Frequency Monitoring Interface Design and System using HackRF

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***Abstract*— Kominfo as a regulator in communication technology, especially in the distribution of frequency usage, always monitors the frequency circulating in the field. However, Indonesia's vast territory makes some areas outside urban areas difficult to reach. Therefore, a portable frequency monitoring system will be created. This prototype was created to maximize the monitoring system in the form of storage, processing, and visualization. Therefore, a dashboard interface that is integrated with Hack RF will be created with historical features and good visualization. This feature is needed with the aim that there are no errors or violations in the use of frequencies circulating in open spaces. The frequency monitoring system created will be accessible from any device in the same network as the website GUI system and integrated with SDR HackRF. In the GUI we will be able to listen to the sound according to the frequency we set, and the most important thing is to know the three main aspects of the spectrum, namely frequency, bandwidth, and gain. These three aspects will then be inputted from the dashboard into the database which will then be compared with the legal frequency data prototype. The results of the comparison will generate an alert system using the telegram bot.**

Keywords—Hack RF, Dashboard, Interface, Frequency, Monitoring.

I. PRELIMINARY

This final project was made with the background of the need for a portable and real time frequency monitoring system. This prototype was created to maximize the monitoring system in the form of storage, processing, and visualization. Therefore, we created a dashboard that integrates with HackRF with real time features and good visualization. This feature is needed to ensure that there are no errors or violations in the use of frequencies circulating in the open space.

The prototype feature will be maximized by the existing system for data storage, processing, and visualization. The scope of work that will be discussed is the development of software development in the form of dashboards, system integration, and finally testing. The architecture that will be built starts from a device that will later be connected to the web dashboard, then connect to a tool that will identify frequencies in open spaces.

Kominfo always monitors the frequency circulating in the field, but the vast territory of Indonesia makes some areas difficult to reach. This situation is usually used by individuals to use a frequency spectrum that is not in accordance with Kominfo regulations. Therefore, a portable device is needed to detect the illegal frequency spectrum circulating.

The use of the radio frequency spectrum must be in accordance with the designation and not interfere with each other because the nature of the radio frequency spectrum can propagate in all directions without recognizing regional boundaries. The use of the radio frequency spectrum is, among others, for the purposes of operating telecommunications networks, special telecommunications operations, broadcasting, navigation and safety, Amateur Radio and KRAP, as well as natural disaster early warning systems that are highly beneficial to the public.

The tool made will be able to receive the frequency spectrum which will be stored in the database and can be visualized to the device via the dashboard. The system will be visualized to the device, and can be flexibly used by users.

The objectives to be achieved from this final project include:

1. Design the FM radio monitoring dashboard layout.
2. Create a database system that is integrated with the dashboard.
3. Creating a radio scanning system and frequency illegality by comparing the frequencies received by HackRF and the Kominfo database.

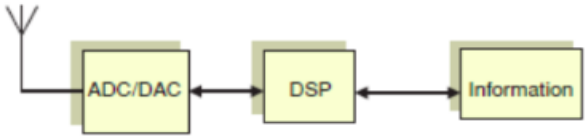
II. GENERAL ANALYTIC

Website system created using Bootstrap, Javascript, and PHP. Bootstrap is a library of CSS that is used to beautify the appearance of the website [1]. Bootstrap is used as a library for CSS because Bootstrap is one of the most frequently used libraries in frontend programming. Javascript acts as a functional of the website. Javascript is a fundamental thing in frontend programming that is why it is used at this time. But usually the frontend programming uses a framework like ReactJS or VueJS, but this design doesn't use it because pure javascript is enough to work on this design. While PHP is used as a liaison between the frontend and the backend. Although PHP is arguably a little old-fashioned, unlike laravel as an example that is often used for fullstack programming, PHP is considered sufficient for the design of this frontend system.

To complete the website system created, several other supporting systems such as XAMPP are also needed. XAMPP is a software or computer application that is widely used in the world of web developers which can also be learned to create websites [2]. XAMPP is a web server-based software that is open source and supports various operating systems such as Linux OS, Windows OS, Mac OS, and also Solaris. XAMPP stands for X (cross platform), A (Apache), M (MySQL/MariaDB), P (PHP), and P (Perl) which are the programs available in this software. XAMPP is usually used to save budget because it can replace the role of web hosting by saving website files into local hosting so that they can be called via the browser.

