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Exigent Role of Internet of Things in Human wellbeing Monitoring System

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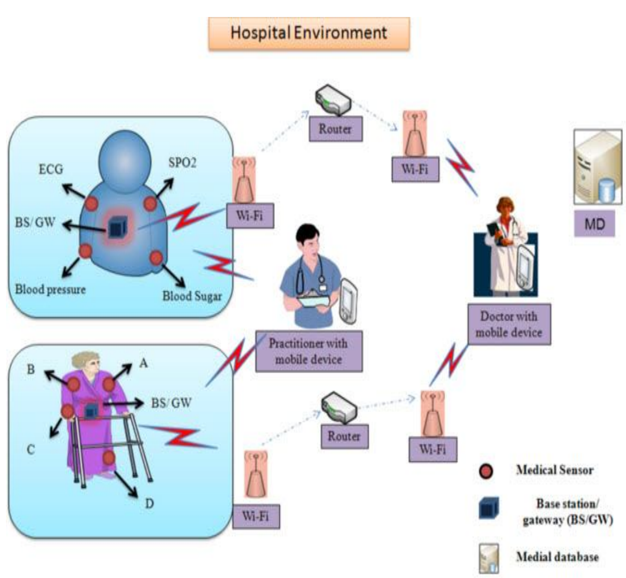
Abstract: ***IOT plays a prominent role in automating the day to day life applications in a most innovative and interactive way. The IOT rebellion is renovating health care system with technical, economic and societal prospects. More advanced and integrated approaches within the scope of the digital transformation of healthcare are starting to be used with regards to health data aspects. IOT is the design of things, particularly everyday objects which are readable, recognizable, locatable, addressable and controllable via the Internet either through WAN , wireless LAN , RFID or by other means. Various medical devices, sensors, diagnostic and imaging devices can be viewed as smart devices or objects constituting a core part of the IOT. IOT has the potential to reduce device downtime through remote provision. This paper proposes advances in IOT based health care technologies and industrial trends. We forth put a novel IOT-alert, smart architecture for automatic monitoring and tracking of patients, personnel, and biomedical devices within hospitals. This paper proposes a Smart Hospital System which relies on different technologies, specifically RFID, WSN, and smart mobile, interoperating with each other through a CoAP/6LoWPAN/REST network infrastructure.***
Index Terms: RFID, WSN, 6LoWPAN, CoAP, REST

I. INTRODUCTION

The concept of Internet of things is the integration of all devices that connect to the network, which can be managed from the web and in turn provide information in real time, to allow interaction with people they use it . Gateways, medical servers, and health databases play vital roles in creating health records and delivering on-demand health services to authorized users.

The goal of the IOT is to enable a variety of things/objects present in the environment to be connected in order to interact and cooperate "anytime, anyplace, with anything and anyone, ideally using any path or network and any service".

From 2017 until 2022, growth in IOT healthcare applications is indeed poised to accelerate as the Internet of Things is a key component in the digital transformation of the healthcare industry. Automatic identification and tracking of people and biomedical devices in hospitals, correct drug-patient associations, real-time monitoring of patient's physiological parameters for early detection of clinical deterioration are only a few of the possible examples.



RFID is a low-cost, low-power technology consisting of passive and/or battery-assisted passive (BAP) devices, named tags, which are able to transmit data when powered by the electromagnetic field generated by an interrogator, named reader. Since passive RFID tags do not need a source of energy to operate, their lifetime can be measured in decades, thus making the RFID technology well suited in a variety of application scenarios, including the healthcare. The recent availability of UHF RFID tags with increased capabilities, e.g. sensing and computation represents a further added value. In fact, RFID-based sensing in healthcare enables zero-power, low-cost, and easyto-implement monitoring and transmission of patients' physiological parameters.

