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**Internet of Things Module Assignment**

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Student Declaration:

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| --- | --- |
| I confirm that I have read and understood the University Policy and Procedures  on Academic Misconduct and that the work submitted is my own. |  |
| I confirm that I have processed and produced this submission in accordance with the University guidelines and the assessment brief regarding the use of generative AI. Where appropriate, I have acknowledged where and how it has been used.  OR  Where generative AI is not permitted in this assignment. I confirm that it has not been used in any part of the process or production of this submission  <https://www.yorksj.ac.uk/policies-and-documents/generative-artificial-intelligence/> |  |

**THE UTILIZATION OF INTERNET OF THINGS (IOT) INNOVATIONS TO TRANSFORM AND ENHANCE HEALTHCARE SERVICES.**

**Abstract**

The Internet of Things (IoT) is at high speed for revolutionizing various industries, including healthcare sectors. This research paper provides an in-depth analysis of the current landscape of Internet of Things (IoT) technology in healthcare, revealing a pressing need for its rapid integration to improve healthcare outcomes. As technology advances rapidly and the demand for efficient, cost-effective healthcare services grows, IoT presents numerous opportunities to enhance patient care, optimise operations, and improve healthcare delivery. We get high-level overview of IoT architecture key drivers, challenges, and potential applications in healthcare, providing a comprehensive understanding of its significance and the urgency for its integration.

**I. Introduction**

The healthcare sector has consistently struggled with rising expenses, limited resources, and the necessity for better patient outcomes. The Internet of Things (IoT) offers a robust solution to these challenges by enabling stressless connectivity, data sharing, and real-time monitoring across various healthcare fields. IoT technologies, including remote patient monitoring, predictive analytics, and intelligent hospital infrastructure, can revolutionize healthcare services. (Aceto et al., 2020).

This review paper delves into the critical need for IoT adoption in the healthcare industry, exploring the key drivers, challenges, and potential applications. By reviewing the current state of the art and future prospects, we aim to provide a detailed insight into the crucial need for integrating IoT solutions into healthcare, highlighting its significance and urgency.

**II. Drivers for IoT Adoption in Healthcare**

There are various factors driving the need for IoT enquiry in the healthcare sector:

**A. Aging Population and Chronic Disease Management**

As the world's population ages, the incidence of chronic illnesses such as heart disease, diabetes, and respiratory conditions is increasing. IoT-enabled remote patient monitoring systems can continuously track vital signs, ensure medication compliance, and detect potential health issues early. This allows for prompt interventions and helps reduce the pressure on healthcare facilities. The ageing population’s growing demand for long-term care has created a pressing need for innovative solutions. IoT-based devices offer essential monitoring capabilities, empowering elderly individuals to maintain their independence, ensuring their safety, and elevating their quality of life.

IoT technologies provide ongoing monitoring for patients with chronic conditions like diabetes and heart disease, allowing for more effective management, prompt interventions, and reduced healthcare expenses related to chronic care.

**B. Demand for Personalized Healthcare**

Patients increasingly expect personalised and proactive healthcare services tailored to their specific needs. IoT technologies, coupled with advanced analytics, can collect and analyse data tailored to individual patients, aiding in developing personalised treatment plans and improving overall patient outcomes. IoT technology optimises hospital operations by automating key processes, including inventory management, bed allocation, patient flow. And scheduling, thereby eliminating waste and enhancing efficiency. Moreover, IoT enabled devices facilitate remote patient monitoring, enabling individuals to receive care in the comfort of their own homes, reducing the necessity for hospital visits and admissions. This, in turn, leads to significant cost savings, optimized resources allocation, and a reduction in hospital readmissions, as continuous remote care minimizes the risk of complications and associated costs.

1. **Cost Reduction and Operational Efficiency**

Healthcare organizations are under constant pressure to reduce costs while maintaining high-quality services. IoT solutions can streamline operational processes, optimize resource utilization and reduce unnecessary hospital admissions and readmissions, resulting in significant cost savings. There is a surging demand for personalized healthcare, driven by the need for medical care that is more targeted, effective, and patient-focused. This approach, also known as precision medicine considers a person’s distinct characteristics, including their genetic profile, lifestyle, environmental factors, and health information, to deliver tailored treatments and interventions that address their unique needs.

