



Framework for Large-scale SDN Experiments via Software Defined Federated Infrastructures

Gino Carrozzo and Kostas Pentikousis on behalf of the FP7 FELIX Consortium

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Introduction



- Testing of innovative solutions for network control calls for experimentation using large-scale testbeds
 - emulate near real-world testing conditions and allow for wide technical and industrial impact
- Network programmability via Software Defined Networking (SDN) and dynamic on-demand network service provisioning are key ingredients
- Experimental research infrastructures are a reality for this thanks to efforts in Europe, Asia, and the Americas
- FELIX is part of this research experimentation infrastructure line of work
 - Future Internet Research Experimentation (FIRE) framework in EU
 - special focus on using SDN and Bandwidth on Demand (based on the Network Service Interface – NSI) for dynamic transit network connectivity



FELIX in a Nutshell

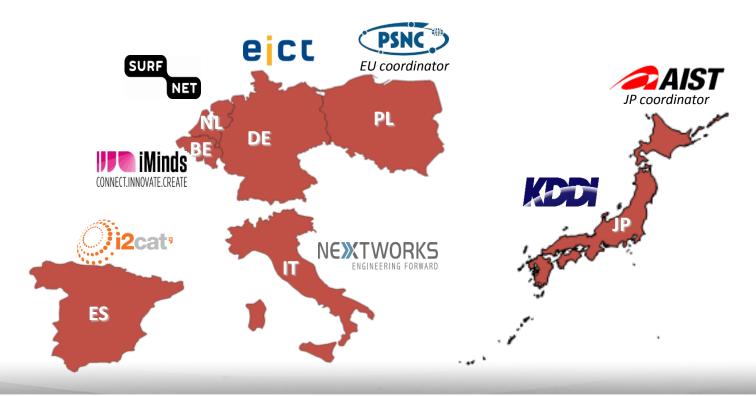


Facts

- EC (EU), MIC & NICT (JP) collaborative project
- Project running from April 2013 till March 2016

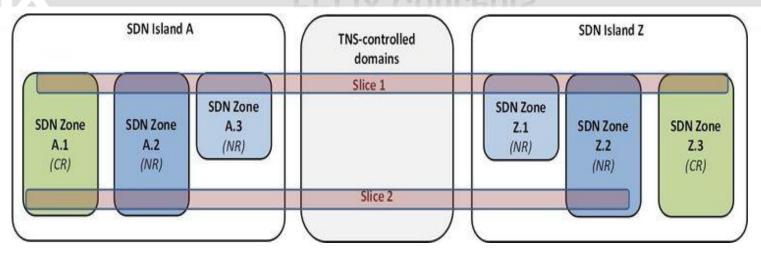
Objectives/Results

- A large-scale testbed federated across two continents
- A reference common architecture for SDN testbeds



FELIX Concepts



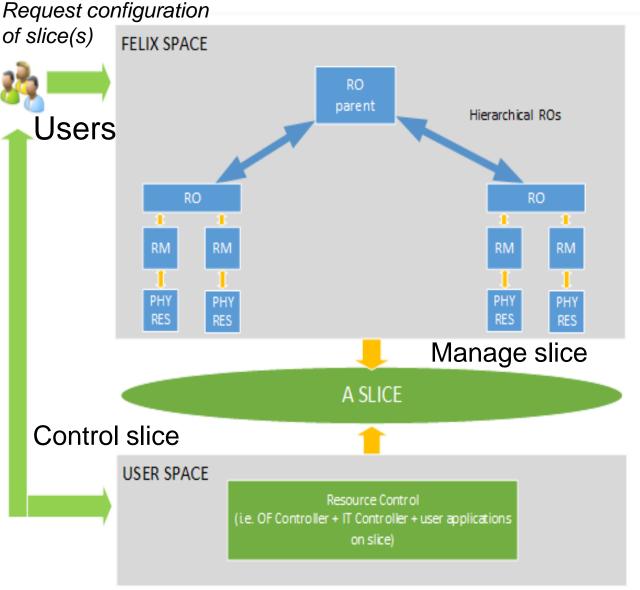


Slice

- Experimental facilities to be provided dynamically on top of the FELIX physical infrastructure (federated testbeds)
- All experimental facilities are controlled programmatically
 - facilities are composed of computing and network resources (CR and NR) belonging to distributed SDN islands in FELIX infrastructure
 - resource orchestration in a multi-domain environment
 - in a slice, facilities are interconnected via transit network (TN) service-controlled domains
- User has access and control of a provided slice

FELIX Architecture Overview





The **FELIX Space** provides users with slices for their own use. Users request slices to an RO.

