FORGE
Forging Online Education through FIRE

D1.2.4 PROJECT FINAL REPORT

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1. Final publishable summary report

1.1 Executive Summary

FIRE (Future Internet Research and Experimentation)[1] is a key initiative that was launched and financed by the European Commission in 2010 and has been growing ever since becoming Europe's Open Lab for Future Internet research, development and innovation. As such, FIRE offers cutting edge test facilities that could not be accessible otherwise by many European players covering a wide variety of areas and vertical segments, including 5G, Smart Cities, Internet of Things, Manufacturing, eHealth. FIRE is formed of sets of large computational resources connected by specialised networks offering researchers world class resources with which to experiment and develop the next generation global communications infrastructure. By aggregating resources across the best research labs in Europe FIRE provides a common resource for research and experimentation that would otherwise not be accessible.

Within FORGE[2] our goal has been to extend the reach of FIRE into the education domain. In short to make the world class computational infrastructures and networks available to learners anywhere/anytime. We have achieved this through the following strands of work:

- Developing a platform (FORGEBox) which links FIRE platforms and testbeds to eLearning technologies such as MOOCs (Massive Open Online Courses) and eBooks. FORGEBox mediates between the complexities of FIRE and a learning interface which may appear in a Learning Management System.
- Creating a methodology which outlines how educators can use our tools to create and deploy new educational interfaces (widgets) or content using our tools.
- An easy-to-use repository of widgets and courses facilitating sharing of learning content at scale and lowering the effort required by educators.
- A suite of courses and an eBook from the FORGE partners to be used off-the-shelf. Our developed courses tightly integrate text, video and FIRE entities allowing students to setup and run FIRE experiments without leaving the learning system (e.g. without leaving the eBook).
- The embedding of Learning Analytics into our online learning materials. Learning Analytics is the application of Data Analytics to learning interaction data. Our platform allows both educators and learners to understand progress against benchmarks from peers or previous presentations of a course enabling reflection and improvement.
- We have conducted a series of Open Calls resulting in nine developed projects with partners across Europe and South America. These projects enabled us to improve our methodologies and tools and demonstrated the robustness of our overall approach.

We have disseminated our work widely at a variety of academic events in the education and internet domains as well as winning prizes (two at NetFutures). We believe that the FORGE results will enable new forms of teaching and learning enhancing the potential to train the next generation of ICT specialists.

[1] https://www.ict-fire.eu/
[2] http://ict-forge.eu/

1.2. Summary description of project context and objectives

Forging Online Education through FIRE (FORGE) has been a project bringing the FIRE and eLearning worlds together. FORGE has specified development methodologies and best practices for offering FIRE experimentation facilities to learners and educators via open and interactive courseware. The project has adopted and built upon the latest developments in education, especially Open Educational Resources (OERs) and MOOCs (Massive Open Online Courses).

OERs can be described as "teaching, learning and research resources that reside in the public domain or have been released under an intellectual property license that permits their free use or repurposing by others depending on which Creative Commons license is used".[3] The emergence of OERs has greatly facilitated online education (eLearning) through the use and sharing of open and reusable learning resources on the Web. Learners and educators can now access, download, remix, and republish a wide variety of quality learning materials available through open services provided in the cloud.

The OER initiative has recently culminated in MOOCs delivered via providers such as Udacity, Coursera and edX[4]. MOOCs have very quickly attracted large numbers of learners; for example over 400,000 students registered within four months for edX courses[5]. More recently, the Open University established FutureLearn as the UK response to the emergence of MOOCs in collaboration with over 85 organisations (52 universities), including the University of Southampton. Since its launch, FutureLearn has attracted more than 3 million registered learners worldwide. In 2015, FutureLearn launched the largest ever MOOC, with over 400,000 enrolments of learners for a British Council course preparing for an English language test[6]. MOOCs are becoming part of more traditional learning processes; MIT will now recognise credit obtained via certain of their courses on edX as counting towards a Master's degree.[7]

These initiatives have led to widespread publicity and also strategic dialogue in the education sector. The consensus within education is that after the Internet-induced revolutions in communication, business, entertainment, media, amongst others, it is now the turn of universities. Exactly where this revolution will lead is not yet known but some radical predictions have been made including the end of the need for university campuses, while milder future outlooks are discussing 'blended learning' (combination of traditional lectures with new digital interactive activities).

The Future Internet Research and Experimentation (FIRE)[8] initiative has been established to ensure that the European Internet Industry evolves towards a Future Internet containing European technology, services and values. So far, it is primarily used by academic and industry professionals for research and development of new Internet technologies, rather than being used for educational purposes. Through FIRE, a variety of facilities have been developed, including cloud computing services, 4G/5G experimental networks, cognitive radio networks, Wi-Fi and sensor network testbeds, infrastructures for High Performance Computing, and more. However, the corresponding costs both for the establishment and operation of these facilities is not to be neglected. Therefore, optimal usage of the FIRE facilities is desired by its owners, a goal which has not been yet achieved.
FORGE has addressed this problem by introducing FIRE to the eLearning community. The main objectives of the project have been the following:

[3] Atkins, D. E., Brown, J. S. & Hammond, A. L. (2007) A Review of the Open Educational Resources (OER) Movement: Achievements, Challenges, and New Opportunities. The William and Flora Hewlett Foundation. Available from http://www.hewlett.org/uploads/files/Hewlett_OER_report.pdf

[4] http://www.udacity.com/, https://www.coursera.org/, https://www.edx.org/

[5] http://www.theguardian.com/education/2012/nov/11/online-free-learning-end-of-university

[6] https://about.futurelearn.com/press-releases/futurelearn-delivers-the-largest-mooc-ever-as-nearly-400000-learners-convene-for-english-language-learning/, http://www.bbc.co.uk/news/education-32721056

[7] https://www.technologyreview.com/s/542201/take-free-online-classes-get-course-credit-at-mit/

[8] http://www.ict-fire.eu

- Study and develop new processes and approaches to online learning based on the integration of FIRE facilities and eLearning technologies.
- Inject into the higher education learning sphere the FIRE portfolio of facilities and tools.
- Introduce the learning community to the concepts of Experimentally Driven Research.
- Increase the overall accessibility and usability of FIRE facilities through the layering of how-to-use resources over the FIRE platforms.

The overall objective of FORGE has been to introduce the FIRE experimental facilities into the eLearning community, in order to promote the concept of experimentally driven research in education by using experiments as an interactive learning and training channel for both students and professionals by raising the accessibility and usability of FIRE facilities. The goal has been to create an open FORGE community and ecosystem where educational resources, collaborative tools and proposed experiments are offered and contributed for free.

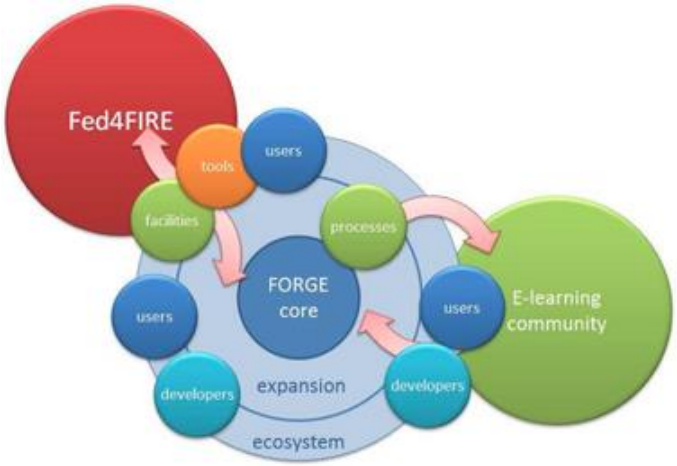


Figure 1: The FORGE approach for bridging the gap between FIRE and education.

FORGE has followed the approach outlined in Figure 1 to introduce the eLearning community to the FIRE experimental facilities and bridge the gap between these two areas. FORGE has created an environment for introducing the eLearning community to the experimentally driven research, but also to act as a training facility for FIRE in general. For this, the FORGE core, which consists of the FORGE project partners, has developed a number of prototype courses. The development of these courses has provided insight in new requirements that have been imposed on FIRE facilities on one hand and on the eLearning community on the other. Additionally, the prototype lab courses have (a) served as exemplars for the educational community (so they can have a look at how these example courses are made when creating their own course) and (b) have also enhanced the access of educators to the FIRE facilities (as the example courses explain how to use FIRE facilities). FORGE has acted as a conduit facilitating the passing of lessons learned to the FIRE facility owners enabling them to enhance their offerings to provide support for educational courses.

FIRE has invested significantly in the last few years in creating its federation. FIRE strives for a harmonization of tools and APIs to facilitate experimentation and the integration of heterogeneous resources around a single experiment under a single account and by using any experimentation tool that the end user wants. All this effort is currently led by FIRE's flagship project, Fed4FIRE (Integrated project, number 318389, funded by the European Commission through the 7th ICT-Framework Programme, 1 Oct. 2012 – 30 Sep. 2016). FORGE has built upon Fed4FIRE's leadership using the project as the main channel to the FIRE facilities. FORGE has thus adopted Fed4FIRE's tools and proposed mechanisms to aid in its role as an intermediary between the learning community and the FIRE facilities and tools.
As shown in Figure 1, the FORGE core has created a set of processes, tools and widgets to facilitate the development of lab courses. The pilot prototype lab courses have generated requirements for learning tools along a number of dimensions, including overall functionality and interaction qualities.

In order to broaden the scope and the usage of the FORGE utilities, an expansion phase was carried out by opening up the FORGE platform and issuing an Open Call. Educators aspiring to exploit FIRE facilities for educational purposes, have responded to the Open Call and contributed to the FORGE ecosystem by developing their own widgets and courseware using the FORGE tools and processes.

1.3. Description of the main S&T results/foregrounds

FORGE aims to introduce the FIRE experimental facilities into the eLearning community, in order to promote the concept of experimentally driven research in education by using experiments as an interactive learning and training channel for both students and professionals by raising the accessibility and usability of FIRE facilities. The goal is to create an open FORGE community and ecosystem where educational resources, collaborative tools and proposed experiments are offered and contributed for free.

Next sections present the main S&T results of FORGE. Last section presents the main objectives of the project and where each one contributed to the main objectives.

1.3.1 FORGE Methodology

The methodology for creating FIRE courseware that has been developed in FORGE guides a course designer that want to include a FIRE facility, from defining the course all the way up to deploying it, considering the educational and technological requirements. The methodology describes the steps that have to be taken in order to create and/or reuse a course within the FORGE context. Figure 2 presents these steps, describing two main stages: a) the course preparation, where the course designer must identify the requirements for the course and b) the FORGE supported activities, where depending on the identified components in stage a, different components will be set.

Educational objectives or learning outcomes cover knowledge, skills and personal, social and/or methodological abilities that a learner should have acquired when successfully having finished a learning opportunity. To develop a course, the course designer must identify and/or define several context components that will affect the course development and deployment since the most suitable FIRE facility and FORGE tools will be adopted based on these components. The most relevant components are: Dates, Number of students, Geolocation and connectivity, Computational devices to be used, Language, Financial matters and Identification of FIRE facilities.

The FORGE supported activities are activities supported by the FORGE tools, which help the course designer to determine what widgets (the interface with the experiment) and adapters (the interface with the facility) to use. The FORGE project has organized and categorized all its components and content in such a way that all interested parties can search, locate and reuse existing software, resources and educational content without the need of creating everything from scratch. It is definitely worthwhile to have a look at the existing widgets and adapters that were created for previously made courses. Most widgets and adapters are created in a generic way, allowing them to be readily (or with minor changes) used for other courses or other facilities and they are released as open source. FORGE offers a large variety of tools and content that has been designed by multiple organizations across Europe. All interested parties are recommended to check the FORGEStore marketplace for any apps, widgets, adapters or even complete courses that they can download and use for their needs, before they start creating their own courses.

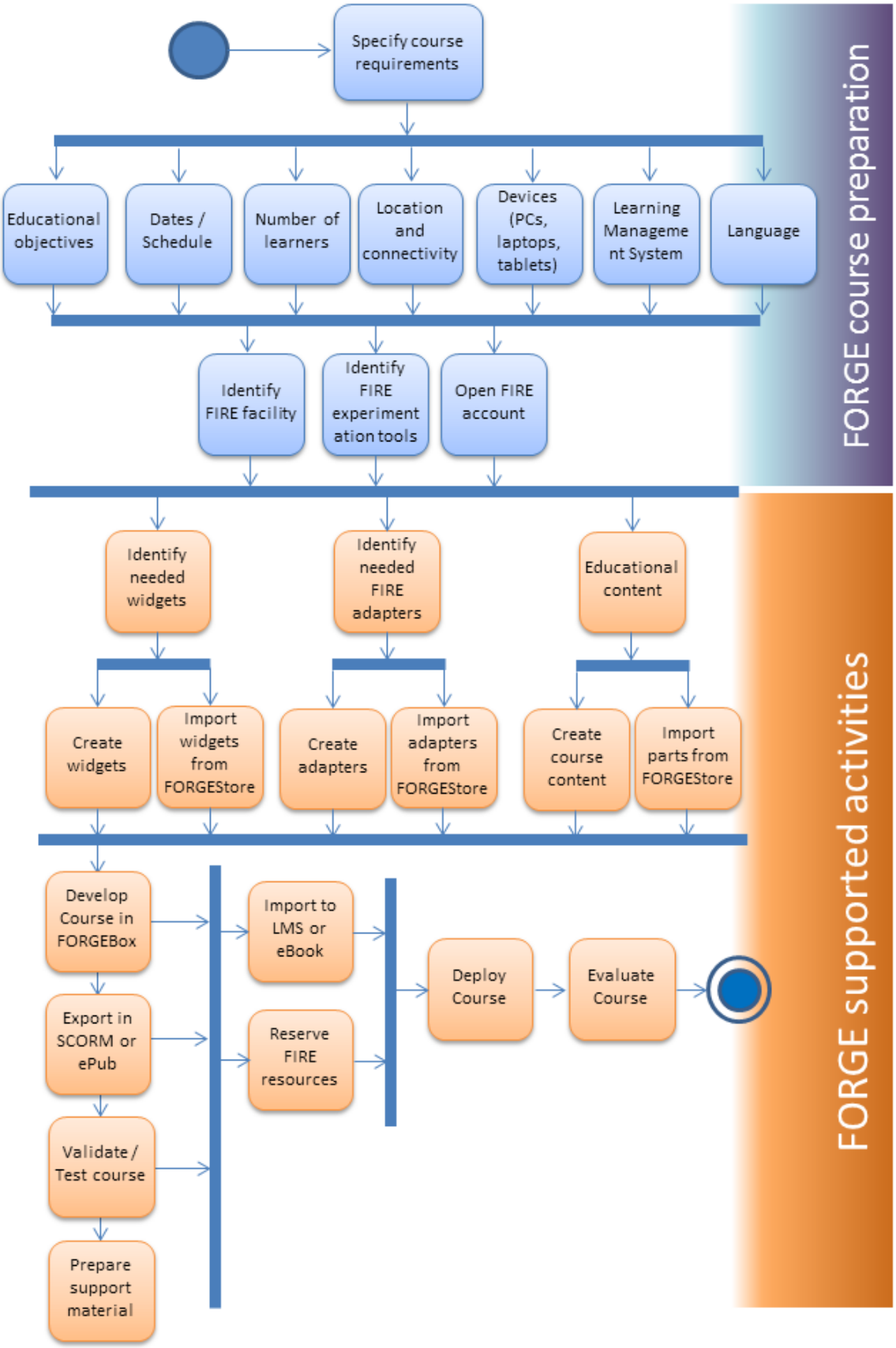


Figure 2: FORGE methodology

1.3.2 FORGEBox

FORGEBox is the component that interconnects learning interactive content with Future Internet Research and Experimentation (FIRE) resources. It comprises a set of services that will provide and host the interactive content of widgets, and interface with the FIRE resources via well-known FIRE APIs or with the Fed4FIRE portal. Learning Management Systems (LMSs), eBooks and any future element that wishes to consume FORGE content, will need to discover reference points of widgets and Lab Courses descriptions (Figure 3). FORGEBox instantiations can provide the host of such interactive content.

FORGEBox is a collection of services provided by FORGE in order to ease the development, management and execution of Lab courses. FORGEBox is a collection of deployed services ready to be used in the premises of organizations wishing to support FORGE enabled courses. The following actors using and interacting with the envisaged FORGE tools and services are supported by FORGEBox. The defined roles are:

- Learner: is the actor who utilizes FORGE provided tools and services in order to learn a specific subject following a course supported by some FIRE infrastructures.
- Lab Course Designer: the actor responsible for designing a course and implementing it by using learning material (e.g. text, figures, videos), widgets and FIRE adapters.
- Lab Course Assistant / Teacher: responsible for the normal execution of a course. Lab Course Assistants/Teachers have different responsibilities, such as creating accounts for FORGE learners, scheduling and reserving FIRE resources (if not carried out automatically when a Learner starts a course), delegating control.
- Widget Provider: develops and maintains widgets (usually for web consumption) providing a user interface for learners to manipulate the experimentation environment.
- FIRE Adapter Provider: develops and maintains FIRE adapters, deployed into FORGE services like FORGEBox.

Widgets have been conceived as the means to present tools and infrastructure access in a more friendly way, via web tools independent of the underlying platform. FIRE Adapters will try to wrap and adapt FIRE APIs to a set of common tools (scripts, libraries) used by these widgets. Therefore FORGEBox is an environment (in terms of middleware) provided in order to host widgets, FIRE Adapters and any tools and utilities that will ease the proposed FORGE methodology.

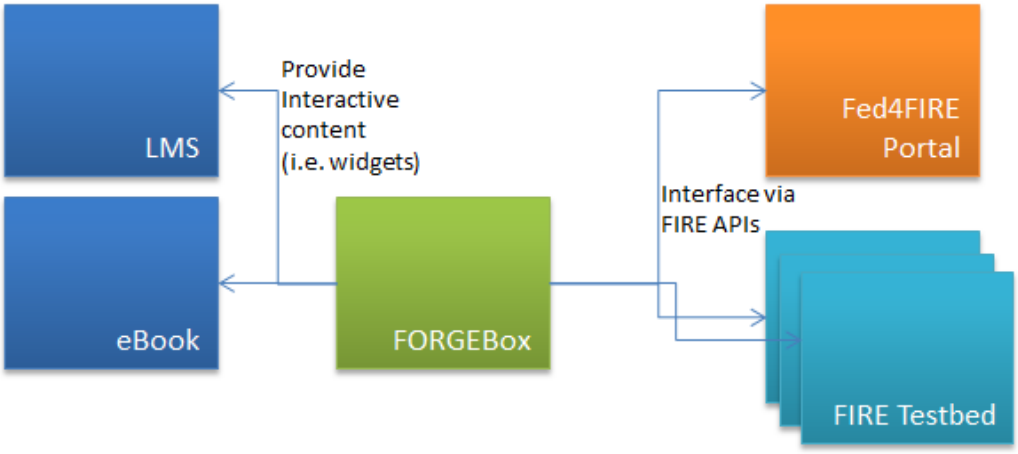


Figure 3: FORGEBox interconnection view

FORGEBox in its birds-eye architectural view is the component that interconnects learning interactive content with FIRE resources. It comprises a set of services that will provide and host for example the interactive content of widgets, and interface with the FIRE resources via well-known FIRE APIs or with the Fed4FIRE portal. LMSs, eBooks and any future element that wishes to consume FORGE content, will need to discover reference points of widgets and Lab Courses descriptions. FORGEBox instantiations can provide the host of such interactive content.

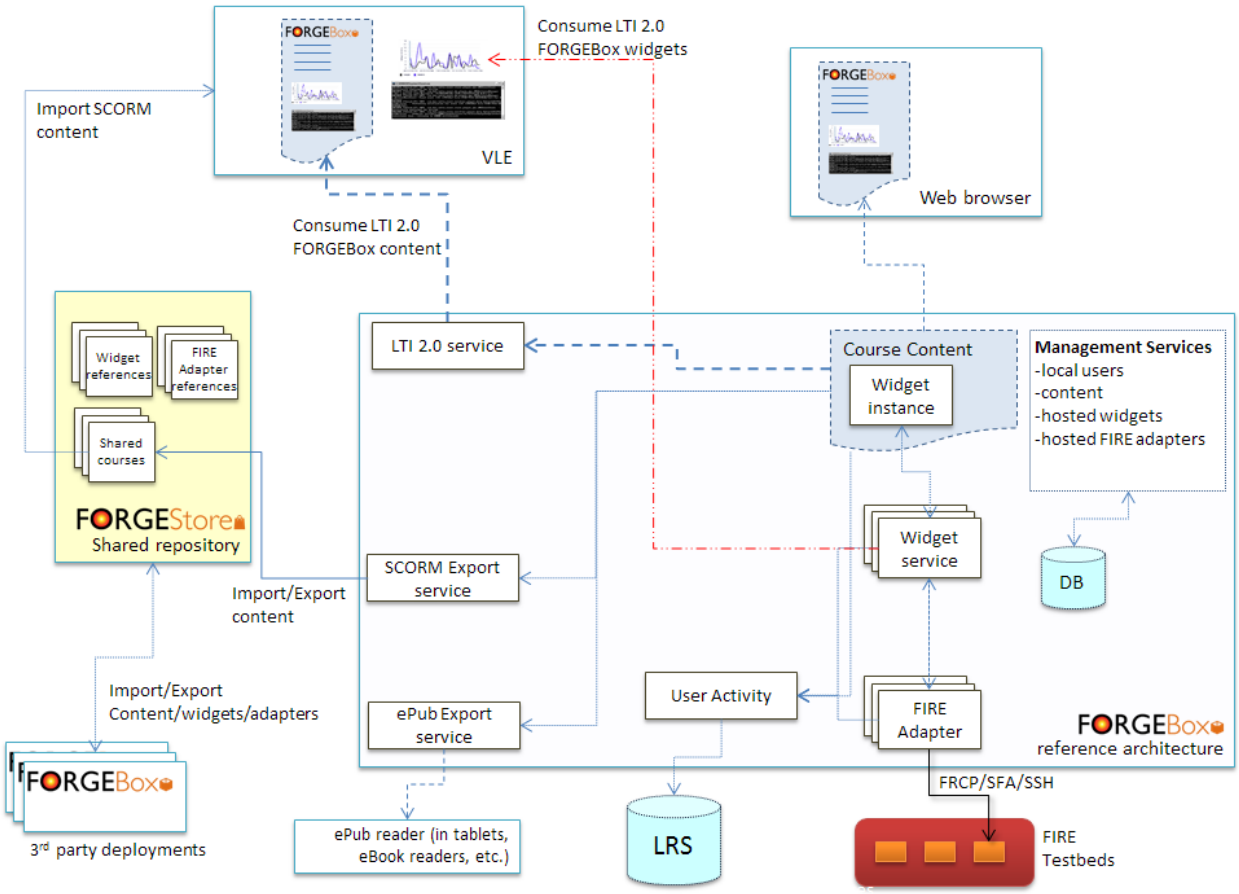


Figure 4: Our FORGE architectural approach

FORGEBox is our reference architecture for the FORGE middleware technology, capable not only to mediate between eLearning tools and FIRE facilities, but also to facilitate several use cases. At a minimum, a main usage of a FORGEBox is to host widgets and FIRE Adapters, acting like a gateway, thus making it capable to offer courses on top of FIRE.

