Driving the FIRE engine to 2020
Virtual test garage
Global approach, local results
Smart apps for connected cities
Test beds without borders
FOREWORD

From experimentation to innovation

The internet keeps on revolutionizing the world – the way we function, interact, behave and evolve.

Likewise, networks are the neural system of our society – connectivity becomes the digital society’s DNA and unplugging it would “black out” most of our activities, hugely affecting our nowadays lives.

We, humans are heuristic and discover through experimentation. And when it comes to the internet, early and realistic experimentation while testing in a large-scale environment involving users works best.

The Future Internet Research and Experimentation – FIRE – initiative is addressing exactly this need to experiment with networks, by creating a multidisciplinary test environment for investigating and experimentally validating highly innovative and revolutionary ideas for new networking and service paradigms.

FIRE offers a methodology, an infrastructure and tools for trying out innovative ideas for the Future Internet. It is creating a dynamic, sustainable, large-scale European Experimental Infrastructure, which is constructed by gradually connecting and “federating” existing and upcoming test beds for Future Internet technologies.

In addition, in FIRE we promote the concept of the experimentally-driven research, combining visionary academic research with the wide-scale testing and experimentation that is required for the industry.

With this net-Xperiment issue being the fourth of the Net Futures magazines, we once more invite you to immerse in the world of the Future Internet and hope FIRE can light the way!

Mario Campolargo,
Director Net Futures
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EDITORIAL

Welcome to net-Xperiment!

It is my great pleasure to give you an insight into what FIRE is all about! A selection of FIRE facility projects, experimentation projects, pilot and demonstration projects and FIRE-related international projects are presented here. Our intention is to give you examples of experimentation that has been successfully undertaken in FIRE. But first we start with a glimpse into the future challenges and aspirations, our vision for 2020 and beyond.

A variety of network experimentation infrastructures and tools with different technologies, various structures and features are already available and trials are being performed. Our facilities evolve in a demand-driven way, supported through Open Calls and also the new mechanism of “Open Access”, an opportunity to use the experimental facilities for free and to obtain support beyond the originally planned lifetime of the respective project.

I invite you as exploratory users to profit from the experimentation opportunities and help shape the FIRE initiative according to your needs! We hope to spark your enthusiasm. Jointly, we can light up the Future Internet, because FIRE is OPEN and ALIVE!

Per Blixt
Head of unit Experimental Platforms

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The EU’s FIRE initiative aims to make its large-scale experimental research facilities the backbone of European internet research and innovation by 2020. How will it get there, and who will set its priorities? FIRE’s stakeholders have the chance to decide what direction the FIRE should take.

As FIRE prepares for 2015-2020, its most focused years for Horizon 2020, it has to choose which trends to invest in. It also has to determine whose needs to support and how to structure that support.

So why not ask the people who built FIRE, or use its facilities, or could potentially use them in the future? This is the role of AmpliFIRE. It provides a forum for industry, researchers and social stakeholders to drive FIRE towards the best facilities and model for their needs.

The AmpliFIRE consultation process lets users identify gaps in FIRE’s platforms and the needs of FIRE’s users and provides ways to discuss various possible research directions for the federation of internet research facilities. To build this roadmap, AmpliFIRE’s “FIRE Radar” process “scans” research and industry trends and estimates what are the most important developments and when they are likely to occur.

From the results of this process, AmpliFIRE proposes collaboration models, service offerings and research opportunities to stakeholders for their feedback. The goal is for FIRE to build a more responsive “pull” model, driven by users’ demands, rather than its previous “push” model, which simply promoted available technologies.

The most recent Radar study shows that user demand is already influencing FIRE’s evolution. Funded open calls, specific targeted research projects (STREPs) and open access opportunities already drive FIRE’s offering. However, the Radar study also identifies the need for a better match between the FIRE facilities and user needs.

Aiming to increase industry participation and social innovation, AmpliFIRE provides a more organised way for users to show how FIRE can become a collaborative, community- and market-driven environment for both scientific and entrepreneurial activities.

**EMERGING PRIORITIES**

AmpliFIRE has already identified possible research directions from the latest Radar study, which shows that internet user demand will be based on four trends.

- **The Internet of Things**: a global, connected network of mobile devices, product tags, sensors and actuators, and mobile devices that interact so that people can achieve shared goals without direct user input. Automated retail stock control systems are typical application of this trend.

- **The Internet of Services**: internet-scaled service-oriented computing, such as cloud software (SaaS) or platforms (PaaS).

- **The Internet of Information**: sharing all types of media, data, and content across the internet in ever increasing amounts and combining data to generate new content.
The Internet of People: people to people networking, where users connect directly with other users privately and securely through their personal cloud. Here, the boundaries between systems and users will become increasingly blurred, giving a user-directed architecture for the internet. However, businesses and individuals cannot benefit from the opportunities these trends offer without the right internet infrastructure. The future internet will need to have an adaptable infrastructure and be software-defined, both wired and wireless and more open than ever before. FIRE’s already extensive federation of different kinds of facilities lets experimenters and end users test that their applications work in the right environments. To support the internet’s further expansion to become an Internet of Things, services, information and people, FIRE will need to offer an even greater range of test facilities. This expansion will lead to a research environment that is richer than the commercial world or individual research laboratories can provide. AmpliFIRE will help users define a “FIRE ecosystem”, a federation of connected regional and urban innovation ecosystems, offering internet infrastructures, services and applications for industry and society.

FUTURE MODELS FOR FIRE

As well as highlighting research priorities, AmpliFIRE’s Radar suggests a number of possible organisational structures for FIRE to discover which best matches users’ needs. Each of these structures corresponds to different driving factors and uncertainties. Two such scenarios are the industrial co-operative model and the social innovation ecosystem model. Which one better fits with the business and social aims of FIRE remains to be seen.

THE INDUSTRIAL CO-OPERATIVE MODEL

In the industrial co-operative model, commercial and non-commercial stakeholders work together to provide experimental infrastructures and services. The federated facilities are centrally organised as a single large-scale federated facility, based upon well-established standards and common platforms. This lets FIRE support commercial R&D into new future internet technologies that require large-scale trials. The facility offers commercial opportunities by providing new services within its test bed, such as data hosting, data processing, and communication brokering. For SMEs and start-ups that develop new software, this gives them the chance to test developments across the federation’s infrastructure. At the same time, each testing facility can charge users on a pay-per-use basis, giving them a financial incentive to join the federation.

With its range of differing infrastructures, FIRE would evolve in an organised fashion to remain at the cutting edge of internet research. Federating access to experimental facilities has already been a theme of FIRE so far, and this model would help its next generation, FIRE+, develop processes and services for an extended smart environment.

ANOTHER VISION – THE SOCIAL INNOVATION MODEL

Alternatively, FIRE could evolve as a self-organising research federation. In the social innovation ecosystem model, FIRE would become a collection of different, dynamic and flexible resources interacting with each other and autonomously creating new software tools to test applications and services. Facilities could include service-based infrastructures, network infrastructure, smart city test beds, user-centred living labs and application-specific sensor-instrumented services. These would be able to use and potentially be composed of one another. Under this model, FIRE’s emphasis would be more on distributed community clouds and generating and maintaining a personal footprint in a real-time wireless “social” network. It would support research exploring interoperability issues in the Internet of Things, including shared, or “sliced”, use of resources.

Perhaps the most novel involvement is that people would be the creators, engineering new social computing platforms and service to support open, community driven innovation with the technologies and facilities available (often with minimal expertise). FIRE would then offer a research tool truly representative of the Future Internet.

ENGAGING THE COMMUNITY

FIRE needs its stakeholders’ input to refine this vision and make its route clear. To achieve this, AmpliFIRE is coordinating a series of public workshops, organising online community discussions, and collecting direct feedback about the latest Radar study. FIRE also plans to collaborate with wider future internet activities, explore how facilities can be shared, and help future internet communities to work together. These communities include the Future Internet Public-Private Partnership (FI-PPP) and its XIFI infrastructure project, and the network of laboratories created under the European Institution of Innovation and Technology (EIT-ICT). AmpliFIRE has created the venues for feedback, more notably the FIRE Forum. It now invites users to come to these events, to contribute their input to the working out FIRE’s vision, and drive the portfolio of future FIRE+ projects to their new destination.
EXPERIMENTING TODAY WITH THE INTERNET OF TOMORROW

Federating experimental test beds will allow researchers to access facilities around Europe. The idea is popular within the research community, as responses to the Fed4FIRE project’s call for experimenters show.

Over a few decades, the internet changed the world forever. This happened through continuous research and experimentation with novel internet technologies. Numerous experimentation facilities have been built – some funded by the EU – each targeting a specific future internet domain. Fed4FIRE’s goal is to federate these facilities.

The resulting platform will enable innovative cross-domain experimentation, providing researchers easy access to resources on different test beds. Some 17 facilities are currently involved, making available a diverse set of technologies, from cloud computing, wired and wireless networking to software defined networking, Internet of Things and smart cities.

Stimulating EU facilities to join the Fed4FIRE federation will not only result in a larger and more diverse set of resources being made available to experimenters, it will also result in an overall improvement of test bed maturity throughout Europe.

CLEAR DEMAND

In May 2013 Fed4FIRE launched a first open call for additional facilities and experiments. For experiments, a proposal could receive a maximum EU contribution of € 80,000, while the total budget was € 600,000. For experimentation facilities, new partners could receive a maximum contribution of € 100,000 from a total budget of € 300,000.

The call proved that Fed4FIRE is highly attractive to the European Future Internet community: a total of 81 proposals were submitted from 19 countries and 91 organisations.

This equates to a budget over-subscription rate of 679% for new experiments, and 796% for new facilities. The corresponding success rate was 14.3% and 12% – after evaluation by independent experts, 11 proposals were included in the project.

