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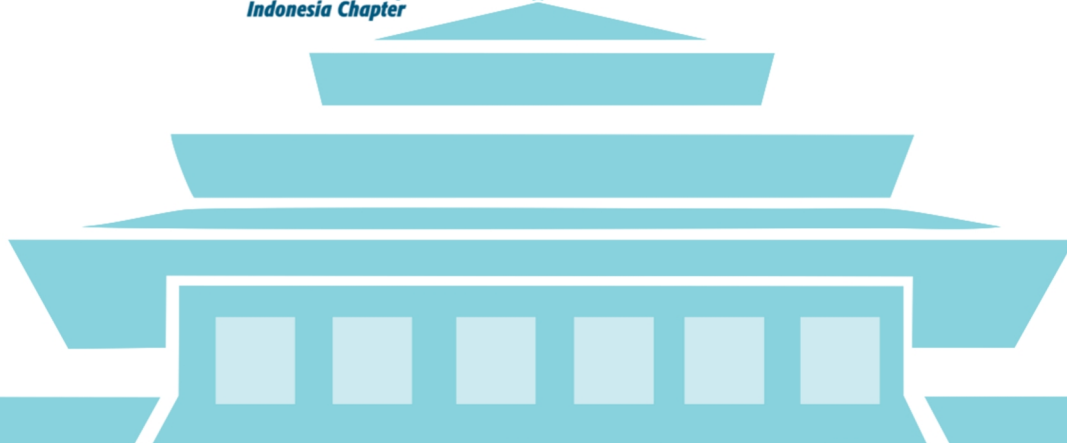
CONFERENCE PROCEEDINGS

13-15 September 2016, Grand Royal Panghegar Hotel, Bandung - Indonesia

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2016 International Conference on Control, Electronics, Renewable Energy, and Communications (ICEREC)

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Part Number: CFP16C03-ART
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TABLE OF CONTENTS

NO.	PAPER TITLES AND AUTHORS NAME	PAGE NO.
1	Comparison with HTTP and MQTT on Required Network Resources for IoT <i>Tetsuya Yokotani; Yuya Sasaki</i>	1
2	A Low Cost Internet of Things (IoT) System for Multi Patient ECG's Monitoring <i>Mochamad Ryan Fajar Nurdin; Sugondo Hadiyoso; Achmad Rizal</i>	7
3	Efficient and Secure Data Delivery in Software Defined WBAN for Virtual Hospital <i>MD Shayokh; Abebe Abeshu; Gandeva Bayu Satrya; Muhammad Arief Nugroho</i>	12
4	Controlling and Monitoring Project Based on Android Application for Fiber Optic Infrastructure <i>Akhmad Hambali; Rizky Pratama; Ridha Negara; Mohamad Ramdhani; Arina Fadhilah; Rohmat Tulloh</i>	17
5	Digital Forensics Study of Internet Messenger: Line Artifact Analysis in Android OS <i>Gandeva Bayu Satrya; Muhammad Arief Nugroho; La Ode Harisman</i>	23
6	Anonymous Sender Data to Kleptocharger Using Android Malware <i>Arief Ikhwanul; Surya Michrandi Nasution; Fairuz Azmi</i>	30
7	Inter-regional Voice Bandwidth Calculation on IMS Network <i>Danu Dwi Sanjoyo; Rendy Munadi; Fidar Laksono; Tjahjo Adiprabowo</i>	35
8	Performance Analysis of Dlife Routing in a Delay Tolerant Networks <i>Zulkhan Kurniawan; Tody Wibowo; Leanna Yovita</i>	41
9	Performance Analysis of Social-aware Content-based Opportunistic Routing Protocol on MANET Based on DTN <i>I Gede Agus Surya Negara; Leanna Yovita; Tody Wibowo</i>	47
10	Analysis Secure Socket Layer Protocol with Heartbleed Bug and Distributed Denial-of-Service <i>Jafar Alim Habibi; Rendy Munadi; Leanna Yovita</i>	54
11	Wideband Parasitic Antennas Design and Realization to Improve Laptop Antenna Reception <i>Max Alexander Rura Patras; Adit Kurniawan; Bambang Nugroho; Yuyu Wahyu</i>	60
12	Design of Attitude Determination and Control System Using Microstrip Magnetorquer for Nanosatellite <i>Defrandi Haryadi; Heroe Wijanto; Budi Syihabuddin; Agus D. Prasetyo</i>	65
13	Modified Wilkinson Power Divider 1 to 4 At S-Band <i>Christian Mahardika; Bambang Nugroho; Budi Syihabuddin; Agus D. Prasetyo; Dwi Andi Nurmantris</i>	70
14	Robust Blind Beamforming for LTE in Multipath Environment <i>Osama Mohamed; Hassan El Kamchouchi; Darwish Mohamed; Wael Ali</i>	74

