**SMART PUBLIC RESTROOM**

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**Abstract:**

Public restrooms play a crucial role in urban infrastructure, offering convenience and hygiene to millions of people every day. However, traditional public restrooms often face challenges related to cleanliness, maintenance, and user experience. To address these issues, a smart public restroom module has been developed, integrating various technological advancements to create a more efficient, user-friendly, and hygienic facility.

The smart public restroom module is a modular system that can be incorporated into existing restroom structures or serve as the foundation for new construction. It consists of several key components:

1. **Sensory Automation Module:** This module incorporates occupancy sensors, touchless fixtures, and real-time monitoring systems. Occupancy sensors enable efficient resource allocation and cleaning schedules, while touchless fixtures, including faucets, soap dispensers, and toilets, enhance hygiene by minimizing physical contact. Real-time monitoring ensures that restroom supplies are adequately stocked and alerts maintenance staff to any issues.
2. **Climate and Energy Management Module:**

This module optimizes the restroom environment for users. It includes climate control systems that adjust temperature and ventilation based on occupancy and environmental conditions, enhancing comfort and energy efficiency. Energy-efficient lighting and fixtures reduce power consumption.

1. **Accessibility and Aesthetic Module:** Ensuring accessibility for all users is a priority. This module integrates features such as ramps, grab bars, and spacious stalls, making the restroom inclusive for individuals with disabilities. Aesthetic design elements provide a modern and inviting atmosphere.
2. **Connectivity Module:** To cater to the needs of the digital age, the smart restroom offers Wi-Fi connectivity and charging stations, enhancing user convenience. QR code access or mobile apps grant users entry without the need for physical tokens or keys.
3. **Maintenance and Feedback Module:** Sensors in the restroom can detect when cleaning and maintenance are required, automatically alerting maintenance staff. Users can provide feedback on cleanliness and overall condition via a mobile app or touchscreen kiosk, enabling continuous improvement.
4. **Water and Waste Management Module:** For sustainability, this module features water-conserving fixtures and efficient waste management systems to reduce environmental impact.

The smart public restroom module redefines the concept of public restrooms, transforming them into efficient, user-friendly, and sustainable facilities. Its modular design allows for easy integration into existing infrastructure, helping cities and municipalities address the challenges of maintaining clean, accessible, and technologically advanced public restrooms. The system not only enhances the user experience but also contributes to overall public hygiene and environmental conservation.

**Hardware Components:**

1. **Arduino Board** e.g., Arduino Uno
2. **IoT Module** e.g., ESP8266
3. **Sensors** (PIR motion sensors, ultrasonic sensors, water flow sensors, air quality sensors, etc.)
4. **Actuators** (solenoid valves for water control, servos for doors, LED displays)
5. **Relays** (for controlling high-power devices)
6. **Feedback Mechanisms** (LED displays, buzzers, or LCD screens for user interaction)
7. **Power Supply** (batteries or external power sources)

ARDUINO WITH IoT PROGRAM :

#include <Arduino.h>

#include <WiFiClientSecure.h>

#include <ESP8266WiFi.h>

#include <Adafruit\_Sensor.h>

#include <Adafruit\_DHT.h>

// Define your Wi-Fi credentials and server details

const char\* ssid = "YourWiFiSSID";

const char\* password = "YourWiFiPassword";

const char\* server = "your-iot-server.com";

const int port = 443;

// Create a client instance

WiFiClientSecure client;

// Define sensor pins

const int motionSensorPin = 2; // PIR motion sensor pin

const int doorControlPin = 3; // Door servo control pin

const int waterValvePin = 4; // Solenoid valve control pin

const int feedbackLED = 5; // LED display or feedback indicator

// Define sensor variables

bool isRestroomOccupied = false;

// Door servo control variables

const int doorClosedPosition = 0;

const int doorOpenPosition = 90;

// Initialize the DHT sensor

#define DHTPIN 6

#define DHTTYPE DHT22

DHT dht(DHTPIN, DHTTYPE);

void setup() {

// Initialize sensors and actuators

pinMode(motionSensorPin, INPUT);

pinMode(doorControlPin, OUTPUT);

pinMode(waterValvePin, OUTPUT);

pinMode(feedbackLED, OUTPUT);