The core of IOT solutions is IPv6 over Low power Wireless Personal Area Networks (6LoWPAN) [1] which is proposed by the IETF to provide Internet connectivity to constrained WPAN devices through IPv6. 6LoWPAN defines message frame formats, fragmentation methods and header compression techniques required to fit IPv6/UDP data grams in the very limited IEEE 802.15.4 frame size. The 6LoWPAN innovations provide IP access to a wide set of networked devices, which, being low-cost, low-power constrained hosts, could not easily benefit from the huge addressing space of IPv6. 6LoWPAN is able to reduce the IPv6/UDP header while maintaining the main functionalities and the size of the addressing space, thanks to a cross-layer optimization approach. This is achieved by inferring parts of the IP headers from the MAC header, thus an IPv6 40-byte header can be shrunk into a single-byte HC1 header, while the UDP header size can be similarly reduced. The 6LoWPAN format is supported by many standardization bodies, including ETSI, IPSO and the ZigBee alliance.

In this effort, a novel IOT-sentient Smart Hospital System (SHS) is presented . It is able to guarantee innovative services for the automatic monitoring and tracking of patients, personnel, and biomedical devices within hospitals by exploiting the potentialities offered by the jointly use of different technologies such as RFID, WSN, smart mobile, 6LoWPAN, and CoAP. Specifically, the designed SHS is able to collect, in real time, both environmental conditions and patients' physiological parameters via an ultralow-power Hybrid Sensing Network (HSN) composed of 6LoWPAN nodes integrating UHF RFID Class-1 Generation2 (Gen2 hereafter) functionalities. In particular, two new kinds of WSN nodes are proposed. The former integrates an RFID Gen2 reader while the latter integrates an augmented RFID Gen2 tag in order to store sensor data and patient information. In this way, physiological parameters of patients can be easily retrieved by RFID Gen2 readers scattered in the hospital and delivered to a control center where an advanced monitoring application makes them easily accessible by both local and remote users via a Representational State Transfer (REST) web service. During normal operations, therefore, no WSN based transmission is performed, thus reducing the node power consumption and limiting the impact on the network capacity. The designed system is also able to timely and reliably manage emergency situations. In fact, in this case, the WSN-based transmission is activated so as to promptly inform the nursing staff via Push Notifications on a customized mobile application. Doctors can also connect their smartphone to a portable UHF RFID reader and use the same mobile application to interact with patients' nodes during daily medical inspections.

Recent advances in micro-electromechanical systems (MEMS) have opened up great opportunities for the implementation of smart environments. Especially in the medical field, several sensors to evaluate different types of vital signs (i.e. heartbeat, body pressure and temperature, ECG, motion, etc.) have been developed, thus enabling the design of innovative services able to substantially improve citizens' healthcare. In this field, among the several research activities already presented in the literature, those related on the use of the UHF RFID technology are mainly focused on tracking patients in hospitals and nursing institutes. In [4], authors combine together wearable tags and ambient tags to develop a fully-passive RFID system, named NIGHT-Care, for monitoring the state of disabled and elderly people during the night. Specifically, NIGHT-Care relies on an ambient intelligence platform which is capable to estimate sleep parameters, classify the human activity, and identify abnormal events that require immediate assistance. In [2], RFID Locator, a web-based application developed at the University of Fribourg (CH) in collaboration with Sun Microsystems, has been proposed to improve the quality of hospital services. Passive RFID technology has been successfully used for equipment localization in hospitals. since RFID tags can operate solely under the reader coverage region, the use of UHF RFID technology is limited to patient/devices monitoring and tracking in quite small environments. Another set of related work proposes the use of WSN technology to implement solutions able to meet the specific requirements of pervasive healthcare applications. The localization and tracking engine rely on the received signal strength indicator (RSSI) and particle filters while bi-axial accelerometers are used to classify the movements of patients. In [4], a wireless localization network able to track the location of patients in indoor environments and also to monitor their physical status is presented. A location-aware WSN to track patients using a ranging algorithm based on environment and mobility adaptive filter (REMA) is proposed in [1]. Specifically, WSN4QoL[5] relies on a three-tier system architecture, where, at the lowest tier, a Bluetooth-enabled wireless body area network (WBAN) connects sensor nodes to a local collector which, in turn, sends measurements reports towards a gateway through a IEEE 802.15.4-based ZigBee network. Finally, the gateway performs local computation and forward data to the public IP network towards the professional caregivers for real time analysis. In [6], the 6LoWPAN standard and smart mobile communication techniques are