15	Scaling Technique of Triple Play Services in Passive Optical Network Using Subcarrier Allocation Algorithm <i>Mihya Zaki; Adit Kurniawan; Rina Pudjiastuti</i>	81
16	Mapping Algorithm Using Ultrasonic and Compass Sensor on Autonomous Mobile Robot <i>Aulian Fathan; Agung Nugroho Jati; Randy Saputra</i>	86
17	Maximum Allowable Time Delay on Networked Control System Using Guaranteed Cost Method <i>Prasetya Dwi Wibawa; Erwin Susanto; Favian Dewanta</i>	91
18	Autonomous Quadruped Robot Locomotion Control Using Inverse Kinematics and Sine Pattern Methods <i>Aditya Hidayat; Agung Nugroho Jati; Randy Saputra</i>	96
19	Design and Implementation of Water Level Control Using Gain Scheduling PID Back Calculation Integrator Anti Windup <i>Sony Cahya Pratama; Erwin Susanto; Agung Surya Wibowo</i>	101
20	Self-configuring Home Automation Networks Based on Psychophysical Principles <i>Jannik Fleßner; Melina Frenken</i>	105
21	Design of on Board Data Handling Using Raspberry Pi for Nanosatellite Payload <i>Aditya Urandra; Burhanuddin Dirgantoro; Budi Syihabuddin</i>	110
22	A Novel Driver Fatigue Monitoring Using Optical Imaging of Face on Safe Driving System <i>Iman R Tayibnapis; Dong-Young Koo; Min-Kook Choi; Soon Kwon</i>	115
23	Configuring SmartGLCD as Universal Data Logger for Monitoring Sound and Movement <i>Mohd Amir Abas; Maznah Dahlui</i>	121
24	Implementation of Low Interaction Web Server HoneyPot Using Embedded System <i>Dandy Rahmatullah; Surya Michrandi Nasution; Fairuz Azmi</i>	127
25	Low Pass Filter Installation for Reducing Harmonic Current Emissions From LED Lamps Based on EMC Standard <i>Fajar Karim; Mohamad Ramdhani; Ekki Kurniawan</i>	132
26	A Multiuser Vital Sign Monitoring System Using ZigBee Wireless Sensor Network <i>Ilham Berliandhy; Sugondo Hadiyoso; Achmad Rizal; Rony Febyarto</i>	136
27	Prototype of KleptoCharger for Android Device <i>Fahmi Siddiq; Surya Michrandi Nasution; Fairuz Azmi</i>	141
28	An Evaluation of 2D Indoor Localization and Mapping Using FastSLAM <i>Mia Puti Amanda; Agung Nugroho Jati; Unang Sunarya</i>	147
29	A Study of 2D Indoor Localization and Mapping Using FastSLAM 2.0 <i>Dwi Kurniawan; Agung Nugroho Jati; Unang Sunarya</i>	152
30	Heart Disorder Detection Based on Computerized Iridology Using Support Vector Machine Classification Method <i>Lintang Permatasari; Astri Novianty; Tito Purboyo</i>	157

31	<p>Wireless Sensor and Actuator Network for Aeroponics Monitoring and Control <i>Muhammad Ikhsan Sani; Simon Siregar; Aris Kurniawan; Rakhmi Jauhari; Chintya Nermelita Mandalahi</i></p>	162
32	<p>Position Estimation and Fire Detection Based on Digital Video Color Space for Autonomous Quadcopter Using Odroid XU4 <i>Muhamad Abdullah; Inung Wijayanto; Angga Rusdinar</i></p>	169
33	<p>Implementation of PID Controller and Pre-Filter to Control Non-Linear Ball and Plate System <i>Agung Adiprasetya; Agung Surya Wibowo</i></p>	174
34	<p>Beef Cattle Weight Determine by Using Digital Image Processing <i>Zein Hanni Pradana; Bambang Hidayat; Sjafril Darana</i></p>	179
35	<p>Forecasting Formulation Model for Amount of Fault of the CPE Segment on Broadband Network PT. Telkom Using ARIMA Method <i>Sonny Yuhensky; Rendy Munadi; Hafiddudin Hafiddudin</i></p>	185
36	<p>Delay Estimation Using Compressive Sensing on WSN IEEE 802.15.4 <i>Asdianur Hadi; Ida Wahidah</i></p>	192
37	<p>Digital Image Steganography with Encryption Based on Rubik's Cube Principle <i>Sevierda Raniprima; Bambang Hidayat; Nur Andini</i></p>	198
38	<p>Skewing and Notching Configurations for Torque Pulsation Minimization in Spoke-Type Interior Permanent Magnet Motors <i>Gadafi M romalan; Erwan Sulaiman</i></p>	202
39	<p>Design of A Hybrid Permanent Magnetic Flux Switching Machine with Compound Rotor Configuration <i>Mohd Fairoz Omar; Erwan Sulaiman</i></p>	208
40	<p>Design Improvement of Flux Switching Permanent Magnet Using Combined Local and Global Method <i>Gadafi M romalan; Erwan Sulaiman</i></p>	214
41	<p>Optimization of 6Slots-7Poles & 12Slots-14Poles Flux-Switching Permanent Magnet Machines for Plug-in HEV <i>Mohd Fairoz Omar; Erwan Sulaiman</i></p>	220