// Connect to Wi-Fi

WiFi.begin(ssid, password);

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

delay(1000);

}

// Start DHT sensor

dht.begin();

// Connect to the IoT server

if (!client.connect(server, port)) {

// Handle connection error

Serial.println("Connection failed");

}

}

void loop() {

// Check occupancy status

int motionSensorValue = digitalRead(motionSensorPin);

if (motionSensorValue == HIGH) {

isRestroomOccupied = true;

digitalWrite(feedbackLED, HIGH);

} else {

isRestroomOccupied = false;

digitalWrite(feedbackLED, LOW);

}

// Control the door

if (isRestroomOccupied) {

openDoor();

} else {

closeDoor();

}

// Read temperature and humidity

float temperature = dht.readTemperature();

float humidity = dht.readHumidity();

// Send data to the IoT server

sendSensorData(temperature, humidity);

// Other actions and controls can be added here

// e.g., water flow control, air quality monitoring, etc.

delay(1000); // Add delay to avoid rapid sensor readings

}

void openDoor() {

// Control the door servo to open the restroom door

// You'll need to adjust this based on your servo and mechanism

// You may also want to implement safety checks

// (e.g., avoid opening when someone is near the door)

// and set a time limit for the door to remain open.

// Here, we assume a simple door servo control.

digitalWrite(doorControlPin, doorOpenPosition);

}

void closeDoor() {

// Control the door servo to close the restroom door

digitalWrite(doorControlPin, doorClosedPosition);

}

void sendSensorData(float temperature, float humidity) {

// Create a JSON payload with sensor data

String payload = "{\"temperature\":" + String(temperature) +

",\"humidity\":" + String(humidity) +

",\"occupied\":" + String(isRestroomOccupied) + "}";

// Send data to the IoT server

client.print(String("POST /your-api-endpoint HTTP/1.1\r\n") +

"Host: " + server + "\r\n" +

"Content-Type: application/json\r\n" +

"Content-Length: " + payload.length() + "\r\n" +

"\r\n" + payload);

// Wait for server response (optional)

while (client.connected()) {

if (client.available()) {

char c = client.read();

// Process server response if needed

}

}

// Disconnect from the server

client.stop();

}

Concept

1. **Occupancy Monitoring**: IoT sensors can be used to monitor the occupancy of restroom stalls. Real-time data can be provided to users through mobile apps or digital signage, allowing them to find available facilities quickly, reducing wait times.
2. **Touchless Fixtures**: To promote hygiene and reduce the spread of germs, smart restrooms can feature touchless fixtures such as sensor-operated faucets, soap dispensers, hand dryers, and toilet flush mechanisms.
3. **Environment Monitoring**: Sensors can monitor environmental conditions within the restroom, including temperature, humidity, and air quality. This data can be used to ensure user comfort and cleanliness.
4. **Water and Energy Efficiency**: IoT systems can help optimize water and energy usage in restrooms. For example, water-saving toilets and urinals can be integrated with sensors to reduce water consumption. Lights and ventilation can be automated based on occupancy and environmental conditions to save energy.
5. **Predictive Maintenance**: IoT sensors can monitor the condition of restroom equipment, such as plumbing systems, hand dryers, and fixtures. Predictive maintenance algorithms can predict when maintenance is needed, reducing downtime and ensuring reliable operation.
6. **User Interfaces**: Smart public restrooms can provide user-friendly interfaces, such as interactive displays or smartphone apps. Users can access information on restroom availability, cleanliness ratings, and even provide feedback.
7. **Security and Safety**: IoT devices can enhance security and safety in public restrooms. Surveillance cameras can monitor for vandalism or emergencies, and smart locks can control access to maintain safety.
8. **Accessibility**: Smart restrooms can include features to make them more accessible to individuals with disabilities, such as audio cues, voice-activated controls, and adjustable fixtures.
9. **Maintenance Management**: IoT data can be used to create maintenance schedules and prioritize tasks. Maintenance staff can be alerted to issues in real time, ensuring a clean and functional restroom.
10. **Data Analytics**: Collected data can be analyzed to improve restroom operations. Insights can be gained on peak usage times, resource consumption, and user satisfaction, allowing for continuous improvement.
11. **Cloud Integration**: Data from IoT devices can be sent to the cloud for storage and analysis. This enables remote monitoring, data access, and the potential for third-party services and applications to interact with the restroom's systems.

