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Wireless Health Monitoring for chronic hypertension community

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ABSTRACT
Chronic blood pressure is a risk factor for heart attacks, strokes, arterial aneurysms, and is a major cause of chronic heart failure. However, various possible high blood pressure and low blood pressure can be avoided as early as possible, by regular blood pressure checks using a Digital Tension meter. Though the hospital service queue becomes a consideration when the patient's age is greater than 50 years. So this applied product research tried to develop health monitoring system, where blood pressure data source obtained from digital A Digital Tension meter, then sent using ESP8266 to computer device through the wireless network. The results of information from several A Digital Tension meters will be displayed simultaneously as the patient's condition monitoring information system. The factors that affect data acquisition are the digital A Digital Tension meter position on the arm, the position of the pressure sensor, the power of the battery supply and the availability of a stable network. Results In this study is the time of data retrieval process of the pumping process, calculating systole, diastole, heart rate and data transfer by an ESP8266 device is 28-30 seconds with the probability of data can be transferred successfully from digital A Digital Tension meter device to server computer is 88-90%

***Keywords*: Chronic Blood Pressure, Health monitoring, Compiler Arduino, ESP8266**

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I. INTRODUCTION

Based on internet stats report in early 2015, from 1999 to 2015, there was a user increase of more than 40 percent. Even predicted, in 2016, internet users in Indonesia will increase to nearly 75 million or 14.8% compared to 2015 and 14.4% when compared with internet users in 1999. Meanwhile, the number of patients with Chronic Blood Pressure is in the age range 50-70 years high enough where the condition of hospitals that provide clinical services BPJS tend to be full and queued. Based on data obtained from dinkes surabaya shows that patient visits mostly dominated by Acute respiratory tract infections, heart disease, high blood pressure, oral cavity, muscle diseases and intestinal infections. A large percentage of illnesses dominate patient care in hospitals while hospital capacity is limited. With the Health Monitoring system is expected enough patients to register and conditions can be monitored using outpatient services online. Patient monitoring is assisted using the EPS8266 A Digital Tension meter and wireless interface, the patient does not need to come far to the hospital. The actual condition of the patient can be seen through a monitor in the hospital directly. If the patient's blood pressure data undergoes significant changes there is a sequence of which patients should be treated first [1]. The development of Wireless Information and Technology (ICT) technology has reached various sectors of human life, as well as developments in the health sector, a blend of ICT technology and health has spawned telemedicine technology [2]. The application of wireless monitoring technology in health and medical applications also shows a positive growth profile. In a study conducted by Fezari, in 2015, they used a sensor system and a graphical display of information related to the health condition of local connected patients using ECG sensors to monitor cardiac activity continuously and display it on screen even in different rooms using X-bee as wireless 2.5 GHz transmitter [3]. Schreiber research in 2014, Code Triage: Integrating the National Children's Disaster Mental Health Concept of Operations Across Health Care Systems, thus requiring the application of a concept that can streamline medical personnel at every natural disaster site such as the concept of triage [4].And in the Harbouche research of 2017 it was revealed that the analysis of wireless sensor network performance for patient pulse monitoring is influenced by the reliability of network infrastructure which is one of the factors affecting wireless network performance performance [5]. Meanwhile, according to AlDossary research in 2017, from the technological aspect, electronic telemedicine health equipment is still limited to use, and even then only in certain hospitals and for general public use is still very limited [6].

Wireless Sensor Network (WSN) or Wireless Networking Sensor is a wireless network consisting of multiple sensor nodes that are placed in different places to monitor environmental conditions. Abreu in his research in 2014 revealed that there are various types of wireless sensing network application model for human health monitoring purposes such as Fundamental of Wireless Sensor Network, proposing internet-based wireless technology to monitor the health condition of patients so that medical record data can be known continuously [7]. Meanwhile, Research conducted by Li, Chao in 2017, runs a prototype Implementation of telemedicine systems utilizing the technical advantages of flexible telecommunication systems based on PDAs and their use is limited to certain hospitals [8].

