Research and Innovation Challenges in Infrastructure Services:

Map between on-going actions and the workprogramme topics

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Content

1. Introduction

1.1. Aim

This open-access document aims to support the activities of the cluster of projects and actions on Cloud partially funded by the European Commission through the FP7-Collaboration-ICT and H2020-LEIT-ICT programmes. It identifies the common topics of interest, the common tools, the common development directions, the commonly used standards. This information is considered essential to identify the key subjects for collaborations and take-ups between the projects and actions.

Moreover, to help the development of new actions and projects, the coverage of the challenges of the incoming calls of H2020-ICT by the research and innovation activities of the cluster projects and actions are identified in this document.

1.2. Scope

The document is reflecting the opinions of the representatives of the projects involved in the cluster of projects, respectively AppHub, ARCADIA, CloudLightning, ClouT, ENTICE, iKaaS, INPUT, Mo-bizz, MIKELANGELO, MODAClouds, MUSA, RAPID, SPECS, SWITCH.

The cluster "New Approaches for Infrastructure services" intends to be a forum for discussing the current research and innovation challenges encountered at infrastructure-as-a-service level generated by the desire to improve the user experiences and the efficient use of the available resources. The current trends are including the integration of special devices from high performance computing ones to mobile devices, the design of decentralised service-oriented systems, the improvement of the virtualization technologies, the overcome of portability and interoperability issues, or the automation the organisation and management of the back-end resources. Cloud-based applications from the fields of Internet-of-Things and Big Data are expected to challenge the new services.

Details about the cluster activities, aims and results are available at:
https://eucloudclusters.wordpress.com/new-approaches-for-infrastructure-services/

1.3. Organisation

The document is organized as follows. The next section reminds the challenges to which the cluster actions have answered as stated in the European Commission in FP7-ICT-Call 8/10 and H2020-LEIT-ICT-Call 1, as well as the challenges from the incoming calls. Section 3 is describing shortly the cluster actions and projects. Section 4 is showing the common topics of interest and targets of the cluster actions and projects. What is missing is identified in Section 5, while several recommendations are provided in Section 6.

2. Following the R&I challenges defined by H2020-LEIT-ICT-2016

The cluster gathers representatives of projects and actions funded by the European Commission under the programmes FP7-Cooperation-ICT and H2020-LEIT-ICT. These projects and actions are aligned with the research and innovation challenges that were exposed to the time of the project proposal calls, respectively FP7-ICT-2011-8[1], FP7-ICT-2013-10[2], CIP-ICT-PSP.2012.5.2[3], and H2020-ICT-2015-1 [3][4]. They are covering various topics from resource management to security or mobile computing as were encountered in the texts of the calls to which they responded (see the project and action descriptions from the next section).

Acting as representative initiatives for European R&I communities, the cluster members are keen, as well as responsible, to be aligned also with the new trends in research and innovation. Part of these trends are expected to be visible in the new calls for action proposal issued by the European Commission. When this document was issued a new call was expected, H2020-ICT-2016-06[5]. New and hot topics are encountered in the new call text when they are compared with the previous calls (e.g. fog computing, software-defined data centers, data integrity, resilience). While these topics are new from the workprogramme point of view, the on-going initiatives involved in the cluster are partially addressing them. Therefore they can be the topics of interest for starting the collaboration between the cluster members, for gap identifications and establishment of new initiatives between the specialists involved in the cluster. A secondary goal is to help the initiatives which will respond to the new call to easy identify the actions and projects that are currently working on the topics of interest and to build on top of their open-access concepts and technologies. The keyphrases selected from the H2020-ICT-2016-06 call text that are considered in this document in Section 4 are the followings:

- Development of distributed, federated and heterogeneous cloud computing model
- Deployment and management of resources: in a decentralised, autonomous way
- Extension of extreme edge of the network
- Software defined networking
- Software defined data center
- Data storage infrastructures
- Security, privacy
- Trust: data and services from different cloud providers
- Federated environments
- Resilience and scale
- Service Level Agreements: for quality critical applications, and novel negotiation mechanisms
- Novel composition model for infrastructures: application aware
- Large-scale experiments
- Interoperability and standardization
- Quality of Service and Quality of Experience

[1] https://ec.europa.eu/research/participants/portal/desktop/en/opportunities/fp7/calls/fp7-ict-2011-8.html
[2] https://ec.europa.eu/research/participants/portal/desktop/en/opportunities/fp7/calls/fp7-ict-2013-10.html
[3] http://cordis.europa.eu/programme/rcn/18727_en.html
[4] https://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/calls/h2020-ict-2015.html
[5] https://ec.europa.eu/programmes/horizon2020/en/draft-work-programmes-2016-17

3. R&I challenges as defined as defined by the cluster actions

3.1 AppHub

General information: Call: H2020-ICT-2014-1, Topic: ICT-07-2014, Type: CSA, Duration: 2 years (started on 1st Jan, 2015), Web site: http://www.apphub.eu.com

Aim: Support the market outreach strategies of EU-supported open source by launching AppHub, the European open source market place. AppHub is a service platform that will help the market to seamlessly identify, position and implement the software outcomes of these projects. The partners that will develop, run and promote AppHub over this two-year project and beyond combine unparalleled expertise in open source community management, EU research projects and a breakthrough technology in software asset management.

Approach:
AppHub will be based on three interrelated services:

- The AppHub Directory allows placing software assets as part of a reference architecture and thus identifying rapidly ways to compose various open source assets into a service architecture.
- The AppHub Factory lets users build and maintain full software stacks as templates using a visual "point and click" interface or APIs.
- The AppHub Store provides users with self-service access to pre-packaged business and IT applications via a customizable, white-labelled app store, and to deploy them in various cloud infrastructures.

Expected impact:

- Better connect EU-supported open source projects with users. The AppHub marketplace will reduce barriers to open source adoption and will make it easy for potential users and integrators to deploy and run the software produced by EU-supported open source projects on many different cloud service providers' platforms.
- Improved market readiness and reputation of EU-supported open source projects. AppHub will provide EU-supported projects with a full service support that will make them better prepared for market acceptance.
- Stronger EU community to support the growth of EU-supported open source project. AppHub will improve community support for EU-supported open source projects and for EU-generated open source software in general.
- Build global visibility and build market position of EU-supported open source projects. AppHub will help enhancing the global recognition of EU open source projects through improved community support, better open source management of open source projects, and greater ease of access to the software. EU-generated open source software in general promoted through AppHub will gain greater visibility and a better market position.

