



Celtic-Plus

Newsletter 1/2015

The future of digital business –
Celtic-Plus Event in Vienna

How Spain fosters international cooperation
within Celtic-Plus

HFCC/G.fast – Hybrid fibre-copper connectivity
using G.fast technology



Editorial

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IMPRINT

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Dear reader,

Every day when I go to work I have to drive through a town with exactly 15 traffic lights within a distance of about three kilometres. None of them is synchronised with the others, so it is purely accidental whether they show red or green when you approach them. Synchronising these 15 traffic lights in an intelligent, real-time context-dependent way would solve various problems, such as saving a lot of energy by avoiding stop-and-go, keeping the drivers happy and in a positive mood, and last not least giving a good and modern impression of the town. This case is a rather simple, but illustrative example comprising several of the current hot ICT topics: Smart Cities, Internet of Things, Future Internet, and 5G.

The chance to solve such issues has never been as good as now. EUREKA has just started an Inter-Cluster Smart City Initiative with the goal of seeing many cross-disciplinary projects helping cities to better manage their energy, transport, water, administration, and many other issues. Nearly always we need ICT networks and services to enable and support these projects. This is a good example that the R&D world is becoming more cross-disciplinary. It is not so much the technical developments, which are in the focus, but the societal challenges like ageing population, health, efficient transport, energy efficiency, and food security.

In the first half of 2015, the ICT R&D community focused a lot on the first 5G-PPP Call within the EU’s Horizon 2020 framework programme. The first 5G-PPP projects are expected to start mid-2015. This creates an ideal scenario for complementary projects within the Celtic-Plus Programme.

To allow Celtic-Plus projects to start in a timely manner, we organise three Celtic-Plus Calls in 2015. The first Call ended in February and resulted in five project proposals. The second Call closed on 29 May with four proposals, and the third Call will close on 15 October. You are very welcome to submit your project proposals under the current call.

The Celtic-Plus programme offers proposers a number of benefits. It uses a bottom-up approach for research topics, i.e. there is no prescribed Call text, and proposals can be about any relevant ICT challenges. In addition, Celtic-Plus has a low administrative overhead, a high success rate, and the time between project proposal and the start of the actual project can be very short.

In this newsletter issue, we present to you a number of results and activities which resulted from our R&D programme. Most prominently, we had our largest ever annual Celtic-Plus Event this year co-located with the B2B Software Days in Vienna in April. You can read the article about this major event in this issue. In this context, we would like to thank Nokia for providing some key event sponsorship which helps us to improve the quality of the Celtic-Plus Events in 2015.

In this issue you will also find a new “Views from Public Authorities” article, which features the R&D activities of Spain, a very active player in the Celtic-Plus programme.

We hope you find this issue of our Newsletter and the articles interesting, and would welcome your comments.

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SPECTRA – Spectrum and energy efficiency in 4G and beyond



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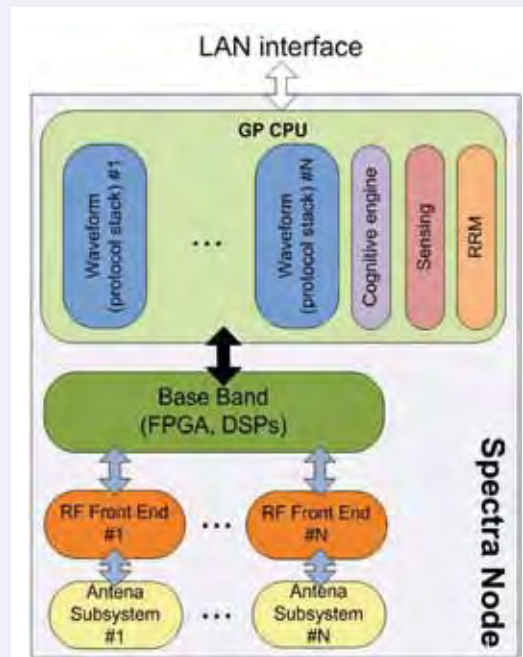
The SPECTRA project (Spectrum and energy efficiency in 4G communication systems and beyond) made significant progress in the field of new cognitive radio algorithms and innovative approaches to designing radio frequency front-end and base-band components. The main goal has been to achieve better spectrum and energy efficiency for communication systems beyond 4G. The realized blocks were integrated on two hardware platforms to show the capability to communicate cognitively in real-time and the significant efficiency gains brought by SPECTRA.