IoT technology can optimize hospital operations by automating tasks such as inventory management, patient flow, and scheduling, thereby minimizing waste and inefficiencies. Additionally, IoT enabled remote monitoring devices allow patients to receive care from the comfort of their own homes, reducing the need for hospital visits and admissions. This is not only leads to significant cost savings but also enables healthcare resources to be allocated more efficiently. Furthermore, continuous remote care through IoT reduces the likelihood of complications, resulting in fewer hospital readmissions and associated costs.

**III. The demand and Contemplation**

While IoT offers numerous benefits to the healthcare sector, its adoption is not without challenges:

**A. Data Privacy and Security**

The healthcare sector requires stringent data privacy and security measures, as personal and medical information are extremely sensitive and vulnerable to exploitation. The execution of Internet of Things (IoT) technologies in the healthcare sector necessitates robust security measures and strict compliance with relevant regulations to safeguard patient information.

Compliance with the Health Insurance Portability and Accountability Act (HIPAA) is essential for IoT implementations in the healthcare sector. HIPAA establishes rigorous criteria for safeguarding the confidentiality, integrity, and accessibility of electronic protected health information (ePHI). Non-compliance with HIPAA regulations can lead to significant penalties and legal repercussions. Healthcare entities should enforce comprehensive security protocols, including encryption, authentication, and access controls to safeguard data privacy and security. Encrypted communication channels and secure data storage mechanisms are essential to prevent unauthorized access and data breaches. Additionally, The role-based access and multi-factor authentication, should be in place to restrict access to sensitive information only to authorized personnel.

Furthermore, conducting regular risk assessments, vulnerability testing, and security audits is crucial for identifying and mitigating potential vulnerabilities in IoT systems. Continuous monitoring and incident response plans should be established to detect and address security incidents swiftly, reducing the impact of data breaches or cyber-attacks.

Healthcare organizations need to prioritize employee training and awareness initiatives that educate them about best practices for handling sensitive data and identifying potential security risks. Collaboration between healthcare providers, technology vendors, and security experts is vital to ensure that IoT solutions are designed and implemented with robust security measures.

By prioritizing data privacy and security and adhering to relevant regulations like HIPAA, healthcare organizations can leverage the benefits of IoT technologies while maintaining the utmost protection for patient data and ensuring compliance with legal and ethical standards.

**B. Interoperability and Standards**

Efficient data exchange and collaboration within the healthcare ecosystem necessitate seamless integration and interoperability among IoT devices, systems, and platforms. Standardization initiatives and adherence to established protocols are critical for achieving this goal. protocols are necessary to ensure seamless connectivity and data sharing.

**C. Change Management and User Adoption**

Effective IoT adoption in healthcare requires strategic change management, user training, and support to overcome technological hurdles and ensure a smooth transition for healthcare providers and patients.

**IV. Potential Applications of Internet Of Things in the Healthcare Sector.**

The healthcare industry can benefit from Internet of Things technology in a wide range of significant ways, such as:

**A. Remote Patient Monitoring**

IoT-enabled wearable devices and sensors revolutionize healthcare sector by enabling continuous remote patient monitoring. Wearable IoT devices, equipped with cutting-edge technology, continuously track vital signs, physical activity, and other key health metrics, allowing for the prompt detection of potential health issues. By delivering real-time insights to healthcare providers, these devices facilitate proactive care and swift action, enhancing patient outcomes.

This approach can significantly improve patient outcomes by facilitating prompt medical attention. Moreover, remote monitoring can reduce hospital readmissions by identifying and addressing health concerns before they escalate, ultimately enhancing the overall quality of care. As the adoption of IoT in healthcare continues to grow, wearable devices and sensors unlock new possibilities for personalized, efficient, and patient-centric healthcare delivery. (Ray, 2021).

**B. Smart Hospital Infrastructure**

By leveraging IoT technologies, hospitals can achieve operational excellence through real-time tracking of assets, inventory, and environmental factors, as well as predictive maintenance. Furthermore, smart building automation and energy management systems can optimize resource utilization, reduce costs, and enhance the overall experience for patients and healthcare professionals.

