A Technical Seminar Report On

Architecture of an IoT-based System for Football Supervision

Submitted to CVR College of Engineering By

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CERTIFICATE

This is to certify that the technical seminar report titled *Architecture of an IoT-based System for Football Supervision* is submitted by *Kamma Sai Tejas*, bearing H.T. No: 20B81A0599, as part of academic requirement of Graduate Engineering Program in Computer Science and Engineering.

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CONTENTS

1. ABSTRACT

Football, also called soccer, is one of the most popular sports in the world, if one considers the number of fans as well as the number of players. However, footballers face serious injuries during the match and even during training. Concussion, hypoglycemia, swallowing the tongue and shortness of breath are examples of the health problems footballers face, and in extreme cases, may lead to death. In addition, many sport clubs and sport academies spend millions of dollars contracting new professional footballers or even developing new professional footballers. The Internet of Things (IoT) is a new paradigm that combines various technologies to enhance our lives. Today's technology can protect footballers by diagnosing any health problems, which may occur during the match or training session, which, if detected early, may prevent any adverse effects on their long term health. This paper proposes an IoT-based architecture for the sport of football, called IoT Football. Our proposal aims to embed sensing devices (e.g. sensors and RFID), telecommunication technologies (e.g. ZigBee) and cloud computing in the sport of football in order monitor the health of footballers and reduce the occurrence of adverse health conditions. The aim is to integrate the IoT environment, in particular the IoT application, intothe field of sport in the form of a new application.

2. INTRODUCTION

Football, with more than 270 million footballers around the globe, is one of the most popular sports in the world, if not the most popular. FIFA, the organization responsible for developing and improving the quality of football around the world, has recently introduced many innovations, which have improved the whole of the ball has crossed the goal line which assists referees in their decision making. This technology has been implemented in approximately 37 stadiums around the world. FIFA is also seeking to make football a healthy sport (e.g. anti-doping regulations, and nutrition for football). In addition, FIFA has published technical recommendations and requirements for building new football stadiums in order to create safe and comfortable environments. Recent research has reported on the frequency and nature of injuries, which occur during matches and training times. Some of the injuries that players face include concussion, hypoglycemia, swallowing the tongue and shortness of breath. These tend to occur when players are fatigued, and sometimes when they have face-to-face incidents with other players. The proposed IoT Football system will help the coach to make accurate decisions regarding the treatment of an injured or exhausted footballer by sending information from the player to the coach.

3. MOTIVATION AND LITERATURE SURVEY

3.1 MOTIVATION

The Internet of Things (IoT) represents a new wave of internet services that facilitates communication between physical devices through the World Wide Web. IoT can be described as a system designed to gather data from sensors, Radio-frequency identification (RFID) devices, or mobile gadgets, transmitting this data through the network layer to the application layer. IoT nodes require identification, management, and control capabilities, enabling interaction with humans and other objects in a Machine-to-Machine (M2M) environment. IoT has the potential to enhance individuals' and societies' lifestyles and can be applied in diverse areas such as healthcare, smart cities, agriculture, smart grids, energy conservation, home automation, smart buildings, intelligent traffic systems, and more.

Numerous studies have been conducted to establish standards for IoT architecture, focusing on specific components, technologies, and classifications relevant to particular domains. One prominent IoT architecture standard is ETSI's M2M, which offers several advantages in terms of components, classification, and layers.

ETSI's M2M standard comprises two layers. The first layer is the default gateway, responsible for collecting information from the devices within the system. The second layer is the network layer and management, which encompasses secure data access, routing, storage, analysis, and application integration. A notable technological development in this field is Wireless Body Area Networks (WBANs), capable of measuring vital physiological parameters like blood pressure, heart rate, and body motion.

This technology has the potential to create a healthcare monitoring system for football players based on IoT, potentially reducing the occurrence of health issues among athletes. Furthermore, IoT's interconnection technologies, such as ZigBee, enable sensor devices to connect to the internet, and 6LoPWAN (IPv6) can be used to equip small devices with IPv6 for low-power and reliable data transmission.

In this paper, we introduce IoT Football, a system designed to closely monitor players during matches or training sessions, enabling immediate analysis and resolution of injuries, incidents, and sports-related risks. This involves placing sensors on footballers to measure essential parameters like body temperature, sweat rate, heart rate, body motion, and respiration rate. Additionally, data from the stadium, including temperature and illumination intensity, is collected and transmitted to the cloud for storage and processing. Feedback is then sent to coaches or supervisors via a mobile application to keep them informed about the players' conditions. This proposed architecture leverages the ETSI's M2M standard to create a reliable and robust system.