AUTHOR INDEX**A**

Abebe Abeshu	12	La Trobe University, Australia
Achmad Rizal	136	Telkom University
Achmad Rizal	7	Universitas Gadjah Mada & Telkom University, Indonesia
Adit Kurniawan	81	Bandung Institute of Technology, Indonesia
Adit Kurniawan	60	ITB, Indonesia
Aditya Hidayat	96	Telkom University, Indonesia
Aditya Urandra	110	Telkom University, Indonesia
Agung Adiprasetya	174	Telkom University, Indonesia
Agung Nugroho Jati	86, 96, 147, 152	Telkom University, Indonesia
Agung Surya Wibowo	101, 174	Telkom University, Indonesia
Agus D. Prasetyo	65, 70	Telkom University, Indonesia
Akhmad Hambali	17	Telkom University, Indonesia
Angga Rusdinar	169	Telkom University, Indonesia
Arief Ikhwanul	30	Telkom University, Indonesia
Arina Fadhilah	17	Telkom University, Indonesia
Aris Kurniawan	162	Telkom University, Indonesia
Asdianur Hadi	192	Telkom University, Indonesia
Astri Novianty	157	Telkom University, Indonesia
Aulian Fathan	86	Telkom University, Indonesia

B

Bambang Hidayat	179, 198	Telkom University, Indonesia
Bambang Nugroho	60	Institut Teknologi Telkom, Indonesia
Bambang Nugroho	70	Telkom University, Indonesia
Budi Syihabuddin	65, 70, 110	Telkom University, Indonesia
Burhanuddin Dirgantoro	110	Telkom University, Indonesia

C

Chintya Nermelita Mandalahi	162	Telkom University, Indonesia
Christian Mahardika	70	Telkom University, Indonesia

D

Dandy Rahmatullah	127	Telkom University, Indonesia
Danu Dwi Sanjoyo	35	Telkom University, Indonesia
Darwish Mohamed	74	AAST, Egypt

Defrandi Haryadi	65	Telkom University, Indonesia
Dong-Young Koo	115	Daegu Gyeongbuk Institute of Science and Technology, Korea
Dwi Andi Nurmantris	70	Telkom University, Indonesia
Dwi Kurniawan	152	Telkom University, Indonesia
E		
Ekki Kurniawan	132	Telkom University, Indonesia
Erwan Sulaiman	202, 208, 214, 220	Universiti Tun Hussein Onn Malaysia, Malaysia
Erwin Susanto	91, 101	Telkom University, Indonesia
F		
Fahmi Siddiq	141	Telkom University, Indonesia
Fairuz Azmi	30, 127, 141	Telkom University, Indonesia
Fajar Karim	132	Telkom University, Indonesia
Favian Dewanta	91	Telkom University, Indonesia
Fidar Laksono	35	Telkom Indonesia, Indonesia
G		
Gadafi M romalan	202, 214	Universiti Tun Hussein Onn Malaysia, Malaysia
Gandeva Bayu Satrya	12, 23	Telkom University & Kumoh National Institute of Technology, Indonesia
H		
Hafiddudin Hafiddudin	185	Telkom University, Indonesia
Hassan El Kamchouchi	74	Alexandria University, Egypt
Heroe Wijanto	65	Telkom University, Indonesia
I		
I Gede Agus Surya Negara	47	Telkom University, Indonesia
Ida Wahidah	192	Telkom University, Indonesia
Ilham Berliandhy	136	Telkom University, Indonesia
Iman R Tayibnapi	115	Daegu Gyeongbuk Institute of Science and Technology, Korea
Inung Wijayanto	169	Telkom University, Indonesia
J		
Jafar Alim Habibi	54	Telkom University, Indonesia

Jannik Fleßner 105 Jade University of Applied Sciences Oldenburg,
Germany

L

La Ode Harisman 23 Feelance Engineer, Indonesia
Leanna Yovita 41, 47, 54 Bandung, Indonesia
Lintang Permatasari 157 Telkom University, Indonesia

M

Max Alexander Rura Patras 60 Telkom University, Indonesia
Maznah Dahlui 121 Maznah, Malaysia
MD Shayokh 12 Kumoh National Institute of Technology,
Bangladesh
Melina Frenken 105 Jade University of Applied Sciences Oldenburg,
Germany
Mia Puti Amanda 147 Telkom University, Indonesia
Mihya Zaki 81 Telkom University & Telkom Indonesia, Indonesia
Min-Kook Choi 115 Daegu Gyeongbuk Institute of Science and
Technology, Korea
Mochamad Ryan Fajar Nurdin 7 Telkom Applied Science, Telkom Unibersity,
Indonesia
Mohamad Ramdhani 17, 132 Telkom University, Indonesia
Mohd Amir Abas 121 Universiti Kuala Lumpur, Malaysia
Mohd Fairoz Omar 208, 220 Universiti Tun Hussien Onn Malaysia, Malaysia
Muhamad Abdullah 169 Telkom University, Indonesia
Muhammad Arief Nugroho 12, 23 Telkom University, Indonesia
Muhammad Ikhsan Sani 162 Telkom University, Indonesia

N

Nur Andini 198 Institut Teknologi Telkom, Indonesia

O

Osama Mohamed 74 Aast, Egypt

P

Prasetya Dwi Wibawa 91 Telkom University, Indonesia

R

Rakhmi Jauhari 162 Telkom University, Indonesia
Randy Saputra 86, 96 Telkom University, Indonesia

