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Internet Reactor Laboratory Application Design on Android Client Devices

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Abstract. Preparation of human resources (HR) is important for the construction and operation of the nuclear power plant (NPP) since the project preparation phase. Preparation is carried out through education and training related to nuclear reactors. The use of nuclear reactors as learning laboratories is needed to support these activities. This research aims to design an internet reactor laboratory (IRL) application that can be operated on android devices. The application developed using LabVIEW data dashboard software with data source from the IRL database. The application is evaluated to determine application compatibility with various screen sizes of Android devices, delay time, data accuracy level, and satisfaction assessment of IRL application users. The IRL program design results consist of IRL host computer programs as a data center, and the IRL application. The test results show that the IRL application can be run on all aspect ratios with a minimum screen resolution of 640 x 360 pixels. The average delay time needed to call the first data is 4.089 seconds, and 1.234 seconds for the next data. The average data accuracy rate is 99.95% with the maximum accuracy is 100%, and the minimum accuracy is 99.10% in the reactor period data. Based on the assessment, the level of satisfaction of users of the IRL application was found to be in the category of satisfied, both overall, and in aspects of ease of use of applications, information quality, and interface quality.

INTRODUCTION

Preparation of human resources (HR) is important for the construction and operation of the nuclear power plant (NPP) since the project preparation phase [1]. It comes from universities and nuclear technology experts who have experienced working on NPP [2]. If the construction of NPP is approved in Indonesia, the number of training on NPP will be increased to provide human resources [3].

Badan tenaga nuklir nasional (BATAN), the Indonesia nuclear energy agency have been operating three nuclear reactors as research and training purpose. There are GA. Siwabessy multipurpose nuclear reactor (30 MW) in Banten, TRIGA 2000 (2 MW) in Bandung, and Kartini reactor (100 kW) in Yogyakarta. The limited number and location of the nuclear reactor become a challenge for BATAN to provide education and training on nuclear expert's preparation. Internet reactor laboratory (IRL), the remote education concept based on internet of things (IoT) can be used to solve this challenge [4]. IRL used a nuclear reactor as nuclear reactor training facilities through the internet [5].

Web-based IRL has developed by BATAN using LabVIEW as data acquisition software and MySQL as database management. Web-based IRL could be accessed using website browser software. Kartini Reactor parameters are shown on the IRL website. The third-party software, LabSocket is needed in this method to create a display page in the virtual instrument (VI) panel accessible from the browser devices [6]. The security of nuclear reactor operation couldn't be guaranteed by the third-party software. LabVIEW on android devices, LabVIEW data dashboard can be used as an alternative method in IRL development. It was developed officially by National Instruments. This alternative considered by the number of devices used in Indonesia at the end of 2017 reached 62.69 million units. An android operating system control around 85.90% of them [7].

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On this research, an IRL application in android devices will be developed. The android devices will be used as a device to show the nuclear reactor parameters. This application will be evaluated by its compatibility on android devices screen size, delay time, data accuracy, and satisfaction assessment of the users.

RESEARCH METHODS

IRL Android system design

The IRL android application divided into two main programs. The first program installed on an IRL android host computer and the second program installed in android devices. The first program developed in LabVIEW 2015 and the other developed using LabVIEW data dashboard. The IRL host program intends to function as the data center for android client devices. Kartini reactors parameters which have stored in the database server computer called, parsed, and distributed to IRL android application through local network connection by this program. The data flow in this system shown in Figure 1.