PYTHON PROGRAM

import random

class Restroom:

def \_\_init\_\_(self):

self.occupied = False

self.toilet\_paper = 100 # Initial toilet paper supply

self.soap = 100 # Initial soap supply

self.hand\_dryer = True

self.cleanliness = 100 # Initial cleanliness level

def is\_occupied(self):

return self.occupied

def enter(self):

if not self.occupied:

self.occupied = True

print("You've entered the restroom.")

def exit(self):

if self.occupied:

self.occupied = False

print("You've exited the restroom.")

def use\_toilet(self):

if self.occupied:

print("You've used the toilet.")

self.toilet\_paper -= 1

self.cleanliness -= random.randint(5, 10)

else:

print("Restroom is unoccupied.")

def wash\_hands(self):

if self.occupied:

print("You've washed your hands.")

self.soap -= 1

self.cleanliness += random.randint(10, 20)

else:

print("Restroom is unoccupied.")

def notify\_maintenance(self):

if self.cleanliness < 50 or self.toilet\_paper <= 10:

print("Maintenance needed. Restroom is not in optimal condition.")

else:

print("Restroom is in good condition.")

if \_\_name\_\_ == "\_\_main\_\_":

restroom = Restroom()

while True:

print("\nOptions:")

print("1. Enter restroom")

print("2. Exit restroom")

print("3. Use toilet")

print("4. Wash hands")

print("5. Check restroom condition")

print("6. Exit program")

choice = input("Enter your choice: ")

if choice == '1':

restroom.enter()

elif choice == '2':

restroom.exit()

elif choice == '3':

restroom.use\_toilet()

elif choice == '4':

restroom.wash\_hands()

elif choice == '5':

restroom.notify\_maintenance()

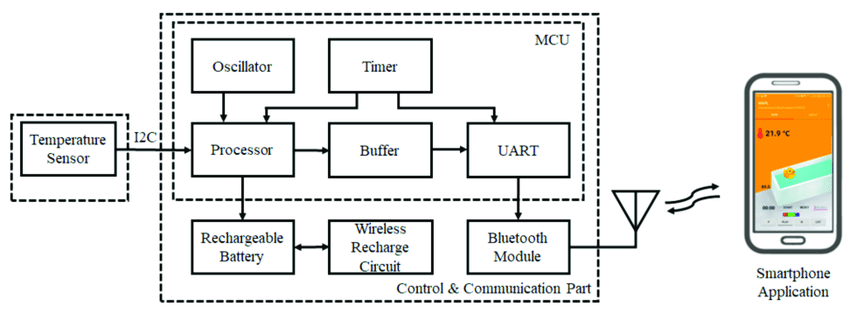
elif choice == '6':

print("Exiting program.")

break

else:

print("Invalid choice. Please select a valid option.")



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"\r\n" + payload);

// Wait for server response (optional)

while (client.connected()) {

if (client.available()) {

char c = client.read();

// Process server response if needed

}

}

// Disconnect from the server

client.stop();

