
# An innovative IoT solution for smart environments in AAL

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01 – Well-being and active ageing

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# 1 – Introduction

We present a proposed architecture of a scaled physical world that is richly and invisibly interwoven with a variety of heterogeneous sensors, actuators, displays, and computational elements, embedded seamlessly in the everyday objects of lives, and connected through a unique uIPv6 wireless network.

The use of Internet Protocol (IP) stack in Wireless Sensor Networks realizations is a key prerequisite for the Internet of Things (IoT) paradigm. The ability to connect thousands of smart objects scattered across physical environment directly to Internet opens exciting scenarios for a variety of application areas, such as e-health, smart metering, smart home, logistics, home automation, ambient assisted living, etc. Furthermore, it allows to achieve the much desired interoperability requirement between the previous systems that to date use heterogeneous protocols and need of G2G communications.

The paper describes the proposed system's major building blocks, its functionalities, the implementation approach, the realized services and the proposed ones. Finally we present the use case of a retirement village named "Triskel Resort" that is rising up in the Marche countryside, in Poggio San Marcello (AN), and whose project integrates the proposed system as realization of our smart environment vision. This structure is designed to offer holiday periods or a permanent residence for self-sufficient people over 65.

## 2 – The Proposed Architecture

Our won challenge is the project and the realization of a self-installing and self-configuring uIPv6 wireless sensor network based on very low cost and ultra low power devices. The microprocessor is of the STM32L series while the transceiver is the low power sub-1GHz Spirit1. Figure 1 depicts the core of the prototype sensor node.

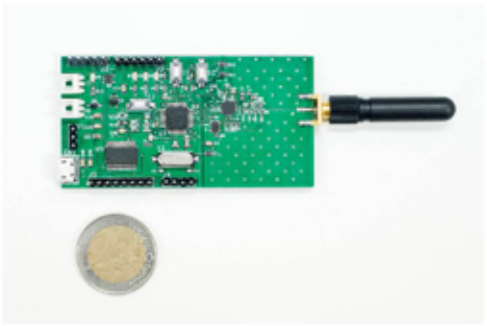

**Figure 1.** The uIPv6 sensor node.

As shown in Figure 2 the Physical and Data Link Layers of the proposed solution are based on the IEEE 802.15.4 standard stating transmission in the sub Giga Hertz range. The communication model used in this work is based on UDP traffic type over uIPv6. The adaptation layer 6LowPAN realizes the header compression, the fragmentation and reassembly mechanism, and the address mapping from IPv6 to IPv4. The routing protocol is the recently proposed RPL (Routing Protocol for Low power and Lossy Networks). It has been designed to fulfill the typical requirements of wireless sensor networks. RPL ensures a very fast network set-up and high degree of network lifetime also in the case of mobility and dead of nodes. Thus the network allows the development of advanced monitoring applications also in critical conditions. At the upper layer the Constrained Application Protocol (CoAP) is implemented. It is a web transfer protocol which provides several Hypertext Transfer Protocol (HTTP) functionalities, re-designed for constrained embedded devices. CoAP allows WSN applications to be built on top of Representational State Transfer (REST) architectures. This significantly eases the IoT application development and the integration of constrained devices with the Web.

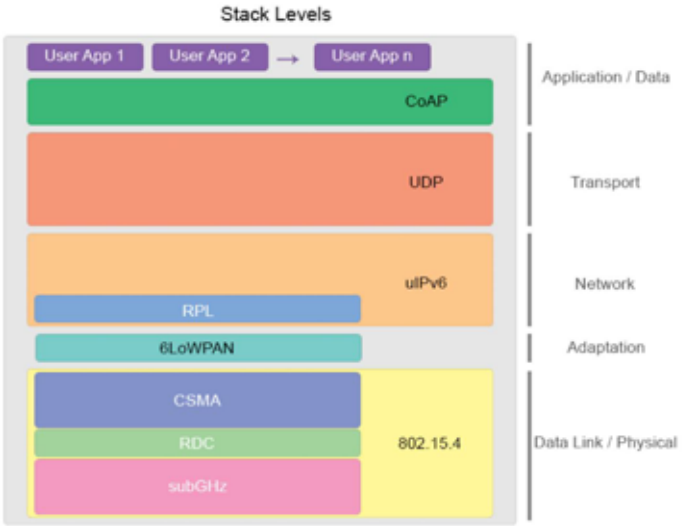


**Figure 2.** The communication model.

Our system is constituted of hundreds of sensor nodes and is able of acquiring a variety of sensing data so monitoring the reality being capable of understand essential features for providing differentiated services to the user.

## 3 – The Smart Environment Scenario

Our contribution is finalized to a real integration and interoperability of solutions for supporting active and independent living of elders in their homes. Particularly, this work presents how to employ the IoT capabilities to built a prototype of an exportable Smart Environment for personalized assistance and heath care in the user's environment (i.e. home, hospital, retirement home, holiday resort, etc.).

The adoption of e-health and others ICT solutions in AAL environments creates new opportunities in more sophisticated care solutions, new methods of medical treatments, but this implies some challenges into the building of an efficient, secure and reliable network platform. Actually these monitoring systems are moving towards the Internet of Things, which offers a global end-to-end connectivity with technologies such as the proposed ones. Specifically the proposed system is able of monitoring remote and continuous vital signs, is functional for mobile and static health applications,

for chronic disease management, but not only. In fact, the IoT realization enables new interaction methods depending on the involved environment and made possible to connect and identify all the people, devices, and things that are surrounding us.