A step further is to offer some minimum functionality of creating course content by easily integrating it with interactive elements like widgets. Many existing solutions can offer content, from a simple Drupal installation to a full LMS like Moodle. The Web first approach followed by FORGE, allows publishing to virtually any platform: Modern web browsers, any LMS, ePub3, Apple iBooks. Still a FORGEBox requirement is to integrate the content with widgets and be interoperable with existing technologies. Thus to support the above, two known eLearning technologies are adopted: SCORM and LTI2.0. Another consideration for FORGEBox was the adoption of Learning Analytics especially while interacting with resources from FIRE facilities. Learning analytics aims to collect and analyse user activities to make learning more effective and efficient. FORGE considers learning analytics services in order to provide means to track user activities and analyse this tracked data. This provides the foundation for guidance mechanisms for students, as well as intelligent decision support for teachers and lab owners.

1.3.3 Interoperability with LMSs and VLEs

Integrating FORGE technology with tools that organizations are using for deploying their courses, such as advanced Virtual Learning Environments (VLEs), will increase FORGE's impact. Therefore within FORGE we considered:

i) how FORGE content can be easily consumed by VLEs
ii) how widgets/FIRE Adapters can seamlessly exchange user information with the VLE and be integrated with the content provided by a VLE.

The technologies considered for interoperability with VLEs are:

- The Learning Tools Interoperability (API) and its latest version 2.0;
- SCORM packaging.

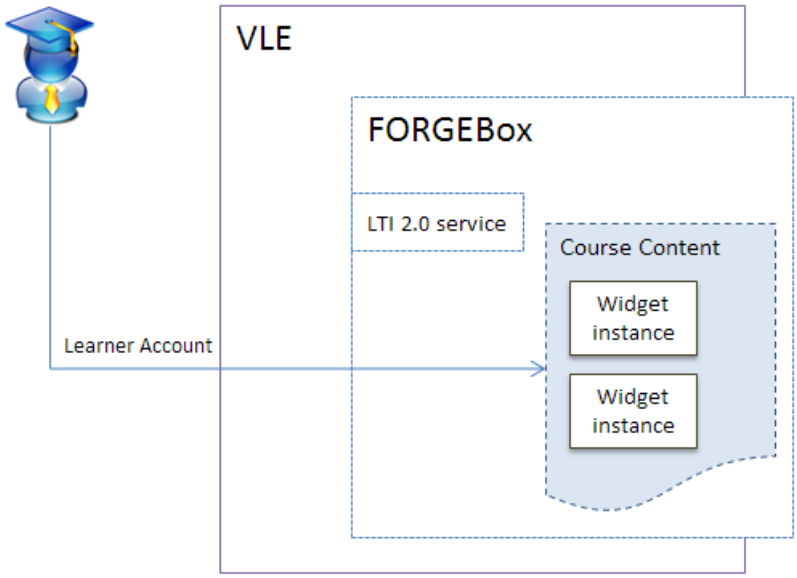


Figure 5: A VLE user access to a FORGEBox course through LTI

The Learning Tools Interoperability (LTI[9]) is a specification that standardizes the APIs between LMSs and external tools, enabling external tools to function as if they were native tools inside the LMS. The LTI specifies a standard way of integrating learning applications with platforms like LMSs, portals, or other educational environments.

Usage of LTI in FORGEBox is to support interoperability scenarios in order to allow LMSs/VLEs to consume course content directly from a FORGEBox instantiation. This is useful in cases like the www.forgebox.eu deployment, where FIRE courses are hosted in a FORGEBox. In this case the whole FORGEBox will be offered as an LTI Tool Provider, thus the VLE will be able to consume the whole course together with its interactive widgets. For such cases, the VLE administrator will need to register the VLE to FORGEBox as a tool consumer and need to select courses that will be offered through the VLE. Any interactive content provided by widgets will function the same as it works when providing the course directly from FORGEBox. An advantage of this approach is the direct simple consumption of a whole course with interactive elements and no further configuration.

Figure 5, displays how a FORGEBox course is displayed in an LTI compatible VLE (e.g. Moodle) . The VLE via LTI is a Tool Consumer and FORGEBox is a Tool Provider. Through LTI user information is exchanged and thus VLE users are able to access a FORGEBox course.

SCORM usage makes FORGE generated content much more easily to share. The difference here is that the FORGE course content with the widgets will be imported within the LMS/VLE and used by learners from the LMS/VLE directly as they normally use other LMS/VLE content. The problem here is that widgets cannot exchange user information, like LTI, and the administrator of the LMS/VLE need to configure extra information when integrating it with the LMS/VLE. SCORM does not offer the seamless connection of web-based, externally hosted applications and content like LTI does.

[9] http://www.imsglobal.org/lti/index.html

Nevertheless, an advantage is that SCORM is a simple way to exchange FORGE course content with many learning environments. The disadvantage is that the course is just copied to the new LMS/VLE and it is not easy to pass user information.

1.3.4 Support for Learning Analytics

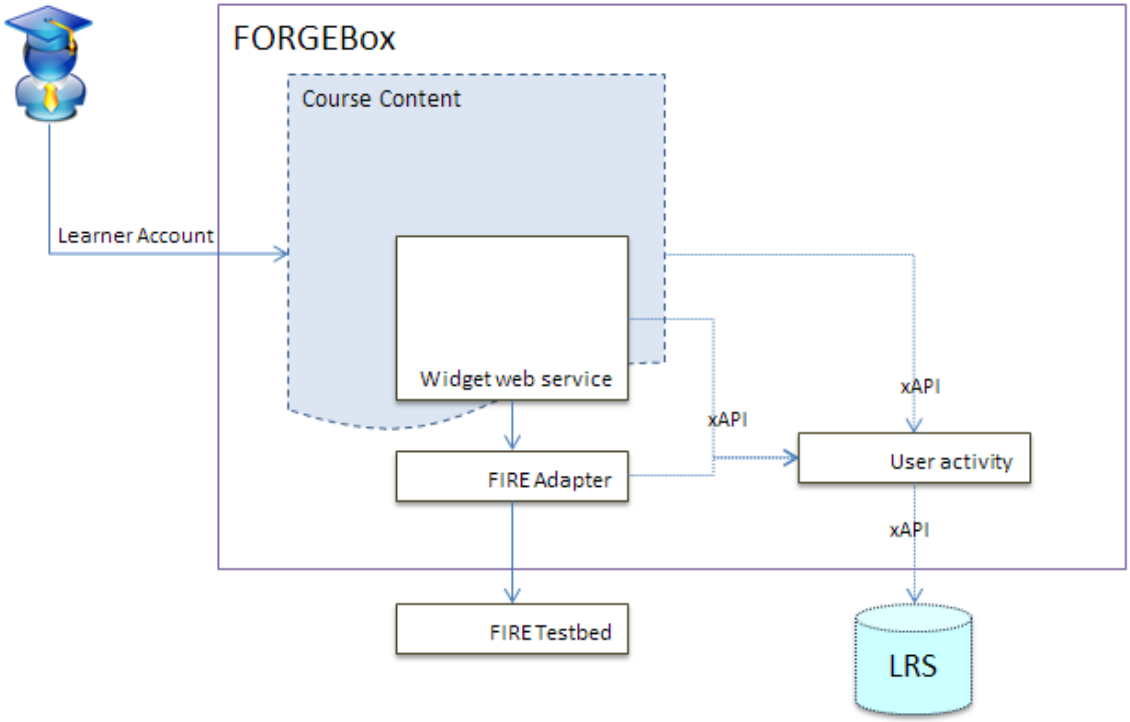


Figure 6: Enabling Learning Analytics in FORGE entities

Learning Analytics is the "measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs". With Learning Analytics in FORGE it is possible to obtain valuable information about how learners interact with the FORGE courseware, in addition to their own judgments provided via questionnaires. Learning Analytics in FORGE is based on tracking learner activities, which consist of interactions between a subject (learner), an object (FORGE learning activity) and is bounded with a verb (action performed).

To support monitoring and reporting user activity, the FORGE architecture includes components that embrace the usage of Learning Analytics. The idea is to know when and which user experienced some content or interacted with a resource. Within FORGEBox we promote the usage of Experience API (xAPI, also known as the TinCanAPI): a specification for learning technology that makes it possible to collect data. There are many open source implementations around xAPI for many well-known programming languages. xAPI is the FORGE choice to build its Learning Analytics.

While learners experience a course, xAPI generates learning records. A Learning Record Store (LRS) is a data store system that serves as a repository for xAPI learning records. Therefore the presence of an LRS is mandatory in the FORGEBox reference architecture. Usually it is very easy for developers to use an LRS, since it is a simple RESTful endpoint where users that want to track their learners have an account.

1.3.5 Deploying FORGEBox

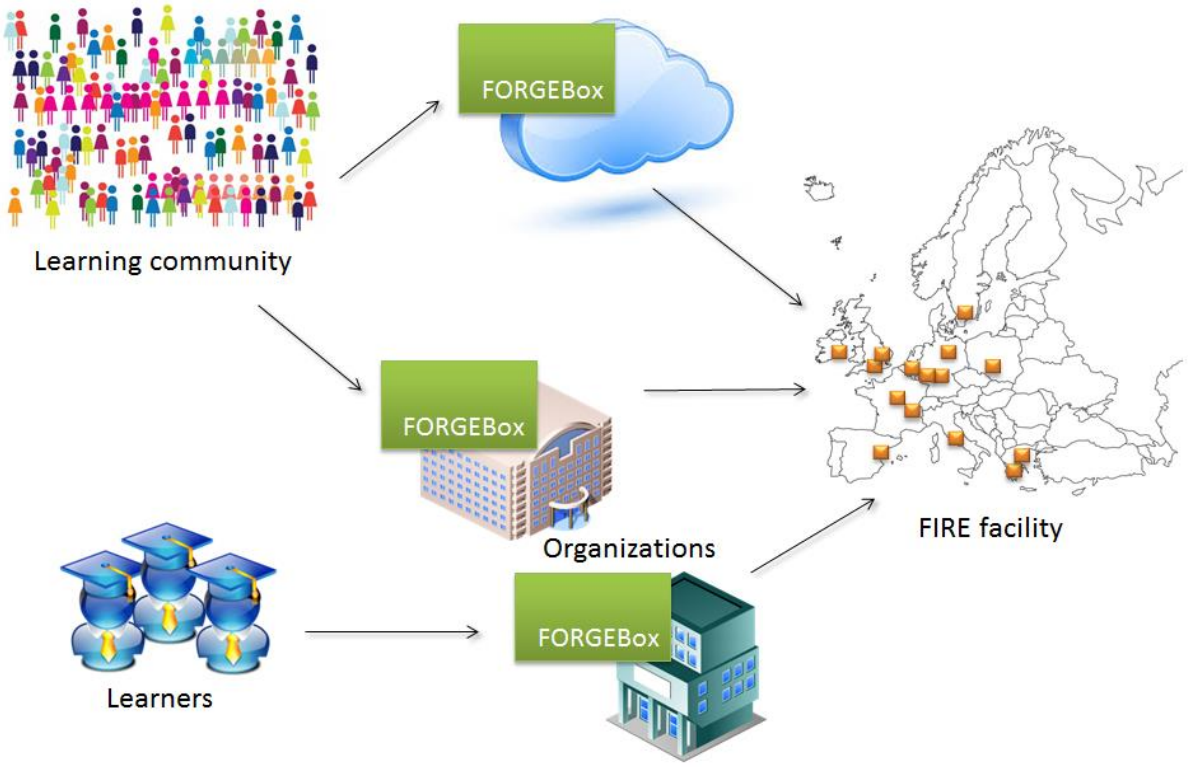


Figure 7: Envisaged scenarios for deploying FORGEBox

Figure 7 presents how FORGE plans to use the FORGEBox solution and it services. A FORGEBox might be hosted by an organization offering certain courses to its learners, installed in organizations datacentre or dedicated nodes. It can also be hosted by organizations (like the OU) that want to provide access to a larger community of learners. Finally, a cloud deployment will be also possible, supporting learning communities in larger scale. When having FORGEBox installed under a certain domain (e.g. myforgebox.example.org) the Lab Courses can have a target to reference for locating content.
FORGEBox is open sourced at: https://github.com/bakkostas/ForgeBox

1.3.6 FORGEStore

FORGEStore is a marketplace for the users' FORGEBox installation. FORGEStore hosts the following types of learning resources:

- Widgets that offer direct access to FIRE experimental facilities and can be readily used within lab courses;
- FIRE adapters that provide APIs to FIRE experimental facilities thus facilitating the development of widgets;
- Lab courses that make use of FORGE widgets and adapters.

All items are developed by the FORGE team members as well as external stakeholders that are interested to create and share learning material for FIRE experimentation.
Figure 8 displays the overall architecture of FORGEStore. There is a backend API Web service that offers a RESTful style API producing/consuming JSON data. The repositories host widget, FIRE adapters and courses metadata, as well as implementation artefacts. That is:

- compressed installable files of FIRE adapters,
- SCORM packages for courses.

Through the API the frontend web UI is supported, as well as the FORGEBox deployment and any other 3rd party consumers of the FORGEStore artefacts, like e.g. an LMS that would like to download a SCORM course.

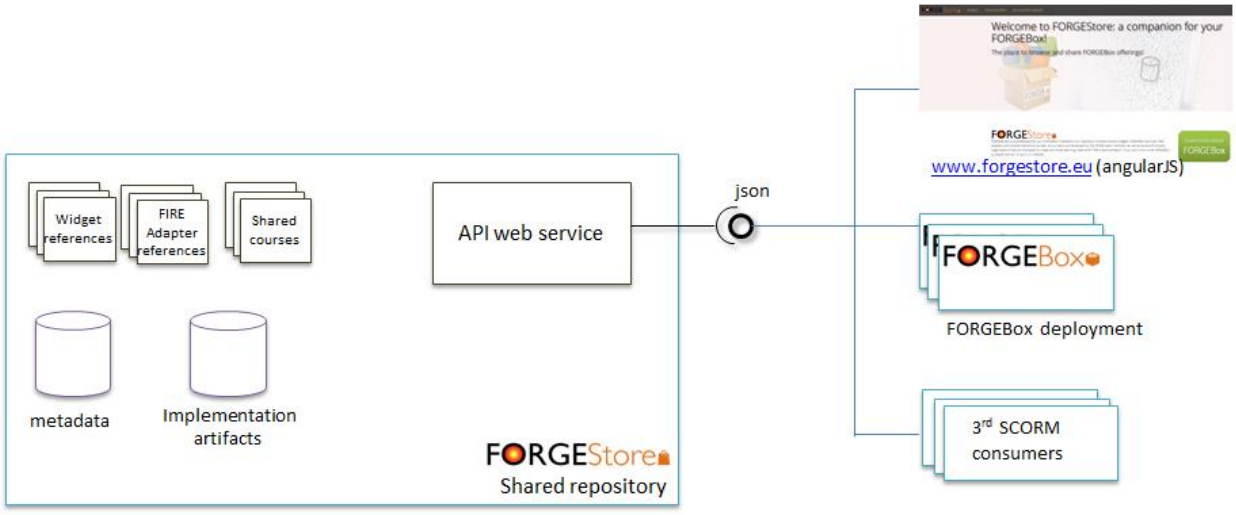


Figure 8: FORGEStore high-level architecture

A running instance of FORGEStore (see Figure 9) can be found at http://www.forgestore.eu with the API endpoint at http://www.forgestore.eu:8080/fsapi/

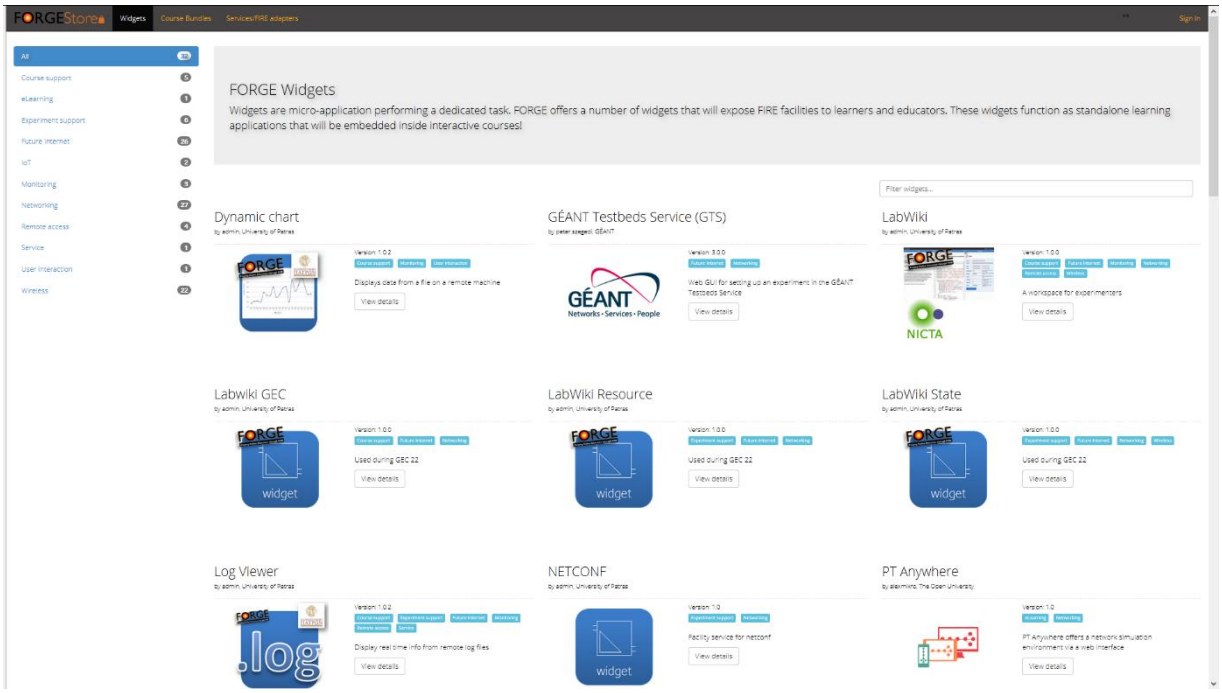


Figure 9: FORGEStore.eu

Both FORGEStore API and FORGEStore web UI are open sourced at: https://github.com/ctranoris/forgestore

1.3.7 Widgets

A **widget** is a micro-application performing a dedicated task. Figure 10 refers to widgets as FORGE uses within the courses: consumable web applications that are hosted in a web server interacting with remote resources. In FORGE case, they are also a bind with FIRE adapters, the services that handle communication with remote FIRE resources. Next, when we refer to widgets, we refer to this combination of web content and backend support for remote interactivity through FIRE adapters.

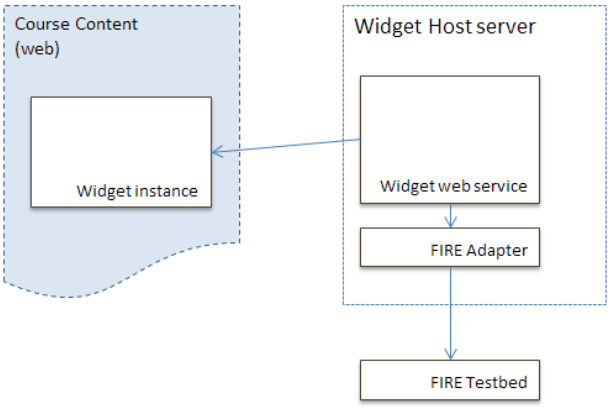


Figure 10: Widgets consumable web applications that are hosted in a web server interacting with remote resources

FORGE developed a number of widgets that exposes FIRE facilities to learners and educators. These widgets function as standalone learning applications that will be embedded inside web pages, eBooks or more general formats like the ePub, as well as inside online courses that are delivered via Learning Management Systems (LMSs). Widgets developed both by project partners and by external contributors are available to the public (through FORGEStore) so that they can be downloaded and reused in different learning contexts.

