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Experimenters, Developers, Innovators

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Measuring Effectiveness of an Opportunistic Network Platform for Sensor Data Collection and Distribution

By MTA SZTAKI

The aim of the experiment was to evaluate the performance and usability of peer to peer mobile technologies as alternative means to central service based solutions to collect and distribute sensor information in an urban area. Various routing protocols, algorithms and applications have been investigated to find ways to support communication and other needs of users without temporal or permanent access to a centralised service. A major point in the experiment was to find out how many autonomous mobile nodes and with what kind of behaviour we need to achieve a service level comparable to an online service.

Two use cases have been considered in the experiment implemented in the **Smart Santander** testbed involving a large number of sensors deployed in the city of Santander:

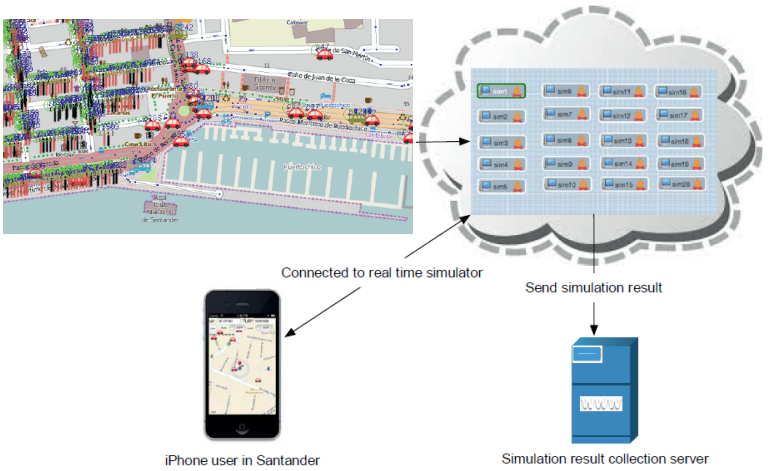
- Free Parking Lot Search application, allowing drivers to find free parking lots in the city, using up to 356 sensor nodes, and
- Siesta Spot Search, helping users to find a suitable place to spend their siesta time, using up to 402 sensor nodes.

in two setups: one for a larger area (covering the whole city, 26,256 km^2) and a smaller one focused on the city centre (6,874 km^2), where the most of the sensors are located.

The **BonFIRE** testbed was used to run multiple real-time simulators in parallel on the same sensor network configured with different parameters.

The experiment showed that 250 - 500 mobile nodes can deliver at 80 - 90 % certainty information of 20 - 200 sensor nodes in a 7 km^2 geographic area. This suggests that in an urban area, like Santander with the involvement of a couple of hundreds of smart phone users (of the 180.000 inhabitants) we could provide valuable services with even regularly changing data (e.g. parking sensors) using an opportunistic, delay tolerant networking system.

With the experiment we wanted to get information about real life usability of our technology and it was also a new experience for us to carry out experiments at this scale, where we could get data of a real life system and could implement close to reality problems to investigate. With Fed4FIRE we had:



- Possibility to access real life sensor network and use its data for experimenting and
- Access to a large scale cloud system, to run powerful parallel simulations.

"It was a great experience to be able to work with Fed4FIRE and to learn a lot about how a complex experimentation infrastructure is built and how easy it is to start experimenting based on this infrastructure. The diversity of resources, the tools and the people behind Fed4FIRE are all very important pieces of Fed4FIRE. The diversity of resources makes it possible to plan experiments, which would otherwise be impossible to organize, because we had to deal with each testbed owner separately. Beside the availability of resources we also needed good tools to hide all the complexity that it takes to make these heterogeneous testbed resources available and usable."