}

Advantage

1. **Improved Hygiene and Sanitation**:
   * Touchless fixtures and controls reduce the spread of germs, promoting better hygiene.
   * Automatic flush systems and faucets help maintain cleaner restroom conditions.
2. **Enhanced User Experience**:
   * Real-time occupancy monitoring helps users find available facilities quickly, reducing wait times.
   * User-friendly interfaces provide information on restroom availability and cleanliness ratings, enhancing user satisfaction.
3. **Resource Efficiency**:
   * Water and energy management systems optimize resource usage, leading to cost savings and environmental benefits.
   * Lights and ventilation can be automatically adjusted based on occupancy, reducing unnecessary energy consumption.
4. **Predictive Maintenance**:
   * IoT sensors and algorithms predict when equipment needs maintenance, reducing downtime and ensuring reliable operation.
   * Maintenance can be proactive, addressing issues before they become significant problems.
5. **Accessibility**:
   * Smart public restrooms can include features to make them more accessible for people with disabilities, enhancing inclusivity and compliance with regulations.
6. **Security and Safety**:
   * Surveillance cameras and smart locks enhance security and safety in restrooms.
   * Emergency alerts and monitoring systems can respond to incidents promptly.
7. **Data-Driven Insights**:
   * Collected data can provide insights into peak usage times, resource consumption, and user behavior.
   * Facility operators can use these insights to make data-driven decisions and improve operations.
8. **Remote Monitoring and Control**:
   * IoT devices allow remote monitoring and control of restroom systems, enabling proactive management and issue resolution.
9. **Maintenance Cost Reduction**:
   * Predictive maintenance and remote monitoring can reduce the overall maintenance costs by preventing equipment failures and addressing issues efficiently.
10. **Sustainability**:
    * Smart public restrooms contribute to sustainability by reducing water and energy consumption and minimizing waste.
    * This aligns with environmental goals and regulations, promoting responsible resource usage.
11. **User Feedback and Engagement**:
    * IoT technology can facilitate user feedback and engagement through digital interfaces.
    * Users can provide feedback on cleanliness and satisfaction, enabling continuous improvement.
12. **Cloud Integration**:
    * Data collected from IoT devices can be sent to the cloud for storage and analysis.
    * Cloud integration enables remote access to data, reporting, and potential third-party services.

Disadvantage

1. **Initial Cost**: Implementing IoT technology in public restrooms involves upfront costs for purchasing and installing sensors, devices, and the necessary infrastructure. This initial investment can be a barrier for some organizations.
2. **Maintenance and Upkeep**: IoT devices require regular maintenance and software updates to ensure they function correctly. If not properly maintained, they can lead to increased maintenance costs and downtime.
3. **Data Privacy and Security**: Collecting data from public restrooms raises concerns about privacy and security. Ensuring that user data is protected and not misused is crucial. Unauthorized access to restroom cameras or data can be a significant issue.
4. **User Acceptance**: Some users may be uncomfortable with the level of technology in public restrooms, especially regarding occupancy monitoring and surveillance cameras. Addressing user concerns and ensuring their acceptance of the technology is essential.
5. **Dependency on Technology**: Public restrooms heavily reliant on IoT technology may face issues in case of system failures, network outages, or power disruptions. It's important to have backup systems in place to ensure restroom functionality.
6. **Complexity**: Smart public restrooms with IoT technology can be more complex to manage and operate. Facility staff need to be trained to handle the technology and troubleshoot issues effectively.
7. **Integration Challenges**: Integrating different IoT devices and systems into a coherent and reliable ecosystem can be challenging. Compatibility issues between various components may arise.
8. **Power Consumption**: While some IoT devices are designed to be energy-efficient, the cumulative power consumption of multiple sensors, displays, and communication devices can still be significant.
9. **Environmental Impact**: The production and disposal of IoT devices and electronics can have environmental consequences. Managing e-waste responsibly is essential.
10. **Regulatory Compliance**: Smart public restrooms may need to comply with various regulations related to data privacy, accessibility, and environmental standards. Ensuring compliance can be complex.
11. **Vandalism and Theft**: IoT devices in public restrooms can be vulnerable to vandalism or theft, leading to repair or replacement costs.
12. **Technical Issues**: Like any technology, IoT systems can experience technical issues, bugs, or malfunctions, leading to disruptions in service and user dissatisfaction.
13. **Cost of Connectivity**: IoT devices require a reliable internet connection. The cost of connectivity, especially in remote or low-coverage areas, can be a drawback.

conclusion

In conclusion, the concept of smart public restrooms with IoT integration presents a promising solution for improving the user experience, operational efficiency, and sustainability of public restroom facilities. While it offers numerous advantages, such as enhanced hygiene, real-time occupancy monitoring, resource efficiency, and data-driven insights, there are also challenges and potential disadvantages to consider.

The successful implementation of smart public restrooms requires careful planning, addressing issues like initial costs, maintenance, data privacy, user acceptance, and regulatory compliance. Organizations must also prioritize security, backup systems, and regular maintenance to ensure the technology functions as intended and doesn't compromise user safety or privacy.

Overall, smart public restrooms with IoT technology have the potential to provide cleaner, more user-friendly, and sustainable facilities, benefiting both facility operators and users. By embracing this concept and addressing its challenges, organizations can create a more efficient and responsive restroom experience, contributing to a higher standard of public hygiene and comfort.

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