More than thirty hardware components were developed by the project, and the integrated system were successfully tested and verified in field trials. The advanced level of the developed hardware components and algorithms led to the release of six new products and to improvements in four existing lines of products with significant positive impact on the business of the project partners.

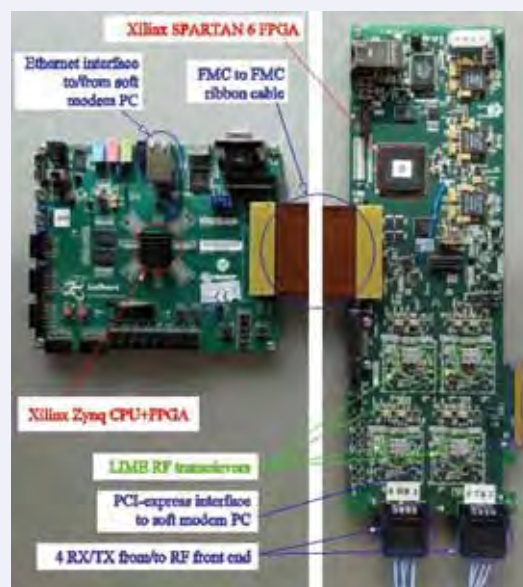
The SPECTRA Node – multi-functional, flexible and efficient

The core of the project has been the development of a flexible and efficient node implementing different waveforms, capable of covering multiple roles in the network (base station, relay and user equipment) and acting cognitively.

The result is the SPECTRA Cognitive Node, which is fully compatible with the LTE standard. Field trials of the prototype realized in a cellular environment showed that the proposed node is capable to act as a base station for existing commercial LTE devices. This guarantees that the SPECTRA solutions have a short time to market, and it makes the SPECTRA Node a serious candidate for the deployment of small cells.



Cognitive Spectra Node Architecture



The SPECTRA hardware platform

Small cells and new spectrum sharing paradigms

The increasing need of resources for mobile communications and the scarcity of available spectrum are pushing regulators all over the world to reconsider the allocation principles of spectrum resources. This will lead to new licensing models. The SPECTRA project provides the key technical components to fully exploit the opportunities of the future flexible spectrum environment.

The SPECTRA prototype and the related open source software released by the project has generated a lot of interest in the telecommunications community. In particular, the hardware platform

realized for the project was produced in several copies and sold to customers in Europe and Asia.

A community has formed around the released software leading to the creation of the "OpenAir Interface" foundation with the mission to maintain, protect and enrich it. The next step will be the creation of a service company to commercially exploit the key project results.

- Further information is available at <http://spectra-celtic.eu>



MediaMap+ – Media management from acquisition to publishing



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In today's context of exponentially growing data, organizations need to adapt and capitalize on rapidly changing scenarios, have better access to information resources, discover new opportunities, and improve their decision process. The MediaMap+ project has tackled these challenges in the area of media management.

The members of the Celtic-Plus project MediaMap+ have addressed some fundamental issues of traceability and broadcasting of audio-visual material. MediaMap+ has integrated a dynamic, low-entry threshold and cost-effective semantic ecosystem into media production systems for the requirements of 360° publishing, i.e. publishing for all types of end devices. Hence, the individual users are at the centre, without prejudging their mode of consumption. This has required new architectures to produce interconnected rich content, paving the way to knowledge.

Semantic ecosystem

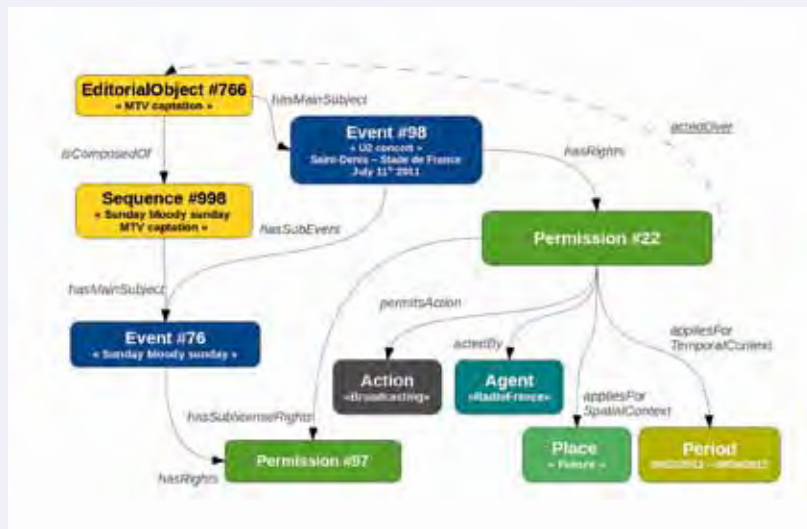
The project has developed a Web as a Brain (WaaB), a networked computer system that lets the network of human, machine, knowledge and know-how cooperate in the creation and the development of augmented audio-visual assets. As the WaaB assumes the traceability of the processes, it guarantees a proper clearance of rights. The project has extended the boundaries of valuation and monetization of the content, allowing mixed marketplaces, collaborative recommendation, and updating content on the fly.