Global Earth Observation System Computed in Cloud

By ELECNOR DEIMOS

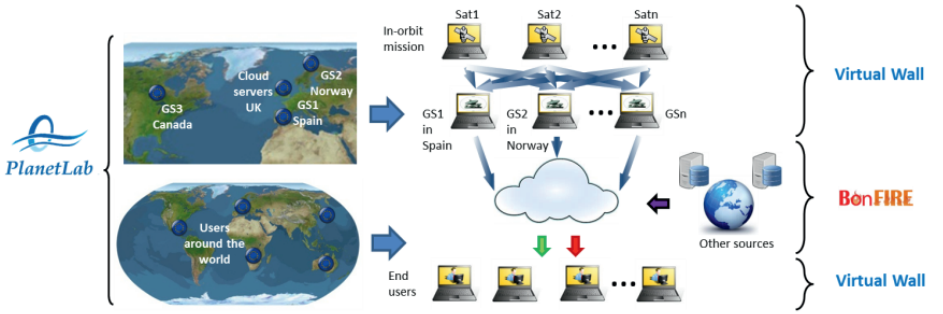
The experiment investigates virtualisation of a conventional Earth Observation system to offer on demand services to clients with the objective of validating its viability, find the strengths and weaknesses of using cloud computing technology and establish possible solutions for a future implementation in the market, by considering the following three components of the system:

- In-orbit mission, generating raw data of un-processed Earth images from satellites in different constellations and downloaded to different ground stations,
- Treatment of data, to be stored, processed, and integrated with other data sources to provide higher quality of service as required, and
- End-users, of the provided services with different levels of remote access rights.

The main objective of the project was to answer the following question: "Does cloud computing and, in general, future internet technologies provide socio-economical viable solutions for highly demanding services in Earth Observation?"

The experiment is a close to reality case implemented in the Fed4FIRE infrastructure and its European platforms **PlanetLab, Virtual Wall and BonFIRE.** The designed scenario is that of a constellation of satellites that covers the Earth's surface in a daily basis at high resolution. The geodata is daily downloaded into a network of ground stations distributed around the world.

The experiment emulates the remote sensing mission with the satellites, the topology network and the communications in the Virtual Wall testbed.



The data acquired from the emulated satellites is transferred to the BonFIRE cloud for its treatment and online distribution via both direct download and web visualization. End users are emulated accessing and broadcasting the cloud in another network implemented in Virtual Wall. Furthermore real networks are tested in PlanetLab Europe to implement realistic impairments in Virtual Wall testbed.

Fed4FIRE allowed us to implement the experiment, which was designed to simulate a realistic complete Earth Observation system, including the simulation of the system dynamics, communications and the use of a cloud infrastructure to value if this approach can provide effective solutions for future web services. With the experiment, we have validated that Future Internet technologies provide viable solutions to the Earth Observation market. Accordingly, we will start from now on developing a pilot near to market, this time incorporating in the loop a real satellite. Furthermore, the results obtained by the experiment can perfectly be applied to other scenarios, products and industries, since remote sensing is multidisciplinary and it is appliedto different sectors. E.g., in this experiment we simulated different applications: disasters management, precision agriculture, infrastructures monitoring and land management and further applications, such as intelligence, maritime surveillance, homeland security among others, are possible to be investigated in the same way as well.

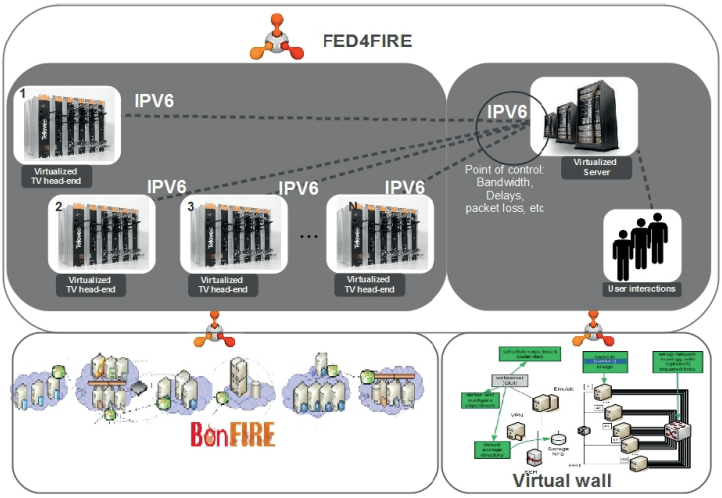
Thanks to Fed4FIRE we could experiment with edge technology testbeds of the Future Internet field. Even though there are commercial infrastructures, as for example Amazon Web Services, Softlayer, etc, with BonFIRE we had more control of the experiment so we could perfectly understand how cloud computing works and we could identify its usefulness for the space sector. Furthermore, we could also integrate PlanetLab Central in our experiment, and not only PlanetLab Europe, enabling the opportunity of emulating a complete network of servers communicating between them as if it were an Internet network designed by us. Finally, we used massive resources distributed around the world as if they were all in our PC. This is very helpful since the experimenter can go directly to the real situation instead of continuously trialling in a laboratory.