The remainder of this paper is structured as follows: Section 2 provides a literature review of the necessary technologies for IoT Football, including the components required for building a dependable IoT-based application. Section 3 outlines the architecture of IoT Football, featuring a case study used in the development of the IoT Football application, along with descriptions of the elements and technologies employed. Section 4 discusses potential challenges that may arise during the real-world implementation of this proposal. Finally, Section 5 concludes the paper and outlines directions for future research.

3.2 LITERATURE SURVEY

In the contemporary era, technology offers a wide array of services that are increasingly user-friendly, secure, and dependable. Wearable monitoring devices have the capability to gather crucial physiological data such as heart rate, blood pressure, blood oxygen levels, daily activity, and more. This advancement holds the potential to revolutionize the healthcare system by shifting its focus towards proactive wellness management, aiming to detect and prevent diseases at an early stage. A groundbreaking technology that has emerged recently with numerous healthcare applications is Wireless Body Area Networks (WBANs). WBANs enable the monitoring and recording of physiological parameters like blood pressure, heart rate, and body temperature. Sensors collect this data and transmit it to a gateway, such as a mobile phone or even an emergency center via the internet.

WBANs are poised to become a primary technology for early disease diagnosis and detection of abnormal events within the human body. They can also offer recommendations for suitable treatments by analyzing the collected data. WBANs can operate in conjunction with IEEE 802.15.6 to provide low-power transmission, short-range, and reliable wireless communication. These sensors support data transmission speeds ranging from 75.9 Kbps to 15 Mbps and can communicate over the internet and other wireless network technologies like ZigBee, WSNs, Wireless Personal Area Network (WPAN), and Wireless Local Area Networks (WLAN).

Numerous recent research endeavors have concentrated on developing healthcare monitoring systems based on WBANs, with the goal of diagnosing an individual's health status before adverse health events occur. However, there is a dearth of research focused on designing a framework for sports-related healthcare, which motivated the proposal of an IoT Football architecture. Various paradigms have been explored and presented in different research articles. For instance, Otto et al. [1] introduced a healthcare system that utilizes WBANs and application software running on devices like personal digital assistants (PDAs) or personal computers. This system employs embedded sensor networks to monitor bodily activities and ECG sensors to track heart activity. Similarly, Yu et al. [2] put forth a monitoring system for daily life and sports activities based on Bodynets, which relies on body networks. It measures multiple physiological parameters, including heart rate, blood pressure, and oxygen levels (SpO2), derived from photoplethysmography signals. After analyzing these parameters, the system can provide guidance to individuals engaged in physical exercises and professional sports. Nevertheless, these two systems, while effective, are limited to specific environments. Sports players require unobtrusive devices during play and training sessions. Recent research envisions that the next generation of health monitoring devices will be lightweight, offer more precise results, and be easy to wear, such as in the form of T-shirts or bracelets [3]. Lee et al. [4] proposed a wearable smart shirt for monitoring physiological ECG signals and physical activity to detect abnormalities in patients' experiences. This system employs IEEE 802.15.4 for low-power consumption. Sazonov et al. [5] introduced a wearable shoe-based device capable of measuring various postures and activities (e.g., sitting, standing, walking, ascending stairs, descending stairs, and cycling) to assist individuals dealing with obesity. Additionally, [6] presented a pH monitoring system using pH sensors that collect sweat from patients.

Since the inception of the IoT paradigm, there has been a proliferation of scientific papers focused on developing healthcare systems based on IoT architecture. Chiuchisan et al. [7] developed an alternative system for patients using IoT technology integrated into a healthcare system, enabling patients to stay in a "smart environment" resembling an Intensive Care Unit within their homes. This system comprises three components: an intensive care unit monitoring device, Microsoft XBOX Kinect, and sensor devices. Furthermore, the authors of [10]

presented a case study of a healthcare system based on the IoT framework, providing a comprehensive blueprint for constructing a reliable healthcare system using ETSI's M2M standard.

Nevertheless, there is a paucity of literature addressing the design of healthcare systems tailored to the realm of sports, offering monitoring services based on the IoT framework. IoT Football proposes an architectural framework with the goal of safeguarding players from injuries, incidents, and sports-related risks. This system monitors footballers' activities by measuring various parameters using sensing technology and also captures environmental data such as stadium temperature and luminous intensity. Achieving this objective necessitates a network comprising embedded sensor devices that can be placed on or implanted within the footballers' bodies. These devices possess IoT characteristics, including individual IP addresses (e.g., 6LoWPAN) and the Constrained Application Protocol (CoAP) technology to facilitate access via web services. Additionally, the Routing Protocol for Low Power (RPL) is incorporated into the IoT Football architecture, and RFID is implemented for player identification. This system is founded on the proposed architecture, and further research is encouraged to construct a reliable, secure system for real-world implementation in a football stadium scenario.