SMEs found it challenging to compete with experiment proposals from universities, research institutes and large industrial parties when responding to the call. Fed4FIRE is therefore implementing two SME-specific call types:

- With dedicated support from a Fed4FIRE partner: € 25,000 per proposal is available for the experimenter, and € 10,000 can be assigned to the consortium partner responsible for supporting the experiment.
- Without dedicated support from a Fed4FIRE partner: € 10,000 per proposal is available for the experimenter. This type of call will only be launched once all those within the other category have closed, and if there is a clear need for them.

Otherwise, both call types are largely similar. Neither imposes innovation criteria, while the proposal document is significantly simplified for both. In each case external judges will evaluate the proposals, but a preliminary feasibility study can be requested from Fed4FIRE. Experimenters will always become subcontractors, not project partners.

If these new call formulas are successful, they will benefit the project itself, as well as SMEs seeking research funding.
CREATING A MATURE ENVIRONMENT

The project’s federation architecture is based on distributed components. In such an approach, adopting common interfaces and making sure that every member is fully compliant with them becomes critical. The team therefore developed a new software tool enabling rigorous integration testing. Called jFed (jfed.iminds.be), the tool is used both for manual testing of new test beds, and for daily automatic testing of operational federated test beds.

The operational status of the federation requires continuous monitoring. This is done through the regular collection of live status information from all facilities, and their combination within a single dashboard. A team of First Level Support operators carefully monitors this dashboard and takes immediate action when needed.

Fed4FIRE is federating test beds at a scale previously unseen in Europe, which puts the project in a strong position to stimulate collaboration with related initiatives around the world. In October 2013, Fed4FIRE hosted a workshop in Leuven, Belgium, to stimulate collaboration between US researchers working on the National Science Foundation’s Global Environment for Network Innovations (GENI) and their EU counterparts.

Thirty participants attended the workshop, selected for their expertise. Several opportunities for collaboration were identified and initiated, including visits by US researchers to specific EU partners and the setting up of joint experiments remotely. Ultimately, the future internet research carried out by EU researchers has the potential to influence internet technology around the world.
KEEPING THE BONFIRES BURNING IN 2014

Capping off the successful completion of the EU-funded BonFIRE project involving a consortium of leading European cloud computing players, a new Foundation has been created to guarantee continued ‘free’ access by researchers to the infrastructure, resources and expertise of its members.

The multi-cloud test bed – virtual testing platform for researchers carrying out complex, often costly and data-heavy experiments on myriad internet cloud services – developed under the recently-concluded BonFIRE research project will be available, free of charge, to ‘experimenters’ throughout 2014.

This comes after the consortium reached an agreement on how to handle intellectual property rights (IPR). The agreement paved the way for core syndicate partners Atos (Spain), IT Innovation (UK), the University of Edinburgh (UK), the University of Stuttgart (Germany), I-Minds (Belgium), the French National Institute for Research in Computer Science and Control, and the Poznan Super Computing and Networking Centre (Poland) to continue offering the cloud experimentation service.

Delivered under the framework of the newly-formed BonFIRE Foundation, the facility provides an open platform to engineer future cloud technologies in a way that is not restricted by current business models. This is important in order to increase innovation in the cloud and boost the success of European companies, especially smaller businesses.

A GOOD DISRUPTION

Clouds have changed how services, such as data storage, apps and email, are performed and fundamentally altered or ‘disrupted’ the way services and software is engineered. BonFIRE recognises this disruption as a major challenge for service providers and that a new approach is needed to support the development of innovative services.

Many organisations cannot afford to invest in their own cloud facility and especially not an industrial-strength cloud spread across many countries or regions. So with funding from the European Commission, BonFIRE has delivered a multifunctional cloud facility with the capability and capacity to carry out large-scale testing of novel cloud ideas.

The BonFIRE consortium brought together leading industrial and academic organisations in cloud computing to deliver a robust, reliable and sustainable ‘virtual’ facility for large-scale experiment-driven cloud research. Running from June 2010 to November 2013, the project included two open calls for experiments.

Using business scenario analysis, real-cost accounting, open access and a novel licensing model, BonFIRE has pioneered and put into action ground-breaking ideas in sustainable infrastructures.

SHIFTING CONTROL

Customers of public clouds – computing power and services available to the general public over the internet – have very little idea of what is going on in the cloud. “Part of the attraction is that the cloud provider takes responsibility for managing the physical infrastructure, but the lack of transparency in public clouds is a problem for testing cloud technology,” notes the BonFIRE project team. “Users (researchers and developers) need to know what is going on in the cloud.”

Better infrastructure and information, on-demand with built-in self-service facilities would improve the reliability and transparency of public clouds, and enable users to “observe and control with the operational conditions they want”.

By focusing on openness and transparent operations, BonFIRE has shifted the ‘control’ from the provider to the customer. Designed according to Open Platform principles, in terms of what developers need for cloud testing and experimentation (i.e. observability, control, advanced cloud features and ease of use), BonFIRE allows users to explore fresh ideas but also to test those that are closer to market.

KEEPING THE LIGHTS ON

Keeping the service alive beyond the lifetime of the research project posed a significant challenge, but BonFIRE planned for such a contingency. Using business scenario analysis, real-cost accounting, open access and a novel licensing model, BonFIRE has pioneered and put into action ground-breaking ideas in sustainable infrastructures.

BonFIRE has been able to make the transition from a European research project to a world-class cloud-testing and experimentation facility with commitment to sustain the offering without EU funding in 2014. The aim is to further promote take-up of the facility and establish it as the platform of choice for distributed systems experimentation.

To use the facilities, all you need is an idea for testing and experimentation that exploits BonFIRE’s unique features. Join BonFIRE on http://www.bonfire-project.eu/access-now.

More info: www.bonfire-project.eu/
MANAGING DIVERSITY ON FEDERATED TEST BEDS

Many federated test beds for internet experimentation have been deployed worldwide. These allow the developers of future internet technologies – ranging from components to complete systems – to conduct large-scale and diverse experiments. The OpenLab project is providing a framework for managing these diverse test bed systems.

The proliferation of test bed management frameworks, and in particular of measurement and monitoring tools, poses a great challenge for experimenters, who may have to adapt their test applications to each test bed. The OpenLab solution, being developed by a number of projects, will cope with divergent requirements for managing experiments. It will do so by:

- evaluating WebRTC service delivery mechanisms, namely the IP Multimedia Subsystem (IMS) and Web service delivery approaches (the WONDER project)
- designing, implementing and evaluating an innovative, resilient software-defined networking (SDN) system able to withstand attacks, failures, mistakes, natural disasters and able to keep operating on fragmented and intermittently connected networks (the EXPRESS project)
- developing and evaluating a new tool for test bed management for peer-to-peer (P2P) applications (OpenLab-Eclectic)
- evaluating a path state protocol (PSP) application running on top of the open and programmable environment for experiments with routers (the OPENER project), with the aim of securing the border gateway protocol (PSP-SEC).

WONDER focuses on the interoperability of IMS and WebRTC services with each other and with standard IMS clients. The experiments aim to clarify which approach is most suitable and under what conditions.

The experiments require a flexible, well equipped test infrastructure able to connect to additional network and service capabilities, including assets provided by telecoms operators, as well as WebRTC related network capabilities like STUN/TURN servers.

With the platforms available at the University of Patras and the Waterford Institute of Technology, WONDER can test functionality on different IMS implementations and test inter-domain interoperability.

Meanwhile, EXPRESS will implement an SDN infrastructure over a federation of three OpenLab test beds (PlanetLab, NITOS and W-iLab.t) and use this infrastructure for evaluating its solution. The NITOS and W-iLab.t test beds will host a number of wireless mesh routers with SDN capabilities and “local” SDN controllers capable to take control of unconnected portions of the network.

The PlanetLab test bed will be used to create an SDN-capable wired backbone that interconnects the wireless mesh networks and hosts a “main” SDN controller.

ON THE WAY TO FULL DEPLOYMENT

Developers of peer-to-peer applications need to ensure scalability and performance under realistic conditions prior to expensive large-scale real-world deployment. OpenLab test beds offer developers the opportunity to test and evaluate their applications under various settings.

However, the diversity of the test beds can require adaptations of the application for each test bed. The OpenLab-Eclectic tool makes it easier for peer-to-peer developers to deploy and monitor experiments.

PSP-SEC has two main requirements – first a large test bed able to create a realistic topology, and second the building an overlay network to implement the out-of-band message exchange required by the PSP-SEC protocol.

OpenLab is able to comply with both requirements by providing a large test bed with full administrator control, and by allowing the use of PlanetLAB. In line with this approach, OpenLab also provides mechanisms to ease the interaction among test beds, simplifying the execution of the PSP-SEC experiment.

GNU Guix – www.gnu.org/software/guix/
Wireless technologies are increasingly common in modern life. But as bandwidth becomes more saturated, it is important to find ways for devices to share spectrum and use it efficiently. The CREW network of test platforms helps researchers develop strategies for flexible spectrum sharing across licensed and unlicensed bandwidths.

As the number of wireless applications and technologies increases, it is getting harder to allocate available spectrum to accommodate them all. The quality of users’ experience of wireless service is also affected by crowding more devices into the same spectrum, leading to slow transfers or even failure. For example, a sensor network for an automated home could be interfered with by a Wi-Fi network in the same building. And as different countries allocate different spectrum to devices type, these need to be able to work with more than one system so that they can operate across borders.

A solution could be ‘cognitive radio’, ‘cognitive networks’ or ‘software defined radio’ – advanced technologies that allow a wireless link or a wireless network adapt itself to different device applications and to changeable wireless environments. By including a cognitive radio card, devices can work with varying standards at the physical level of wireless communication, adapting to different protocols for medium sharing, advanced spectrum sensing and other changing conditions. These abilities make it possible for devices to adopt different parts of the spectrum according to availability.

