Design And Development Of A Baby Sleep Monitoring System Based On Internet Of Things (Iot)

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Abstract.
A baby's condition during sleep is a condition that requires intense attention directly from the parents. The quality and quantity of baby sleep are very much affected by the conditions and setting of the environment where the baby sleeps, including the baby's space for movement, room temperature, light intensity, sound/noise, and humidity of the room. Keeping the quality of the baby's sleep is very important both for the baby and for parents. The Design and Development of a Baby Sleep Monitoring System Based on the Internet of Things (IoT) aim to help parents monitor their baby while sleeping and optimize the quality of baby's sleep by monitoring the conditions of the baby's bedroom environment without being present in person. Parents can monitor their baby's condition while sleeping by getting alerts to their smartphone if the conditions exceed the threshold of the ideal limits received from the IoT sensors, like sound sensor, movement sensor, temperature, and humidity sensor. Therefore parents can feel serenely in doing their daily activities, and the baby still gets the appropriate sleep needs.

Keywords: *Internet of Things, Monitoring System, Baby's Sleep Condition Parents*

I. INTRODUCTION

Nowadays, the development of technology has a massive influence on human life in various fields and changes interactions with the environment. Based on studies in the health sector, the condition of a baby's sleep is a form of adaptation of a baby to its environment and is one of the basic needs for optimal growth and development for a baby. Based on research, most babies have regular sleep patterns, but 30% of children have sleep problems. Children's sleep patterns are affected by several factors, namely internal factors in children and physical environmental factors, with parental support playing an essential role in the formation of good sleep patterns for children. [1][7].The quality and quantity of baby sleep are affected by the conditions and setting of the environment where the baby sleeps, including the baby's movement space, room temperature, light intensity, sound/noise, and humidity of the room. Maintaining the quality of baby sleep is very important because poor sleep can cause physiological and psychological imbalance disorders.Internet of Things is a concept that has the best capabilities in implementing remote surveillance systems that can be done at any time in real-time to maximize the aspects of supervision, warning, and prevention [2][8][9].

The scope of the study is:
1. Prototype of the Baby Sleep Monitoring System based Internet of Things (IoT) using Raspberry PI 3 Model B with sensor/module: PIR motion sensor HC-SR501, temperature, and humidity sensor DHT22, sound detection sensor KY037, dan Pi camera module V2.
2. For the design and development, the monitoring system uses Python programming language with IDE Thonny 3,3 for Raspberry Pi build, which Data recording at present is called Real-time monitoring system. A real-time system is a management system that records data according to current conditions either through video or with other media. It will send notifications/warnings to Smartphone devices via e-mail and the Telegram messenger app.

II. METHODS

a. Baby Sleep Condition.

Defining the word baby means a child who has not been born long. Referring to the Ministry of Health of Indonesia [3] [10]. Baby are children aged 0 to 1 y.o. The Ideal Conditions for Sleeping Babies Based on the guidelines made by the Ministry of Health on "Air Health in the Home Room," the physical requirements for space between the parameters as the followed table:

Table 1. Ideal conditions of baby sleep room.

No	Parameter/ variable	Unit	Ideal Range
1	Temperature	^{O}C	18-30
2	Humidity	% RH	40-60
3	Sound/Audio	dB	0 - 50

b. Monitoring System.

The monitoring system is a system that is useful for watching an activity, observing an activity, and recording it [4] [11-13]. The monitoring system is used to see events or see the reaction of an event over a long period. According to current conditions, the excellent monitoring system has a fast data reading interval. Data recording at present is called a Real-time monitoring system. A real-time system is a management system that records data according to current conditions either through video or other media.

c. Internet of Things (IoT).

Internet of Things is a concept that aims to expand the benefits of continuously connected internet connectivity. IoT connects machines, equipment, and other physical objects with network sensors and actuators to acquire data and manage performance. Then allows machines to collaborate and even act independently to acquire new information. Internet of Things is an idea where all objects in the real world can

communicate as part of an integrated system using the internet network as a framework[5].

d. Raspberry Pi.

