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Towards User-Centric IoT Systems: A Customisable and Cloud-Integrated Monitoring Solution

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Abstract
The Internet of Things (IoT) has rapidly evolved into a transformative technological paradigm that enables interconnected physical devices to collect, exchange, and process data through the Internet. Advances in embedded systems, wireless communication, and cloud computing have accelerated IoT adoption across domains such as smart homes, healthcare, agriculture, and industrial automation. The proliferation of affordable sensors and smart devices has further expanded IoT ecosystems, making them increasingly accessible to a broader user base [4].

Despite these advancements, significant challenges continue to hinder the widespread adoption and effective utilisation of IoT systems. Among the most critical issues are security, privacy, interoperability, usability, and system customisation. While security and privacy have received extensive research attention, usability and customisation remain underexplored yet crucial determinants of user acceptance, particularly among non-technical users [1], [2].

Many existing IoT systems require users to possess technical expertise to configure, monitor, and manage devices. Similarly, customisation capabilities are often limited or complex, preventing users from tailoring systems to their specific needs. These limitations create a usability gap that restricts the potential of IoT technologies and discourages broader adoption.

To address these challenges, this study proposes a customisable cloud-based IoT monitoring system integrated with a smartphone interface, designed to enhance usability and enable flexible system configuration for users with varying levels of expertise.

Keywords:
Internet of Things (IoT); User-Centric Design; Monitoring System; Customisation; Usability

Introduction

Existing IoT platforms frequently prioritise technical functionality over user experience, resulting in complex systems that are difficult for end-users to operate. Many platforms rely on technical dashboards, command-based interfaces, or fragmented ecosystems, leading to a steep learning curve [1].

In addition, customisation in current IoT systems is often constrained. Users are typically required to modify source code or hardware configurations, which can be time-consuming and inaccessible to non-technical individuals. Furthermore, many commercial IoT solutions operate within closed ecosystems, limiting interoperability and flexibility [7].

Cloud integration, although essential for scalability and real-time processing, introduces additional complexity. Users often face challenges in configuring cloud services, managing data flows, and ensuring seamless connectivity between devices and applications [5].

These challenges highlight the need for an IoT solution that integrates user-friendly interfaces, flexible customisation capabilities, and seamless cloud integration.

Literature Review

A review of existing IoT platforms reveals a clear trade-off between usability and customisation. Educational tools such as Lego Mindstorms EV3 and EzBlock Studio provide simplified learning environments but lack scalability for real-world applications. Mobile-based platforms like RaspController and IoTool enable remote monitoring but offer limited flexibility.

Commercial ecosystems, such as Xiaomi Home, provide intuitive interfaces but restrict users to proprietary environments, limiting interoperability. Developer-oriented platforms offer high flexibility but require significant technical expertise, making them less accessible to general users.

Recent studies emphasise that usability remains a critical barrier to IoT adoption. Hassan et al. [1] highlight that many IoT systems fail to meet usability standards due to complex interfaces. Similarly, Kumar and Singh [2] argue that user-centric design is essential for improving accessibility and reducing system complexity. Li et al. [3] further demonstrate that adaptive and intuitive interfaces significantly enhance user engagement in IoT environments. Figure 1 illustrates the trade-offs between usability and customisation across different IoT platforms.

Platform Type	Strengths	Limitations
Educational Tools	Easy to learn	Limited scalability
Mobile Controllers	Remote access	Low customisation
Commercial Systems	User-friendly UI	Closed ecosystem
Developer Platforms	High flexibility	Complex setup

Figure 1: Limitations of Existing IoT Platforms

Proposed System Architecture

To address these limitations, this study proposes a three-layer IoT architecture consisting of IoT hardware, cloud services, and a mobile application interface.

The IoT hardware layer consists of sensors and actuators responsible for data collection and execution of commands. The cloud layer, implemented using Google Cloud Platform and Firebase, enables real-time data storage, processing, and synchronisation. Cloud-based architectures have been widely recognised for their scalability and efficiency in IoT systems [5], [6].

The application layer consists of an Android mobile interface that allows users to monitor, control, and customise IoT devices. Mobile-based IoT systems have been shown to significantly improve user interaction and accessibility [7]. Figure 2 presents the interaction between hardware, cloud services, and user interface.