Furthermore, in a study conducted by Kim in 2014, by making a device that utilizes wireless sensor network for remote monitoring of patient signals based on Bluetooth technology. Bluetooth replaces the role of the sensor connector to a computer that will transmit medical data to a medical server [9]. Another study by Khalily in 2017 on the implementation and performance evaluation of wireless devices is the application of wireless sensor networks for monitoring the patient's pulse rate. wireless sensor network devices are used to monitor the heart rate as a WSN implementation on monitoring the patient's pulse rate. The programming used is C language or Arduino programming to perform data processing and to form ad-hoc networks. This test is done with two stages, namely the delivery and data reception. From the test results indicate that this WSN can work well on the sender side and there is delay delivery of variable signal [10, 11]. Research conducted by Kamimura, in 2017, on A self-organizing network coordination framework enabling collision-free and congestion-less wireless sensor networks. Data sent and received does not overlap because this system uses Time Division Multiple Access or commonly abbreviated TDMA. 5 sensors are controlled using the node coordinator. The node coordinator will connect to the server system over the wireless network. In this study, the experimental results show between experiment and simulation at 1 (one) meter distance and the same node number of 5 sensors, the ratio of throughput is 83.21% versus 94.46%. The further the data transmission distance from the node sensor to the node coordinator the smaller the resulting throughput [12, 13].

The Applied Product Research proposed here combines telemedicine and wireless node sensor electronics by measuring and monitoring parameters of high blood health and heart rate making it easy to use. The patient's actual condition can be monitored through the information system media in the hospital. This study produces data that match the conventional measurements of the pulse and body temperature, and can be used by the general public as it is made flexible and user-friendly. The purpose of this study is to help the community of outpatients with chronic hypertension, identify patients requiring immediate care based on age, level or level of condition and location, help to reduce hospital queue BPJS and medical clinic queue, and implement Wireless Sensor Network with ESP8266 , test the success of data acquisition and implement decision support in priority handling of patient care. Through the cluster development model approach The information system of hypertensive outpatients, this research is expected to generate new breakthroughs to overcome the problems that have been faced by outpatients and hospitals such as Repair service hospital service, patient efficiency with high queue level, Tranquility patients in outpatient and improve nurse skills in obtaining data acquisition level.

II. RELATED WORK

2.1 A Digital Tension meter

A digital tension meter is a tool used to measure blood pressure using digital technology. By knowing how much blood pressure, we can assess whether our blood pressure is normal or not. The normal human adult blood pressure is 100-130 mmHg for systolic pressure and 60-90 mmHg for diastolic pressure. Systolic pressure is the blood pressure in the event of heart muscle contraction. Diastolic pressure is the blood pressure when the heart is rested. Someone is said to suffer from high blood pressure if blood pressure above 140/90 mmHg. Someone is said to suffer from low blood pressure if blood pressure below 90 / 60mmHg. The procedure of using A Digital Tension meter is to sit with the bare sleeve, may use a short-sleeved shirt or a long sleeves rolled upwards. Look at the sleeve rolls, not too tight. Place your arms freely on the table, with your arms at equal height with your heart position [14].

The installation of the A Digital Tension meter in the arm is approximately 2.5 cm from the elbow. Make sure the A Digital Tension meter installation is not too tight. Give a 2 finger distance between the A Digital Tension meter and the arm. Put pressure on the A Digital Tension meter by pumping or by pressing the on-off button. When the pumping stops, the pressure on the A Digital Tension meter will decrease and the blood can flow again to the forearm. The first pulse to appear is systolic pressure and the last heard sound is diastolic pressure [15].

In A Digital Tension meter, the result will automatically exit the screen. Approximately 30 minutes before the measurement do not do too heavy activities, smoking, drinking caffeinated drinks such as coffee, tea, coca-cola and do not consume drugs containing caffeine, such as extra Panadol, Paramex Before doing the measurement sit quietly for 5 minutes and do not stress.As long as do the measurement press with A Digital Tension meter, do not talk. Make measurements 2-3 times, with at least 2 minutes interval, and calculate the average result. For patients with hypertension, routine blood pressure is required to determine the effects of antihypertensive drugs taken. Check at the same time each day to get more accurate results [16].

