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Warehouse Door Security System Based on Internet of Things (IoT) Using Reed Switch Sensor Connected to Smartphone Notification

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Abstract

A robust warehouse door security system is crucial for safeguarding assets and stored objects against theft or illegal access. This research seeks to build and construct an Internet of Things (IoT)-based security system employing reed switch and PIR sensors to identify suspicious behavior near the warehouse entrance. Developed for PT. Anugerah Terang Persada's system incorporates real-time notifications for the warehouse proprietor or manager's smartphones. Reed switch sensors identify the door's opening and closing, whereas PIR sensors observe movement in the surrounding area. The ESP32-CAM microcontroller processes data from various sensors, capturing photos or movies during unforeseen movements or door opens. This data is transmitted via the internet to the mobile application, facilitating real-time notifications.

The principal advantage of this research is improved warehouse security using accessible and cost-effective IoT technology. The solution delivers enhanced efficiency relative to conventional security approaches by providing instantaneous alerts and visual proof for prompt action. The ESP32-CAM facilitates automatically recording photos or videos upon detecting suspicious activity, thereby enhancing security by preserving digital evidence for further review. This system can also be linked with other IoT devices, improving overall security monitoring. This research presents novel options for firms requiring dependable and economical warehouse security, diminishing dependence on conventional ways while enhancing flexibility and convenience in facility administration.

Keywords : *Warehouse Door Security, Internet of Things (IoT), Reed Switch Sensor, PIR Sensor, ESP32-CAM*

INTRODUCTION

Security is essential to warehouse operations, particularly in the contemporary digital age, where thieves increasingly target facilities housing high-value goods. (Mustika et al., 2023; Shruthi et al., 2023) Conversely, information and communication technology improvements have yielded more efficient alternatives, including the Internet of Things (IoT). The Internet of Things (IoT) integrates several security devices into a unified system that can be monitored and operated in real-time via an internet-connected smartphone. (Sicari et al., 2019)

Ramadhani & Putri (2023) asserts that security is a fundamental component of existence designed to safeguard valuable possessions while offering its proprietors a sense of safety and comfort. Diverse studies and innovations have been conducted to augment security via technology breakthroughs that assure proprietors of their safety when vacating a spot. (Sonamoni et al., 2024) Telegram provides an API for delivering real-time notifications through automated messages to users. The utilization of reed switch sensors, PIR sensors, and the ESP32-CAM microcontroller is essential for the operation of this device, enabling it to transmit information regarding activities inside the sensor vicinity autonomously. This is especially significant considering the countless instances of theft in which perpetrators have damaged CCTV cameras to eradicate evidence of their activities.

Vardakis et al., (2024) defines the Internet of Things (IoT) as a notion wherein internet-enabled devices can exchange information with one another and their environmental objects. The Internet of Things (IoT) is commonly perceived as "the next significant advancement" in contemporary technology, presenting a multitude of potential generated by IoT advancements (Mabasha et al., 2023).

The Internet of Things is a sophisticated technology that denotes the extensive array of items and systems globally interconnected through the Internet, facilitating data exchange. These technologies encompass sensors and software engineered to communicate, control, connect, and exchange data with other devices, provided they maintain an internet connection, hence facilitating wireless functionality without wires. The Internet of Things (IoT) is strongly associated with the concept of machine-to-machine (M2M) communication, with equipment capable of M2M interaction commonly designated as smart devices (Priharti et al., 2020).

The Internet of Things (IoT), sometimes called smart gadgets, can be utilized across multiple domains, including residential settings, workplaces, industrial sectors, transportation, healthcare, education, and environmental contexts (David Fadlianda et al., 2024). Technology functions as a mechanism to streamline human activities or acquire new knowledge, and this advancement is experienced universally by all technology users. The Internet of Things (IoT) is among today's most prevalent and widely utilized technologies (Salikhov et al., 2021).

The author intends to research and design a warehouse door security system that utilizes Internet of Things (IoT) technology. The system will incorporate reed switch sensors linked to smartphone security notifications.

METHOD

D. Michael and D. Gustina (in Darnita, Y., et al., 2021) define a prototype as a system development process that employs a rapid and iterative approach to program creation, facilitating prompt user review. This research is categorically divided into two system types: hardware and software.