3.2 ARCADIA

General information: Call: H2020-ICT-2014-1, Topic: ICT-09-2014, Type: RIA, Duration: 3 years (started on 1st Jan, 2015), Web site: http://www.arcadia-framework.eu

Aim:
Given the inability of Highly-Distributed-Application-Developers to foresee the changes as well as the heterogeneity on the underlying infrastructure, it is considerable crucial the design and development of novel software paradigms that facilitate application developers to take advantage of the emerging programmability of the underlying infrastructure and therefore develop Reconfigurable-by-Design applications. In parallel, it is crucial to design solutions that are scalable, support high performance, are resilient-to-failure and take into account the conditions of their runtime environment. Towards this direction, the ARCADIA project aims to design and validate a Novel Reconfigurable-By-Design Highly Distributed Applications Development Paradigm over Programmable Infrastructure.

Approach:
The proposed framework will rely on the development of an extensible Context Model which will be used by developers directly at the source-code level. Proper Context-Model will be assisted and validated by IDE-plugins in order to re-assure that the generated executable files contain meaningful semantics. According to ARCADIA's vision, the generated executables should be on-boarded by a Smart Controller which will undertake the tasks of translating annotations to optimal infrastructural configuration. Such a controller will enforce an optimal configuration to the registered programmable resources and will pro-actively adjust the configuration plan based on the Infrastructural State and the Application State. The Context-Model and the aforementioned ARCADIA toolset will be complemented by a Development Methodology that will assure that developed Highly Distributed Applications are Reconfigurable-By-Design. The framework is planned to be validated and evaluated on three use cases that will be deployed over testbeds that host heterogeneous programmable infrastructure.

Expected impact:
ARCADIA's reference implementation and developed toolkits are going to facilitate application developers to design and develop infrastructural-agnostic applications and lead to the evolvement of novel and innovative paradigms for the deployment of advanced applications, boosting in this way the competitiveness of the software development industry. ARCADIA will facilitate significantly the deployment and maintenance of applications from application developers and network administrators and thus will boost their productivity. Furthermore, the development of applications executed over programmable networks will enable the deployment of eco-systems offering a plethora of innovation opportunities for software industry as well as SMEs. Advanced applications and end-to-end services may be introduced at lower risk while keeping the network reliable and secure and improving its utilization and operational efficiency. The deployed developer ecosystems and the empowerment of all kind of heterogeneous resources will enable innovation, invention, creation and deployment of new business models and jobs in all economic sectors and societal challenges.

3.3 CloudLightning

General information: Call: H2020-ICT-2014-1, Topic: ICT-07-2014, Advanced Cloud Infrastructures and Services, Type: RIA, Duration: 3 years (started on Feb 1st, 2015), Web site: www.cloudlightning.eu

Aim: CloudLightning seeks to efficiently exploit heterogeneous cloud resources to reduce application development effort, make optimisations easier, and simplify service deployment and delivery. It will create a new way of provisioning heterogeneous cloud resources to deliver cloud services. The new self-organising system will make the cloud more accessible to cloud consumers and provide cloud service providers with power-efficient, scalable management of their cloud infrastructures.

Approach: CloudLightning is committed to deliver three main technologies:

- service description languages for heterogeneous clouds
- algorithms and software for self-organisation of cloud infrastructures
- cloud support for graphics processing units, many integrated cores, and data flow engines

The CloudLightning solution comprises the following elements:

- a declarative approach to service provision;
- the introduction of decentralised self-management; and
- the exploitation of heterogeneous resources.

The CloudLightning solution will be demonstrated in three application domains: genome processing, oil and gas exploration, and ray tracing.

Expected impact: European cloud service providers that adopt the CloudLightning delivery model can be impacted by:

- increased competitiveness resulting from providing a differentiated solution with those currently available in the market;
- operational savings (that may be passed to cloud consumers;
- greater accessibility to cloud computing will facilitate the consumption of cloud resources generating competitive advantage.

Enterprise IT departments using CloudLightning-enabled cloud services will benefit through:

- increased accessibility to heterogeneous processing resources;
- greater choice within the market due to the portability of the declarative service descriptions;
- greater energy efficiency and reduction in associated costs;
- reduced development, deployment and optimisation effort.

In addition to contributing to competitivess in EU enterprises, greater server utilisation resulting from CloudLightning deployments will result in less energy consumption and associated energy savings, a strategic objective for European society and industry and can contribute to the 20/20/20 climate energy targets.

3.4 ClouT

General information: Call: FP7-ICT-2013- EU-Japan, Type: STREP, Duration: 3 years (started on 01 April 2015), Web site: http://clout-project.eu

Aim: ClouT, which stands for "cloud of things", is providing infrastructure, services, tools and applications that will be used by municipalities, citizens, service developers and application integrators to create, deploy and manage applications that take advantage of the latest advances in the Internet of Things (IoT) and Cloud domains. The project aims at providing a reference Cloud + IoT architecture and developing its instances to be deployed in 4 pilot cities: Santander, Genova, Fujisawa and Mitaka. The ClouT project is bringing together prestigious private companies such as ST Microelectronics, Engineering, Panasonic, NTT as well as academic institutes such as CEA, University of Cantabria, Keio University and National Institute of Informatics, which are strongly committed to bring this first EU-Japan initiative to a success. Cities have been experiencing emerging challenges such as efficient energy management, economic growth and development, security and quality of life of its inhabitants. To tackle these issues, two recently emerged set of technologies from ICT have great potential to provide the necessary enablers: Internet of Things and Cloud Computing. ClouT's overall concept is leveraging the Cloud Computing as an enabler to bridge the Internet of Things with Internet of People via Internet of Services, to establish an efficient communication and collaboration platform exploiting all possible information sources to make the cities smarter. ClouT aims at helping cities to provide their infrastructures as services that can be reused by different platforms and service providers.

Approach: ClouT, with its user-centric approach, aims at making citizens aware of city resources and helping them to use and care for them by means of smart IoT services in the Cloud. ClouT will also offer end-users the possibility of creating their own Cloud services and share them with other citizens. ClouT will support the following major features:

- city data acquisition capability leveraging Internet of Things and Internet of People; data from trillions of things and billions of people are integrated in the Cloud data hosting functionality keeping their universal interoperability;
- city data provision functionality to easily develop scalable, dependable, and semantic services;
- innovative city applications in four pilot cities: Santander and Genova in EU, Mitaka and Fujisawa in Japan.