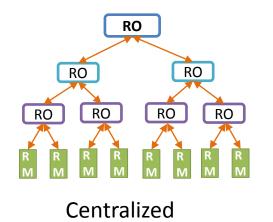
- RO: ResourceOrchestrator
- RM: Resource Manager
- PHY RES: physical resources (testbed)

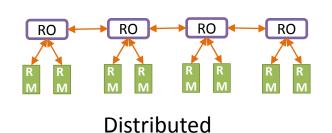
The **User Space** consists of any tools and applications that a user wants to deploy to control a slice or execute particular operations

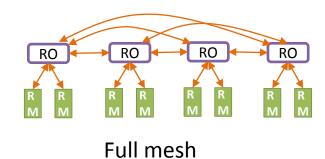


RO Hierarchical Structure Options





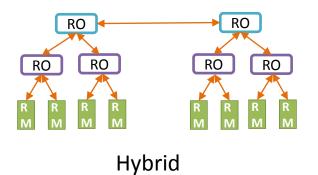






RO Continent RO

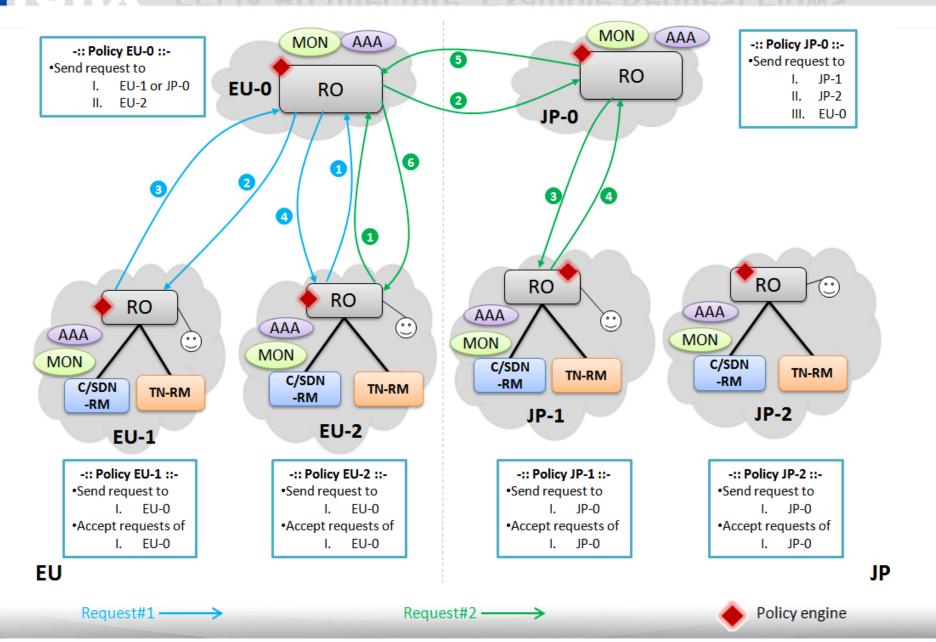
RO Island RO



Selected for implementation

FELIX Architecture: Example Request Flows 🚨 •

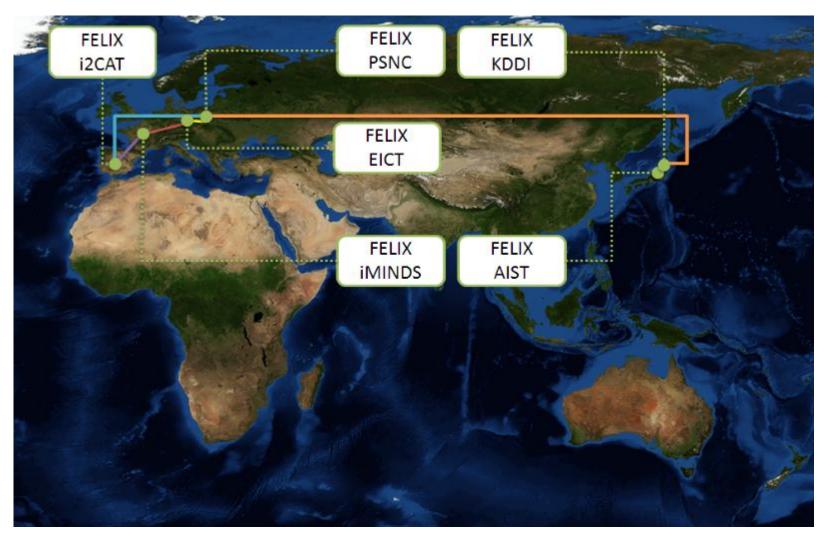




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FELIX Experimental Facility



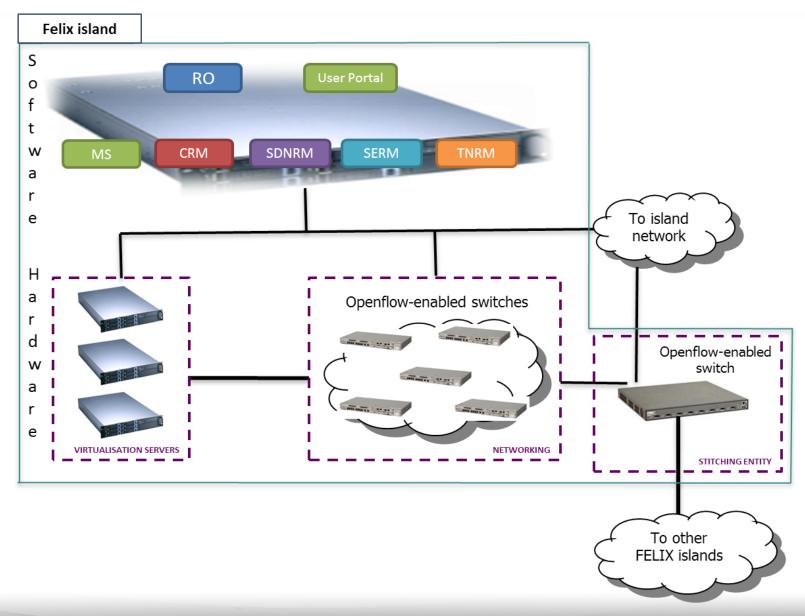


Source: www.ict-felix.eu



FELIX Island Blueprint





FELIX Island Instantiations AIST labs PSNC island domain #1 Management server (Dell R620 #1) SE SW. NEC PF5248 SDN SW. 10TB RAID Open vSwitch Storage Server head PC for SDN-RM, C-RM, Virtualization server (IBM x3550 #2) TN-RM, SE-RM OpenFlow 1.0 switch (Juniper MX80 #1) 1GbE Open VPN connections over public Internet (100 Mbps) 2x1GbE 1 server (node03) 1 Open vSwitch switch Stitching Entity C-Plane, HUAWEI S5600 (ofsw02) OpenFlow 1.0 1GbE (Juniper MX80 #1) 2x1GbE domain #2 Supporting server (IBM x3550 #1) NETWORKING VIRTUALISATION SERVER SE SW. NEC PF5248 SDN SW, 10TB RAID 1GbE Open vSwitch 2x1GbE Storage Server OpenFlow 1.0 switch (Juniper MX80 #2) head PC for SDN-RM, C-RM, 1GbE SE-RM OpenVPN server (IBM x3550 #1) C-Plane, HUAWEI S5600 i2CAT island **KDDI** 3X Virtualisation servers 5x OpenFlow 1.0 switches SDN switch (SuperMicro SYS-6010T-T) Switching Entity (NEC IP8800) JGN-X NSI NSI switch (NEC PF5240) (NEC PF5240) (Juniper MX80) 8x1GbE Verdaguer I I 1GbF JGN-X Stitching Entity RISE OpenFlow 1.0 (HP ProCurve 3500 yl) Rodoreda AIST PC for SDN-RM, C-RM JGN-X L2 TN-RM, SE-RM 1GbE 5x1GbF **Pacific Wave** StarLight TEIN Surfnet VIRTUALISATION **PSNC** Source: www.ict-felix.eu SERVERS OpenFlow Switches GEANT Management server i2Cat (SuperMicro **iMinds** SYS-6010T-T) OpenVPN server