“To summarise; without Fed4FIRE the experiment could not be executed as it would involve the creation of an ad-hoc infrastructure to carry out the experiment, causing a prohibit cost just to deploy an experiment. In addition, the experimentation environment is trustworthy. It is secure and private. The federated cloud environment with the large amount of resources of the Fed4FIRE testbeds can provide us elastic facilities and can offer us the possibility of getting support from the team of experts that constitute the federation. Also, thanks to the Fed4FIRE tools and great “familiar” support from Fed4FIRE team and experimenters’ forum the experimentation became faster and more effective.”

Head-End Management System over Fed4FIRE

By TELEVES

The experiment aimed to overcome the difficulties to test the specific head-end communications protocol and a new TV head-end management system in a real scenario, where a high number of users and TV head-ends are connected through a server. The main issue is the complete analysis of the new head-end management TV system and its protocol, scalability, number of users and head-ends that the system can support combining different kind of services and parameters, to verify that TV head-end management system can fulfil the actual and future demands of users and to foresee the feasibility to upgrade the system for future services. The entire experiment consisted of four set-ups to perform particular tests, by using **BonFIRE** and **Virtual Wall** testbeds:



- To increase number of TV head-ends in the management system, interconnected through a best-effort network, and observe overall performance of the system,
- To proof performance of implemented communications protocol while simulating real network behaviour; bandwidth limitations, delays, and packet losses,
- To observe behaviour of the entire system in an IPV6 environment, and
- To observe impact of ongoing firmware update service vs. varying number of TV head-ends.

The experiment has been used to answer a number of technical questions the experimenters had before, such as maximum number of head-ends to be supported and how to increase it, maximum number of users the server can support, ways to improve communications protocol, and IPV6 conformance of the investigated system, in particular while considering continuously increasing number of end users of the system. The results have exceeded the expectations because small problems in the protocol were known, but after the experiment further important needs for improvements have been found.

These improvements guarantee the future of the "TV Head-end management system", where new services like updating service will be offered and a high number of TV head-ends will be connected to the system. The use of the results obtained with the experiment will allow design of a robust TV head-end management system with necessary capabilities, strengthening the experimenter position in the market beyond Europe, in particular in US. The use of Fed4FIRE enabled us in a shorter time make right decisions about the immediate future of the management system and its improvement.

"We think if no federation of testbed infrastructure would be available, the execution of experiment will be very difficult and even impossible, because to attempt to do it we will need invest a lot of resources, both human resources and economic. In addition the amount of time spent may be unaffordable. Furthermore, numerous Fed4FIRE resources and tools were easy to use from one single experimenter account. In terms of data protection and privacy guarantees, the Fed4FIRE environment is trustworthy. The main mechanisms of security used allow a high level of safety for our software and data."

Intelligent Protection Cloud Service for the FIRE Federated Infrastructure

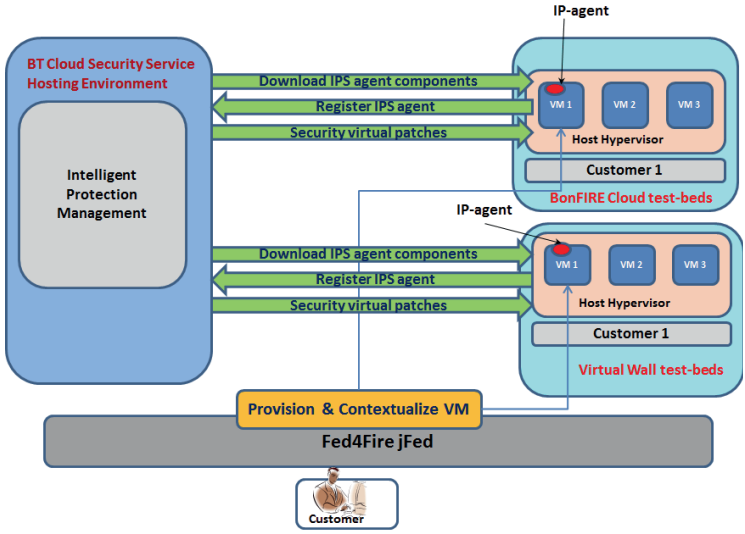
By UNIVERSITY OF KENT & BT

The experiment focus on the orchestration of cloud and user resources for efficient and scalable provisioning and operations of the Intelligent Protection security services and on the improvement of the operational security management of the protected services applications and cloud resources, following the four aims:

- To validate the efficiency and flexibility of deploying the agent-based components of Intelligent Protection on the Virtual Machines hosted on hybrid and multiple cloud platforms,
- To analyse the scalability of the intelligent protection provisioning and operational security management scheme on large number of VMs simultaneously and in different architectures,
- To analyse versatility by automating the deployment of the protection agents, and
- To study the development of a professional service around the deployment and automatic deployment of proprietary security patches.

The experiment involves cloud infrastructures at **Virtual Wall** and **BonFIRE** testbeds as well as the hosting environments for cloud security services at BT. The involved Fed4FIRE testbeds leverage the agent-based deployment capability of the Intelligent Protection, while the corresponding server is hosted at BT offered as a cloud-based service to the experiment. The ultimate goal of the experiment is to demonstrate users performing protection over a multi-cloud environment, to understand the process of creating proprietary security patches for applications deployed on third party clouds.

The main value obtained from this experiment is testing and validation of our Intelligent Protection solutions in geographically distributed, large scale and heterogeneous cloud and physical test-bed environment of Fed4FIRE, where we proved that we can automatically deploy the Intelligent Protection components in a hybrid multi-cloud environment, on a heterogeneous and scalable infrastructure. From the observation of deployment during the experimen-



tation, we recorded that the Intelligent Protection agents were deployed and configured in less than 1 minute after the VMs were booted. It was also observed than the Intelligent Protection agent deployment was consistent even in the scaled environment of 50 VMs.

We see this experiment contributing to influencing the direction of future product development. In this experiment the validation in heterogeneous multi-cloud operation has strengthen the case for a cloud-based Intelligent Protection service that can be used for multiple clouds including but not restricted to BT Compute.

The geographical distributed federated and multi-cloud environment was one of the main objective of this experiment and testing our solution without a federated environment would have certainly reduced our confidence in working of our solution in such environment.

"The availability of a geographically distributed, large scale and heterogeneous testbed resources provided by Fed4FIRE for the experimentation was the direct value for us. The indirect value was the experience obtained while working with federation APIs, tools and technologies within Fed4FIRE testbed environment such as jFed tool for resource provisioning. Work experience with the tools and technologies in Fed4FIRE has enhanced our skills that can directly/indirectly be used within other within other systems and projects."

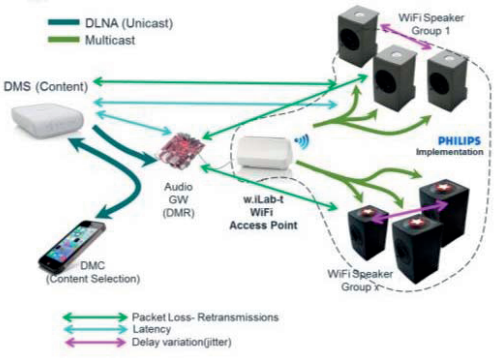
Experiments on Synchronous Wireless Media Streaming Entertainment Applications in Residential Networks, Exploiting PGM

By WOOX INNOVATIONS

The experimentation addresses a new technology for in-home network media streaming based on IP multicasting that exploits the Pragmatic General Multicast protocol. As simple IP multicasting is implemented over UDP, loss of packet in media streaming applications cannot be corrected leading to perceivable quality distortion of media streams. PGM supports packet retransmission for error detection in a very simplistic way to avoid increasing bandwidth utilization. As PGM is an experimental protocol we created a number of network configurations for synchronous wireless media streaming applications to test IP multicasting performance over PGM under various application configurations and congestive home network conditions.

The scope of the experiment, implemented in **w.iLab** testbed, was to evaluate performance of PGM in serving multicast IP streaming by verifying its effect on the traffic profile of audio streams. Thus, the setup environment allowed observing the following:

- Wireless bandwidth density: test behaviour of multicast traffic in densely populated wireless networks,
- Injection of background traffic: PGM traffic priority and resulting quality as a function the background traffic expressed in different profiles, and
- Signal strength: how streaming quality is influenced as a function of the signal quality of the AccessPoint.