Expected impact:

- Strategic European and Japanese impact for future collaborations by joining the forces and create a long-lasting synergy for smart city initiatives between Europe and Japan.
- Technological impact by exploiting existing European and Japanese assets in terms of IoT and Cloud achievements and by sharing with existing projects its experience within its multi-cultural inter-continental nature.
- Economic impact by providing valuable benefits to various economic actors in the IoT and Cloud domain by opening new market opportunities for device manufacturers, telecom operators, service providers and application integrators (in particular for SMEs) by taking benefit from the ClouT's service oriented approach.
- Social impact for cities and citizens by improving citizens' interaction with the city services, keeping the user in the loop of city life. Field trials have been planned in four pilot cities (Santander and Genova in EU, Mitaka and Fujisawa in Japan) . Target applications are enhanced public transportation, participatory sensing, safety and disaster management, social event detection, care-giving for elderly persons, sharing IoT devices in the cloud.

3.5 ENTICE

General information: Call: H2020-ICT-2014-1, Topic: ICT-07-2014, Type: , Duration: 3 years (started on 0102, 2015), Web site: http://www.entice-project.eu/

Aim: ENTICE will research a environment targeting federated Cloud infrastructures for: (i) simplifying the creation of lightweight and highly optimized VM images; (ii) automatic decomposition and distribution of VM images based on multi-objective optimization (performance, economic costs, storage size, and QoS requirements) and a knowledge collection and reasoning infrastructure, and (iii) auto-scaling of Cloud resources that supports interoperability of VMs across Cloud infrastructures without provider lock-in. We gathered an interesting selection of complementary use cases from energy management to earth observation and cloud orchestration which will be used to validate the ENTICE environment and that are provided by two SME and one industrial partners of the project.

Approach:
A multidisciplinary team of computer scientists and application providers will research a ubiquitous repository-based technology called ENTICE environment that provides a universal backbone for IaaS VM management operations, which accommodate the needs for different use cases with dynamic resource (e.g. requiring resources for minutes or just for a few seconds) and other QoS requirements. The ENTICE technology is completely decoupled from the applications and their specific runtime environments, but continuously supports them through optimised VM image creation, assembly, migration and storage. The ENTICE environment is designed to receive unmodified and functionally complete VM images from users, and transparently tailor and optimise them for specific Cloud infrastructures with respect to their size, configuration, and geographical distribution, such that they are loaded, delivered (across Cloud boundaries), and executed faster and with improved QoS. ENTICE will gradually store information about the environment in a knowledge base that will be used for interoperability, integration, reasoning and optimisation purposes. VM images management will be supported by ENTICE on an abstract level, independent of the middleware technology supported by the underlying Cloud computing infrastructure.

Expected impact:
Direct advantages and impacts we see for IaaS providers are:

- provide means to export images (currently limited to fetch disc/image functionality);
- size optimized VM images could have significant space/cost savings;
- additional support of different image types that can be fetched and converted;
- optimised, distributed and interoperable VM-repository-as-a-service offering;
- different levels of QoS related to performance, cost and storage, currently not supported by any provider on the market.

3.6 iKaaS

General information: Call: H2020-EUJ-2014 , Topic: EUJ-1-2014, Type: R&I , Duration: 3 years (started on 1 October, 2014), Web site: www.ikaas.com

Aim: iKaaS – (intelligent Knowledge-as-a-Service) Platform, is developing an intelligent, privacy preserving and secure Smart City Platform based on a Big Data resource and an analytics engine built atop heterogeneous cloud platforms with data collected from a variety of sensors from Internet of Things (IoT) environments deployed as mobile terminals, smart devices, and smart homes. We envisage that these data and the analytics engine – a knowledge base – would be fundamental building blocks for cross-border business-to-government (B2G), business-to-business (B2B) and business-to-consumer (B2C) applications, such as lifestyle recommendation, future city planning, academic research and analysis, location-and behaviour-specific targeted services and so on. The platform features will be demonstrated by means of Smart City applications promoting self-management of health and safety of citizens, as well as an information system improving data analysis for a smarter life in the city.

Approach: In over to achieve its ambitious aims, iKaaS is following a structured approach that addresses the whole lifecycle of such a platform, from its development based on related requirements to its validation through added-value applications. In brief this approach involves:

- Defining a universal data model based on the Semantic Web for data collected from IoT and stored in cloud platforms
- Defining and developing the various concepts in trust-management-by-design for the data
- Developing and implementing a decentralized heterogeneous secure multi-cloud environment spanning across borders
- Building an integrated analytics engine to implement the knowledge-as-a-service platform concept
- Developing multiple applications for validation
- Validating the analytics methodology and determining the utility of the distributed knowledge-base through experiments in model smart cities and smart homes

Expected impact:
iKaaS will bring the cognitive IoT into the cloud so as to realize the notion of Everything as a Service. Through the exploitation of the power of the cloud computing, with the massive and distributed resources this paradigm offers, together with the introduction of cognition and intelligence, iKaaS is expected to greatly simplify the autonomic service provisioning over distributed clouds addressing at the same time the security concerns in such ecosystems. We envision that this will make it possible for various business players to enter the Cloud and IoT world, extending the range of new added value services that can be created and offered, through simplified management that reduces the need for human intervention, consequently leading to lower OPEX. From a societal perspective, the services leveraging on the iKaaS platform are expected to have a significant impact on quality of life and increased productivity.

3.7 INPUT

General information: Call: H2020-ICT-2014-1, Topic: ICT-07-2014, Type: RIA, Duration: 3 years (started on 01/01, 2015), Web site: http://input-project.eu

Aim: The INPUT Project aims at designing a novel infrastructure and paradigm to support Future Internet personal cloud services in a more scalable and sustainable way. The INPUT technologies will enable next-generation cloud applications to go beyond classical service models, and even to replace physical Smart Devices (SDs), usually placed in users' homes (e.g., network-attached storage servers, set-top-boxes, video recorders, home automation control units, sensors etc.) with their virtual images, providing them to users "as a Service."

Approach:
The INPUT Project will overcome current limitations on the cloud service design by:

- introducing computing and storage capabilities to edge network devices in order to allow users/telecom operators to create/manage private clouds "in the network";
- moving cloud services closer to end-users and smart devices, in order both to avoid pointless network infrastructure and datacenter overloading, and to provide lower latency to services;
- enabling personal and federated cloud services to natively and directly integrate themselves with the networking technologies close to end-user SDs in order to provide new service models;
- Assessing the validity of the proposed in-network cloud computing model through appropriately designed use cases and related proof-of-concept implementations.