Summary



- FELIX facilitates the federation and integration of different network and computing resources controlled via SDN and Network Service Interface (NSI) / bandwidth on demand (BoD) in a multi-domain heterogeneous environment across spanning Europe and Japan
- FELIX designed and implements a common control framework where users can request, monitor and manage a slice provisioned over distributed and distant SDN experimental facilities
- FELIX orchestration and resource management software is currently deployed in a number of interconnected SDN island across Europe and Japan
- The FELIX framework uses a combination of recursive and policy-based hierarchical configurations for orchestration, request delegation and inter-domain dependency management
- Resource orchestrating entities are responsible for the synchronization of resources available in particular administrative domains.

Further Info



- G. Carrozzo, et al., "<u>Large-scale SDN experiments in federated environments</u>", Proc. SACONET, Vilanova i la Geltrú, Spain, June 2014, p 1-6.
- 2. C. Fernandez, et al., "A recursive orchestration and control framework for large-scale, federated SDN experiments: the FELIX architecture and use cases", International Journal of Parallel, Emergent and Distributed Systems.
- 3. G. Carrozzo and K. Pentikousis, "Recursive orchestration of federated virtual network functions", <u>draft-felix-nfvrg-recursive-orchestration</u>
- 4. FELIX Tutorial at EWSDN 2015 (www.ewsdn.org) in Bilbao, Spain.



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Thanks for your attention!

Questions and comments?

Acknowledgement

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