Final Project Report on

Agri-Tech Innovation: A Simulated IoT-Based Smart Humidity and Mold Prevention System

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Abstract

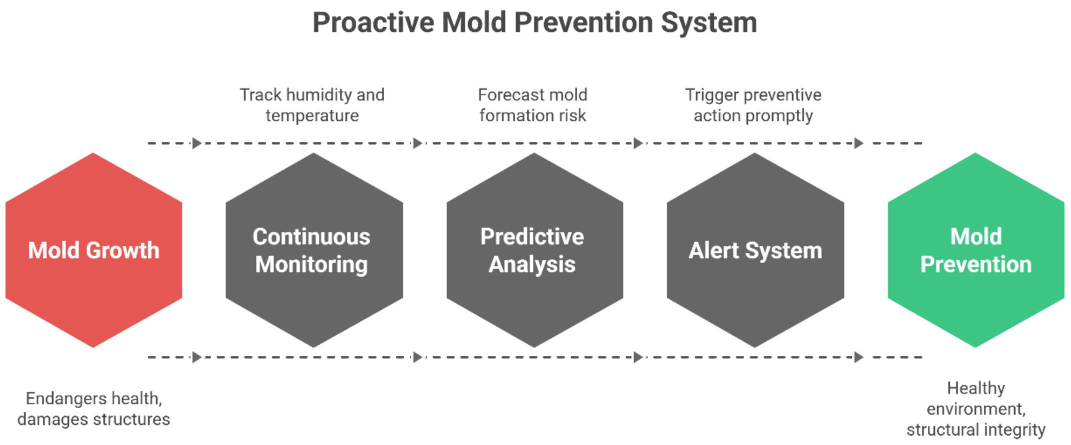
This report details the design, implementation, and verification of a proof-of-concept (PoC) simulation for a **Smart Humidity and Mold Prevention System**. Building on earlier research into IoT-enabled intelligent buildings, the project targets a high-impact application: **mitigating health risks and structural damage caused by persistent indoor humidity**—a challenge particularly relevant in climates such as Varanasi.

The system employs a distributed network of simulated sensors, a central data-processing engine with a predictive risk algorithm, and a real-time monitoring dashboard. Communication relies on the **MQTT protocol**, demonstrating a robust, scalable architecture suited to advanced IoT networks and smart-building deployments.

1 Introduction

The rapid growth of the Internet of Things (IoT) has enabled intelligent environments that can sense, analyze, and act on real-world data. Our initial proposal explored broad Agri-Tech integration within smart buildings.
This project refines that vision into a focused system addressing a critical problem: **the detection and prevention of mold growth**.

Mold endangers human health and compromises structural integrity. Because mold thrives under sustained high humidity and moderate temperatures, traditional remediation is often **reactive**. We instead propose a **proactive networked solution** that continuously monitors conditions, predicts mold formation risk, and issues alerts to trigger preventive action.


Proactive Mold Prevention System
Track humidity and temperature
Forecast mold formation risk
Trigger preventive action promptly
Mold Growth
Continuous Monitoring
Predictive Analysis
Alert System
Mold Prevention
Endangers health, damages structures
Healthy environment, structural integrity

2 System Architecture

The design follows a **multi-layered IoT architecture** for modularity and scalability. Core communication uses **MQTT**, a lightweight publish/subscribe protocol ideal for low-bandwidth or high-latency networks.

Layer	Functionality	Implementation
Sensing	Simulated nodes publish temperature and humidity readings for high-risk areas (bathroom, basement, kitchen).	sensor_node.py publishes JSON messages to topics
Communication	Transports data from sensors to processing engine.	Public MQTT broker (test.mosquitto.org) used for PoC.
Processing & Analytics	Ingests data and calculates a **Mold Risk Score**.	prevention_system.py maintains state and runs the risk algorithm.
Visualization & Application	Human–computer interface for real-time monitoring.	dashboard_app.py (Flask + Socket.IO) with a live web UI (index.html).

