Challenges in Future Internet Test Beds Cooperation EU-China

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Gaogang Xie, Institute of Computing Technology, CAS & Jiangsu Future Network Innovation Institute
Outline

• **Vision & Rationale**
  A Facility – A playground for the future Internet

• **Towards an Internet of Testbeds**
  An architecture for federation
  Fundamental components for testbed federation

• **From vision to Implementation: Enabling CENI**
  The CENI Experimental Facility
  CENI as part of the federation
Innovation pathways

Various paths to innovation, especially those related to exploring the future internet, using experimentally driven research, prototyping and living labs (user in the loop).
Vision and Rationale

• Scientific
  Can we **trust** the results that we produce. Can we **reproduce** them?

• Economical
  Plenty of **valuable** resources out there

• Technological
  Original, cutting-edge and diverse technologies

• Architectural
  **Federating** a wide-variety of eco-systems and develop **openness**
Federation empowers to run services (and tests) using resources provided by autonomous networks.
TOWARDS AN INTERNET OF TESTBEDS
Technology Accelerators

- **Virtualization**
  - Allows synthetic polymorphism (diversity of technologies) from one platform
  - Can create policy and security boundaries that are not the same as physical boundaries

- **Open Source**
  - Network testbeds affordable to all
The “Hourglass” as the model

<table>
<thead>
<tr>
<th>Layer</th>
<th>Protocols at that layer</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Application</td>
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<tr>
<td></td>
<td>SMTP</td>
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<td>FTP</td>
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<td>3</td>
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<td>IP</td>
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<tr>
<td>2</td>
<td>Link</td>
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<tr>
<td></td>
<td>Ethernet</td>
</tr>
<tr>
<td></td>
<td>ATM</td>
</tr>
<tr>
<td></td>
<td>Frame Relay</td>
</tr>
</tbody>
</table>

- There are dozens of application level protocols (perhaps not all equals, e.g. DNS)
- One datagram oriented transport (UDP), one reliable stream protocol (TCP)
Customers and Providers

- Interconnection and Economics
  - IGP
  - BGP

End-to-end communication

PROVIDER A

PROVIDER B

Customer C1

Customer C2

Content provider

IP traffic

Provider/Customer

Serge Fdida et al., Beijing, April 17th 2014
Formalization of the problem

• What is the right level of abstraction, the minimum set of functionalities to be adopted to share resources owned by various authorities?
  Expose the resource characteristics to the user
  Provide a mean to control the experiment

• What is the governance model that best supports subsidiarity?

• Is there a business model?
## Testbed abstractions

<table>
<thead>
<tr>
<th>object</th>
<th>service</th>
</tr>
</thead>
<tbody>
<tr>
<td>resource</td>
<td>Testbed ensures proper management of nodes, links, switches, ...</td>
</tr>
<tr>
<td>user</td>
<td>Testbed guarantees the identity of its users</td>
</tr>
</tbody>
</table>
| slice | A distributed container in which resources are shared:  
  - sharing with VMs, in time, frequency, within flowspace, etc.  
  The base for accountability |
| authority | An entity responsible for a subset of services (resources, users, slices, etc.) |
The issue with testbed isolation

 Authorities

 Users

 Tools

 Testbed resources
Experimenter

Testbeds resources

Generic & Testbed Specific

A secure and distributed thin waist

Common API
SFA aims to provide a secure common API with the minimum possible functionality to enable a global testbed federation.
Governance

Not a single point of control

Subsidiarity of each Authority/Testbed

Peering: expectations and responsibilities

Provide users with resources they need (SLAs, etc.)

Enforce accountability (incidents, billing, etc.)