Rendy Munadi	35, 54, 185	Telkom University, Indonesia
Ridha Negara	17	Telkom University, Indonesia
Rina Pudjiastuti	81	Telkom University, Indonesia
Rizky Pratama	17	Telkom University, Indonesia
Rohmat Tulloh	17	Telkom University, Indonesia
Rony Febyarto	136	BPPT, Indonesia

S

Sevierda Raniprima	198	Institut Teknologi Bandung, Indonesia
Simon Siregar	162	Telkom University, Indonesia
Sjafril Darana	179	Padjadjaran University, Indonesia
Sonny Yuhensky	185	Telkom University, Indonesia
Sony Cahya Pratama	101	Telkom University, Indonesia
Soon Kwon	115	Daegu Gyeongbuk Institute of Science and Technology, Korea
Sugondo Hadiyoso	7, 136	Telkom University, Indonesia
Surya Michrandi Nasution	30, 127, 141	Telkom University, Indonesia

T

Tetsuya Yokotani	1	Kanazawa Institute of Technology, Japan
Tito Purboyo	157	Institut Teknologi Bandung & Telkom University, Indonesia
Tjahjo Adiprabowo	35	Telkom University, Indonesia
Tody Wibowo	41, 47	Telkom University, Indonesia

U

Unang Sunarya	147, 152	Telkom University, Indonesia
---------------	----------	------------------------------

W

Wael Ali	74	AAST, Egypt
----------	----	-------------

Y

Yuya Sasaki	1	Kanazawa Institute of Technology, Japan
Yuyu Wahyu	60	LIPI, Indonesia

Z

Zein Hanni Pradana	179	Telkom University & ST3 Telkom Purwokerto, Indonesia
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WELCOME MESSAGE FROM THE CONFERENCE CHAIR

Dearest Scientists, Engineers, Colleagues, Ladies and Gentlemen,

It is our great pleasure and honor to welcome you to ICCEREC 2016, The 2nd International Conference on Control, Electronics, Renewable Energy, and Communications and also to our beautiful Bandung. This city was nicknamed “City of Flowers” and “Paris Van Java” (“*The Paris of Java*”).



ICCEREC 2016 is organized by School of Electrical Engineering Telkom University and technical co-sponsored by the IEEE Communications Society Chapter Indonesia, so that ICCEREC has a strong foundation of bringing together industry and academia.

This conference provides an international forum for researchers, academicians, professionals, and students from various engineering fields and with cross-disciplinary interests in ***Control and Automation, Electronics, Renewable Energy, and Communications***.

Accepted papers on ICCEREC 2016 are published in the ICCEREC 2016 Conference Proceedings and presented papers will be submitted to **IEEE Xplore**. As information, the Proceedings of ICCEREC 2015 has been published in **IEEE Xplore** and indexed by **SCOPUS**.

In this moment, I would like to thank, all those who have contributed to the success of ICCEREC 2016, such as Organizing Committee from School of Electrical Engineering Telkom University, IEEE Communications Society Chapter Indonesia. We also say thank you to the TPC Chair, the TPC Members, the Keynote Speakers, Tutor Speaker and the Technical-sessions Moderator of ICCEREC 2016.

The last, we hope all participants will have valuable and also enjoyable experience during this event and very pleasant stay at Bandung.

Sincerely Yours,

General Chair

Muhammad Nasrun
Telkom University

WELCOME MESSAGE FROM TPC CHAIR

Dear Ladies and Gentlemen,



On behalf of the ICCEREC 2016 Technical Program Committee, we are very delighted to welcome you to the 2nd edition of International Conference on Control, Electronics, Renewable Energy, and Communications (ICCEREC 2016), in Bandung, Indonesia. Located right in the middle of West Java, Bandung is a beautiful, multi-cultural and multi-ethnic city, and the temperature is mildly warm. Modern buildings intertwined with colonial architecture, parks with full of color, streets, markets, mosques, and houses mingle in an exotic blend, which are active during the day and night.

In this conference, we are trying hard to make a high quality technical committee that will feature three plenary talks to enlighten the audience with world-class speakers on the latest topics on Signal Processing, Renewable Energy and Telecommunications, tutorial sessions presenting hot topics on several subjects, and technical sessions with high quality papers. We set a high standard for a paper, that each paper should have been reviewed by minimum 4 international reviewers. Our professional team is committed to establishing a conference for sharing the latest technical/research advancements. In addition, the conference will also feature with the launching of a new Indonesian Chapter of IEEE Signal Processing Society.

We would like to thank all the authors who submitted their papers to ICCEREC 2016. It is our pleasure to know that you will appreciate the high quality and wide variety of the ICCEREC 2016 technical programs, have fruitful discussions with other researchers, and enjoy the beautiful venue. We would like to express our sincere appreciation to the Technical Program Committee members and paper reviewers for their great work in shaping the technical program and handling the paper review process. The TPC particularly wish to thank the organizing committee colleagues. You have all helped to create a technical program of the greatest interest. We hope you all enjoy it!