Software Defined Radio (SDR) is a radio communication system that uses reconfigurable software-based components for digital signal processing and conversion [7]. Unlike traditional radio communication

systems, this SDR is very flexible and versatile [7]. SDR hardware is divided into three parts, namely antenna, modulation scheme, analog-to-digital converter (ADC), and digital-to-analog converter (DAC) [7]. One of the advantages of using SDR is that SDR hardware is portable and flexible, making it easy to carry. The following is the architecture of the SDR.



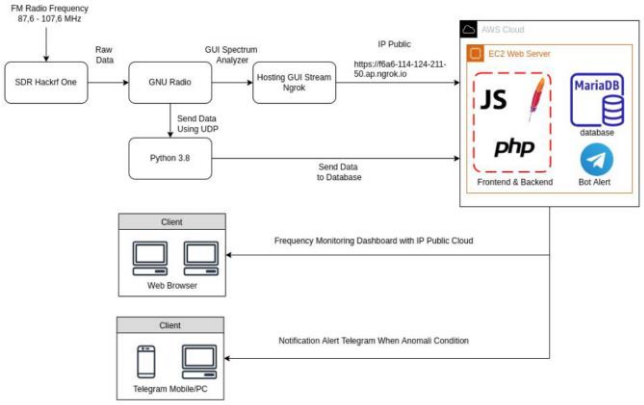
Gambar 1 SDR Architecture

In the ADC/DAC block, the main function is to convert between analog signals and digital signals. This ADC/DAC depends on the SNR value, heat dissipation, and the number of samples per sample. Furthermore, the DSP lok has a function to become a transceiver. The DSP process generally uses FFT because the influence of the sample rate on the SDR is very sensitive. [3]

HackRF One is a device that can convert radio signals with a working frequency of 1 MHz to 6 GHz, which can work on common devices such as Bluetooth, FM Radio, NFC, and cellular technology. HackRF One works with supporting components such as PCs/laptops, radio devices, Micro-USB to USB cables, and telescopic antennas with appropriate frequencies [3].

III. General System Design

An overview of the system created can be explained in detail in the block diagram below.



Gambar 2 Detail Design

The antenna connected to HackRF will pick up the signal in open space. Then the signal will be identified by GNU Radio which is integrated with Hack RF. The signal will be processed and monitored, and the data will be entered into the database. The data in the database can be accessed by a device through a dashboard which can later be seen by the user.

Website system created using Bootstrap, Javascript, and PHP. Bootstrap is a library of CSS that is used to beautify the appearance of the website. Bootstrap is used as a library for CSS because Bootstrap is one of the most frequently used libraries in frontend programming. Javascript acts as a functional of the website. Javascript is a fundamental thing in frontend programming that is why it is used at this time. But usually the frontend programming uses a framework like ReactJS or VueJS, but this design doesn't use it because pure javascript is enough to work on this design. While PHP is used as a liaison between the frontend and the backend. Although PHP is arguably a little old-fashioned, unlike Laravel as an example that is often used for fullstack programming, PHP is considered sufficient for the design of this frontend system.

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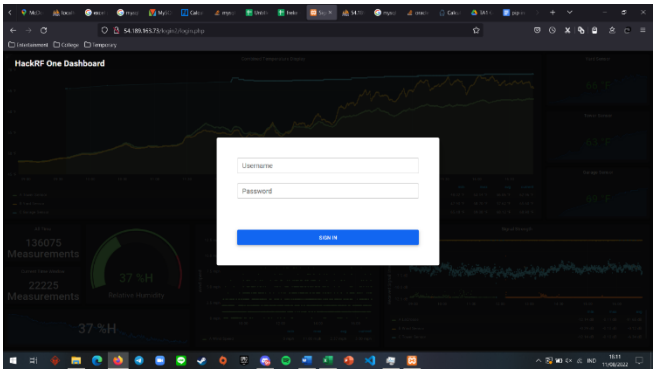
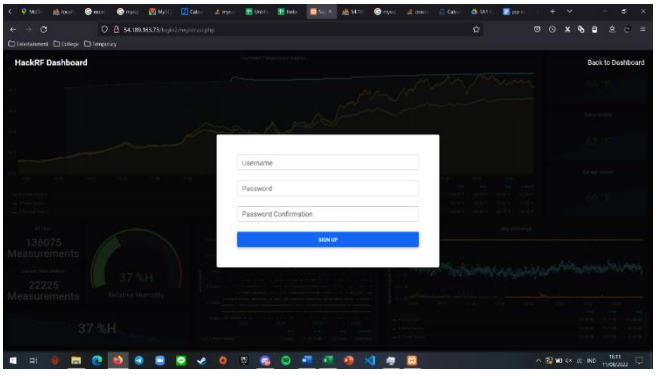
IV. Design and System Dashboard Interface

In the front-end sub-system, a layout for the login and dashboard has been made along with the basic features needed. Layout design using Bootstrap. In the login layout, a form is created to fill in the username and password. The design used is also adjusted to the theme of the dashboard that will be created. For the login page layout, two username and password fields are created, as well as a login button.