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combined to monitor the health condition of patients and provide several effective healthcare services. More in detail, the proposed solution makes use of WSN devices to measure photo plethysmogram (PPG) signals and deliver them to a server through the Internet. An Android device is used to provide a mobile healthcare service by means of a customized application. Unlike the UHF RFID technology, the use of WSN allows the patients to be monitored in a more efficient manner at the cost of complex algorithms required for their precise tracking. The combined use of the UHF RFID and WSN technologies, on the contrary, could bring considerable benefits, thus paving the way for the development of innovative, smart services. To design a flawless structure easily deployable in a variety of scenarios, the use of a WSN based on the Constrained Application Protocol (CoAP) for connecting and monitoring medical sensors is advocated [7]. The CoAP adoption in healthcare scenarios represents an important aspect since some CoAP built-in features, such as resource observation, particularly useful for real-time monitoring of patients' vital-signs. This exertion aims at designing and implementing an IOT based Smart Hospital System (SHS) having, as main peculiarity, the capability to readily combine different, yet complementary, technologies enabling new functionalities. Basically, the system we envision should be able to collect, in real time, both environmental conditions and patients' physiological parameters and deliver them to a control center. At this point, an advanced monitoring application should analyze the received data and send alert messages in case of emergency. The conceived SHS has been put into effect according to the architecture illustrated in Fig. 1.

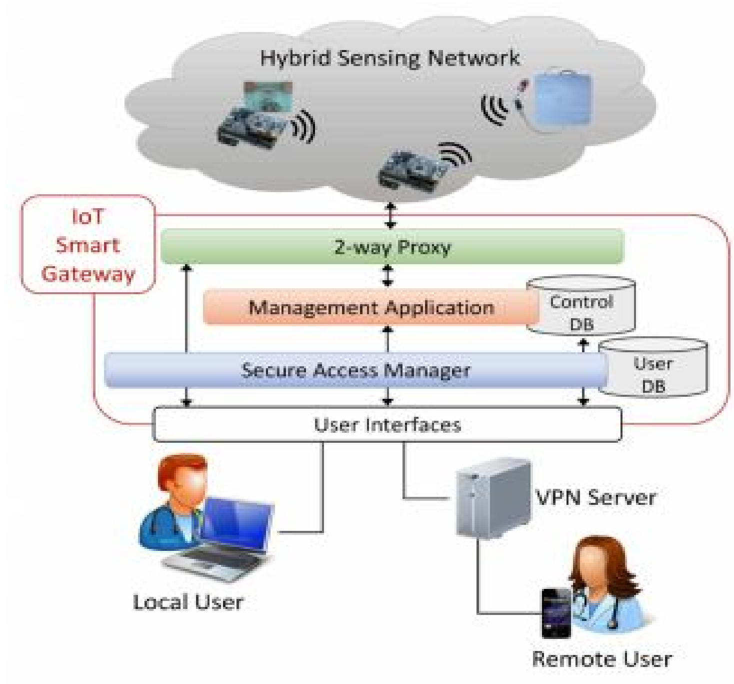

Fig. 1. Overview of the Smart Hospital System (SHS) architecture.

A. As shown, it is composed of three main parts

1) the RFID-enhanced wireless sensor network, named Hybrid Sensing Network (HSN)
2) the IOT Smart Gateway,
3) the user interfaces for data visualization and management.