Sincerely Yours,

TPC Chair,

Dr. Ing. Fiky Yosef Suratman
Telkom University

PROGRAM AT A GLANCE**Day One: Tuesday, 13 September 2016**

TIME	AMARTAPURA C	MADHUKARA A	AYODYA C
07.00 - 08.30	Table Registration		
08.30 - 08.45	Opening Speech		
08.45 - 09.00	Speech from the Chair of ICCEREC and APWiMob		
09.00 - 09.15	Launching IEEE SPS Indonesia Chapter		
09.15 - 10.00	Keynote Session I		
10.00 - 10.30	Coffee Break & Photo Session		
10.30 - 11.15	Keynote Session II		
11.15 - 12.00	Keynote Session III		
12.00 - 13.00	Lunch Break		
13.00 - 15.00		Tutorial Session I	Technical Session I
15.00 - 15.15		Coffee Break	Coffee Break
15.15 - 17.00		Tutorial Session II	Technical Session II

Day Two: Wednesday, 14 September 2016

TIME	MADHUKARA A	AYODYA C	AYODYA D
08.00 - 09.30	Tutorial Session III	Technical Session III	Technical Session IV
09.30 - 09.45	Coffee Break	Coffee Break	Coffee Break
09.45 - 11.00	SPS (Signal Processing Society) Indonesia Chapter 1 st Meeting	Technical Session V	Technical Session VI

A Low-Cost Internet of Things (IoT) System for Multi-Patient ECG's Monitoring

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Abstract— This paper discussed one application of IOT as media data transmission for the electrocardiogram (ECG) signal. We developed ECG monitoring system that can be accessed by several users simultaneously via the internet network. The system consists of ECG hardware, transmission module based on Zigbee and web server for data storage and web application. The ECG signal taken from body's patients is acquired by the ECG machine, and then raw data is sent serially to the computer server using Zigbee. Furthermore, the data can be accessed by other authorized parties via the web pages for the purpose of treatment or consultation. By using this application, patients with heart diseases can interact and consult with a cardiologist anytime and anywhere. The testing result shows that the system can handle up to 20 users without errors. Meanwhile for 50 – 150 user some errors occurred due to insufficient bandwidth or high data traffic on the server.

Keywords—Telemedicine, ECG, IoT, Webserver, Zigbee, Wireless sensor network

I. INTRODUCTION

Development of telemedicine technology increase rapidly becomes more sophisticated and widely used to support applications in the health sector. One of the technologies which are support telemedicine is wireless sensor network (WSN) for a vital signal monitoring system. Furthermore, WSN is connected to the internet that can be accessed widely; the technology is commonly known as the Internet of Things (IOT). IOT is a dynamic network that can use the intelligent interface that can be effortlessly integrated into the global information network [1].

One of a vital signal in health is the ECG signal which can provide heart health information [2]. Observation of the ECG signal is sometimes performed continuously and not limited to space and time, which means not only in health care centers. Therefore, we need a system that can answer the challenge. An ECG machine that can connect to the Internet to facilitate the exchange of information is required.

Some researchers have made a vital signs monitoring system based IOT and the majority focus on the ECG signal. Nguyen et.al [3] developed healthcare monitoring system (Many Vital Sign Monitor) use the IOT-based 6LoWPAN network. The researcher made a real-time monitoring system centrally with multiple network topology for multiple users.

Hardware used is medical sensor nodes TI CC2538 SoC with ARM Cortex M3 as a processing unit.

Another study by Mohammed et.al [4] present a remote patient monitoring using web services and cloud computing. The focus of his research is to make an Android application for ECG signal monitoring and data storage for later upload to the cloud that can be accessed by the medical side. Their paper did not discuss the use of multi-user.

In our previous research, we developed Android applications to detect arrhythmias using Bluetooth as a communication medium between the signal acquisition device with a smartphone [5]. The monitoring system is point to point, the ECG device is connected to a smartphone and can only be accessed on a Bluetooth communication radius. In other paper, we reported ECG monitoring system using openMTC platform [6]. In the paper, ECG signal was transferred point-to-point. openMTC platform is allowed to expand the system into bigger system scale, but cost issue makes some limitation in system development [6].

In this paper, we present a low-cost internet of things (IOT) System for multi-patient monitoring ECG. ECG signals are sourced from a number of users acquired by the sensor nodes. By MCU, the signal is digitizing and then sent serially to the server computer using ZigBee as a medium of communication. Contributions of the studies are: create a system to monitor ECG IOT with low costs and resource material MCU memory as small as possible, monitoring can be done for many users who connect to the internet and web-based applications to realize the information widely accessible.

The paper is organized as follow; the design and implementation of our proposed system are presented in Section II. Section III explains the result of our testing on the proposed system, and the conclusion of the paper is presented in Section IV.

II. DESIGN AND IMPLEMENTATION

A. ECG Hardware

An ECG hardware is used for ECG signal acquisition process. The disposable electrode is attached to the skin surface to convert ion current in the body to electron current in the bio-potential circuit. We use Einthoven's triangle for electrodes

placement as showed in Fig.1. Meanwhile, the biopotential amplifier circuit is shown in Fig.2.