Figure 12 displays our proposed reference architecture for a widget, with architectural components that a developer would need to implement in order to achieve the best desirable result of bridging learning with FIRE remote resource interactivity. Since widgets are web services hosted somewhere on the Internet ready to be consumed by other web content, the architecture defines both the widget UI as well as the backend domain logic and core architectural components. Widgets should support different user roles (Learners, Instructors, VLE administrators) and behave different according to user roles (i.e. different UI for Learners and Instructors/Teachers).

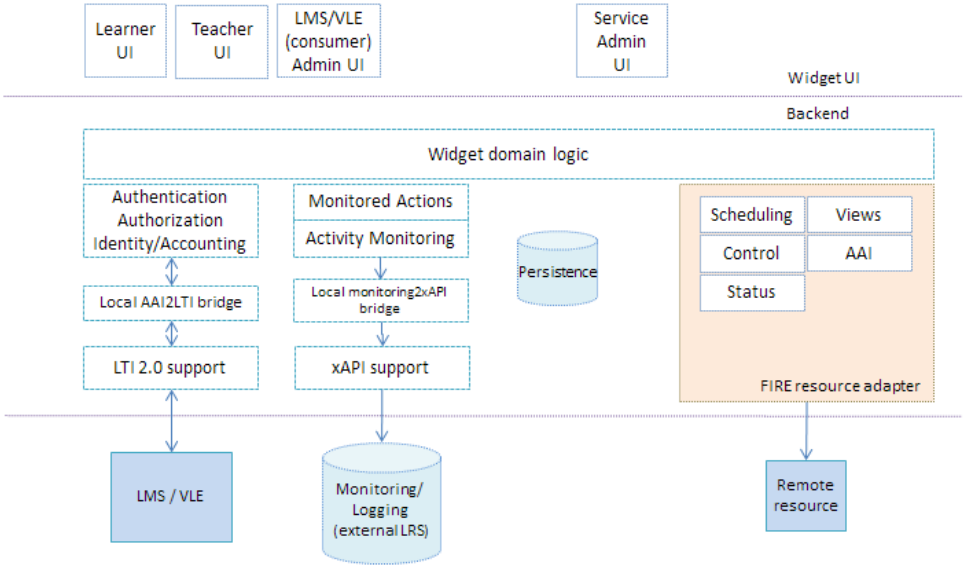


Figure 11: Reference architecture for a widget

1.3.8 Widgets as LTI Tool Providers

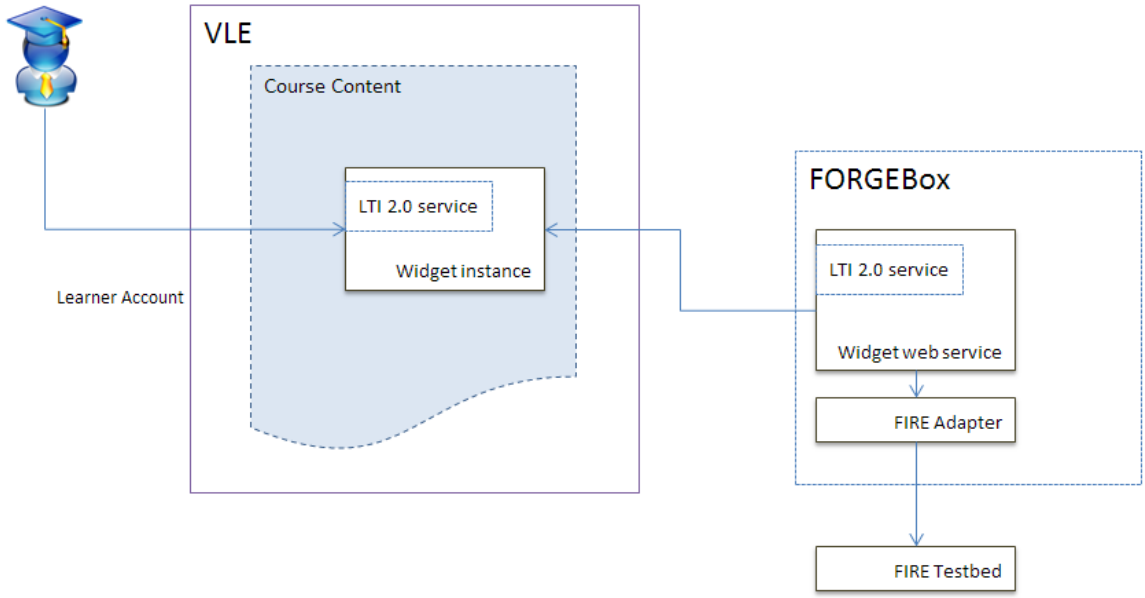


Figure 12: Widgets themselves support the LTI standard

Another way to support interoperability between FORGE technologies and LMSs/VLEs is that widgets themselves support the LTI standard. Although this requires some extra implementation effort by the widget developer, LTI will allow widgets to be securely connected to the LMSs/VLE in a standard way without having to develop custom integrations. A widget therefore will have access to all the features and user information available from the LMS/VLE such as user account, and could also be used to provide feedback about user activity directly back to LMS/VLE.
LMS/VLE Administrators are responsible for registering a widget to their LMS /VLE. When a teacher is creating a course within the LMS /VLE, he needs to integrate and configure the widget with the course content.
An advantage of the widgets supporting LTI is that LTI provides flexibility to lab course designers.The next example image shows where a widget is directly consumed by Moodle.

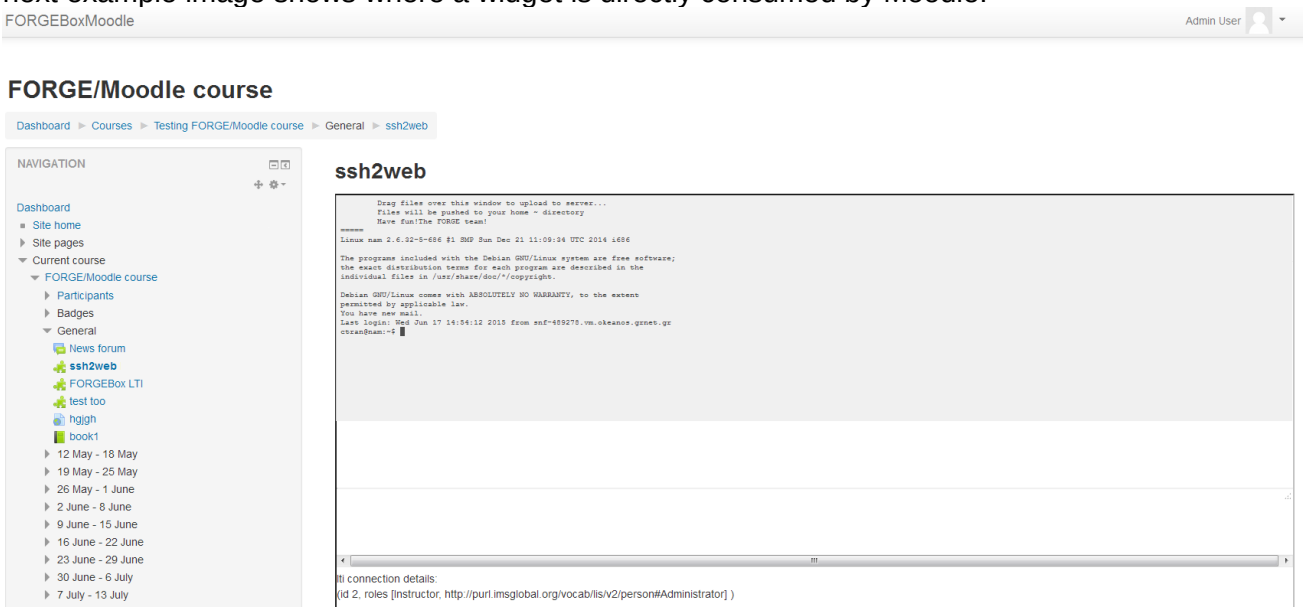


Figure 13: The ssh2web widget is consumed in Moodle via LTI 2.0

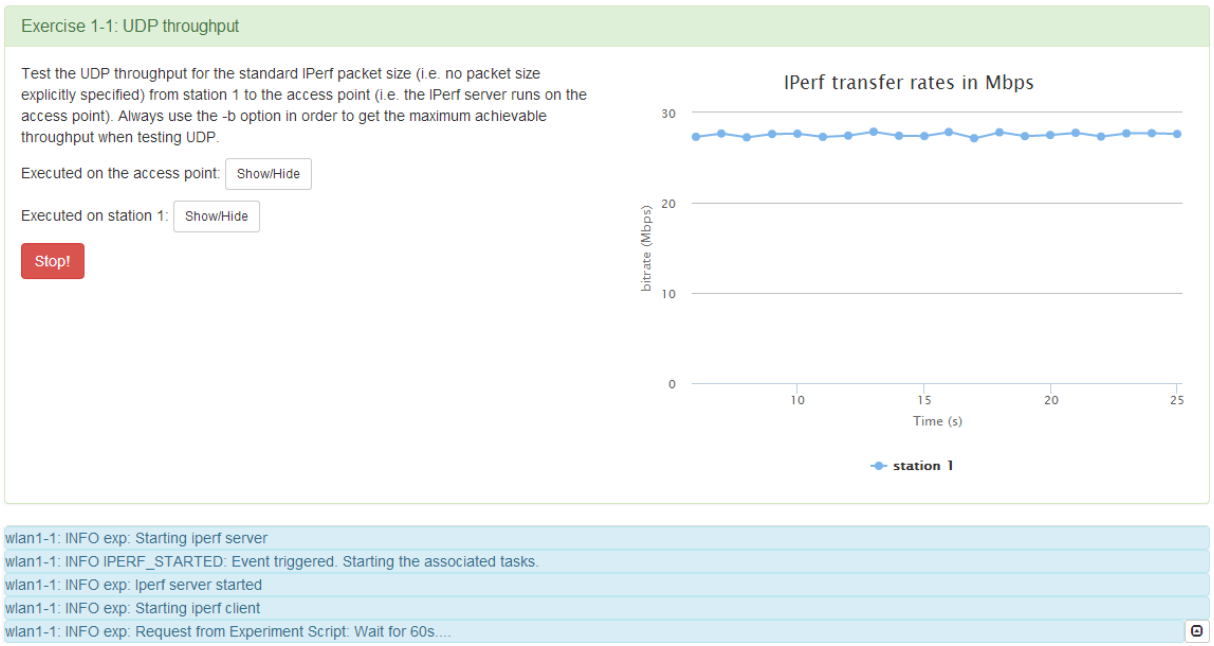


Figure 14: example of widget used in WiFi course

All three components of the iMinds widget bundle in a single view
There are about 30 widgets registered in FORGEStore.eu

1.3.9 FIRE Adapters/Services

A **FIRE adapter** is a service that enables a widget to communicate with the FIRE facilities with the functionality that is required for usage in an eLearning context. To this end, FIRE adapters will try to interact with the 'Fed4FIRE APIs' and 'Fed4FIRE tools' and offer content to a widget.
FIRE adapters can have different functionalities:

- Extend or add functionality of Fed4FIRE APIs and Fed4FIRE tools (only if needed and not possible within the scope of Fed4FIRE).
- Wrap the communication with the Fed4FIRE APIs and Fed4FIRE tools into a different format when required (e.g. to call Fed4FIRE APIs and tools from within a web page).
- Use FIRE Adapters to setup and reserve resources. FIRE adapters are also used by lab course designers and lab course assistants to do tasks like resource setup and resource reservation before allowing learners execute experiments.
- Use FIRE Adapters for Learning Analytics. A FIRE Adapter can track user actions and record these in a Learning Record Store. To enable this functionality within FORGE, we use existing Learning Analytics APIs (e.g. the Tin Can Experience API).
- Use FIRE Adapters for security. As the adapters let users connect with the FIRE resources, the adapters can restrict specific user actions. For example they could track malicious commands, sent by learners towards an experimentation machine, and avoid their execution.

A number of FIRE Adapters has been developed from FORGE partners as well as from the Open Calls. These are:

- "TCP Congestion Control" by UoP
- "A hands-on Wireless LAN connectivity course" by iMinds
- "A hands-on experience with Application layer protocols and how to provide a reliable data communication" by NICTA
- "Metrology of the Internet" (METRO) by INRIA, supported by UPMC
- "Impact of geographic distance on HTTP traffic" by UPMC

- “Project-based learning for master level students” (PRO-LEARNING) by Universitat Politècnica de València, supported by iMinds
- “GÉANT Testbeds Service – User Certification Programme” (GTS-UCP) by GÉANT Association, supported by Open University
- “FORGE-based Local Area Networks” (FORGELAN) by Universidade de Brasília (UnB), supported by iMinds and Trinity College Dublin
- “Education on Analytics over IoT Data Streams through FIRE” (IoTSTREAMS) by University of Ioannina, supported by University of Patras
- “Enabling Video Streaming Education using FORGE” (ENVISAGE) by University of Thessaly, supported by NICTA
- “Wireless Networks course in Spanish” (WN_SP) by Tecnologico Nacional de Mexico, supported by iMinds and Trinity College Dublin

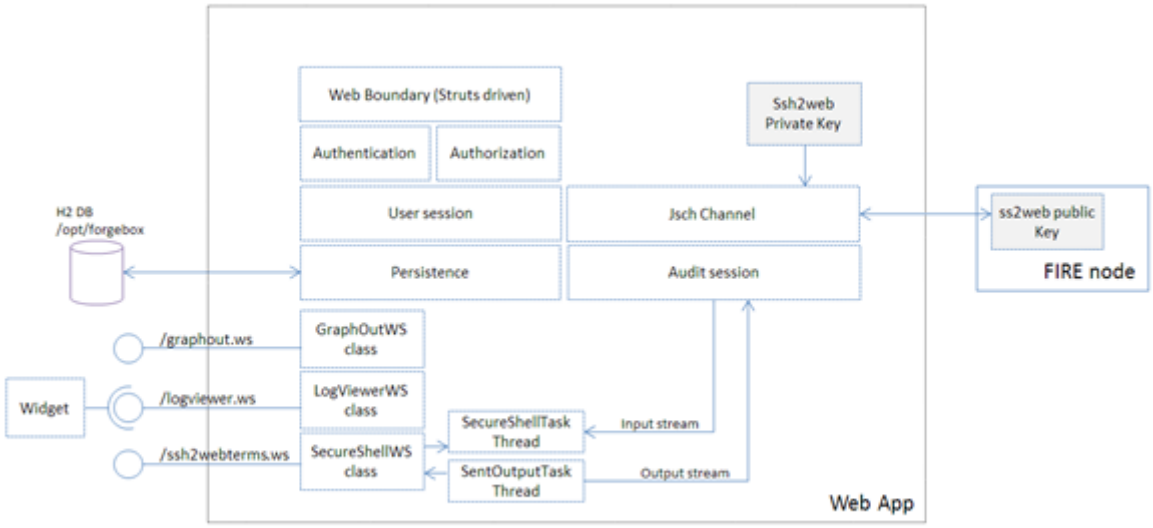


Figure 15: ssh2web service architecture

An example FIRE Adapter is displayed in Figure 15 which describes the architecture of ssh2web web application. The figure presents the core components of the architecture and the way they interact with boundary elements, widgets and remote FIRE nodes supporting Secure Shell access.

1.3.10 Courses

A FORGE course is a self-study learning pathway that leads to achieving certain learning outcomes. Most commonly, the learners will study the course at their own pace, since there is no predefined start or end time.

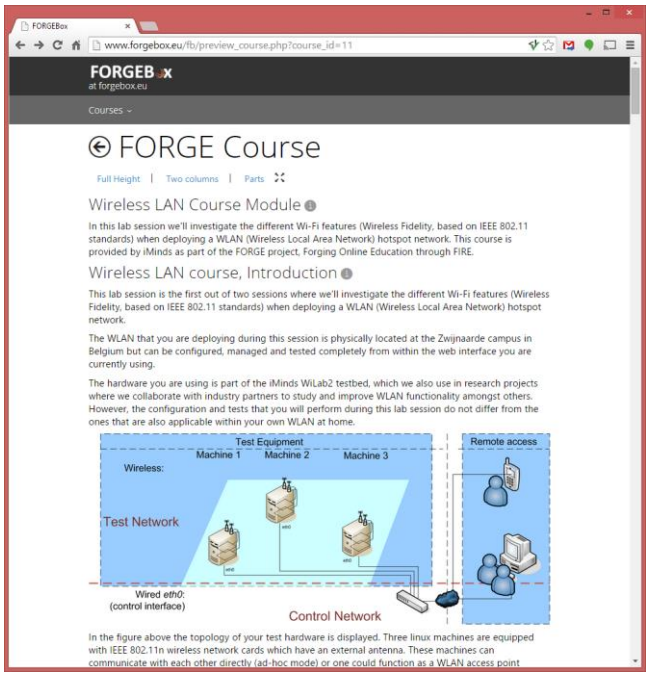


Figure 16: FORGE course deployed in FORGEBox

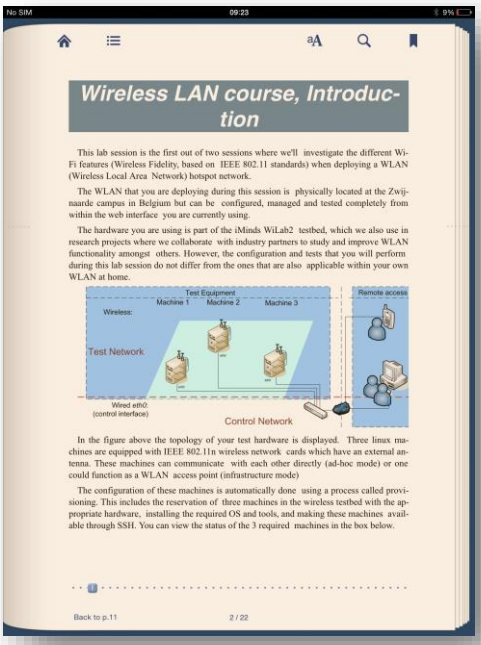


Figure 17: FORGE Course in an open ePub format

At the FORGE deployment phase there are different strategies to follow. These include:

- Course installation on FORGEBox.eu. This has the benefit of using LTI and Learning Analytics. The drawback is that you need to use a separate LMS system.
- FORGE has a Moodle installation that can consume LTI courses and offer FORGEBox Learning Analytics. The drawback is that this is a shared installation and also the sustainability of the course is not guaranteed.
- If it is possible create support pages and Widgets/Adapters that target instructors and facilitate course deployment and FIRE testbed setup. This is why the activity of "preparing support material" was added to the "FORGE Supported Activities" process of the methodology in Figure 1. This process includes the preparation and development of Course Support Web Pages, Widgets/FIRE Adapters that enable the course/testbed setup.
- It is recommended to adopt the Sharable Content Object Reference Model (SCORM) or use FORGEBox to export SCORM functionality directly and share the course through FORGEStore.

Table 1 List of FORGE Courses

Course	Partner Responsible	No of Courses Run	No. of Participants (to date)	Date
Orthogonal Frequency Divisional Multiplexing (OFDM)	TCD	9 times	148	Throughout 2015/2016
TCP Congestion Control	UPMC	2 times	318	2014/2015
Wireless Local Area Network (WLAN)	iMinds	7 times	265	throughout 2015 & 2016
Long Term Evolution (LTE)	iMinds	2 times	100	throughout 2015 & 2016

Basic Network Router Configuration	OU	N/A[10]	390[11]	Original release: March 15, 2014. Latest update: April 28, 2016.
TCP Congestion Control Theory	UoP	6 times	>600	2014/2015/2016
Network Management Lecture (Models)	UoP	1	25	
Evolution of HTTP Course	NICTA	3	20	January 16
Network Capacity Planning	NICTA	2	150	June 14
Reliable Transport Protocols	NICTA	3	20	January 16

1.3.11 FORGE iBook

FORGE has developed an interactive eBook in the Apple iBooks format. This is available to download for free via iTunes. The FORGE iBook features selected FORGE courses, which consist of instructional videos, quizzes and self-assessment exercises and offer access to FIRE facilities via interactive widgets.

