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ARCFIRE

Large-scale RINA Experimentation on FIRE+

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D4.2 Report on available experimental infrastucture

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1 Introduction

ARCFIRE sets out to prove the effectiveness of the RINA architecture in mitigating key issues observed in the past decades in the deployment of TCP/IP as the core technology underlying the Internet. To do so, it will conduct large experiments making use of publicy available infrastructure and RINA prototype software, in order to investigate and evaluate the benefits of a RINA deployment at scale.

This document provides an overview of the network facilities available to ARCFIRE, particularly focusing on the FIRE+ network testbeds in the areas of core networking, wireless (Wi-Fi and LTE), IoT (bluetooth, 801.15.4, Zigbee) and 5G SDN/NFV converged networks.

1.1 Purpose

The purpose of this document is to list the key features of each of the available test facilities so that the experiment designers in ARCFIRE have a reference to make quick but informed decisions which testbeds can be used, both at the experiment design phase and during actual experimentation. This document will list an initial selection of testbeds. Given the development of an all-in-one toolset to set-up and conduct experiments, gather the experiment results and perform initial analysis, this document provides an overview of the available interfaces each testbed provides.

The summary table in section 4 is replicated on the ARCFIRE collaboration website for on-demand access during the project.

2 FIRE+ testbeds

2.1 The Fed4FIRE federation

This section provides a very brief summary of the testbeds available through Fed4FIRE[1]. More details about these testbeds (and the ones that will be available through Fed4FIRE+) is available online: `https://www.fed4fire.eu/testbeds/`.

Two ARCFIRE imec and i2cat are already partners of the Fed4FIRE (and the upcoming Fed4FIRE+) federation.

2.1.1 Virtual Wall, imec

The Virtual Wall is an Emulab deployment in Ghent. The experimental setup is configurable through Emulab, allowing to create any network topology between the nodes, through VLANs on the switch. On each of these links, impairments (delay, packet loss, bandwidth limitations) can be configured. The Virtual Wall nodes can be assigned different functionalities ranging from terminal, server, network node to impairment node. The nodes can be connected to test boxes for wireless terminals, generic test equipment, simulation nodes (for combined emulation and simulation) etc. The Virtual Wall features Full Automatic Install for fast context switching (e.g. 1 week experiments), as well as remote access.

There are currently 2 deployments of the Virtual Wall at imec Ghent (Virtual Wall 1 with 190 nodes and Virtual Wall 2 with 134 nodes). In Fed4FIRE the initial target is to allow access to the newest instance, the Virtual Wall 2.

2.1.2 wiLab.t, imec

The w-iLab.t testbed is composed of two separate deployments, of which initially only the one called w-iLab.t Zwijnaarde will be available through the Fed4FIRE federation for the first round of open call experiments. This testbed is intended for Wi-Fi and sensor networking experimentation.

2.1.3 Tengu, imec

Of all users of Big Data environments, typically researchers require those environments to adapt as quickly and flexibly as possible in order to find the most appropriate combinations of Big Data elements. Tengu has been developed with those needs in mind, allowing researchers to quickly set up series of specific, modular Big Data environments and facilitating their automatic deployment in clusters. This results in fast instantiation and effortless configuration of the required environments, without the need for in-depth implementation expertise in Big Data or clusters.

2.1.4 Planetlab Europe, UPMC

Planetlab Europe is the European arm of the global PlanetLab system, the worlds largest research networking facility, which gives experimenters access to Internet-connected Linux virtual machines on over 1000 networked servers located in the United States, Europe, Asia, and elsewhere. Researchers use PLE for experiments on overlays, distributed systems, peer-to-peer systems, content distribution networks, network security, and network measurements, among many other topics.

2.1.5 UltraAccess, UC3M & Stanford

UltraAccess is a Next Generation of Optical Access (NGOA) research testbed. UltraAccess models a Future Internet where users have both the best-effort Gb/s capable access and also a dedicated point-to-point packet-switched and optically-switched service connections of up to 10Gb/s to application servers for ultra-high speed low-latency services. UltraAccess integrates the infrastructure of two research groups at Universidad Carlos III de Madrid (Spain) and Stanford University (USA).