The HSN consists of an integrated RFID-WSN 6LoWPAN network composed of four topologies: (1) 6LowPAN Border Routers (6LBR), (2) 6LowPAN Routers (6LR), (3) 6LowPAN Router Readers (6LRR), and (4) 6LowPAN Host Tag (HT). According to the 6LoWPAN standard, the 6LBR is in charge of connecting the network to the Internet by translating 6LowPAN packets into IPv6 packets and vice-versa, while the 6LR provides forwarding and routing capabilities. Referring to the proposed RFID-WSN integrated system, the 6LRR is defined as a 6LR node interfaced with an RFID Gen2 reader while HT identifies a typical 6LowPAN Host (i.e. a node without routing and forwarding capabilities) interfaced with an RFID Gen2 tag. More details about HSN nodes with RFID Gen2 capabilities are provided in Section IV. At a finer level of detail, the proposed SHS assumes that several 6LR are deployed in the hospital to collect data from the environment, such as temperature, pressure, and ambient light conditions. The main function of 6LRR nodes is to track patients, nursing staff, and biomedical devices labeled with RFID Gen2 tags. In particular, we envisage patients wearing a HT node which is capable to detect important physiological parameters, such as heartbeat and movement/motion. Sensed data are periodically logged on the user memory of the RFID Gen2 tag, thus allowing 6LRR nodes deployed in the environment to retrieve and deliver them to the IOT Smart Gateway. This last one is connected, on the one hand, directly with the HSN and, on the other hand, with the Internet through a Local Area Network (LAN). Therefore, in the proposed architecture, the gateway plays the role of 6LBR, enabling the communication between WSN nodes and remote users. A Monitoring Application (MA) running on the gateway analyzes the received data and store them into the database (Control DB). To make the collected data easily accessible by both local and remote users, the REST Web-based paradigm has been adopted. Specifically, a Web-based graphical interface allows network operators to manage environmental parameters of sensor and actuator nodes. The same interface allows doctors with specific privileges to access both real time and historical patient data. Such information can also be managed remotely by the medical staff through a customized mobile software application. Furthermore, doctors can be equipped with a smartphone connected to a portable RFID Gen2 reader and running a customized application, named Medical App. Through this App, during the daily medical inspections in hospital, doctors can interact directly with the HT node worn by the patient and check his/her physiological parameters by reading the most recent information stored into the user memory of the RFID Gen2 tag or historical information stored into the Control DB. The Medical App allows doctors also to update the memory content with important information to remind (e.g. the last visit, changes of patient therapy, health examinations, etc.). As clarified in the next section, the RFID Gen2 technology not only provides standardized EPC global identification and tracking of both patients and nursing staff wearing the HT node, but also enables quasi-zero-power read/write memory operations. By exploiting the RFID-WSN integration, the developed SHS architecture is also able to timely manage emergency situations. Indeed, only in case of critical events, such as patient falls or heartbeat irregularities, the HT node resorts to its long-range, high-power, reliable IEEE 802.15.4 radio transceiver to send a notification to the MA. This strategy allows the HT nodes to always use the RFID Gen2 radio interface for routine operations, e.g. medical inspections, data logging, identification/tracking, while keeping the IEEE 802.15.4 radio off for most of the time, thus maximizing battery lifetime. At the IOT Smart Gateway, the MA exploits Push Notifications (PN) to inform the nursing staff about patient location (i.e. the last position where the RFID Gen2 tag has been read) and health status. The doctor can then check patient vital signs through the Web application or directly on his/her smartphone. Since the system collects sensitive and confidential data, the platform must ensure an adequate level of security to data access and management. For this reason, users need to be authenticated before they can access the platform. Moreover, also local and remote communications must be adequately protected. In the former case, the mobile application could exploit a local Access Point (AP) for connecting to the Local Area Network (LAN) and interacting with the SHS. Obviously, the mobile app should be properly configured to guarantee the desired level of security. In the latter case, it is necessary to provide a stronger communication channel, since the interaction between the remote application and the SHS is performed through the public Internet. To do so, the proposed solution exploits a Virtual Private Network (VPN) channel that links the mobile device with the IOT Smart Gateway. Once this access is granted, whether local or remote, the user can act on the system.

II. CONCLUSION

A novel IOT-based, Smart Hospital System (SHS) architecture for automatic monitoring and tracking of patients, personnel, and biomedical devices within hospitals has been proposed. With the IOT vision in mind, a complex network infrastructure relying on a CoAP, 6LoWPAN, and REST paradigms has been implemented so as to allow the interoperation among UHF RFID Gen2, WSN, and smart mobile technologies. In particular, taking advantage of the zero-power RFID-based data transmission, an ultra-low power Hybrid Sensing Network (HSN) has been implemented. It is able to collect the real-time variation of any critical patients' physiological parameter as well as of the environmental conditions. The sensed parameters are delivered to a control center where they are made easily accessible by both local and remote users via a customized REST web service. The proposed system perform identification and tracking of patients, nursing staff, and biomedical devices within hospitals.

