An Inventory Tool for Receiving Practicum Report Based on IoT by Using ESP32-CAM and UV Sterilizer: A Case Study at Muhammadiyah University of Sidoarjo

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Abstract *– Currently, there are several problems related to practicum report collection in the electrical engineering laboratory at the Muhammadiyah University of Sidoarjo. The first problem is the presence of crowds during practicum report collection that have their dangers, specifically during the Covid-19 pandemic. Another problem is the absence of laboratory assistants in the electrical engineering laboratory when there are students who will collect reports. A tool that can receive practicum reports was made from these problems, and it can be monitored remotely by a laboratory assistant. By putting an RFID card to the RFID sensor on the box so that the solenoid can open the box door and the student can put the report into the box. At the same time, ESP32-CAM takes pictures of students collecting the report. Then, notification in the form of photos and student information will be sent to the laboratory assistant through the Telegram application. After the report is placed into the box, the UV Sterilizer will turn on to disinfect the report. The expectation of making this tool is to facilitate the collecting report process of practicum results and reduce the crowd in the laboratory.*

Keywords*: Covid-19, ESP32-CAM, RFID, Telegram, UV Sterilizer*

I. Introduction

From March 2020 until today, Covid-19 positive cases in Indonesia have reached more than 4 million people [1] [2]. Its easy transmission makes the spread of this virus extremely fast [3]. To break the transmission chain, the government limits many communities from doing activities outside the home, crowding, doing social distancing, and disinfecting goods periodically [4]. The electrical engineering laboratory of Muhammadiyah University of Sidoarjo is one of the parties affected by the Covid-19 virus, which makes students have to do online lectures, even though the practice cannot be done optimally online. Lack of student discipline in social distancing implementation when collecting practicum reports creates dangers. Another problem related to practicum report collection is when students' collecting practicum report results, the laboratory assistant is not in the electrical laboratory. Therefore, students leave the report to another laboratory assistant or put the practicum report result in any place that causes the practicum report to be damaged or lost. From these problems, a tool is made to receive practicum reports that can be monitored remotely. This tool is equipped with ESP32-CAM and UV Sterilizer. This tool can receive practicum reports by putting an RFID card on the RFID sensor; then, the ESP32-CAM will send photos and student group information through the Telegram and Google Sheets applications. After the report is placed into the box, the report will be sterilized with a UV Sterilizer. Therefore, practicum reports are spared from viruses.

I.1. NodeMCU ESP8266

NodeMCU ESP8266 is a microcontroller module that contains ESP8266 inside. NodeMCU ESP8266 can connect to WiFi networks. NodeMCU ESP8266 can be programmed using the Arduino IDE programming language [5]. In Fig. 1 is shown the NodeMCU ESP8266 microcontroller module [6].

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Fig 1. NodeMCU ESP8266 [6]

I.2. RFID

Radio Frequency Identification (RFID) is a method that uses radio waves. It is used to track, store, and identify information utilizing an RFID tag device [7] [8].

I.3. Selenoid door lock

Selenoid door lock is an electronic component that uses electromagnetic working principles. It can be used when given a voltage of 12 Volts [9].

I.4. LCD 20x4

LCD (Liquid Crystal Display) is a tool that can display the value of a sensor, display writing, and display menus on the microcontroller [10].

I.5. UV sterilizer

Ultraviolet light (UV light) is a type of electromagnetic radiation with wavelengths ranging from 4nm to - 400Nm. UV light technology is an easy and simple non-chemical disinfection method [11][12][13].

I.6. Telegram

Telegram is a messaging service app with a focus on speed and security. Telegram can be used on all work devices at the same time. The messages can sync seamlessly across any phone, tablet, or computer (Windows, Mac, and Linux) [14].

I.7. ESP32-CAM

ESP32-CAM is a camera module used for indoor and outdoor monitoring. This module is also equipped with Bluetooth and WiFi, designed like a microcontroller [15].

II. Research Method

II.1. System block diagram

There were three parts in this box: input, process, and output. In the input section there was RFID as an input to open the box. In the process section there were Arduino Mega microcontrollers, NodeMCU ESP8266 and ESP32-CAM. Arduino Mega was used to verify RFID inputs and control Selenoid door lock relays, and UV Sterilizers. NodeMCU ESP8266 was used to send notifications to Telegram and Google Sheets. The ESP32-CAM was used to send photos to Telegram. In the output section there was a 20x4 LCD to display the commands and conditions of the tool, Selenoid door lock as a tool door safety, UV Sterilizer as a sterilizer when the report was entered into the box, Telegram and Google Spreadsheet as a recapitulation of incoming data. Fig. 2 shows the system block diagram in this research.