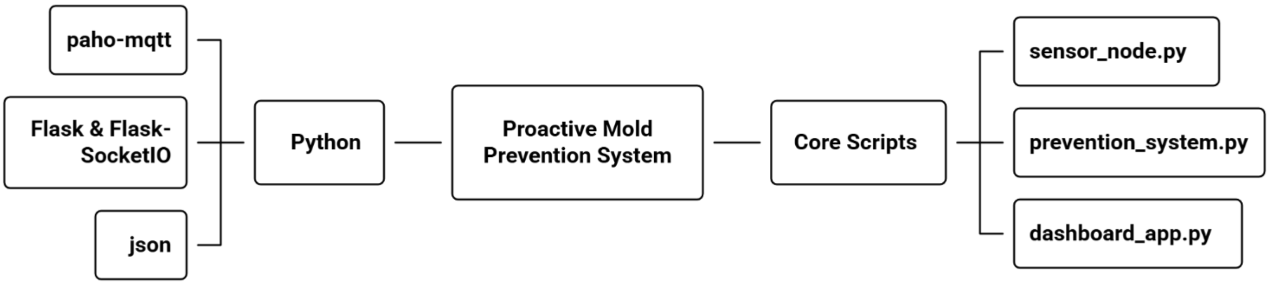
3 Implementation Details

The entire PoC is written in **Python**, using:

- **paho-mqtt** – MQTT publish/subscribe client.
- **Flask & Flask-SocketIO** – micro-web framework and real-time push channel.
- **json** – lightweight serialization of sensor messages.

Three core scripts run concurrently:

1. sensor_node.py – generates and publishes data.
2. prevention_system.py – subscribes and applies the predictive algorithm.
3. dashboard_app.py – serves a real-time dashboard via WebSocket.



4 Predictive Mold-Risk Algorithm

To move beyond simple threshold alerts, a **stateful scoring model** was developed:

- **State Maintenance** – Each room has a risk_score (initially 0).
- **Risk Conditions** –
  - HUMIDITY_THRESHOLD = 70 % RH
  - TEMP_THRESHOLD = 20 °C
- **Dynamic Scoring** –
  - If both thresholds are exceeded, increment the room’s score.
  - Otherwise, decrement the score gradually to simulate drying.
- **Action Trigger** – When a room’s score surpasses a configurable RISK_ACTION_THRESHOLD (e.g., 80), a **high-priority alert** is issued to activate ventilation or a dehumidifier.

This cumulative, time-aware approach reflects real mold-growth dynamics better than a simple on/off alarm.