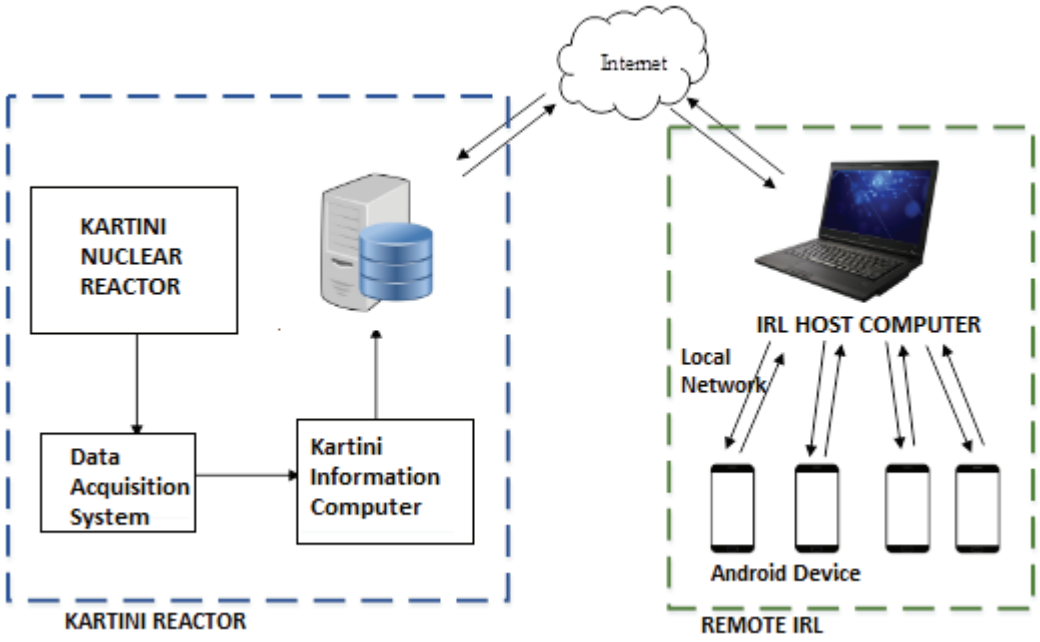


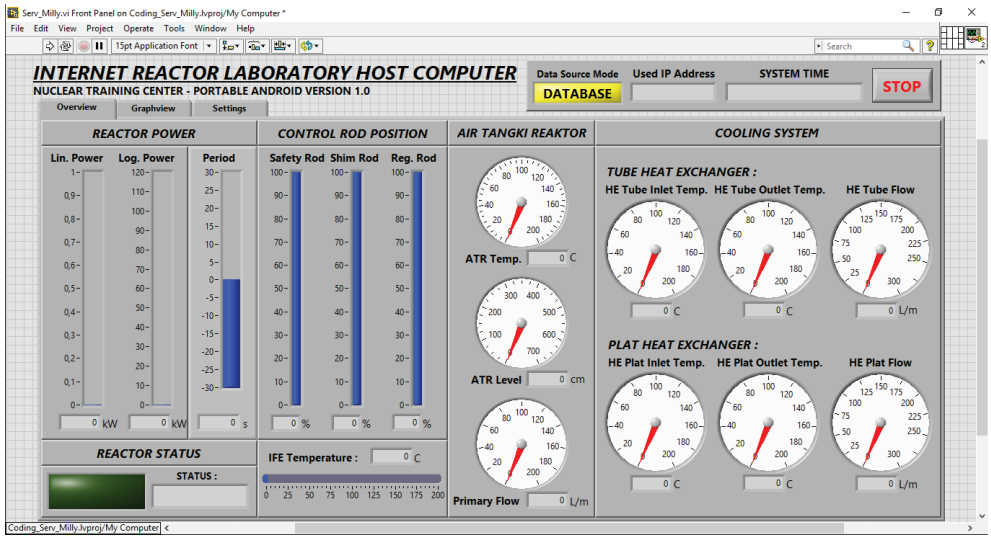
FIGURE 1. IRL Android system data flow schematic

Based on Figure 1, IRL host computer connected to IRL server through internet connection using data source name (DSN) configuration. The internet protocol (IP) address of IRL server computer, username, password and table name needed for this configuration. Android device connected to the IRL host program using a local network connection and the specific host computer address defined using local IP address. This IRL host program developed using pseudocode:

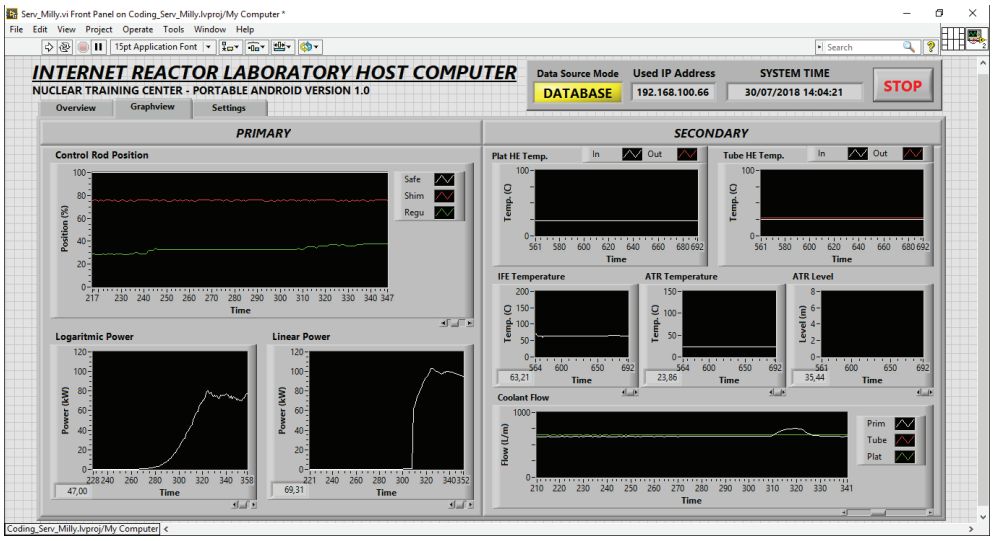
```
begin
  read nilai ID, DSN, table_name, stop_button, realtime_button
  connect to IRL database
  if realtime = 0
   fetch record IRL database where ID = ID
  else
   fetch record IRL database where ID = max
  parse record table
  convert into numeric variables
  create chart
```

```
  generate shared variables
  save data to text
  if stop_button = 0 do
   repeat from row 2
  if stop_button = 1
end.
```

The display of IRL host program shown in Figure 2. It displays the reactor primary and secondary data stored in the IRL database both in instrument and graphical view. IRL host program display was made similar to the computer information located in the Kartini reactor main control room. It aimed to make easier for the instructor to explain the reactor parameters in the remote class.



(a)



(b)

FIGURE 2. Overview of IRL host program instrument view (a) and graphical view (b)

SQL Query for data calling

There are two data sources option developed on this program, using stored data or real-time data chosen by the IRL host operator. The primary key of the data stored in the IRL database server used to determine which data will be called by the IRL android host program. When the operator chose the stored data, the stored data will be called by IRL host program every second based on the program algorithm. The value of ID declared by the operator and its value will be increase every second. The SQL query used to call the stored data is:

```
SELECT * FROM dbmackerel
WHERE ID = 1
```

Dbmackerel is the name of table IRL database in IRL server computer. The ID is the primary key used in a dbmackerel table, so the data that received by the IRL host is data with ID value 1. When real-time data was chosen, SQL query will call the maximum value of the primary key ID. The SQL query used to call the real-time data is:

```
SELECT * FROM dbmackerel
WHERE ID
IN (SELECT MAX (ID) FROM dbmackerel)
```

The maximum value of the primary key is the last data stored in the IRL database from Kartini reactor. It is reflected as the real-time data. When the new data stored in the database, the value of ID is increasing continuously, so that data called by the IRL host program is the real-time data from Kartini reactor.

Data parsing unit

A row of data contains 23 columns received from the IRL database to the IRL host program every second. A parsing data system is used to parse this array based on its column number. This parsing unit was done by using the index array function provided in LabVIEW function palette. This function will call the data in the array according to its specific index. The specific index is the row and column number. The block diagram of each parsing unit shown in Figure 3.