**C. Predictive Analytics and Decision Support**

The incorporation of IoT technologies in healthcare produces a vast amount of data from diverse sources, including wearables, remote monitoring systems, and electronic health records. By leveraging advanced analytics and machine learning techniques, this data can be converted into valuable insights that enhance patient outcomes and optimize healthcare services. Predictive analytics play a crucial role in early disease detection by recognizing patterns and trends that signal potential health threats, enabling prompt interventions and preventative measures.

Machine learning algorithms analyse patient data, medical histories, and treatment outcomes to recommend personalized treatments tailored to individual needs and characteristics. Furthermore, these analytical tools aid in resource allocation optimization by analysing patient volumes, resource utilization, and operational metrics, guiding informed decisions on staffing, equipment procurement, and budgeting. As IoT adoption in healthcare continues to grow, leveraging data through advanced analytics and machine learning becomes increasingly crucial for delivering personalized, proactive, and efficient care, ultimately enhancing patient results and elevating the overall quality of healthcare services.

**D. Real-time Asset Monitoring and Supply Chain Visibility**

Implementing IoT technology for asset tracking and supply chain management can significantly improve inventory transparency, reduce losses, and guarantee the availability of critical medical supplies and equipment when needed, ultimately leading to improved operational efficiency and enhanced patient care (Haghi et al., 2017)"

**V. Conclusion**

The adoption of IoT in healthcare is both necessary and time-sensitive. IoT technologies offer a wealth of opportunities to enhance patient outcomes, streamline processes, and reduce expenses. Nevertheless, overcoming obstacles like data privacy, interoperability, and user adoption is essential for successful integration. By surmounting these challenges and leveraging IoT solutions, the healthcare industry can unlock the technology's full potential, leading to more tailored, accessible, and high-quality healthcare services.

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**PART TWO**

**AUTOMATIC TRAFFIC LIGHT CONTROL SYSTEM**

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1. **Introduction**

Automatic light control systems are commonly used to manage traffic flow at busy road junctions, but coordinating multiple traffic lights to ensure smooth traffic flow is a complex challenge due to various factors. Traditional systems struggle to adapt to changing traffic volumes and don't account for factors like interference between adjacent lights, emergency vehicle passage, and pedestrian crossings. As a result, these limitations often cause traffic congestion and jams.

The leads to traffic jam and congestion. Traffic congestion poses a significant challenge in urban environments, resulting in extended travel times, higher fuel consumption, and increased environmental pollution. Conventional traffic light systems follow fixed timing schedules, often proving inefficient and incapable of responding to real-time traffic conditions. This project seeks to create an intelligent traffic light control system that improve traffic flow by dynamically changing light timings according to real-time traffic data.