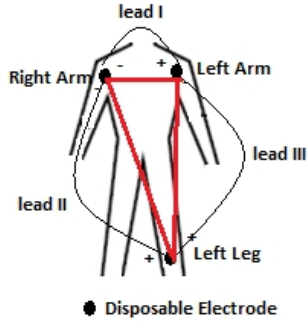


Fig. 1. Einthoven's triangle [7]

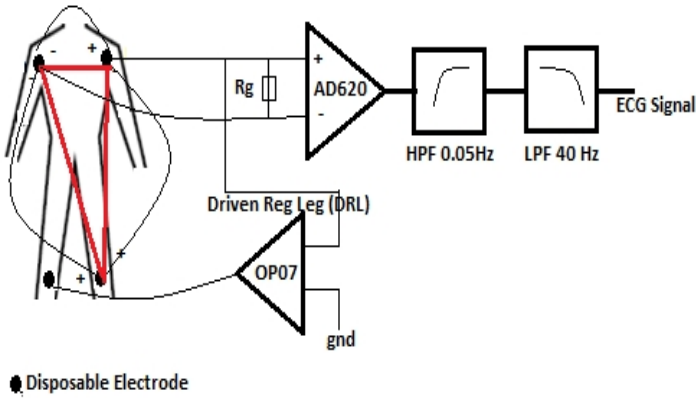


Fig. 2. Bio-potential amplifier circuit [8]

In this research, we use first-order High-Pass Filter (HPF) with a cut-off frequency 0.05 Hz to reduce motion artifact noise. HPF is implemented using R-C in a parallel manner where the R-C value obtained from (1).

$$F_c = \frac{1}{2\pi RC} \quad (1)$$

To reduce high-frequency noise then we made 3rd-order Butterworth LPF with a cutoff frequency of 40 Hz. At this frequency range, the ECG signal can be analyzed without damaging the signal information. The value of R-C for 3rd-order LPF can be calculated using (2).

$$\begin{aligned} C_1 &= \frac{1}{2\pi f_c R} \\ C_2 &= \frac{2Q}{R\omega_0} \\ C_3 &= \frac{1}{2\pi f_c 2R} \end{aligned} \quad (2)$$

B. Microcontroller

The ATmega328 is used as a processing unit for converting analog signals into digital data and then transmit 10-bit serial data to the server with ZigBee as transmission media. Each ECG machine has a unique code that is sent along with the data raw ECG to differentiate patients with one another. The illustration can be seen in Fig. 3.

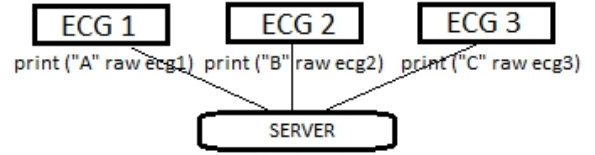


Fig. 3. Illustration of data transmission format

The characters A, B, and C, are used to identify the patient's ID. So the raw ECG signal can be reconstructed on the system in agreement with the signal source. This is the code of program:

```
void loop() {
  adc_data = analogRead(0); //read ADC channel 0
  Serial.print("A"); //Sign Header from Node 1
  Serial.print(adc_data); //Send serial data
  delay(10); //delay 10 ms
}
```

C. ZigBee

In this study, the data is transmitted wirelessly using XBee Series 2 that can support the mesh topology of PAN 802.15.4 standard communication protocol. XBee hardware and pin connection to the microcontroller can be seen in Fig. 4.

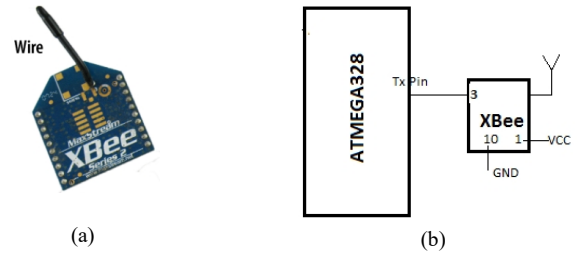


Fig. 4. (a) XBee Radios [9] (b) Pin Connection

In this study, each ECG device is connected to the XBee that acts as an end device. On the server side, XBee is functioned as coordinator to forward the data sent by all connected ECG devices. XBee settings are set using the XCTU freeware application as shown in Table 1.

TABLE I. XBEE CONFIGURATION

Coordinator AT	
Pan ID	Pan ID all node
SH Address	DH Address end device
SL Address	DL Address end device
All End Device AT	
Pan ID	Pan ID all node
DH Address	SH Address coordinator
DL Address	SL Address coordinator