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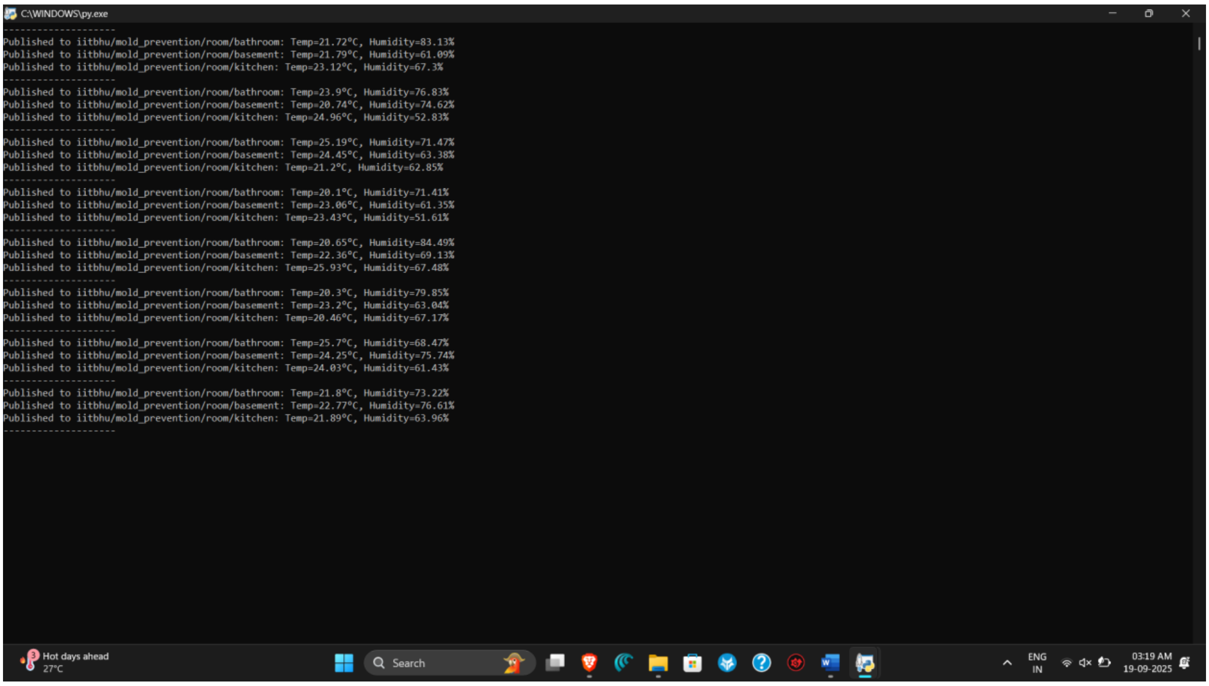
5 Results and Verification

The full simulation validated end-to-end data flow:

1. **Sensor Node** – Continuous publication of packets confirmed in the terminal.



```
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Published to iitbhu/mold_prevention/room/bathroom: Temp=21.72°C, Humidity=83.13%
Published to iitbhu/mold_prevention/room/basement: Temp=21.79°C, Humidity=61.09%
Published to iitbhu/mold_prevention/room/kitchen: Temp=23.12°C, Humidity=67.3%
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Published to iitbhu/mold_prevention/room/bathroom: Temp=23.9°C, Humidity=76.83%
Published to iitbhu/mold_prevention/room/basement: Temp=20.74°C, Humidity=74.62%
Published to iitbhu/mold_prevention/room/kitchen: Temp=24.96°C, Humidity=52.83%
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Published to iitbhu/mold_prevention/room/bathroom: Temp=25.19°C, Humidity=71.47%
Published to iitbhu/mold_prevention/room/basement: Temp=24.45°C, Humidity=63.38%
Published to iitbhu/mold_prevention/room/kitchen: Temp=21.2°C, Humidity=62.85%
--------------------
Published to iitbhu/mold_prevention/room/bathroom: Temp=20.1°C, Humidity=71.41%
Published to iitbhu/mold_prevention/room/basement: Temp=23.06°C, Humidity=61.35%
Published to iitbhu/mold_prevention/room/kitchen: Temp=23.43°C, Humidity=51.61%
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Published to iitbhu/mold_prevention/room/bathroom: Temp=20.65°C, Humidity=84.49%
Published to iitbhu/mold_prevention/room/basement: Temp=22.36°C, Humidity=69.13%
Published to iitbhu/mold_prevention/room/kitchen: Temp=25.93°C, Humidity=67.48%
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Published to iitbhu/mold_prevention/room/bathroom: Temp=20.3°C, Humidity=79.85%
Published to iitbhu/mold_prevention/room/basement: Temp=23.2°C, Humidity=63.04%
Published to iitbhu/mold_prevention/room/kitchen: Temp=20.46°C, Humidity=67.17%
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Published to iitbhu/mold_prevention/room/bathroom: Temp=25.7°C, Humidity=68.47%
Published to iitbhu/mold_prevention/room/basement: Temp=24.25°C, Humidity=75.74%
Published to iitbhu/mold_prevention/room/kitchen: Temp=24.03°C, Humidity=61.43%
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Published to iitbhu/mold_prevention/room/bathroom: Temp=21.8°C, Humidity=73.22%
Published to iitbhu/mold_prevention/room/basement: Temp=22.77°C, Humidity=76.61%
Published to iitbhu/mold_prevention/room/kitchen: Temp=21.89°C, Humidity=63.96%
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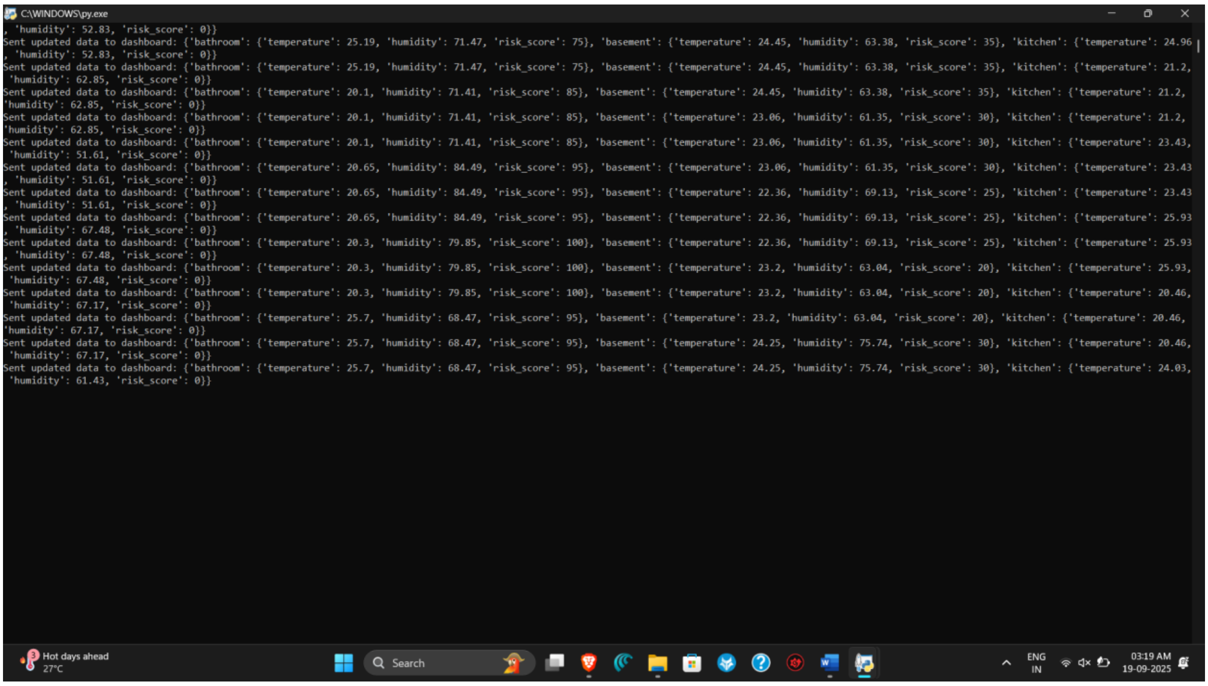
```