The phases encompassed in this prototype methodology are:

1. Conveyance
   During this phase, the author will ascertain and evaluate user requirements by collecting information from users and other pertinent stakeholders regarding the required software specifications.
2. Expedited Strategy
   This step entails creating a software prototype derived from the basic concept stated. The prototype will offer a comprehensive overview of the design and functionalities of the intended software. The author will create sketches and models of the prototype to offer to users for their comments.
3. Rapid Design Modeling
   Rapid design modeling is the preliminary phase in system or device development that offers a preliminary concept of the system's appearance or functionality before advancing to more intricate development phases.
4. Prototype Development

Following the design of the hardware and software, the subsequent step is to integrate the hardware design into a warehouse door security system prototype.

Assessment and Testing of the Prototype

This software prototype will assess if the software fulfills user expectations. This phase encompasses system testing, whereas software entails data input validation and rectification.

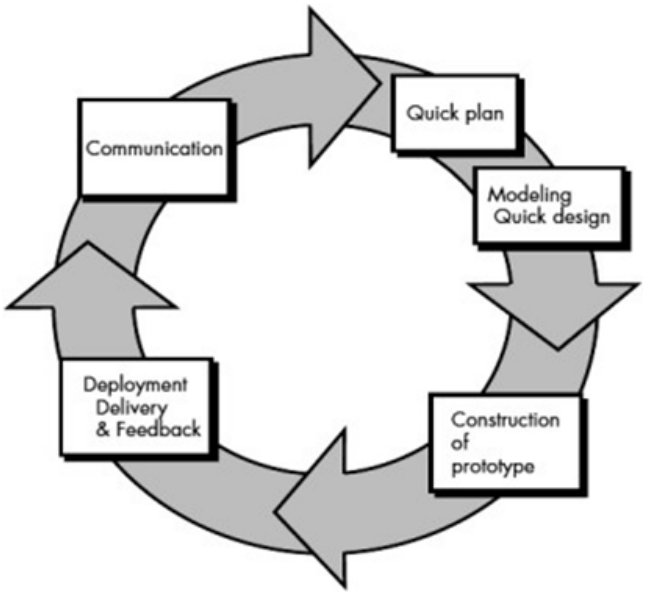

Figure 1. Pressman Prototype

RESULT AND DISCUSSION

System Design Stage

The system design phases entail constructing a comprehensive framework derived from system analysis outcomes, culminating in formulating a new system model. The primary objective of output design is to minimize data entry costs, attain high precision, and guarantee that the data provided is comprehensible to the user. Subsequently, system process design facilitates seamless data processing, producing precise information while overseeing the system's operations. Furthermore, database design encompasses a compilation of interconnected data, establishing a unified framework for information administration. The control design phase guarantees that the implemented system is dependable to avert errors, damage, and process failures, enhancing overall system efficacy.