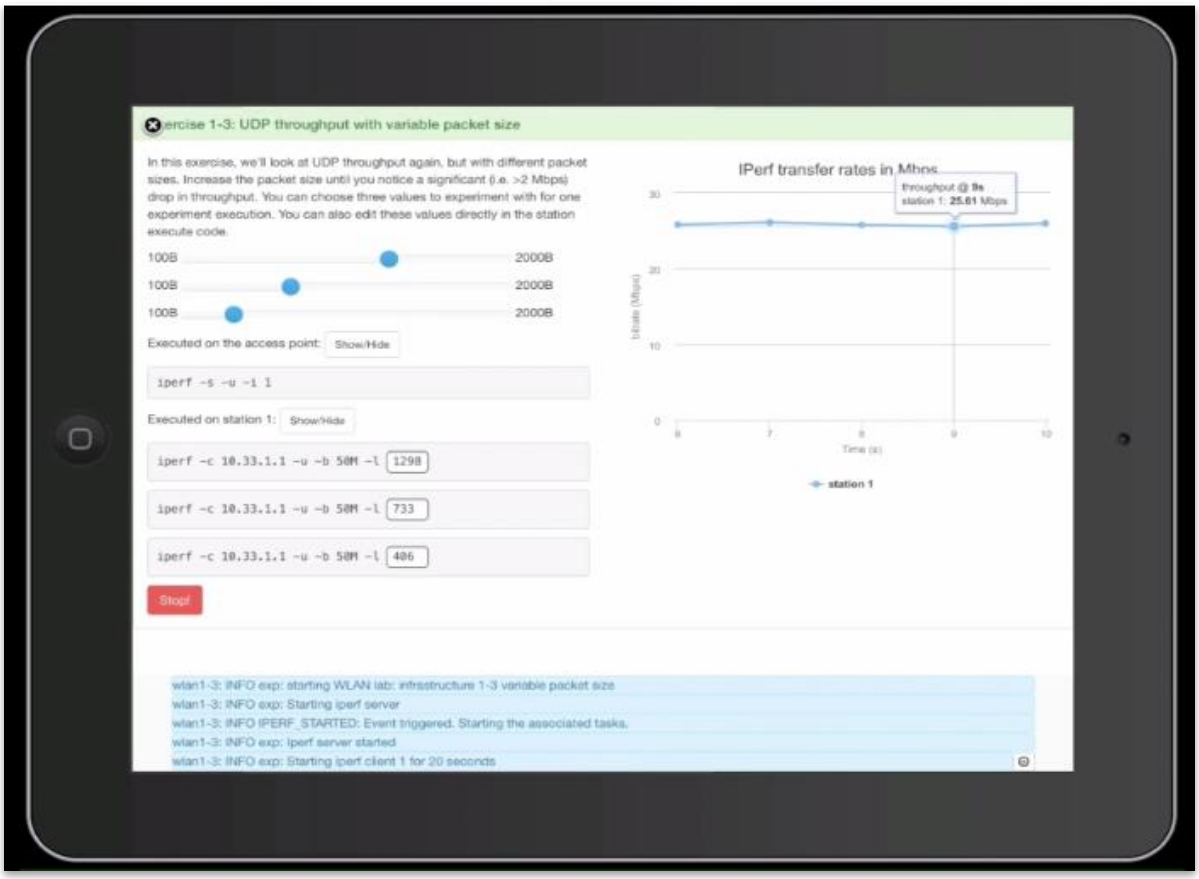


Figure 18: A still from the FORGE iBook teaser video, demonstrating the use of an HTML5 widget inside the FORGE iBook

[10] Delivered as an open course for informal learning.
[11] Number of informal learners that participated in the evaluation of the course (see D5.3).

The iBook contains 6 courses developed from FORGE partners regarding WiFi Networks, TCP Congestion Control, CISCO based Packet Tracer and an advance course on LTE throughput.

Figure 19: FORGE iBook

1.3.12 Teacher Companion Lab courses Widgets/FIRE Adapters

FORGE has developed also technology to support the instructors when deploying a lab course on top of a FIRE facility. A Teacher's companion lab course is a kind of a special Widget/FIRE adapter combination to assist Teachers on easily managing remote lab FIRE facilities for a course. Usually these companions will be built by experts of FIRE facilities. They will be applied over a specific lab course in order to automate some reservation and provisioning processes of the underlying target infrastructure needed by the learners to perform the course. For example the TCP congestion control lab course has a companion for setting easily the setup on iMinds Virtual Wall, regardless the number of users. A Teacher's companion lab service can provide the following features:

Simple predefined testbed setup: Given a simple user interface, teachers will be able to just set the requirements of the lab (i.e. number of students, time schedule, etc.) and the setup will be provisioned to the FIRE testbed

Hide some complexity from FIRE tools: Since these companions will be built by FIRE experts, they can hide all the complexity of setting up specific experiments and exposing only some necessary information just too quickly set up all the needed resources. Usually a FIRE testbed can be set up by tools like jFed, MySlice, or through RSpec specifications. These can be hidden and pre-defined and a FIRE adapter will wrap all the functionality. The only things to expose will be reservation schedule and how many resources needed to be reserved for the course.

Simple reservation scenarios: Resource reservation mechanisms are crucial for a FIRE remote facility because of the limited physical resources. Besides that, teachers want to be able to reserve a FIRE remote facility for a certain period during their class. FIRE tools like MySlice offer aggregated views of resources across testbeds so potentially this functionality could be reused by these companions.

Repeatability of deployment: Having these companions, teachers are ensured that the same setup can be safely repeated for many lab courses in future.

Portability of deployment: Having FIRE as the basis of making lab courses, the APIs to manage and control resources are the same across different testbeds. Thus a certain setup described by a companion lab recipe could be repeated in a similar FIRE testbed.

Enable scalability: Similar as above, the common APIs of FIRE allow us to smoothly scale the resources if there is an increased demand. Given the federated nature of FIRE, if the resources of a testbed are not enough for a lab course, they could be complemented with resources from another testbed offering similar technology.

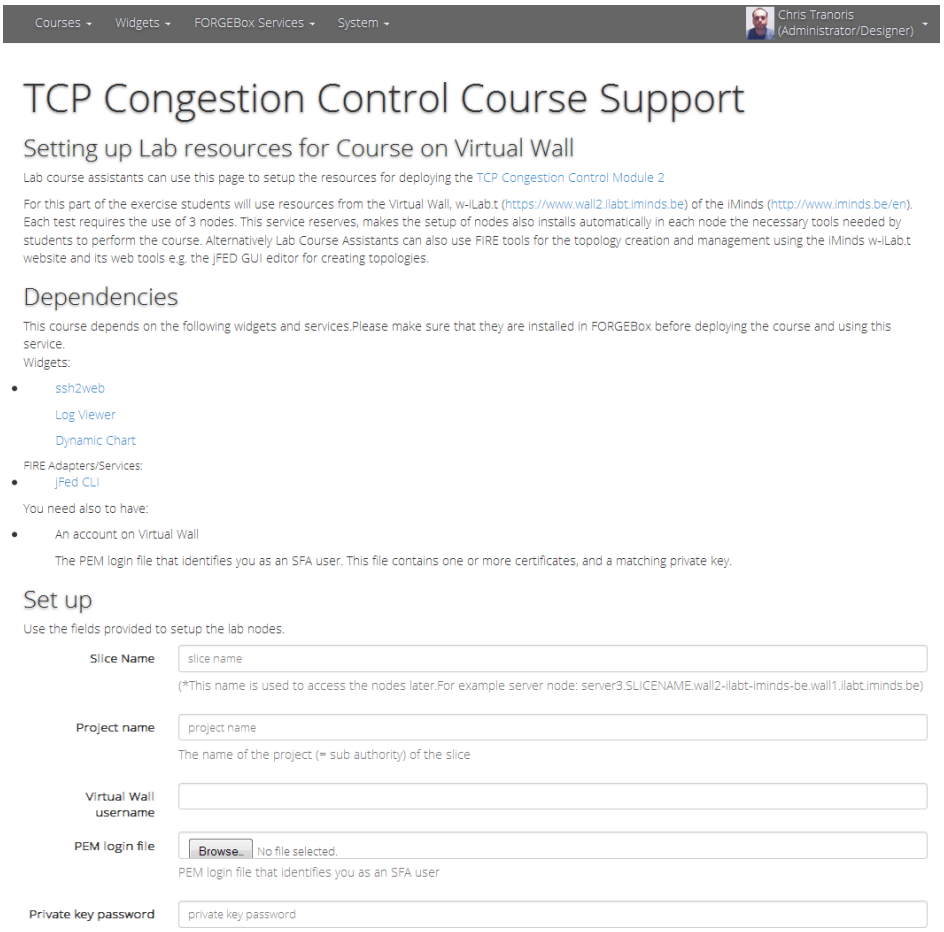


Figure 20: The TCP Congestion Control Course Setup Companion

Prototypes of such companions for FIRE labs are the TCP Congestion Control Course Setup (as Figure 20 shows), which is used to recreate the experimentation environment needed to execute the course for congestion control on the Virtual Wall testbed. Also iMinds developed a w-iLab.t testbed lab course companion service, allowing a teacher to reserve and provision multiple non-interfering wireless instances on the w-iLab.t testbed at a chosen time slot without technical knowledge of the underlying tools and mechanisms.

1.3.13 Mapping to main objectives

This section summarizes FORGE detailed objectives. It provides which FORGE technology and actions addressed each one.

Objective #1: Study and develop new processes and approaches to online learning and remote experimentation based on the integration of FIRE facilities and eLearning technologies.

Objectives	*FORGE technologies, offerings and actions*
Coupling the spheres associated with the online higher education revolution and the FIRE facilities.	*FORGE methodology, FORGEBox, Widgets, Fire Adapters, iBook, Learning Analytics, Interoperability (LTI, SCORM) , FORGEStore*
Opening FIRE facilities in general to wider audiences including learners and educators.	*FORGEBox, Widgets, Fire Adapters, iBook, LTI Interoperability*
Determining the interaction and behavioural characteristics that FIRE facilities need to provide to support online learners.	*FORGEBox, Fire Adapters*

Outlining a roadmap specifying how FIRE tools can be transformed to support online learning at scale.	*FORGE methodology*
Allowing learners to gain hands-on experience with the world-class equipment and experimentation tools that FIRE provides.	*FORGEBox, Widgets, Fire Adapters, iBook*
Promoting the openness and reusability of FIRE facilities to the eLearning community, by making them available as OERs.	*FORGEBox, LTI Interoperability, iBook*
Examining the interfaces of FIRE's federation mechanisms and exploring how resource providers can address the specific resource demands of online courses with potentially large numbers of students.	*FORGE methodology, Fire Adapters,*
Exploring how to best support courses in other disciplines.	*FORGE methodology, Open Calls instrument*
Enhancing the FIRE facilities to support online courseware for the needs of both learners and tutors.	*FORGEBox, Fire Adapters, Teacher Companion Lab courses Widgets/FIRE Adapters*
Investigating how to best introduce the concept of Experimentally Driven Research to the educational community.	*FORGE methodology, FORGEBox*
Developing and promoting the notions of an open learning environment and also constructivist learning models based on FIRE.	*FORGE methodology, FORGEBox, Learning Analytics, FORGE Questionnaires*

Objective #2: Inject the FIRE portfolio of facilities, the associated tools and the concepts of Experimentally Driven Research into the higher education learning sphere

Objectives	***FORGE technologies, offerings and actions***
Complement traditional online courses with interactive laboratory courses supplying an in-depth and hands-on educational experience by redefining the processes associated with Lab Courses which include FIRE facilities.	*FORGE methodology, FORGEBox, Widgets, Fire Adapters, iBook, Learning Analytics, LTI Interoperability*
Redesign eLearning tools and enhance existing Learning Management Systems (LMSs) with new functionalities to enable a seamless interactive experience when accessing FIRE facilities.	*FORGEBox, Widgets, Fire Adapters, Learning Analytics, LTI Interoperability, FORGEStore*
Enable learners to make use of the FIRE facilities from within state-of-the-art online learning tools.	*FORGEBox, Widgets, Fire Adapters*
Identify and document the behaviour and needs of different actors (tutors, lab builders, lab users).	*FORGE Methodology*
Provide a hands-on experience on the latest technological equipment, with evidence of innovative and advanced practice for learners.	*FORGEBox, FORGE courses*
Engage learners to extensively use FIRE facilities and related resources when working on their course projects.	*FORGEBox, Widgets, Fire Adapters,*
Enabling educators to be able to efficiently create, use and re-use FIRE based learning experiences through our tools and techniques.	*FORGEBox, Widgets, Fire Adapters, Teacher Companion Lab courses Widgets/FIRE Adapters*
Enable equity of access to the latest ICT systems and tools independent of location and at low cost.	*FORGEBox, Widgets, Fire Adapters, FORGEStore*

Objective #3: Increase the overall accessibility and usability of FIRE facilities through the layering of how-to-use resources over the FIRE platforms.

Objectives	*FORGE technologies, offerings and actions*
Creating reusable educational content and learning widgets that can be reused by LMSs and eBooks available on tablet devices able to provide an enhanced user experience.	*Widgets, Fire Adapters, FORGEStore, LTI Interoperability, iBook*
Strengthening the culture concerning the use of online experimentation tools and remote facilities and extending this culture to non ICT disciplines.	*FORGE methodology*
Disseminating our processes through the Creative Commons licensing scheme enabling the implementation of open education portals for students and researchers in Academia through which the FORGE environment can be disseminated in the widest possible manner.	*FORGEBox, Widgets, Fire Adapters all offered open source, iBook*
Building, hosting and maintaining a repository of FIRE lab experiments and courses will increase the reusability of FORGE assets across a broad range of courses.	*FORGEBox, FORGEStore, Open Calls instrument*
Supporting the crowdsourcing of FIRE-specific learning materials by the broad educational community thus increasing FIRE's usability	*FORGEBox, FORGEStore, iBook*

Objective #4: An added value for FIRE

Objectives	*FORGE technologies, offerings and actions*
Transforming FIRE into a widely distributed lab ecosystem (FIRE as a Laboratory Service).	*FORGEBox, FORGESTore, Widgets, Fire Adapters*
Providing a single point of entry for training people in the FIRE culture.	*FORGEBox, FORGESTore*
Attracting non-ICT communities as well as multidisciplinary educators and learners.	*Open Call instrument, GoLab collaboration*
Delivering an overall contribution to the future FIRE sustainability as making students aware of FIRE features makes them more likely to use FIRE facilities within their professional (research) career.	*FORGE Methodology, FORGEBox*
Attracting new testbed facilities as they emerge to be included into the FIRE/FORGE ecosystem.	*Open Call instrument*
Enabling the specialized advanced (re)training of researchers, engineers and others within work or home environments.	*FORGEBox, LTI Interoperability, iBook*
Promoting associations between FIRE facility owners and the ICT industry in general leading to new partnership schemes based upon educational use.	*FORGE Methodology*

1.4 Potential impact, the main dissemination activities and exploitation results

1.4.1 FORGE's potential impact

One of the key challenges in (STEM) education is to transition to more active learning approaches such as Inquiry Based Science Education (IBSE), where students are encouraged to take the lead in learning activities and learning is embedded or blended with everyday environments. IBSE has been promoted by the European Commission as a key factor to motivate students in science education – an area highlighted for having an alarming decline in young people's interest despite a continued rise in the importance of data, high demand by employers, and attractive salaries.[12] In their report titled *"Science education now: a renewed pedagogy for the future of Europe",* the EC recommends that *"improvements in science education should be brought about through new forms of pedagogy: the introduction of inquiry-based approaches in schools, actions for teacher training to IBSE, and the development of teachers' networks should be actively promoted and supported."* Furthermore, a recent report from the Massachusetts Institute of Technology recommends that new technologies should be used to support teachers and allow them to free up time from conveying content to focus on high-value in-person interactions with students. This approach aligns with the principles of blended learning, where technologies and teachers cooperate across online and in-person spaces[13].

FORGE has contributed to IBSE via blended learning by responding to the need for remote experimentation in a learning context, in which students are actively learning-by-doing. Live educational experiments can now easily be performed remotely on actual state of the art hardware and software of FIRE facilities, focusing on acquiring deep insight, without time-consuming and troublesome configurations by teachers nor students.

This way, FORGE has brought together the online learning community and FIRE, making FIRE facilities part of the education path. By targeting students we aimed at the next-generation future-internet users who, having learnt through FORGE, have become aware of the FIRE facilities and (part of) their capabilities. By investing in students, FORGE has opened a possible path for FIRE's long-term sustainability. Some of these students are becoming future FIRE users, and they are going to be the researchers of tomorrow regardless if they work as members of industrial or academic organizations. FORGE has increased the usage of FIRE facilities by introducing the European (and worldwide) education sector as a customer group for FIRE facilities. **Thus far, over 2000 students have participated in 'FORGE-enabled' courses!** And while business modelling was not subject to an in-detail study, license fees from educational institutions could constitute a revenue stream aiding the sustainability of FIRE facilities in the long-term. (With reservation, given that it should be further studied to validate the commercial exploitation and viability.)

The next generations of students are intensively using mobile devices such as tablets, smartphones, smartwatches etc. (most probably even further evolving towards an Internet of Things), rather than fixed computer hardware. This is a global trend and is even happening in those areas where traditional computer hardware was not everywhere available. "While education struggles to cope, mobile communication has grown exponentially. Africa is today the fastest growing and second largest mobile phone market in the world. […] These connections offer an opportunity for education. Already, we are starting to see the beginnings of change."[14]

FORGE has immediately adapted to this new reality in numerous ways: our courses are freely available, are responsively built (i.e. they scale in a dynamic and adequate manner towards the screen size and capabilities of the user device), they are available on a multitude of platforms (dedicated websites, Learning Management Systems, e-books etc.), tools are converted for mobile usage (e.g. PT-Anywhere), courses are IPv6-compliant etc.

[12] http://ec.europa.eu/research/science-society/document_library/pdf_06/report-rocard-on-science-education_en.pdf
[13] Online Education: A Catalyst for Higher Education Reforms
https://oepi.mit.edu/sites/default/files/MIT%20Online%20Education%20Policy%20Initiative%20April%202016_0.pdf
[14] http://www.bbc.com/future/story/20120823-what-africa-can-learn-from-phones

Unfortunately today, we still have a growing divide between rich and poor regions in the world. This also translates into the so-called 'digital divide' where state-of-the-art hardware and software is not available to all people. This is true within the European Market (and recognized by the European Union with proposed tools via the Digital Single Market strategy[15]) and is even further accentuated on a world wide scale when comparing developed and developing countries. By enabling the easy usage of state-of-the-art hardware and software of the FIRE facilities into education programmes via FORGE, all students – provided that they have an Internet connection – can now use this equipment and tools, which might be unaffordable by themselves or by their own institution. While the idea of sharing hardware and software was already inherent to FIRE itself, it was practically restricted to well-educated researchers. **FORGE has simplified FIRE usage to enable its inclusion in educational programmes and has therefore extended the reach of FIRE to a much wider audience: all students worldwide** (with a main focus on computer science programmes).

We are proud to state that we have incorporated some of the FORGE lab courses (i.e. the iMinds' WLAN course and TCD's OFDM course) into an engineering master course of a Brazilian University (Universidade de Brasília), via FORGE's Open Call mechanism. This way, FORGE transcended European borders by contributing to the improvement in education in Brazil, which is one of the BRIC countries (i.e. Brazil, Russia, India & China), known to be rapidly developing countries.

"This Moodle integration helped me to keep all class materials conveniently located in the same virtual space (class notes, lab exercises, assignments, etc.). This is great for teaching. I believe that this is a powerful educational tool, and I would certainly use them again, if allowed, in future offerings of this course. I will certainly recommend FORGE tools and methodologies to other faculty as well."

Marcelo Carvalho, Professor at Universidade de Brasília, Brasil – FORGELAN project[16]

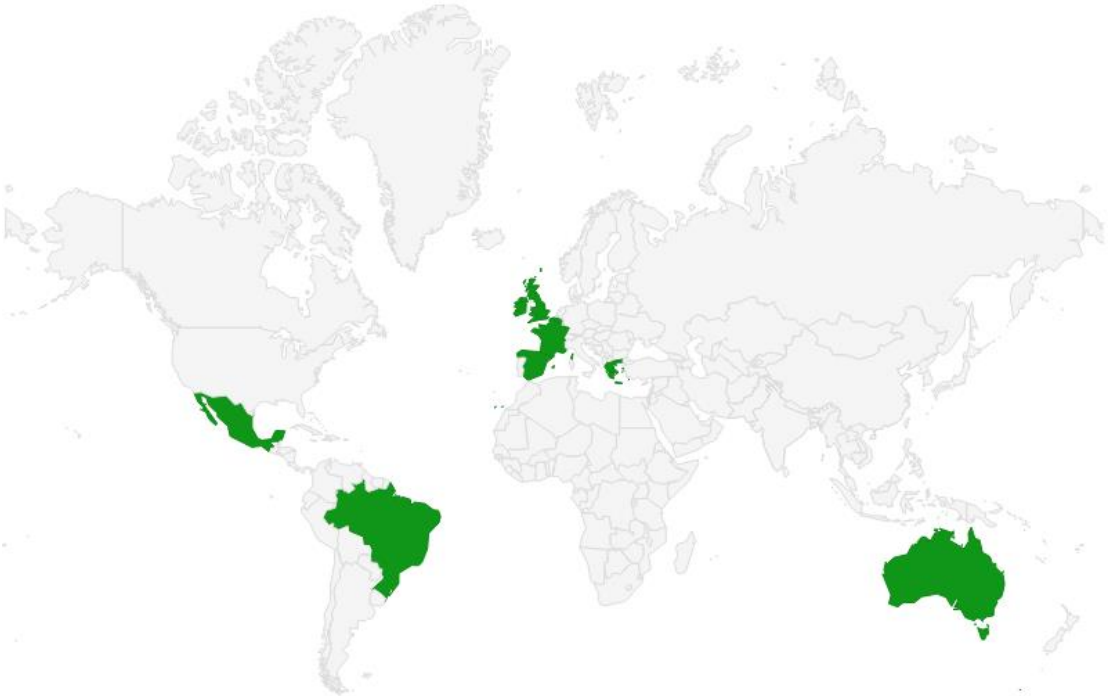


Figure 21: Geographical impact of FORGE - Indication of countries (green coloured) worldwide where students were actively involved in FORGE courses (2014-2016)

[15] https://ec.europa.eu/digital-single-market/en/news/eu-digital-divide-infographic
[16] FORGELAN is a project developed as a response to FORGE Open Call http://ict-forge.eu/opencall/open-call-projects/

1.4.2 Main dissemination highlights

Open Call Courses

FORGE launched an Open Call, which was addressed to stakeholders from the learning community and elsewhere, who wanted to exploit FIRE facilities for educational purposes and contribute to the FORGE ecosystem. Within this initiative, external partners were able to implement experiment-driven courses using FIRE facilities together with the FORGE tools. Four separate rounds for submission of proposals were announced, during which 15 proposals were received. Following the prioritization/evaluation criteria that were set during the process, 9 proposals were accepted for implementation.