Gambar 3 Login Page

For the registration page layout, it is almost the same as the login page. However, the difference is that the registration page adds one more column, namely the “password confirmation” column which makes it easier for users to confirm the password that is filled in.



Gambar 4 Registration Page

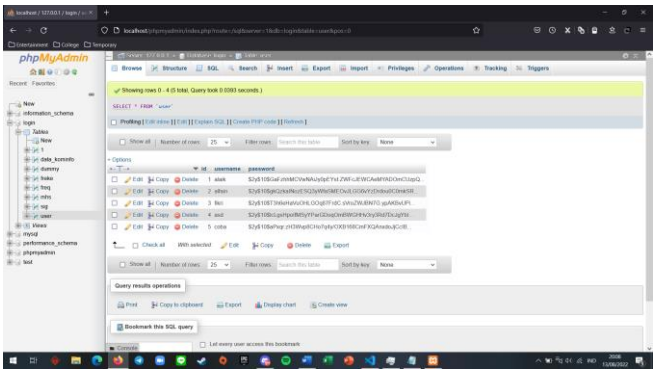
For the logout feature, a supporting page is created that can break the session that was created at login, so that it will automatically be thrown to the login page.

After logging in, the user will enter the dashboard. In the dashboard, there are five pages, namely: Frequency Spectrum, HackRF database, Kominfo database, FM radio scanning, and a list of illegal frequencies, each of which has its own function. The following is the script code for the Frequency Spectrum page. The method used is localhost GUI will be formed iframe for its appearance.

Gambar 5 Dashboard Page

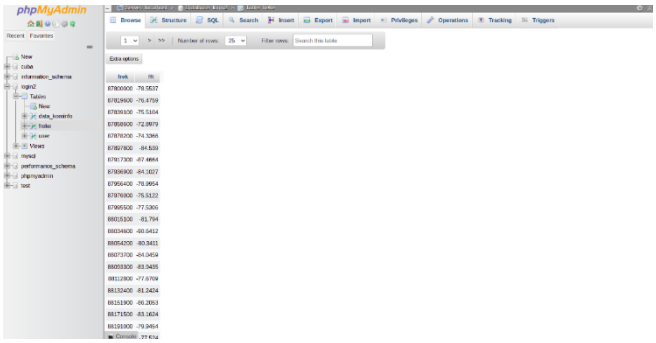
The database uses mariaDB which is built into XAMPP. In total, three databases were created in the form of tables, namely a database for logins, a HackRF database, a Kominfo database, and also two databases in the form of views for radio scanning and illegal detection. The difference is that the value of the database in the form of a table is independent, the value is in accordance with what is inputted, while the database is in the form of a view, the value depends on the value of another database. According to the needs, the value of the radio scanning and illegal detection database is in accordance with the comparison of HackRF and Kominfo databases. The logic for the comparison already exists in the analysis subsystem.

In the table for logging in, two columns are created, namely the username column and also the password column that are in accordance with the login and registration layout. The password itself will be hashed so that password security will be maintained.



Gambar 6 Login database

In the HackRF database table, two columns are created, namely for the frequency and the relative gain value. The two columns match the input that comes from HackRF itself.



Gambar 7 HackRF database

As for the Kominfo database, there are a lot of columns because the csv obtained includes all of them, but only those that are needed will be displayed such as the name of the radio station, radio frequency, radio station address, and others as shown in the layout image.

To connect the web to the database, a page is created to connect to it and it can load automatically. Next, a mySQL View will be created to create a scanning and illegal database that can change automatically according to the getdata from HackRF itself.