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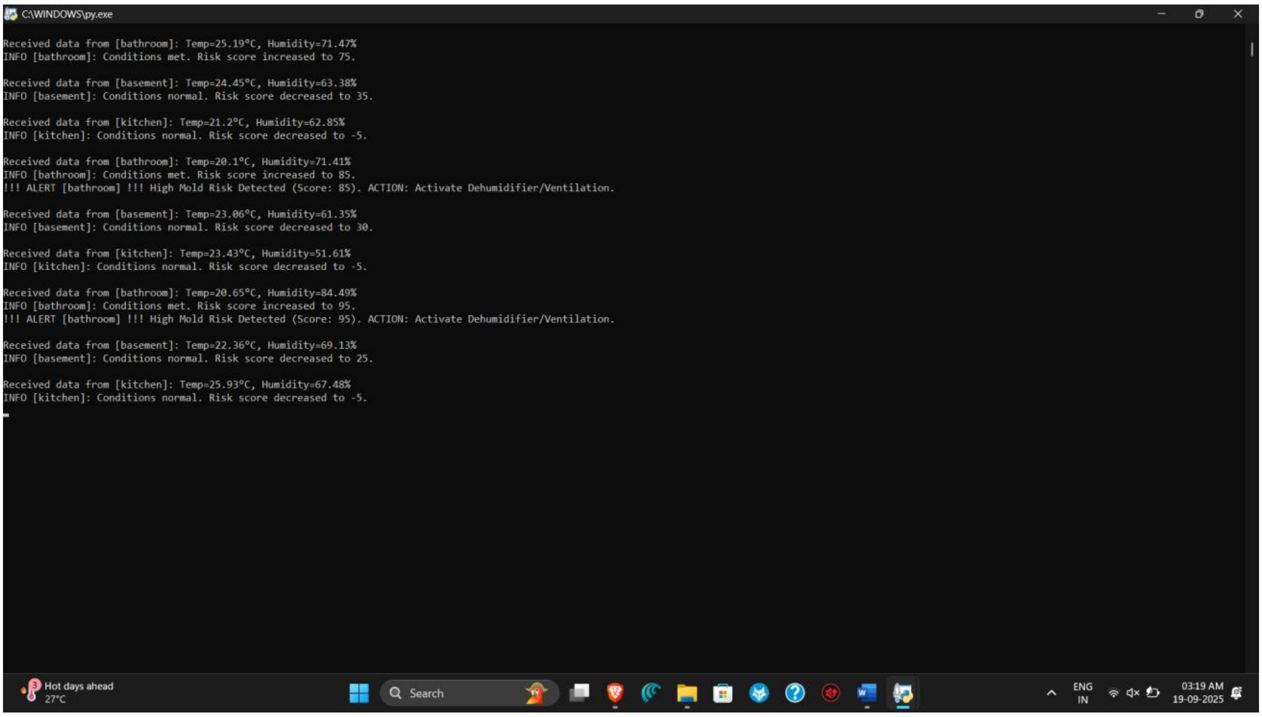
, 'humidity': 52.83, 'risk_score': 0}}
Sent updated data to dashboard: {'bathroom': {'temperature': 25.19, 'humidity': 71.47, 'risk_score': 75}, 'basement': {'temperature': 24.45, 'humidity': 63.38, 'risk_score': 35}, 'kitchen': {'temperature': 24.96
, 'humidity': 52.83, 'risk_score': 0}}
Sent updated data to dashboard: {'bathroom': {'temperature': 25.19, 'humidity': 71.47, 'risk_score': 75}, 'basement': {'temperature': 24.45, 'humidity': 63.38, 'risk_score': 35}, 'kitchen': {'temperature': 21.2,
 'humidity': 62.85, 'risk_score': 0}}
Sent updated data to dashboard: {'bathroom': {'temperature': 20.1, 'humidity': 71.41, 'risk_score': 85}, 'basement': {'temperature': 24.45, 'humidity': 63.38, 'risk_score': 35}, 'kitchen': {'temperature': 21.2,
'humidity': 62.85, 'risk_score': 0}}
Sent updated data to dashboard: {'bathroom': {'temperature': 20.1, 'humidity': 71.41, 'risk_score': 85}, 'basement': {'temperature': 23.06, 'humidity': 61.35, 'risk_score': 30}, 'kitchen': {'temperature': 21.2,
'humidity': 62.85, 'risk_score': 0}}
Sent updated data to dashboard: {'bathroom': {'temperature': 20.1, 'humidity': 71.41, 'risk_score': 85}, 'basement': {'temperature': 23.06, 'humidity': 61.35, 'risk_score': 30}, 'kitchen': {'temperature': 23.43,
 'humidity': 51.61, 'risk_score': 0}}
Sent updated data to dashboard: {'bathroom': {'temperature': 20.65, 'humidity': 84.49, 'risk_score': 95}, 'basement': {'temperature': 23.06, 'humidity': 61.35, 'risk_score': 30}, 'kitchen': {'temperature': 23.43
, 'humidity': 51.61, 'risk_score': 0}}
Sent updated data to dashboard: {'bathroom': {'temperature': 20.65, 'humidity': 84.49, 'risk_score': 95}, 'basement': {'temperature': 22.36, 'humidity': 69.13, 'risk_score': 25}, 'kitchen': {'temperature': 23.43
, 'humidity': 51.61, 'risk_score': 0}}