4.OBJECTIVE

The objective for the proposed IoT Football architecture is to leverage Internet of Things (IoT) technologies to enhance the safety and well-being of football (soccer) players during matches and training sessions. The key objectives include:

1. **Player Safety**: The primary goal is to ensure the safety of football players by continuously monitoring their physiological parameters and physical conditions during play or practice. This includes early detection of health issues such as heart attacks, concussions, or other medical emergencies.

2. **Injury Prevention**: The system aims to prevent injuries and incidents by monitoring player movements and conditions. It can provide real-time feedback to coaches and supervisors, helping them make informed decisions to protect players from potential harm.

3. **Health Status Monitoring**: The architecture should enable the monitoring of a player's health status over time, including their medical history, fatigue levels, and other relevant health metrics. This information can help in long-term health management.

4. **Data Analytics:** Utilize cloud-based data analytics to process and analyze the data collected from sensors. Predictive analytics can be employed to anticipate potential health issues or injuries, allowing for proactive intervention.

5. **Enhanced Coaching:** Provide coaches and supervisors with valuable insights into the physical and physiological conditions of their players. This information can aid in making informed decisions related to player substitutions, rest periods, and training programs.

6. **Interoperability:** Ensure that the IoT Football system is interoperable with various sensors and devices worn by players. It should also be compatible with different software platforms to deliver comprehensive services.

7. **Security:** Implement robust security measures to protect player data and ensure the integrity of the system. Data privacy and confidentiality should be maintained at all times.

8. **Reliability and Low Latency:** The system should offer reliable communication between sensors, gateways, and the cloud. Low latency is crucial for real-time monitoring and timely response to emergencies.

9. **Scalability:** Design the architecture to be scalable, allowing for easy expansion to accommodate larger teams or additional features in the future.

10. **Usability:** Create a user-friendly interface for coaches, supervisors, and medical staff to access player data and receive alerts. The system should be easy to set up and operate.

11. **Cost-Efficiency:** Strive to develop a cost-effective solution that can be adopted by football teams and organizations of varying sizes.

5. TOPIC DESCRIPTION

IoT is a new paradigm that enables a huge number of devices to communicate with each other using the World Wide Web. There are a number of sensors that have low power consumption, are light weight, and have their own IPv6 capabilities (i.e. 6oLWPAN) as well as the ability to measure physiological parameters such as heart rate, body temperature, respiration rate, sweat rate and body motion and at the same time, these devices are able to transmit this information to the Default Gateway. Furthermore, there are other sensors around the stadium to measure other conditions, such as the temperature and illumination level. This layer is known as the perception devices. The Constrained Application Protocol (CoAP) is used in the sensor devices to communicate to the gateway. The CoAP is an application protocol used mainly to translate traffic between the devices and gateway to HTTP for integration with the web. Moreover, CoAP has many advantages in terms of low header overhead, multicast support, asynchronous message exchange and is based on User Datagram Protocol (UDP) transport with an application layer.

The second block is referred to as a Network layer, its main function being to gather all the information from the perception devices and transmit them to the cloud system. ZigBee technology is a default gateway that is used in the IoT Football system. The ZigBee base station transmits the data that is collected from the perception devices to the Internet using wired cables because it is highly secure, very reliable and has a high date rate rather than the wireless network technology (e.g. Cellular Network or WIMAX). The communication between the default gateways and the cloud service is by mld interface.

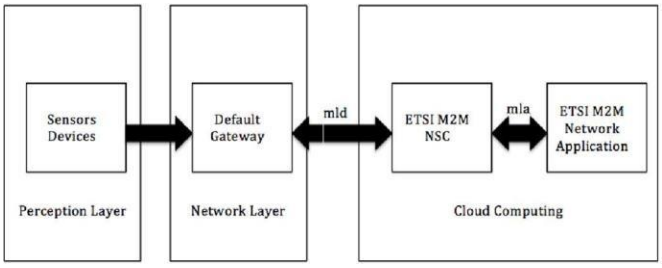

Figure 1. Football IoT Architecture

Cloud computing in the ETSI's M2M standard is classified into two parts. ETSI's M2M NSC (Network Service Capabilities) is used for registration, security, routing and NAT. The other part of the cloud is for the network application. The interface between NSC and the network application is mla interface, and is a bidirectional data flow.