Raspberry Pi is a small computer in the form of a single circuit board equipped with a complete computer's functions to run office programs and computer games, as a media player, and simulate hardware operations[6] [14][15].

e. Methodology

The methodology used for the final project is the network design method approach introduced by Cisco, PPDIOO (Prepare, Plan, Design, Implement, Operate, Optimize), with the steps/phase as follows:

1. Prepare phase.

- Choosing Research Topic.
- Data Collecting:
  - Observation Method.
  - Study of Literature.
- Problem Analysis with SWOT.
- System Requirements Analysis

Table 2. Table of SWOT

Internal Factor	
Strength (S)	**Weakness (W)**
- We are using the latest technology (IoT). - Human resources (parents) are familiar with the internet and mobile technology.	There is no complete sensor feature for monitoring and warning the baby's sleeping environment.
External Factor	
Opportunity (O)	**Threat (T)**
Easy online access to the system can be used on mobile devices with similar systems but with fewer sensors so that the system is already familiar to the public.	Internet development is not distributed fairly in Indonesia, There are still blackouts in several villages/cities. Make control system distance range distress.

2. Plan phase
   - Define problem boundaries
   - Define the scope of study
3. Design phase
   - Design Prototype schematic
   - Design Flow Diagram with UML
   - Design the monitoring system

4. Implement phase
   - Assembling Hardware
   - Building Monitoring System
   - Implementing System
5. Operate phase
   - Running test on System
   - Running System
6. Optimalize phase
   - Improve the System
   - Develop the System
   -

III. RESULT AND DISCUSSION

3.1 Design System

The data during the research are in the form of system documentation that has been designed and built consisting of System Architecture Design, Data Flow, Raspberry PI Prototype Block Diagram Design, Raspbian OS Setup, and Configuration, and Prototype Installation.

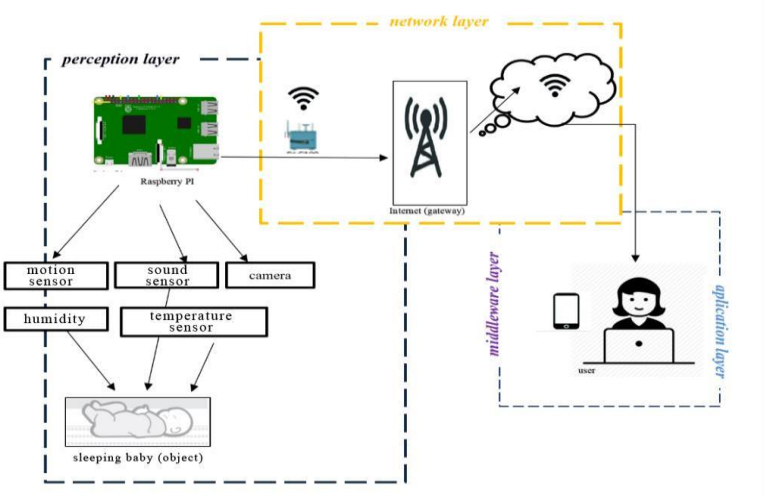


Fig 1. System Overview

As shown in the picture (Figure 1. System Overview), the system works based on a 4-layer Internet of Things architecture model or a 4-layer IoT architecture model, where each sensor (motion, temperature, humidity, sound) and camera module installed on the prototype, will retrieve data. From the physical object (preception layer), the data received by the prototype will be processed if the received variable exceeds the threshold (threshold), and a warning will be sent from Raspberry via the internet network (network layer). Then the data is forwarded using a device owned by the user in the form of a warning (warning) through the process of the middleware layer device that will be received via the user's email at the application layer. The

design of the UML statechart diagram is shown in the picture (Figure 2. Statechart System) below:

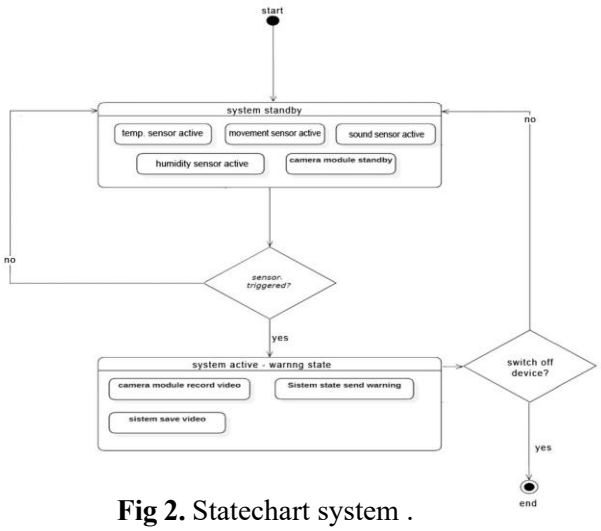


Fig 2. Statechart system .