Sent updated data to dashboard: {'bathroom': {'temperature': 20.65, 'humidity': 84.49, 'risk_score': 95}, 'basement': {'temperature': 22.36, 'humidity': 69.13, 'risk_score': 25}, 'kitchen': {'temperature': 25.93
, 'humidity': 67.48, 'risk_score': 0}}
Sent updated data to dashboard: {'bathroom': {'temperature': 20.3, 'humidity': 79.85, 'risk_score': 100}, 'basement': {'temperature': 22.36, 'humidity': 69.13, 'risk_score': 25}, 'kitchen': {'temperature': 25.93
, 'humidity': 67.48, 'risk_score': 0}}
Sent updated data to dashboard: {'bathroom': {'temperature': 20.3, 'humidity': 79.85, 'risk_score': 100}, 'basement': {'temperature': 23.2, 'humidity': 63.04, 'risk_score': 20}, 'kitchen': {'temperature': 25.93,
 'humidity': 67.48, 'risk_score': 0}}
Sent updated data to dashboard: {'bathroom': {'temperature': 20.3, 'humidity': 79.85, 'risk_score': 100}, 'basement': {'temperature': 23.2, 'humidity': 63.04, 'risk_score': 20}, 'kitchen': {'temperature': 20.46,
 'humidity': 67.17, 'risk_score': 0}}
Sent updated data to dashboard: {'bathroom': {'temperature': 25.7, 'humidity': 68.47, 'risk_score': 95}, 'basement': {'temperature': 23.2, 'humidity': 63.04, 'risk_score': 20}, 'kitchen': {'temperature': 20.46,
'humidity': 67.17, 'risk_score': 0}}
Sent updated data to dashboard: {'bathroom': {'temperature': 25.7, 'humidity': 68.47, 'risk_score': 95}, 'basement': {'temperature': 24.25, 'humidity': 75.74, 'risk_score': 30}, 'kitchen': {'temperature': 20.46,
 'humidity': 67.17, 'risk_score': 0}}
Sent updated data to dashboard: {'bathroom': {'temperature': 25.7, 'humidity': 68.47, 'risk_score': 95}, 'basement': {'temperature': 24.25, 'humidity': 75.74, 'risk_score': 30}, 'kitchen': {'temperature': 24.03,
 'humidity': 61.43, 'risk_score': 0}}
```

2. **Processing Engine** – Correct real-time calculation of Mold Risk Scores with high-priority alerts when thresholds were breached.