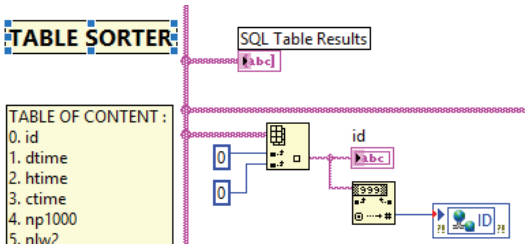


FIGURE 3. Each unit of parsing unit and shared variable generator block diagram

Figure 3 will parse the data with a specific index is 0, 0. It is the ID value. An ID value will be obtained at this process and the name will be defined after the data was parsed. This single data saved as a string variable and shown in the front panel of the IRL host program.

Shared variable generator

A single parsed data is generated into a shared variable. The shared variable used to define the value of a variable in the IRL android application. This step is necessary, so the value of the variable in the IRL android application can be defined. IRL android application will be read this shared variable and shown this value in the display panel. In Figure 3, the data from a string variable converted as an integer variable using string to integer function and inputted as the shared variable ID value. ID value in IRL android application will have the same value with ID value on this IRL host program.

Data saving unit

Testing process needed to evaluate the system delay time and data accuracy. To support this process, the SQL query sent to the IRL database, and the received data will be stored in text form with .txt file format. The data stored by using the write to text file function. The data will be stored with additional supporting information in the form of time when writing files. Delay time can be obtained by comparing time between SQL query sent time and data receiving time contained in this text file. The data accuracy also can be obtained by comparing the received data and stored data in IRL database.

IRL Android Application

The IRL android application was developed by using the LabVIEW data dashboard application available on Google Play store. It formatted as LabVIEW data dashboard file (lvdd). LabVIEW data dashboard application needed to install on an android device to open the IRL application. The data on the IRL application received from the IRL host program through a local network connection. The specific local IP address of the host computer inputted to the application to define the host computer address. When the IRL host program executed, shared variables will be generated. The IRL application will find the shared variables located in the host program and show it in the IRL application display. The IRL application built using pseudocode:

```
begin
  read stop_button, IP komputer host
  connect to komputer host
  read shared variables
  show shared variables
  create charts
  if stop_button = 0 do
   repeat from row 2
  if stop_button = 1
end.
```