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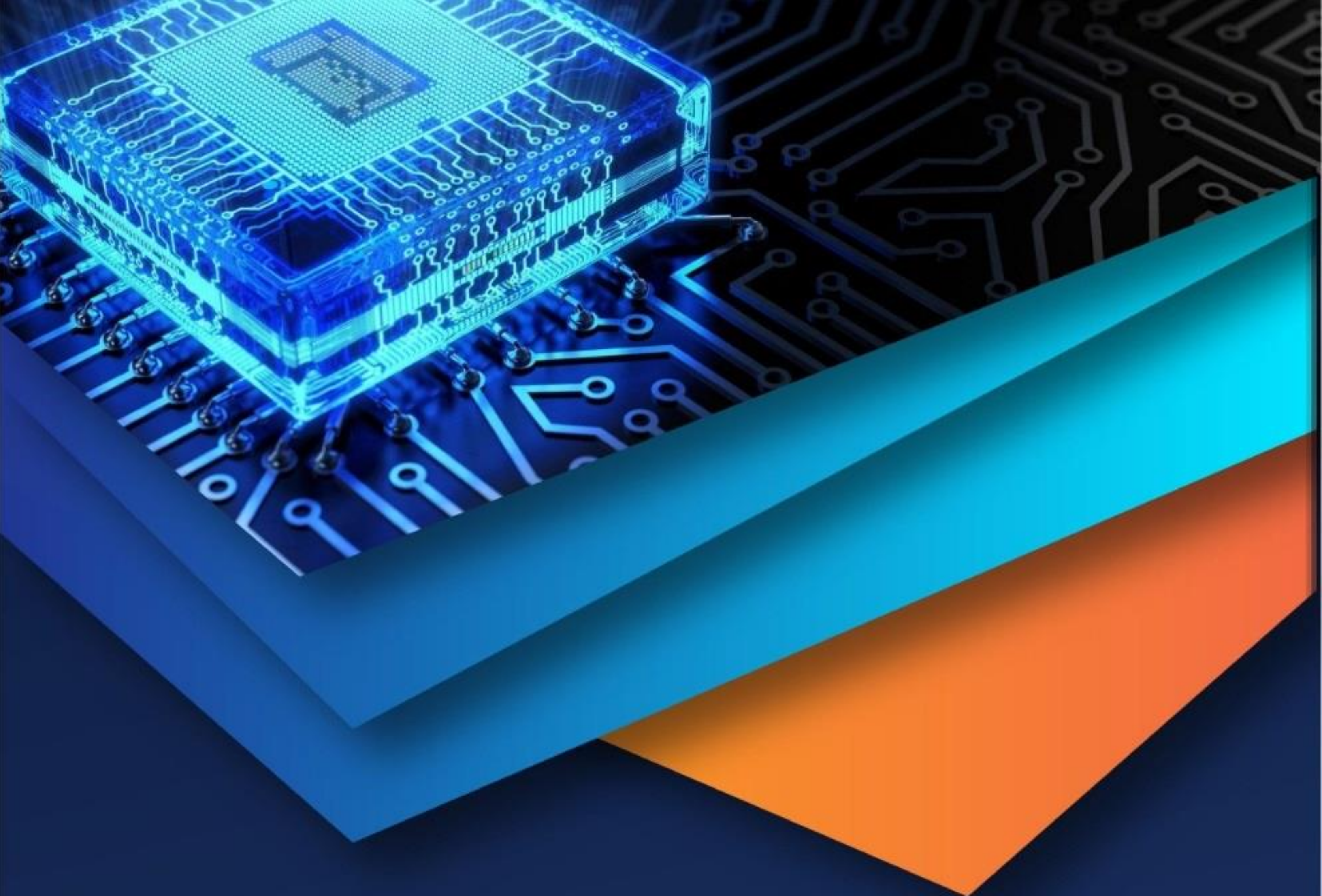

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