Expected impact:
The INPUT Project will foster future-proof Internet infrastructures that will be "smarter," fully virtualized, power vs. performance optimized, and vertically integrated with cloud computing, with a clear impact on Operating and Capital Expenses (OPEX and CAPEX) of Telecoms, of service providers, and of end-users. Moreover, the INPUT infrastructure and approach will contribute to the top line growth of European Telecom Operators by increasing the revenue opportunities, thanks to new service offers and shifting their role in a higher position in the value chain
The novel customizable "in-network" intelligence will bring a number of key advantages, such as:

- the possibility of overcoming well-known scalability problems of current network technologies;
- the possibility of directing traffic and caching information where needed (close to end-users), reducing the number of hops and related workload in the network;
- the possibility of exploiting highly efficient network hardware to off-load applications (e.g., by providing storage, caching, security and trusting primitives) otherwise running on general purpose IT hardware.

3.8 MIKELANGELO

General information: Call: H2020-ICT-2014-1, Topic: ICT-07-2014, Type: RIA, Duration: 3 years (started on 1st Jan, 2015), Web site: http://www.mikelangelo-project.eu

Aim: To significantly improve I/O performance, agility, and security of virtual infrastructures. For I/O performance the aim is to reach near-native speeds with full virtualisation to compete with native and container-based. For agility the aim is to leverage OpenStack to enable flexible deployment and management of services. For security the aim is to reach an even higher degree of security of full virtualisation, leaving container-based virtualisation far behind. Partners in MIKELANGELO are at the pinnacle of technical expertise in the fields of Linux kernel, guest operating system, KVM, Cloud and HPC. This technical excellence will fuel the project to achieve a successful exploitation story, building on and exploiting open source software - a task supported by four use-cases and business experts in the consortium.

Approach:
MIKELANGELO is based on the following pillars:

- Technical improvements:
  - sKVM - maximizing I/O performance of virtual machines
  - OSv, an operating system build for the cloud with minimal footprint
  - Application packaging to ensure smooth application deployment and management
- Integration
  - All components harmonise thanks to cross-layer optimisation
  - Scalable, holistic, real-time monitoring across all layer of the MIKELANGELO computing stack
  - Integration of MIKELANGELO with OpenStack to maximise uptake and impact
- Improved security (inter VM attacks) to ensure trust in sensitive environments
- Use-Cases: four high impact use cases, showing MIKELANGELO's main strengths - well-known, to ensure well understood benefits of the MIKELANGELO technology stack

Expected impact:
- Unified use of MIKELANGELO technology stack in heterogeneous environments:
  - Unparalleled performance of virtualised software presents acceptable performance hit for HPC environments, balanced by increased flexibility and security. HPC centres adopting the MIKELANGELO solution to increase internal flexibility, provide traditional services (e.g., tightly-coupled problems, based on MPI) and novel services (e.g., high performance data analytics)
  - Cloud environments with massive virtualised IO requirements - e.g. interactive data exploration algorithms.
- Uptake of the MIKELANGELO open source additions into KVM and OSv source trees.
- Faster time to market for EU SMEs, through use of available talent (more talent is available in the field of Cloud than HPC technologies) and resources.
- Global recognition of EU-supported know-how in open-source, high-performance technologies.

3.9 MO-BIZZ

General information: Call: CIP-ICT-PSP.2012.5.2; Topic: Mobile Clouds for business applications, Web site: www.mobizz-project.eu

Aim: The main objective of mo-bizz is to open up a mobile cloud ecosystem to a pan-European and global audience. It will be a widely accessible platform for business applications that satisfies the needs of a highly diverse customer population of corporate and individual users.

Approach:

Technology

Investigate and design a highly flexible, resource-optimized and dynamic mobile network and service architecture for a system that encompasses and integrates three major domains:

- Network and Computing Infrastructures.
- Mobile Networks.
- Cloud Services.

Business

Develop a business model and rapid service development environment that allows businesses to expose their key functionalities to their customers and integrate with existing business applications where necessary.

No such capability currently exists and the availability of this would propel the adoption of these new technologies in the commercial domain.

Impact:

mo-bizz will develop several pilot projects to showcase the potential of mobile cloud computing as a unique way to foster productivity in EU companies. In each pilot, the partners will be responsible to collect the information need to produce models addressing the following characteristics: Elasticity, Measured service, On-demand self-service, Ubiquitous network access, Resource pooling, interoperability, Portability, Integration, SLA, federation, Multi-tenancy, Available APIs.

As result of the European ecosystem provided by the its partners, mo-bizz project will benefit from an integrated structure to analyse the cross collaboration through different pilots; spread out towards the local pilots the results of the synthesis performed; produce some benchmarks about mo-bizz results.

The concept of the pilots is to benefit from both local and global Ecosystems provided by mo-bizz partners according to the following sequence:

- (Local) Define models of mobile cloud situation in order to derive user case scenarios.
- (Global) Elaborate particular and generic requirements.
- (Local) Validate requirements.
- (Global) Develop experimentations, capitalize generic knowhow and disseminate best practices.

mo-bizz envisages the validation of a platform to support the delivery of high quality business applications with strong focus on two key target groups: (1) developers and IT providers, and (2) large industries and vertical market segments businesses. mo-bizz envisages also to stimulate the adoption of mobile cloud solutions in enterprises and support the emergence of a strong and enthusiastic community of app developers in Europe.

3.10 MODAClouds

General information: Call: FP7-ICT-2011.1.2, Topic: Cloud Computing, Internet of Services and Advanced Software Engineering, Type: IP , Duration: 3 years (started on Oct 1st, 2012), Web site: www.modaclouds.eu, Reference publication: [1]

Aim: The main goal of MODAClouds is to provide methods, a decision support system, an open source IDE and run-time environment for the high-level design, early prototyping, semi-automatic code generation, and automatic deployment of applications on multi-Clouds with guaranteed quality of service.