But there’s a catch. Developing and testing new cognitive wireless solutions requires a lot of specific, and often expensive, equipment, putting this process out of the reach of smaller-scale developers. What if this equipment was available for every interested researcher? Thanks to the EU-funded CREW project, a set of cognitive radio and cognitive network testing facilities have been opened up to academia and industry.

STRENGTH IN NUMBERS
CREW creates a federation of wireless test bed facilities and experimentation tools from five institutions:
- iMinds, Belgium (w-iLab.t, a heterogeneous ISM test environment)
- Technische Universität Berlin (TWIST, a sensor network test environment for indoor wireless)
- Technische Universität Dresden (an LTE cellular test bed)
- the Jožef Stefan Institute, Slovenia (LOG-a-TEC, a sensor network test environment for outdoor wireless)
- Trinity College Dublin (the CCVTR’s IRIS, a cognitive radio test bed for licensed bandwidth, including TV bands).

From the commercial sector, the project also includes Thales, France (providing a transceiver API), IMEC, Belgium (with a state-of-the art sensing engine) and EADS, Germany (managing applications testing).

Users can access all of the federation’s software and hardware facilities through a single portal. There are three levels of testing: single test bed testing, testing across two linked parts of CREW, and testing across multiple parts of the federation. Each or a combination of these levels allow users to develop products to work across different scenarios. CREW also provides benchmarks, realistic training data and controlled testing conditions, to help users evaluate results from reproducible experiments and performance testing. Feedback from experimenters has been very positive. Researchers have welcomed access to state-of-the art
equipment and the opportunity to test and validate advanced cognitive radio technical developments. They said that overall, access to the federation helped them learn a lot about using test beds.

BUILDING KNOW-HOW

Started in 2010, the project has carried out several of its own experiments, such as work on wireless communication in airplane cabins by consortium member EADS. It has also organised three open calls, attracting researchers from academia as well as industry.

The first open call attracted three experiments:
- sensitivity of spectrum sensing devices and wireless environment measurements (Durham University, United Kingdom)
- clear channel assessment agent in a CSMA MAC using IRIS modular software platform (Technische Universität Ilmenau (Germany)
- collaborative spectrum sensing (Tecnalia, Spain).

The second open call was organised in 2012 and resulted in four testing and validation projects:
- power consumption and latency measurements of spectrum sensing devices (University of Thessaly, Greece and National ICT Australia)
- optimal usage of TV white spaces with a geolocation database (CMSF-Sistemas de Informação and Instituto de Telecomunicações, Portugal)
- fast switching (on the fly changing) of MAC protocols and cognitive radio control signalling (Consorzio Nazionale Interuniversitario per le Telecomunicazioni, Italy)
- on-the-fly changing of cognitive radio control signalling (WINGS ICT Solutions, Greece).

More recently, the third open call, from 2013 to mid-2014 allowed smaller experiments. Seven of these, from academic and industrial research teams throughout Europe, have been accepted by CREW.

IT'S A RESULT

Overall, CREW allowed researchers to calibrate diverse spectrum sensing hardware in different physical environments provided by the different individual test facilities of the federation.

The project shared data from the experiments, benefiting other researchers. For example, the measurements performed by the University of Durham improved understanding of the wireless propagation properties of different physical environments.

Researchers also found the facilities extremely useful. In particular, they said that the interface for controlling software-defined radio hardware platforms provided better performance than previous radio drivers they used and that CREW’s modular software architecture for building highly reconfigurable radio networks (IRIS) was extremely easy to use, well documented and resulted in stable, bug-free software.

They also found that the framework for controlling wireless test infrastructure is very powerful. As well as describing and running experiments, it could be used for radio and network control as part of the solutions under test.

In the future, external experimenters will play a more important role, as the CREW facilities are now entering into an open access phase. Different access rights, permissions and tariffs could be introduced for different types of users (CREW core and open call partners; best effort external experimenters; premium external experimenters).

In its final year, the project – from October 2014 to September 2015 – will focus on ensuring the sustainability of the CREW solution. This year will be used to assess its long-term future and ensuring access to its facilities. Policy makers, funding bodies, other research projects, and other FIRE facility projects like Fed4FIRE will all have a role in sustaining the CREW facilities.

But whether the project continues, moves to the Fed4FIRE project or dissolves, one thing is sure – bringing together Europe’s best minds to work together on a solution is helping wireless technologies get along.

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**CREW Roadmap**

- **OPEN CALL 1**
  - Y1
  - OC1 exp.
- **OPEN CALL 2**
  - Y2
  - OC2 exp.
- **OPEN CALL 3**
  - Y3
  - OC3 exp.

**PHASES**

- Set-up
- Optimization and extensions
- Towards sustainability
- Beyond CREW

**OPEN ACCESS AND USE OF CREW PLATFORM**

Source: CREW

More info: www.crew-project.eu
A VIRTUAL TEST GARAGE FOR START-UPS

A free test bed for internet applications. What more could a budding developer with visions of the future internet ask for? OFELIA does just that by allowing researchers to experiment on a test network with precise and dynamic control at their fingertips. The service is evolving to cater for the demanding world of today’s applications.

The OFELIA project ended in October 2013 after three years of work on building a pan-European OpenFlow-based test bed. During this period we witnessed no less than a revolution in communication networks. What used to be a research idea – separating control and data planes in the internet – is now one of the hottest developments for data centres, and increasingly as well for carrier networks. Software-defined networks (SDN) are currently the dominating research area for data centres, but not much is being done outside of this because of the diversity and complexity of managing such networks.

What sparked the OpenFlow solution was the attempt to create a standardised interface between networking hardware and the operating system needed to configure and control it. OpenFlow was developed within the Clean Slate Programme at Stanford University and supported by Deutsche Telekom Laboratories from its early days.

A popular analogy to such an interface is the BIOS (Basic Input/Output System) that was made open by IBM in the late 1970s, allowing garage start-ups like Microsoft to develop an operating system independent from the underlying hardware, the personal computer.

In retrospect, the act of standardising BIOS was a historical moment, as it decoupled the innovation cycles of software and hardware, leading to an explosion of software and applications that changed everyone’s lives.

OFELIA set out to create a pan-European test bed for OpenFlow, providing European students and industrial researchers with a tremendous opportunity to test their applications.

The test bed was constructed while similar efforts were underway or about to start in the US (GENI), Japan (JGN-X), China and Brazil. Currently, any researcher can use the current test facility to deploy and test new routing protocols, content delivery strategies, or new addressing schemes for a future internet. These control applications are the core of what will be a network operating system.

WHAT DOES OFELIA OFFER?
The short answer is: a slice of a network and a way to use OpenFlow’s capabilities, which allows users to create a virtual network and it through secure and standardised interfaces. Researchers can dynamically create virtual machines and connect these to a networking substrate that is controlled by their own OpenFlow controller. The virtual machines are on standard Linux installations that can act as traffic sources or sinks (traffic simulators). It is the controller implementation that sets the forwarding rules in switches and lets the researcher define paths through the internet.

The control plane is sliced by means of FlowVisor, a shim-type controller that assigns parts of the overall address space (a combination of ports/MAC/IP addresses and wildcarded header fields) to a slice in a network. The network can be shared by filtering the OpenFlow messages and assigning them to the appropriate controller.

Some limitations…and ways to overcome them
FlowVisor does not actually slice the forwarding capacity, so the scope of experimentation is limited for quality-of-service (QoS) tests. As the entire OFELIA test bed is implemented as an overlay over the legacy internet in large parts, bandwidth-hungry applications are currently out of scope.

The OFELIA network is based on a mix of OpenFlow-enabled Ethernet switches (the majority being NEC’s IPB800) running OpenFlow v1.0. In the meantime (until the end of 2013) OpenFlow standardisation has progressed to version 1.4. As FlowVisor limits the current controllers and the installed hardware to v1.0, the research facility becomes less attractive. Because of this, the FIRE project ALIEN was started in 2012 to improve programmability of both the OFELIA hardware as well as the control framework.

ALIEN’s first results are multi-version data paths and new tools for control slicing that remove the need for FlowVisor.

At the end of 2013 a new types of virtual machine was added to OFELIA’s servers. SPIRENT, one of the major providers of network testing equipment, has provided a number of licenses for their virtual TestCenter appliances. This means that any OFELIA user now can install professional network testing equipment on several parts of the network and use them as sources/sinks for highly specific network traffic.

WHO USES OFELIA, AND WHO COULD USE IT?
Mainly, still, but not exclusively, OFELIA is used for master theses and student projects. Increasingly, teaching activities take place that use parts of the test bed. We also see small- and medium-sized enterprises using the service for functional and performance product testing. So far,
technically, experiments deal with routing and different forms of addressing, and only very recently with first end-user applications like distributed video caching, content delivery network strategies and so on.

THE IMPLICATIONS
Software-defined network (SDN) changes the landscape of communication networks. The recent OpenDayLight initiative appears to be an attempt to define a full-blown operating system deployable across a number of switches from different vendors.

This will naturally decrease the role of current system integrators, as the glue between the pure hardware and the network operators will be open source and supported by a bigger community. At the same time, network operators need to become more software literate, rather than just being able to change a few configuration scripts. This leads to DevOps software development methods and completely different skill sets needed by network operators.

FURTHER STEPS
OFELIA will continue to grow in the coming months and years, as new islands – nodes or facilities – become part of the project’s test bed network from the ALIEN and FIBRE projects. Many problems still remain to be solved, such as improving usability, shortening the work flow for successful experiments and creating bigger and more powerful network infrastructure.

During 2013, software development together with the GENI project office was started. The results will hopefully end up in a common clearing house, easing the way for researchers to use GENI and OFELIA.

By signing a memorandum of understanding, OFELIA’s island owners have ensured the test facility will continue to be available in 2014 and 2015. The agreement provides for a not-for-profit foundation that will continue to steer the technical development of the test bed control framework, provide a platform for the resulting open source software, and guarantee the stable operation of the existing test bed.