2.2. ESP 8266 Module

ESP8266 is a wifi module that serves as a microcontroller enhancement such as Arduino to connect directly to wifi and create TCP / IP connections. This module requires about 3.3v power by having three wifi modes ie Station, Access Point and Both. This module also comes with processor, memory, and GPIO where the number of pins depends on the type of ESP8266 we use. So this module can stand alone without using any microcontroller because it already has equipment like a microcontroller. It has Message Queuing Telemetry Transport (MQTT). The low power consumption and low bandwidth of MQTT protocol make this system practical for patients and low-cost that quite suitable for small or rural hospitals[17] .

Fig.1. ESP8266 Module

ESP 8266 shows by Fig.1. The default firmware used by this device uses NodeMCU using basic Lua programming, Arduino Editor with C ++ programming and GCC compiler [18].

2.3. Data Acquisition

Data acquisition system is a collection of components that work together that the purpose of collecting, storing, data processing, and data distribution to generate meaningful information and useful for decision-making process. The data acquisition system is used to measure and record signals that are basically obtained in two ways. Signals derived from direct measurements are electrical quantities. They can be voltages, frequencies, or resistance, and things that are often encountered in testing electronic components, environmental research, and quality analysis. Signals originating from transducers, eg strain-gage, thermocouple, and others. Data acquisition systems can be grouped into two main classes, namely the analog data acquisition system, and the digital data acquisition system.

2.4. RSS (Received signal strength).

To get the approximate distance between nodes based on signal strength gain, the actual and Calibration condition measurements can be made. Simple Log distance that can be used is

$$10n\log d = P_{Tx}-P_{Rx} + G_{Tx} + G_{Rx} + 20\log(\lambda) - 20\log(4\pi) \quad (1)$$

In Eq.1. where P_{Tx} [dBm] and P_{Rx} [dBm] are transmitted and received power levels. G_{Tx} [dBi] and G_{Rx} [dBi] are the relative antenna gain of the transmitter and receiver. λ[m] is the wavelength, and d [m] is the distance between the sender and the receiver. The exponent n is assumed to attain a value of 2 outside environments. To calculate the strength of the received signal, the comparison between the estimated movable moving distance RSS (d) and measured by Position (Δx) with The distance between nodes and gateways is estimated as (r1 + d) using RSS and measured as r2 with the calculation Eq.2.

$$20\log d = P_{TX} - P_{RX} + \alpha \quad (2)$$

The RSS estimates of the distance between nodes and gateways consider to r_0 (acceptable gateway connectivity range) is set to 25m based on the average distance of packet reception.

Table 1. Signal Power based on Network Requirements

Signal Strength Function		Fungsi
-30 dBm	Maximum signal strength achieved. Client Distance is very close to Acsess Point. Not typical in the real world	N / A
-67 dBm	Minimum signal strength for applications requiring timely delivery of packets, very reliable	VoIP / VoWiFi, streaming video
-70 dBm	Minimum signal strength for reliable packet	delivery. Email,
-80 dBm	Minimum signal strength for basic connectivity. Package delivery may not be reliable	N / A
-90 dBm	Sink in floor noise. Any function is highly unlikely	N / A

III. IMPLEMENTATION

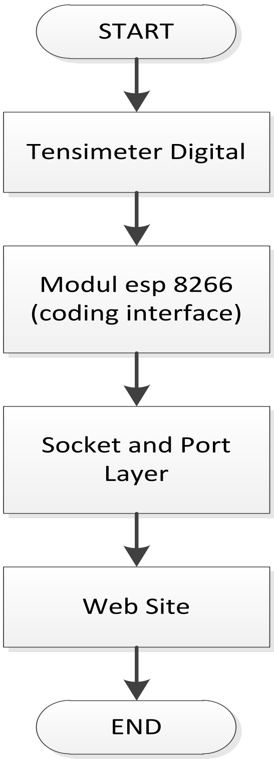

Fig.2. Block working diagram

In Fig.2 it is explained that the process of taking blood pressure systole, diastole and heartbeat of the patient comes from a digital thermometer that stores data in the form of Hexadecimal then transmitted using ESP 8266 module which is a wifi module. Inside the ESP8266 module, there is a microcontroller module that can connect to a computer that acts as a server side. The connected ESP8266 device with PC is using the concept of Access Point where ESP 8266 will act as a client and send the data in the form of hexadecimal code tension reading to be transmitted to PC Server. Meanwhile, to make ESP8266 acting as a client, Setting is done through HP device by accessing IP 192.168.4.1 when power ON A Digital Tension meter device which is IP of ESP8266 acting as an Access point. Next after connected to a wireless client-server where IP wireless ESP8266 acts as a client and IP wireless PC as server then this data is received by PC and then analyzed on PC device.

