Software defined Testbed
The critical triangle

- **user**
  - usage

- **capex**
  - capital expenditure

- **opex**
  - operational expenditure
The critical triangle

Sustainability

- capex (capital expenditure)
- opex (operational expenditure)
- user
- usage
Most testbeds today are a research effort in itself
- Less attractive to the end user (non CS)

Testbed on demand
- Depends on the experiment itself
- It must be easy to use also for domain scientists not from CS
- A testbed independent of the operational network

Comparable to
- Astronomers with big telescopes which must be shared
- Physicists with their collider infrastructure (CERN / LHC)
- ...

To do
- Offer an infrastructure (the facility hosts) like the Géant network
- Include offers from cloud providers
  - bare metal machines / virtual machines
- Create a software defined testbed which can easily federate
The architecture
**Tomato** – Editor and Features

- **graphical editor**
  - Creating topologies by drag/drop
  - Connects topologies
  - Resource usage per topology

- **Topologies**
  - Colored icons show virtualization technology (*KVM, OpenVZ, …*)
  - Linux and Windows OS
  - Link style shows link attributes
  - Complex topologies (multi-homing)

- **On link basis properties**
  - Bandwidth, Latency, Jitter, …
  - Packet capturing (Cloudshark)

- **Console access**
  - HTML5, Java applet
Scaling up

- **Single-host deployment**
  - Hostmanager, Backend and Web-Frontend can run on the same host
  - Easy for local tests

- **Isolated multi-host setups**
  - Running multiple hosts with a single backend and web-frontend on user premises
  - Isolated infrastructure for SMEs

- **Federated setups**
  - TêMaTo hosts can be used by multiple backends
  - The TêMaTo community consists of over 100 hosts at several sites

- **Testbed on demand**
  - Dynamically allocate cloud resources for experiments
  - Current research effort
    - Master thesis on allocating resources from CloudLab for TêMaTo
    - Master theses on allocating resources from AWS
    - Bachelor thesis on dynamic host (VMs) allocation
Summary

- **What should future fixed networking testbeds offer**
  - Less capex and opex
  - Cover a broad area of applicability
  - Independent of the operational network

- **and how can they attract users?**
  - Easy to use especially for scientists NOT from CS
  - Pay per use
  - Easy adaptation to research questions

- **Tomato Testbed on demand**
  - Depends on the experiment itself
  - A testbed independent of the operational network
    - Each topology runs in its own VPN
    - Independent of the operational network
  - On demand integrating of Infrastructure
    - CloudLab, Amazon, Google,…
    - bare metal machines / virtual machines
  - Create a software defined testbed which can easily federate
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G-Lab is a virtual research platform for distributed experiments - not restricted to computer science / network science - flexible setup.

Brings its own monitoring and control environment - Nagios, CoMon, MyOps, DFN-Tools - PlantLab, ToMaTo, Seattle, custom boot images, … - close cooperation with Princeton, BBN, …

ToMaTo is a new network experimentation tool - based on virtualization (KVM, openVZ) - easy to use graphical front end - open-source since version 2.0 (http://dswd.github.com/ToMaTo/)

Federation - close federation with GENI - especially with GpENI

Questions?


> Paul Müller, Dennis Schwerdel and Justin Cappos, **ToMaTo a Virtual Research Environment for Large Scale Distributed Systems Research**, PIK - Praxis der Informationsverarbeitung und Kommunikation, 2014.

> Dennis Schwerdel, David Hock, Daniel Günther, Bernd Reuther, Paul Müller and Phuoc Tran-Gia, **ToMaTo - a network experimentation tool**, 7th International ICST Conference on Testbeds and Research Infrastructures for the Development of Networks and Communities (TridentCom 2011), Shanghai, China, April 2011.