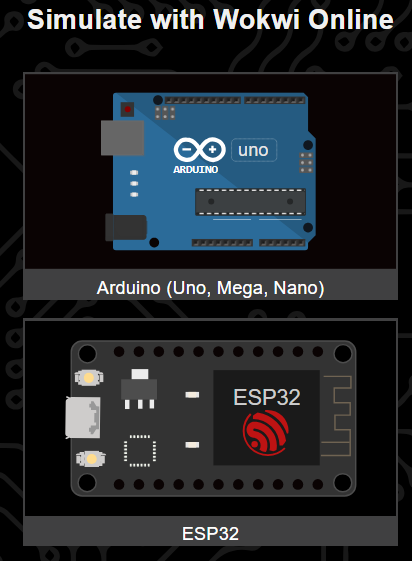
**II. System Overview**

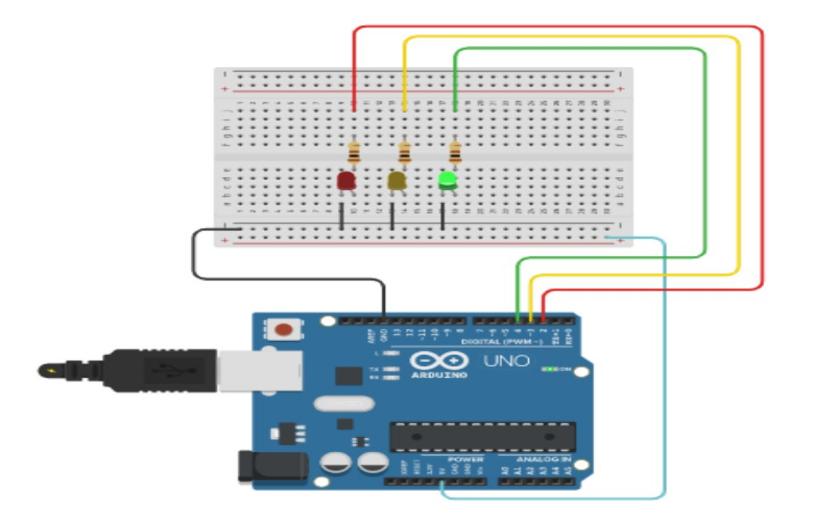
The intelligent traffic light control system includes of the following parts:

1. **Microcontroller Board**: An ESP32 board is the main control unit responsible for processing sensor data, implementing the traffic light control algorithm, and managing communication with other components.
2. **Traffic Light LEDs**: Red, yellow, and green LEDs simulate the traffic light signals.
3. **Infrared Sensors**: Infrared sensors are placed at each intersection to detect the presence and count of vehicles.
4. **Wi-Fi Module**: A Wi-Fi module is integrated to enable communication with a central traffic management system or for data transmission and remote monitoring.

**III. Wokwi Circuit Design**

The circuit design for the intelligent traffic light control system is created and simulated using the Wokwi online platform. The circuit diagram is shown below:





The ESP32 board is connected to the traffic light LEDs (red, yellow, and green) and two infrared sensors (one for each direction). The Wi-Fi module is also connected to the ESP32 board for communication purposes.

**IV. Software Implementation**

The intelligent traffic light control system software is developed using the Arduino programming language and uploaded to the ESP32 board through the Wokwi platform.

**A. Traffic Light Control Algorithm**

The traffic light control algorithm is implemented using a combination of timed delays and sensor data. The algorithm follows these steps:

1. Initialize the traffic light state to green in one direction and red in the other.
2. Continuously read the sensor data to detect the presence of vehicles.
3. If vehicles are detected in the current green direction, extend the green light duration by a predefined time interval.
4. If no vehicles are detected in the current green direction, switch the traffic light state to yellow and then red after a fixed delay.
5. Switch the traffic light state to green in the other direction and repeat the process.

**B. Wi-Fi Communication**

The Wi-Fi module transmits traffic data and receives commands from a central traffic management system or for remote monitoring purposes. The code includes functions to establish a Wi-Fi connection, send sensor data, and receive commands to override the traffic light timing if necessary.

**C. Code Implementation**

The complete code for the intelligent traffic light control system is provided below:

*// Include necessary libraries*

#include <WiFi.h>

*// Wi-Fi network credentials*

const char\* ssid = "YOUR\_WIFI\_SSID";

const char\* password = "YOUR\_WIFI\_PASSWORD";

*// Pin definitions*

const int redPin1 = 26;

const int yellowPin1 = 25;

const int greenPin1 = 33;

const int redPin2 = 32;

const int yellowPin2 = 35;

const int greenPin2 = 34;

const int sensorPin1 = 39;

const int sensorPin2 = 36;

*// Traffic light states*

bool trafficLight1 = true; *// true = green, false = red*

bool trafficLight2 = false;

*// Traffic data*

int vehicleCount1 = 0;

int vehicleCount2 = 0;

*// Timer variables*

unsigned long greenTimer1 = 0;

unsigned long greenTimer2 = 0;

const unsigned long greenDuration = 5000; *// 5 seconds*

const unsigned long yellowDuration = 3000; *// 3 seconds*

void setup() {

*// Initialize serial communication*

Serial.begin(115200);

*// Connect to Wi-Fi network*

WiFi.begin(ssid, password);

while (WiFi.status() != WL\_CONNECTED) {

delay(1000);