Main results

The customer interface has been drastically improved in the past decade, and it speeds up. Actual Internet pure players have demonstrated a semantic ecosystem is a key factor of success to



WaaB : Web as a Brain



The semantic Event & Rights modelling

conquer and develop market segments. This is the essential difference between the GAFA (Google, Apple, Facebook, Amazon) and traditional brands.

The MediaMap+ project reshapes the business intermediation, thanks to a better traceability of the assets' life cycle, and a continuous enrichment process. MediaMap+ fixes interoperability and operational issues of Big Data and media. For its targets, it enables open, collaborative and transversal approaches of the business.

Conclusion

This efficient and effective exploitation of the Web 3.0 opportunities opens new business opportunities to the members of the consortium, who in less than six month since the end of the project, already delivered their breakthrough solutions to the market.

The results will bring innovation not only to the European media industry. It is relevant to any business that requires capitalizing upon its knowledge and listen to its ecosystem like in e-commerce, media agency and media brand markets, for instance. And thus it addresses local issues like proliferation of open networked knowledge bases or curation of sustainable knowledge.

- Further information is available at <http://mediamapplus.eu>



COMMUNE – Network management under uncertainty



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The Celtic-Plus project COMMUNE (Cognitive network Management under UNcEr-tainty) explored how to manage networks under conditions of increased complexity and uncertainty.

Telecommunication networks are growing in size, complexity and heterogeneity, with a rich blend of services being deployed on top of them. The Future Internet will consist of a set of cooperating players including network operators, service providers, and content providers. Cooperation between these players will be necessary in order to provide end-to-end services.

The multiplicity of devices, networks, providers and service domains, along with the introduction of a virtualisation layer that hides the actual resources from their users, will make network management and operation very challenging. This leads to increased complexity in the management of future networks.

Focus and approach

Uncertainty is an intrinsic property of future telecom networks, and currently in the real world only human operators are able to deal with this problem. COMMUNE addressed the problem by using technologies which support learning capabilities, also called cognition. It utilised a scenario-oriented approach to identify the causes of uncertainty, and characteristics and requirements of a number of relevant use cases.

The use cases included radio access (self-organizing network - SON) management, Fibre to the Home (FTTH) management, Internet of Things (IoT) and multimedia Quality of Experience (QoE) management for both peer-to-peer (P2P) and mobile networking cases. The outputs of the scenarios' work and the uncertainty models were used to select the suitable cognitive algorithms for each scenario. The combination of the overall scenarios and the knowledge repre-



The COMMUNE vision

sentation choices guided the design of the COMMUNE cognitive network framework. In the end, a small number of applications were prototyped and further validated using both simulations and experimentation.

The figure illustrates the COMMUNE vision, where the different COMMUNE concepts are grouped along the well-known MAPE (Monitor-Analyze-Plan-Execute) loop.

Results

The generic architecture for the autonomic and cognitive network management ("GARSON" from Orange) provided a comprehensive architecture for the implementation of cognitive algorithms in a number of different network management scenarios. GARSON is a very high-level approach in which the management architecture is decomposed into several planes, namely monitoring, actuating, knowledge, cognition and policy.

A number of scenarios indicated that a hybrid management approach, i.e. a combination of centralized and decentralized management, is often more appropriate than a unilateral approach. In addition, the suitability of different distributed implementation frameworks for the network management, including the Programmable Distributed Execution Environment (PDEE) framework which combines OSGi and FIPA technologies, was demonstrated. These were used in a distributed SON management scenario involving a number of partners. Substantial input was also made to IETF standardisation in the IoT area.

Conclusions

According to the EC's Digital Agenda for Europe, realizing the promise of next generation (5G) communications in terms of flexible and cost-efficient provisioning of versatile and context-aware services faces fundamental challenges in the domain of network management. Together with the infrastructure and services evolution, the management systems require a major step forward to efficiently manage the complexity and the diversity of these new infrastructures and services, while helping to satisfy the overall goal of cost efficiency. A high degree of automation and cognition is required to continuously tune the network to the current communication demands, and to concurrently improve the efficiency in the use of resources.