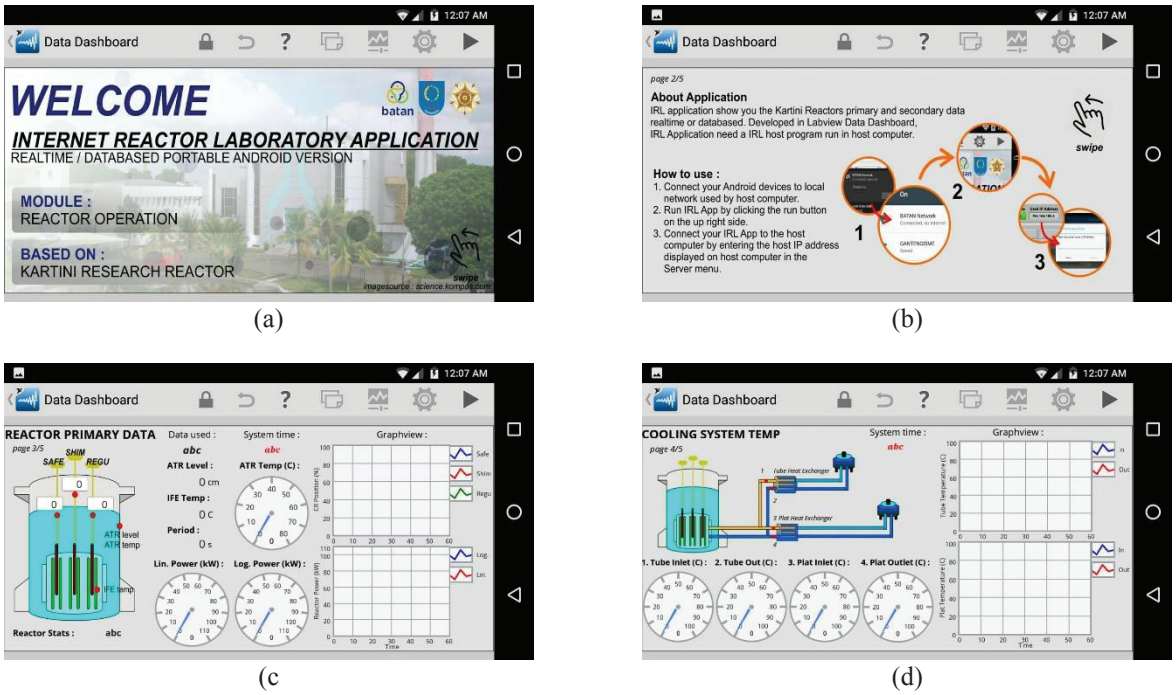


FIGURE 4. Overview of IRL android application welcome page (a), about application page (b), reactor primary data page (c) and cooling system page (d)

Figure 4 shown the IRL application display. The application consists of the main page, instruction page, primary data page, temperature, and coolant flow rate page. The display was created using graphic design software. The background image tuned similar to the Kartini reactor scheme in order to describe nuclear reactors and the location of instruments.

RESULT OF TRIALS

Screen testing

IRL android application screen compatibility testing was done by using NOXPlayer Android emulator. This emulator configured at the screen resolution up to 4K UHD size. The testing process was done by varying the size of the screen resolution with the results shown in Table 1.

TABLE 1. Screen resolution compability test

No	Screen Size	Resolution	*Aspect Ratio*	Can be Operated	Screen Full
1	QVGA	320×240	4 : 3	No	No
2	WQVGA	400×240	5 : 3	No	Yes
3	nHD	640×360	16 : 9	Yes	Yes
4	qHD	960×540	16 : 9	Yes	Yes
5	HD	1280×720	16 : 9	Yes	Yes
6	FHD	1920×1080	16 : 9	Yes	Yes
7	QHD	2560×1440	16 : 9	Yes	Yes
8	4K UHD	3840×2160	16 : 9	Yes	Yes

The IRL Android Application couldn't be displayed on a screen size of 320×240 pixels due to the small size resolution. It is only enough to display the toolbar in the LabVIEW data dashboard application, so the application couldn't be operated. In WQVGA resolution types with a resolution of 400×240 pixels, IRL android application can be displayed in full without any parts hidden. But the program execution button at WQVGA resolution is hidden. The IRL android application can be operated at the lowest screen resolution of 640×360 pixels (nHD). At the size of the resolution, the toolbar of the LabVIEW data dashboard application could be displayed full size including the application execution button.

The aspect ratio compatibility test results in Table 2 show that the IRL application could be fully displayed and can be operated in all aspects ratio of the android devices. The IRL android application display can maintain the aspect ratio at 16:9, so there is no part of the screen application hidden.

TABLE 2. Aspect ratio compatibility test

No	Screen Size	Resolution	*Aspect Ratio*	Can be Operated	Screen Full
1	VGA	640×480	4 : 3	Yes	Yes
2	WVGA	720×480	3 : 2	Yes	Yes
3	WVGA	800×480	5 : 3	Yes	Yes
4	WVGA	768×480	16 : 10	Yes	Yes
5	FWVGA	854×480	16 : 9	Yes	Yes
6	HD+	1440×720	18 : 9	Yes	Yes

Delay time testing

Delay time counted since the SQL query was sent from the host computer program and the result show in Table 3. The average time delay is 1.234 seconds. It requires an average time of 1.342 seconds in the morning test and 1.127 seconds in the night test. The morning delay results are greater than the night delay time due to the network busyness, both the internet network on the IRL server computer and the internet network at the IRL host computer.

TABLE 3. Delay time test

No	Test Time	Test Number	Delay Time (second)	Average (second)
1	Morning	1	1.420	
2	Morning	2	1.175	
3	Morning	3	1.431	1.342
4	Night	1	1.212	
5	Night	2	1.078	
6	Night	3	1.090	1.127
Average				**1.234**

Data accuracy testing

Testing the accuracy of data processed by the IRL host program was done by calling 100 lines of data. Data is stored in the form of text, then compared with data on the server computer database. Based on the tests conducted, data accuracy was obtained as shown in Table 4.