The biggest challenge ahead will be how to reach out to real users, as the debate over net neutrality continues to be a controversial topic. SDN provides an elegant way out of the dilemma for users and network providers.
INSTANT INFORMATION FOR A COOLER LOCAL EXPERIENCE

Getting all the information you want about one place usually means visiting lots of different websites. But at Schladming Ski Resort, tourists and residents can access all of the internet’s relevant information at once, using its online information centre, Digital Schladming.

There are times when you want information about just where you are, not about everywhere else. And local content producers – like businesses – just want to talk to you, not the whole world. You both want to share the information quickly. So it’s frustrating for users to browse through lots of different websites or waste time trying to access password-restricted sites.

For tourists and residents at Schladming Ski Resort in Austria, that frustration might be a thing of the past. Media company IN2 have successfully concluded a trial of the site “Digital Schladming”, which gives instant access to information about everything related to the resort – accommodation, transport, weather, events, visitors’ experiences and, of course, the skiing.

Schladming Ski Resort is a leading international ski resort in Austria and part of Austria’s Ski Amadé ski resort network. As host of events such as the FIS Alpine World Ski Championships 1982 and 2013, Schladming attracts sports professionals and amateurs to enjoy sports and social activities within the region, all looking for the information to make the most of their visit.

The ski resort is already part of the EU’s EXPERIMEDIA project for new media and social networks. As a smart venue offering live events and communities of all ages and lifestyles, its digital infrastructure is well-placed for researching and testing innovative technologies for new forms of social interaction and experience.

This is where Digital Schladming comes into play. It offers a virtual stage to showcase all the relevant content about Schladming to the world. Content is hyperlocal – only related to the ski resort – but comes from many different sources, using content syndication and advanced filtering to pull together only the information users need.

It enhances visitor experience by providing access to all of Schladming’s social media channels in one place in real time. Information feeds from social media, blogs, video and image sharing platforms are aggregated, while registered users benefit from a private space where they can store their Schladming memories and instantly share them with the community.

Digital Schladming builds on IN2’s state-of-the-art ON:meedia platform, which manages multimedia content. It incorporates innovative EXPERIMEDIA components to enable video content delivery, collect content from multiple social media sources and analyse online data for relevant information. The interface boasts a powerful search functionality with dynamic filters for the search results.

The resulting application is completely web-based and responsive, making it accessible on almost all user devices. Digital Schladming has benefited visitor experience and stakeholders in the local region. When planning their vacation, tourists can easily get a visual overview of what Schladming is about by visiting the Schladming ‘Pinboard’, a collection of images. All the social media channels that they could use are already there.

For Schladming, their online presence is more dynamic and visually engaging. Stakeholders can regain control of the content they share on social media channels and are able to tap into a new opportunity for engaging with their guests.

The experiment proves the potential of hyperlocal media for the broader tourism sector and marks the beginning of a collaboration with the region of Schladming. Local stakeholders are happy with the results of the trialled solution, and the Digital Schladming system will soon be available on the official Schladming Ski Resort site http://www.planai.at.

More info: www.experimedia.eu/
Digital Schladming – www.onmeedia.com/apps/schladming/
Is the past boring? Perhaps not if you can visit it with your friends. Imagine moving through ancient streets at your own pace, examining objects and sharing your impressions as you look around – all with expert advice on hand. The Interactive Digital Dome at the Foundation of the Hellenic World allows you to do just that.

The Foundation for the Hellenic World (FHW) in Athens is a world-leading cultural and heritage centre. Like many high-tech museums, it uses advanced 3D virtual reality (VR) installations for virtual tours through reconstructions of heritage sites. The museum wanted to extend its VR exhibitions to make them more immersive. By incorporating live remote experts and letting visitors direct narratives, they hoped to appeal to new audiences that want more interactive and communicative experiences.

Future Media Internet (FMI) technologies offer the potential to add just such features to museum visits and learning. However, these technologies have been largely ignored when it comes to audience participation in large-scale VR shows.

Using the EU’s EXPERIMEDIA test facilities, the FHW explored how to address this underused application to deliver meaningful interactivity in a large dome show for 100+ visitors. It asked the following questions: What pre-show events enhance educational dome shows? How can remote experts take part in presentations and interact with learning groups? How can participants contribute to the narrative in real-time?

The experiment aimed to engage audiences using three FMI technologies – augmented reality (AR) (using digital effects to enhance images of real objects), live video streaming and social media. It used the show “A Walk Through Ancient Miletus”, which transfers the visitors to the ancient city of Miletus as it was 2000 years ago, as a test for its innovations.

In the enhanced show, participants could use a dedicated AR smartphone app to explore digital images of artefacts before the VR show, to prepare for and develop interest in the presentation. Live video streaming broadcast the VR show to academic experts, who replied with a video feed of their reactions on the dome screen. Finally, a specially developed Facebook-based application connected visitors and experts to a dedicated event page, where they could post messages throughout the VR walkthrough presentation.

The experiment had three major impacts. First, it improved visitor participation. In the AR event, visitors explored objects and interacted together, while the streaming and social networking in the VR show let them share reactions and ask questions to the expert without disturbing the main presentation.

Secondly, the enhancements promoted education. Besides being very interactive, the AR pre-show event disseminated historical information and created anticipation about the VR show: visitors could identify artefacts in the show as those they had already seen in the AR app. The dedicated social media application and live video streaming during the show also allowed visitors to ask questions freely without hesitation or interruption. As a result, the museum educators witnessed an increase in the number of questions asked, especially during the live video session with the remote expert.

Finally, user evaluation showed that the additional features can have a financial impact. Most of the visitors were willing to pay additional fees for these experiences, while the publicity through the live video feed and chat resulted in higher visitor numbers on the museum’s website and Facebook page.

The project demonstrated how dome shows can increase the learning experience by using emerging technologies. Future work will advance the state of the art by incorporating real-time reconstruction of 3D avatars so experts can appear fully immersed within virtual worlds.

“A unique experience. During the show of ancient Miletus we could send any question using our phones and get instant feedback.”

Capeleria Antonia, Visitor
Community networks, combining low-cost hardware and open source software, enable a community to enjoy access to the internet independent of commercial providers. EU-funded research has taken a ‘glocal’ partnership approach to providing better access to wireless internet for community stakeholders and the resulting technology is now being commercialised by a project partner.

Communication is an essential part of everyday life, whether it is talking to your neighbour over the fence (one-to-one) or broadcasting to many people through newspapers, radio and television (traditional one-to-many media). Now the internet has revolutionised the world’s media, offering alternative channels and opportunities to send and receive information as well as interact with one another (many-to-many communication).

While Europe has worked hard to provide equal access to the internet – and increasingly broadband internet – digital inequalities still exist. Indeed, a small fraction of the world’s population can afford expensive commercial services; and in many regions privacy and security risks, plus the prospect of mass surveillance and censorship can severely limit internet services. Community networks enable any group of people to create their own computer network to enjoy the freedom of unfettered internet communication.

Affordable, low cost and easy to deploy community networks support democracy, human rights and the free flow of information when and where it is needed. And experimentally-driven, collaborative research has helped to remove the remaining obstacles to setting up a resilient network which can adjust itself (‘self-optmise’) to ensure the highest quality service.

Building on the work of existing community networks, the CONFINE-FIRE project, which started in 2011, has carried out research on community networks using its Community-Lab test bed. The project is a public-private partnership between citizens, local authorities, local SMEs and international research partners including UPC university, the Guifi.net community network and Routek, among others.

The research carried out over the past two years has been enabled by open spectrum, inexpensive wireless and optical fibre equipment, as well as open software and open knowledge source. Results include the design of small and efficient computer devices for the test bed which the SME partner Routek is now building and selling as home servers.

“It is satisfying to see that public academic research is making a tangible contribution to the common good,” says Leandro Navarro, researcher at UPC and coordinator of the CONFINE project. “This result … stems from an experimentally-driven collaboration between community networks, a small innovative enterprise, and public research institutions around Europe supported by funding from the FIRE FP7 programme.”

Experiments on the test bed developed by CONFINE with new software and network technologies have contributed to more robust, easier to set up community network nodes. As well as connecting more people and enriching the digital society, these advances have helped to extend the Guifi.net community network and expand the market for Routek, which is also reaching new customers beyond community networks.

These results were possible thanks to a combination of very low cost hardware and easy-to-use open software tailored to cope with the specific needs and traits of community networks, typified by unstable links, availability issues, and no or few ‘quality of service’ guarantees.

“This work is the first major contribution towards the ‘materialisation’ of the computing cloud concept in community networks, the so-called community clouds,” suggests the project team.

More info: Routek SME: www.outek.net
Guifi.net community network: www.guifi.net
Universitat Politècnica de Catalunya: www.upc.edu
CONFINE: www.confine-project.eu
Community-Lab test bed: www.community-lab.net

‘GLOBAL’ APPROACH, ‘LOCAL’ RESULTS FOR NEW COMMUNITY NETWORKS

All people should have easy and affordable access to a free and open internet to improve their lives and create a more just world.
European research is shedding light on our relationship with the internet thanks to a better understanding of the ‘semantic’ meaning of rich content – photos, films, texts, statistics, timelines – we are all constantly creating, updating ... and often regretting!

Hailed as the biggest milestone since Gutenberg’s invention of the printing press, the internet has truly democratised information and how it is consumed and produced. While buying and publishing books was initially limited to a small class of society who were able to read and write and afford to buy books, the web has empowered everyone.

The internet paves the way for ever-greater participation in what and how information is generated and disseminated. Today, we not only read and view content (passively) but also contribute our own content. And this new class of ‘prosumers’ – combining the roles of producers and consumers – creates amazingly rich content at dizzying speed, from community edited encyclopaedias (or wikis), to blogs and all kinds of social media.

