On the reproducibility of experiments in the Cloud

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Today’s talks

- 17 had an evaluation part.
- 3 used analytical study.
- 8 used testbed or real deployment.
- 1 used an unknown technique.
Evaluation! Why?

- Validate concepts and ideas,
- understand complex systems,
- compare solutions.
How to evaluate?

- Analytical methods
  - e.g., mathematical models
- Empirical methods
  - e.g., simulations, emulations, deployments
Tools to support evaluation

- Theory.
- Simulators
  - imitate the behaviour of real systems.
- Emulators
  - combine system models with real system components.
- Testbeds
  - dedicated infrastructures to conduct experiments under live conditions.
- Live deployment
  - experiment in the targeted environment.
3R: Repeatability, Reproducibility, Replicability

- **Repeat**: clone the experiments results on a given platform.
- **Reproduce**: clone the procedure to conduct an experiment on a given platform.
- **Replicate**: clone the experiment scenario on a different (similar) platform.
Automate evaluations is essential

- Rigorous experimentation is multifold and challenging

Experiment Life Cycle

- Design
- Deploy
- Monitor
- Collect Results
NEPI to automate

- NEPI, *Network Experiment Programming Interface*, is a framework to automate network experiments
  - that abstracts components behind a common interface: the resource
  - to automate experimentation steps.
- Runs locally, no need to modify the experiment facility
  - e.g., ns-3, PlanetLab, Grid’5000.
And the Cloud?
The fundamentals of the Cloud

- **Service sharing** is the foundation of cloud computing.

**How to reach the 3 Rs?**

- Partial isolation.
- Elasticity.
Observations

- Cloud services are deployed in data centers.
  - Easy to rent resources in the infrastructure
  - but hard to modify the infrastructure (hard or soft).
- Data centers are expensive to build.
- Each data center is different.
Observations (contd.)

- Research community has easy access to grid computing infrastructures.
  - Enormous processing power.
  - High speed network.
  - High quality storage.
- e.g., Grid’5000.
Data centers in the Grid - DiG

- Emulate data center topologies in a Grid
  - respecting computing and network resource constraints
  - with performance guarantees
- to run cloud applications and algorithms.
The 3 steps of DiG

- Experimental Network Embedding
- Configuration Generation
- Deployment
Experimental Network Embedding

- Target network and physical grid infrastructure modelled in DOT language
  - using labels to represent workload and constraints.
- Resolution of the Virtual Network Embedding (VNE) problem
  - with ALEVIN [BLF+14]
- to generate a node mapping file.

Configuration Generator for Experimental Network

- Prepare configurations to be put on each resource of the grid infrastructure.
  - Softwares to install.
  - Docker and VMs.
  - Resource limitations, CPU affinity.
Deployment

- Build a L2 overlay network in the grid to carry the experiment

  - OVS switches
  - L2TPv3 tunnels
  - network conditions controlled with \textit{tc}.

- Deploy the experiment on top of the overlay based on the configurations.
Deployment (contd.)

- Centralised management of the experiment.
- Dedicated node in the grid.
- Dedicated (isolated) virtual network.
Demo

- Hadoop benchmark suite in a fat-tree data center on Grid 5000

- https://www.youtube.com/watch?v=zikbQN8B7OE
Take away message

- Cloud incurs large variability.
- A lot of “hidden” hard technical work.
  - Hard to reproduce experiments.
  - Hard to compare solutions.
- Let’s keep the 3Rs in mind while performing evaluations.
Question?
Backup
Network solutions evaluation costs

- The cost to fix a defect increases exponentially [BP88].

Modules interactions

Experimental Network Embedding

Configuration Generation

Deployment