V I T R O
Virtualized dIstributed plaTfoRms of smart Objects

KEYWORDS: virtual sensor networking, network coding, trust-aware routing, service-oriented architecture, population protocol.

At a glance: VITRO

Virtualized Distributed Platforms of Smart Objects

Project Coordinator

Name: Evangelos Ladis

Organization: Hellenic Aerospace Industry

Email: eladis@haicorp.com

Project website: www.VITRO-ICT.eu

Partners:

- Hellenic Aerospace Industry (GR)
- Thales Communications France (FR)
- Telefonica I+D (ES)
- Centre Tecnologic de Telecomunicacions de Catalunya (ES)
- Research and Academic Computer Technology Institute (GR)
- Technological Educational Institute of Chalkida (GR)
- Zodianet (FR)
- W-LAB (IT)
- Elsag-Datamat (IT)

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Main Objectives

Virtual Sensor Networking (VSN) is an emergent approach that aims at providing support for collaborative multi-purpose WSNs. VITRO main objective is to extend and realize the concept of VSN and increase the reliability and deployment simplicity of Wireless Sensor Networks (WSN), a missing, yet crucial link between highly heterogeneous wireless sensors and actuators platforms. VITRO will develop architecture, algorithms and engineering methods and toolsets, which will enable the realization of scalable, flexible, energy-efficient and trust-aware VSN platforms. Hence, VITRO will increase the reliability and boost deployment of cooperative, virtualized smart communicating objects.

VITRO aims to extend the notion of virtual sensor networks and address innovative engineering/ research topics for the realization of VSN

To achieve these objectives, VITRO enabled platforms will:

• **Provide a homogeneous abstract appearance** to enable federated collaboration with external entities and thereby extending the networking degree by several orders of magnitudes.

• **Simplify the discovery and management of the underlying hardware and software resources** of large collections of heterogeneous smart objects.

• **Achieve energy-efficiency, trust-awareness and seamless connectivity and communication** in large-scale heterogeneous WSN deployments and thereby enable dependable, virtualized, secure and scalable inter-objects collaboration.

The VITRO outcomes will be packed in a **VITRO application toolbox**, consisting of middleware, advanced core communication components and a user-friendly management tool, which will enable easy configuration and instant support for deploying VSN applications. Although VITRO aims to be application-neutral, the proposed architecture and protocol toolbox will be validated through extensive simulation testing and implemented in a federated network of sensor nodes and smart objects in smart home and building automation application domains.

COOPERATION

European Commission
Information Society and Media

Technical Approach

The concept of VSNs introduces a truly new and dynamic collaboration paradigm. In order to cope with the augmented collaboration requirements of this new paradigm, VITRO will pay special attention on issues like seamless connectivity, energy-efficiency and operational reliability, as well as trusted routing in large-scale harsh environments. VITRO will evaluate network-coding techniques and follow an application-aware approach, leading to better utilization of the medium. The proposed MAC will be simulated and evaluated to show minimization of transmission collisions and improved communication performance in terms of network throughput and packet loss reduction. In Network Layer, VITRO will combine ideas and work in progress, mainly from the IETF ROLL workgroup, and propose a novel trust-aware routing protocol implementation, suitable for VSN, consisting of thousands of smart objects with dynamically shared resources. Furthermore, we will propose an innovative middleware solution to be applied, in order to discover where resources are located, categorize them, and extract semantics information based on their syntactic descriptions. For the purposes of VITRO, an enriched version of WSN-SOA supporting virtualization will be developed. Finally, we will use the population protocol model and its extensions to model and verify specific properties of the implemented VITRO protocols. This will help us obtain a first insight in the behaviour of the system and identify which characteristics need to be included.

Key Issues

In order to realize an operational VSN-supporting protocol stack, VITRO will focus and propose beyond the state-of-the-art solutions in the following research areas:

- *Energy Efficiency and Operational Reliability:* VITRO aims at improving energy efficiency by the use of distributed network-channel coding and network coding division multiplexing, heavily tailored to the embedded system deployment.
- *Seamless Connectivity:* VITRO will design an innovative, multichannel, flexible MAC solution, able to support VSN functionality through graph-colouring algorithms to minimize transmission collisions and guarantee the predefined hard-delay constraints.
- *Trust-Aware Routing Protocol for VSN:* VITRO will work on open IETF ROLL RPL parameters for development (e.g. the ETX parameter), in conjunction with the underlying IEEE 802.15.4e MAC specifications to provide an interoperable, trust-aware management scheme.
- *Verification through Population Protocol Model:* The population protocol model will be used to model VSN networks and the interactions, as dictated by the protocol stack, providing the ability, in a formal and modern way, to define the system in a minimalist way.
- *Middleware Support for Network-Centric Dynamic Resource Discovery, Virtualization & Management:* The VITRO middleware solution will be based on a multi-level approach that implements existing SOA standards on higher tiers, across with the appropriate modifications on the protocol stack, which brings the benefits of SOA to low capacity nodes.
- *User-Friendly Configuration, Commissioning, Self-Organization & Maintenance Tools:* In order to be able to easily adopt the VITRO infrastructure in various WSN environments, both the initial configuration and the real-time reconfiguration of the VITRO nodes will be performed in a user friendly and fully automated way by a specially developed toolset which will take advantage of the developed middleware.
- *Interoperability of Multiple VSN's:* In VITRO, the concept of virtualization will be further extended, in order not only to cover cases where one Administrative Domain borrows resources from smart objects controlled by another Administrative Domain, but also provide engineering methods for direct inter-VSN communication without the need for centralised control. This will enable the development of more intelligent applications combining information gathered through different VSNs.
- *Reduced Complexity of System Maintenance:* Federating the above, an ultimate goal of VITRO is to ensure zero-outage, instant-response, green-operational and adaptive systems of lowest possible deployment, maintenance and troubleshooting complexity.

Expected Impact

VITRO aims to extend and realize the concept of VSN and increase the reliability and deployment simplicity of WSN. Hence, VITRO is expected to increase the reliability and boost deployment of cooperative, virtualized smart communicating objects. The VITRO toolbox will enable user-friendly configuration, self-organization and maintenance of VSN, with low complexity and minimal effort. Moreover, VITRO will target everyday applications such as smart homes, buildings and large scale infrastructures.