2.1.6 NORBIT, NICTA

The NORBIT testbed is a Wi-Fi testbed located in Sydney, Australia. It belongs to the NICTA group. The testbed consists of 38 nodes equipped with a 1 GHz VIA C3 CPU, 512 MB RAM, 40 GB HD, 2 GbE interfaces and 2 IEEE 802.11a/b/g/n interfaces. These nodes are installed indoors in an office environment, and are fully managed by OMF. One of the GbE interfaces of all the nodes is attached to a configurable OpenFlow (OF) switch. This provides an experimental 1Gb wired network, in addition to the experimental wireless networks that the nodes can build.

2.1.7 FuSeCo, Fraunhofer

The Future Seamless Communication (FUSECO) Playground offers a unique, independent and open testbed for research and prototype development of mobile broadband communication and service platform. The flexible and modular design of the FUSECO Playground allows fast prototyping and simplified Proof-of-Concept (PoC) validation spanning from devices over access- and core network technologies to services domains of physical or virtualized telecommunication environments. Integrated multi-access network environments (DSL/WLAN/2G/3G/4G-LTE/LTE-A and 5G), Machine to Machine (M2M) communication systems/IoT, sensor networks, SDN/OpenFlow & NFV cloud environments help to shape the vision of a Future Internet in areas like Industry 4.0, Smart Cities, Automotive, eHealth, eGovernment, Smart Metering and more.

2.1.8 NITOS, CERTH

NITOS facility is comprised of 2 wireless testbeds for experimentation with heterogeneous technologies. An outdoor testbed, featuring Wi-Fi, WiMAX and LTE support and an indoor isolated testbed comprised of advanced powerful nodes. The NITOS testbed is designed to achieve reproducibility of experimentation, while also supporting evaluation of protocols and applications in real world settings.

The control and management of the testbed is done using the cOntrol and Management Framework (OMF) open-source software. Users can perform their experiments by reserving slices (nodes, frequency spectrum) of the testbed through NITOS scheduler that together with OMF management framework, support ease of use for experimentation and code development.

The NITOS platform is open to any researchers who would like to test their protocols in a real-life wireless network. They are given the opportunity to implement their protocols and study their behavior in a custom tailor-made environment. NITLab is constantly in the process of extending its Testbed capabilities.

2.1.9 NETMODE, NTUA

The NETMODE testbed is a Wi-Fi testbed belonging to the National Technical University of Athens (NTUA). It consists of 20 x86 compatible nodes positioned indoors in an office environment. 18 of these nodes consist of an alix3d2 board with two IEEE 802.11 a/b/g interfaces, one 100Mbit ethernet port, two USB interfaces and a 1GB flash card storage device. The other 2 nodes are more powerful, applying an Intel Atom CPU, a 250 GB hard drive, and providing two 802.11 a/b/g/n interfaces and one Gigabit ethernet interface.

2.1.10 SmartSantander, UA

The Smart Santander facility is a large scale smart city deployment in the Spanish city of Santander.

The testbed supports two types of experiments: Internet of Things native experimentation (wireless sensor network experiments) and service provision experiments (applications using real-time real-world generated sensor data). At the moment, it is only planned to include service provision experiments in Fed4FIRE.

2.1.11 PerformLTE, UMA

PerformLTE tesbed follows a holistic approach combining different type of equipments, LTE radio access emulators equipments, Evolved Nodes B (eNBs), User Equipments (UEs) both commercial and engineered to provide measurements, and an Evolved Packet Core (EPC) emulation system. All these elements can be combined and experimentation can be performed in all the components of a LTE network. In general terms LTE connectivity is provided through three different solutions, each one with a focus on a different research aspect, moving between emulation and real-world environments.

