

Publishable Summary

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2 Publishable Summary



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Start date: 1st October 2010

Grant Agreement: **257243**

Duration: 36 months

Project website: <http://www.tclouds-project.eu/>

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Mission of TClouds

To develop an advanced cloud infrastructure delivering computing, networking, and storage that achieves a new level of security, privacy, and resilience yet is cost-efficient, simple, and scalable. To change the perceptions of cloud computing by demonstrating the prototype infrastructure in socially significant application areas: energy and healthcare.

The TClouds Project

TClouds envisions and builds a Future Internet where federations of standardized resilient and privacy-protecting global infrastructure clouds offer virtualized computing, communication, and storage resources that allows hosting of critical and non-critical ICT systems. Particular focus is placed on privacy protection in cross-border infrastructures and on ensuring resilience against failures and attacks.

Motivation

State-of-the-art cloud computing enables seamless access to services and global availability of information, but inherent risks severely limit the application of this technology. In a cloud environment, pertinent data is accessed via information and communications technology (ICT) using remote hardware instead of being stored only on a local server or computer. The benefits of increased storage at reduced cost allow information to be made readily available. However, the current cloud computing model comes with perceived risks concerning resilience and privacy. There are three fundamental trends in ICT whose risks mutually reinforce each other:

- the push towards an Internet of Services - most services are provided on the web as a platform;
- cost pressures drive a migration of ICT into so-called Infrastructure clouds;
- growing importance of ICT as the critical “nervous system” for socially relevant “smart” infrastructures – such as healthcare, energy, environmental monitoring, or mobility.

Protecting data and services in the cloud is important to governments, organizations and enterprises across all industries, including healthcare, energy utilities, and banking. Thus, the perceived security and dependability risks of cloud computing are limiting its application.

The TClouds project targets cloud computing security and minimization of the widespread concerns about the security of personal data by putting its focus on privacy protection in cross-border infrastructures and on ensuring resilience against failures and attacks.

Objectives & Overall Strategy

Trustworthy Clouds (TClouds) aims to build a prototype Internet-scale ICT infrastructure which allows virtualized computing, network, and storage resources over the Internet to provide scalability and cost-efficiency. The following objectives contribute to achieving the overall goal:

- Identifying and addressing the legal and business implications and opportunities of a widespread use of infrastructure clouds, contributing to building a regulatory framework for enabling resilient and privacy-enhanced cross-border infrastructure clouds.
- Defining an architecture and prototype for securing infrastructure clouds by providing security enhancements that can be deployed on top of commodity infrastructure clouds (as a cloud-of-clouds) and assessing the resilience and privacy benefits of security extensions of existing clouds.

- Providing resilient middleware for adaptive security on the cloud-of-clouds. The TClouds platform will provide tolerance and adaptability to mitigate security incidents and unstable operating conditions for a range of applications running on such clouds-of-clouds.

To demonstrate TClouds, scientists prototype two scenarios involving critical IT-systems including:

- A smart energy grid with Portugal's leading energy and solution providers Energias de Portugal and EFACEC ENG: A combination of smart metering and a Web-based real-time status and energy consumption control system enables public utility providers to monitor and efficiently control a public lighting network. TClouds will show how such energy-preserving systems can be migrated to a cloud infrastructure while increasing their resilience, privacy protection and tolerance, from both hackers and hardware failures.
- A patient-centric home healthcare service with San Raffaele Hospital in Milano, Italy, will remotely monitor, diagnose and assist patients outside of a hospital setting. TClouds will demonstrate how the quality of in-home healthcare can be improved cost-efficiently without reducing privacy.

The above objectives are to be achieved within the three main activities as displayed in Figure 1 below.