We are documenting our news, thoughts and hopes, our family histories, and our every movement in ever-more creative formats and platforms. And the internet has become a de facto ‘live’ archive as it systematically captures the digital footprints of our society, and allows us to travel back in time to explore the zeitgeist of previous times – and bad hairdos.

MINING THE ARCHIVED GOLD MINE

Web archives are a veritable gold mine for analysts across different application areas, from political analysts and marketing agencies to academic researchers and product developers. The self-proclaimed keepers of our online legacy, the Internet Archive initiative and its European partner Internet Memory Foundation, have ‘captured’ (retained for posterity) more than 350 billion web-pages since 1996.

The EU-supported LAWA project set out to create a Virtual Web Observatory (VWO) on top of the Internet Memory Foundation’s rich repository, in order to explore and analyse content from web-pages and social media longitudinally (over time).

But they struck a problem: internet content is often far from self-explanatory, especially when it dates back years or decades. Typically, background knowledge is needed to interpret the content. For instance, when reading about the debate on renewable energy across Europe after the Fukushima nuclear disaster, you can understand the arguments put forward based on statistical evidence, such as renewable energy data, from the EU’s statistics organisation Eurostat. However, identifying relevant statistics and other background information for any given piece of web content is a more difficult task.

A solution developed in LAWA lifts the content to a semantic level by identifying ‘named entities’ such as people, places, organisations, events, etc. But why are named entities crucial here? Because they can be mapped onto semantic knowledge bases such as Yago or Freebase – the heart of Google Knowledge Graph.

As a result, content is no longer merely ‘plain text’, but annotated with semantic information about entities, and other valuable background knowledge. This way, the computer can infer that a document mentioning energy companies, such as Vattenfall or E.ON, is highly related to the topic of renewable energy and associated statistics. This helps to bridge the gap between text-based web content and statistical evidence.

THE WEB TIME-MACHINE

LAWA’s public demonstrators include analytics interfaces (ways of using the analytical tools) and browser plug-ins that help to semantically enrich, classify, query, analyse and visually explore digital content at web-scale (anywhere!).

"LAWA facilitates large-scale studies of different types of web content and has added a new dimension to the Future Internet research roadmap," notes the project team.

The work of this unique European project has provided valuable impetus to the emerging field of temporal web analytics. Moreover, LAWA has been a driving force behind the launch of the Temporal Web Analytics Workshop series at the internationally-recognised WWW conference, building a thriving research community focused on tackling the challenges and opportunities presented by Big (web) Data.

About LAWA

To support innovative Future Internet applications, we need a deep understanding of internet content characteristics (size, distribution, form, structure, evolution, etc.). The three-year FP7-funded LAWA project on ‘Longitudinal Analytics of Web Archive’ data is building an internet-based experimental test bed for large-scale data analytics.

More info: www.lawa-project.eu
Yago: www.yago-knowledge.org
Internet Archive: www.archive.org/about/
Internet Memory: www.internetmemory.org/en/
Google Knowledge Graph: www.google.com/insidesearch/features/search/knowledge.html
A SMART APPS TOOLKIT FOR CONNECTED CITIES

Connectivity and city governments are a winning combination, with dedicated city apps providing online access to local services and data. What if developers could deliver new apps faster, using an app from one city to build one for another?

Smart city apps use the internet and mobile connectivity to make local services more accessible to citizens. They also help city governments save money on providing information and services. So naturally, local governments are inspired by technology giants like Google, Facebook and Netflix to develop their own apps for sharing data with citizens. But software developers are interested in wider markets for their apps than just one city, and another city's good idea can be time-consuming and expensive to replicate. One solution is to develop comparable programming interface standards for different cities so that one app can be easily applied locally elsewhere.

First, cities need to create their own internal standards for data, which is not easy. Mark Headd, who works on this issue as the US city of Philadelphia’s first chief data officer, says on his blog: “Creating open data standards for cities is really, really hard. It’s also really, really important.”

It is only when these standards are in place that cities can develop apps that use the data. And once one city can share an app with another, a myriad of new possibilities becomes available.

In Europe, the CitySDK project is taking this next step, aiming to unify interfaces across cities. Using shared application development tools, apps developed for Helsinki and Lisbon are being scaled up to other cities. Together with Amsterdam, Barcelona, Istanbul, Lamia, Lisbon, Manchester and Rome, these cities are helping create a toolkit of open, comparable interface specifications, which will apply to three target areas: mobility, tourism and participation (for reporting issues directly to local government departments).

CitySDK application programming interfaces (APIs) offer a one-stop-shop for developers, who will be able to make better apps and services for end users more cheaply and quickly. Cross-European dataset standards will make it easy to scale up applications and grow a smart city app developer community. And if standards and software are open-source, cities can easily implement and adapt APIs and apps for local needs.

The APIs developed for the project have had very positive outcomes for the cities involved. For example, the CitySDK mobility API has produced the OpenData Globe application. This visualizes data, such as live public transport data, for nine European cities, including five in the project. The CitySDK tourism API enabled the award-winning cross-city app “Spot” series which provides information on transport routes, events and tourist attractions for Helsinki, Lisbon, and Lamia.

The APIs have gained interest beyond local governments. In Helsinki, the CitySDK issue-reporting API has also been used by media company Sanoma, the Korjaa Kaupunki association and some SMEs.

These days, cities need to manage changing and emerging datasets, electronic devices, software applications and apps – a challenging task. With the CitySDK APIs, cities can keep on top of these tasks and use innovative apps and services to change the way citizens interact with them: whether by getting feedback on bus stops, sharing tourist routes or reporting potholes.

With the CitySDK APIs developers can build scalable solutions that improve everyday life for urban residents. And the best part is that any city can join the smart team.

More info: CitySDK – www.citysdk.eu
OpenData Globe – http://dev.citysdk.waag.org/visualisation/

1) www.civic.io/2013/02/26/on-data-standards-for-cities/
CUTTING OUT THE NOISE

Railways, aircraft and traffic are the main causes of urban environmental noise pollution. Studies reveal that of those exposed to such noise, approximately 30% are troubled by aircraft, about 20% by road traffic and about 10% by trains. The noise is not only irritating – it results in decreased quality of life, health problems, mood changes and increased stress levels.

EU Directive 2002/49/EC provides guidelines for the assessment and management of this noise pollution. A starting point is accurate monitoring tools. Using wireless sensor networks within smart cities opens up new opportunities to monitor traffic density and quantify noise levels. Some sensors are in place already, for example for measuring light, CO₂ and humidity.

But the potential benefits of audio as a monitoring tool have been largely ignored, despite several clear advantages: audio sensors are cheap, energy-efficient and often easy to deploy, do not depend on line-of-sight (NLOS), allow for omnidirectional sensing and are not affected by weather conditions or lighting.

The EAR-IT project is investigating how to incorporate acoustic modalities into traffic density monitoring applications. Technology would be used to classify noise type and acoustic events, and to quantify and assess noise on a subjective level. By incorporating this novel information into existing data management systems, more reliable noise maps – including their historical progression – could be developed. Parameters are derived to intelligently and adaptively steer traffic management systems, e.g. to actively reduce noise pollution in a certain area. Applications would therefore have high social, economic and ecological value.

Seeing the need for an intelligent sensor in line with the current definition of Internet of Things (IoT) devices (low-power, small, cheap, interconnected), the EAR-IT team developed an Acoustic Processing Unit (APU). In comparison with existing solutions, the APU has increased processing power thanks to an embedded processing platform able to process complex algorithms with high quality audio. It is equipped with a modular software framework for acoustic event detection. The APU is highly adaptable due to its modular structure, fully automated, respects privacy and is non-obtrusive.

Several APUs were deployed in the SmartSantander test bed in Spain (www.smartsantander.eu), complementing the existing sensor infrastructure, and allowing for experimentation. The EAR-IT team is currently investigating two different kinds of algorithm for traffic density monitoring: computationally low-cost deterministic approaches and more complex, machine-learning-based algorithms that would lead to a computationally scalable solution.

After further development, APUs will create a base technology that can easily be modified for applications beyond traffic density monitoring while remaining affordable, easy to produce and to deploy.

More info: www.ear-it.eu
Private and public cloud computing is growing rapidly, along with the huge server farms needed to maintain such services. Demand is also rising for a more comprehensive way to measure and reduce cloud computing’s carbon footprint.

Current approaches to reducing the cloud’s carbon footprint focus on increasing the energy efficiency of computing devices, on reducing the environmental impact of hardware, on virtualisation, and on dynamic mechanisms for better allocating workload. Some approaches also seek to increase the energy efficiency of non-IT components, for example cooling systems. The ECO2Clouds team took a more comprehensive approach; one that included CO₂ emissions produced by data centres and their running applications – and the output of all software and hardware components.

The approach resulted in a method, guidelines and the technology for measuring this environmental impact, and for reducing energy consumption and overall CO₂ footprint. This “carbon-aware” solution works by managing workloads on clouds through federated cloud infrastructures, where applications may span several cloud sites.

The technology has been integrated into the FIRE facility BonFIRE. The solution focuses on cloud computing models and metrics, for which the project proposes a federated cloud model and energy metrics.

The ECO2Clouds solution includes components for monitoring energy consumption and for adapting the infrastructure, virtualisation, and application levels to achieve energy efficiency and reduce the CO₂ footprint.

The project’s cloud model includes indicators on the energy consumption and CO₂ footprint of cloud facilities and their applications. These quantify environmental impact. The cloud model also provides ways to more efficiently use and deploy cloud configurations which reduce energy use. The workload is distributed according to the infrastructure used and Virtual Machine (VM) levels.

Energy metrics are indicators allowing cloud services to assess energy efficiency. The proposed metrics reflect energy efficiency for each level of the cloud architecture (infrastructure, virtualisation and application) and according to the interrelation between the different levels.

