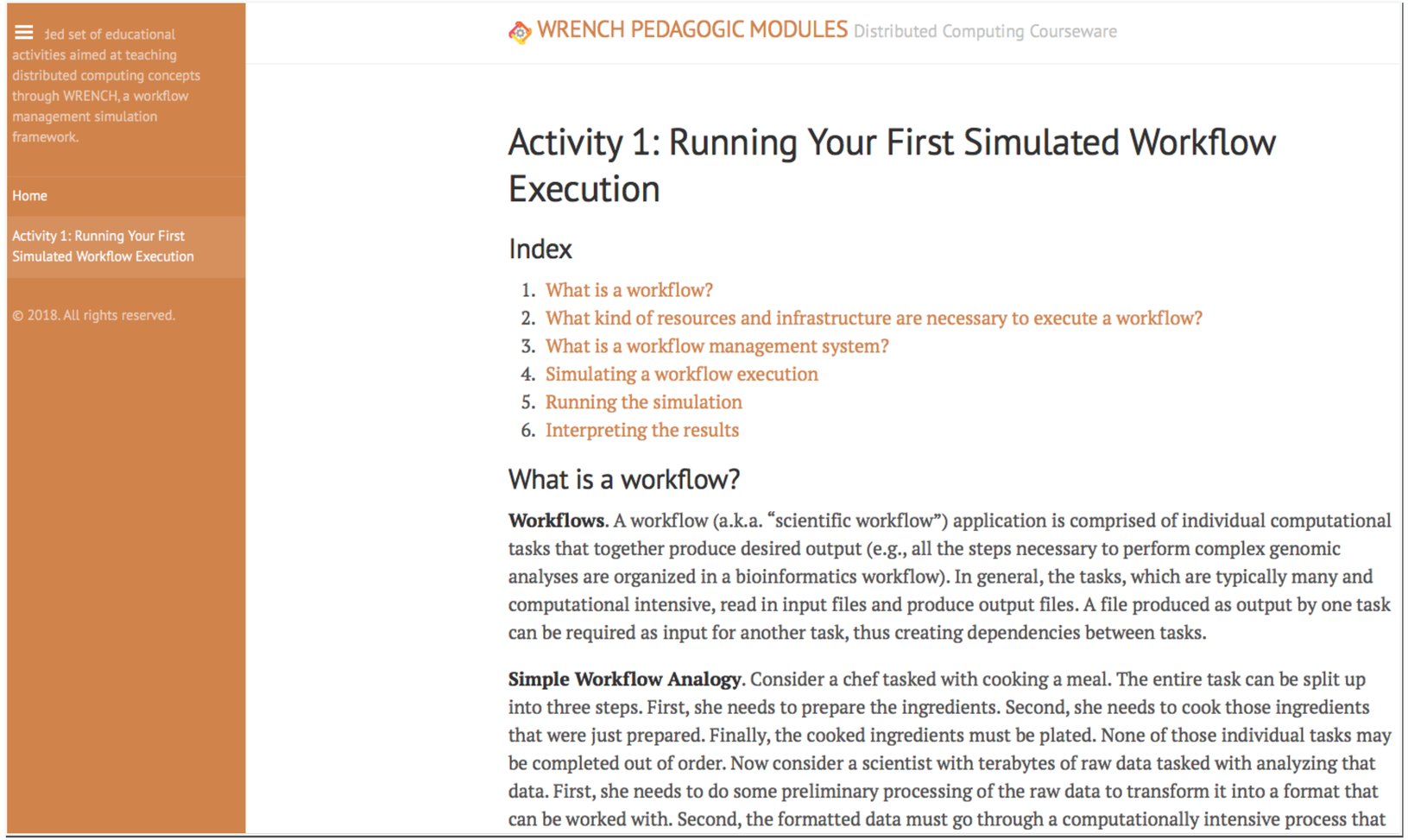
But it is not easy

giving students access to sufficiently diverse and **realistic** software/hardware platforms

dealing with platform **down-times** and **instabilities**

dealing with time-consuming and possible **costly executions**

Simulation resolves these difficulties and WRENCH provides the foundation for **pedagogic modules on parallel and distributed computing** that use workflows as a motivating context



Simulation Building Blocks

Prototype implementations of Workflow Management System (WMS) components and underlying algorithms

Simulation Accuracy

Captures the behavior of a real-world system with as little bias as possible via validated simulation models

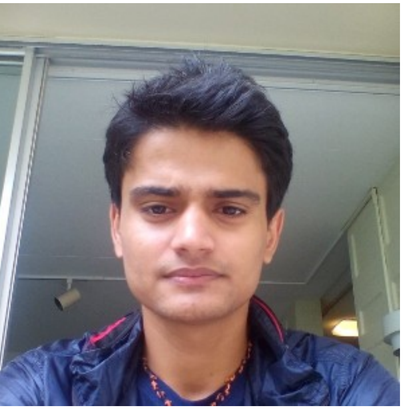
Scalability

Low ratio of simulation time to simulated time, ability to run large simulations on a single computer with low compute, memory, and energy footprints

Reproducible Results

Enable the reproduction or repetition of published results by a party working independently using the same or different simulation models



Our Team

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Thank You

Get Started:

http://wrench-project.org