Trust comes from careful monitoring (health, usage, etc.)
FUNDAMENTAL COMPONENTS FOR FEDERATION
Building International Federation

PLANEETLAB
An open platform for developing, deploying, and accessing planetary-scale services

Est. 2007

PLANEETLAB Europe
An open platform for developing, deploying, and accessing planetary-scale services
Slice-Based Facility Architecture (SFA)

- A **secure and distributed thin waist** to enable a global federation:
  - **Naming**: uniquely identifies objects; links; requires sharing of namespace;
  - **Identity / Authentication**: X509 certificates;
  - **Authorization**: Non standardized credentials;
  - **Control plane API**: Manipulate objects and their associations; authorization + policies;
  - **Data model**: Resource description: Resource specification (RSpec), which is an XML transported by the SFA layer. Independent from SFA.
The experiment lifecycle

1. User account & slice creation
2. Authentication
3. Resource discovery
4. Resource reservation & scheduling
5. Configuration/instrumentation
6. Execution
7. Repatriation of results
8. Resource release
Federate your testbed with the SFA community

SFAWrap - http://www.sfawrap.info

Condition 1/ The local testbed resources must be described in an RSpec that the testbed’s aggregate manager can both send and understand

- Handles most of the complexity (crypto, etc.)
- Open community development model
  - Free software - Mutualized developments
SFAWrap adoption

- PlanetLab Europe
- IoT-Lab, INRIA, France
- Cortexlab, France
- NITOS, University of Thessaly, Greece
- Fuseco Playground, Technische Universität Berlin
- IMS, University of Patras, Greece
- Federica, Europe
- BonFire (within Fed4Fire), Europe
UI: The MySlice portal

A portal integrates the various tools and services.

Condition 2: A friendly user interface must be available for researchers to be able to browse the available resources, express their requirements, and reserve the desired set of resources of this testbed in a fashion that is consistent with the rest of the federation.
### MySlice contributors & adopters

<table>
<thead>
<tr>
<th>Contributors/Adopters</th>
<th>Country/Region</th>
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<tbody>
<tr>
<td>UPMC, France</td>
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</tr>
<tr>
<td>INRIA, France</td>
<td>France</td>
</tr>
<tr>
<td>UTH, Greece</td>
<td>Greece</td>
</tr>
<tr>
<td>NTUA, Greece</td>
<td>Greece</td>
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<tr>
<td>TUB, Germany</td>
<td>Germany</td>
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<tr>
<td>iMinds, Belgium</td>
<td>Belgium</td>
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<tr>
<td>i2Cat, Spain</td>
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<tr>
<td>Univ Bristol, UK</td>
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<td>UNIFACS, Brazil</td>
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<td>UFF, Brazil</td>
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<td>UFRJ, Brazil</td>
<td>Brazil</td>
</tr>
<tr>
<td>FNII-ICT - CAS, China</td>
<td>China</td>
</tr>
</tbody>
</table>
Projects/Testbeds using MySLice

- Fantaastic (EU)
- Fed4Fire (EU)
- Openlab (EU)
- FIBRE (Brazil)
- FORGE (EU)
- SMARTFIRE (Sth KOREA)
- F-Lab (France)
- FIT (France)
OneLab Experimental Facility

First open and independent Portal for international federation

• A diversity of testbeds technologies
• Operate services for federation:
  authority, portal, monitoring, etc.

at opening (Q2 2014)

• A large user community
• All bound by a consortium agreement

http://www.onelab.eu

Fdida - Xie, Beijing, April 18th 2014
The OneLab NOC
Enabling CENI
Background

- Research on Internet
  - FIA, protocols and applications
  - Testbeds for experiment
- Two Types of Testbeds
  - Host-based overlay
  - Router-based testbed
- CENI Proposal
  - China Environment for Network Innovations
  - Submitted to NDRC in 2010
  - Approved to be listed as one of the 16 national major scientific infrastructures by the State Council on 2013
Overview of CENI Testbed

- Open
- Virtualization with isolation
- Programmability and Configurability
CENI prototype

Tools & Data
(Traffic Generator, Measurement, Monitoring, e.g.)