The goal of the Celtic-Plus project COMMUNE was to investigate cognitive techniques in order to solve problems or failures where the root causes cannot be completely identified. COMMUNE built an innovative solution for cognitive network management under uncertainty for selected scenarios. It was successful in demonstrating the mitigation of uncertainty by using suitable cognitive methods. It is expected that the technologies and concepts developed in the project will also be used as a platform for future research, particularly for research related to SDN and 5G.

- Further information:
<http://projects.celtic-initiative.org/commune/>



The future of digital business

Celtic-Plus Event in Vienna



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This year's Celtic-Plus Event in Vienna attracted more than 500 international experts and decision makers from the digital sector. They gathered in the Austrian capital on 27th and 28th April 2015 to discuss nothing less than the future of digital business. The major annual event of Celtic-Plus presented results of the programme's past and ongoing ICT projects and offered ample matchmaking opportunities for developing new project ideas.

For the first time, the Celtic-Plus Event took place in Vienna. This reflected the strong commitment of Austria's public authorities for research and innovation to further boost the country's role in the European ICT domain. The event was co-located with the B2B Software Days 2015 and was hosted by the Austrian Research Promotion Agency FFG, together with the Austrian Chamber of Commerce and the Vienna Business Agency.



High level of interaction at the plenary sessions of the Celtic-Plus Event.

Matchmaking and awards

The first day of the two-day event was dedicated to bilateral meetings of researchers, developers and innovation managers. The purpose of the matchmaking activity was for participants to meet other experts from the ICT community to discuss emerging R&D needs and proposals for collaborative projects.

At the networking event in the evening, the Celtic-Plus Awards were presented to the partners of the winning projects. There were three excellence awards for outstanding achievements in the categories Network Technologies, Services and Applications, and Connecting People, as well as an Innovation Award for a project which finished some years ago and has meanwhile generated significant business impact from its innovative results (see text box).

Conference and exhibition

The conference on the second day was opened with welcome speeches by Andrea Höglinger from FFG, the Austrian research promotion agency, and Jacques Magen, chairman of Celtic-Plus. The highlight of the opening session was a keynote by Jean-Sebastien Bedo from Orange Labs, who presented the 5G Infrastructure Association's 5G vision. In the next session, representatives of the award winning Celtic-Plus projects MediaMap+, CIER, SPECTRA, and Opera-Net presented their results.

The ensuing session focused on the successful projects of tomorrow: 13 researchers and developers from all over Europe presented their innovative project ideas for the next call of Celtic-Plus in short pitches.

The conference also included presentations by representatives from Canada and South Africa, who provided insights into their countries' R&D priorities and project achievements. Charles Despins, President of the Canadian innovation agency Prompt, explained how Canada is driving sustainability through an integrated telecoms and energy infrastructure. Jeanette Morwane, Director ICT and Service Industries at the South African Department of Science and Technology, presented telecoms research trends in her country. Canada and South Africa fully participate in Celtic-Plus, which means, participants from these countries are eligible for Celtic-Plus projects.

The conference concluded with a high-level panel discussion on the future of telecommunications, moderated by Eurescom director David Kennedy. The discussion focused on industry involvement, future services and business models.





Panel on the future of telecoms (from left): Thabo Malebadi, e-Mbizo Solutions; Jesús Canadas, Spanish Ministry of Industry, Energy and Tourism; Jean-Sebastien Bedo, Orange Labs; Martin Lehrbaum, Kapsch CarrierCom.



Manfred K. Mueller, Siemens Convergence Creators; Waltraud Müllner, A1 Telekom Austria; Fisseha Mekuria, CSIR Meraka Institute (from left).

The event was complemented with an exhibition, including results from 15 Celtic-Plus projects. Their prototypes provided an interactive experience of the technological progress they achieved. Many of these results have already made it to the market, which once again highlighted the benefits of the industry-driven focus of Celtic-Plus.

- Further information on the Celtic-Plus event, including videos, photos and presentations, is available at <https://www.celticplus.eu/videos-and-presentations-from-the-celtic-plus-event-2015-in-vienna/>

Celtic-Plus Awards 2015

Innovation Award: Opera-Net

The Opera-Net project on 'Optimised Power Efficiency in mobile Radio Networks' developed a solution which has been rolled out by French network operator Orange across most of Europe, Africa and the Middle East, reaching more than 140 million customers. Technologies developed in the project enabled savings between 2% and 3% of power consumption in Orange's 2G/3G radio networks, corresponding to an OPEX reduction of about 5 million euro per year.