2.1.12 C-Lab, UPC

Community-Lab is an open, distributed infrastructure for researchers to experiment with community networks. The goal of Community-Lab is to advance research and empower society by understanding and removing obstacles for these networks and services. It was developed by the FP7 CONFINE project (Community Networks Test bed for the Future Internet, FP7 Integrated Project 2011-2015). The goal of the test bed is to supporting experimentally driven research on community networks. To achieve this goal, the CONFINE test bed integrates with and extends six existing community networks: Guifi.net (Catalonia in Spain), FunkFeuer (Vienna and Graz in Austria), AWMN (Athens in Greece), Sarantaporo.gr (Sarantaporo and 15 villages in Greece), Ninux (Several cities in Italy), Wireless Belgi (several cities in Belgium). Community-Lab is an open, distributed infrastructure where researchers can select among more than 125 nodes, create a set of containers (a slice), deploy experimental services, perform experiments or access open data traces.

2.1.13 OFELIA island, i2CAT

The i2CAT OFELIA island provides an open facility to test and validate experimental research aligned with Future Internet technologies, specifically Software Defined Networking (SDN) and virtualization. The infrastructure is virtualized in order to offer logical isolated substrates to enable simultaneous disruptive research experiments in productive environments without interfering to parallel research users; following an IaaS (Infrastructure as a Service) mode.

2.2 Fed4FIRE+

Fed4FIRE+ starts Jan 2017. this section lists infrastructure that is not already available in Fed4FIRE (Q3 2016).

2.2.1 Homelab, imec

The imec Homelab is a flexible environment in which IoT experiments can be set up without any limitations in terms of installation, technologies and devices. It bridges the gap between technical testbeds (where technical tests are run in a lab environment) and living labs (where users are confronted with a given technology).

2.2.2 Officelab, imec

OfficeLab brings the Internet of Things to the everyday work environment, aiming to create and test technological developments to improve and optimize working conditions. Automated air conditioning and lightning systems, optimized teleworking solutions and collective intelligence are just a few of the technological innovations to be developed and help build the offices of tomorrow.

2.2.3 City of Things (CoT), imec

The imec City of Things (CoT) project brings the Internet of Things which uses the Internet to connect physical objects with each other and with us to the City of Antwerp.

Hundreds of smart sensors and wireless gateways positioned at carefully selected locations across streets and buildings will transform the city into a true living lab for the Internet of Things (IoT). The long-term objective is to connect thousands of Antwerp citizens with numerous innovative solutions that will considerably improve their quality of life by positively impacting mobility and public safety in the city, among other things.

2.2.4 FITUPMC, UPMC

The FIT Equipex project (French national project) aims to develop an experimental facility, a federated and competitive infrastructure. This effort is materialized through the OneLab facility.

The FIT UPMC Lab is mainly composed of: 4 analysis servers, 1 data storage server, 1 hosted calculation server, 40 NITOS WiFi nodes, switches.

2.2.5 IRIS, TCD

Iris the reconfigurable radio testbed at Trinity College Dublin provides virtualized radio hardware to support the experimental investigation of the interplay between radio capabilities and networks. Our facility pairs underlying flexible radio and computations resources with various hypervisors in the form of software radio frameworks to realize various research and testing configurations. We employ 16 ceiling mounted USRP N210s equipped with SBX daugtherboards, reaching frequencies between 40 MHz and 4 GHz, as underlying radio resources. These platforms are connected to a private computational cloud, allowing us to deploy an array of computational environments. To expose the functionality of these platforms for a variety of applications, we employ a variety of radio hypervisors, each with different capabilities and organized into the two categories of open standards compliant and blue sky oriented systems. The category of open standards compliant hypervisors includes frameworks based on open implementations of proven waveforms, such as the OpenBTS or Amarisoft frameworks. Blue sky oriented hypervisors, on the other hand, freely enable prototyping of wireless systems, as exemplified by GNURadio. Together these radio hypervisors enable the realization of heterogeneous radio platforms for composition into networks. Therefore, this facility is ideally equipped to investigate the combination of various physical layer approaches into coexisting or coherent networks.

2.2.6 LOG-a-Tec, JSI

LOGaTEC (http://www.logatec.eu) is an open experimental facility for experimentallydriven research on advanced spectrum sensing, cognitive radio and cognitive networking strategies. LOGa TEC is based on a custom wireless sensor platform VESNA (http://sensorlab.ijs.si/hardware.html) with application specific extension modules. The facility currently consists of more than 70 VESNA sensor nodes installed outdoors in several geographically distributed clusters. The sensor nodes are distributed in two locations: the town of Logatec and the at the Joef Stefan Institute campus in Ljubljana.