```
Received data from [bathroom]: Temp=25.19°C, Humidity=71.47%
INFO [bathroom]: Conditions met. Risk score increased to 75.

Received data from [basement]: Temp=24.45°C, Humidity=63.38%
INFO [basement]: Conditions normal. Risk score decreased to 35.

Received data from [kitchen]: Temp=21.2°C, Humidity=62.85%
INFO [kitchen]: Conditions normal. Risk score decreased to -5.

Received data from [bathroom]: Temp=20.1°C, Humidity=71.41%
INFO [bathroom]: Conditions met. Risk score increased to 85.
!!! ALERT [bathroom] !!! High Mold Risk Detected (Score: 85). ACTION: Activate Dehumidifier/Ventilation.

Received data from [basement]: Temp=23.06°C, Humidity=61.35%
INFO [basement]: Conditions normal. Risk score decreased to 30.

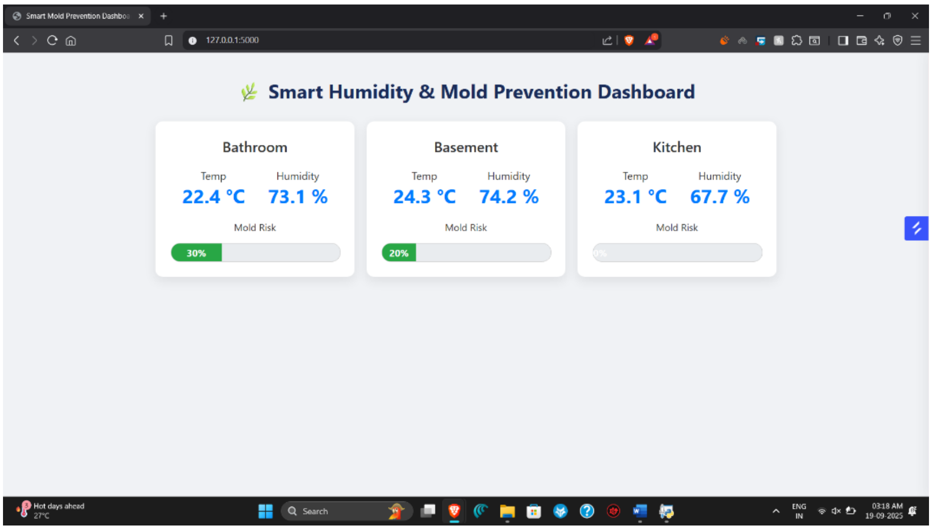
Received data from [kitchen]: Temp=23.43°C, Humidity=51.61%
INFO [kitchen]: Conditions normal. Risk score decreased to -5.

Received data from [bathroom]: Temp=20.65°C, Humidity=84.49%
INFO [bathroom]: Conditions met. Risk score increased to 95.
!!! ALERT [bathroom] !!! High Mold Risk Detected (Score: 95). ACTION: Activate Dehumidifier/Ventilation.

Received data from [basement]: Temp=22.36°C, Humidity=69.13%
INFO [basement]: Conditions normal. Risk score decreased to 25.