This proposed integrated monitoring environment is based on the previously introduced uIPv6 wireless sensor network. The system provides a multitude of nodes in the indoor and outdoor environment, wearable nodes, etc. that realize the adaptive and self reconfiguring mesh network infrastructure supporting multiple services besides of acquiring the variables of interest for a variety of applications. Figure 3 presents the scenario deployed under our work.

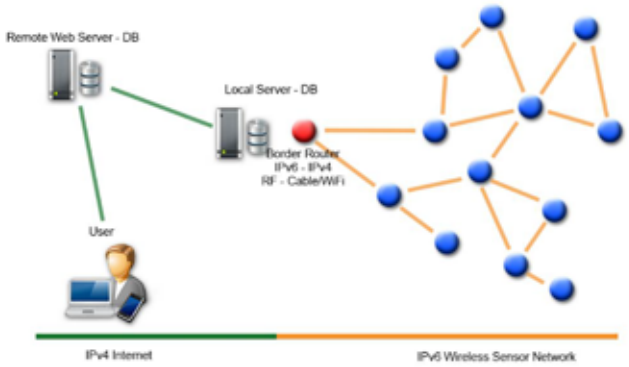


**Figure 3.** The proposed Smart Environment scenario.

The scenario is composed of four parts. The first component is the uIPv6 network that offers the capabilities to reach global addressing and connectivity in order to interact with and identify every device belonging to the network. As previously emphasized, each IPv6 node can be a wearable node or an environmental one supporting a series of measurements and actions (e.g. clinical sensor such as wearable electrocardiogram rather than a fall detection system or a flooding detector, a thermostatic valve, a light controller, etc.).

The second element of the system is a border router incorporating the required functionalities for the connection of the local uIPv6 wireless network to the global IPv4 Internet.

A local Server for the temporary storage of the data and their periodic upload towards the remote data base is the third element.

Finally there is a centralized Web Server for logging the monitored information (i.e. patients' health status recording and monitoring, anomalies detection and alarms

generation, communication services with specialists, caregivers and users in general, environmental data monitoring and control, lighting management, energy metering, etc.). The Web platform integrates a REST/CoAP WSN with a REST Web application and allows a user to visualize the WSN measurements and to interact with the nodes by means the Web browser.

## 4 – Use Case

Triskel resort is a place where the ultimate application of ambient assisted living, home automation, e-health, smart energy, smart lighting, new construction technologies, food science converge to give the best answers to the needs of the elderly.

The project complies with Itaca protocol on the energy and environmental sustainability of the buildings. It uses less natural resources, produces less impact on the environment and guarantees a greater home comfort than conventional construction. The certification is not only limited to energy consumption but tends to counter the housing dispersion rewarding those buildings located within urban areas denser and more central. Other sensible parameters are the proximity to public transportation, public services or business or the ability to move on foot or by bicycle. Additional criteria relate to the quality of indoor comfort through the examination of temperature, ventilation and lighting.

Sensorized environments, transparent to the user and easily customizable, integrated into everyday objects (lighting, heating/air conditioning, water treatment, etc.) are added to wearable sensors for monitoring the safety and health of the guests. As an example of the last solutions, a wearable IMU (Inertial Measurement Unit) platform was developed to provide a fall prevention and detection device and to analyze the activity level of each guests. Additionally, a small sensor node capable of 24h monitoring the body temperature may be worn. Others wearable biomedical sensors can be used for tele-home-care purposes adding new possibilities for monitoring of vital parameters and giving the patient the freedom to be mobile and still be under continuously monitoring and thereby to better quality of patient care. As a last example, a wearable electrocardiogram (ECG) sensor is intended for detecting occurrences of cardiac arrhythmias and to follow up critical patients while they are carrying out daily activities.

Furthermore, each wearable sensor node can also play the role of a target node within a localization service. The infrastructure constituted of anchor nodes still is realized through fixed sensors supporting the other types of services and have thus the functionality of creation of the mesh network too. So through a wearable node we are

able to provide the user's location within the Triskel resort and pay immediate aid in case of falls, alarms of any kind, and every time there is the need to localize an host.

Finally, the integration with the community of residents, made possible by the overall organization of Triskel, promotes coexistence between the different generations, children, young and old.

The achievement of all the previous objectives is made possible by the integration of all aspects of design involved through a single network infrastructure of wireless cooperating sensors whose architecture is previously described.

Figure 4 depicts the map of the resort across which the wireless sensor network is under test.

**Figure 4.** The Triskel resort map.

## 5 – Conclusion

The present work proposes an innovative approach to the project of AAL systems and not limited to this. The realized infrastructure allows to integrate into a single solution systems up to now not directly interoperable with each other except through the use of specific gateways. Sectors such as AAL, home automation, smart city, etc. may well find a unique implementation that increases the capabilities and potential of each of them.

In fact, the reuse opportunity of the presented architecture are theoretically unlimited. Furthermore the proposed technology is natively finalized to integrate a variety of

different solutions for supporting active and independent living of elders even in their homes or in other different environments.

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Triskel Resort

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