Sample metrics for infrastructure include those measuring site and storage use or Green Efficiency Coefficient (GEC), a standard measure. Metrics for virtual machines measure CPU, Storage, I/O, and memory use. For applications, the metrics measure task execution time, response time, throughput, A-PUE (application PUE), application energy productivity (AeP) and Application Green Efficiency Coefficient (A-GEC).

The different levels of energy metrics allow cloud service providers to develop deployment strategies that, along with other tasks (such as allocating cloud resources to match application requirements) consider energy consumption and the CO₂ footprint of cloud applications.

BonFIRE – www.bonfire-project.eu
ROUTING FOR THE INTERNET’S GROWTH

The EULER project has developed a blueprint for a novel distributed and dynamic routing system that can overcome the challenges posed by the internet’s rapid growth and evolution – along with the tools to help make the concept a reality.

Currently the internet’s routing mechanisms are not dynamic enough and not scalable enough to keep up with its expansion. Looking at possible solutions, the EULER team designed and experimentally valuated novel dynamic internet-wide routing models and algorithms – taking into account future changes. The project became among the first to conduct large-scale routing experimentation involving thousands of emulated components on FIRE’s test beds, the team says. The experiments involved prototyping a routing engine and emulating routers to reproduce most of the actions an actual routing engine performs.

THE BENEFITS OF EMULATION

EULER combined emulation with simulation experiments, which allowed the team to evaluate and compare the performance of routing models and algorithms. Emulation experiments complemented the results from simulation by focusing on trends and sensitivity in time and resource consumption of the routing components under different conditions.

Emulation allowed the team to evaluate time-related metrics (for example, convergence time and the proportion of time needed performing routing sub-functions) in a more realistic manner and in more detail.

All actions that corresponding routing engines could execute were also modelled in the emulated prototype. This approach allowed the research team to compare and infer trends under controlled but changing parameters of the same emulation prototype, or between similar software prototypes running under comparable conditions.

The team was also able to evaluate resource-related metrics, such as CPU usage, and memory space, in a more detailed manner – the resources consumed by the prototype provided the means to estimate the actual resources integrated production systems would consume.

FAR-REACHING RESULTS

As a result of the testing, EULER developed new approaches to measuring the internet’s behaviour, which are expected to be more widely appropriate for understanding complex networks. The project’s designs for routing schemes are aimed at helping sustain growth and evolution of the internet’s infrastructure; they can be scaled independently of the number of network nodes, links and reachable address prefixes. They also rely on an addressing system not subject to allocation policies, and support resiliency and recoverability when network failures occur.

The project’s dynamic multicast routing scheme (referred to as GCMR for Greedy Compact Multicast Routing) positions itself as an alternative to the PIM/mBGP routing scheme currently used for IPTV. The first demonstration was conducted at the Hands-On FIRE! event at the FIA-Dublin on May 2013.

SOME RECOMMENDATIONS

The findings led the EULER team to call for FIRE to extend its facilities by offering software platforms tailored to help researchers perform emulation experiments themselves, without relying on highly skilled system and software engineers.

These platforms should be able to help researchers evaluate, validate and verify their state-of-the-art proposals instead of limiting their experimental work – as it is often the case today – to the execution of one of many designs on open software engines, the team says.

Failing to extend experimental facilities beyond inter-connected hardware would limit access by forcing researchers to perform experiments only by simulation, the team adds.

More info: www.euler-fire-project.eu
THE NEXT STEP FOR E-LEARNING: SCIENCE EXPERIMENTS ONLINE

Learning online, or e-learning, has opened up an exciting new way to deliver training and education to more people, when they want it. The FORGE project wants to push e-learning into new territory by developing a way to conduct scientific experiments online in an open format using FIRE facilities.

EU countries spend an average of around 6% of gross domestic product (2009 figures) on education. With public budgets under pressure in some countries, e-learning could provide a cost-effective alternative.

Techniques for e-learning are already quite developed. Information and communications technologies ICT have allowed educators to create a wide range of e-learning methods, varying from one-way assisted-learning systems to highly dynamic and interactive platforms. And online learning has become an important component of informal and formal education, whether for personal interest, at work, or to attain a certificate from an established provider.

One way to encourage its further evolution is to provide e-learning facilities for scientific experiments. Achieving this goal requires two main components: the ability to conduct remote test bed experiments and online platforms capable of interacting with those test beds.

FORGE aims to bring these two components together by leveraging FIRE’s experimentation facilities for the development of e-learning materials. The FORGE team will also build a framework where teaching and educational materials, tools and experiments become available to educators and students through open scheme policies.

TO LEARN, TO EXPERIMENT

The ability to conduct experiments is key to learning, especially in the engineering field. However, conducting an experiment is often expensive, difficult to do, and may require specific guidance during the process so as to avoid mistakes or injuries to the experimenter.

Simulation can sometimes replace physical experimentation for some engineering topics. However in most areas, physical experiments are mandatory. Physical experiments allow engineering students to fully understand design procedures, practical limitations and trade-offs.

In this sense, both physical experimentation and simulation can contribute to engineering education and be integrated on the same computer-based platform. Laboratories can provide remote access to experiments and can allow students to access experiments without time and location restrictions, providing the necessary guidance and constraining operation in order to avoid setup integrity issues.

The remote laboratory concept provides a means to sustain a learner-centric teaching approach as experiments can be available all the time.

Thus the FORGE framework will allow educators and learners access to FIRE’s high-performance test bed facilities for conducting scientific experiments. These facilities cover a wide range of different domains belonging to the Future Internet ecosystem, such as cloud computing platforms, wireless and sensor network test beds, software defined networking and OpenFlow facilities, the infrastructure for high-performance computing, long-term evolution (LTE) test beds, and smart cities.

More info: www.ict-forge.eu
@ICT_FORGE
NO DEPENDABILITY, NO INTERNET OF THINGS

For the Internet of Things to become a reality the sensor networks which form its backbone must provide dependable real-time information all the time, on time. The RELYonIT project team is working to ensure dependability by testing possible solutions on FIRE’s test beds.

The Internet of Things (IoT) depends on a network of connected sensors and actuators embedded in physical objects, such as appliances and medical devices, providing people, businesses and governments with real-time online access to the state of things and places.

This connectivity will result in a wide range of new services, applications and data, leading to smart cities, electricity grids and healthcare services, for example. To realise these benefits, the sensors and actuators interacting over the wireless networks must be dependable.

However wireless sensors and actuators do not currently offer dependable performance, as they are often affected by the surrounding environment. For example, temperature variations can lead to a loss of synchronisation and a degradation of the quality of the wireless connection. Radio interference from wireless devices and other electrical appliances can also impair low-power communications, reducing speed and leading to high latencies.

How then can developers create smart city solutions if sensors that transmit information on the number of parking spots available or on the concentration of pollutants in the air are not operating as expected during the hottest times of the day or in the presence of radio interference?

The dependability of embedded wireless networks cannot yet be taken for granted, and there is hence a need to increase understanding of the performance of these devices under a wide range of environmental conditions. Only in this way can the promise of the future internet become a reality.

KEY RESULTS

To obtain a deep understanding of performance in relation to environmental conditions and to provide dependable solutions, the RELYonIT team has extended existing FIRE facilities to enable the repeatable playback of pre-recorded environmental conditions.

In particular, the team has successfully created low-cost extensions for wireless sensor networks test beds that allow researchers to:

‣ study the impact of temperature with few hardware overheads (TempLab)
‣ create realistic and repeatable interference patterns without hardware overhead (JamLab).

These test bed extensions play a crucial role in the investigation of network performance by allowing researchers to rerun experiments under identical environmental conditions.

For example, TempLab can accurately reproduce temperature traces recorded in outdoor environments with an average error of only 0.1 °C. Preliminary experiments using TempLab have revealed that high temperature can drastically change the topology of a network and lead to partitions, significantly reduce the performance of MAC protocols, and increase the processing delay over the network.

JamLab provides simple models to emulate the interference patterns generated by typical appliances, as well as a playback capability to regenerate recorded interference patterns. Through a simple software up-load, JamLab automatically selects the portion of the test bed nodes that reproduce interference. RELYonIT used these test beds to devise accurate models capturing the impact of the environment on IoT hardware and protocols, and to develop protocols that can be automatically configured to meet application-specific dependability requirements.

MORE DEPENDABILITY, MORE BUSINESS

The solutions developed by RELYonIT will find wide application in the market. Industrial partners in the consortium are developing a new line of dependable real-world applications involving different types of sensors and actuators.

These applications focus on highly demanding monitoring scenarios such as smart parking systems and geological sub-soil imaging for oil and gas infrastructures. At the same time, the academic partners will exploit the acquired know-how to train the next generation of engineers and researchers.

More info: www.relyonit.eu
HOUSEWORK IS A CINCH, THE SOCIAL WAY

Imagine buying a 3D printer and deciding to produce a teacup. You would soon realize that making a printer do this task is rather complex. You could decide to devote a couple of months to program the printer by yourself. But the social solution is cheaper: via the Web, ask someone who knows more than you to provide your machine with the list of instructions. If you are lucky, you may be able to accomplish the task in 20 minutes.

Take another example – the ability to control a dishwasher through the internet, allowing you to wash dishes exactly as you want. For instance, you would be able to limit water consumption and the amount of detergent used without a loss of quality – the dishes would be clean.

Both examples would represent instances of a ‘social network of facts’, says the team behind the EU-funded Social&Smart project. Their concept is of a social network for sharing physical processes in place of documents, and feasible nowadays due to the increasing support available through the Internet of Things. The Social&Smart project, which began in November 2012, aims to make this concept a reality by developing a physical and computational infrastructure that allows people to control their household devices and appliances through a network.

Users would be able to virtually inject intelligence into their appliances by employing the social network – rather than by embedding them with autonomously cognitive chips as you would a robot – to develop finely tuned instructions that can then be sent to control the appliances.