Approach: Within the MODAClouds approach we have experimented with model-driven development enhanced with the possibility of exploiting models not only as part of design but also as part of the runtime. In this case the system model becomes a live object that evolves with the system itself and can be used to send back to the design time powerful information that enables a continuous improvement of the system. In new terms, this approach goes into the direction of offering a valid tool to support DevOps, that is, the ability to support development and operation in a seamless way.
The MODAClouds model-driven approach is supported by the MODAClouds Toolbox. The toolbox helps lowering existing barriers between Development and Operations Teams and helps embracing DevOps practices within IT teams. Thanks to it, organizations of any size can Build and Run Cloud Applications driven by business and technical needs and quality requirements. The toolbox is comprised of the following elements:

1. Creator 4Clouds, an Integrated Development Environment (IDE) for high-level application design;
2. Venues 4Clouds, a decision support system that helps decision makers identify and select the best execution venue for cloud applications, by considering technical and business requirements;
3. Energizer 4Clouds, a Multi-Cloud Run-time Environment energized to provide automatic deployment and execution of applications with guaranteed Quality of Service (QoS) on compatible Multi-Clouds.

All these tools are available as open source, see http://www.modaclouds.eu/software/

Expected impact:
The vendor neutral solution enable the use of a multiple Cloud solutions and the ability to migrate from Cloud provider to provider. This will increase the competitive advantage and agility of European Cloud providers or Cloud brokers. The proposed abstractions over Cloud providers will reduce the complexity of implementation over multiple Clouds, thus increasing the possibilities of SMEs to realise benefits. Moreover, the proposed solution improve the trust in Cloud-based applications by monitoring performance and behaviour and providing an approach for moving applications and data from Cloud to Cloud according to requirements. MODAClouds solutions enable a better control over services of Cloud providers, and the possibility to combine services from different Cloud providers. It defines design and runtime quality measures, prediction models, and assurance techniques. It also supports the measurement and identification of non-functional characteristics of these applications in their original environments, and by guiding developers in defining the right modelling abstractions for these applications.

3.11 MUSA

General information: Call: H2020-ICT-2014-1, Topic: ICT-07-2014, Type: RIA, Duration: 3 years (started on 1st Jan, 2015), Web site: www.musa-project.eu, Reference publication: [2]

Aim:
The most challenging applications in heterogeneous cloud ecosystems are those that are able to maximise the benefits of the combination of the cloud resources in use: multi-cloud applications. They have to deal with the security of the individual components as well as with the overall application security including the communications and the data flow between the components.

The main objective of MUSA is to support the security-intelligent lifecycle management of distributed applications over heterogeneous cloud resources, through a security framework that includes: security-by-design mechanisms to allow application self-protection at runtime, and methods and tools for the integrated security assurance in both the engineering and operation of multi-cloud applications.

Approach:
The MUSA framework leverages security-by-design, agile and DevOps approaches in multi-cloud applications, and enables the security-aware development and operation of multi-cloud applications. The framework will be composed of

1. an IDE for creating the multi-cloud application taking into account its security requirements together with functional and business requirements,
2. a set of security mechanisms embedded in the multi-cloud application components for self-protection,
3. an automated deployment environment that, based on an intelligent decision support system, will allow for the dynamic distribution of the components according to security needs, and
4. a security assurance platform in form of a SaaS that will support multi-cloud application runtime security control and transparency to increase user trust.

Expected impact:
The project will demonstrate and evaluate the economic viability and practical usability of the MUSA framework in highly relevant industrial applications representative of multi-cloud application development potential in Europe.

3.12 RAPID

General information: Call: H2020-ICT-2014-1, Topic: ICT-07-2014, Type: RIA, Duration: 3 years (started on 1st Jan, 2015), Web site: http://www.rapid-project.eu

Aim: RAPID aims to develop of an efficient heterogeneous CPU-GPU cloud computing infrastructure, which can be used to seamlessly offload CPU-based and GPU-based (using CUDA API) tasks of applications running on low-power devices such as smartphones, notebooks, tablets, portable/wearable devices, robots, and cars to more powerful devices over a heterogeneous network (HetNet). In addition, RAPID will develop a secure peer-to-peer model where almost any device can operate as an accelerated entity and/or as an accelerator serving other less powerful devices. The RAPID device can probe the central RAPID Directory Server, which includes information for all the accelerators, in order to automatically find and connect to the appropriate accelerators.

Approach: The RAPID acceleration mechanism mainly consists of the following three entities:

- Acceleration Client: This is a runtime library, which is employed by a locally accelerated application in order to find nearby accelerators, decide whether the tasks defined by the application developer should be executed locally or offloaded remotely.
- Acceleration Server: This software receives tasks from Acceleration Clients and other Acceleration Servers, executes them, and returns the results. Two versions of the Acceleration Server are defined: the Plain and the Enhanced. The Plain Acceleration Server executes all incoming tasks locally. The Enhanced Acceleration Server uses the Acceleration Client library in order to decide for each incoming task, if it should be executed locally or forwarded to another Acceleration Server.
- Directory Server: This server keeps status and resource information of the RAPID accelerators, This information is used by Acceleration Clients in order to find and connect to the appropriate accelerators

Several flavors of each of the aforementioned software entities will be developed depending on the target Entity. For example, an Acceleration Server running on a public cloud will use more complex task scheduling algorithms than an Acceleration Server running on a smartphone or a PC.

Expected impact: RAPID will open many new innovation opportunities to service providers by introducing Acceleration as a Service, a novel heterogeneous cloud-based service. Application developers, be they scientists, engineers, system administrators or developers, all need a simpler user experience in order to access cloud resources.

Moreover, RAPID opens the door of GPU-based computation in the cloud. Using recent NVIDIA's hardware-assisted GPU technology, RAPID will be the first to utilize efficiently cloud GPUs in many domains such as gaming, antivirus, augmented reality, face and speech recognition, movement detection, biometrics, and CCTV.

3.13 SPECS

General information: Call: FP7-ICT-2013-1, Topic: Trustworthy ICT, Type: STREP, Duration: 2,5 years (started on 1/11/2013), Web site: www.specs-project.eu, Reference publication: [3]

Aim: The Cloud offers attractive options to migrate corporate applications without the corporate security manager needing to manage or secure any physical resources. While this "ease" is appealing, several security issues arise, typical examples are: (i) access of unauthorized CSP personnel to data residing remotely with the Cloud Service Provider (CSP), (ii) assessment of a CSP's ability to meet the corporate security requirements, (II) comparison of security trades-offs offered by different CSPs or the capability for a customer to monitor and enforce the agreed Cloud security levels with the CSP. SPECS aims at offering a solution for such problems, offering mechanisms to specify Cloud security requirements and assess the standalone and comparative security features offered by CSPs and offering the ability to integrate desired corporate security services into Cloud services. SPECS offers systematic approaches to negotiate monitor and enforce the security parameters specified in Service Level Agreements (SLA) and to develop and deploy security services that are "Cloud SLA-aware", implemented as an open-source Platform-as-a-Service (PaaS).