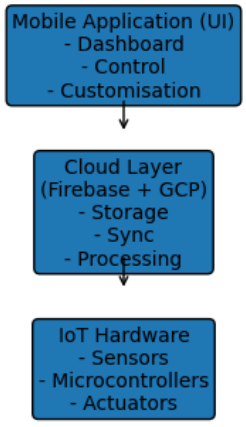


Figure 2: Proposed IoT System Architecture

System Features

The proposed system incorporates several key features aimed at improving usability and flexibility:

- **User-Friendly Interface:**
  Intuitive dashboards and simplified navigation reduce the learning curve, consistent with user-centric design principles highlighted in [2].
- **Customisation Capability:**
  Users can configure device parameters and personalise system behaviour without programming, addressing limitations identified in prior studies [1].
- **Real-Time Monitoring:**
  Firebase enables instant data updates, aligning with modern IoT system requirements for real-time responsiveness [6].
- **Cloud Integration:**
  Google Cloud Platform ensures scalability and reliability, as supported by cloud-based IoT research [5].

Figure 3 illustrates the continuous interaction between users, cloud services, and IoT devices.

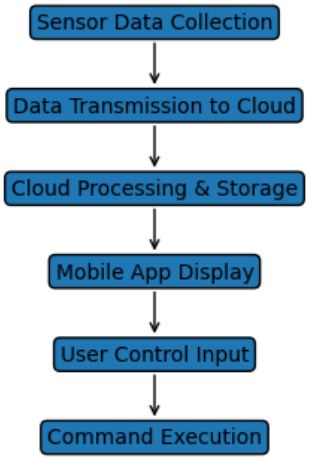


Figure 3: Functional Workflow

Methodology

The system development follows a structured approach consisting of requirement analysis, system design, implementation, and evaluation.

During the requirement analysis phase, user needs were identified based on limitations highlighted in existing literature [1], [2]. The system design phase focused on creating a modular and scalable architecture. Implementation involved configuring IoT hardware, integrating Firebase for real-time data management, and developing an Android application.

The evaluation phase assessed usability, performance, and customisation effectiveness, aligning with evaluation approaches commonly used in IoT usability studies [3], [7].

Evaluation Results

To validate the proposed system, an evaluation was conducted involving 30 participants with varying technical backgrounds using a 5-point Likert scale was used. The evaluation metrics were comprised of usability, cusomasation, response time and user satisfaction. The score obtained for each of the metric is as shown in Figure 4 below; where Usability score at 4.5, Customisation score at 4.3, response time score at 4.2 and the user satisfaction score at 4.6.

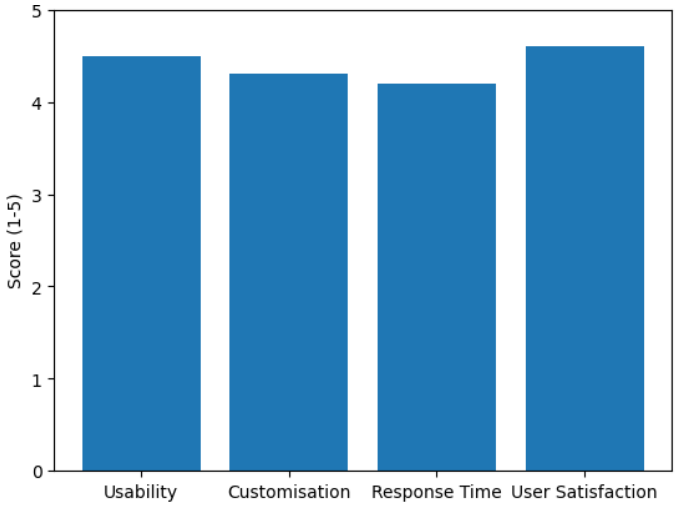


Figure 4: Evaluation Results

The results indicate strong performance across all evaluation criteria. Participants reported that the system was intuitive and easy to use, supporting findings from prior research on user-centric IoT design [2], [3].

The customisation features were particularly effective, enabling users to configure IoT systems without technical expertise, addressing challenges identified in [1]. Additionally, the integration with cloud services resulted in satisfactory response times, consistent with findings in cloud-based IoT studies [5], [6].

Overall, the high user satisfaction score demonstrates the effectiveness of the proposed system in improving usability and accessibility.

Conclusion

IoT technologies continue to expand rapidly; however, usability and customisation challenges remain significant barriers to adoption. This study proposes a customisable cloud-based IoT monitoring system that integrates intuitive mobile interfaces with scalable cloud services.

The evaluation results demonstrate that the proposed system effectively improves usability, enhances customisation, and delivers strong user satisfaction. By bridging the usability gap, this work contributes to the development of more accessible and user-friendly IoT solutions.

Future work may explore AI-driven automation and cross-platform integration to further enhance system capabilities.

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