The final goal of the experiments is to assess PGM level of maturity for adoption on commercial connected entertainment audio solutions. Our study has shown that contrary to the current practice of unicasting, multicast may offer a very efficient way of streaming with minimal traffic volume, as long as multicast streams are constrained in dedicated subnets. The sole problem of packet loss when multicast is performed on the wireless link can be solved with PGM, a protocol that as shown in our analysis is designed to guarantee in sequence packet retransmission.

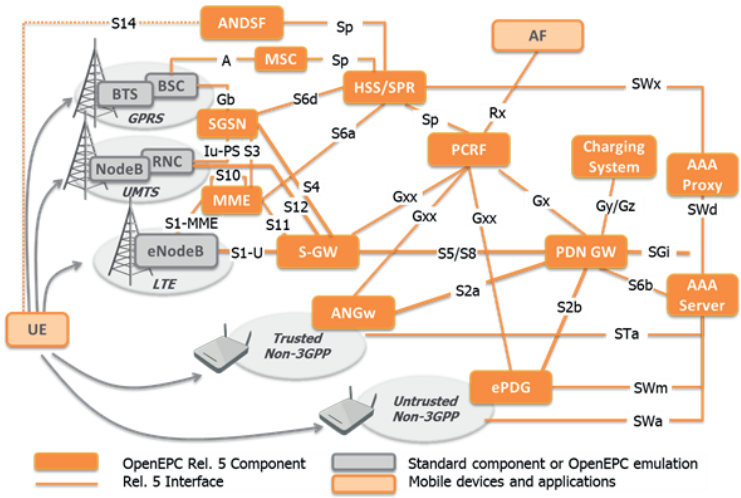
Thus, PGM has shown tolerance to communication errors and capacity to restore lost packets via retransmissions within reasonable time. In this respect PGM may be considered as a worthy addition to the protocol stack of these products to allow coping with errors appearing on the wireless interface. Thanks to the experimentation PGM it is possible for WOOX to bring down the cost of multiroom audio entertainment speakers as well as end up with a standard design that could be easily manufactured on ODM basis.

"Without Fed4FIRE it would have been impossible to find an environment for testing in large scale PGM deployed on a large number of prototype devices. We must say that from the point of view of selecting platforms to work with, the overall jFed environment has provided a surprisingly nice and easy-to-use environment for setting up distributed nodes and overall connectivity. It was indeed very easy and straightforward in use and had a nice online ticketing utility for capturing use comments/problems and providing response."

Mobile Train: QoS Measurements on Mobile Packet Network Technologies

By NAUDIT HIGH PERFORMANCE COMPUTING & NETWORKING, S.L.

The Mobile Train innovative experiment aimed at the development of QoS measurements on mobile packet networks (e.g. HSPA, LTE) based on a packet train method with the most accurate results. Precisely, the experiment aimed at studying the influence on network quality measurements of different factors such



a link technology, signal-to-noise ratio (SNR), movement, concurrent users competing for the channel, etc. The main objective of this experiment has been to implement new active network monitoring tools which are able to provide the best results on mobile access networks, adapting the measurement parameters to the concrete scenario, based on the acquired knowledge.

FUSECO and **Perform LTE** Fed4FIRE testbeds have been used in the experiment because they provide different mobile access network technologies, making it possible to perform measurements and validate them in various environments, providing different wireless transmission links; 2G, 3G, and 4G.

Based on the acquired knowledge, Naudit is applying the obtained results to provide new active network monitoring tools able to give the most accurate QoS measurements on mobile access network technologies. Such tools are offered to Naudit's clients, including network operators in Europe and America.