The whole process exceeded expectations, both in terms of participation to the call, and in terms of the feedback received from the participants. In specific, the proposals that were submitted and accepted for implementation were more than expected and defined in DoW (according to the Key Performance Indicators in the DoW, the "Number of external Lab Courses, attracted by the Open Call and possibly implementing FORGE approach" was set to 5). In addition, the feedback received from all the parties involved in Open Call process as well as in the execution and delivery of Open Call specific projects has been very positive, both for the actual open call process which ran smoothly as well as for the overall experience with regards to the exploitation of courses.

The Open Call initiative provided an excellent opportunity of increasing FORGE's interaction with the community. FORGE has had significant benefits from working with the external partners, not only in terms of dissemination and sustainability, but also in terms of enhancing and optimising many of its tools and processes based on the valuable feedback that was received by the external users.

It is worth mentioning that the courses will continue to be taught at the Educational Institutions during the following academic years, as depicted in the evaluations of external users. The interest of external users into the project's methodology and approach are described in detail in deliverables D5.3 "Evaluation of the execution of prototype and external lab courses" [M34] and D6.8 "Opening the FORGE platform and engaging the community" [M36].

Table 2 List of Open Call Partner Courses In Development, Developed, and Executed (M1-M36)

Course	External Partner Responsible
METRO MOOC: Metrology of the Internet	INRIA, France
PRO-LEARNING: Project-based learning for master level students	Universitat Politècnica de València, Spain
GTS-UCP: GÉANT Testbeds Service – User Certification Programme	GÉANT Association (Netherlands), Friedrich-Alexander University of Erlangen-Nuremberg (Germany)
FORGELAN: FORGE-based Local Area Networks	Universidade de Brasília, Brazil
IoTSTREAMS: Education on Analytics over IoT Data Streams through FIRE	University of Ioannina, Greece
ENVISAGE: Enabling Video Streaming Education using FORGE	University of Thessaly, Greece
WN_SP: Wireless Networks course in Spanish	Tecnologico Nacional de Mexico, Mexico
DySIRE: Dynamic and Static Internet Routing Exercises	Piraeus University of Applied Science (PUAS) - Department of Electronic Engineering, COmputer Networking & SErvices Research Team, Greece
AstroLab: Astronomy Experiments for the Science Classroom	Ellinogermaniki Agogi School, Greece

Our Awards

In recognition of impressive project results, throughout Year 1 to 3 the FORGE project got shortlisted and nominated for various awards. These include the Trinity College Dublin IRIS testbed and FORGEBox layer being a finalist in the "Irish Education Laboratory of the Year" and the FORGE

consortium being nominated to the 2014 GOLC[17] International Online Laboratory Awards. The FORGE consortium achieved the following awards.

Future Internet Assembly (FIA 2014) best Poster award
The FORGE project won the best Poster Prize at the Future Internet Assembly (FIA) Poster awards in Athens, Greece in 2014. There were 150 projects eligible to enter this competition, and FORGE's entry beat off stiff competition. There were over 750 attendees at the conferences with over 150 European projects worth more than half a billion euros present at the event.

Net Futures 2015 FORGE won the Hottest Pitch Award
FORGE won the Perfect Pitch Panel award at NetFutures 2015. It competed against eight other projects in the competition. The criteria projects were assessed against economic and societal impact and market readiness and take-up. John Domingue, the FORGE project coordinator, presented a live demo of the FORGE iBook running remote experiments on iMinds testbed in Ghent, and showing a simulated Internet on a shared area running on a KMi server. FORGE won the 'Hottest Pitch' prize at the event, which was presented by Net Futures Director Mario Campolargo.

Figure 22: FORGE Best Poster Award

Figure 23: The Hottest Pitch Award

[17] GOLC Awards http://online-engineering.org/GOLC_online-lab-award.php

1.4.3 Sustainability

FORGE project acted as an umbrella for creating and providing those educational enablers needed to support all the actors of our network namely educational institutions, FIRE experimentation facilities and learners. Since FORGE project funding has ended, in order to continue the operations of the created assets all these enablers and also their maintenance will move to either Educational Institutes or FIRE experimentation facilities. The educational enablers that need to be sustainable are mainly the following assets:

- The FORGE technology itself (FORGEBox, FORGEStore, FORGE widgets, FIRE adapters)
- All the created FIRE enabled courses
- The underlying infrastructure

For the FORGE technology, FORGEBox and FORGEStore will continue to be operational since they are independent from the FORGE project website (http://ict-forge.eu/). Partners that have created technology and especially UoP (which leads the code and operates them) are committed to maintain the websites source code for the upcoming years, since they will use the technology for their own purposes. GRNET which hosts the services commits to allow the operations for the following 2-3 years. Moreover, the source code is publicly open sourced to github with proper licensing schemes. The open architecture of FORGEBox allowed the easy deployment to other interested parties (like the Mexican open call courses) as well as their adaptation and enhancements. Moreover, the adoption of recent standards (LTI, xAPI) allows FORGE technology to be easily reused within the organizations. Proper documentation is online available in order FORGE adopters to be able to deploy their own installation of FORGE technology. UoP and GRNET as well as other partners commit to help any interested future partners that want to use the FORGE technology. All widgets and FIRE Adapters, will be part of the courses and their respective owners commit to maintain them since they will reuse them, at least for the upcoming years.

All the created FIRE enabled courses (both those from FORGE partners as well as those from the open calls) will continue to be available from their respective owners. Almost all courses will be used in the upcoming years by their respective owners into their own curricula.
The underlying infrastructure is still guaranteed, despite the FIRE's agenda new scheme. The Fed4FIRE+ project which will run for the next 4 years as from 1st of January 2017 will provide the necessary resources to deploy FORGE courses.

FORGE technology itself can be a great asset for those adopting it. First FIRE facilities themselves, which would like to use FORGE technology for teaching computer science topics or other scientific domains would not only increase the usage of the facility but it would also engage learners to extensively use FIRE facilities and related resources when working on their course projects and also raise FIRE awareness in the long term.

FORGE technology could be also introduced and exploited in all future H2020 projects. Learning new technologies through innovative means like FORGE's technology assets, can be a great way to disseminate project results. We expect this to be a parallel and complementary activity in future projects of various domains like IoT, 5G or even part of the recently introduced new research initiative called "Next Generation Internet", part of the Horizon 2020 research programme.

The FORGE iBook will continue to be available for free in iTunes and offered to 50 countries worldwide. Additionally, PT Anywhere will continue to be hosted in the servers of The Open University and offered as a free service to the eLearning community, both as a standalone network simulation tool and as part of the interactive exercises of the FORGE iBook.

Several former FIRE facilities hosted at UPMC are still managed by OneLab. After being a FIRE project, OneLab is now a consortium consisting of different higher education and research institutions. OneLab is devoted to make testbeds used for network computer communications available to enterprises, scientific researchers, and educators. OneLab is administered from the NOC (network operations centre) located at UPMC. The engineering team managing the NOC is involved in the integration and maintenance of former FORGE widgets on OneLab portal to secure the work done and to guarantee the access to the used facilities for the comings yeas. Finally, OneLab is secured by strategic national projects and industrial contracts. For example, some FORGE widgets were using PlanetLab Europe, a FIRE facility administered by UPMC and secured by new national long lasting funding and several commercial clients (like Telefonica).

Finally, the different iMinds FIRE facilities will also remain available for the world wide educational and research audience, considering the importance of these FIRE facilities for iMinds' internal roadmap and for the educational usage within iMinds' affiliated universities. This is proven by the recent move of the facilities to a new location for more expansion opportunities and with an even higher professional support. A capacity increase of these facilities is currently on-going. As of October 1st 2016, iMinds and its facilities have merged within imec which is promising even more exciting new opportunities.

Real world community engagement

FORGE consortium has successfully delivered FORGE based presentations and workshop sessions throughout project lifespan. In addition consortium members have been very active and a driving force behind various standardisation efforts as presented below.

Table 3: Workshops organised by FORGE

Venue	No. Participants Reached	Date
Net Futures 2016	100	21st Apr '16
EC-TEL 2016 (see Deliverable 6.10)	50 (estimation based on last year's attendance)	13th Sep '16
EC-TEL 2015	50	15th Sep '15
"Using FIRE Experimental Facilities to Boost Digital Skills" workshop (co-organised with the European Commission) 	Unknown	30th Sep '15
Building Remote Labs for Online Scientific Experimentation" in the 18th International Conference on Interactive Collaborative Learning (ICL 2015)[18]	unknown	20th-24th Sep '15

[18] http://icl-conference.org/icl2015/

Table 4: Some of FORGE Demos

Venue	No Participants Reached	Date
Patras IQ	~150	16/4/2016
Perfect Pitch Panel @ NetFutures 15	100	25/03/2015
CI FIRE Methodology Workshop @ NetFutures 15	40	24/03/2015
London Digital Catapult Centre/FUTURE INTERNET OPPORTUNITIES FOR INNOVATIVE EUROPEAN BUSINESSES/disseminating Open Call	30	09/03/15
Demo in conjunction with CREW project. CREW Y4	Unknown	19/11/14
EWT Workshop	Unknown	18/11/14
iMinds The Conference 2014	Unknown (1300 attendees)	23/10/2014
promoting FORGE to Educational Directorate of Ghent University	2	23/06/2015
IGIP/ICL workshop at WEEF	15	20/09/2015
iMinds Meeting	2	15/12/2015

In addition to the workshops and demos, throughout M1 to M36 FORGE consortium members have been very active and a driving force behind various standardisation efforts including: IEEE P1876 Standard for Networked Smart Learning Objects for Online Laboratories; IEEE Actionable Data Book (ADB); and SIP Remote Labs and Online Experimentation. Contributions include:

- Attending bi-yearly face-to-face meetings
- Joining weekly conference call meetings
- Proving documented use-cases
- Teaching the FORGE approach to interoperability
- Presenting the FORGEBox framework structure and model
- Showcasing the FORGE Methodology
- Describing the FORGE Widget Reference Architecture

The FORGE project comes to an end in September 2016. However, contribution from FORGE partners towards these standardisation efforts will continue past the project's lifetime, in at the very least, SIG Remote labs and Online Experimentation and IEEE ADB book standards.

Online community engagement

Website

The FORGE website has had over 11,500 unique visitors, over 34,000 page views from over 130 countries since the project's inception in 2013. The FORGE website can be accessed at http://ict-forge.eu and is IPv6-compatible. The website serves as the main online point of reference for the project. It offers the latest news about the project, its objectives, details about its consortium and participating partners, as well as the various outputs of the project, such as deliverables, publications, and more. The FORGE website also offers access to the learning resources developed by the project, including courses, widgets and instructional videos. The website features dedicated sections for the Open Call the dissemination materials of the project, as well as a password-protected section reporting all the dissemination activities of the project

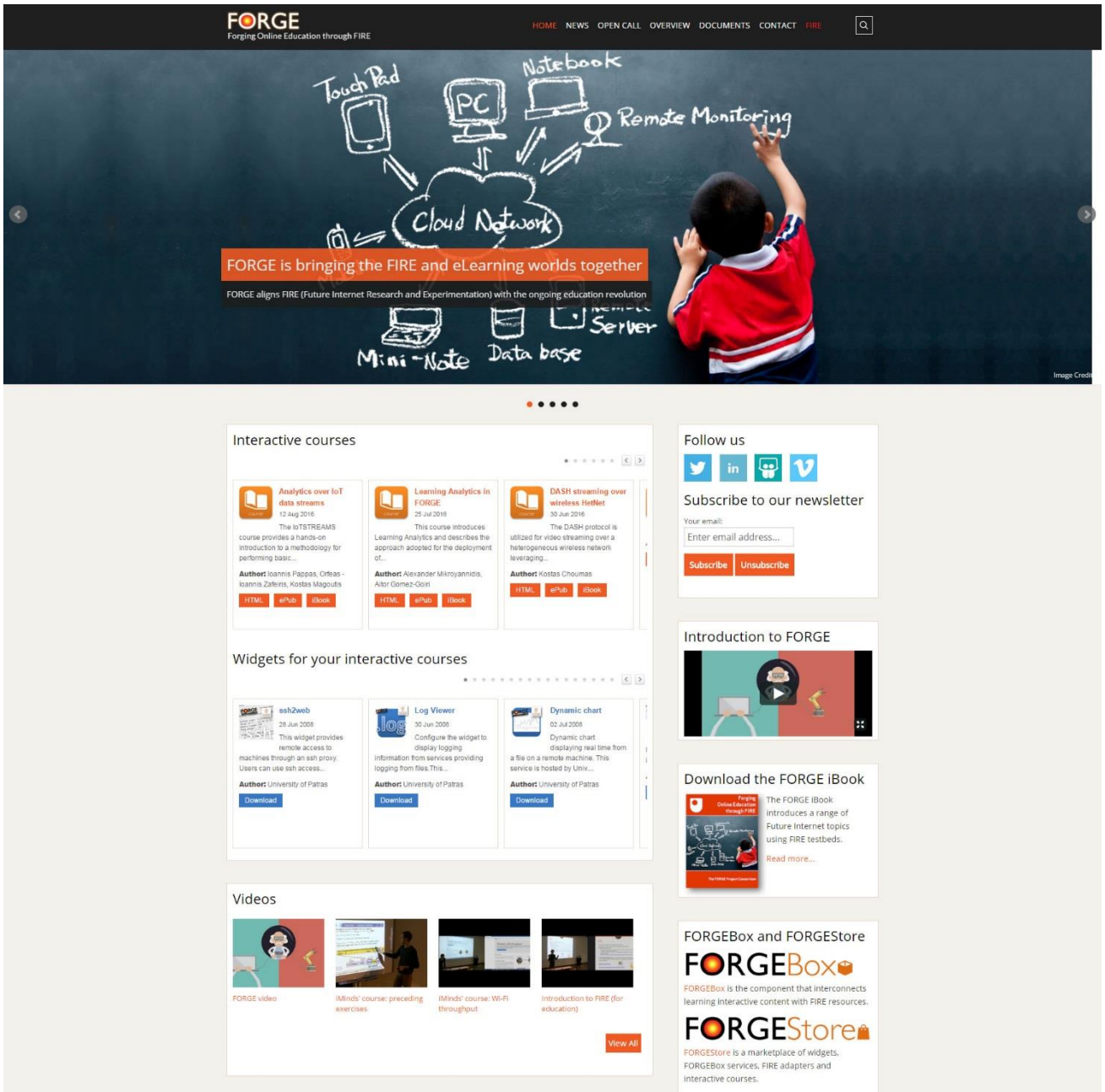


Figure 24: FORGE website at http://ict-forge.eu/

iBook

The FORGE iBook[19] was published on the Apple iBook Store on 27th November 2015 and is now available in 51 stores worldwide. This has been a major milestone in the FORGE project. The iBook has several topics and experiments related to networking protocols and infrastructure that access FIRE testbed infrastructure including the Cisco Networking Academy collaborated PT Anywhere Packet Tracer network simulation widget and iMinds introduction to WI-FI networks that run on iMinds w-iLab.t facility. It was updated on May 19th 2016 with additional chapters about TCP Congestion Control. Moreover, it includes an advanced networking course on 4G Long Term Evolution (LTE) Throughput, which was developed by Ghent University and iMinds. To date[20], the FORGE iBook has been downloaded 131 times. The region breakdown is as follows:

- Europe: 111
- USA and Canada: 18
- Asia Pacific: 2

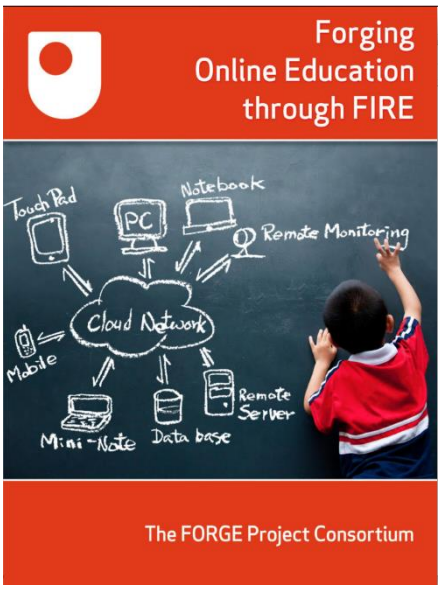


Figure 25: The FORGE Project Consortium iBook

Vimeo

The FORGE Vimeo channel has 27 videos uploaded since 2013. These videos have been played over 1,400 times. The number of plays has increased steadily with 45 plays in 2014, 498 in 2015 and 935 until end of August 2016[21]. Our videos range from educational and architectural to promotional. The most popular video added in year three is the FORGE (promotional) Video, which has been played 321 times since its launch. It should be noted that 13 out of 27 videos are part of the Open Call series of webinars and online tutorials that were launched in Y3 in order to provide more insight into the main FORGE concepts, methodologies and tools. These videos were a means to attract more interest to the FORGE Open Call and were particularly useful to those interested in submitting a proposal within the call.

Figure 26: Screenshot from FORGE video.

[19] FORGE iBook https://itunes.apple.com/us/book/forging-online-education-through/id1062612920?mt=11
[20] iBook download statistics captured on 22nd of August 2016
[21] Figures captured on 26th August 2016

Twitter

Throughout the lifespan of project, Twitter has increased the visibility of the FORGE project across different demographics of people with Tweets from high profile individuals such as Nikos Isaris from the European Commission at Net Futures 2015 and the Mexican Ambassador to Ireland Mr Carlos García De Alba visit to TCDs (see below).

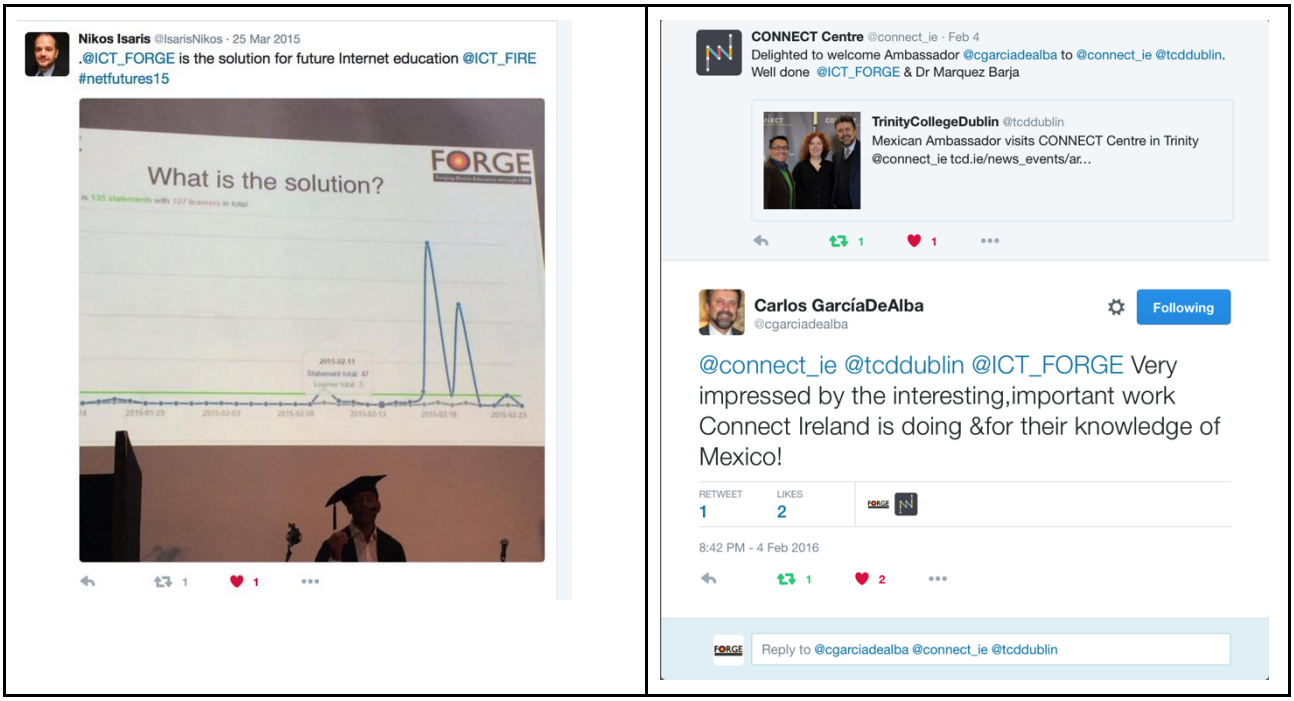


Figure 27: Tweets from Nikos Isaris of the European Commission at Net Futures 2015 and Carlos García De Alba, Mexican Ambassador to Ireland.

SlideShare

The FORGE SlideShare channel has a total of 23 presentations available. These presentations have been viewed over 5,000 times since 2013. In Year 3 of the project, the FORGE SlideShare channel accumulated a total of 4,000 views. This represents a 300% increase on Year 2 figures (1,000 views).