Serial.println("Connecting to WiFi...");

}

Serial.println("Connected to WiFi");

*// Initialize pin modes*

pinMode(redPin1, OUTPUT);

pinMode(yellowPin1, OUTPUT);

pinMode(greenPin1, OUTPUT);

pinMode(redPin2, OUTPUT);

pinMode(yellowPin2, OUTPUT);

pinMode(greenPin2, OUTPUT);

pinMode(sensorPin1, INPUT);

pinMode(sensorPin2, INPUT);

*// Set initial traffic light state*

updateTrafficLights();

}

void loop() {

*// Read sensor data*

vehicleCount1 = digitalRead(sensorPin1);

vehicleCount2 = digitalRead(sensorPin2);

*// Traffic light control logic*

if (trafficLight1) {

*// Green light for direction 1*

if (vehicleCount1) {

*// Extend green light duration if vehicles are detected*

greenTimer1 = millis();

} else if (millis() - greenTimer1 >= greenDuration) {

*// Switch to yellow light after green duration expires*

digitalWrite(greenPin1, LOW);

digitalWrite(yellowPin1, HIGH);

delay(yellowDuration);

digitalWrite(yellowPin1, LOW);

digitalWrite(redPin1, HIGH);

trafficLight1 = false;

trafficLight2 = true;

greenTimer2 = millis();

}

} else {

*// Red light for direction 1*

if (millis() - greenTimer2 >= greenDuration) {

*// Switch to yellow light after green duration expires*

digitalWrite(greenPin2, LOW);

digitalWrite(yellowPin2, HIGH);

delay(yellowDuration);

digitalWrite(yellowPin2, LOW);

digitalWrite(redPin2, HIGH);

trafficLight1 = true;

trafficLight2 = false;

greenTimer1 = millis();

}

}

*// Update traffic lights*

updateTrafficLights();

*// Transmit traffic data or receive commands over Wi-Fi (implementation not shown)*

*// ...*

delay(100); *// Adjust delay as needed*

}

void updateTrafficLights() {

if (trafficLight1) {

digitalWrite(redPin1, LOW);

digitalWrite(greenPin1, HIGH);

digitalWrite(redPin2, HIGH);

digitalWrite(greenPin2, LOW);

} else {

digitalWrite(redPin1, HIGH);

digitalWrite(greenPin1, LOW);

digitalWrite(redPin2, LOW);

digitalWrite(greenPin2, HIGH);

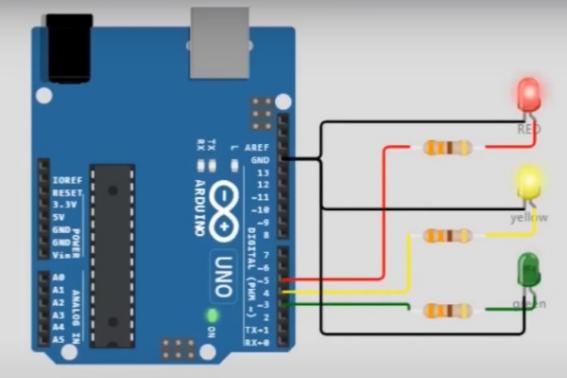
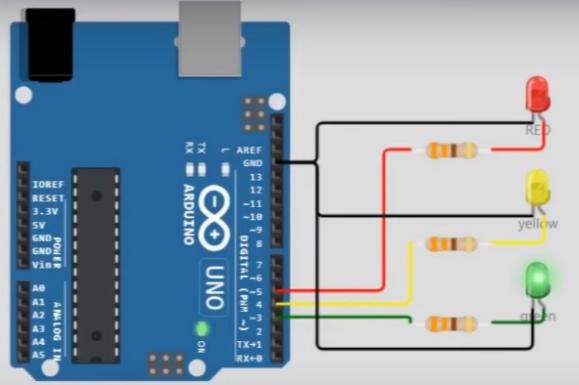
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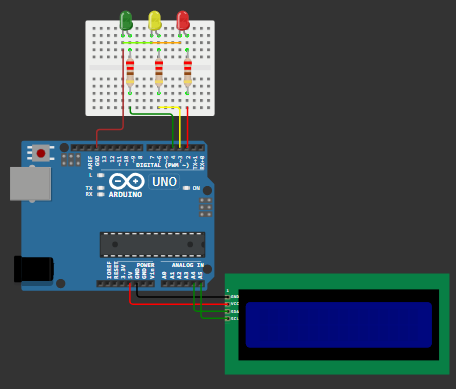
}