3.2 System Algorithm

Using Python as the programming language, the algorithm used in a system is as follows:

```
Import libraries
From libraries import var
pir.motion=gpio(4)
dht.tmper=gpio(3)
sound=gpio(17)
cam=PiCamera()
msg=telegram.pot[text,id]
miMe=email.gmail[from,to,text,att]
tmp.hmd=dht.tmper[temperature][humidity]
define handle():
  if msg.receive =(/start,banana_bot)
    print(”message receive from:” +(id))
    msg.send.bot(system standby)
While true:
    main()
  else if msg.receive =(/end,banana_bot)
    print(”message receive from:”+(id))
    msg.send.bot(system OFF)
define main():
 file = open (sensor_loger.csv,’w’)
 file.write (timestmp,tmp,hmd,motion,snd \br)
 if pir.motion == 1
```

```
    print(”motion detected”)
        send.notif(motion)
  if 40 < hmd > 60 or 18 < tmp > 30
    print( ”temperature and humidity treshold” )
        send.notif(hmdtmp)
  if sound > 50
    print(”sound treshold”)
        send.notif(soundDb)
define send.notif():
  try motion:
    msg.send.bot (”warning: motion detected!”)
    cam.start.record(5)
    save video.mp4
    msg.send.bot(video.mp4)
    miMe.send.mail()
  try hmdtmp:
    msg.send.bot(”Warning! Temperature and Humidity is not ideal”)
      msg.send.bot( temperature :+tmp,  humidity : +hmd, sound : +sound)
  try soundDb:
      msg.send.bot( ”Warning! Sound not ideal!”)
      msg.send.bot( temperature :+tmp,  humidity : +hmd,  sound : +sound)
```

3.3 Network Design

Raspberry PI sensors send data over a wireless network using a home gateway. A modem then transmits it via the internet to devices used by users using a cellular network. The detailed computer network design of the monitoring system is shown in Figure 3.

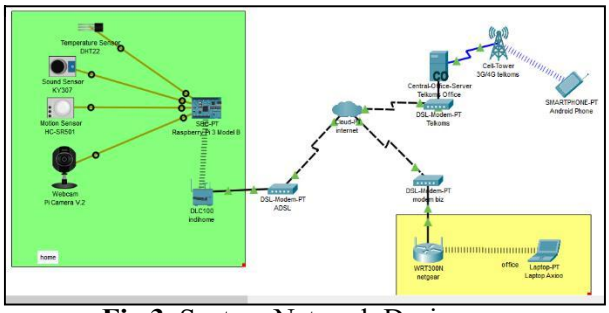
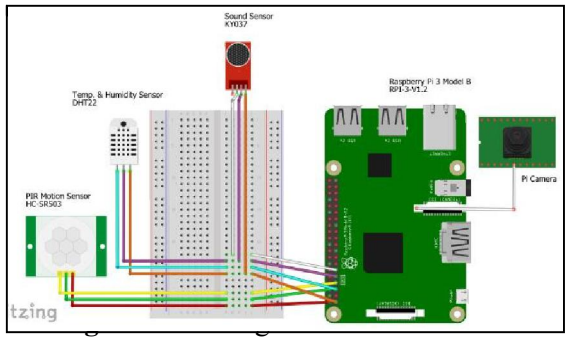


Fig 3. System Network Design.

3.4. Prototype Development

The device can retrieve data from the environment using sensor modules installed on the Raspberry PI 3 as the prototype. The prototype block diagram schematic is designed as shown in the following figure (Figure 4. Block Diagram Schematic):



The prototype that develops is a Raspberry Pi electronic circuit, and the breadboard is placed in the box to prevent changes to the jumper and short circuit cables. In contrast, sensors and modules are placed outside the box for sensing, which other objects should not obstruct. The result of the prototype that has been built is shown in the following figure (Figure 5. Prototype Device).

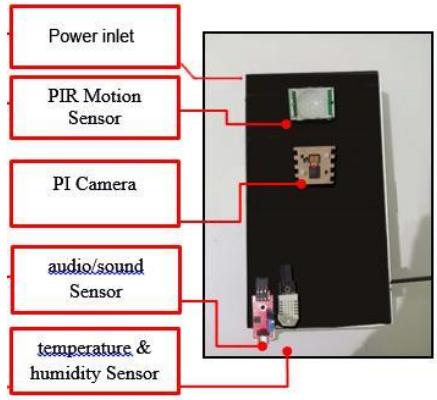


Fig 5. Prototype Device

In the build and design of a prototype of the Baby Sleep Monitoring System based on the Internet of Things (IoT) using hardware and software in the following table:

Table 2. Prototype Components.