Newsletters

Newsletter Issue no. 1 was released on 15th Nov 2014. A newsletter has been released every three months since that date up to and including the final month of the project September 2016. In total there is currently 8 issues available22. These publications have highlighted FORGE's major achievements and milestones since the project's inception. News items range from the availability of new courses e.g., TCDs OFDM course, to details about organised workshops e.g., EC-TEL 6th Workshop on Awareness and Reflection in Technology Enhanced Learning (13th Sept 2016), information about the release of the FORGE iBook to news about visits from top dignitaries (such as the visit from the Mexican Ambassador to Ireland Mr Carlos García De Alba to TCDs CONNECT centre23).

[22] http://ict-forge.eu/documents/newsletter/
[23] 4th February 2016

May 2016

FORGE
Forging Online Education through FIRE

FORGE NEWS

Forge Project Newsletter

In this issue:

- FORGE Open Call — update
- FORGE-enabled MOOC has been launched
- What we are up to a.k.a. dissemination of FORGE

Opening the FORGE platform -

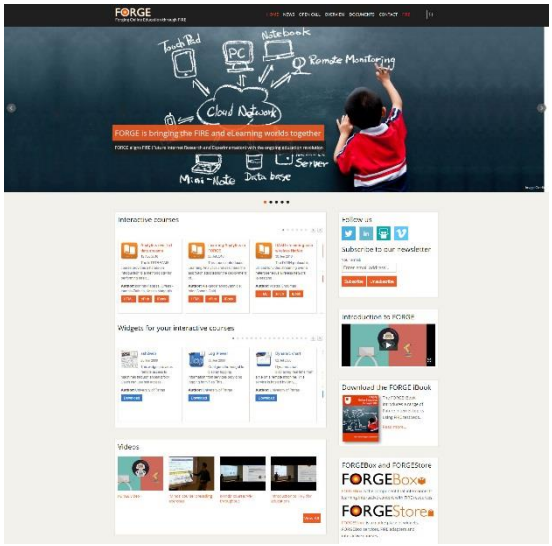
Open Call news and updates

Introducing three new projects! Following a very active period of receiving and discussing many different ideas with the community, 8 proposals have been submitted so far within the 4th (and final) round of the FORGE Open Call. After the first cut-off date for proposal submission on April 8th, three of them have already been approved for implementation and have commenced with their work. New subject areas and interesting features come into play. Let's have a closer look!

Figure 28: Example of FORGE newsletter

1.5 Public website and contact details

Public website:



http://ict-forge.eu/

Contact details:

The Open University

Prof John Domingue john.domingue@open.ac.uk

2. Use and dissemination of foreground

2.1 Section A1 (public) – list of all scientific publications

TEMPLATE A1 – LIST OF ALL SCIENTIFIC (PEER REVIEWED) PUBLICATIONS RELATING TO THE FOREGROUND OF THE PROJECT

NO.	Title	Main author	Title of the periodical or the series	Number, date or frequency	Publisher	Place of publication	Year of publication	Relevant pages	Permanent identifier[24] (if available)	Is/Will open access[25] provided to this publication?
1	FORGE Toolkit: Leveraging Distributed Systems in eLearning Platforms	Guillaume Jourjon	IEEE Transaction on Emerging Trends in Computing	No. 99, 29th Dec 2015	IEEE	-	2015	1-1	http://10.1109/TETC.2015.2511454	No
2	Implementation of temporal spectrum sharing for radar bands	Francisco Paisana	IEEE International Symposium on Dynamic Spectrum Access Networks (DySPAN)	29th Sep – 2nd Oct. 2015	IEEE	Stockholm, Sweden	2015	271 - 272	http://10.1109/DySPAN.2015.7343913	No
3	Applying a methodology for the design, delivery and evaluation of learning resources for remote experimentation	Alexander Mikroyannidis	Global Engineering Education Conference (EDUCON), 2016 IEEE	10th -13th Apr 2016	IEEE	Abu Dhabi, UAE	2016	448 - 454	http://10.1109/EDUCON.2016.7474592	No
4	FORGE: Enhancing eLearning and research in ICT through remote experimentation	Johann M. Marquez-Barja	2014 IEEE Global Engineering Education Conference (EDUCON)	3rd -5th Apr 2014	IEEE	Istanbul, Turkey	2014	1157	http://10.1109/EDUCON.2014.7096835	No

[24] A permanent identifier should be a persistent link to the published version full text if open access or abstract if article is pay per view) or to the final manuscript accepted for publication (link to article in repository).
[25] Open Access is defined as free of charge access for anyone via Internet. Please answer "yes" if the open access to the publication is already established and also if the embargo period for open access is not yet over but you intend to establish open access afterwards.

5	Interactive learning resources and linked data for online scientific experimentation	Alexander Mikroyannidis	WWW '13 Companion Proceedings of the 22nd International Conference on World Wide Web	13th – 17th May 2013	ACM	Rio de Janeiro, Brazil	2013	431-434	10.1145/ 2487788.2487959	No
6	Virtualizing testbed resources to enable remote experimentation in online telecommunications education.	Johann M. Marquez-Barja	Global Engineering Education Conference (EDUCON), 2015 IEEE	18th -20th Mar 2015	IEEE	Tallinn, Estonia	2015	836 - 843	http://10.1109/ EDUCON.2015.7096069	No
7	Online Learning and Experimentation via Interactive Learning Resources.	Alexander Mikroyannidis	Experiment International Conference	5th May 2016	IEEE	SÃO Miguel Island Azores, Portugal	2015	191 - 196	10.1109/ EXPAT.2015.7463264	No
8	FORGE Enabling FIRE Facilities for the e-Learning Community	Olivier Fourmaux	19th International Conference on Interactive Collaborative Learning	22nd Sep 2016		Belfast, UK	2016	-	https://hal.archives-ouvertes.fr/hal-01366688	No
9	Deploying learning analytics for awareness and reflection in online scientific experimentation	Alexander Mikroyannidis	5th Workshop on Awareness and Reflection in Technology Enhanced Learning (ARTEL)	15th Sep 2015		Toledo, Spain	2015	n/a	http://oro.open.ac.uk /45435/	No

2.2 Section A2 (public) – list of dissemination activities

TEMPLATE A2: LIST OF DISSEMINATION ACTIVITIES								
NO.	**Type of activities[26]**	**Main leader**	**Title**	**Date/Period**	**Place**	**Type of audience[27]**	**Size of audience**	**Countries addressed**
1.	Conference	TCD	CTVR Communications showcase 2013. Dublin, Ireland	5th Sep 2013	Dublin, Ireland	Scientific Community, Industry	>200	Ireland
2.	Leaflets, Conference	TCD	IFIP/IEEE WirelessDays 2013, Valencia, Spain	13th – 15th Sep 2013	Spain	Scientific Community, Industry	Unknown	Spain, EU
3.	Website / Press	All Partners	The website (www.ict-forge.eu) is one of the main carriers of the FORGE message and dissemination material	10/2013 – 09/2016	Worldwide	Scientific Community Industry, Civil Society, Policy makers, Medias, Other	>11,500 unique visitors, over 34,000 Page Views	Worldwide (over 130 countries)
4.	Press	GRNET	GRNET website, The kick-off of FORGE announced	Oct 2013	Greece	Scientific Community, Industry	Unknown	Greece, EU
5.	Press	OU	KMI – OU website , The kick-off of FORGE announced	Oct 2013	UK	Scientific Community, Industry	Unknown	UK, EU
6.	Press	UoP	UoP website , The kick-off of FORGE announced	Oct 2013	Greece	Scientific Community, Industry	Unknown	Greece, EU

[26] A drop down list allows choosing the dissemination activity: publications, conferences, workshops, web, press releases, flyers, articles published in the popular press, videos, media briefings, presentations, exhibitions, thesis, interviews, films, TV clips, posters, Other.

[27] A drop down list allows choosing the type of public: Scientific Community (higher education, Research), Industry, Civil Society, Policy makers, Medias, Other ('multiple choices' is possible).

7.	Press	All Partners	FORGE website www.ict-forge.eu, The kick-off of FORGE announced	Oct 2013	UK	Scientific Community, Industry	Unknown	EU
8.	Social Media / Press	TCD, OU	Twitter, News about FORGE	10/2013 – 09/2016	EU	Scientific Community Industry, Civil Society, Policy makers, Medias, Other	327 followers	EU
9.	Social Media / Press	TCD	LinkedIn, Discussion group, FORGE news	10/2013 – 09/2016	UK	Scientific Community Industry, Civil Society, Policy makers, Medias, Other	61 Members	EU
10.	Presentation	iMinds	Course 'Mobile & broadband access networks	Oct 2013	Belgium	Scientific Community	Unknown	Belgium
11.	Leaflets, Conference	All Partners	ICT 2013, FORGE promoted via flyers at the FIRE booth	Nov 2013	Lithuania, EU	Scientific Community, Industry	4882	Lithuania, EU
12.	Press	TCD	FIRE News: The kick-off of FORGE announced & FORGE News	27th Nov 2013	N/a	Scientific Community, Industry	Unknown	EU
13.	Leaflets, Conference	All Partners	ACM CoNext, Santa Barbara, USA, FORGE promoted via flyers	Dec 2013	N/a	Scientific Community, Industry	Unknown	USA
14.	Email, Press	TCD	FIRE Group - FORGE has joined the group in order to align the promotion of FORGE with the FIRE communication and dissemination actions	Dec 2013	N/a	Scientific Community, Industry	Unknown	EU
15.	Email, Press	All Partners	Greek R&E community related issue - News about FORGE	Jan 2014	N/a	Scientific Community, Industry	Unknown	EU
16.	Presentation	UoP	UoP Course, FORGE material using Virtual Wall testbed	2nd Semester 2013-2014	Patras, Greece	Scientific Community	Unknown	Greece
17.	Presentation	TCD supported by NICTA and iMinds	5C2 Wireless and Communications class at TCD for 5th year students– Remote experimentation, Dublin, Ireland	01/2014 – 05/2014	Ireland	Scientific Community	Unknown	Ireland

18.	Presentation	NICTA	NICTA Course FORGE produced material using remote labs	Semester 1 2014	Australia	Scientific Community	Unknown	Australia
19.	Presentation	OU	FIRE Projects Day	Jan 2014	Brussels, Belgium	Scientific Community, Industry	Unknown	EU
20.	Email, Press	TCD	CLUSTER (Consortium Linking Universities of Science and Technology for Education and Research network) academy network	Feb 2014	n/a	Scientific Community	Representing a community of 3,000 professors, 11,000 academic staff, 14,000 PhD students and more than 140,000 undergraduate students.	EU
21.	Press		FIRE Magazine Feb13 Article about FORGE submitted and accepted to be published	Feb 2014	EU	Scientific Community	Unknown	EU
22.	Presentation	TCD	Net-TechFuture – A publicatio n from The European Commissi on's CONNEC T-Communi cation Networks, Content andTechnolo gy Directorat e-General - Paper published: The next step for e-learning: Science experiments online	14th Feb 2014	Worldwide	Scientific Community Industry, Civil Society, Policy makers, Medias, Other		Worldwide
23.	Social Media / Press / Videos	OU	Vimeo	Apr 2014	Worldwide	Scientific Community Industry, Civil Society, Policy makers, Medias, Other	27 videos, played over 1,400 45 plays in 2014, 498 in 2015, 935 until end of August 2016	Worldwide
24.	Video	UoP	TCP congestion control exercise 9/9	26th Apr 2014	n/a	Scientific Community, Industry, Medias	26	n/a
25.	Video	UoP	TCP congestion control exercise 7/9	26th Apr 2014	n/a	Scientific Community, Industry, Medias	3	n/a
26.	Video	UoP	TCP congestion control exercise 8/9	26th Apr 2014	n/a	Scientific Community, Industry, Medias	4	n/a

27.	Video	UoP	TCP congestion control exercise 5/9	26th Apr 2014	n/a	Scientific Community, Industry, Medias	3	n/a
28.	Video	UoP	TCP congestion control exercise 4/9	26th Apr 2014	n/a	Scientific Community, Industry, Medias	4	n/a
29.	Video	UoP	TCP congestion control exercise 3/9	26th Apr 2014	n/a	Scientific Community, Industry, Medias	8	n/a
30.	Video	UoP	TCP congestion control exercise 2/9	26th Apr 2014	n/a	Scientific Community, Industry, Medias	3	n/a
31.	Video	UoP	TCP congestion control exercise 1/9	26th Apr 2014	n/a	Scientific Community, Industry, Medias	24	n/a
32.	Video	UoP	TCP congestion control exercise 6/9	26th Apr 2014	n/a	Scientific Community, Industry, Medias	3	n/a
33.	Video	OU	Demo of network cables	26th Apr 2014	n/a	Scientific Community, Industry, Medias	67	n/a
34.	Video	OU	Demo of a Cisco network router	26th Apr 2014	n/a	Scientific Community, Industry, Medias	117	n/a
35.	Presentation and Demo	OU	OU open day	29th Apr 2014	Milton Keynes, UK	Scientific Community, Industry, Medias	Unknown	UK
36.	Workshop	TCD	GENI	11th -12th May 2014	Princeton, NJ, USA	Scientific Community	Unknown	USA
37.	Conference	TCD, OU, UoP, GRNET	FIA 2014 Session related to Future of Learning Poster and Leaflet presented *Won the best poster award	17th -20th May 2014	Athens, Greece	Scientific Community Industry, Civil Society, Policy makers, Medias, Other	>714 60 Attendees to FORGE	43 Countries

38.	Workshop	OU, UPMC	Beyond MOOCs: The Future of Learning on the Future Internet (FIA Session)	20th May 2014	Athens, Greece	Scientific Community Industry, Civil Society, Policy makers, Medias, Other	>714 60 Attendees to FORGE	43 Countries
39.	Video	UoP	FORGE iBook teaser	17th Jun 2014	n/a	Scientific Community, Industry, Medias	348	n/a
40.	Workshop	UPMC, OU	CI-FIRE Industry Workshop	27th Jun 2014	Paris, France	Scientific Community, Industry	40	France, EU
41.	Presentation and Demo	TCD	FIRE Communications and Dissemination Working Group Session	2nd Jul 2014	EU	Scientific Community, Industry, Medias	unknown	EU
42.	Presentation	GRNET	Programme Committee of the consortium of National Research and Education Networks (NRENPC) implementing GÉANT in Europe Presentation of FORGE as part of the agenda of a meeting dedicated to the Open Education initiatives currently under initiation in GEANT.	2nd July 2014	Greece	Scientific Community	Unknown	Greece
43.	Website / Press	All Partners	The website (www.forgestore.eu)	07/2014 – 09/2016	Worldwide	Scientific Community Industry, Civil Society, Policy makers, Medias, Other	Unknown	Worldwide
44.	Video	UoP	Teaching the Internet over the Internet: Lessons Learnt and Future Scenarios from the Cisco Networking Academy	8th Jul 2014	n/a	Scientific Community, Industry, Medias	65	n/a
45.	Website / Press	All Partners	The website (http://www.forgebox.eu)	07/2014 – 09/2016	Worldwide	Scientific Community Industry, Civil Society, Policy makers, Medias, Other	>8,700 unique visitors, over 15,000 Page Views	Worldwide (over 110 countries)

46.	Flyers	TCD	IEEE steering committee Ireland	15th Aug 2014	Dublin, Ireland	Scientific Community Industry, Civil Society, Policy makers, Medias, Other	Unknown	Ireland
47.	Presentation	TCD / UoP	IEEE P1876TM Standard for Networked Smart Learning Objects for Online Laboratories. FORGE established the official contact and started the process to join the committee. Johann M. Marquez-Barja (TCD), Christos Tranoris (UoP) and Hamadou Saliah-Hassane (WG Chair) have started such collaboration	Aug 2014	EU	Scientific Community, Industry	>3	EU
48.	Poster and Presentation	OU	Summer school ESWC	1st - 6th Sep 2014	Kalamaki, Crete	Scientific Community	50	Crete, EU
49.	Presentation	UoP	UoP Course	2nd semester 2014-2015	Patras, Greece	Scientific Community	Unknown	Patras, Greece
50.	Flyers	UoP	2nd European Conference of Future Internet	17th -18th Sep 2014	Munich, Germany	Scientific Community	Unknown	Germany, EU
51.	Press	GRNET	GÉANT News/ Press Releases, FORGE material - contact GÉANT's Public relations (PR) and try to establish a permanent communicatio n with other European NRENs either through GÉANT or through each NREN PR	Oct 2014 - Sep 2016	EU	Scientific Community	Unknown	EU
52.	Presentation	All Partners	Joined SlideShare	Oct 2014	Worldwide	Scientific Community	23 presentations, Viewed >5,000 times	Worldwide
53.	Presentation	UPMC	UPMC 1st Prototype course run	20th Oct 2014	Paris, France	Scientific Community	Unknown	France
54.	Presentation	TCD / UoP	IEEE P1876TM Standard for Networked Smart Learning Objects for Online Laboratories.	22nd Oct 2014	Madrid, Spain	Scientific Community	Unknown	Spain
55.	Conference	iMinds	iMinds The Conference 2014	23rd Oct 2014	Brussels, Belgium	Scientific Community	Unknown	Belgium
56.	Newsletter	TCD/OU	November 2014 issue http://ict-forge.eu/wp-content/uploads/2014/11/FORGE-newsletter02.pdf	November 2014	UK	Scientific Community, Industry	Unknown	Worldwide

57.	Video	UoP	FORGEbox tutorial	13th Nov 2014	n/a	Scientific Community, Industry, Medias	46	n/a
58.	Video	OU	Completing a lab exercise in the FORGEBox platform	21st Nov 2014	n/a	Scientific Community, Industry, Medias	44	n/a
59.	Presentation	TCD	Science Foundation Ireland	4th -5th Dec 2014	Dublin, Ireland	Scientific Community, Industry	unknown	Ireland
60.	Presentation	NICTA	NICTA Course FORGE produced material using Remote Labs	Semester 1 2015	Australia	Scientific Community	Unknown	Australia
61.	Presentation	All Partners	FORGE Brochure	13th Jan 2015	n/a	Scientific Community Industry, Civil Society, Policy makers, Medias, Other	97	n/a
62.	Presentation	All Partners	FORGE - Best poster award FIA14	13th Jan 2015	n/a	Scientific Community Industry, Civil Society, Policy makers, Medias, Other	138	n/a
63.	Presentation	All Partners	About FORGE presentation	13th Jan 2015	n/a	Scientific Community Industry, Civil Society, Policy makers, Medias, Other	163	n/a
64.	Presentation	TCD	TCD – 5C2 Master module – Wireless nets and comms.	18th Jan 2015	Dublin, Ireland	Scientific Community Industry, Civil Society, Policy makers, Medias, Other	Unknown	Ireland

65.	Presentation	UoP	FORGE project	21st Jan 2015	n/a	Scientific Community Industry, Civil Society, Policy makers, Medias, Other	198	n/a
66.	Presentation	OU	FORGE project	21st Jan 2015	n/a	Scientific Community Industry, Civil Society, Policy makers, Medias, Other	157	n/a
67.	Presentation	OU	FORGE: BRINGING FIRE AND THE E-LEARNING SPHERES TOGETHER	21st Jan 2015	n/a	Scientific Community Industry, Civil Society, Policy makers, Medias, Other	131	n/a
68.	Presentation	TCD	FORGE: Enhancing eLearning and research in ICT through remote experimentation	21st Jan 2015	n/a	Scientific Community Industry, Civil Society, Policy makers, Medias, Other	180	n/a
69.	Presentation	iMinds	FORGE poster @ iMinds Conference	21st Jan 2015	n/a	Scientific Community Industry, Civil Society, Policy makers, Medias, Other	144	n/a
70.	Presentation	All Partners	The next step for e-learning: Science experiments online	21st Jan 2015	n/a	Scientific Community Industry, Civil Society, Policy makers, Medias, Other	134	n/a

71.	Presentation	NICTA	FORGE: Enhancing eLearning and research in ICT through remote experimentation	21st Jan 2015	n/a	Scientific Community Industry, Civil Society, Policy makers, Medias, Other	163	n/a
72.	Presentation	TCD	Virtualizing testbed resources to enable remote experimentation in online telecommunications education	21st Jan 2015	n/a	Scientific Community Industry, Civil Society, Policy makers, Medias, Other	196	n/a
73.	Presentation	TCD	TCD – 5C2 Master module – Wireless nets and comms.	15th Feb 2015	Dublin, Ireland	Scientific Community Industry, Civil Society, Policy makers, Medias, Other	Unknown	Ireland
74.	Presentation	iMinds	WLAN prototype execution	18th Feb 2015	Ghent, Belgium	Scientific Community Industry, Civil Society, Policy makers, Medias, Other	Unknown	Ireland
75.	Newsletter	TCD/OU	February 2015 issue http://ict-forge.eu/wp-content/uploads/2014/11/FORGE-newsletter02.pdf	Feb 2015	UK	Scientific Community Industry, Civil Society, Policy makers, Medias, Other	Unknown	Worldwide
76.	Conference	OU, iMinds, TCD	London Digital Catapult Centre/FUTUR E INTERNET OPPORTUNITI ES FOR INNOVATIVE EUROPEAN BUSINESSES	9th Mar 2015	London, UK	Scientific Community, Industry	Unknown	UK
77.	Other, meeting	TCD	IEEE P1876 Standardisation	18th -20th Mar 2015	Tallinn, Estonia	Scientific Community, Industry	Unknown	Estonia