Project leader: Orange Labs, France. Consortium: nine other industry and academic partners from Belgium, Finland, France, Ireland, and Singapore. Duration: June 2008 – May 2011

Opera-Net Website: <https://www.celticplus.eu/project-operanet/>

Excellence Award for "Connecting People": CIER

The CIER project brings broadband connectivity to rural areas in Europe and Africa. The project developed a plug-and-play radio-frequency communication system that brings high-speed Internet to rural areas. In a field trial in Tanzania, a 90 km network has connected three schools and a Hospital. A first commercial deployment has been done in the German City of Nordhorn, connecting a business area in a few days.

Project leader: Fraunhofer FOKUS, Germany. Consortium: seven further industry and academic partners from Finland, France, and Germany. Duration: February 2011 – July 2014

CIER Website: <https://www.celticplus.eu/project-cier/>

Excellence Award for "Network Technologies": SPECTRA

The SPECTRA project implemented novel cognitive-radio techniques which allow automated self-configuration of devices. SPECTRA developed the hard- and software components and demonstrated two proof-of-concept platforms which are able to communicate cognitively in real time. They can be used in quite different application cases, including LTE network, femto-cells but also in emergency communication systems.

Project leader: Thales Communications & Security, France. Consortium: six further industry and academic partners from France, Monaco, and Spain. Duration: September 2010 – 31 August 2014

SPECTRA Website: <http://spectra-celtic.eu/>

Excellence Award for "Services and Applications": MediaMap+

The MediaMap+ project made it possible to produce a TV programme with much less effort for manipulating and verifying media content prior to the broadcast. MediaMap+ provides an integrated workflow for audio-visual productions covering the whole production chain. It makes audio-visual content easily identifiable and available for re-use in future media productions. Videos are enriched with semantic meta-data that allow users to find relevant video sequences via a built-in search function. The MediaMap+ toolset enable a high degree of automation throughout the whole media production.

Project leader: SGT, France. Consortium: five further industry and academic partners from Belgium and France. Duration: April 2012 – June 2014

MediaMap+ Website: <http://mediamapplus.eu>



How Spain fosters international cooperation within Celtic-Plus



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In Spain two ministries are involved in the management, representation and promotion of CELTIC-Plus and other EUREKA Clusters: the Ministry of Industry, Energy and Tourism (MINETUR), and the Ministry of Economy and Competitiveness through the Spanish Innovation Agency, the Centre for Industrial Technological Development (CDTI).

The Ministry of Industry, Energy and Tourism (MINETUR) is the responsible institution for defining the national ICT policies, in agreement with other departments.

CDTI participates actively in Celtic-Plus due to the added value of innovation performed internationally and the ability to enable Spanish companies to foster their technological capacities. This allows the companies to expand the impact of their products, processes and services on the global market. EUREKA Clusters have become an excellent way to foster the Spanish industry for global competitiveness.



TILAS Project: Detail of the nodes with antennas and encapsulated customized deployment

EUREKA Clusters and their projects offer Spanish industry the advantage that they are bottom-up international initiatives to stimulate collaborative R&D in Europe. Within the Clusters, Celtic-Plus is particularly relevant, as the R&D field of Celtic-Plus – telecommunications, including networks, services and applications – has gained great relevance in the ICT-related industry, which is of importance for Spain. Spain has made major contributions to very successful Celtic-Plus projects, two of which are presented below.

Successful Celtic-Plus projects in Spain

The HIPERMED project, funded by MINETUR, has developed an open high-performance low-cost telemedicine platform that has a huge potential for reducing healthcare costs in developed countries and provides cost-effective healthcare to remote areas of developing countries. It has received the following European awards:

- Celtic-Plus Excellence Silver Award (April 2014)
- Winner of the EUREKA Award in the category “Added Value” (August 2014)
- Winner of the prestigious EUREKA Innovation Award (November 2014)



Celtic-Plus project HIPERMED: First real deployments of HIPERMED rehabilitation solutions

The TILAS project on Technology Improvements for Large Scale Smart Cities Deployments, funded by CDTI, provides technological solutions that enable the deployment of IoT (Internet of Things) devices in large-scale smart cities environments. The breakthroughs are focused on new models of end-to-end security devices with limited resources, management of massive remote firmware upgrades, new routing protocols, incorporation of IPv6 on PLC and actual deployments of validation in urban environments. Several articles have been published about TILAS at international level.