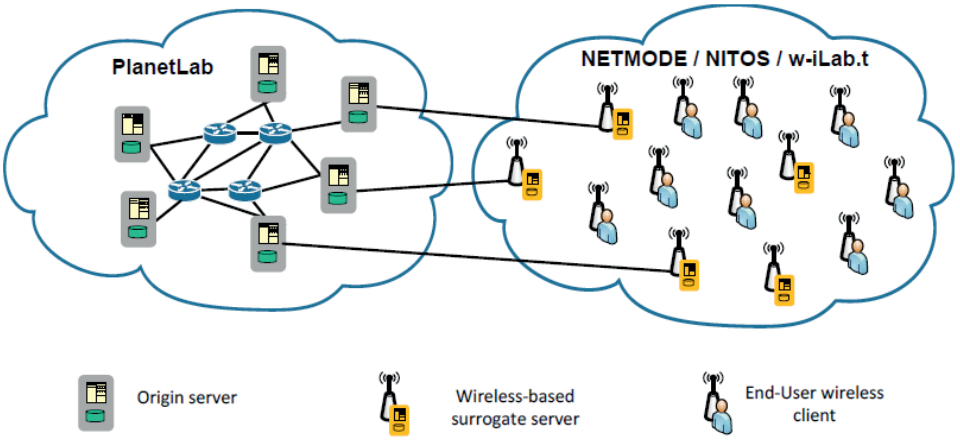
"The availability of two different Fed4FIRE testbeds with similar functionality has allowed us to compare and validate the obtained results. In fact, we have observed that the results are very dependent on the configuration of the measured network. If we had to deploy our product directly on a real network, we would have to face all the problems we have already addressed thanks to the experiment we have developed in Fed4FIRE."

Rich Media Content Delivery

By VCI S.A INNOVATIVE IT SOLUTIONS

The objective of this experiment was to evaluate various wireless cloud-based Content Delivery Network topologies and configurations in a number of different testbeds, subjected to different volumes of traffic, and topological characteristics, towards deriving fruitful business plans capable of providing to VCI and its customers the competitive advantage in the area of rich media content delivery in terms of

a) fine-tuning the effectiveness and performance of VCI's wireless content delivery platform,
b) devising the testbeds capabilities and topologies that can facilitate the infrastructure requirements for accommodating projected traffic,
c) reducing the overall management and operational cost of the cloud infrastructure



d) assessing the efficiency of the CDN platform implemented in different wireless cloud topologies, through specific online metrics, to evaluate the Quality of Experience under diverse traffic conditions.

The experiment was realized in the following Fed4FIRE testbeds:

- **Planetlab Europe**, which was used to deploy traffic seeds in different geographical zones for delivery of Rich Media content (e.g. videos),
- **NETMODE** wireless testbed which was used both in indoor and outdoor environment to accommodate both CDN and wireless clients which generated multiple users' requests for rich media content, and
- NITOS and **w-iLab.t** wireless testbeds that was utilized to assess the performance of the proposed approach in larger scale testbeds, providing however separate outdoor and indoor environments respectively, along with the study of the reproducibility of the experiments.

Through RIMECODE, VCI explored, evaluated and validated the opportunities provided by a wireless cloud environment for content delivery, promising increased performance at a fraction of the cost. VCI, via RIMECODE, will be capable of offering optimized, proficient rich media delivery services to its customers, ensuring the end-user experience optimization.

"The testbed federation provided by the Fed4FIRE was of great importance for the conduction of the experiment, which exploited the combination of wired and wireless infrastructures featuring variable features and characteristics in order to provide more accurate results. Furthermore the opportunity of pairing VCI's business goals and strategic roadmap with EU FIRE facilities adds trustworthiness and prestige to its business."

Deployment of the Super Stream Collider as an Experimental Run Test in the Scope of the Fed4FIRE Technology Testbeds Validation

By NATIONAL UNIVERSITY OF IRELAND GALWAY

The Super Stream Collider (SSC) middleware platform, developed by DERI-NUIG, aspires to be the world's largest and fastest Linked Data Stream platform. In the context of the experiment, we aim for testing the full stack service capability to process collected sensor data and to provide data streams in the form of easy-configurable data services and by means of an easy-to-use friendly and programming-free end user interface. Fed4FIRE is seen as an appropriate platform for validation of the SSC as well as of complete stack building IoT applications and services based on distributed information.