MP (SFA)

CP

DP

Inbund & Outbund

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PEARL: Programmable Virtual Router Platform

VRI$_1$
IPv4/6

VRI$_2$
IPv4/6+IPS

VRI$_3$
OpenFlow

VRI$_n$
FIA (NDN, XIA, SOIFA)


VRI: Virtual Router Instance
Add New Nodes

SFA Clients

SFA API

Thin Waist

Testbeds

MySlice
SFace
SFI
Flack
Omni

OneLab Rspec
ProtoGENI Rspec
Openflow Rspec
PEARL Rspec

OneLab Nodes
Emulab Testbeds
Openflow Routers
PEARL

SFA Clients

Rspects

Rspects

Rspects
Tool Nodes
Experiments on Prototype of CENI
http://www.fnii.cn
http://fi.ict.ac.cn
USAGE & DEMOS (recorded) :
Live Demos

• **OpenLab demo 1:**
  Robots' dance @ ICT2013
  also available at:
  http://myslice.info/download/ict2013demo.avi

• **OpenLab demo 2:**
  Mobile sensing and tracking
MySlice

- Short intro
- Demonstration
OneLab Portal

- Access resources through a Portal
OneLab Portal in Federation

- Authenticate users
- Aggregate data
- Browse resources
- Reserve resources

MySlice Architecture

Web interface

Plugins

API

Core

SFA

Other sources ...

Measurement tool

Gateways

Testbed A

Testbed B

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Control plane using MySlice

- User registration
- Account validation
- Request slice
- Manage your account
- Browse testbeds
- Browse resources
- Reserve resources
- Aggregated Measurements
Account registration / validation

Principal Investigator (PI)
Request / Validate slice
Manage your account

MySlice Account

<table>
<thead>
<tr>
<th>Personal Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Email</strong></td>
</tr>
<tr>
<td><strong>Password</strong></td>
</tr>
<tr>
<td><strong>Full Name</strong></td>
</tr>
<tr>
<td><strong>Authority</strong></td>
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</table>

Generate Keys

<table>
<thead>
<tr>
<th>Generate Keys</th>
<th>Generate a new Key Pair</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Public Key</strong></td>
<td>*********</td>
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<tr>
<td><strong>Private Key</strong></td>
<td>*********</td>
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</tbody>
</table>

**Tradeoff:** Ease-of-use vs Security.

**Ease-of-use:** Automatic account delegation. Don't delete private key.

**Security:** Manual account delegation. Download & Delete private key.
Browse testbeds

<table>
<thead>
<tr>
<th>PLATFORM</th>
<th>PLATFORM_LONGNAME</th>
<th>GATEWAY_TYPE</th>
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<tbody>
<tr>
<td>omf</td>
<td>NITOS</td>
<td>sfa</td>
</tr>
<tr>
<td>ple</td>
<td>PlanetLab Europe</td>
<td>sfa</td>
</tr>
<tr>
<td>wlab</td>
<td>Wlab2</td>
<td>sfa</td>
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</table>

Showing 1 to 3 of 3 entries
Browse resources: Query

User

slice page (url)

Query

MySLICE

SFA Gateway

get_resources

ListResources

ListResources

Nitros

Aggregate Manager

PLE

Aggregate Manager

WiLab

Aggregate Manager
Browse resources: Result

---

User

slice page (url)

Query

Result

slice page (url)

---

SFA Gateway

ResultValue

RSpec

---

Nitros
Aggregate Manager

PLE
Aggregate Manager

WiLab
Aggregate Manager
Browse resources
Browse resources

<table>
<thead>
<tr>
<th>NETWORK HRN</th>
<th>HRN</th>
<th>TYPE</th>
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</table>
Aggregated Measurements
OpenLab use mixing wireless techs
Demonstration

ssh connection for BS configuration

Android Smartphone equipped with microcontroller featuring environmental sensors and running UTH’s Android RC

WiMAX to WiFi

WIMAX Dongle

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An Internet of Testbeds comes true

