

1.1 Publishable summary

Trescimo improves Future Internet Research Experimentation testbed capabilities in Europe and in South Africa, demonstrated through experimental research linking smart and green technological and social innovation.

Smarter and greener cities are essential to address economic, social, and environmental challenges due to the increase in urbanization, requiring informed decisions based on Internet of Things generated data. A particular challenge is the unstable power supply of cities in developing countries (e.g. South Africa), thus requiring smart energy management. Future handling of grid overload in South Africa involves demand-response mechanisms, installing small devices at the end-user, communicating over different network technologies to a central controller, allowing loads to be measured and limited if necessary. Further challenges include the deployment of affordable smart sensors (e.g. air sensors) as well as gathering information from nodes with limited power access.

In scenarios from energy consumption to waste bin levels, data is either sent over IP networks (which delivers data immediately) or collected in a delay tolerant mode by mobile devices of individuals or crowds. In delay tolerant mode the data is stored locally, to be delivered when a suitable network is reached. In cases of open data collection the devices in this Future Internet realm are targets of security attacks and might be vendor-locked with proprietary software stacks.

Our approach to address these issues is to interweave sophisticated Smart City platforms (CSIR/I2CAT) and an ETSI/oneM2M compliant Machine-to-Machine (M2M) communication framework (TUB/FOKUS OpenMTC). We emphasize secure identification and authentication of sensors and users as well as policy-based store and forward functionality.

Figure 1 depicts components associated with the TRESCIMO reference architecture. The integration of several frameworks and associated applications involve two testbeds for smart cities M2M communication: one at the Technical University of Berlin (TUB), Germany, and another at the University of Cape Town (UCT), South Africa, enabling two trials: the Smart Energy System Trial in Gauteng, South Africa (CSIR/Eskom), and the Smart City Environmental Monitor Trial in Sant Vicenç dels Horts, near Barcelona, Spain (I2CAT/ABS). In addition it was implemented an in-house Proof-of-Concept related to smart energy, to be deployed at the CSIR premises in Pretoria, South Africa. The planned solutions are positioned to address high level goals associated with smart energy and environmental monitoring. TRESCIMO is already integrated into the Fed4FIRE SFA client, powered by FITeagle2, running under the following URL: <https://federation.trescimo.eu>

Short Description of the **Testbeds**:

- At Technical University of Berlin, Germany
 - Experimental Machine to Machine testbed
 - Providing Testbed management using the FITeagle Future Internet Testbed Management Framework
 - Based on OpenStack, a cloud computing software, and OpenSDNCore, a orchestrator replacement developed by Fraunhofer FOKUS
 - Control flow: FITeagle → OpenSDNCore → OpenStack
 - Interconnection with other FIRE facilities through the Slice-based Federation Architecture (SFA)

- At University of Cape Town, South Africa
 - Experimental Machine to Machine testbed
 - To be used for early and scalability-driven evaluation
 - Based on FOKUS OpenMTC and OpenStack
 - Hosts devices and gateways for aggregating and exchanging data.

Short description of the **Trials**:

- **Smart Energy System Trial**, in Gauteng, South Africa is planned for Year 2 of the TRECIMO project. The trial will utilise a collection of ActivePlugs, and ActiveGateways to link a number of households to the Smart City Platform. The aim of the trial is to establish means to for demand-side management (i.e. data acquired, communicated, processed and the result communicated to a device or to a person). The interface to the person is of particular importance in the trial. A mobile application linking to the complete platform stack is planned and will provide a view into an occupants' household. This aspect will measure the concept of a "smart bill", while the technology implementation will measure and validate the technical feasibility of such a configuration over intermittent networks.
- **Smart City Environmental Monitor Trial**, in Sant Vicenç dels Horts, near Barcelona, Spain: The trial consists in the deployment of a Delay Tolerant Networks (DTN) based system for Environmental Monitoring in Smart Cities with no need of an on-purpose infrastructure for interacting with the sensors distributed through the city. It is an energy-efficient solution based on enhanced radio wake-up system mechanisms and bidirectional communication with the sensors (allowing monitoring and configuration).

Short Description of the **Proof of Concept**, in Pretoria, South Africa:

A proof-of-concept is being implemented at the CSIR premises. This proof-of-concept integrates all technology building blocks into an end-to-end future internet experimental platform. This entails linking energy related sensors (Active devices) through gateways and interworking proxies to an instance of OpenMTC. Similarly, environmental sensors (e.g. air pollution) sensors are connected via a delay-tolerant network to the OpenMTC instance. The Smart City Platform provides a base for applications (i.e a visualization mobile application). The Smart City Platform is linked to the OpenMTC instance via another interworking proxy. This proof-of-concept will link to the federated research facilities (via FitEagle) which will allow for provisioning and control of the various building blocks in the proof-of-concept. The proof-of-concept provides a full-featured experimental facility for new research and development.