Funding in Spain

Usually MINETUR and CDTI grant the Celtic-Plus projects a funding of 25% or more for large companies and about 35% for SMEs. Research centres and universities must be sub-contracted by industry.

Both, MINETUR and CDTI, have a proven method to foster this kind of projects due to the high potential for Spanish participants to improve their competitiveness and exploitation capacities on the European market. Besides, CDTI has rein-

forced the funding tools for EUREKA Cluster projects with loans up to 85% of the fixed interest rate Euribor, and a 30% non-repayable part, the highest offered by CDTI for R&D projects.

21 projects have been funded by MINETUR and CDTI since 2011. While MINETUR opens specific calls for Celtic-Plus Projects, CDTI has an open call the whole year round.

Conclusions

Celtic-Plus is a bottom-up R&D programme that complements other international and national programmes and offers an International cooperation framework. It is a very interesting programme for Spanish companies, and it provides the best solution for applying technology at key and strategic sectors.

The Spanish Authorities have a high interest in Celtic-Plus, involving two Ministries with complementary funding tools for Spanish organisations, mainly for industry, although research centres or universities are welcome within the consortiums if they are sub-contracted by companies.

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Seed4C – Security embedded element and data privacy for the Cloud



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The virtualization of critical business applications is still restrained by security and data protection issues in the Cloud. The Seed4C project is determined to overcome these restrictions. It has therefore developed an approach which consists of attaching hardware-based Secure Elements (SE) to Cloud nodes in order to offer strong security enforcement and to support an end-to-end process ranging from security policy modelling to security assurance.

Security in the Cloud

The benefits of Cloud Computing are widely recognized, but enterprises are still hesitant to rely on Cloud infrastructure for their sensitive data and applications, as they fear potential data security and privacy issues. Moreover, some sensitive data are subject to constraints due to regulations. Seed4C proposes therefore an approach allowing the strong enforcement of security policies which are typically defined in the Service Level Agreement established with the Cloud Service Provider (e.g. on data location or processing isolation). In addition, the Seed4C approach allows providing some guarantees that these policies have been well enforced all along the lifecycle of the applications in the Cloud.

End-to-end security based on Secure Elements (SE)

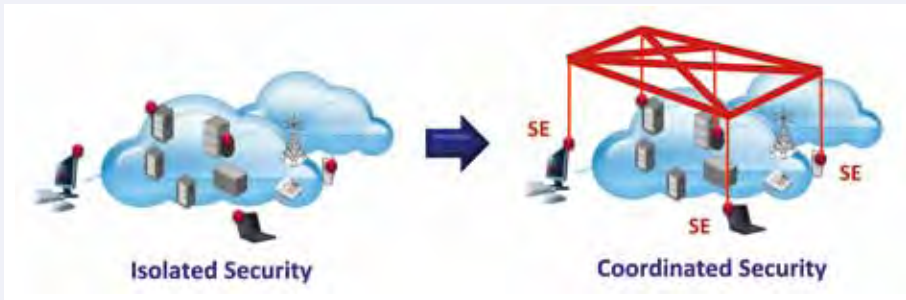
Seed4C allows the end-to-end and in-depth enforcement of security in Cloud infrastructures handling critical data and applications. The main

idea has been to attach hardware-based Secure Elements (SE) to Cloud nodes in order to enforce various security policies, e.g., using the node certified location stored in the SE. In addition, relying on these SEs, additional security services are offered to enforce security policies with various Security Services Modules (SSM). The SEs are connected through a Network of Secure Elements allowing for instance to get the certified security context (e.g. location) of a remote Cloud node. Finally, Seed4C provides an assurance verification mechanism offering the customer, or an auditor, a comprehensive view of the security level of his Cloud applications.

Seed4C security process

Seed4C has defined an end-to-end security process which consists of the following stages: (i) security policy modelling, (ii) application and policy deployment in a Cloud platform, (iii) SE-based policy enforcement, and (iv) monitoring and assurance of the enforcement of these policies.





From isolated security to coordinated security in the Cloud

In order to support this process, the following tools have been designed and prototyped:

- A Policy Modelling tool allowing the modelling of the application (i.e. its different components and data flows) and its security policies such as confidentiality, isolation, or integrity.
- An extended OpenStack platform allowing the application deployment according to the previous security model and the configuration of the security policies using the SE. For this purpose, SE-based security services allows the dynamic configuration of different SSM such as firewall, Mandatory Access Control, or Data Protection engine.
- The policy enforcement also relies on these SE-based services (e.g. to get the node certified location or encrypt/decrypt a sensitive data). Administration tools are also offered to manage the network of SEs and, for each tenant, to manage its own critical data (e.g. keys) in a secure space in the SEs.
- Monitoring and Security Assurance tools allow testing the security policies and aggregating all the test results via security assurance metrics to establish a security dashboard showing to an administrator the overall security status of the Cloud infrastructure and applications.