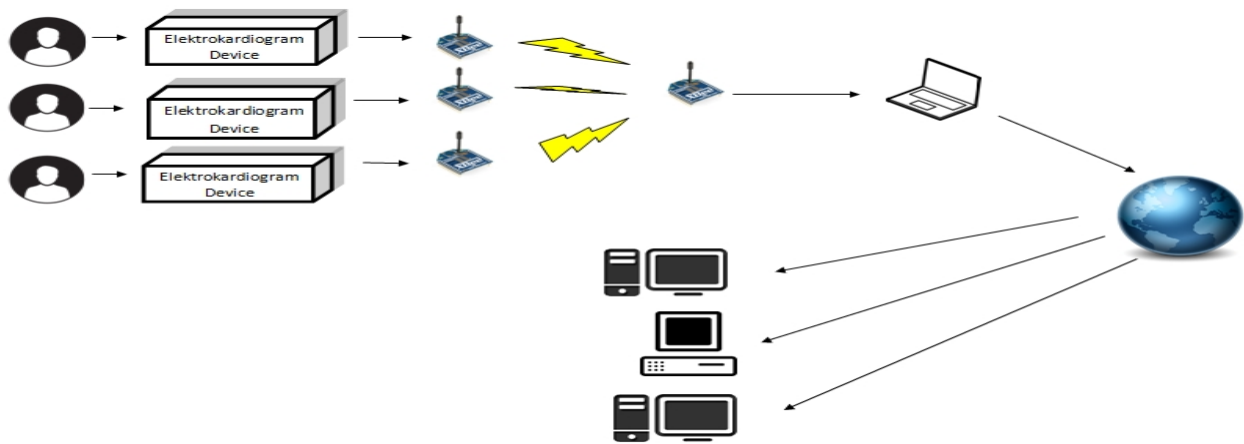


Fig. 5. System Design

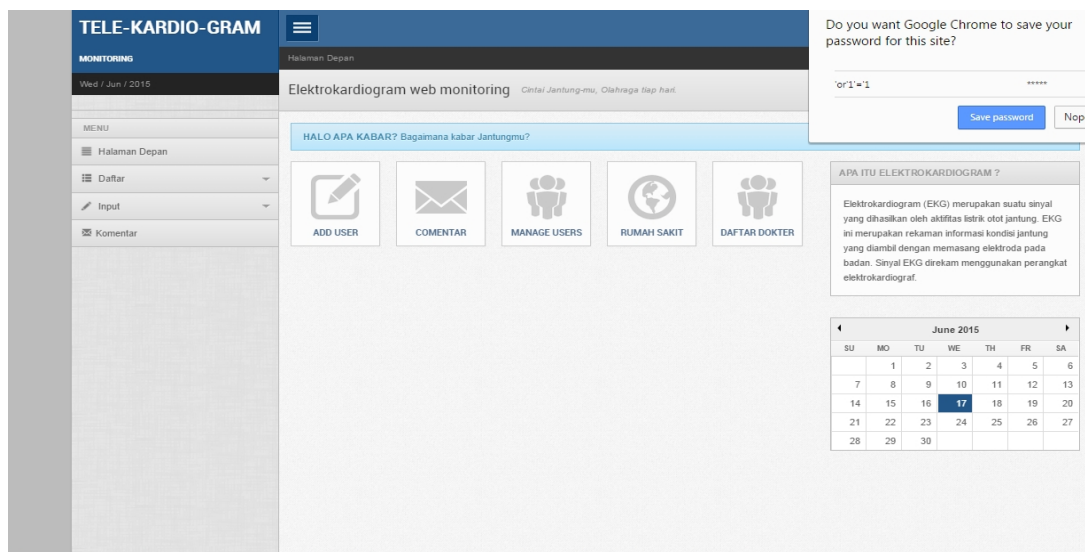


Fig. 6. Main page of web application

D. System Design

The ECG monitoring system scenario which is implemented in this paper can be seen in Fig. 5. When the ECG signal is measured, each user is connected to the ECG device. All signal data is stored on a computer server and then are forwarded to the network, the Internet cloud. Authorized person can monitor and interact through message box which is available from the Web page that can be accessed using a PC, Laptop, Smart Phone, PDA's, etc.

Received ECG signal is stored in the database and displayed on a Web Application. There are three types of authority level that can access data: Administrator, Physician, and Patient. Administrators have the highest privileges on this website. The administrator can create new user account, user or the new administrator. The administrator can upload the ECG data graph all the patient. Administrators have the right for user management to change the data from each patient.

Doctors can monitor ECG graph of all patient. Doctors are also allowed to access the comments feature for consultation

between patient and doctor. Patients are only allowed to view their ECG signal after getting a username and password from the administrator. Patients are also allowed to access features available in the patient web page such as comments, search hospitals, and physician search. The main page of the web application can be seen in Fig. 6.

E. Testing Scenario

There are two main test scenarios: display the graph on the application page and web server load testing. Graph display test is performed to determine whether the transmitted data can be displayed on a graph presented in the form of web applications. The web server load testing is done using Web Stress Tools and Apache Benchmark. Web applications and Apache Benchmark Tools Stress are used for simulating predetermined number users to access the page.

III. RESULT AND DISCUSSION

In this section, we discuss the results of system testing with the scenario described in the previous section. The analysis

focuses on the application performance in representing data and networking capabilities to handle user when performing the concurrent access.

A. ECG Signal Graph

ECG raw data plotting on the web application is performed to determine whether the transmitted data and the data displayed are correct and appropriate. The acquired data are stored in the form of a text file (.txt) by ECG viewer application. The data is containing character sequence integer markers as patient ID information. Admin will upload File.txt result of the data by the patient's account. Moreover, uploaded data will be plotted to display the ECG signal in ECG monitoring web applications that have been made both on the patient and the doctor.

