Future Internet Activities at NTUA: Federated Testbed Projects

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The Future Internet (FI) Ecosystem

- FI emerges as a complex ecosystem, offering holistic services to users over **shared federated interconnected platforms**.

- **Challenge**: innovative research in a bottom-up approach, addressing a critical area in FI ecosystem: **How FI users (including Data Center Managers & Cloud Service Providers) securely share a multi-domain networking substrate**.

- **Solution**: a framework (information model, test tools and algorithms) that empowers FI users to discover, view, monitor, control and provision isolated/virtualized networking resources within a federated networking substrate, thus **complementing their distributed storage & computing service baskets with interconnection-specific resources**.
Benefits of Federated FI Testbeds

- Possibility to perform experiments that break the boundaries of different testbeds (wireless, wired, OpenFlow, cloud computing, smart cities, services, etc.)
- Ubiquitous access to all the required resources with a single account (Single-Sign-On federations: EU - EduGain, US - InCommon)
- User can focus on his/her core task of experimentation, instead of on practical aspects such as learning to work with different tools for each testbed, requesting accounts on each testbed separately, etc. → Elastic Testbed-as-a Service across interconnected infrastructures
- Orchestration of NFV-based services (on-demand, virtualized network functions)
- Use of common state-of-the-art technologies (e.g. Slice-based Federation Architecture - SFA, cOntrol and Management Framework - OMF) supported by large communities and constantly extended to meet testbed needs
Challenges of FI Testbed Federation

• How to federate different kinds of e-Infrastructures

• How to integrate Virtualized Network Functions (VNF) in a holistic networking/computing virtualized infrastructure (VMs as cloud services, VNFs for networking services)

• How to formally describe virtualized network & cloud objects in a complex environment, assisted by semantic methods. What ontologies are best suited to describe resources of different kinds

• How to build combined slices of virtualized infrastructure at the data, control, monitoring and provisioning planes. How to describe their relationships and technical attributes

• How to (co-) allocate resources with QoS attributes and how to set up the monitoring system to allow for accountable, predictable FI services; multi-domain virtual network embedding

• How to enrich FI experimental platforms (IaaS, PaaS) with federated models and methods enabling comprehensive and reproducible experiments, towards Experiments–as-a-Service
A Federation Framework
Presented by the FIRE Research Project NOVI:
Networking innovations Over Virtualized Infrastructures

- EC FP7 – Cooperation (DG INFSO-F, FIRE Unit)
- 13 Partners (NRENs, Academic & Research Institutions, Industry)
- 30 Months (starts Sept. 2010)
- Coordinator: NTUA (NETMODE Lab)
The NOVI Consortium

1. National Technical University of Athens - NTUA (Coordinator, Greece)
2. Martel GmbH (Switzerland)
3. Université Pierre & Marie Curie - UPMC (France)
4. Consortium GARR (Italy)
5. Universiteit van Amsterdam - UvA (Netherlands)
6. Fundació i2CAT (Spain)
7. DFN Verein (Germany)  
   + Universität Erlangen - Nürnberg
8. Institut National de Recherche en Automatique et Informatique - INRIA (France)
9. Eötvös Loránd Tudományegyetem - ELTE (Hungary)
10. Poznan Supercomputing and Networking Center - PSNC (Poland)
11. Cisco Systems International B. V. (Netherlands)
12. Fraunhofer Gesellschaft zur Förderung der angewandten Forschung (Germany)
13. Universitat Politècnica de Catalunya – UPC (Spain)
NOVI Control & Management (C&M) Architecture
FI and the Greek Research Infrastructures Roadmap

- An initiative of the **Greek Secretariat for Research & Technology** (GSRT, Greek Ministry of Education & Religious Affairs) as an ex-ante conditionality within the **Partnership Agreement 2014-2020** (Structural Funds) - EU DG REGIO, Greek Ministry of Development & Competitiveness

- National **Research Infrastructures (RI) Roadmap** Objectives:
  - Address a broad national interest (*defined in the strategy for research and innovation plan or the multi-annual Partnership Agreement 2014-2020 with the European Union*)
  - Enable cutting-edge research at the national level, with international visibility (H2020 priorities)
  - Form part of a coherent structure, with nodes available at one or more locations in Greece, in terms of distributed research installations or access points
  - Promote synergies and networking of mature RI’s: Integration of distributed facilities across Greek Universities & Research Centers
  - Provide open access to researchers, industry and the broader public domain in the country and internationally → innovation at regional & national levels

- Two FI proposals passed eligibility thresholds based on evaluations by panels of international experts:
  - **National Networking & Computing Research Infrastructure - NNCRI** (Coordinator: GRNET)
  - **Federation of Greek Future Internet Experimental Facilities - HELNET** (Coordinator: University of Thessaly)
Federation of Greek Future Internet Testbeds

**HELNET:** A proposal to the Greek RI Roadmap by 4 collaborating FI Testbeds in Greek Universities, coordinated by the University of Thessaly (UTH):