Project achievements

These technical achievements have been presented in 18 publications and at various Cloud-related events. The Seed4C platform has been implemented in use cases of different business domains, like, e.g., airport management system, telecommunication, security management. Furthermore, it has created a new product and several improvements of existing products.

Seed4C has interacted with various standardization bodies (e.g. GlobalPlatform, Trusted Computing Group, ETSI Network Function Virtualization), allowing leveraging the expertise built in the project on SE-based Cloud security. Recently Gemalto has purchased Safenet (HSM provider of Amazon AWS), which opens another opportunity for further impacts of the project in the industry. Finally, Seed4C advisory board meetings organized with other industrial actors (e.g. railway operator, electricity supplier) have shown the relevance of the Seed4C approach to address the security concerns of other businesses which want to virtualize their critical applications.

Conclusion

Seed4C has demonstrated how hardware-based Secure Elements – embedded in Cloud nodes – can strongly improve the security of sensitive data and applications in the Cloud. The approach chosen by the project serves a wide range of challenges. There is for instance an increased demand for data sovereignty and control of critical flows in the Cloud, e.g. trans-border flow control.

In this context, the upcoming Network Function Virtualization combined with the Software Defined Network technology brings new benefits along with strong security concerns that can also be addressed by exploiting Secure Elements attached to Cloud nodes or network equipment. In another context, the digital services offered on various devices, or in IoT objects, are holding and exploiting an increased volume of sensitive data and are becoming more and more invasive for people’s lives. Exploitation of dedicated attached hardware Secure Elements may also improve data protection and privacy control, increasing as well the trust of each customer in this new digital and Cloudified world.

- Further information is available at <http://www.celticplus-seed4c.org/>



Seed4C end-to-end security process

HFCC/G.fast – Hybrid fibre-copper connectivity using G.fast technology



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The HFCC/G.fast project can be seen as a response from the broadband industry to the 100 Mbits/s ambitions set out in the European Commission's Digital Agenda. Mass deployment of fibre-to-the-home broadband being prohibitively expensive, industry looked for a solution to combine deep fibre deployment with short copper drops to deliver gigabit speeds to homes. To reach the targets of at least 100 Mbits/s to European citizens, a new telecommunication standard was needed.

The HFCC/G.fast project had three goals:

- Complete the standardization of G.fast, a process started by the Celtic project 4GBB (2009-2012).
- Maintain a European technology lead in the fixed-line broadband area and thus lay the foundation for continued export success stories.
- Address the path from the completed G.fast standard into a commercial, widely deployed success.

The project consortium and how it worked

The project included 14 partners from nine countries, many of them self-funded, which indicates both the value of participating in the project and the high commitment of the partners. Self-funded partners are also a credit to the value creation of Celtic as a platform for collaborative work.

The project also served as an arena for innovation and knowledge generation. At the start of the G.fast work, it was largely believed that using the public telephony copper wiring in the intended way was impossible or at least impractical. A joint learning journey revealed surprising potential, which was very stimulating for the many individuals working in the project. The frequent physical meetings, where technical discussions were given ample time, were always well attended, and provided high-quality results.

The consortium composition with partners from the whole value chain turned out to be of unexpected importance. One of the project's main achievements is the shortening of time-to-market of about five years compared to previous comparable standards. This can be seen in the table below. Keep in mind for this comparison that G.fast is in its structure very complex and that it really is a whole family of standards.

	ADSL	VDSL	G.fast
Start of standard development	1992	1996	2011
First approved ITU standard	1999 (T1.413 approved in 1996)	2004	2014
Start of interoperability tests	~2003	~2006	2015
Start mass deployment	~2000	~2009	Expected 2016
Years to deployment	11 years	13 Years	5 Years

We can illustrate how time was saved by an exaggerated anecdote: Normally when an integrated circuit chip is ready, time is needed to integrate this into a prototype; time is needed to develop test plans; time is needed to negotiate and allocate testing in operators' labs; and time is needed for testing. In our case you could imagine chips being dropped into their sockets in otherwise complete and integrated prototypes that were already hooked up into measurement setups in operator labs.

This high development speed also put expectations on others to keep up and created the trust needed for others to move quickly. The trust creation, both inside and outside the project, and the importance of this trust creation was not foreseen from the beginning, and hence a very positive surprise.