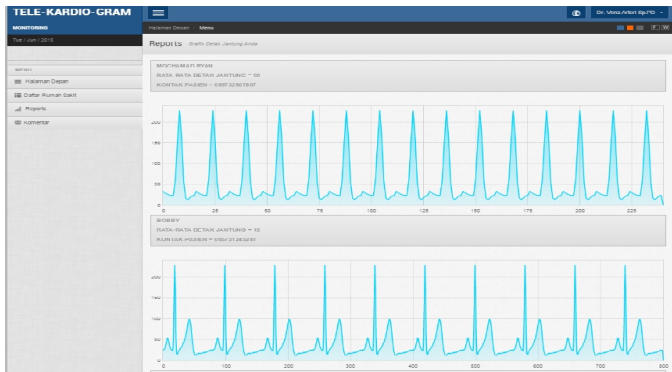


Fig. 7. Graphic samples for two patients

In ECG signal graph displayed on a web application contain information about the patient identity and the average heart rate per minute. Early diagnosis of heart health conditions based on heart rate is also shown on the application. Figure 7. show the appearance ECG signal chart displayed in web application meanwhile and information about patient heart rate.

After analyzes and conclude the health condition of the patient's heart, the physician can directly send messages through a menu, and the patient can consults with the doctor via the menu.

B. Webservice Load Testing

The test was conducted to determine the ability of the web server to handle access from several users simultaneously. Testing is performed using Web Stress Tool 8 software and Apache Benchmark. We simulate data access from 10, 20, 50, 100, and 150 users. The test results can be seen in Fig. 8 and Fig. 9.

Based on test results in Fig. 8, the web application can serve 10-20 users without error. When 50-150 users access web application simultaneously, some errors are detected. Several factors cause the errors are high traffic data, insufficient available bandwidth.

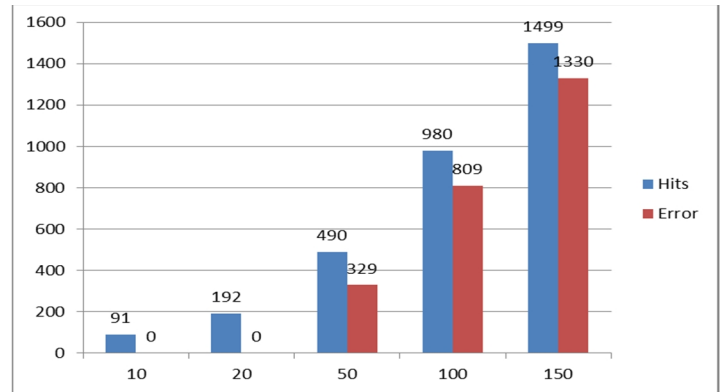


Fig. 8. Web server load testing using Web Stress Tool

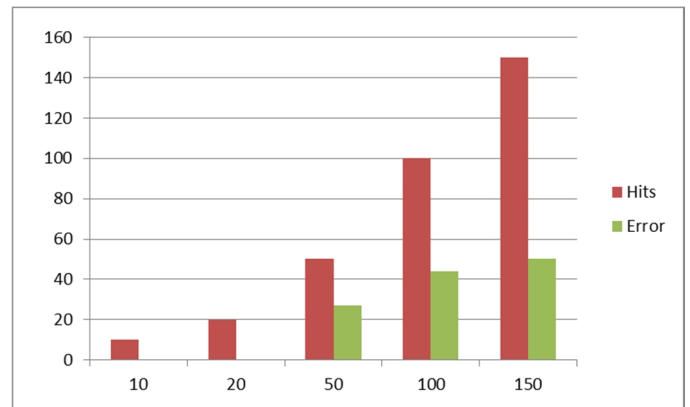


Fig. 9. Web server load testing using Apache Benchmark

The same result is shown in Fig. 9. The web server can handle 20 users simultaneously without generating an error. It can be concluded that additional server capacity is needed so the applications can run well when the number of users.

C. Discussion

There are two main features that are offered on the research on wireless ECG monitoring. The first is the number of users that can be handled at the same time. The second is the ability to recognize the pattern of the ECG signal automatically [10]. Some wireless devices ECG monitor can only handle one user as in [5] or as the proposed system that is capable of handling up to 20 users. For the ability to recognize patterns of the ECG signal, usually only one pattern ECG signal abnormality that can be detected as in [5], [10], [11], this is caused by so many patterns of the ECG signal. In the end, the main function of a wireless ECG monitoring is the ability to display ECG signals accurately from a distance so as to facilitate the doctor examined the patient ECG signal. In the develop system, the number of users can be added to a specified amount. The addition of this user at some point it will reduce the quality of the signal. For the future should be made a standard platform in order to increase the number of users can be done easily without compromising signal quality.

IV. CONCLUSION

From system testing result, we conclude that the web application for distributed ECG monitoring system has worked properly. The system can identify the patient ID code and plot the graph according to their credentials. Thus, the physician can monitor the entire patient ECG signal graphs simultaneously, interact with patients through the provided message box and so on. At this early stage of research, the server can serve 20 users simultaneously without causing an error. For next study, further signal processing is required to diagnose abnormalities of the heart and increase server capacity to serve more users.

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