In the interface, process as shown in Fig.3, the ESP8266 module is enabled to bridge the wireless process. The configuration is done through client mode by remote to the host and set the SSID configuration.

What it does is open ports, set SSID settings, password settings, and IP hosts, while in client mode do identify the network and private key for a password to host. The script to define ESP8266 as client when connected to PC Server is done in the Arduino Compiler as shown in the script below and then uploaded to ESP 8266 ROM memory

```
#include <ESP8266WiFi.h>DataSiap
#include <EEPROM.h>
char ssid      [40] ;// = "Nama_SSID";
char password  [40] ;//= "Password_SSID";
char host      [20] ;//= "IP Server_WIFI";
char streamId  [40] ;// = "A00001";
char privateKey[40] ;// = "WithLoveWeDo";
int  PORT_         ;// = 2020
```

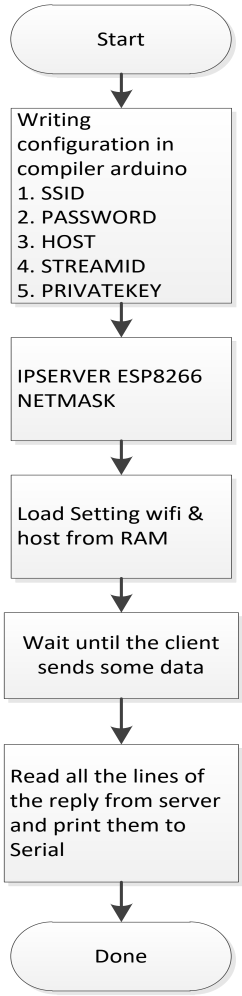

Fig.3. Interface configuration

Arduino compiler is done at once setting when ESP8266 applies as the Client or server with purpose when as a client then ESP8266 will be detected in an Access point or MIFI, while functioned as a server with IP 192.168.4.1 (default), ESP 8266 is used to send connection setting client to PC server.

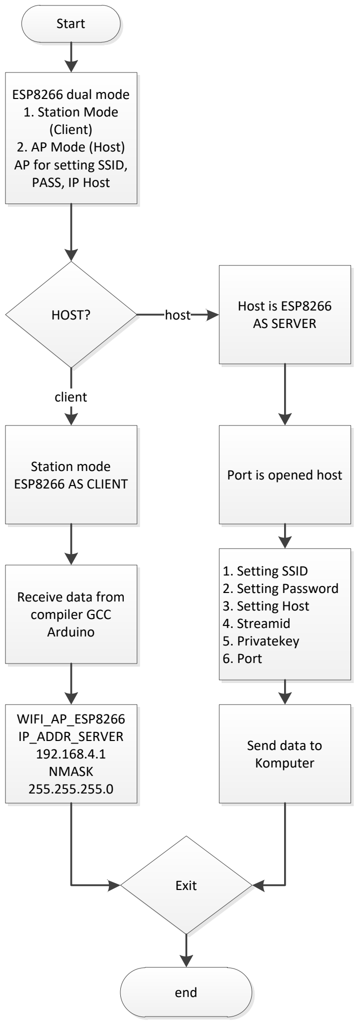

Fig. 4. ESP 8266 dual mode

Fig.4 shows ESP8266 with dual Mode function. IP dynamic Wireless is obtained from WIFI Modem (MIFI) when PC / Laptop server is connected MIFI. For example in the CMD can be typed ipconfig and obtained wireless PC Server IP is 192.168.1.100. Furthermore, this IP will be used as input on ESP8266 connection to PC Server. If there are 4-5 clients, each device will get a different IP with a fixed IP Server at 192.168.1.100. Next the opening of the port on the host (server) by each IP client to send blood pressure data from the digital A Digital Tension meter device. The stability of the connection is necessary to produce the right data acquisition. If there is no connection stability then setting access point could not be done. ESP8266 is a dual mode system in which there are host and client functions. As a client to receive configuration data from GCC Arduino compiler uploaded from the computer. As server to send data from A Digital Tension meter device to PC device via wireless module.