78.	Presentation	TCD	Presentation: Virtualizing testbed resources to enable remote experimentation in online telecommunications education @EDUCON'15 Conference)	20th Mar 2015	n/a	Scientific Community Industry, Civil Society, Policy makers, Medias, Other	196	n/a
79.	Workshops, web, press releases, flyers	GRNET, TCD	Open Call announcements	Mar 2015 – Sep 2015	-	Scientific Community, Industry	unknown	-
80.	Presentation	TCD	TCD – 5C2 Master module – Wireless nets and comms	20th Mar 2015	Dublin, Ireland	Scientific Community	Unknown	Ireland
81.	Workshop	iMinds and OU	CI FIRE Methodology Workshop @ NetFutures 15	24th Mar 2015	Brussels, Belgium	Scientific Community, Industry, Policy makers, Medias, Other	Unknown	Belgium, EU
82.	Workshop	iMinds and OU	CI FIRE Methodology Workshop @ NetFutures 15	24th Mar 2015	Brussels, Belgium	Scientific Community, Industry, Policy makers, Medias, Other	Unknown	Belgium, EU
83.	Workshop	Whole consortiu m	FIRE/GEANT Meeting @ NetFutures 15	24th Mar 2015	Brussels, Belgium	Scientific Community, Industry, Policy makers, Medias, Other	Unknown	Belgium, EU
84.	Presentation, Demo	Whole consortiu m	FIRE Board Meeting @ NetFutures	25th Mar 2015	Brussels, Belgium	Scientific Community, Industry, Policy makers, Medias, Other	30	Belgium, EU
85.	Presentation	iMinds, OU	Perfect Pitch Panel @ NetFutures 15	25th Mar 2015	Brussels, Belgium	Scientific Community, Industry, Policy makers, Medias, Other	Unknown	Belgium, EU

86.	Presentation	OU	Delivering Industry Education within Academic Programmes	25th Mar 2015	Milton Keynes, UK	Scientific Community, Industry,	Unknown	UK
87.	Presentation	iMinds	Net Futures Conference	25th Mar 2015	Brussels, Belgium	Industry	Unknown	Belgium, EU
88.	Website	GRNET	FORGE Open Call website section http://ict-forge.eu/opencall/	Mar 2015 – Sep 2015	Website	Scientific Community, Industry	Unknown	-
89.	Presentation	OU	FORGE - Perfect Pitch Panel @ NetFutures 15	5th Apr 2015	n/a	Scientific Community Industry, Civil Society, Policy makers, Medias, Other	208	n/a
90.	Presentation	OU	FORGE Methodology - CI FIRE Methodology Workshop @ NetFutures 15	5th Apr 2015	n/a	Scientific Community Industry, Civil Society, Policy makers, Medias, Other	214	n/a
91.	Presentation	OU	FIRE in a Book - Future Internet Opportunities for Innovative European Businesses @ NetFutures 2015	5th Apr 2015	n/a	Scientific Community Industry, Civil Society, Policy makers, Medias, Other	170	n/a
92.	Website	GRNET	Event co- organized by the Bulgarian Research and Education Network (BREN)	24th Apr 2015	Troyan, Bulgaria	Scientific Community, Industry	Unknown	Bulgaria
93.	Presentation	iMinds	Event co- organized by the Bulgarian Research and Education Network (BREN)	24th Apr 2015	Troyan, Bulgaria	Scientific Community, Industry	Unknown	Bulgaria
94.	Presentation, exhibitions, poster	OU, iMinds	Event coorganized by the Bulgarian Research and Education Network (BREN)	24th Apr 2015	Troyan, Bulgaria	Scientific Community, Industry	Unknown	Bulgaria

95.	Presentation (SlideShare)	OU	Transforming education through FORGE	27th Apr 2015	Worldwide	Scientific Community Industry, Civil Society, Policy makers, Medias, Other	155	Worldwide
96.	Presentation (SlideShare)	iMinds	Education using FIRE	27th Apr 2015	Worldwide	Scientific Community Industry, Civil Society, Policy makers, Medias, Other	343	Worldwide
97.	Other, meeting	OU	IEEE P1876 Standardization	5th May 2015	Azores, Portugal	Scientific Community, Industry	Unknown	Portugal
98.	Newsletter	TCD/OU	May 2015 issue http://ict-forge.eu/wp-content/uploads/2014/11/FORGE-newsletter03.pdf	May 2015	UK	Scientific Community, Industry	Unknown	Worldwide
99.	News, Media	OU	FORGE and Go-Lab establish EATEL SIG	8th May 2015	UK	Scientific Community, Industry Civil Society, Policy makers, Medias, Other	unknown	Worldwide
100	Presentation, film	UoP	Patras Seminar for collaborative learning	11th -12th May 2015	Patras, Greece	Scientific Community, Industry	Unknown	Greece
101	Workshops, web, press releases, flyers	GRNET	Press Release (in Greek)	11th May 2015	-	Scientific Community, Industry	Unknown	-
102	Presentation	iMinds	WLAN prototype execution	14th May 2015	Brasilia, Brazil	Scientific Community, Industry	Unknown	Brazil
103	Flyers	UPMC	French Research and Higher Education visit Minister	15th May 2015	Paris, France	Scientific Community, Industry Civil Society, Policy makers, Medias, Other	Unknown	France

104	Presentation	OU	WWW 2015	18th -22nd May 2015	Florence, Italy	Scientific Community, Industry	Unknown	Italy
105	Flyers, Video, Press	OU	KMi's 20th celebration	20th May 2015	Milton Keynes, UK	Scientific Community, Industry Civil Society, Policy makers, Medias, Other	Unknown	UK
106	Presentation	UoP	Deploying UoP course	2nd Jun 2015	Patras, Greece	Scientific Community	Unknown	Greece
107	Workshops, web, press releases, flyers	GRNET	Release (in English)	3rd Jun 2015	Greece	Scientific Community, Industry	Unknown	-
108	Workshops, web, press releases, flyers	GRNET	Announcement in the GÉANT Association (former TERENA) PR	4th Jun 2015	Greece	Scientific Community, Industry	Unknown	-
109	Presentation	iMinds	Promoting FORGE to Educational Directorate of Ghent University	23rd Jun 2015	Ghent, Belgium	Scientific Community, Industry	Unknown	Belgium
110	Flyers	TCD, UPMC	EuCNC 2015	29th Jun 2015	Paris, France.	Scientific Community, Industry	Unknown	France
111	Presentation	TCD	"Experimenting with Software Defined Radio" Course @ Universidade de Brasilia	2nd -5th Jul 2015	Brasilia, Brazil	Scientific Community	Unknown	Brazil
112	Presentation	TCD	"Experimenting with Software Defined Radio" Course @ Universidade Federal do Rio de Janeiro	7th -10th Jul 2015	Rio de Janeiro, Brazil	Scientific Community	Unknown	Brazil
113	Presentation	TCD	"OFDM" advanced course @ Universidade Federal do Rio de Janeiro by local Prof. Rozende	13th -15th Jul 2015	Rio de Janeiro, Brazil	Scientific Community	Unknown	Brazil
114	Flyers	TCD	IEEE steering committee Ireland section	13th Jul 2015	Dublin Ireland	Scientific Community, Industry	Unknown	Ireland
115	Presentation	OU	FORGE demoing to industry: Jaguar Land Rover, and Santander UK	18th Jul 2015	London, UK	Industry	Unknown	UK

116	Flyers	TCD	Promoting FORGE @ Coursera Course: Learning to Teach Online by University of South Wales	20 June to TCD 17 August 2015. Coursera	Dublin, Ireland	Scientific Community	Unknown	Worldwide
117	Newsletter	TCD/OU	August 2015 issue http://ict-forge.eu/wp-content/uploads/2015/08/FORGE-newsletter-Aug-01.pdf	Aug 2015	UK	Scientific Community, Industry	Unknown	Worldwide
118	Video	OU	Inside a server room at the Open University	11th Aug 2015	n/a	Scientific Community, Industry Civil Society, Policy makers,	158	Worldwide
119	Flyers	UPMC	Mobicom 2015	7th -11th Sep 2015	Paris, France	Scientific Community, Industry	Unknown	France
120	Workshop	Whole consortium	ARTEL 2015 Workshop [organized by FORGE]	15th -18th Sep 2015	Toledo, Spain	Scientific Community, Industry	Unknown	Spain
121	Workshop	Whole consortium	Satellite workshop of the ICL 2015 Conference [organized by FORGE]	20th Sep 2015	Florence, Italy	Scientific Community, Industry	Unknown	Italy
122	Workshop	Whole consortium	eSkills workshop within the European Commission [Co-organized by the EU and FORGE]	29th Sep 2015	Brussels, Belgium	Scientific Community, Industry	Unknown	Belgium
123	Website	Whole consortium	eSkills workshop within the European Commission	29th Sep 2015	Brussels, Belgium	Scientific Community, Industry	Unknown	Belgium
124	Workshop	iMinds	FORGE within FI CREW Project Workshop: How open wireless testbeds can help you to develop more robust wireless solutions	29th Oct 2015	Brussels, Belgium	Scientific Community, Industry	67	Belgium, EU
125	Press	GRNET	GÉANT	Sept 2015 – Sept 2016	Unknown	Scientific Community, Industry	Unknown	Unknown

126	Flyer, Newsletter	TCD	FORGE @ CLUSTER and CLUSTER board members	Nov 2014	n/a	Scientific Community, Industry	Unknown	Europe
127	Flyer, Newsletter	TCD	FORGE @ CLUSTER and CLUSTER board members	Feb 2015	n/a	Scientific Community, Industry	Unknown	Europe
128	Flyer, Newsletter	TCD	FORGE @ CLUSTER and CLUSTER board members	May 2015	n/a	Scientific Community, Industry	Unknown	Europe
129	Flyer, Newsletter	TCD	FORGE @ CLUSTER and CLUSTER board members	Aug 2015	n/a	Scientific Community, Industry	Unknown	Europe
130	Flyer, Newsletter	TCD	FORGE @ CLUSTER and CLUSTER board members	Nov 2015	n/a	Scientific Community, Industry	Unknown	Europe
131	Presentation	TCD	FIRE Dissemination Working Group	2015	n/a	Scientific Community, Industry	Unknown	Europe
132	Presentation, Slides	iMinds	Education using FIRE	20th Sep 2015	n/a	Scientific Community, Industry Civil Society, Policy makers, Medias, Other	260	Worldwide
133	Presentation, Slides	iMinds	Developing interactive learning resources	29th Sep 2015	n/a	Scientific Community, Industry Civil Society, Policy makers, Medias, Other	194	Worldwide
134	Presentation, Slides	iMinds	Education using FIRE (for IGIP workshop 2015)	1st Oct 2015	n/a	Scientific Community, Industry Civil Society, Policy makers, Medias, Other	182	Worldwide
135	Flyer	All partners	Open Call series of webinars and online tutorials, also available at https://vimeo.com/album/3598372	6th Oct 2015 - 31st Mar 2016	-	Scientific Community, Industry	1000>	Unknown

136	Video	OU	Remote Computer Network Simulation within an iBook/HTML5 interface	7th Oct 2015	n/a	Scientific Community, Industry Civil Society, Policy makers,	36	Unknown
137	Flyer, News	GRNET	FORGE Open Call website section http://ict-forge.eu/opencall/	Oct 2015 - Sep 2016	-	Scientific Community, Industry	Unknown	Unknown
138	Flyer, News	All partners	Multiple locations, institutions of Open Call partners	Oct 2015 - Sep 2016	-	Scientific Community, Industry	Unknown	Unknown
139	Flyer, News	All partners	Multiple locations in various events/conferences	Oct 2015 - Sep 2016	-	Scientific Community, Industry	Unknown	Unknown
140	Newsletter	TCD, iMinds	FI Project Crew Newsletter: Use of CREW (FI Project) Facilities for Education	15th Oct 2015	-	Scientific Community, Industry	183	Unknown
141	Video	OU	Introduction to the project: description, vision, objectives, results so far	16th Oct 2015	n/a	Scientific Community, Industry Civil Society, Policy makers	27	Unknown
142	Video	OU	Developing Interactive Learning Resources Using Widgets and eBooks	16th Oct 2015	n/a	Scientific Community, Industry Civil Society, Policy makers	32	Unknown
143	Video	UoP	The FORGE Project: Introduction to FORGE Technologies	22nd Oct 2015	n/a	Scientific Community, Industry Civil Society, Policy makers	32	Unknown
144	Video	GRNET	FORGE Open Call: Submission tutorial	22nd Oct 2015	n/a	Scientific Community, Industry Civil Society, Policy makers	20	Unknown

145	Video	GRNET	FORGE Open Call-Courseware implementation tutorial	22nd Oct 2015	n/a	Scientific Community, Industry Civil Society, Policy makers	31	Unknown
146	Video	iMinds	Introduction to FIRE (for education)	4th Nov 2015	n/a	Scientific Community, Industry Civil Society, Policy makers	54	Unknown
147	Newsletter	TCD	Nov 2015 issue http://ict-forge.eu/wp-content/uploads/2014/11/FORGE-newsletter-Nov15-01.pdf	Nov 2015	EU	Scientific Community, Industry	>1934	EU
148	Presentation	iMinds	WLAN+LTE Prototype Execution (Open Call course, Valencia, Spain)	1st Nov 2015	Valencia, Spain	Scientific Community	6	Spain
149	Presentation	OU	Special Interest Group (SIG) on Remote labs and Online Experimentation FORGE and Go-Lab projects	Nov 2015	Dublin, Ireland	Scientific Community	10	Ireland, UK, Switzerland
150	Presentation, Slides	TCD	FORGE Keynote @ IT Mexicali, October 2015	9th Nov 2015	n/a	Scientific Community, Industry Civil Society, Policy makers, Medias, Other	192	Worldwide
151	Flyer	GRNET	Open Call Announcement to FIRE Dissemination Working Group mailing list	13th Nov 2015	-	Scientific Community, Industry	Unknown	Unknown
152	Presentation	UPMC	UPMC master students including EIT Digital Master students (Paris, France)	24th Nov 2015	Paris, France	Scientific Community	150	France
153	Publication	All Consortium	FORGE iBook	27th Nov 2015	Worldwide	Scientific Community, Industry Civil Society, Policy makers, Medias, Other	131	51 stores worldwide
154	Presentation	OU	The Dutch Data Science Summit 2015/Data Science Centre Eindhoven	1st Dec 2015	Eindhoven, Holland	Scientific Community, Industry	Unknown	Holland, EU

155	Presentation	iMinds	FIRE Forum	9th Dec 2015	Brussels, Belgium	Scientific Community, Industry	Unknown	-
156	Presentation	OU, GRNET	FORGE iBook demo & Open Call presentation to FIRE Dissemination Working Group	15th Dec 2015	Brussels, Belgium	Scientific Community, Industry	15	EU
157	Presentation, Conference	OU	Conference on Transforming Europe Towards the Digital Age	15th Dec 2015	Luxembourg	Scientific Community, Industry	Unknown	-
158	Presentation	iMinds	Briefing iMinds' Communication Department	15th Dec 2015	Ghent, Belgium	Scientific Community, Industry	2	
159	Press	iMinds	News article “FORGE: closing the gap between students and researchers” (See deliverable 6.10)	12th Jan 2016	Belgium	Scientific Community, Industry Civil Society, Policy makers, Medias, Other	unknown	Belgium
160	Press	iMinds	News article “FORGE is een project dat de wereld van FIRE en eLearning bij elkaar brengt”	18th Jan 2016	Belgium	Scientific Community, Industry Civil Society, Policy makers, Medias, Other	18500	Belgium
161	Video	iMinds	Education using FIRE	22nd Jan 2016	n/a	Scientific Community, Industry Civil Society, Policy makers, Medias, Other	182	Worldwide
162	Video	iMinds	iMinds' course: Wi-Fi throughput	22nd Jan 2016	n/a	Scientific Community, Industry Civil Society, Policy makers, Medias, Other	205	Worldwide
163	Demo	OU	PT Anywhere large scale test	28th Jan 2016	UK	Scientific Community, Industry	390	UK

164	Press	TCD	CONNECT Centre, TCD	4th Feb 2016	Dublin, Ireland	Scientific Community, Industry Civil Society, Policy makers, Medias, Other	2,169 Tweet impressions	Ireland, Mexico
165	Press	GRNET	Press Release (in Greek)	8th Feb 2016	Greece	Scientific Community, Industry	Unknown	Greece
166	Press	GRNET	Open Call announcement	8th Feb 2016	Greece	Scientific Community, Industry	1293	Greece
167	Presentation	UPMC	iBook deployment on iPads at UPMC	9th Feb 2016	Paris, France	Scientific Community	11	France
168	Newsletter	TCD	February 2016	Feb 2016	EU	Scientific Community, Industry	>1934	EU
169	Presentation	TCD	TCD – 5C2 Master module – Wireless Networks & Communications.	17th Feb 2016	Dublin, Ireland	Scientific Community	207	Ireland
170	Presentation	OU	Apple European Headquarters Meeting	Week of 22nd to 26th of Feb '16	London, UK	Industry	4	UK, Europe
171	Video	iMinds	iMinds' course: preceding exercises	23rd Feb 2016	n/a	Scientific Community, Industry Civil Society, Policy makers, Medias, Other	149	Worldwide
172	Presentation	TCD	PhD Forum at IEEE REV 2016 13th International Conference on Remote Engineering and Virtual Instrumentation	24th -26th Feb 2016	Madrid, Spain	Scientific Community, Industry	40	Spain
173	Presentation	TCD	IEEE REV 2016 13th International Conference on Remote Engineering and Virtual Instrumentation	24th -26th Feb 2016	Madrid, Spain	Scientific Community, Industry	150	Spain
174	Presentation	TCD	IEEE P1876: Standard for Networked Smart Learning Objects for Online Laboratories Working Group	24th -26th Feb 2016	Madrid, Spain	Scientific Community, Industry	Unknown	Spain

175	Presentation	GRNET	Open Call Presentation to FIRE Dissemination Working Group (DWG)	25th Feb 2016	EU	Scientific Community	15	EU
176	Flyers, Press	GRNET	Open Call Presentation to FIRE Dissemination Working Group	25th Feb 2016	-	Scientific Community, Industry	20	-
177	Presentation	TCD	TCD – 5C2 Master module – Wireless Networks & Communications.	3rd Mar 2016	Dublin, Ireland	Scientific Community	20	Ireland
178	Presentation	iMinds	WLAN+LTE Prototype Execution (Ghent University, Belgium)	9th Mar 2016	Ghent, Belgium	Scientific Community	90	Belgium
179	Presentation	UoP	IEEE Actionable Data Book (ADB) for STEM Education	11th Mar 2016	Unknown	Scientific Community, Industry	5+	USA, Europe
180	Social Networks	UPMC	UPMC Tweet about METRO MOOC Open Call	16th Mar 2016	Unknown	Scientific Community, Industry Civil Society, Policy makers, Medias, Other	1,018 Tweet Impressions	Unknown
181	Presentation	UPMC	iBook deployment on iPads at UPMC	22 Mar 2016	Paris, France	Scientific Community	11	France
182	Presentation	TCD	TCD – 5C2 Master module – Wireless Networks & Communications. WiFi	23rd Mar 2016	Dublin, Ireland	Scientific Community	36	Ireland
183	Presentation	TCD	TCD – 5C2 Master module – Wireless Networks & Communications. OFDM	23rd Mar 2016	Dublin, Ireland	Scientific Community	24	Ireland
184	Video	GRNET	Creation of the FORGE Promotional Video	31st Mar 2016	Worldwide	Scientific Community, Industry Civil Society, Policy makers, Medias, Other	1300 through mailing lists, more than 320 on Vimeo	Worldwide
185	Flyers, Press	GRNET	Open Call Announcement to Greek Research and Education community (in Greek)	1st Apr 2016	Greece	Scientific Community	1293	Greece
186	Flyers, Press	GRNET	Open Call Announcement to FIRE Dissemination Working Group mailing list	4th Apr 2016	EU	Scientific Community	1293	EU
187	Flyers, Press	GRNET	Open Call Announcement to various educational groups and lists (FIRE Dissemination Working Group, SEFI, IEEE Education Society mailing list, “Discussion on Open Educational Resources" list)	4th Apr 2016	EU	Scientific Community	Unknown	EU

188	Flyers, Press	UoP	Patras IQ Open Call	15th-17th Apr 2016	Patras, Greece	Scientific Community, Industry	>300	Greece
189	Workshop	UoP	Patras IQ	16th Apr 2016	Patras, Greece	Scientific Community, Industry	>300	Greece
190	Conference	TCD, iMinds, UPMC, GRNET	Net Futures '16 Open Call	21st – 22nd April 2016	Brussels, Belgium	Scientific Community, Industry	200	Belgium, EU
191	Conference	TCD, iMinds, UPMC	Net Futures '16 Booth	21st – 22nd April '2016	Brussels, Belgium	Scientific Community, Industry	200	Belgium, EU
192	Workshop	OU	Net Futures '16	21st Apr 2016	Brussels, Belgium	Scientific Community, Industry	100	Belgium, EU
193	Presentation	TCD	FIRE Board Meeting @ NetFutures	21st Apr 2016	Brussels, Belgium	Scientific Community, Industry	31	Belgium, EU
194	Presentation	TCD, GRNET	FIRE DWG Monthly Meetings	Monthly	-	Scientific Community, Industry	24+	EU
195	Flyers, Press	TCD	FORGE Newsletter: FIRE News Mailing List	Quarterly	-	Scientific Community, Industry	1934	-
196	Flyers, Press	TCD	FORGE Newsletter: The FIRE Dissemination and Communication Group	Quarterly	-	Scientific Community, Industry	32	-
197	Flyers, Press	TCD	FORGE Newsletter: FIRE web portal (www.ict-fire.eu)	Quarterly	-	Scientific Community, Industry	unknown	-
198	Presentation	TCD	IEEE Actionable Data Book (ADB) for STEM Education	Weekly	-	Scientific Community, Industry	5+	USA, Europe
199	Publication	All Consortium	FORGE iBook	19th May 2016	Worldwide	Scientific Community, Industry Civil Society, Policy makers, Medias, Other	131	51 stores worldwide