Approach: SPECS offers an open source framework to offer Security-as-a-Service, by relying on the notion of security parameters specified in Service Level Agreements (SLA) and providing the techniques to systematically manage their life-cycle. The SPECS framework addresses both CSP's and users to provide techniques and tools for:

A. Enabling user-centric negotiation of security parameters in Cloud SLA, along with a trade-off evaluation process among users and CSPs, in order to compose Cloud services fulfilling a minimum required security level.
B. Monitoring in real-time the fulfillment of SLAs agreed with CSPs, notifying both users and CSPs, when a SLAs not being fulfilled.
C. Enforcing agreed SLA in order to keep a sustained Quality of Security (QoSec) that fulfills the specified security parameters. SPECS' enforcement framework will also "react and adapt" in real-time to fluctuations in the QoSec by advising/applying the requisite countermeasures.

The proposed framework has an open-source core, and offer simple interfaces to motivate its adoption. It will offer a set of reusable PaaS components for service developers to enable them to integrate SPECS' SLA-oriented security mechanisms into existing Cloud services. Using real case studies SPECS demonstrates that the SPECS framework and architecture can be integrated "as-a-Service" into real life Cloud environments, with a particular emphasis on small/medium CSPs and end users.

Expected impact: SPECS Security SLA Model relies on the actual Cloud and SLA standards and the SPECS Consortium actively engages with the standardization bodies and participates in the process of building the SLA standards. SPECS framework can help a larger adoption and diffusion of standardized security SLAs and to the definition of standard security metrics. SPECS approach enable End-users to compare CSPs in terms of security properties, in such a way it helps End-users to be aware of the choice done and helps in increasing the trust in the adoption of the cloud paradigm. SPECS framework was adopted to produce a Security Metric Catalogue, which aims at collecting existing and novel security metrics, representing them in a standard format.

3.14 SWITCH

General information: Call: ICT-09-2014, Topic: Software tools and methods for large, complex and data-intensive systems, Type: RIA, Duration: 3 years (started on Feb/1, 2015), Web site: www.switch-project.eu, Reference publication: [4]

Aim:
The SWITCH project (Software Workbench for Interactive, Time Critical and Highly self-adaptive Cloud applications) addresses the urgent industrial need for developing and executing time critical applications in Clouds.

Approach:
SWITCH addresses these problems by providing an interactive and flexible software workbench that, by using discovery tools at the networking level and QoS requirements from the application level, can provide the tools necessary to control the lifecycle for rapid development, deployment, management and dynamic reconfiguration of complex distributed time-critical cloud applications. At the core idea of the SWITCH environment, a new development and execution model, an application-infrastructure co-programming and control model, will be developed for time-critical Cloud applications. The new model brings together the application composition, execution environment customisation, and runtime control, which are normally treated in separated processes, into one optimisation loop based on the time critical requirements. The workbench contains three subsystems:

1. *The SWITCH Interactive Development Environment (SIDE)* subsystem provides interfaces for all user- and programmer-facing tools, by exposing a collection of graphical interfaces and APIs. SIDE will be engineered fully responsive on the front end, providing interactivity and end-user device portability.
2. *The Dynamic Real-time Infrastructure Planner (DRIP)* subsystem prepares the execution of the applications developed in the SIDE subsystem by 1) semantic modelling and linking of different QoS/QoE attributes, 2) defining an optimal virtual runtime environment, 3) creating a Service Level Agreement with the resource provider, and 4) deploying the platform required by the application.
3. *The Autonomous System Adaptation Platform (ASAP)* sub system 1) monitors the status of the application and the runtime environment, 2) examines the actual performance of the required quality attributes, 3) autonomously manipulates the application and runtime environment to maintain optimal system level performance against time critical constraints, and 4) learns from its own decision history to improve its intelligence in making future decisions for autonomous reconfiguration of the application.

Expected impact:
The programming and control model, and the software tools developed in the SWITCH project, will make considerable impact on:

1. Improving development productivity of time critical Cloud applications.
2. Upgrading industrial technologies of time critical applications to use Cloud infrastructure.
3. Improving deployment efficiency of time critical applications.
4. Reducing operational cost of time critical services.
5. Promoting business competitiveness of Clouds. By 2020, the Clouds technologies will contribute 1% of GDP to the entire EU, about 160 billion euro, of which Software as a Service will be 30-40 billion euro.

4. Maps

4.1 Research point of view

The following table identifies which cluster initiative is working on topics identified in H2020-LEIT-ICT-2016-6.

Research subjects as in WP 2016-2017[6]	AppHub	ARCADIA	CloudLightning	ClouT	ENTICE	iKaaS	INPUT	Mikelangelo	Mo-Bizz	MODAClouds	MUSA	RAPID	SPECS	SWITCH
Development of distributed, federated and heterogeneous cloud computing model		X	X			X			X		X	X		X
Deployment and management of resources: in a decentralised, autonomous way		X	X	X	X	X	X			X	X	X	X	X
Extension of extreme edge of the network							X							X
Software defined networking,		X			X		X							X
Software defined data center							X						X	
Data storage infrastructures				X	X									
Security, privacy						X					X	X	X	
Trust: data and services from different cloud providers						X					X		X	
Federated environments			X								X			
Resilience and scale		X		X										X
Service Level Agreements: for quality critical applications, and novel negotiation mechanisms,		X			X						X	X	X	X
Novel composition model for infrastructures: application aware			X											X
Large-scale experiments				X										
Interop and standardization	X	X		X		X	X						X	X
QoS and QoE		X			X	X	X		X	X		X		X

[6] Note: The above topics are referring to the text of ICT-6 from the Workprogramme LEIT-ICT 2016-2017 available at https://ec.europa.eu/programmes/horizon2020/en/draft-work-programmes-2016-17

4.2 Examples of contributions

The following table identifies what the cluster initiatives are doing in relationship with the topics identified in H2020-LEIT-ICT-2016-6.