**V. Simulation Results**

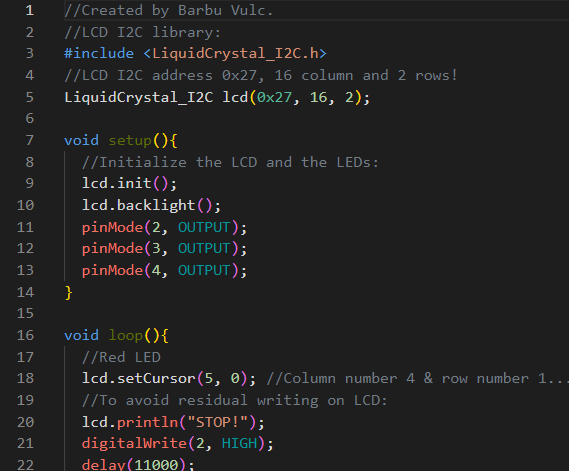
The intelligent traffic light control system was successfully simulated using the Wokwi platform. The simulation results demonstrated the system's ability to adapt traffic light timing based on real-time traffic data.

The following pictures shows the simulation in action, with the traffic lights adjusting their timing according to the detected vehicle presence:



**CODES**



In the simulation, vehicles are represented by infrared sensor readings. When a car is detected, the duration of the green light is extended. If no vehicles are detected, the traffic light switches to another direction after a fixed duration.

**VI. Conclusion**

The intelligent traffic light control system designed and simulated using Wokwi display the prospective of IoT solutions in enhancing traffic flow and reducing congestion. This innovative system to make use of the power of real-time data or engages the effective of the traffic light timing adjustments to revolutionize traffic management efficiency.

The Wokwi platform played a crucial role in developing and testing this system, providing a virtual environment for iterative design, simulation, and refinement without the initial need for physical hardware. This approach enabled rapid prototyping, debugging, and system optimization before real-world deployment.

At its core, the system integrates IoT technologies and data-driven decision-making. Strategically placed sensors at critical intersections collect real-time data on traffic flow, vehicle density, and congestion patterns. This data is then processed and analyzed to adjust the timing of traffic lights dynamically, ensuring optimized vehicle flow and minimized bottlenecks.

One of the key advantages of this system is its ability to adapt to changing traffic conditions in real time. Unlike traditional traffic light control systems with predetermined timing schedules, this intelligent solution continuously monitors and responds to the ever-changing traffic dynamics. If a particular intersection experiences an unexpected surge in vehicle density, the system can immediately adjust the traffic light timing to alleviate congestion and facilitate smoother traffic flow.

The Wokwi simulation environment enabled developers to experiment with various scenarios and fine-tune the system's algorithms and parameters. Potential issues were identified by simulating different traffic patterns, road layouts, and sensor configurations, and the system's performance was optimized before deployment.

Future enhancements could include integrating the system with a central traffic management system for coordinated traffic management across multiple intersections and cities. Additionally, incorporating machine learning algorithms could enable the system to learn from historical traffic patterns and make more accurate predictions, leading to more efficient traffic management.

Furthermore, integrating additional sensors for pedestrian detection and prioritization of emergency vehicles could enhance the system's capabilities. By detecting pedestrians at crosswalks, the system could adjust traffic light timing to prioritize their safe passage. Similarly, detecting and prioritizing emergency vehicles could ensure their unimpeded passage through congested areas, potentially saving lives.

The intelligent traffic light control system represents a significant step forward in IoT-enabled traffic management solutions. By leveraging real-time data, dynamic decision-making, and the power of simulation and prototyping, this system holds the potential to revolutionize traffic optimization and congestion reduction, ensuring efficient and sustainable urban mobility.

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