Proposed System Analysis

Figure 2. Context Diagram of the Proposed System

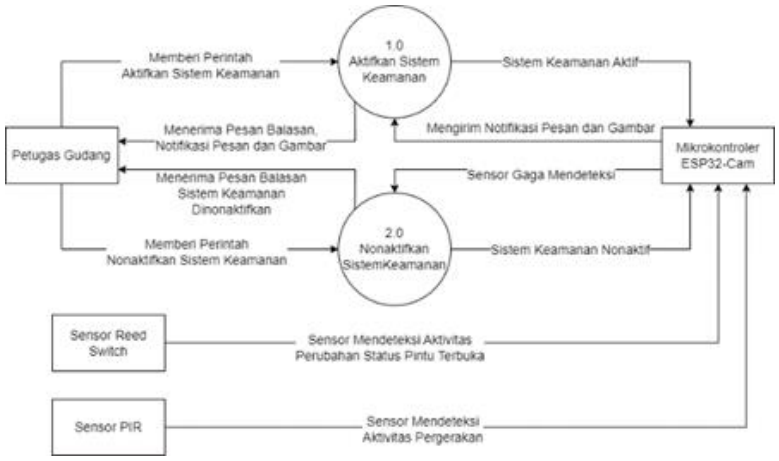

Figure 3. Data Flow Diagram Level 0

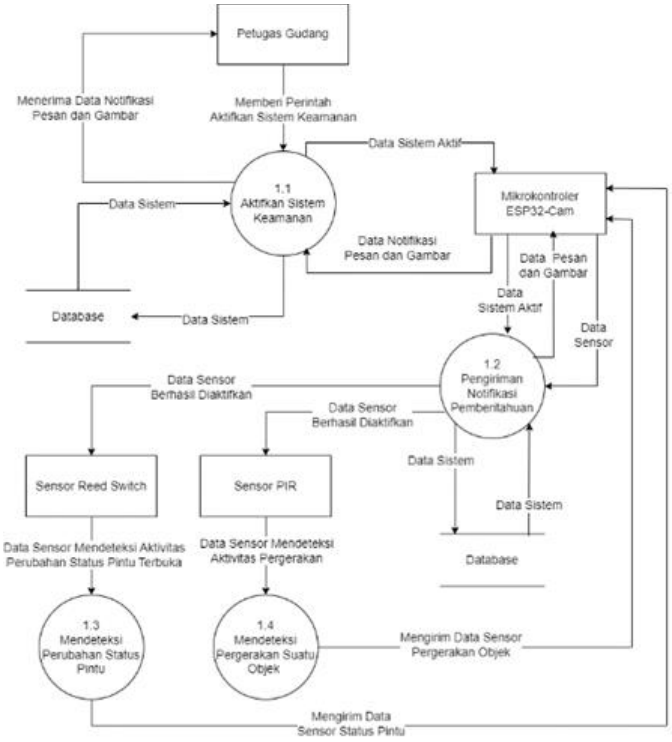

Figure 4. Data Flow Diagram Level 1

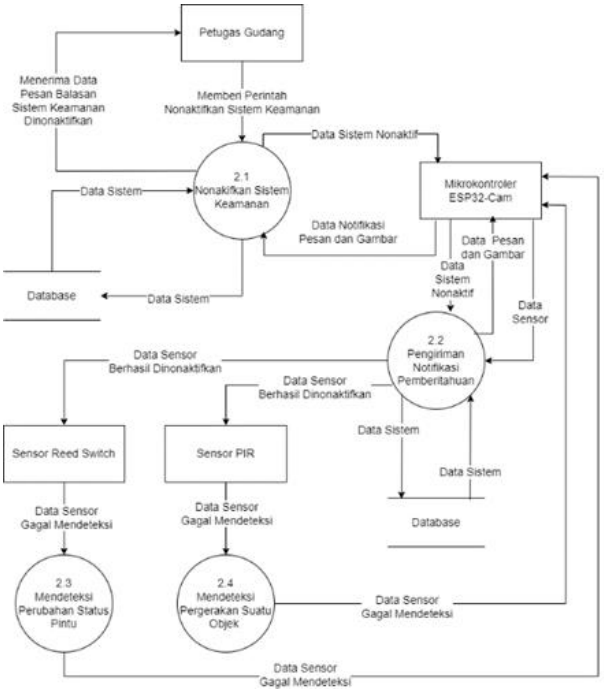

Figure 5. Data Flow Diagram Level 2

Table 1. Database Model (Evidence Table)

No	Nama Kolom	Tipe Data	Keterangan
1.	id_bukti	INT (PRIMARY KEY)	ID unik untuk bukti
2.	id_sensor	INT (FOREIGN KEY)	ID sensor yang memicu pengambilan bukti
3.	jenis_bukti	ENUM ('foto')	Jenis bukti, apakah berbentuk foto
4.	tanggal_bukti	TIMESTAMP	Tanggal dan waktu pengambilan foto

Table 2. Sensor Table

No	Nama Kolom	Tipe Data	Keterangan
1.	id_sensor	INT (PRIMARY KEY)	ID unik untuk bukti
2.	id_pengguna	INT (FOREIGN KEY)	ID sensor yang memicu pengambilan bukti
3.	jenis_sensor	ENUM ('reed', 'PIR')	Jenis bukti, apakah berbentuk foto.
4.	status_sensor	ENUM ('aktif', 'nonaktif')	Status sensor (aktif atau tidak)
5.	terakhir_diaktifkan	TIMESTAMP	Tanggal dan waktu pengambilan foto.

Table 3. Table Structure

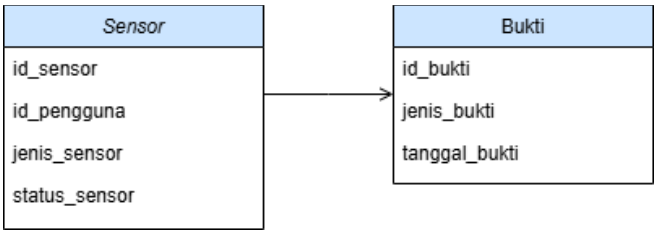

Table 4. User Data

No.	Kolom	Tipe Data	Deskripsi
1.	id_user	INT (PRIMARY KEY, AUTO_INCREMENT)	ID unik pengguna
2.	nama	VARCHAR(100)	Nama pengguna
3.	email	VARCHAR(100)	Email pengguna
4.	password	VARCHAR(255)	Kata sandi pengguna
5.	id_role	INT	Role ID dari table Roles
6.	created_at	TIMESTAMP	Tanggal dibuatnya akun