Topics	**What the clustered projects are doing**
Development of distributed, federated and heterogeneous cloud computing model	iKaaS is developing a hierarchical cloud computing model formed from a Global Cloud (legacy cloud computing) and Local Clouds (formed on demand). MUSA aims at offering solutions to develop multicloud applications granting security requirements RAPID aims to develop an efficient CPU-GPU heterogeneous multi-tier infrastructure. The offloading framework aims to support application offloading from Android, Linux, and Windows devices. ARCADIA is to provide for the deployment of Highly Distributed Applications in multi-IaaS environments.
Deployment and management of resources: in a decentralised, autonomous way	Improving the efficiency of deployed resources/Deploying of resources efficiently - use of low overhead, very efficient virtual technology stack. iKaaS is developing distributed autonomic resource (cloud, IoT) allocation mechanisms, taking into account service needs and resource capabilities and availability. The Dynamic Real-time Infrastructure Planner (DRIP) subsystem in SWITCH prepares the execution of the applications by defining an optimal virtual runtime environment from one or more Cloud providers, and deploying the platform required by the application. ClouT is developing a mechanism to manage several different kind of distributed sensors and actuators (legacy, IoT based, virtualized and "sensorized" devices). The received data are treated as real-time data for some applications and are stored in a cloud storage to be used as historical data. SPECS provides solution to deploy services in Coud according to SLA life cycle. It offers tools that automatically enforce and monitor security properties INPUT is moving cloud services closer to mobile end-users and smart devices in an autonomous, energy-efficient, and dinamically fashion, in order both to avoid pointless network infrastructure and datacenter overloading, and to provide lower latency to services; RAPID will develop a secure peer-to-peer model where almost any device can operate as an accelerated entity and/or as an accelerator serving other less powerful devices. ARCADIA is to provide a Novel Reconfigurable-By-Design Highly Distributed Applications' Development Paradigm over Programmable Infrastructure. Resources of the registered infrastructures are handled by the smart controller component, responsible for the optimal allocation and reconfiguration of resources to satisfy objectives and requirements of a running application while meeting the objectives and policies of the service and infrastructure providers.

Extension of extreme edge of the network	INPUT is introducing computing and storage capabilities to edge network devices in order to allow users/telecom operators to create/manage private clouds "in the network."
Software defined networking,	At the core idea of the SWITCH environment, a new development and execution model, an application-infrastructure co-programming and control model, will be developed for time-critical Cloud applications. The new model brings together the application composition, execution environment customisation, network programmability and runtime control, which are normally treated in separated processes, into one optimisation loop based on the time critical requirements. INPUT is enabling personal and federated cloud services to natively and directly integrate themselves with extended software defined networking and network function virtualization technologies close to end-user SDs in order to provide new service models. ARCADIA is to provide a Novel Reconfigurable-By-Design Highly Distributed Applications' Development Paradigm over Programmable Infrastructure. Software defined networking and network function virtualization technologies are employed to provide for illustrating an application's chain consisting of application tiers, middleboxes and other networking functions.
Software defined data center	One of the SPECS case study, developed by EMC, focuses on adoption of SLA in ngDC (next generation Data Centeres)
Data storage infrastructures	ClouT will provide a CDMI Cloud Storage to store sensor data and binary data objects (such as images or videos). The storage will be fully compliant with CDMI 1.1.1 specification and will provide scalability and elasticity to store a virtually unlimited amount of data and to manage sudden bursts. SPECS provides a mechanism for End-to-End Encryption, offering even metrics to be used to grant the security in an SLA. SPECS provides an application for Virtualized Cloud Data storage protected with SLA.
Security, privacy	Increasing of security in virtual infrastructure - detection and protection against inter VM attacks iKaaS is developing the notion of a security gateway that ensures access to various databases is granted only to authorized applications. SPECS provides a Security SLA Model that enable to represent security in SLAs. Moreover SPECS provide a set of security mechanisms that can be used to enhance the security level on services offered by CSPS MUSA aims at offering libraries to enforce security in multicloud applications RAPID will implement security solutions to protect the communication between an accelerated device and the accelerator server. Users or developers can decide the importance of the data being offloaded and the system will dynamically adapt the security measures according to their settings.
Trust: data and services from	In iKaaS, the security gateway addressed both intra- and inter-cloud concerns with respect to data manipulation and exploitation. In addition, trust and reputation mechanisms to define

different cloud providers	the suitability of data generating devices are being developed. SPECS offers solutions to compare the security offered by different CSPs.
Federated environments	CloudLightning intends to offer a broker system for Heterogenous HPC resources offered as services. MODAClouds has developed technologies that allow the deployment of Cloud aware applications in multiple Clouds. The approach is following the concepts of model-driven development to abstract the differences between various Cloud service APIs.
Resilience and scale	The ASAP subsystem in SWITCH autonomously manipulates the application and runtime environment to maintain optimal system level performance against time critical constraints ClouT will manage and storage a virtually unlimited amount of data that will be available to citizens especially in case of emergency (e.g. natural disaster). The availability in case of emergency is one of the key use cases of ClouT ARCADIA manages an application through it lifetime, satisfying at all time requirements and meeting objectives while supporting horizontal scaling of applications when required as well as resilience to failures.
Service Level Agreements: for quality critical applications, and novel negotiation mechanisms,	The Dynamic Real-time Infrastructure Planner (DRIP) subsystem in SWITCH prepares the execution of the applications by creating a Service Level Agreement with the resource provider(s), and deploying the platform required by the application. SPECS proposes an advanced Security SLA Model, as an extension of WS-Agreement, that enable to concretely represent security in SLAs. Moreover SPECS offers a Security Metric Catalogue, built on top of existing standard and tools offered at the state of the art. SPECS offers a Security negotiation module, devoted to negotiate SLAs according to end users needs. MUSA project aims at studying how to offer Security SLA in multicloud applications RAPID will have tools that monitor offloaded tasks' performance when executed on the cloud. The SLA model will provide the mean to access to the monitoring information related to the agreed QoS aspects, in such a way it will be possible to determine whether SLAs are being fulfilled or not. It will be able to deal with several monitoring platforms, since it allows for customization through a system of plug-ins. ARCADIA provides for the execution of applications with diverse strict requirements and constraints while meeting objectives and policies of the service and infrastructure providers.
Novel composition model for infrastructures: application aware	At the core idea of the SWITCH environment, a new development and execution model, an application-infrastructure co-programming and control model, will be developed for time-critical Cloud applications. The new model brings together the application composition, execution environment customisation, and runtime control, which are normally treated in separated processes, into one optimisation loop based on the time critical requirements.
Large-scale experiments	ClouT team is working on an intercontinental demo involving the four pilot cities (Santander in Spain, Genoa in Italy, Mitaka and Fujisawa in Japan) to show how data will