Received data from [kitchen]: Temp=25.93°C, Humidity=67.48%
INFO [kitchen]: Conditions normal. Risk score decreased to -5.
```

3. **Web Dashboard** – Accessible at http://127.0.0.1:5000, with live cards per room and a color-coded risk meter (green → yellow → red).

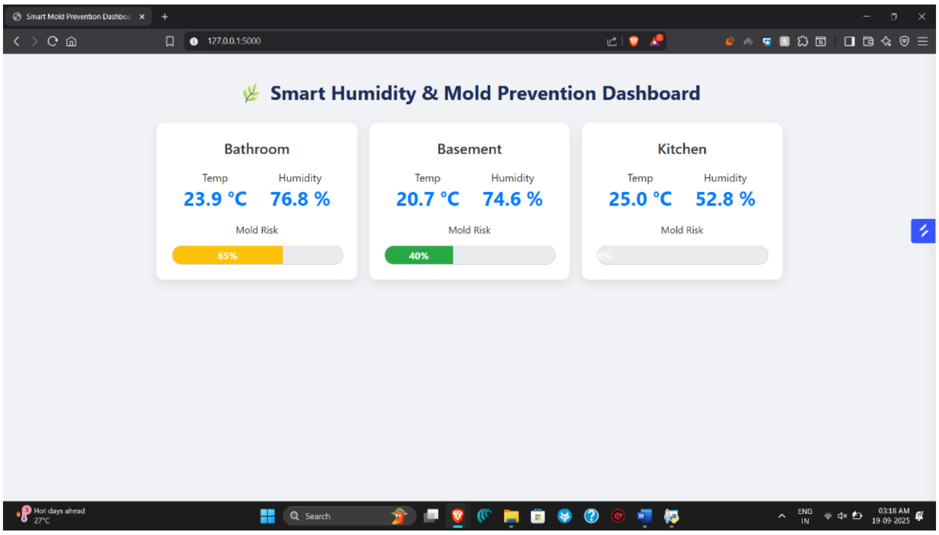


Smart Humidity & Mold Prevention Dashboard

Bathroom
Temp 22.4 °C Humidity 73.1 %
Mold Risk
30%

Basement
Temp 24.3 °C Humidity 74.2 %
Mold Risk
20%

Kitchen
Temp 23.1 °C Humidity 67.7 %
Mold Risk
0%

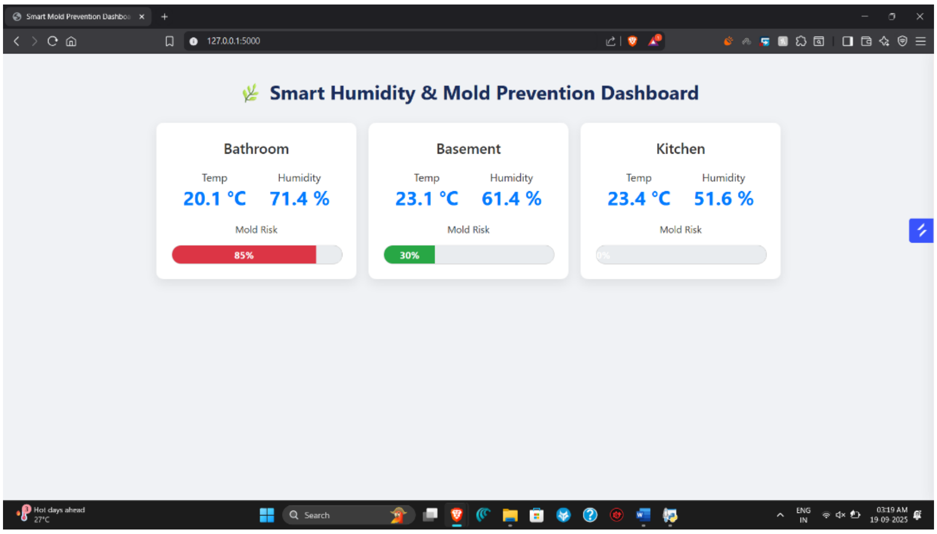


Smart Humidity & Mold Prevention Dashboard

Bathroom
Temp 23.9 °C Humidity 76.8 %
Mold Risk
65%

Basement
Temp 20.7 °C Humidity 74.6 %
Mold Risk
40%

Kitchen
Temp 25.0 °C Humidity 52.8 %
Mold Risk
0%



Smart Humidity & Mold Prevention Dashboard

Bathroom
Temp 20.1 °C Humidity 71.4 %
Mold Risk
85%

Basement
Temp 23.1 °C Humidity 61.4 %
Mold Risk
30%

Kitchen
Temp 23.4 °C Humidity 51.6 %
Mold Risk
0%

Successful interaction across all layers via MQTT demonstrates the feasibility of the architecture.

6 Conclusion and Future Work

This project successfully **designed and simulated** a functional Smart Humidity & Mold Prevention System, showcasing:

- Robust IoT communication using **MQTT**.
- Real-time data processing and predictive analytics.
- A scalable, modular architecture for smart-building environments.

Future directions:

- **Physical prototyping** with ESP32/DHT22 sensors and smart plugs.
- **Machine-learning risk prediction** using historical data.
- **Network security**—TLS, authentication, and larger node deployments.
- **Alternative protocols** such as **LoRaWAN** for long-range, low-power coverage.

References

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