The concept of radio scanning is to see if there is an incoming frequency that has a relative gain value above the average. If there is, the frequency will be matched with the Kominfo database which will then display the name of the station, radio frequency, and so on. The relative gain value is determined to be 64 because based on observations, this value is able to sort out which radios are in range and radios that are out of range or noise. Below is mySQL logic codescript to create database scanning.

```
CREATE VIEW scan AS

SELECT DISTINCT B.STN_NAME, B.FREQ FROM `data_kominfo` AS B, `freke` AS A WHERE (((A.frek/1000000 > (B.FREQ - (1/2000)*B.BWIDTH)) AND (A.frek/1000000 < (B.FREQ + (1/2000)*B.BWIDTH))) AND (A.fft > -64))
```

The concept of illegal frequency detection is to see if there is an incoming frequency that has a relatively high gain above the average but does not fall into any of the radio frequency ranges in the Kominfo database. If there is, it will show how many detected frequencies are and their relative gains. The relative gain value is determined which is the same as the radio scanning concept. Below is a mySQL logic codescript to create an illegal database.

```
CREATE VIEW ilegal2 AS


SELECT DISTINCT frek, fft FROM freke WHERE frek NOT IN (

SELECT DISTINCT A.frek FROM `data_kominfo` AS B, `freke` AS A WHERE ((A.frek/1000000 > (B.FREQ - (1/2000)*B.BWIDTH)) AND (A.frek/1000000 < (B.FREQ + (1/2000)*B.BWIDTH)))) AND (fft > -64) AND (frek/1000000 < 97.69 OR frek/1000000 > 98.59)
```

V. Testing Conclusion

The purpose of making several main pages is so that each page has its own special function, making it easier for users to use this website. For the GUI page, it is used to view the frequency spectrum with the FM radio range. For the HackRF database page, to view the values that have been recorded by HackRF. The Kominfo database page serves to view lists of FM Radio stations with their frequency and bandwidth values. Scanning page and illegal to view the calculation results for scanning and illegality of the database.

The scanning calculation is done by matching the relative power value obtained by HackRF, with the FM radio frequency range in the Kominfo database. If there is a match, the station name and frequency will be displayed. For illegality calculations, it is done by seeing if there is a frequency with a relatively large power value obtained by HackRF and does not enter the FM Radio frequency range in the Kominfo database. If there is, then the frequency and relative power will be displayed on the page.

Tabel 1 Radio FM Scanning result

No	Cisitu Lama, 7 September 15.10	Cisitu Lama, 8 September 15.33	Cisitu Lama, 9 September 14.42	Pasir Kaliki, 11 Agustus 20.13	Pasir Kaliki, 11 Agustus 20.18	Pasir Kaliki, 11 Agustus 20.22
	Frekuensi (MHz)	Frekuensi (MHz)	Frekuensi (MHz)	Frekuensi (MHz)	Frekuensi (MHz)	Frekuensi (MHz)
1	88,5	88,1	88,1	88,1	88,1	88,1
2	90,1	88,5	88,5	89,3	89,3	89,3
3	90,5	88,9	88,9	90,5	90,5	90,5
4	90,9	90,1	90,1	91,7	91,7	91,7
5	91,7	90,5	90,5	92,1	92,1	92,1
6	93,3	90,9	90,9	92,5	92,5	92,5
7	93,7	93,3	93,3	92,9	92,9	92,9
8	94,4	94,4	93,7	93,7	93,7	93,7
9	96,4	96,4	94,4	94,4	94,4	94,4
10	97,2	97,2	96,4	95,2	95,2	95,2
11	97,6	97,6	97,2	95,6	95,6	95,6
12	98,4	98,4	97,6	96,4	96,4	96,4
13	99,2	99,2	98,4	97,6	97,6	97,6
14	100	100	99,2	98	98	98
15	100,4	100,4	100	98,4	98,4	98,4
16	101,5	101,5	100,4	100	100	100
17	101,9	101,9	101,5	100,4	100,4	100,4
18	102,3	102,3	101,9	101,5	101,5	101,5
19	103,1	103,1	102,3	101,9	101,9	101,9
20	104,3	104,3	103,1	103,5	103,5	103,5
21	104,7	105,1	104,3	103,9	103,9	103,9
22	105,1	105,5	105,1	104,7	104,7	104,7
23	105,5	105,9	105,5	105,5	105,5	105,5
24	105,9	106,3	105,9	105,9	105,9	105,9
25	106,3	106,7	106,3	107,1	107,1	107,1
26	106,7	107,1	106,7			
27	107,1		107,1			

From table 2, it can be seen that the differences in the location of data collection affect the scanning results of FM radio transmitters. For the old Cisitu location, 27 or 26 FM radio transmitter stations were obtained, while the Kaliki Sand location obtained 25 FM radio transmitter stations. This is because differences in observation locations can distinguish FM radio transmitters that enter the receiver's range. Then apart from differences in location, differences in the time span of taking time can also affect the results of observations. Observations with a short time span will provide better consistency of results, while observations with a longer time span can provide less good consistency of results.

VI. References

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