IV. RESULTS AND OUTCOMES

The results and Outcomes achieved in this study is a digital A Digital Tension meter product that can be connected to the server wirelessly so that patient data include systole blood pressure, diastole and heart rate can be monitored remotely.

Fig.5. ESP8266 module embedded in a digital A Digital Tension meter device

Fig.5 shows the ESP8266 module inserted on the left side of the digital A Digital Tension meter device by providing power and data source connections. This module works using 2 AAA battery consumption so that both give voltage 1.5Vx2 = 3V. This ESP8266 module has a sleep mode so when not operated after 2 minutes then the connection will be disconnected and Module in a sleep state. This effect when the setting should be no more than 2 minutes. There are Scenarios Experiments conducted to obtain data acquisition conducted in two stages; The First Trials of A Digital Tension meter devices and The second Tests using DNS servers.

4.1. Trial of A Digital Tension meter devices

Fig.6. Local Area Network Configuration

Fig.6 shows the local configuration performed to test the A Digital Tension meter device in local area network. The configuration is uploading from Arduino Compiler: SSID, password, host, Streamid, private key, Port, WIFIAPPSk and AP_nameString. Once uploaded, open ESP8266 settings via phone by first connecting to IP 192.168.4.1 where ESP8266 functioned as a server, Make WIFI setting by entering MIFI SSID, MIFI password and Host. After that send on computer server monitored using H-Term to get ASCII data stating that the PC get the data from ESP8266 which acts as Client. The next request stream can be done after opening the port in the server software.

4.2.Tests using DNS servers

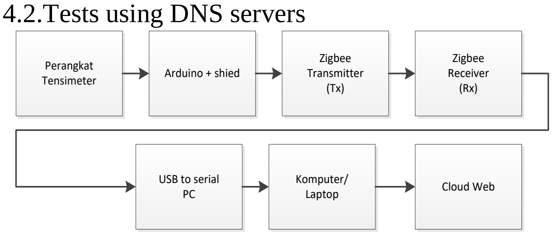

Fig.7. Configuring through DNS

Fig.7 shows a digital A Digital Tension meter configuration that uses a connection facility via a mobile phone tethering or a local WIFI that is not located in one place on the server. The configuration is done. Upload from Arduino Compiler: SSID, password, host, Streamid, privatekey, Port, WIFIAPPSk and AP_nameString do not need to be done if test 1 has been done. Once uploaded, open ESP8266 settings via phone by first connecting to IP 192.168.4.1 where ESP8266 functioned as a server, Make WIFI setting by entering MIFI SSID, MIFI password and Host is IP Wireless Server where Host has changed not IP but DNS name eg A Digital Tension meter.budids.net. DNS dynamic and IP forwarding configuration is set first by redirecting the wireless IP server to the DNS address. It is intended if the patient is on the LAN or server, the device can still provide information through DNS dynamic without having to know where the server position and without setting the local network.

4.3. Signal Analysis (RSS)
By using signal strength test can be tested ability of device to gateway node as shown in Table 2.

Table 2. Receive Signal Strength

	Node distance to AP, Without Obstruction					
	Receive Signal Strength (dBm)					
	2-4m	H	>5m	H	>10m	H
T-01, P-1	-48	S	-62	S	-78	S
T-01, P-2	-47	S	-62	S	-68	S
T-01, P-3	-44	S	-65	S	-82	G
T-02, P-1	-48	S	-62	S	-68	S
T-02, P-2	-48	S	-64	S	-81	G
T-02, P-3	-46	S	-61	S	-68	S
	Node distance to AP, Wall obstruction					
	Receive Signal Strength (dBm)					
	2-4m	H	>5m	H	>10m	H
T-01, P-1	-52	S	-70	S	-84	G
T-01, P-2	-67	S	-66	S	-86	G
T-01, P-3	-52	S	-67	S	-84	G
T-02, P-1	-52	S	-65	S	-87	G
T-02, P-2	-52	S	-64	S	-84	G
T-02, P-3	-52	S	-72	S	-84	G

With T = A Digital Tension meter, P = Experiment, H = Outcome, S = Success and G = Failed, with Receive Signal Strength unit is dBm.