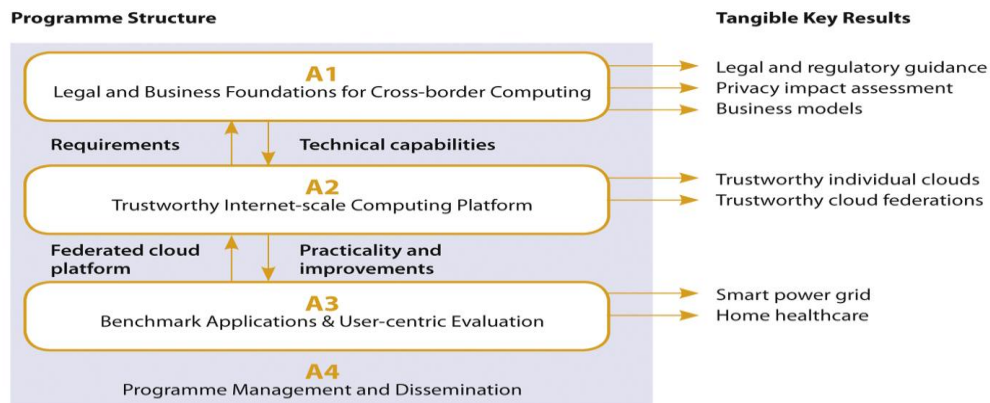


Figure 1: TClouds project activities

The work plan of TClouds encompasses four independently managed activities and twelve tightly integrated work packages.

Description of the work performed and results in the first project period

The TClouds project started in October 2010 and is set to run for 36 months. During the first project phase, corresponding to the first project year, the focus was placed on the analysis of requirements and specification of a platform architecture. All work packages, apart from WP 3.3 that has not started, initiated work and produced altogether 15 deliverables throughout the first project year.

At the beginning, major effort was put into the successful launch of the project. The major goal was to establish a sound basis for a good and fruitful cooperation of the project partners towards the research objectives. We managed to demonstrate collaboration while creating a large number of publications documenting ideas that we can leverage and extend in subsequent years. This has been achieved by strong leadership and by optimizing the organisation and infrastructures. We managed to provide all the relevant management components like contractual, financial, legal, technical, administrative and ethical issues as well as catching upcoming obstacles well ahead of time. Furthermore, a public project website and the internal IT communication infrastructure were established, and a dissemination plan for the entire project duration was compiled.

The progress achieved by all work packages within the first project year is in line with the initial plan and can be summarized as follows.

WP1.1 (Requirements and Roadmap) made very good progress with regard to the identification of cloud trends and drivers. A scenario framework that guides the future work in the WP was defined. We conducted expert interviews that allowed us to map the cloud landscape. Based on this expert input, we decided to extend the scenario building into the second year and to update the methodology to match this new strategy. One advantage of the revised objectives and methodology is that instead of generating 'swift scenarios' solely based on experts' opinions at a very early stage of the project we have now built up a good knowledge base within the WP1.1 team. Another advantage is that at this point of the project the technical development and the description of the use cases in the two application scenarios are well developed. Both factors ease to focus the scenario building on the requirements and specifics of the two application scenarios (home health care and smart grid) and to generate output from WP1.1 that can later partially be used for the evaluation carried out in WP3.3. With the extension of the work period of WP1.1 all tasks are on track and all objectives will be achieved with the desired level of improved quality (as compared to the original work plan) by the end of the second year.

Within **WP1.2 (Legal Implications and Impact of Cross-Border Cloud Implementations)**, all reports and deliverables are on track. A preliminary role model, which serves as a helping guide to identify the involved actors in complex cloud computing scenarios, was created and reviewed. Furthermore, a definition and analysis of the general legal framework and requirements of the European data protection law was made and their relevance to cloud computing scenarios investigated. This allowed for different ways of achieving data protection compliance (contractual, organisational, and technical) to be identified. Finally, we created an internal activity paper for jointly defining the requirements of logging process from the legal point of view, to achieve data protection goals in the project. This paper will be further developed and enhanced to provide guidance for the technical implementation of logging functionalities compliant with European data protection requirements.

Within **WP1.3 (Business Impact of and Business Models for Infrastructure Clouds)**, a first analysis of commercial factors impacting cloud computing (R1.3.2.1.) was completed. This includes: Cloud Business Case Factors, Cloud Operational Factors, Security & Privacy Factors and Legal & Compliance Factors. The identification of a cloud business model ontology was also carried out and results included in D1.3.1.