2.2.7 Grid5000, INRIA

Grid'5000 is a largescale and versatile testbed for experimentdriven research in all areas of computer science, with a focus on parallel and distributed computing including Cloud, HPC, Big Data and Networking.

It aims at giving scientists an instrumented platform whose state is traceable, and with maximum experiment control.

Versatile: aims at supporting all distributed computing scientific domains with the same testbed: Cloud, HPC, Big Data, Networking, and also other experimental areas of computer science

Largescale: 9 sites, 29 clusters, 1060 nodes, 10474 cores

Reconfigurable: reconfiguration of baremetal nodes (Kadeploy), of network (KaVLAN)

Traceable: verified description, generated standard, and reference environments Instrumented: infrastructurelevel probes for power consumption and network traffic

Grid5000 is a testbed with the type of hardware available in the internet of datacenters and clouds.

2.2.8 R2lab, INRIA

R2lab is a wireless testbed featuring an anechoid chamber that protects its traffic from any external activity, thus allowing for totally reproducible experiments. Its usage model is that the testbed is reserved as a whole, so that one can be entirely sure to avoid unwanted interferences from the inside of the chamber. Its 37 nodes are exposed as bare metal, so that experimenters can run any OS they like. A subset of the nodes have USRP extensions that allow to deploy experimental scenarios involving Software Defined Radio. Typical use case for this testbed are finegrained studies on MIMO usage, on reflexionbased interferences, multihop routing, and similar. We are currently studying the opportunity to support OpenAirInterface as an additional capability of some of the testbed nodes, so as to en large the room's spectrum to 5G.

2.2.9 10GTraceTester, UAM

10GTrace-Teste is a testbed that allows to send a given traffic trace at any speed up to 10 Gbps line rate to a virtual machine running a SDN switching or routing Device Under Test. Interestingly, 10GTrace-Tester can be fed with any pcap traffic trace and particularly with those readily available from the FP7 European Network of Excellence in Internet Science (EINS), together with others that can be downloaded from well-known repositories such as CAIDA. As a result, not only does 10GTrace-Tester bring along a unique traffic generation testbed for SDNs but it also exploits the synergies with other significant EU-funded efforts.

2.2.10 EXOGENI, NICTA

The NICTA ExoGENI rack is a cluster composed of 1 head node and 10 worker nodes, all based on an IBM Xeon 6 core configurations. The rack has a total storage capacity of 24TB. All nodes are connected via a 10G Ethernet network, which is linked to RENCI and Internet2 in the US. It is a full part of the available GENI/NSF set of resources and thus allows experimentations with the wider GENI testbeds, including similar ExoGENI racks in various US Universities. NICTA provides VM images based on recent OS distributions which already preinclude the OMF and OML software for experiment control and measurement.

2.2.11 PL-LAB, PSNC

PL-LAB is a distributed laboratory for Future Internet built of eight laboratories interconnected over the Polish NREN PIONIER. The laboratories are geographically dispersed, and associated with leading Polish research and academic centers (Warsaw University of Technology, Poznan Supercomputing and Networking Center, National Institute of Telecommunications, Gdansk University of Technology, Poznan University of Technology, Wrocaw University of Technology, The Institute of Theoretical and Applied Informatics and AGH University of Science and Technology).

2.2.12 FIONA, Adele Robots

FIONA is a cloud platform for creating, improving and using virtual robots, which represent a new way of interacting with technology that includes access to information, web-based services and also actions over intelligent environments. FIONA allows users to create and use intelligent virtual robots and/or to do them more interactive, more striking and smarter. Developers, researchers, companies, geeks and designers from around the world contribute to the platform uploading their killer feature, a specific behaviour, an amazing character or the best of their knowledge in a topic, which are encapsulated as Sparks and that can be combined to create different behaviours and personalities for the characters to enable diverse skills and capabilities. While the end-user of the platform is able to run it on any device, FIONAs cloud infrastructure runs the whole intelligence of the agent, and also is the platform to share the experience gained by the individual agents.