Table 5. Role Table

No.	Kolom	Tipe Data	Deskripsi
1.	Id_role	INT (PRIMARY KEY, AUTO_INCREMENT)	ID unik peran
2.	Nama_role	VARCHAR(50)	Nama peran (misal: Pemilik, Petugas)

Table 6. User Role

No.	Kolom	Tipe Data	Deskripsi
1.	id_user_role	INT (PRIMARY KEY, AUTO_INCREMENT)	ID unik peran pengguna
2.	id_user	INT	ID pengguna dari tabel Users
3.	id_role	INT	ID Peran dari table role

Table 7. Table Users

No.	Id_user	Nama	Email	Password	Id_role	created_at
1.	1	Pemilik	Pemilik01@gmail.com	Atp72823	1	2024-09-21 10:00:00
2.	2	Petugas	Petugas02@gmail.com	Atp72824	2	2024-09-21 11:00:00

Table 8. Table Role

No.	Id_role	Nama_role
1.	1	Pemilik Gudang
2.	2	Petugas Gudang

Table 9. Table User Role

No.	Id_user_role	Id_user	Id_role
1.	1	1	1
2.	2	2	2

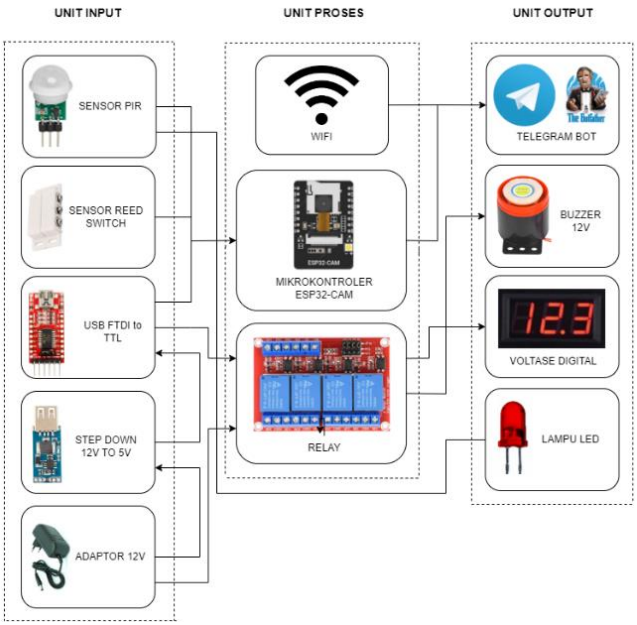

Figure 6. System Requirements Analysis

Systematic Hardware Design

The systematic design of hardware pertains to the segment that delineates the components required for the devices. The security system design employs a reed switch and PIR sensors linked to smartphone notifications via the Telegram app to issue alerts upon door openings. Furthermore, the PIR sensor functions to identify motion from human entities.