200	Presentation	iMinds	WLAN Prototype Execution in Spanish	May 2016	UnB, Brazil	Scientific Community	8	Brazil
201	Presentation	TCD	TCD OFDM Wireless Course Deployed	31st May 2016	UnB, Brazil	Scientific Community	16	Brazil
202	Newsletter	TCD/OU	May 2016 issue http://ict-forge.eu/wp-content/uploads/2014/11/FORGE-newsletter-May16-v01.pdf	May 2016	UK	Scientific Community, Industry	>1934	Worldwide
203	Flyers, Press	GRNET	Open Call Announcement to Greek Research and Education community (in Greek)	10th Jun 2016	Greece	Scientific Community, Industry	1300	Greece
204	Press	iMinds TCD	Next Generation Internet Experimentation: Drivers Transforming Next Generation Internet Research and Experimentation	Jun 2016	-	Scientific Community, Industry Civil Society, Policy makers, Medias, Other	Unknown	EU
205	Presentation	iMinds	WLAN Prototype Execution in Spanish (IT Mexicali, Mexico)	14th Jul 2016	IT Mexicali, Mexico	Scientific Community	15	Mexico
206	Workshop	OU	EC-TEL'16 6th Workshop on Awareness and Reflection in Technology Enhanced Learning	13th Sep 2016	Lyon, France	Scientific Community, Industry	50	France, EU
207	Newsletter	TCD/OU	September 2016 issue http://ict-forge.eu/wp-content/uploads/2014/11/FORGE-newsletter-Sep16-FINAL.pdf	Sep 2016	UK	Scientific Community, Industry	>1934	Worldwide
208	Newsletter	TCD	FIRE Dissemination and Communication group	Nov 2015, Feb 2016, May 2016, Sept 2016	EU	Scientific Community, Industry	32	EU
209	Newsletter	TCD	FIRE web portal	Nov 2015, Feb 2016, May 2016, Sept 2016	EU	Scientific Community, Industry		EU
210	Newsletter	TCD	IEEE Education Society	Nov 2015, Feb 2016, May 2016, Sept 2016	EU	Scientific Community, Industry	700	EU

211	Newsletter	TCD	CLUSTER board mailing list	Nov 2015, Feb 2016, May 2016, Sept 2016	EU	Scientific Community, Industry	10	EU
212	Newsletter	TCD	FORGE Newsletter mailing list	Nov 2015, Feb 2016, May 2016, Sept 2016	EU	Scientific Community, Industry	60	EU
213	Newsletter	TCD	Website Downloads	Nov 2015, Feb 2016, May 2016, Sept 2016	EU	Scientific Community, Industry	184	EU
214	Conference	TCD	ICL 2016	21st Sep 2016	EU	Scientific Community, Industry	>30	EU

2.2 Section B (public) – Exploitable foreground

Although it was not initially foreseen in project's description of work, FORGE consortium members performed a step further in preparing exploitation plan, by studying and modelling the FORGE ecosystem a potential business model as well as a detailed cost analysis. The study was based on the elements that can be subject to exploitation: the architecture, software, methodologies and other public results of the project for courses given to students and other learners.

More specifically, the objects that have the potential to demonstrate the added value of FORGE and the project in general and could have further applications through the opening of the FORGE platform are:

- **FORGEBox**: FORGEBox is the component that interconnects learning interactive content with Future Internet Research and Experimentation (FIRE) resources. It comprises a set of services that will provide and host for example the interactive content of widgets, and interface with the FIRE resources via well-known FIRE APIs or with the Fed4FIRE portal. Learning Management Systems (LMSs), eBooks and any future element that wishes to consume FORGE content, will need to discover reference points of widgets and Lab Courses descriptions. FORGEBox instantiations can provide the host of such interactive content.
- **FORGEStore**: FORGEStore is a marketplace for the users' FORGEBox installation. The repository contains shared widgets, FORGEBox services, FIRE adapters and shared interactive courses. All items are developed by the FORGE team members as well as external stakeholders that are interested to create and share learning material for FIRE experimentation.
- **Widget**: A widget is a micro-application performing a dedicated task. FORGE and/or external stakeholders develop a number of widgets that expose FIRE facilities to learners and educators. These widgets function as standalone learning applications that can be embedded inside interactive courses.
- **FIRE Adapters/Services**: A FORGEBox service or FIRE Adapter enables a widget to communicate with the FIRE facilities with the functionality that is required for usage in an eLearning context.
- **Course**: A FORGE course is a self-study learning pathway that leads to achieving certain learning outcomes. Most commonly, the learners will study the course at their own pace, since there is no predefined start or end time. Most of the exploitation objects coming from the Open Call are expected to belong to this category, since most of the external stakeholders are expected to be interested in creating new or complement existing experiment-driven courses.
- **FORGE iBook**: FORGE has developed an interactive eBook in the Apple iBooks format. This is available to download for free via iTunes. The FORGE iBook features selected FORGE courses, which consist of instructional videos, quizzes and self-assessment exercises and offer access to FIRE facilities via interactive widgets.

From the study the consortium provided the following future scenarios:

Option 1: Commercialize the results of FORGE via a (spin-off) company

In the proposed value network FORGE assets are operated by a (spin-off) company. To compensate for the loss in EU funding, the (spin-off) company starts to charge the educational institutions for the usage of the education enablers (i.e. courses, widgets, etc.) and the FIRE experimentation facilities start to charge the educational institutions for the usage of their resources. In addition the (spin-off) company must pay a fee for testing on the FIRE experimentation facilities.

Another option is that the (spin-off) company is a single point of contact for the educational institutions. In that case, the value stream will go from the educational institutions towards the (spin-off) company and via the (spin-off) company to the FIRE experimentation facilities.

Exemplary investors in the spin-off could be:

- Specialized course material providers such as Pearson Education
- Educational institutions or associations of educational institutions
- FIRE experimentation facilities

Option 2: Integrate FORGE within the FIRE facilities

In the proposed value network all FORGE assets are integrated with the other roles of the FIRE experimentation facilities, i.e. a FIRE facility operates alone a FORGE instance. The benefit of this value network configuration is that a single actor combines all roles required to offer interactive courses on real resources.
In addition to the educational institutions (e.g. universities or other institution of higher education), specialized course material providers and private companies who wish to set up training courses for their employees could become customers of the FIRE experimentation facilities.

Future business, cost model and plan

Now that todays and the future ecosystem is given shape, we are able to describe a possible business model for the provider of the education enablers. The goal of a business model is to indicate the way value is being generated by interacting with other actors in the ecosystem.
The value proposition consists out of a set of education enablers that are offered towards educational institutions. These education enablers are widgets and course bundles, which can be easily integrated in the course material of educational institutions. The widgets are developed based on a set of generic features, which can be reused in future widgets/courses:

- Reservation module via web interface: to reserve resources online on the FIRE experimentation facilities
- Queuing module: to allow the usage of the same hardware by multiple students
- Integration with other systems: eBooks, learning management systems
- Learning analytics: to keep track of the progress of a student
- (Certification of courses/FIRE facilities – not available today)

The key activity is the development and marketing of the education enablers. These are highly focused functions that should be done by (a team of) educated specialists. Their wage is the main cost for the company offering the educational enablers. Another cost will be the cost for testing on the FIRE facilities. In return for the service, universities, course material providers and ICT companies pay a license fee for the usage of FORGE's enablers.

For universities and course material providers the cost of using the FIRE experimentation facilities' resources consists of two components and has to be calculated per case and according to the institutions' policies:

- Usage fee for resources
- License fee for getting access to enablers

While the commercialization of offering 'educational enablers' using FIRE facilities could theoretically be done by a dedicated entity, no legal entity showed interest so far. For the time being, we therefore fall back to the scenario where typically only FIRE facilities themselves will offer some education enablers (without a charging scheme but with a strong focus towards

their own facilities of course, although some enablers are interoperable with multiple facilities). Further development depends upon their goodwill and/or on bilateral agreements or MoUs.

In order for a dedicated entity, offering educational enablers using FIRE, to erect one should investigate more thoroughly the different techno-economics and business aspects which come into play and the required mechanisms to be put in place (e.g. issuing licenses, offering certified courses etc.). The amount of effort and expertise to do this however is considerable. The 'Common Exploitation Booster' (http://exploitation.meta-group.com/SitePages/default.aspx), supported by the EU, might be useful for similar ends but this initiative will only start after the FORGE project ends.

Nevertheless, the obtained accomplishments within the project itself will be sustainable as each partner within the current FORGE consortium will exploit these by e.g. continuing the usage of these flipped labs within the educational programmes of themselves and their partners and/or export them into other platforms (e.g. EIT ICT Labs) or even creating MoUs between partners.

In the white papers of the FIRE community, such as the 'FIRE Vision, Strategy and Roadmap towards 2020' document, using FIRE within education platforms is still pinpointed as 'one of the gaps to resolve'. Therefore, the consortium partners will also continue to seek new funding opportunities to collaborate on the combination of eLearning and FIRE:

- by monitoring the different calls within the different units within the EU 'Future Networks' Directorate in DG CONNECT (as the FIRE unit is no longer a separate unit but spread across these different units) and;
- by following the specifications and guidelines that will be stipulated by the EU project that will be the successor of Fed4FIRE.

FORGE did not produce any patents, trademarks or registered designs.

3. Report on societal implications

A General Information *(completed automatically when **Grant Agreement number** is entered)*

Grant Agreement Number:	610889
Title of Project:	Forging Online Education through FIRE
Name and Title of Coordinator:	Prof John Domingue

B Ethics

1. Did your project undergo an Ethics Review (and/or Screening)? • If Yes: have you described the progress of compliance with the relevant Ethics Review/Screening Requirements in the frame of the periodic/final project reports? Special Reminder: the progress of compliance with the Ethics Review/Screening Requirements should be described in the Period/Final Project Reports under the Section 3.2.2 *'Work Progress and Achievements'*	***No***
2. Please indicate whether your project involved any of the following issues (tick box) :	***N/A***
RESEARCH ON HUMANS	
• Did the project involve children?	***No***
• Did the project involve patients?	***No***
• Did the project involve persons not able to give consent?	***No***
• Did the project involve adult healthy volunteers?	***No***
• Did the project involve Human genetic material?	***No***
• Did the project involve Human biological samples?	***No***
• Did the project involve Human data collection?	***No***
RESEARCH ON HUMAN EMBRYO/FOETUS	
• Did the project involve Human Embryos?	***No***
• Did the project involve Human Foetal Tissue / Cells?	***No***
• Did the project involve Human Embryonic Stem Cells (hESCs)?	***No***
• Did the project on human Embryonic Stem Cells involve cells in culture?	***No***
• Did the project on human Embryonic Stem Cells involve the derivation of cells from Embryos?	***No***
PRIVACY	
• Did the project involve processing of genetic information or personal data (eg. health, sexual lifestyle, ethnicity, political opinion, religious or philosophical conviction)?	***No***
• Did the project involve tracking the location or observation of people?	***No***
RESEARCH ON ANIMALS	
• Did the project involve research on animals?	***No***
• Were those animals transgenic small laboratory animals?	***No***
• Were those animals transgenic farm animals?	***No***
• Were those animals cloned farm animals?	***No***
• Were those animals non-human primates?	***No***
RESEARCH INVOLVING DEVELOPING COUNTRIES	
• Did the project involve the use of local resources (genetic, animal, plant etc)?	***No***
• Was the project of benefit to local community (capacity building, access to healthcare, education etc)?	***No***
DUAL USE	
• Research having direct military use	***No***
• Research having the potential for terrorist abuse	***No***

C Workforce Statistics

3. Workforce statistics for the project: Please indicate in the table below the number of people who worked on the project (on a headcount basis).

Type of Position	Number of Women	Number of Men
Scientific Coordinator		1
Work package leaders	1	5
Experienced researchers (i.e. PhD holders)	2	13
PhD Students		5
Other	5	9

4. How many additional researchers (in companies and universities) were recruited specifically for this project?	5
Of which, indicate the number of men:	3

D Gender Aspects

5. Did you carry out specific Gender Equality Actions under the project?

☒ No

6. Which of the following actions did you carry out and how effective were they?

		Not at all effective				Very effective
❑	Design and implement an equal opportunity policy	○	○	○	○	○
❑	Set targets to achieve a gender balance in the workforce	○	○	○	○	○
❑	Organise conferences and workshops on gender	○	○	○	○	○
❑	Actions to improve work-life balance	○	○	○	○	○
○	Other:					

7. Was there a gender dimension associated with the research content – i.e. wherever people were the focus of the research as, for example, consumers, users, patients or in trials, was the issue of gender considered and addressed?

○ Yes- please specify

☒ No

E Synergies with Science Education

8. Did your project involve working with students and/or school pupils (e.g. open days, participation in science festivals and events, prizes/competitions or joint projects)?

○ Yes- please specify

☒ No

9. Did the project generate any science education material (e.g. kits, websites, explanatory booklets, DVDs)?

☒ Yes- please specify: Widgets and courses available via FORGEBox and as an eBook.

○ No

F Interdisciplinarity

10. Which disciplines (see list below) are involved in your project?

○ Main discipline[28]: **5.3**

○ Associated discipline[28]: **2.2**

○ Associated discipline[28]:

G Engaging with Civil society and policy makers

11a Did your project engage with societal actors beyond the research community? *(if 'No', go to Question 14)*

○ Yes
☒ No

11b If yes, did you engage with citizens (citizens' panels / juries) or organised civil society (NGOs, patients' groups etc.)?

○ No

○ Yes- in determining what research should be performed

○ Yes - in implementing the research

○ Yes, in communicating /disseminating / using the results of the project

[28] Insert number from list below (Frascati Manual).

11c In doing so, did your project involve actors whose role is mainly to organise the dialogue with citizens and organised civil society (e.g. professional mediator; communication company, science museums)?	○ ○	Yes No

12. Did you engage with government / public bodies or policy makers (including international organisations)

- ○ No
- ○ Yes- in framing the research agenda
- ○ Yes - in implementing the research agenda
- ☒ Yes, in communicating /disseminating / using the results of the project

13a Will the project generate outputs (expertise or scientific advice) which could be used by policy makers?

- ○ Yes – as a **primary** objective (please indicate areas below- multiple answers possible)
- ☒ Yes – as a **secondary** objective (please indicate areas below - multiple answer possible)
- ○ No

13b If Yes, in which fields?

Agriculture		Energy		Human rights	
Audiovisual and Media		Enlargement		Information Society	
Budget		Enterprise		Institutional affairs	
Competition		Environment		Internal Market	
Consumers		External Relations		Justice, freedom and security	
Culture		External Trade		Public Health	
Customs		Fisheries and Maritime Affairs		Regional Policy	☒
Development Economic and Monetary Affairs		Food Safety		**Research and Innovation**	
		Foreign and Security Policy		Space	
Education, Training, Youth	☒	Fraud		Taxation	
Employment and Social Affairs		Humanitarian aid		Transport	

13c If Yes, at which level?

- ○ Local / regional levels
- ○ National level
- ○ European level
- ☒ International level

H Use and dissemination

14. How many Articles were published/accepted for publication in peer-reviewed journals?	**1**
To how many of these is open access[29] provided?	**1**
How many of these are published in open access journals?	**0**
How many of these are published in open repositories?	**1**
To how many of these is open access not provided?	**0**
Please check all applicable reasons for not providing open access:	**n/a**
❑ publisher's licensing agreement would not permit publishing in a repository ❑ no suitable repository available ❑ no suitable open access journal available ❑ no funds available to publish in an open access journal ❑ lack of time and resources ❑ lack of information on open access ❑ other[30]: ……	**n/a**

15. How many new patent applications ('priority filings') have been made? *("Technologically unique": multiple applications for the same invention in different jurisdictions should be counted as just one application of grant).*		**0**
16. Indicate how many of the following Intellectual Property Rights were applied for (give number in each box).	Trademark	**0**
	Registered design	**0**
	Other	**0**
17. How many spin-off companies were created / are planned as a direct result of the project?		**0**
Indicate the approximate number of additional jobs in these companies:		**0**

18. Please indicate whether your project has a potential impact on employment, in comparison with the situation before your project:

☒	Increase in employment, or	☒	In small & medium-sized enterprises
❑	Safeguard employment, or	❑	In large companies
❑	Decrease in employment,	❑	None of the above / not relevant to the project
❑	Difficult to estimate / not possible to quantify		

19. For your project partnership please estimate the employment effect resulting directly from your participation in Full Time Equivalent (*FTE = one person working fulltime for a year*) jobs:	*Indicate figure:*
Difficult to estimate / not possible to quantify	☒

[29] Open Access is defined as free of charge access for anyone via Internet.
[30] For instance: classification for security project.

I Media and Communication to the general public

20. As part of the project, were any of the beneficiaries professionals in communication or media relations?

☒ Yes ○ No

21. As part of the project, have any beneficiaries received professional media / communication training / advice to improve communication with the general public?

☒ Yes ○ No

22 Which of the following have been used to communicate information about your project to the general public, or have resulted from your project?

☒	Press Release	☒	Coverage in specialist press
☒	Media briefing	☒	Coverage in general (non-specialist) press
❑	TV coverage / report	☒	Coverage in national press
❑	Radio coverage / report	☒	Coverage in international press
☒	Brochures /posters / flyers	☒	Website for the general public / internet
☒	DVD /Film /Multimedia	☒	Event targeting general public (festival, conference, exhibition, science café)

23 In which languages are the information products for the general public produced?

☒	Language of the coordinator	☒	English
☒	Other language(s)		

***Question F-10*:** Classification of Scientific Disciplines according to the Frascati Manual 2002 (Proposed Standard Practice for Surveys on Research and Experimental Development, OECD 2002):

FIELDS OF SCIENCE AND TECHNOLOGY

1. NATURAL SCIENCES

1.1 Mathematics and computer sciences [mathematics and other allied fields: computer sciences and other allied subjects (software development only; hardware development should be classified in the engineering fields)]

1.2 Physical sciences (astronomy and space sciences, physics and other allied subjects)

1.3 Chemical sciences (chemistry, other allied subjects)

1.4 Earth and related environmental sciences (geology, geophysics, mineralogy, physical geography and other geosciences, meteorology and other atmospheric sciences including climatic research, oceanography, vulcanology, palaeoecology, other allied sciences)

1.5 Biological sciences (biology, botany, bacteriology, microbiology, zoology, entomology, genetics, biochemistry, biophysics, other allied sciences, excluding clinical and veterinary sciences)

2 ENGINEERING AND TECHNOLOGY

2.1 Civil engineering (architecture engineering, building science and engineering, construction engineering, municipal and structural engineering and other allied subjects)

2.2 Electrical engineering, electronics [electrical engineering, electronics, communication engineering and systems, computer engineering (hardware only) and other allied subjects]

2.3. Other engineering sciences (such as chemical, aeronautical and space, mechanical, metallurgical and materials engineering, and their specialised subdivisions; forest products; applied sciences such as geodesy, industrial chemistry, etc.; the science and technology of food production; specialised technologies of interdisciplinary fields, e.g. systems analysis, metallurgy, mining, textile technology and other applied subjects)

3. MEDICAL SCIENCES

3.1 Basic medicine (anatomy, cytology, physiology, genetics, pharmacy, pharmacology, toxicology, immunology and immunohaematology, clinical chemistry, clinical microbiology, pathology)
3.2 Clinical medicine (anaesthesiology, paediatrics, obstetrics and gynaecology, internal medicine, surgery, dentistry, neurology, psychiatry, radiology, therapeutics, otorhinolaryngology, ophthalmology)
3.3 Health sciences (public health services, social medicine, hygiene, nursing, epidemiology)

4. AGRICULTURAL SCIENCES
4.1 Agriculture, forestry, fisheries and allied sciences (agronomy, animal husbandry, fisheries, forestry, horticulture, other allied subjects)
4.2 Veterinary medicine

5. SOCIAL SCIENCES
5.1 Psychology
5.2 Economics
5.3 Educational sciences (education and training and other allied subjects)
5.4 Other social sciences [anthropology (social and cultural) and ethnology, demography, geography (human, economic and social), town and country planning, management, law, linguistics, political sciences, sociology, organisation and methods, miscellaneous social sciences and interdisciplinary , methodological and historical S1T activities relating to subjects in this group. Physical anthropology, physical geography and psychophysiology should normally be classified with the natural sciences].

6. HUMANITIES
6.1 History (history, prehistory and history, together with auxiliary historical disciplines such as archaeology, numismatics, palaeography, genealogy, etc.)
6.2 Languages and literature (ancient and modern)
6.3 Other humanities [philosophy (including the history of science and technology) arts, history of art, art criticism, painting, sculpture, musicology, dramatic art excluding artistic "research" of any kind, religion, theology, other fields and subjects pertaining to the humanities, methodological, historical and other S1T activities relating to the subjects in this group]

4. Final Report On The Distribution Of The European Union Financial Contribution

This report shall be submitted to the Commission within 30 days after receipt of the final payment of the European Union financial contribution.

4.1. Report on the distribution of the European Union financial contribution between beneficiaries

Name of beneficiary	Final amount of EU contribution per beneficiary in Euros
1.	
2.	
n	
Total	