2.2.13 Géant Testbed Services, Nordunet

The GEANT Testbeds Service is a service offered by the GEANT Project a consortium of 35+ R&E networks across Europe. As Activity Leader for the development and future roadmap for GTS, these services will be made available for the FIRE community though the FED4FIRE+ project. GTS is based upon an emerging open Generalized Virtualization Model (GVM), which will also underly the NORDUnet Global Virtualization Service (GVS). The NORDUnet GVS will have presence in both Europe and in the US and provide seamless interconnectivity among the GVS and GTS facilities. These will also be available to FED4FIRE+.

Both services are constructed around GVM Pods consisting of computational servers, SDN switching platform(s), high performance storage, and underlying data transport virtual circuit infrastructure. The infrastructure in each pod can vary according user requirements and available budget, but the services are expected to provide approximately 80100 servers in the 2016/17 timeframe, with advanced user controlled SDN switching capabilities and high performance storage available at every location. The locations served by GTS include: London, Amsterdam, Hamburg, Prague, Milan, Bratislava, Ljubljana, Paris, and Madrid. The NORDUnet GVS will be deployed in Copenhagen, Geneva, Washington DC, and Miami in 2016.

The GTS Software Suite employs OpenStack for the allocation of Virtual Machines to GTS environments. This allows the GVM services that use the GTS software to integrate easily with

OpenStack managed data centers. Bringing such data centers into the common interoperable GVM service region is also planned for GTS in the 2016/2017 time frame.

GTS software suite also employs the NSI Connection Services provisioning standards for provisioning virtual circuits. This allows GVM compliant services to set up data transport circuits among GVM services across any NSI compliant transit network even if that transit service does not support GVM. This dramatically simplifies the transport provisioning and allows the GVM service cloud to scale globally.

3 GENI

GENI is a federated virtual laboratory that provides access to multiple different testbeds to GENI experimenters, enabling networking and distributed systems research.

GENI racks are being implemented to meet the goals specified by the GPO GENI Rack Requirements. Current rack projects can be characterized as follows:

ExoGENI A higher cost, flexible virtual networking topologies solution including OpenFlow, that also delivers a powerful platform for multi-site cloud applications. These racks are typically deployed as an integrated part of a campus network.

InstaGENI - A mid-range cost, expandable GENI Racks solution that can will be deployed at a large number of campuses, delivering Internet cloud applications support, along with OpenFlow and VLAN networking. These racks are normally deployed outside a site firewall.

OpenGENI - Also a mid-range, expandable GENI Racks solution delivering Internet cloud applications support, along with OpenFlow and VLAN networking. These racks are deployed on Dell hardware.

Cisco GENI - A dual data plane fabric expandable GENI Rack solution that combines ExoGENI software with Cisco UCS-B and -C series servers, UCS disk and NetApp FAS 2240 storage, and Nexus 3548 dataplane switches. These racks support OpenFlow, virtual topologies, and multi-site cloud applications.

Ciena GENI - A GENI Rack solution that combines ExoGENI software with Ciena switches. These racks are still in development.

All GENI Racks have layer 3 connections to the Internet and layer 2 connections to the GENI core networks (Internet2 AL2S). The racks use commodity Internet for control access to rack resources, and shared VLANs for the application and experiment data connections. The racks may also use layer 3 Internet connections for some experiments, particularly IP cloud experiments.

ARCFIRE can make use of GENI through Fed4FIRE+ and the jFed tools.