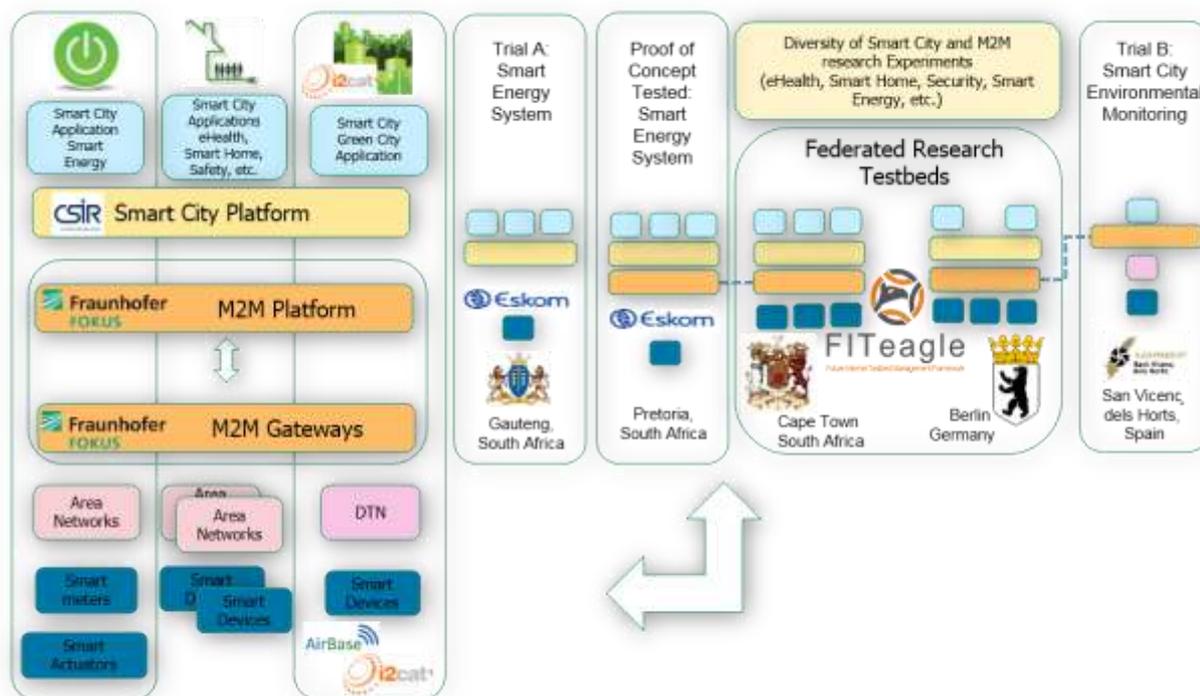


Figure 1 TRESIMO Reference Architecture

TRESIMO is a Future Internet Research Experimentation (FIRE) project, for EU-South Africa cooperation on future Internet experimental research and testbed interconnection. It started on January the 1st, 2014 and will be finish after 24 months, on December the 31st, 2015.

FIRE addresses the emerging expectations which are being put upon the Internet, by providing a research environment for investigating and experimentally validating highly innovative and revolutionary ideas.

TRESIMO's vision is to bring FIRE closer to offer Smart Infrastructures as a Service and the project key achievement is to provide a reliable and standard compliant Smart City Software Stack as a Service for evaluation purposes based on European and South African requirements of Smart Cities.

To come closer to this vision and contribute to the key achievement, the main objectives of the project are:

- Strengthen the interconnection and extension of existing experimental facilities across continental boundaries with a specific focus on Smart Cities and Smart Energy;
- Integration of software-based cross-industry horizontal M2M frameworks with real world sensors and IoT device deployments;
- Usage of autonomic communication methods for end-to-end M2M communication in Smart Cities focusing on smart energy management;
- Combine delay tolerant communication with crowd-sensing approaches to support opportunistic information transmission;
- Leverage existing standards in the field of M2M and foster their global adoption;
- Deployment and federation of testbeds across countries and continents, with a focus on underdeveloped countries and structurally challenged areas.

During its first year (January 2014 – December 2014) TRESCIMO achieved the following main results associated with the respective work performed on the:

- **Scenarios and Requirements:** CSIR lead this WP and Task 2.1, while Eskom lead Task 2.2 and Fraunhofer Task 2.3. The WP has been completed. The deliverables D2.1 (Scenario Specification), D2.2 (User and Technical Requirements) and D2.3 (Final Requirements and Scenarios) has been completed and delivered on time and within budget.

- **Architecture and Implementation:** The architecture specification has been completed and published in D3.1, leading to the first version of the integrated prototype, which is described in D3.2.

- **Experimentation:** The experiments to be conducted in the TRESCIMO Virtual Private Network environment and the TRESCIMO Federated Environment were defined, and it was selected the evaluation criteria, in real world environments and in scalable testing facilities, for the assessment of the architecture and components. D4.1 presents the results.

Towards the end of the project, by completing all its planned activities, TRESCIMO outcome encourages the development of affordable technologies for future Internet, research activities on delay tolerant networks and opportunistic communications, as well as developments supporting innovative applications for social integration, improving the capabilities of testbeds on Future Internet technologies in Europe and in South Africa.

The development of the TRESCIMO technology (testbeds and platforms) will be used as best practice to guide the research, development and implementation of similar technologies for application in South Africa and the African continent.

The execution of the validation trials will provide insight and experience that will be beneficial for human infrastructure development with regard to technologies needed for the M2M and Smart Cities platforms. Based on the TRESCIMO developed technology and insights through validation in the South African context, the CSIR Meraka is able to channel and contextualize European developed M2M technologies into the South African market for improved decision making in the context of energy utilization at both national, regional and city level.

With respect to future smart grid, both at national level as well as at municipality level the TRESCIMO project will contribute to awareness rising at citizen level and encourage behavioural change leading to energy savings in public and private buildings and homes.

The developed technology of the TRESCIMO project will be beneficial for supporting and enabling existing initiatives and foreseen programs in other domains, i.e. smart city programs dealing with water, waste, healthcare, education, transport, and logistics.

All the progress and project achievements are published on the project website under the European and the South African domains: <http://trecimo.eu/> and <http://www.trecimo.org.za/>.