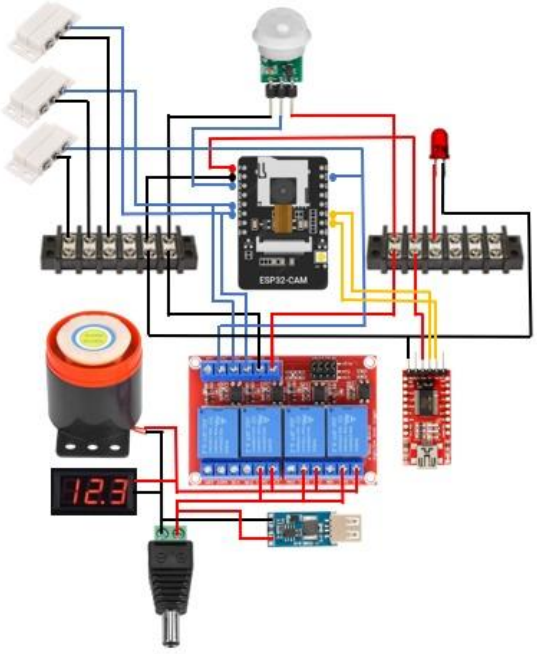

Figure 7. Systematic Hardware Design

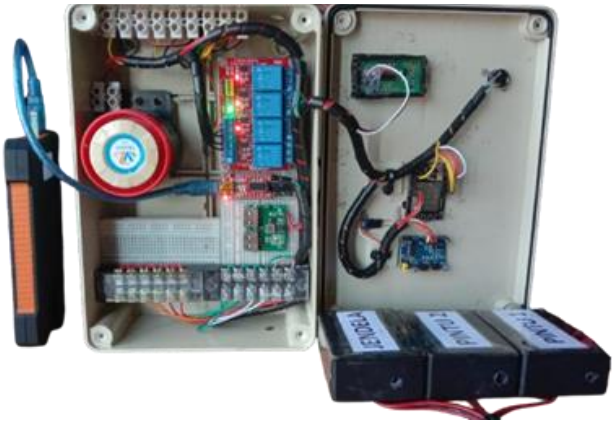

Figure 8. Hardware Prototype Design

Table 10. Reed Switch Sensor Measurement

Nama Sensor	Jarak (Centimeter)	Logika	Keterangan
Sensor *Reed Switch*	1 cm	0	Tidak Terdeteksi Gerakan
	1,5 cm	1	Gerakan Terdeteksi
	2 cm	1	Gerakan Terdeteksi
	2,5 cm	1	Gerakan Terdeteksi
	3 cm	1	Gerakan Terdeteksi

Table 11. PIR (Passive Infrared Receiver) Sensor Measurement

Nama Sensor	Jarak (Meter)	Logika	Keterangan
Sensor *PIR*	1 Meter	1	Gerakan Terdeteksi
	2 Meter	1	Gerakan Terdeteksi
	3 Meter	1	Gerakan Terdeteksi
	4 Meter	1	Gerakan Terdeteksi
	5 Meter	1	Gerakan Terdeteksi
	6 Meter	1	Gerakan Terdeteksi
	7 Meter	1	Gerakan Terdeteksi
	8 Meter	1	Gerakan Terdeteksi
	9 Meter	0	Gerakan Tidak Terdeteksi

Table 12. Testing the Number of ESP32-CAM Responses When the Reed Switch Sensor Detects a Change in Door Status

Pengujian ke -	Waktu (Menit)	Jumlah gambar yang berhasil diambil ESP32-Cam	Delay (Detik)	Sensor *Reed Switch*
1	1	5	09,66	Aktif
2	2	10	09,24	Aktif
3	3	15	09,50	Aktif
4	4	20	09,41	Aktif
5	5	25	09,60	Aktif

Table 13. Testing the Number of ESP32-CAM Responses When the PIR Sensor Detects Motion

Pengujian ke-	Waktu (Menit)	Jumlah gambar yang berhasil diambil ESP32-Cam	Delay (Detik)	Sensor *PIR*
1	1	4	14,48	Aktif
2	2	6	19,47	Aktif
3	3	10	17,98	Aktif
4	4	15	16,67	Aktif
5	5	19	15,78	Aktif

Table 14. Overall System Implementation & Testing

No	Pengujian	Proses	Hasil yang diharapkan	Hasil pengujian
1	Pengujian jarak sensor *Reed Switch* bertujuan dapat mengirimkan pemberitahuan ketika pitu dalam keadaan terbuka	Pengukuran dilakukan dengan jarak 1-3 cm dari medan magnet	Saat terdeteksi perubahan posisi pintu terbuka *ESP32-CAM* mengirim pesan dan gambar kepada *Bot Telegram*	Berhasil
2	Pengujian jarak Sensor *PIR* dapat mendeteksi gerakan	Pengukuran dilakukan dengan jarak 1-9 meter dari objek	Saat terdeteksi Gerakan *ESP32-CAM* mengirim pesan dan gambar kepada *Bot Telegram*	Berhasil

3	Lampu Flash untuk mengambil mengambar dengan sensor atau menggunakan perintah dari pengguna	Dilakukan pengujian fungsi perintah menghidupkan lampu flash	Pada saat terdeteksi gerakan sensor akan bekerja lalu mengambil gambar dengan lampu flash secara otomatis	Berhasil
4	Pengujian keseluruhan sistem	Melakukan pengujian keseluruhan sistem	Sistem berjalan dengan baik	Sedikit mengalami gangguan respon ketika jaringan internet tidak stabil

CONCLUSION

The author's research yields many conclusions. The research effectively deployed reed switch and PIR sensors on the ESP32-CAM module, facilitating notifications via Telegram. Test results indicate that this system effectively identifies movement and alterations in indoor status via the reed switch sensor, transmitting notifications in real-time as text messages and images to the Telegram application. Furthermore, the system provides an efficient solution for security surveillance and automation in warehouses and residences, allowing users to receive prompt notifications regarding activities identified by the sensors. The system employs the ESP32-CAM and Telegram, reducing expenses while leveraging readily available technologies accessible to a broad audience.

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