4.4. Tests to retrieve patient data

This trial was conducted to test the reliability and data acquisition. Basically, the inequality of experimental results in the same process occurs due to the position of the tool that is not the same, the influence of arm position, the patient's condition, and the stability of the network at that time as shown in fig.8.

Fig.8. Trial result of connection to the server

This trial is done by using 2 pieces of digital A Digital Tension meter device. From both devices are sent data systole, diastole and heart rate simultaneously. Each device has its own ID and ordered. Dynamic IP obtained from wifi modem (MIFI).

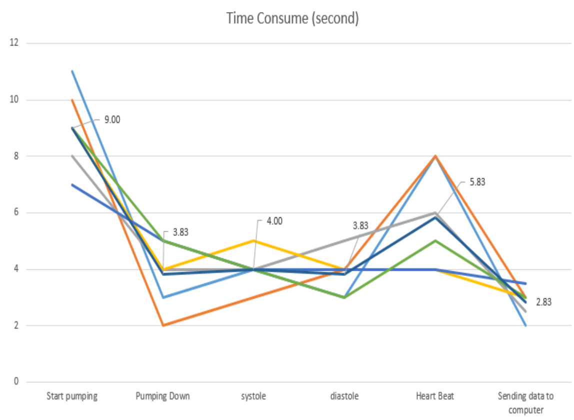

Fig.9. Consumption of device time

From Fig.9 it can be seen that there is pumping process, discharge pump, calculate systole value, calculate diastole, value and heartbeat rate followed by data transfer with an ESP8266 interface with average transfer time is 3-4 seconds and total consumption time of tool usage is about 29- 30 seconds.

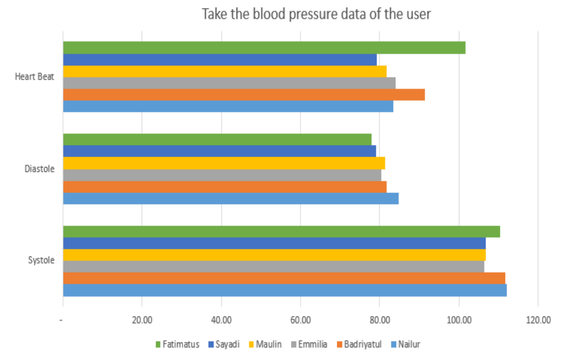

Fig.10. User's blood pressure taking

Fig.10 shows graphs of high blood pressure, low blood pressure, and user heart rate. The retrieval is done 3 times in a row on each user and the graph is the average result of systole, diastole and heartbeat values. As for the data shows that if the user has high blood pressure, then the heart rate is also likely to be high. The Trial of device data transfer was performed using 50 experimental data derived from the direct retrieval of patient data. There are some instances of data failed to transfer due to several factors such as the position of the arm does not fit so that an error occurs. Where this is because of the position of the pressure sensor, error because the network has not connected / slow connection and power battery run out / weak. As for the data, if the stable connection tends to be accepted is 100%.

Table 3. Test Result of devices have failed or succeeded.

		Number of events	
		Successful	Failure
1	Device Data Transfer 1 (ID A0001)	5	45
2	Device Data Transfer 2 (ID A0002)	6	44

Table 3 shows the Percentage of Devices 1 experienced the success of data transfer is = 45/50 = 90% and Percentage of Device 2 experiencing the success of data transfer is = 44/50 = 88%.

V. CONCLUSION

ESP8266 successfully performs its task of carrying ASCII data containing the systole, diastole and heart rate values of digital A Digital Tension meter devices to PC servers over wireless networks for both local and network networks via operators. The factors that affect data acquisition are digital A Digital Tension meter position on the arm, pressure sensor position, battery power supply, stable network availability. The device response time since the pumping process, calculating the value of systole, diastole and heart beat and data transfer from ESP8266 to server average is 28-30 seconds with the probability of the success rate of transfer 88-90% .As for suggestions for further research is an improvement on the mechanical process of pumping blood pressure, because in addition to require sufficient and stable power also required sensitivity valve sensor to the outside air so that no leakage occurs during the pumping process.

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