In order to deploy IoT Football in reality, there are several functions and characteristics the system must possess. The next section details the functions that are required in each layer. The Football IoT consists of three main layers as follows:

1- Perception Layer
2- Network layer
3- Application in Cloud layer

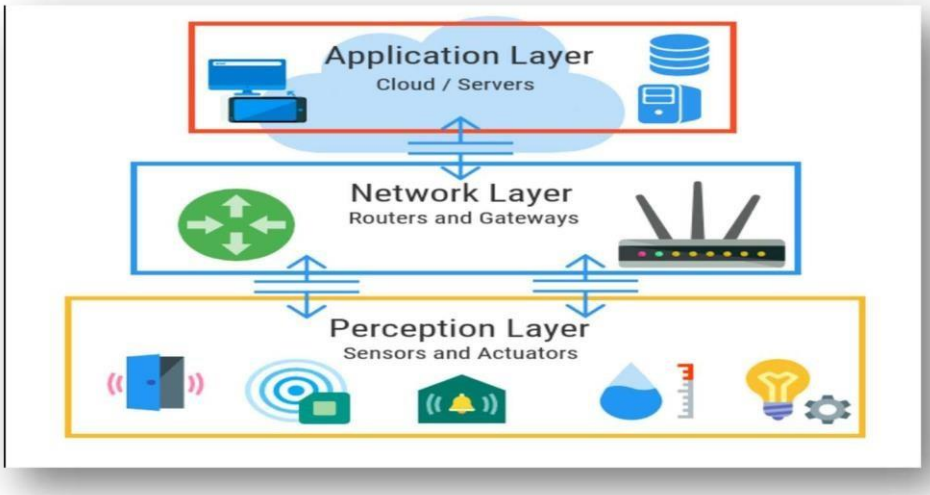

Figure 2: Football IoT Architecture

First Layer: Perception Layer in IoT Football architecture:

Within the initial layer, known as the Perception Layer in the IoT Football architecture, we have two sets of sensor networks. The first set comprises Body Wireless Area Networks (WBANs), which are sensors designed to measure various physiological parameters from the footballer's body. These sensors must remain lightweight and wearable, for example, integrated into a T-shirt. Regarding communication with the gateway, each body sensor needs to possess its individual IPv6 address (utilizing 6LoWPAN) and operate seamlessly with the Routing Protocol for Low-Power (RPL). These sensors should work in conjunction with a gateway to transmit and receive data packets using the CoAP protocol. Furthermore, these in-body sensors must meet stringent security requirements and ensure Quality of Service (QoS). Lastly, they should be adaptable and re-configurable to promptly address any changes in the network topology.

On the other hand, the devices positioned around the stadium, responsible for measuring temperature and illumination levels, may not require identical capabilities as the body sensors. However, they must maintain interoperability with the body sensors in terms of their interaction with the same cloud service and deliver precise and accurate results.

Second Layer: Network Layer in IoT Football architecture:

ZigBee technology is used for the base station in the system. The base station must be connected with a network domain via a wired connection. The base station also needs to work with 6oLWPAN, which means supporting the IEEE 802.15.4 based network. In addition, the gateway must implement the CoAP protocol to send and receive packets to and from sensor devices. Finally, it must have security capabilities and QoS requirements.

Third Layer: Application Layer in IoT Football architecture:

Cloud services must analyse all the data traffic that comes from the devices to give accurate feedback to the coach or supervisor. Predictive analytics in data mining could be used for analysing and predicting possible injuries or conditions to the footballer. The cloud services must also activate the security capabilities and QoS. The data must be stored in a safe place. Finally, the cloud service must be compatible with different software platforms to provide all services to the coach or the supervision. For example, it should be able to provide the footballer’s details including health status, previous illnesses, and fatigue level.

6. CONCLUSION

The Internet of Things (IoT) represents a cutting-edge generation of internet services that facilitate communication among physical devices through the World Wide Web. It significantly enhances the quality of life for both individuals and society as a whole, with numerous applications spanning healthcare, smart cities, energy conservation, home automation, intelligent buildings, traffic management, and more. In this paper, we introduce the IoT Football architecture, designed to monitor football players and provide timely analysis and resolution of injuries, incidents, and sports-related risks. This approach involves equipping footballers with sensing devices during matches or training sessions, collecting data from these sensors, transmitting it to the cloud for storage and processing, and sending real-time notifications to coaches or supervisors via a mobile application to keep them informed about the footballers' conditions. This architecture proposal adheres to the ETSI's M2M standard and can be adapted for various sports, including volleyball, basketball, and others. Our next steps involve implementing this system using TinyOS simulation and addressing any potential challenges or issues that may arise during the process. We plan to document these developments in a future paper in greater detail.

7. QUESTIONS ASKED BY EXPERTS

1. How will data move from perception layer to network layer?
Ans: Data from the Perception Layer, includes sensors that monitor physiological parameters and conditions of football players, is transmitted to the Network Layer for further processing and communication to the cloud. The communication process involves several components and technologies, Sensor Data Acquisition, Data Processing, Protocol Translation, Wireless Communication, Base Station, Wired or Cellular Communication, Cloud Integration, User Interfaces.

2. Where will the sensors be placed on the body?
Ans: The sensors are used to detect the temperature, blood pressure, heart rate and other such factors. They are placed on the palm, back of the body, on the shoulder, knees and on the ankle.

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