



## **A MODEL-DRIVEN METHODOLOGY FOR THE DESIGN OF AUTONOMIC AND COGNITIVE IOT-BASED SYSTEMS: APPLICATION TO HEALTHCARE**

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### **ABSTRACT**

Nowadays healthcare monitoring system is more crucial to constantly monitor patient's physiological parameters from sensors on the patient's body. This system has the ability to monitor physiological parameters periodically every 10 seconds. Sensor nodes are capable to sense the heart rate, temperature of body, ECG signals, blood pressure etc. After capturing the sensor data, we perform some pre-processing techniques to resolve duplication, errors (outliers) and missing values in sensors data. This healthcare monitoring system mostly detects the abnormality conditions in patient's body and if any abnormality condition happens then this system immediately send a message to the doctor or emergency center within one minute. The major advantages of this healthcare system in comparison with the previous system is to reduce the power consumptions, a long lifetime, Increase the speed and enhance the communication coverage area and also provide security and privacy to patient's data. This healthcare monitoring system has provided a secure IoT based communication with the help of advanced encryption standard (AES) Techniques.

### **I.INTRODUCTION**

In recent period, we observed a gradual rise in expectations of life in various part of the world, which leads to frequent increase in number of aged peoples. As per the report of

United Nations the aged people will be about 2.0 billion (22% of the total world's population) by 2050 [4]. In a research found that nearly 89% of the aged peoples are living individually. However, in a medical research



survey found that it is 80% of the aged people elder than 65 and they suffering from at least one disease and older people have every difficult to caring of themselves. By WHO 2015 report 400 million peoples donot have necessary Health facility. Numbers of patients have increased nearly double in every four decades, and it is difficult for hospitals to care all patients. According to the United States report, we can avoid about 41 million deaths yearly if we provide Healthcare facility at time. To provide a gracious quality of life to patient is a big social challenge. Body sensor network provides a large convenience to detect the abnormality in patient's body and provide a proper treatment at time. Sensors sense the physiological data (Body's Temperature, Heart Rate, Blood Pressure, ECG Signal etc.) periodically in every 10 seconds from the patient's body. In capturing the physiological data from sensor at patient's body, we need to process data pre-processing techniques on sensor-data to resolve duplication, errors (Outliers) and missing values in data. After correcting the errors from sensors data, these data are passes through Raspberry Pi to do Algorithmic Process and compare this data with normal range of data. If there is any

abnormality will occurs, it gives an alarm and simultaneously sends a message to doctor. And it will be continuous store the new data and delete the previous old data from the database. The healthcare system work with secure cloud computing. This IoT system has 128-bits advanced encryption standard (AES) technique which encrypt the patient information and store at cloud database. Only authorized people have permit to access the cloud data with login passkey, this login passkey has ability to decrypt the cloud data in original form. This make it a secure IoT based healthcare monitoring system. Secret passkey must be similar length in both ends. This system provides the privacy of patients also. Only Doctor have full access to know about the patient personal information (age, sex etc.), and others users have permit to access only reports of patients by patients ID.

## II. METHODOLOGY

### A) System Architecture

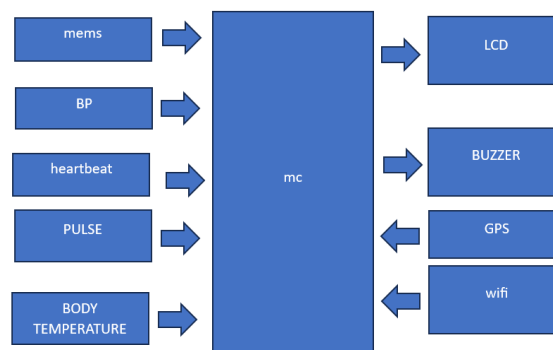




Fig1 .Block Diagram

At the core, IoT devices such as wearable sensors and medical devices continuously collect real-time health data, including heart rate, blood pressure, and glucose levels. This data is transmitted to a central processing unit, where autonomic and cognitive algorithms process and analyze the information. The system uses model-driven engineering to create dynamic models that automatically adapt to changing patient conditions and environmental factors. Cognitive capabilities allow the system to learn and make decisions, such as adjusting treatment plans or sending alerts based on predicted health risks. The system also includes cloud computing for data storage, analytics, and remote monitoring, enabling healthcare providers to access and act on real-time information. Edge computing might be used for low-latency processing, ensuring quick responses for critical healthcare needs. This architecture offers a scalable, adaptable, and intelligent solution for improving patient care and healthcare efficiency.

## **B) Proposed Raspberry pi**

The Raspberry Pi Pico is an affordable microcontroller board created by the Raspberry Pi Foundation. Unlike full-fledged

computers, microcontrollers are small and have limited storage and peripheral options, such as the absence of devices like monitors or keyboards. However, the Raspberry Pi Pico is equipped with General Purpose Input/Output (GPIO) pins, similar to the ones found on Raspberry Pi computers, allowing it to connect with and control a variety of electronic devices. Introduced in January 2021, the Raspberry Pi Pico is based on the RP2040 System on Chip (SoC), which is both cost-effective and highly efficient. The RP2040 SoC includes a dual-core ARM Cortex-M0+ processor that is well-known for its low power consumption. The Raspberry Pi Pico is compact, versatile, and performs efficiently, with the RP2040 chip as its core. It can be programmed using either Micro Python or C, providing a flexible platform for users of various experience levels. The board contains several important components, including the RP2040 microcontroller, debugging pins, flash memory, a boot selection button, a programmable LED, a USB port, and a power pin. The RP2040 microcontroller, custom-built by the Raspberry Pi Foundation, is a powerful and affordable processor. It features a dual-core ARM Cortex-M0+ processor running at 133 MHz, 264 KB of internal RAM, and supports



up to 16 MB of flash memory. The microcontroller provides a wide range of input/output options, such as I2C, SPI, and GPIO. The Raspberry Pi Pico has 40 pins, including ground (GND) and power (Vcc) pins. These pins are grouped into categories such as Power, Ground, UART, GPIO, PWM, ADC, SPI, I2C, System Control, and Debugging. Unlike the Raspberry Pi computers, the GPIO pins on the Pico can serve multiple functions. For instance, the GP4 and GP5 pins can be set up for digital input/output, or as I2C1 (SDA and SCK) or UART1 (Rx and Tx), though only one function can be used at a time.