No	Components	Specification/ Tipe
	Hardware	
1.	Raspberry Pi 3	Model B
2.	Micro SD Card	8GB SDHC
3.	Power Supply	Raspberry PI 3 Standard micro USV 3V/5A
4.	Motion Sensor	HC-SR501 PIR
5.	Temperature and Humid. Sensor	DHT22
6.	Audio/Sound Sensor	KY037
7.	Camera	Raspberry Pi Cam v2

8.	Raspberry Pi Case/ Enclosure	ABS Plastic Case
9.	Jumper Cable Male to Female	20-29AWG
10.	Breadboard	Mini breadboard
11.	Exoskeleton	Eco friendly carton box
	Software	
1.	Operating System	Raspberry PI OS 64x
2.	IDE	Thonny 3.3 Phyton IDE
3.	Remote Desktop	Real VNC

3.5 Result

In the system testing, monitoring of sleeping babies has been carried out with good results.

Fig 6. Testing the System.

The Sleeping Baby Monitoring System that has been built and installed on the prototype will respond when the variable exceeds the limit and trigger a warning that is sent via email to the user, as shown in the following screenshot (Figure 7. Warning via email):

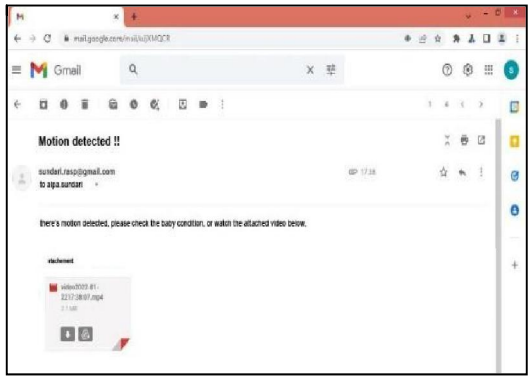


Fig 7. Warning via email.

As for the warning on telegram app as shown as screenshot below (Figure 8. Warning via Telegram App):

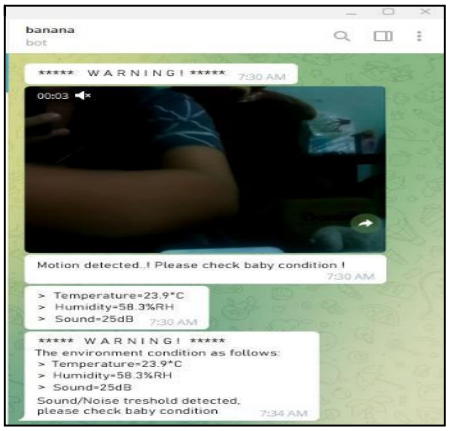


Fig 8. Warning via Telegram App.

For the data logger system stored on the prototype in the form of a text log, based on the data logger, a graph has been made (Figure 9. Graph data-log system) to facilitate data processing in tabular form.

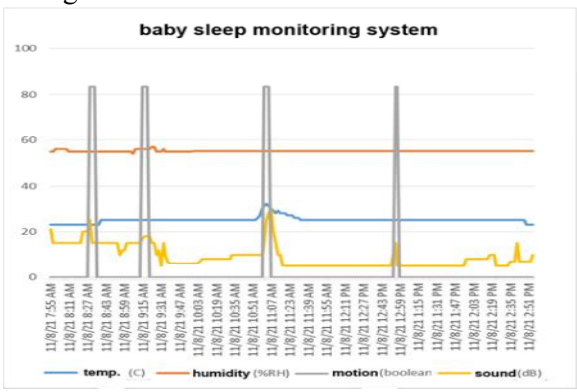


Fig 9. Graph data-log system.

The results at the implementation phase of the Sleeping Baby Monitoring System, the data stored in the data-log for detecting sleeping baby movements is affected by room temperature that exceeds the ideal limit as in the test.

IV. CONCLUSION

Based on the research and testing results, it can be concluded that the Sleeping Baby Monitoring System prototype has been successfully built, and the prototype can work well. This prototype device has the highest level of accuracy at a distance of no more than 5 m. As for the temperature and humidity sensors, the accuracy obtained by self measure is with an error margin of ± 0.5%.

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