- Federation is real, beyond a proof-of-concept
- **OneLab portal** opens beginning of 2014
- Based on open and standard components
- Join us!

http://www.onelab.eu - info@onelab.eu

- J. Augé *et al* - Tools to foster a global federation of testbeds - *Computer Networks - Special issue on Future Internet Testbeds*, 2013

- S. Fdida *et al* - **OneLab**: An open federated facility for experimentally driven future internet research - *New Network Architectures*, pp 141-152, *Springer*, 2010
# Key technologies for federation

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
<th>Technology</th>
<th>Language</th>
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<tbody>
<tr>
<td><strong>TESTBED</strong></td>
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</tr>
<tr>
<td>SFAWrap</td>
<td>Control plane management</td>
<td>SFA</td>
<td>Python</td>
</tr>
<tr>
<td>OMF RC</td>
<td>Experimental plane management</td>
<td>FRCP</td>
<td>Ruby</td>
</tr>
<tr>
<td>TopHat</td>
<td>Measurement plane management – Interconnect measurement systems</td>
<td>Manifold</td>
<td>Python</td>
</tr>
<tr>
<td>sfatables</td>
<td>Policies</td>
<td>SFA</td>
<td>Python</td>
</tr>
<tr>
<td><strong>USER</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>MySlice</td>
<td>Federation portal – Web GUI (+ API + library) support experiments from setup through completion Glu between existing services, with a tight integration of measurements and monitoring.</td>
<td>Manifold</td>
<td>Python, HTML5, JS</td>
</tr>
<tr>
<td>NEPI</td>
<td>Tool allowing users to design and run experiments</td>
<td>ssh, FRCP, Manifold</td>
<td>Python</td>
</tr>
<tr>
<td>OMF EC</td>
<td>OMF Experiment Controller</td>
<td>FRCP</td>
<td>Ruby</td>
</tr>
</tbody>
</table>
SFA Architecture

MANAGEMENT LEVEL = SFA Registry

users

belongs to

resources

slices

belongs to

EXPERIMENT LEVEL = SFA Aggregate Manager

is attached to

is attached to

authorities
SFA AM API calls

**GENI v2**

- GetVersion()
- ListResources()
- CreateSliver()
- SliverStatus()
- DeleteSliver()
- RenewSliver()
- Shutdown()
- ListSlices()

**GENI v3**

- GetVersion()
- ListResources() Describe()
- Allocate() Provision()
- Status()
- Delete()
- Renew()
- Shutdown()
- ListSlices()
- PerformOperationalAction(start)

Fdida - Xie, Beijing, April 18th 2014
SFA Registry API calls

- GetVersion()
- GetCredential()
- Resolve()
- List()
- CreateGid()
- Register()
- Update()
- Remove()
MySlice API - Queries

• GET METADATA
  • select table, column.name, column.qualifier, column.type, column.is_array, column.description, column.default, key, capability from local:object

• GET RESOURCE METADATA
  • select column.name from local:object where table == "resource"

• GET urn, type FROM RESOURCE
  • SELECT urn, type FROM resource

• GET urn, type FROM a specific testbed
  • SELECT urn, type FROM iotlab:resource
  • SELECT urn, type FROM ple:resource
Get started with MySlice

- http://myslice.info

- http://trac.myslice.info/

- git://git.onelab.eu/myslice.git
The Open Multinet Forum

- Contribution to **open standards**:
  - SFA (control plane)
  - FRCP (experimental plane)
  - ontologies
  - etc.

**Website**: [http://www.open-multinet.info](http://www.open-multinet.info)

- (documents, wiki, working groups, mailing lists, etc.)
More information

- http://www.ict-openlab.eu/
- http://www.onelab.eu/
- http://www.ict-fire.eu/home.html
- http://www.fed4fire.eu/
- http://f-lab.fr/
- http://new.fit-equipex.fr/
- http://www.geni.net/
- http://www.ict-fire.eu/home.html
- http://fibre-ict.eu