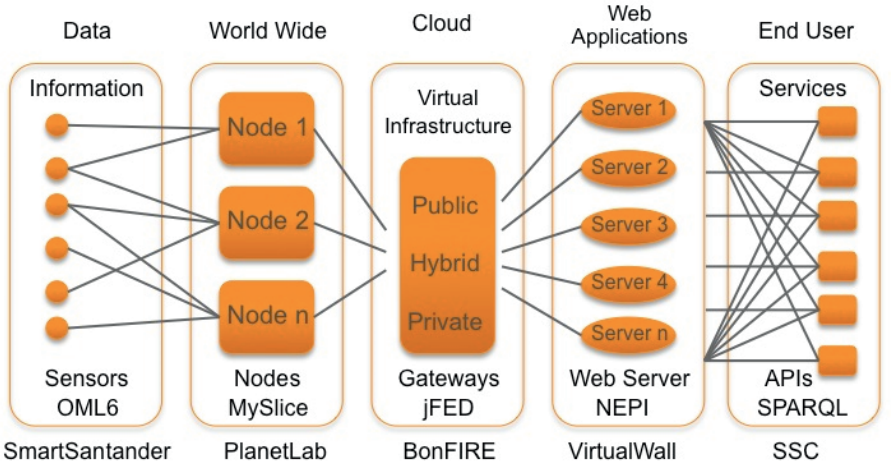
As part of the experiment, a use case focused on Smart City applications has been created, where data from sensors needs to be offered as stream data mashup that is used by web services and to distribute multiple users (SSC). By means of this use case, data from **Smart Santander** testbed is collected and transformed into universal open format (RDF) data streams and then distributed in SSC distributed data servers hosted by **PlanetLab** testbed. The cloud-based distributed processing is performed in **BonFIRE** testbed and as response of the service request in the form of multiple queries over the streamed data generated. Finally the SSC visual interface provides access to all the Smart Santander sensor data distributed in the world by using **Virtual Wall** testbed.

Fed4FIRE has provided us with access to a large set of different technologies and testbeds enabling experimentation with edge technology in all current research trends that can be seen as an initial trend technology for a future business opportunity. It was crucial for developing the experimentation part and thus has a better understanding about the dimension of escalating software platforms in cloud environments.

In Fed4FIRE we tested the extensibility of the experiments not only by using Super Stream Collider associated infrastructure but external infrastructures.

The experience gathered in this experiment opens also many opportunities to improve the SSC middleware, as only when deploying the middleware in different infrastructures we were able to identify problems like recursive request, multiple query conflict resolutions, and others.

The practices and results of the experiment can be perfectly applied to other scenarios, we experienced in Internet of Things Data for smart city scenarios but the same case can be applied for energy that fro grid or even healthcare.



“By using Fed4FIRE platforms we can reduce the effort required to experiment and hence certainty reduces the time for experiments and allows easy control of the Europe-wide spread technology. Although we mainly worked with command line interface and specific APIs to configure the used testbeds, jFed provides a solid start to set up and monitor experiment as an intuitive, user-friendly and easy to use tool. It does a good job at providing a transparent layer between users and testbeds.”

Use Fed4FIRE Open Acess now and run your experiment

Fed4FIRE provides a set of tools enabling easy configuration and execution of experimental set-ups on a wide range of Fed4FIRE testbeds. These testbeds cover various technology domains, including but not limited to cloud computing, wireless and wired networking, sensor networks, and software defined networking. Fed4FIRE testbeds can be fully operated remotely, where the only technical requirement for experimenters is to have standard Internet connectivity.

If you are interested in using the Fed4FIRE facilities to evaluate or characterize your research, development or innovation, our support team is at your service to provide you with the necessary assistance to answer your questions related to the feasibility and applicability of your planned set-up, and will get you started in no time by guiding you through the entire process.

In the scope of Fed4FIRE Open Access, usage of our facilities is free of charge – subject of feasibility confirmation by Fed4FIRE.

Getting Started

Once you have a clear picture on which experiment you want to run (e.g. to test your prototype or product, service or application, a new protocol or process, etc.) and what you would like to test; which parameters or features you would like to investigate, which problem you would like to solve, technology or solution choice you would like to made, etc…. you should get in contact with us so that we can assist you with:

- Identifying necessary technical requirements derived from your initial idea and
- Identifying suitable Fed4FIRE testbeds to implement your experiment

How to proceed?

Experienced experimenters can define needed tests by considering Fed4FIRE documentation and information about testbeds, and directly proceed by using our tools.

Or, **take advantage of an experienced Fed4FIRE support team** to help you and contact us at **contact@fed4fire.eu**.

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