### **C) Design Process**

The design of embedded systems follows a methodical, data-driven process that requires precise planning and execution. One of the core elements of this approach is the clear separation between functionality and architecture, which is crucial for moving from the initial concept to the final implementation. In recent years, hardware-software (HW/SW) co-design has gained significant attention, becoming a prominent focus in both academia and industry. This methodology aims to align the development of software and hardware components, addressing the integration challenges that

have historically affected the electronics field. For large-scale embedded systems, it is essential to account for concurrency at all levels of abstraction, impacting both hardware and software components. To facilitate this, formal models and transformations are employed throughout the design cycle, ensuring efficient verification and synthesis. Simulation tools are vital for exploring design alternatives and confirming the functional and timing behavior of the system. Hardware can be simulated at different stages, including the electrical circuit, logic gate, or RTL level, often using languages like VHDL. In certain setups, software development tools are integrated with hardware simulators, while in other cases, software runs on the simulated hardware. This method is generally more suited for smaller parts of an embedded system. A practical example of this methodology is the design process using Intel's 80C188EB chip. To reduce complexity and manage the design more effectively, the process is typically divided into four main phases: specification, system synthesis, implementation synthesis, and performance evaluation of the prototype.

### **APPLICATIONS**

Embedded systems are being increasingly

incorporated into a wide range of consumer products, such as robotic toys, electronic pets, smart vehicles, and connected home appliances. Leading toy manufacturers have introduced interactive toys designed to create lasting relationships with users, like "Furby" and "AIBO." Furbies mimic a human-like life cycle, starting as babies and growing into adults. "AIBO," which stands for Artificial Intelligence Robot, is an advanced robotic dog with a variety of sophisticated features. In the automotive sector, embedded systems, commonly referred to as telematics systems, are integrated into vehicles to offer services like navigation, security, communication, and entertainment, typically powered by GPS and satellite technology. The use of embedded systems is also expanding in home appliances. For example, LG's DIOS refrigerator allows users to browse the internet, check emails, make video calls, and watch TV. IBM is also developing an air conditioner that can be controlled remotely via the internet. Given the widespread adoption of embedded systems across various industries.

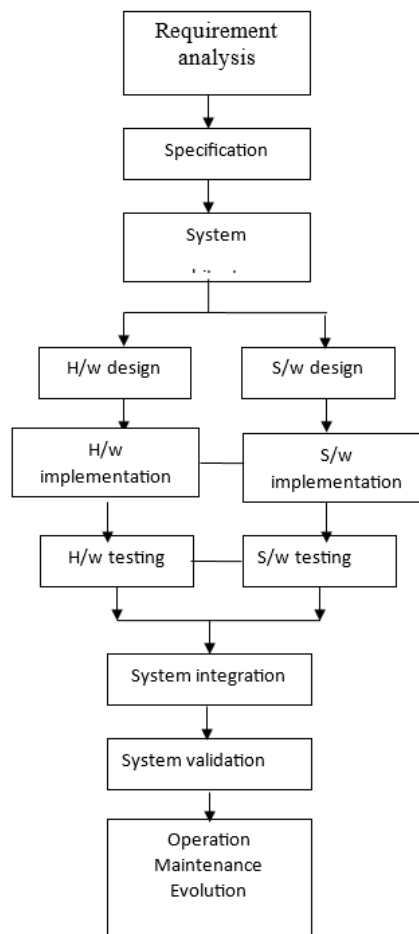


Fig 2. Embedded Development Life Cycle

### III.CONCLUSION

The numbers of patients are nearly doubled in every four decades, and it is difficult for hospital to taking care of all these patients. This healthcare system works on real time and if any abnormality occurs, then it immediately put an alarm and simultaneously sends a message to doctor within a minute. Hence, we can avoid a critical situations and able to provide a treatment at time. The main



purpose to develop such a system is to diminished health care overheads and also offers a system which detects abnormalities in seconds. The major advantage of this system, compare to earlier system is to reduce the electricity consumptions, a long lifetime, Increase the speed and enhance the communication coverage area. This healthcare monitoring system can be easily introduced in hospitals, clinics, houses. With the help of IoT huge data can be stored at cloud database. This system is decreases the patients visit to hospital for consistent routine check-ups. Accordingly, this system provides a quality of life to patients.

#### IV.FUTURE SCOPE

The future scope of a model-driven methodology for designing autonomic and cognitive IoT-based systems in healthcare lies in enhancing personalized care through advanced AI and machine learning algorithms, enabling more accurate predictions and tailored treatments. Integration with 5G networks will enable faster, real-time data transfer for continuous monitoring and instant decision-making. The system could also incorporate predictive analytics for proactive health management, identifying risks before they manifest.

Furthermore, edge computing will allow for even more localized processing, reducing latency and improving the efficiency of critical care decisions. As healthcare systems become more interconnected, these IoT-based systems could support collaborative care among multiple healthcare providers, offering seamless integration with electronic health records (EHR) and enabling more holistic, patient-centric solutions.

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