Table 4. Data accuracy test

No	Data Name	Accuracy (%)	Num.	Data Name	Accuracy (%)
1	ID	100.00	10	Fuel Temp	100.00
2	Safe	100.00	11	Prim Flow	100.00
3	Shim	100.00	12	Tube In	100.00
4	Reg	100.00	13	Tube Out	100.00
5	Lin	100.00	14	Tube Flow	100.00
6	Log	100.00	15	Plat In	100.00
7	Period	99.10	16	Plat Out	100.00
8	ATR Temp	100.00	17	Plat Flow	100.00
9	ATR Level	100.00	**Average**		**99.95**

The average overall data has an accuracy rate of 99.95%. All data processed by the IRL host computer program has 100% data accuracy except in the reactor period data. This shows that the entire data displayed similar to the reactor data that in the IRL server computer except in the reactor period.

The reactor period data has the smallest accuracy rate than the other. This error occurred because of the accuracy of the differences at reactor period data processing carried out by IRL host programs. The period reactor data in the server computer database is a decimal number with accuracy up to 10^{-3}, while the reactor period data output has been processed as an integer. The reactor period accuracy can be increased by changes the data processing in the reactor period so that the data displayed has the same level of accuracy.

Satisfaction assessment

User satisfaction assessment was conducted by surveying 30 respondents. Respondents consisted of 26 students and 4 lecturers. The assessment results obtained for each statement shown in Figure 5. Based on the likert scale, all aspect of the assessments included in the satisfied category. It means that the design of IRL Application is accepted by IRL android application users.

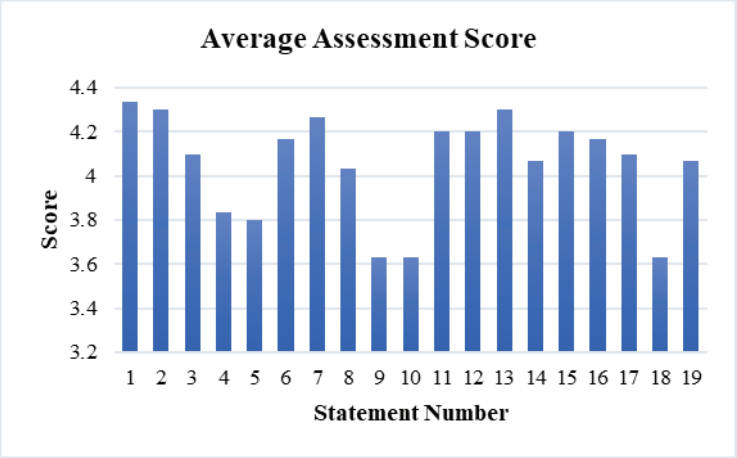


FIGURE 5. Graph of user satisfaction assessment

The low assessment rating caused by various factors. When there is an error in reading the shared variables data, there is only a notification message in the form of a warning sign without repair instruction. Some steps needed to repair the correct shared variables, so the rating given is low. The application must be stopped, set up on the instrument, enter the IP address of the IRL host computer, select the shared variables library, and choose the shared variables that are used. The low assessment of the elements of display quality caused by the limited development of the applications to data origin from the database. IRL android application has not been able to display all of the physical data of the Kartini reactor. This problem becomes a recommendation for further development of the IRL android application.

CONCLUSIONS

The IRL application on android client devices design consist of IRL host program as a data center, and IRL application on android devices. The test results show that IRL application can be operated in all screen aspect ratio with minimum resolution 640 × 360 pixels. The average delay time to call the first data is 4.089 seconds, and 1.234 seconds for the next continuous data. The average data accuracy is 99.95% with the highest accuracy of 100%, and the lowest accuracy is 99.10% in the reactor period data. Based on the assessment test, the level of user satisfaction obtained by the IRL application is in the satisfied category, both overall and in aspects of application ease of use, information quality, and display quality. For future work, this application will be developed to display all of the physical data of the Kartini reactor. Then it will be integrated with the web based IRL learning system.

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