This infrastructure would enable the social network to produce “recipes” of computational intelligence to be dispatched to household appliances grouped in homes through a domestic local area network (LAN). A recipe in this case would be a set of scheduled, possibly conditional, instructions to be managed by home-based middleware so it could be transmitted through suitable protocols to the right appliances for doing everyday housekeeping tasks.

The feedback of the social network’s members, more or less experienced, would feed into a database of open source knowledge, which they may proactively share and refine with other people who own the same or other smart appliances.

KEEPING DECISIONS IN USERS’ HANDS

Control of private information would remain in the hands of users. If a user requests a recipe, he would not want the information to be transferred to a third party, possibly an appliance manufacturer. Rather, a user would ask the social network for a recipe compliant with their specific task and personal preferences, for example in terms of green goals or wash quality, local environment conditions, and perhaps electricity rates. The final command is then made by the user, who decides whether or not to accept, modify or simply reject the recipe suggested.

INTELLIGENCE AS THE BASIS OF SUGGESTIONS

To issue valuable recipes the network requires a suite of computational intelligence tools, able to interpret requests, mine similar ones from a database and produce a new recipe on the basis of the feedback log. It’s a networked intelligence processing distributed information coming from members.

CONCRETE IMPLEMENTATION, NOT SIMPLY CONCEPTS

To test their concept the Social&Smart team has connected a washing machine in a lab at Italy’s University of Milano. It responds to network requests such as “I want to wash blue cotton trousers stained with grease.” The washing machine will also soon be connected to the CARTIF Technology Centre in Valladolid, Spain. A bread-making machine, also located in the Milano lab, is set up to respond to requests such as “I’d like a crusty loaf of white bread, not too soft.” The bread-making machine will also be connected to Malmö University in Sweden.

More info: www.sands-project.eu
According to estimates, 70% of us will be living in a major town or city by 2050. It will be increasingly crucial for cities to manage the services required by their populations effectively and efficiently – and urban mobile apps can help. IES Cities is helping cities mine and share information their residents need.

The cities of the future need to be sustainable, offering the best possible services efficiently and improving the overall quality of urban life. Meeting this goal will involve finding ways of interacting with city residents to help shape public services, for example transport and healthcare.

To address this challenge, cities have a number of assets at their disposal. They can, for example, make better use of their sensor and data infrastructures. They can also draw on the input of smartphone-empowered residents. Many citizens already use mobile devices to access city services in their everyday activities.

FROM OPEN GOVERNMENT...

A number of questions arise in this context. How, for instance, can city authorities gain a better understanding of the needs of residents and local businesses? How can they boost openness and transparency? And how can technology help to foster closer interactions between the authorities, citizens and businesses in order to enrich open government data?

The IES Cities project set out to address these questions in a bid to bridge the gap between innovation and the adoption of open government services. The project’s main aim is to validate internet-enabled services that citizens can access through mobile urban apps. It focuses on the development of an innovative and open technological framework that will draw citizens and businesses into the innovation process in a number of European cities.

... TO OPEN INNOVATION

The IES Cities platform is the core element for collaboration on creating a city’s digital services. User-centric mobile services will be able to exploit open data and combine this with citizen-supplied information, notes and recommendations. By making it easier to establish a city-wide ecosystem of such apps, the platform stimulates open innovation – where companies, citizens and councils interact to develop a smarter city that is better equipped to address and meet residents’ needs.

IES Cities is making its platform available in Bristol (UK), Majadahonda and Zaragoza (both in Spain) and Rovereto (Italy). The platform will enable citizens to take on a more active role in their communities – they are no longer mere consumers of information but can act as “prosumers” – providers, producers and consumers of information through their smartphone’s apps.

For example, people would be able to use IES Cities-based apps to find public services in a particular area, report a street light that is not working, share community information using collaborative maps, or monitor energy use at home or work. The project plans to offer one app service available in each city this year and at least two by the end of the project.

More info: www.iescities.eu
@IESCities
SOCIAL NETWORKING COMES OF AGE

As a group, older people don’t embrace online living as readily as their grandchildren might. Many have concerns about social networking sites; others are unfamiliar with ICT or simply don’t see the point. Thanks to Life 2.0, that may be about to change.

A woman in Finland needs a lift to a meeting, and someone online has offered to take her along. Migrants in Barcelona set up a group to learn Catalan; new members join and they all meet on- and offline.

There is nothing unusual about stories such as these, apart from the fact that the people involved are all over 65 – an age group that doesn’t always take to new technologies. Life 2.0, a project funded under the ICT-PSP scheme, has listened to their concerns and built a platform that meets their requirements.

WHAT OLDER USERS WANT

Prospective users in four pilot locations – situated in Denmark, Finland, Italy and Spain – helped to formulate the criteria for the new platform, which the project then set out to address. Key considerations included the target group’s predominant unfamiliarity with ICT and its diffidence towards the openness of most social networks.

It also emerged that older users’ main interest lies in staying in touch with their local contacts. In contrast to younger generations, which use social networks to overcome geographical distances and – sometimes – to replace direct social contacts, older users find this kind of application helpful in linking to their local context and the real life around them.

The platform’s simple and user-friendly interface is one of its main assets. About 120 people are currently using the system in the four pilot locations, for example to partner up for the weekly shop, to form bowling teams or to update each other on their holidays. The platform is also open to local organisations, businesses and services of interest to the users.

AN ONLINE EXTENSION OF THE LOCAL COMMUNITY

Earlier social networking applications for senior citizens were designed along the same lines as any other social platform. Life 2.0 is the first platform built specifically for and jointly with older users.

This approach helped the project to understand that big buttons and large fonts are a side issue: the real challenge lies in building a platform that generates trust and seems relevant. More specifically, the test users requested a closed application rather than an open one – a network older people feel they can trust, because they know who is involved – and local content of direct relevance to their daily lives.

These two criteria shape the application. They also have implications for the growth of the network, as expansion of the type experienced by many other social networking applications would defeat its purpose. In order to preserve its local focus and a reasonable level of user confidence, the platform will expand by nodes, that is, by forming new communities, with a provider the members trust.

Rather than projecting elderly people into the virtual space, Life 2.0 thus generates an augmented reality that provides more and better information about the local community. It increases the chances for senior citizens to meet, to help each other and to maintain their independence.

More info: www.life2project.eu
IT’S GOOD TO TALK – IT’S BETTER TO SEE

Picking up the phone to talk to local government offices or to share ideas can help sort out problems quickly. But sometimes you need to show and not just tell. High-quality video-based networks are being developed for cities to bring reliable video-to-video communications to public services.

Video-conferencing and chatting are already familiar in private use. So why not use the technology to enhance services for a city’s citizens? Doctors could treat patients before they reach them; schools could work together without leaving their buildings. But although video-based communications systems already exist in the market, video calls are still far from being as easy, reliable and ubiquitous as phone calls are today.

A core priority of current European policy is to support internet-based innovation that improves citizens’ living standards – and to create real “smart cities” – as part of the rapidly-developing Internet of the Future. To achieve this, a critical challenge is to find out how to deploy effective, high-quality video-to-video (v2v) networks that support facilities, applications and services for modern cities.

Five major European cities – Athens, Dublin, Luxembourg (city), Valladolid and Greifswald – are working with the LiveCity project to help develop such networks. Creating a city-based “Living Lab”, the project will pilot-test live v2v applications on ultrafast wireless or wired internet infrastructures to see how applications work with real user communities.

LOOK TO THE FUTURE

By modelling and then trialling specific cases, LiveCity aims to show that a real-time v2v internet connection allows citizens to interact with each other and their city more efficiently and productively.

Some of the services being trialled with city v2v networks are:

- video-provided municipal support and tourist services, which allow citizens to avoid spending time travelling to city offices
- shared education and learning capabilities for pupils and teachers from different schools, for example around selected domains such as literature, sports or arts where they can work on joint projects
- extended cultural, educational and artistic experiences for visitors to video-connected, networked museums within or between cities, through joint exhibitions or supplementary input for displays
- support for patient tele-monitoring and e-health medical applications, so that medical support personnel can give better, more convenient and more cost-effective support to patients
- ambulance-emergency room v2v connections to improve a remote doctor’s input during an emergency, improving the treatment outcome … after the ambulance arrives with the patient.

To achieve these networks, LiveCity uses a wide internet ecosystem made up of public service providers, network infrastructure operators, technology providers and experts. The partnership of providers supplies services that the user communities access through shared service platforms.

So that any potential user, in any involved city, can experience live high-density v2v as efficiently as possible, the federated network aims to include a Right of Way (ToW) throughout to cancel out interference from unwanted traffic. Wireless networks will be based on WiMax, HSPA and LTE standards, while wired networks will be xDSL-based.

LiveCity is a pure “technological incorporation trial” that provides modern internet-based services to over 2,750 users in the cities involved. Along with the time and transport fuel savings it can provide, it also hopes to support the acceleration of v2v mass-market start-ups across cities in Europe.

More info: www.livecity-psp.eu/
When visualising a smart city, images of Mediterranean islands are unlikely to come to mind. While numerous, the islands are small and often lack the infrastructure for sustainable management.

Using ICT to increase efficiency and encourage engagement will improve quality of life for citizens and also boost tourism – a key sector for the Mediterranean area in today’s economic climate. A ‘Smart-Island’ provides its inhabitants and visitors with ICT-based services in sectors such as mobility, tourism, leisure, real estate, weather, sea conditions and the environment. Information can be consulted free of charge via a 3D tablet (iOS, Android) or desktop interface. While spatial data infrastructures (SDIs) for islands and smart services do exist, they cannot be used to create a ‘Smart-Island’ as geographic datasets and databases are not integrated or harmonised.