	be able to be shared, computed and used in real time across two continents.
Interop and standardization	iKaaS has already contributed to oneM2M and also plans to contribute to OGC ClouT will provide implementations of some specifications and standards, such as CDMI and XMPP. SPECS security SLA model founds on the existing and on-going standards. SPECS consortium proactively participate to standardization bodies, INPUT is supporting and managing a new working item in ETSI-EE for extending the Green Abstraction Layer towards SDN/NFV paradigms. ARCADIA will consider as a major objective in optimal allocation of programmable resources for the execution of diverse applications, the energy efficiency. To this end, ETSI Green Abstraction Layer will be supported while advancements to it will be followed and when possible contributions will be provided.
QoS and QoE	In iKaaS, service quality related metrics have been identified and are being considered by the service provisioning mechanisms The Dynamic Real-time Infrastructure Planner (DRIP) subsystem in SWITCH prepares the execution of the applications by semantic modelling and linking of different QoS/QoE attributes and defining an optimal virtual runtime environment from one or more Cloud providers. The INPUT framework will exploit the monitoring of network and cloud QoS, and the perceived QoE of end-customer in order to enable a smart and energy-efficient management of resources. RAPID will take into account QoS/QoE attributes in order to select the appropriate accelerators per client. The QoS attributes of a task/application will be instructed by the developer at implementation time. The SLAM will monitor if these QoS attributes are satisfied, and notify the user if this is not the case. In ARCADIA an application is considered through its entire lifetime, starting from its development where several QoS constraints are specified, to its termination. Monitoring of the infrastructure, profiling of the applications and demand prediction strategies will provide for meeting the diverse QoS requirements at most times while when strictly not possible the QoE will be sustained.
Virtualization technology (guest, host)	Performance increase in virtualised IO RAPID will use OpenStack platform with KVM hypervisor on the cloud side to host different flavors of virtual machines. Each virtual machine will accommodate one acceleration server.

4.3 Development point of view

The following table identifies the categories of technologies that are developed by the cluster initiatives.

Category of software tools developed in the frame of the action/project	AppHub	ARCADIA	CloudLightning	ClouT	ENTICE	iKaaS	INPUT	MIKELANGELO	Mo-bizz	MODAClouds	MUSA	RAPID	SPECS	SWITCH
Resource management		X	X	X		X	X	X	X	X		X	X	X
Energy efficiency		X	X				X					X		
Privacy and Security				X		X		X			X	X	X	
Cloud federation						X					X			X
Cloud brokering						X				X			X	X
SLAs		X			X						X	X	X	X
Monitoring		X		X		X	X	X	X	X		X	X	X
Software Life Cycle (semi-)automation	X	X	X						X				X	X
Software defined networking		X					X							X
Human Cloud interaction				X										X
IDE		X		X						X	X			X
Virtualization technology (guest, host)				X				X				X		

4.4 Software tools and standards used within the projects

The following table identifies the categories of technologies and standards that are used by the cluster initiatives.

Software tools and standards used[7]	AppHub	ARCADIA	CoudLightning	ClouT	ENTICE	iKaaS	INPUT	MIKELANGELO	Mo-Bizz	MODAClouds	MUSA	RAPID	SPECS	SWITCH
Tools														
Docker		X			X	X					X			X
CloudFoundry											X			
VMWare	X				X									X
XEN	X				X									
KVM	X	X			X		X	X				X		X
OpenStack	X	X	X	X	X	X	X	X		X	X	X	X	X
OpenNebula					X									
CloudStack	X													
Eucalyptus									X	X			X	
Chef			X		X				X		X		X	X
Puppet									X	X	X			
Jclouds					X								X	
libcloud			X											
deltaCloud														
OSv								X						
Standards														
OCCI					X									X
CDMI				X										
CIMI														
TOSCA		X	X											X

[7] Note: current or in future (despite the fact that the projects are in different stages)

CloudML		X							X	X	X			
OVF					X									X
Openflow		X					X							X
WS-Agreement					X						X			X
Open Geospatial consortium (OGC)						X								
oneM2M						X								
XMPP				X										
MQTT				X										
OSGi				X										
ETSI GAL		X					X							

4.4 Innovation map

The following table identifies the categories of the innovations that are followed by the cluster initiatives.

	AppHub	ARCADIA	CloudLightning	ClouT	ENTICE	iKaaS	INPUT	MIKELANGELO	Mo-Bizz	MODAClouds	MUSA	RAPID	SPECS	SWITCH
Exploitation model														
Open Source	X	X	X	X	X	X	X	X		X	X	X	X	X
Commercial	X	X	X			X	X	X		X	X	X		X
Patents		X		X		X	X							
Supported licenses (if open source)		Apache, GPL, BSD	Apache	Apache			BSD	Apache, GPL, BSD		Apache, GPL		Apache, LGPL	Apache, GPL	Apache
Maintains a community that uses its software and contributes to its development (if open source)								X		X		X	X	X
Supported open standards		X	X	X	X		X			X	X		X	X
Measures to improve software quality														
Project performs quality management		X						X		X		X	X	X
Project maintains requirements on its software and a project roadmap		X	X					X		X		X	X	X
Project provides documentation such as user or installation guides along with its software?		X		X		X		X		X		X		X
Project follows well-accepted software architecture principles (component based, software patterns, etc.)		X	X	X				X		X				X

Project implements a throughout testing process		X		X				X		X		X		X
Project manages stability and maintainability of your software		X		X				X		X		X		
Project performs versioning and configuration management		X		X						X				X
Standardization *Actual contribution to standardization activities*														
oneM2M						X								
OMA LWM2M				X										
OSGi				X										
ETSI GAL		X					X							

6. Conclusions and future work

The current document points towards the efforts that the members of the cluster with collaborative purposes are pursued in the directions of research and innovation that are mentioned in the the call text of the workprogramme with the indicative H2020-LEIT-ICT-2016-06.

The maps between the R&I topics and the project/action activities are helping the cluster members to have a common view on the potential collaboration subjects and on the technical background of the other members. However it is expected that this document can help the readers to gather a general image on the initiatives that are working in the topics of his or her interest.

This document is the starting point for the following activities of the cluster:

- best practices collection
- identification of the gaps in terms of the coverage of the analyzed topics
- recommendations for future initiatives in R&I

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