4 Summary

Testbed	Hardware available	potential number of physical RINA nodes	potential number of RINA nodes (VMs)	API	Notes
Fed4FIRE+ federation					
Virtual wall	400 physical servers, highly interconnected, 1G-10GE.	~400, up to ~200 in a single experiment	~1000 - ~10000, maybe more, depending on experiment loads and constraints	jFed, emulab, SFA	Due to the availability of a large number of high-performance bare metal servers, this testbed is the preferred testbed for wired experiments in ARCFIRE. IRATI and PRISTINE have made use of previous versions of this testbed.
w-iLab.t	110 fixed nodes (50 zotac + 50 apu + 10 DSS), 20 mobile nodes (also DSS), all have 802.15.4, bluetooth dongle and two WiFi a/b/g/n interfaces. Half of the nodes are equipped with an 802.11ac interfaces (apu devices have 2 ac cards, DSS devices have 1). Additionally complete LTE setup with 2 base stations, 20 clients and 3 OpenAirInterface devices available.	~150	~300 - ~500	jFed, emulab, SFA	This is the preferred wireless testbed for ARCFIRE. The testbed will typically need to be reserved in full, so experiments that make use of this testbed will need to plan according to availability.
Tengu	Software on top of Virtual Wall				This testbed provides a Hadoop deployment on the virtual wall infrastructure, which is not required for the experimentes in the scope of ARCFIRE.
Planetlab Europe	343 internetconnected servers at 205 sites in Europe (Feb 2015)	-	~10000 (LXCs)	PlanetLab Central API, NodeManager API, jFed, SFA	Planetlab nodes can be reserved via jFed.
UltraAccess	WDM PON infrastructure			SFA, jFed	WDM PONs are not within the scope of ARCFIRE.
NORBIT	38 with 1 GHz VIA C3 CPU, 512 MB RAM, 40 GB HD, 2 GbE interfaces and 2 IEEE 802.11a/b/g/n interfaces	38	38	SFA, jFed	Wireless tesbed that could be used in some experiments.
NITOS	100 wireless nodes (i7, 4GB RAM, SSD), 7 blade servers	~100	~100 - ~1000	jFed, SFA	Wireless tesbed that could be used in some experiments.
NETMODE	18 Alix wireless nodes, 2 intel atom nodes, 2 a/b/g/n and GbE	~20	~20	jFed	Wireless tesbed that could be used in some experiments.
SmartSantander					Only supports service provisioning, no possibility to apply RINA to this testbed.
i2CAT OFELIA island	Blade servers, NEC openflow-capable switches		~20 - ~100	jFed, OCF	General purpose servers that already have hosted the IRATI prototype during the IRATI and PRISTINE projects.
FITUPMC	40 NITOS nodes	40	~40 - ~400	jFed	Wireless tesbed that could be used in some experiments.
IRIS	USRP N210s SDR				out of scope for ARCFIRE
Grid5000	1079 nodes	Dependent on experiment load	Currently unknown, integration with Fed4FIRE ongoing	jFed	All the infrastructure should be available, but number of nodes in a single experiment will be limited.
R2Lab	37 bare metal nodes				Software Defined Radio testbed, out of scope of ARCFIRE.
10GTracetester	Test device up to 10G				This testbed is for running 10G tests to a single server, insufficient scale for ARCFIRE and thus out of scope.
PL-LAB	18 servers (HP ProLiant DL360), 7 platforms with pNP-3 EZappliance (EZchip), 11 servers with NetFPGA (Virtex2/Virtex5), 4 traffic generators/measurement devices (Spirent), 9 Juniper MX80/240 (with router virtualization features)	Unknown	Unknown	jFed	NetFPGA cards may be useful for hardware acceleration.
Geant Testbed Service	Up to 17 or more GTS pods			jFed	probably only operational end of 2017
GENI					
GENI infrastructure	Racks: ExoGENI, InstaGENI, OpenGENI, CiscoGENI, CienaGENI	No bare metal access	Potentially 1000s, but depends on available resources	jFed	VMs in GENI racks are available through jFed.

Table 1: Summary table

5 Conclusions

This document provides an overview of the research infrastructure available to ARCFIRE. Table 2 presents the testbed selection for ARCFIRE:

Table 2: Testbed selection

Testbed	preferred	in scope	out of scope
Fed4FIRE+ federation			
Virtual wall	X		
w-iLab.t	X		
Tengu			X
Planetlab Europe		X	
UltraAccess			X
NORBIT		X	
NITOS		X	
NETMODE		X	
SmartSantander			X
i2CAT OFELIA island	X		
FITUPMC		X	
IRIS			X
Grid5000		X	
R2Lab			X
10GTracetester			X
PL-LAB		X	
Geant Testbed Service		X	
GENI			
GENI infrastructure		X	

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