WP2.1 (Trustworthy Cloud Infrastructure) is in very good shape. A number of research papers were written and the deliverable D2.1.1 was delivered in time (M12). The security analysis of infrastructures of existing cloud providers and cloud solutions identified several weaknesses that have been considered during the specification of the TClouds high-level architecture. We even overachieved our plans, as we already have some implementation prototypes available after year one. For example, the trusted communication mechanism (Trusted Channel) to be used for secure communication between TClouds management and the single cloud has already been implemented. Another example of an already available prototype is a cloud infrastructure analysis tool that generates information about virtual machines and network connections between them.

The plan for the first year in **WP2.2 (Cloud of Clouds Middleware for Adaptive Resilience)** has been fulfilled. The deliverable D2.2.1 was delivered on time. We designed many protocols and algorithms to enhance legacy clouds and to build trustworthy clouds from scratch. For example, we devised a trustworthy cloud-of-clouds storage service that can be built using a number of non-trustworthy cloud storage services. We proposed an architecture that was broadly accepted within the project.

WP2.3 (Cross-layer Security and Privacy Management) addresses concepts to manage federated virtualized infrastructures. It analysed and identified the technical requirements for the automated management of cloud infrastructure that provide security and privacy by design. Several papers were written and published about this approach. Two papers define clouds self-managed services at the virtual layer and application layer. They discuss the challenges and identify the technical requirements for supporting the automated management of cloud infrastructure. Another paper explores the operational trust in clouds, which discusses the main criteria for assessing clouds operational trustworthiness. The project developed a verification approach for audits of virtual systems. This is a novel method and a corresponding tool for security audits of virtual computing environments (typically hundreds of nodes). It performs information-flow analysis, integrates ontology-based reasoning, and has been prototyped. The system was also involved in customer pilots and is described in publications.

In **WP2.4 (Architecture and Integrated Platform)**, the main outcomes of the work done during Y1 are a consistent design of 15 subsystems, including secure block device, cloud of cloud storage, access control and logging and auditing, that will be developed by partners and an initial installation of the TClouds platform Version v0, i.e. an unmodified instance of OpenStack – the selected open source cloud computing framework – on top of which a prototype application from Activity 3 is currently running. The work done during Y1 within WP2.4 was organized in phases ended at M2, at M4 (technical meeting in Lisbon), at M8 (technical meeting in Turin) and at M12. In each phase, one or more activities were carried out, where usually the majority of the partners was involved. Each activity ended with a written report (or activity paper) to consolidate the results, which are collected in the deliverable D2.4.1. All the work for the use cases selection, design of the high-level architecture, draft API and test methodology was done by each partner on his sub systems, following the common methodology shared along the project. This iterative process led to the description of the sub systems that forms Part II of the deliverable D2.4.1. All the public report and the deliverable D2.4.1 successfully met the scheduled deadlines.

In **WP3.1 (Cloud Applications Data Structures for Home Healthcare Benchmark Scenario)** the main outcomes of the work done during Y1 include defining the technical and legal requirements for the healthcare use case, designing the preliminary architecture and the architecture for the year 1 implementation, as well as the preliminary middleware architecture. Results are presented in the relevant reports, the deliverable D3.1.1, and the year 1 implementation.

Work within **WP3.2 (Cloud-middleware and Applications for the Smart Grid Benchmark Scenario)** focused on the definition of Smart Lighting specifications, architecture, and design. Furthermore, a Smart Lighting application mock-up was defined and developed, and is currently hosted at Amazon's EC2 cloud. Inputs and results were all integrated into the relevant reports and deliverables.

WP3.3 (Validation and Evaluation of the TClouds Platform) is due to start only in year 2 so no activities were reported.

The TClouds Consortium

The consortium comprises 14 partners from 7 different countries: reputable universities and recognised companies from six European Union member states (Austria, Netherlands, Germany, Portugal, Italy and the United Kingdom) plus Switzerland. All partners are experts in their field. This partnership of experienced professionals is anticipated to result in a successful project.



Figure 2: The TClouds Consortium

TClouds Disclaimer

All public information will be marked with the following TClouds project disclaimer: "This work was partially supported by the European Commission through the FP7-ICT program under project TClouds, number 257243. The information in this document is provided as is, and no warranty is given or implied that the information is fit for any particular purpose. The user thereof uses the information at its sole risk and liability. The opinions expressed in this deliverable are those of the authors. They do not necessarily represent the views of all TClouds partners."