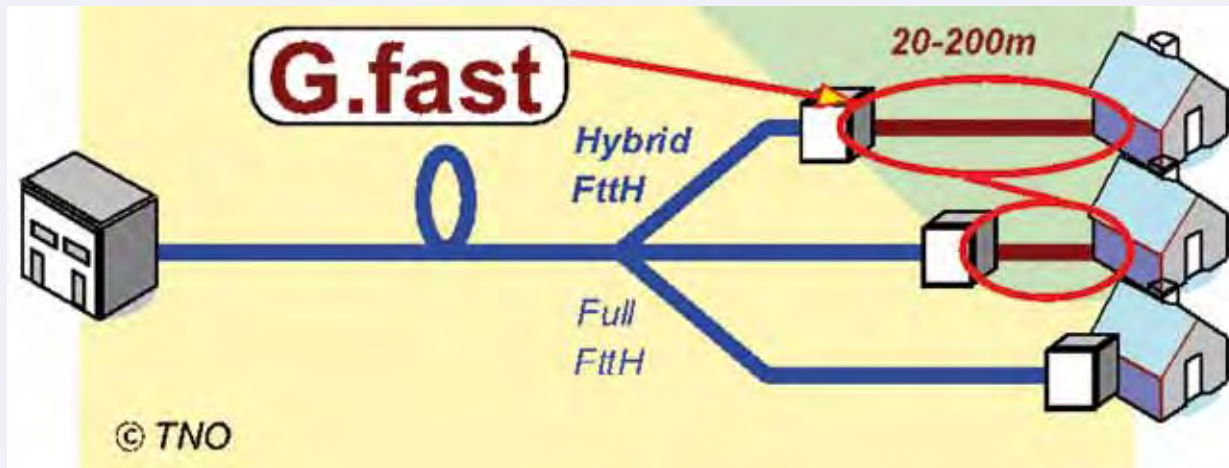
G.fast and other standard-like activities

During the course of the project, the G.fast standard (G.9701) was initially 'consented' by the ITU in December 2013 and approved in December 2014.

In parallel to the work in the ITU, there were also activities in ETSI and the Broadband Forum on key solutions to enable the deployment of G.fast including reverse power feeding for small G.fast fibre-fed nodes, Zero Touch operations administration and maintenance (OAM), to avoid the need for manual intervention in the field and the development of test methods to drive delivery of high performance interoperable system components.

The approval of the G.fast standard G.9701 led to the immediate delivery of chipsets that can provide an aggregate throughput of almost 1Gbps speeds over standard twisted-pair copper wires at a range of 100 meters, and up to 170Mbps has been reported at a range of 480





G.fast use case

meters using silicon designed by HFCC/G.fast partner Scipio Technologies. The figure shows a use case for G.fast. The surprisingly good performance of the technology over ranges longer than 200m has even increased the operational envelope compared to the initial performance estimations.

Chips, prototype development and trials

G.fast can be considered as an ideal interim technology where the existing copper infrastructure of the local loop is utilised until it becomes economical to universally deploy a full Fibre-To-The-Home (FTTH) access network. The operators

in the project consortium, Orange, BT, Telefonica and TNO (on behalf of KPN), are currently performing trials. In particular, BT has publically announced that this summer it will commence the deployment of two G.fast pilots at two different locations with around 4,000 businesses and homes participating.

Conclusion and outlook

The Celtic project HFCC/G.fast has achieved the three main goals set at the outset of the project, and large pilots are being implemented. A successor project “GOLD “(Gigabits Over the Legacy Drop)” has just started. By increasing the deploy-

ment range, it makes G.fast an even more useful technology to network operators since it will now be capable of replacing VDSL2 services in the access network and thus serve more customers from a point deeper in the network. The field trials starting in the summer of 2015 will boost the research and development of deployment procedures and best practises. The field trials will surely also reveal new challenges to be overcome.

- Further information is available at <http://www.4gbb.eu>



About Celtic-Plus

Celtic-Plus is an industry-driven European research initiative to define, perform and finance through public and private funding common research projects in the area of telecommunications, new media, future Internet, and applications & services focusing on a new “Smart Connected World” paradigm. Celtic-Plus is a EUREKA ICT cluster and belongs to the inter-governmental EUREKA network. Celtic-Plus is open to any type of company covering the Celtic-Plus research areas, large industry as well as small companies or universities and research organisations. Even companies outside the EUREKA countries may get some possibilities to join a Celtic-Plus project under certain conditions.