- **NITOS** Testbed @ UTH (University of Thessaly)
- **NETMODE** Testbed @ NTUA (National Technical University of Athens)
- **P2E** Testbed @ UPATRAS (University of Patras)
- **SCAN** Testbed @ UoA (University of Athens)

Technologies

- Wireless (802.11a/b/g/n, 3G, LTE, Wimax)
- Software Defined Radios (SDR) / USRPs
- Software Defined Networking (SDN) / OpenFlow
- Cloud computing
- Sensors (humidity, temperature, light, etc.)
HELNET - FI Testbeds Map
HELNET Testbeds within Fed4FIRE (EC-FP7 FIRE IP): Federation of FI Testbeds across Europe
Overview of NETMODE Testbeds: Wireless Testbed

18 Alix-based (Nodes 1-18)
- alix3d2 board
- 100Mbit Ethernet port
- 2 802.11 a/b/g interfaces
- 1GB flash card storage device

2 PC-based (Nodes 19-20)
- Intel Atom CPU
- 1Gbit Ethernet port
- 2 802.11 a/b/g/n interfaces
- 250 GB hard disk
Overview of NETMODE testbeds: OpenFlow Testbed

- HyperVisor
- OVS
- HP Procurve 2510 (Management)
- HP Procurve 2510 (Data Plane)
- FlowVisor
- OF Controller
  - (User 1)
  - (User 2)
  - (User 3)
  - (User N)
- NEC IP-8800
- Traffic Inspection

Monitoring Data
Scalable DDoS Attack – Mitigation
DDoS Attacker IP Clustering Effect
Virtualization within NRENs: The GÉANT OpenFlow Facility (GOFF)

Local Facility A
Local Facility B
Local Facility C
Local Facility D

NREN
NREN
NREN
NREN

GÉANT

Federated Services
NOC - Gateway

Internet
FIRE Core Facility
GENI Platforms

Local Facility A
GÉANT
Internet
Federated Services
NOC - Gateway
GENI Platforms
FIRE Core Facility
Local Facility B
Local Facility C
Local Facility D

NREN
FI Experimental Research: Synergies with NRENs

• **Requirements:**
  – Sharing optical backbones & housing for FI experiments
    • Emulating real-world conditions
    • In isolation from production traffic (slicing, virtualization)
  – Interconnection of local testbeds (e.g. OpenFlow, wireless labs)

• **NRENs as infrastructure providers & innovation brokers:**
  – In **Europe**: FI Private-Pubic Partnership (PPP) & FIRE → provisioning of NREN GÉANT facilities (e.g. FEDERICA)
  – In the **US**: GENI experimental platforms → provisioning of Internet2, NLR, ESnet, RON facilities
  – In **APAN**: SINET (JP), CERNET (CN), KOREN (KR), AARNet (AU),…
  – In **Greece**: GRNET and major Universities (NTUA…)
    • Advanced connectivity for all Universities & Research Centers
    • Leader of the **GOFF SDN testbed** (together with NTUA)
    • Data-center provisioning & cloud services OKEANOS
    • The **NNCRI** proposal to the Greek RI Roadmap
Potential role of GÉANT – NRENs in the FI Ecosystem

• **Provision FI federated platforms** (FIRE, FI PPP) with WAN substrate Gigabit+ connectivity at all protocol layers/planes (including Bandwidth on Demand) & core virtual facilities (systems, logical routers, virtualized data centers...)

• Support virtual resource allocation, scheduling, federated admission control, roaming AAI & secure operation of isolated communities, instantiating the concept of **Infrastructure as a Service (IaaS)**

• Deploy and test early prototype tools to create, monitor and control virtual resources allocated to FI user communities, towards the **Network on Demand** vision

• Complement efforts towards common, context aware descriptions of heterogeneous virtual networking elements, enabling **resource discovery & provisioning** of composite services to meet user demands

• Export **NOC functionality** to virtual communities to enable scalable management of virtual resources by stake-holders of federated overlays
Vision of Federated FI Experimental Platforms

FI experiments will run within a shared multi-domain ecosystem (integrated campus, national and international facilities) whereby:

• Experimenters (users) should be able to run their applications / experiments by dynamically selecting diverse elastic slivers in a slice (basket) of global federated FI facilities
• Federated FI facilities should be able to upgrade their scope by incorporating additional testbeds, thus attracting a wider user base
• FI experimental platforms should reach-out into established R&E e-Infrastructures:
  – Elastic Public Clouds & Virtualized Data Centers
  – Mobile & Sensor Networking Platforms
  – Advanced Wide Area Networking infrastructures provided by the global NREN community
• Users should be network (and location?) aware by exploiting SDN features (e.g. OpenFlow controllers) in combining computing – storage – networking resources

CAUTION: The only multi-domain control plane success stories have been SS7 in Telephony and BGP in the Internet