The project has already produced apps for 17 islands – 10 in Greece, 7 in Italy, plus one each for Malta, Ibiza (Spain) and Nicosia (Cyprus). More are planned. To develop the apps, the team created a complete SDI comprising several datasets. These included a Digital Elevation Model (DEM), orthophotos (aerial photographs) of the island, and information on points of interest collected on site and via a web-based end-users’ app. This information collection app was developed using a harmonised data model and is designed to retrieve open-data information from third parties and build an update mechanism for the Smart-Islands apps. Users may contribute to the information available by editing details of a point of interest or suggesting a new one, be it a hotel, restaurant shop or something else.

The applications were developed using the Unity3D software-development kit. They provide citizens and users with accurate and timely services and data, such as information on a city’s facilities; maps indicating tourist sites, facilities and routes; travel booking services; real-time weather forecasts; GPS detection; 360° photos; videos; event information and access to social networks so that information can be shared with friends.

The project team is currently commercialising the apps, which can be downloaded via the Apple and Android stores. The goal is to have recovered all investment by 2015 – two years after the project finished.

More info: www.smart-islands.eu
TEST BEDS WITHOUT BORDERS: EU–JAPAN COLLABORATION

Drawing up a framework for SDN future internet test beds dotted around the globe, FELIX is creating the conditions for validations on a scale never previously seen.

Although invisible, most governments, businesses and schools – and many homes – rely on them: networks are intrinsic to today’s internet. But the complex and rigid internetworking system leaves network administrators and users struggling to observe what happens to their traffic as it traverses the network.

Designing alternative future internet architectures has therefore become a priority in network research. At the heart of this work are open and programmable test beds, based on Software Defined Networking (SDN) principles, such as those built around the world within future internet programmes: FIRE (EU), GENI (USA) and RISE (Japan), for example. Test bed-oriented international cooperation in SDN research creates a strong foundation for advanced, high-impact programmable network research. Cooperation gives researchers unparalleled opportunities to validate their novel network applications and solutions in world-class test beds, capitalising on resources from different administrative and geographically remote facilities. Such large-scale validations would not otherwise be possible. The EU–Japan project FELIX creates an SDN test bed federation between the partners’ key research labs.

FELIX is defining a common framework for federated SDN future internet test beds dispersed across continents (Europe and Japan in particular). Such a framework will enable users to request and obtain resources across different test bed infrastructures; manage and control the network paths that connect the federated SDN test bed infrastructures; and execute distributed applications on the federated infrastructure.

The resources available through FELIX include networking, computing and storage capacities, available at geographically dispersed facilities, under the administrative control of different but cooperating stakeholders.

The FELIX team envisages a virtual networked infrastructure, spanning multiple administrative domains, using OpenFlow control mechanisms in the local switching infrastructure. It will be coupled with WAN-based network service reservation mechanisms such as Network Services Interface (NSI).

The project has defined six specific use cases and grouped them into two major clusters (Data Domain and Infrastructure Domain) to reflect the primary application area and stakeholders. The FELIX Data Domain use cases mostly target SDN and dynamic interconnections via a network services interface (NSI). Data caching, fast delivery, streaming and related workflow management are central to these use cases:

- data on demand – delivery of distributed data by setting data flows over the network
- pre-processing and delivery of nearly real-time (satellite) data to geographically distant locations (from EU to Japan and vice versa)
- high-quality media transmission over long-distance networks.

The FELIX Infrastructure Domain use cases focus more on the efficient use of federated and dispersed FI resources (in different continents) to migrate entire workloads (VMs and data) or virtual infrastructures in a more efficient way (e.g. with energy saving targets) and enhanced features (e.g. data/service survivability in case of disasters):

- data mobility service by SDN technologies
- follow-the-sun/follow-the-moon principles
- disaster recovery by migrating IaaS to a remote data centre.

The FELIX team is currently working on the architectural foundation and software tools needed to implement these use cases. Preliminary demonstrations are expected for 2014.

More info: www.ict-felix.eu
CHINA AND THE EU: A SHARED INTEREST IN THE FUTURE INTERNET

The EU-China-FIRE (ECIAO) project supports cooperation between Europe and China on mutually beneficial activities for future internet research and experimentation. The aim is to make the Future Internet a truly global success.

ECIAO currently focuses on two key areas: test beds and best practice in IPv6 deployment. More specifically, it encourages the federation of test beds, promotes the exchange of experience and supports the establishment of interconnected IPv6 pilots involving Europe and China.

DEVELOPING TEST BEDS

The Chinese Ministry of Education, together with China’s Science and Technology Center, Tsinghua University, the Beijing University of Post & Telecommunications and more than 120 Chinese universities, set up an organisation called the Internet Innovation Union (IIU) in September 2012. The primary objective of the IIU is to create a large-scale, networked experimental facility throughout its member universities by linking up network equipment and test beds. At the end of 2013, the IIU involved more than 40 member universities with nearly 500 interconnected network devices, and its scale continues to expand. Like FIRE, the IIU has built up a platform for online resource reservation and experimentation in order to achieve test bed federation. Known as Dragonlab, which is short for Distributed Research Academic Gigabits Open Network Lab, this platform enables users to easily identify and reserve the devices they need, design topology, run experiments and receive results. The IIU strives to become a worldwide federated test bed project with an influence equivalent to FIRE and GENI (Global Environment for Network Innovations).

ADVANCING THE DEPLOYMENT OF IPV6

A number of initiatives and factors promote the deployment of IPv6 in China. They include the development of the Internet of Things, the increasing use of mobile devices as reflected in the adoption of Verizon 4G deployment with IPv6, and China’s 12th five-year plan. The next few years will be critical for IPv6 development in China and extremely promising for the IPv6 industry as a whole. At the end of 2013, 9 million users had IPv6 access, and by the end of 2015, this figure is likely to reach 25 million. Because of this, efforts by Europe and China to build a platform together for the exchange of best practices will help globalise the use of IPv6. The EU-China FIRE project has therefore created an EU-China IPv6 “Best Practice” Expert Group that will support and encourage global IPv6 adoption. One of the first successful examples of a use case has been highlighted by the expert group concerned with the deployment of IPv6 at the University of the Free State (UFS) in South Africa. This project involved a complete re-design of the campus network. It resulted in innovations in terms of VoIP and multicast and led to a 70% performance increase at a cost of less than $50,000.

SUPPORTING COLLABORATION

EU-China-FIRE has set up a collaborative space on its website for discussions related to the future internet. It also operates a helpdesk service and broadcasts news items via the usual social network channels.

More info: www.euchina-fire.eu
@EUChinaICT
EUROPE’S BRAZIL CONNECTION

Although complex, today’s internet still has its roots anchored in the original TCP/IP architecture and protocol foundations. Over the last decade, networks, servers, storage, and applications have all undergone significant changes with the introduction of virtualisation, network overlays and orchestration. Infrastructure innovation is generally risky and will definitely benefit from experimental test beds, where innovative and disruptive future internet solutions can be validated before being used in production networks.

The FIBRE project, co-funded by the Brazilian Council for Scientific and Technological Development (CNPq) and the European Union, has created an intercontinental test bed for large-scale experimentation involving distributed network applications relying on Software Defined Networking (SDN) and network programmability via OpenFlow.

Using Slice-based Federation Architecture (SFA) FIBRE has created a federation of IT and networking devices bringing together independent resources located in remote test beds around Europe and Brazil. Interfaces and data types aggregate resources, allowing the slice-based network substrates to work together.

The physical devices deployed in FIBRE are virtualised so that they may be shared between different users/experiments. This virtualisation and slicing of both servers and network switches is made possible through third-party software tools like XEN-server (for IT resources) and Flowvisor (for network resources).

A dedicated ‘per-slice’ SDN controller then allows the experimenter to test and validate new network applications and routing strategies in an isolated environment.

Federation is not only available at device level—the entire test beds (in Europe and Brazil) are also federated; federation interfaces allow their different control monitoring frameworks (CMFs) to share data.

This has been made possible by incorporating results from previous EU-funded projects, such as OFELIA, OMF and ProtoGENI. The FIBRE team enhanced its software tools to create a more powerful, northbound interface.

The experimentation facilities are showcased in a selection of use cases. For example, users can access OpenFlow-controlled network resources located in the laboratories of CPqD (Campinas, Brazil) and i2CAT (Barcelona, Spain), through a VLAN-based L2 connection provided by GEANT, Internet2 and RedCLARA.

Particularly innovative in this use case is an enhanced NOX (OpenFlow) controller, integrated with a Flow-aware Path Computation Element, allowing the computation of network flow routes to be installed dynamically in the federated test bed.

The NOX controller communicates with a Web client that receives information about the virtual network topology, calculates flows, installs them in the switches, and schedules the routing paths taking into account bandwidth, time and VLAN constraints.

FIBRE chose OSCARS, a Bandwidth on Demand (BoD) system, to act as a Web user interface for this use case. This will make it possible to explore the full interoperability of OpenFlow-based islands with BoD systems and related control technologies.

More info: www.fibre-ict.eu
@FIBRE_project
net-Xperiment future is produced by the Experimental Platforms unit of the European Commission’s DG Connect – ‘Net Futures’ Directorate. The Experimental Platforms unit coordinates and makes available to researchers experimental facilities through the FIRE initiative (Future Internet Research and Experimentation). This is an open research environment to facilitate strategic research and development of new internet concepts, giving researchers the tools they need to conduct large-scale experiments on new paradigms.

The magazine features a number of EU-funded projects presenting both academic and industrial partners working together to bridge the gap between visionary research and large-scale experimentation.

net-Xperiment future is a concrete response to calls by citizens for more openness and communication on science and technology developments. Through a community-focused approach, the magazine seeks to broaden understanding of the work of internet researchers, innovators and entrepreneurs.

More info:
www.ec.europa.eu/ict-fire

About DG CONNECT

The Directorate-General Communications Networks, Content and Technology helps to harness information and communications technologies in order to create jobs and generate economic growth; to provide better goods and services for all; and to build on the greater empowerment which digital technologies can bring in creating a better world, now and for future generations.

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