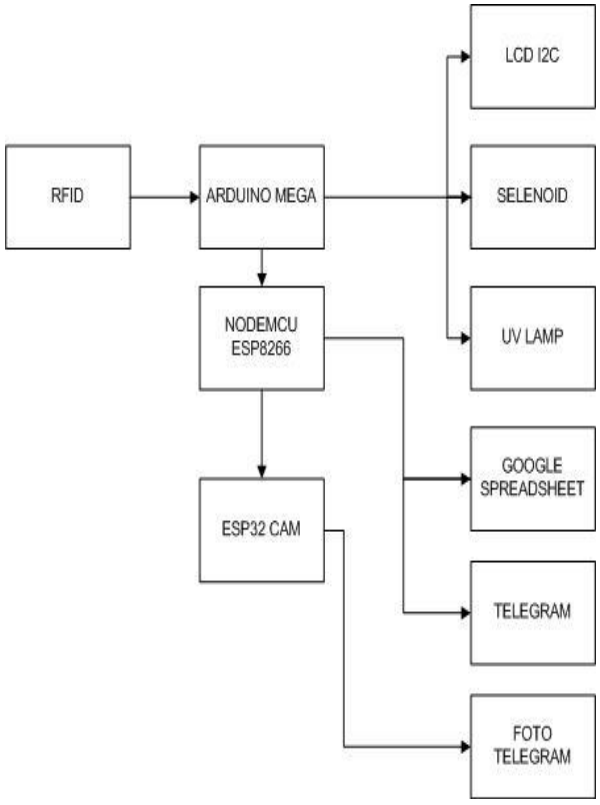


Fig 2. Tool Block Diagram

II.2. Program flowchart

The program began with a WiFi connection. If the WiFi has connected the RFID card to the RFID sensor could be placed. After the RFID card was verified, the Selenoid door lock would open. After the door was opened and the report was entered, ESP32-CAM would take pictures of students collecting reports. After that, NodeMCU ESP8266 would send a message in the form of group information and students' photos who had collected reports via the Telegram application. The data would also be stored on Google Spreadsheet. The Selenoid door lock would automatically close after 30 seconds. After the box door was closed, the UV Sterilizer would be active to sterilize the practicum report. Finally, the LCD would display the text that the collection of reports has been successful.

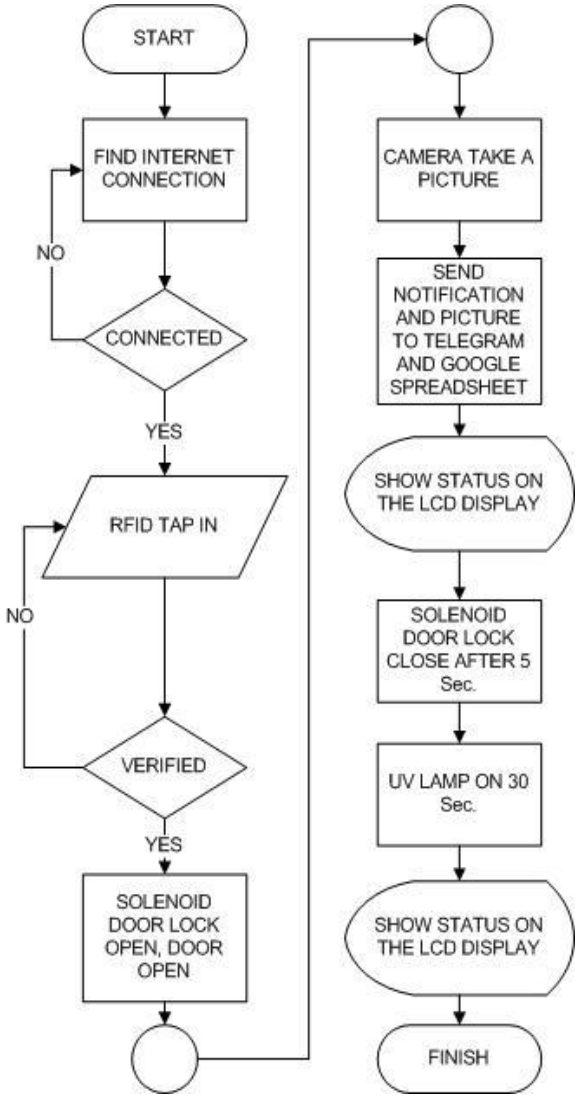


Fig 3. Flowchart program

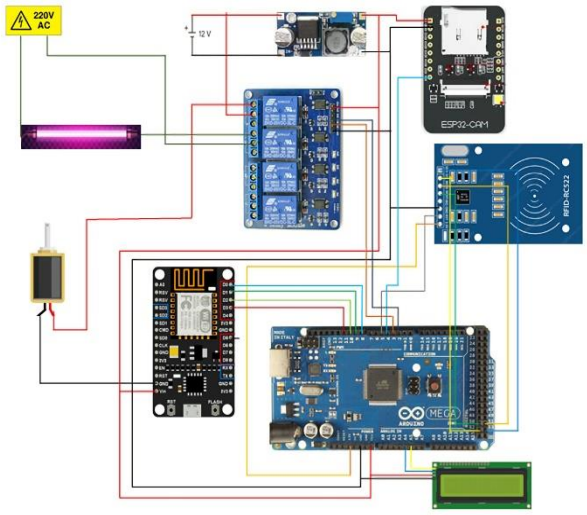


Fig 4. Wiring design

TABLE I
NODEMCU ESP8266 PORT USAGE

NO	*NodeMCU port*	*Usage*
1	D0	Group A notifications
2	D1	Group A notifications
3	D2	Group A notifications
4	D3	Group A notifications
5	Vin	5V
6	Gnd	Gnd

TABLE II
ARDUINO PORT USAGE

NO	*Arduino Port*	*Usage*
1	Pin SCL	Pin SCL LCD
2	Pin SDA	Pin SDA LCD
3	Pin 2	Solenoid door lock
4	Pin 3	UV Sterilizer
5	Pin 4	ESP32-CAM 32
6	Pin 5	Reset pin
7	Pin 8	Group A notification command
8	Pin 9	Group B notification command
9	Pin 10	Group C notification command
10	Pin 11	Group D notification command
11	Pin 50	Miso RFID
12	Pin 51	Mosi RFID
13	Pin 52	Sck RFID
14	Pin 53	Ss pin RFID

TABEL III
ESP32-CAM PORT USAGE

NO	ESP32-CAM Port	Usage
1	5V	VCC
2	GND	GND
3	GPIO 04	INPUT

Fig 3. Shows the flowchart program, while the wiring design of this research was shown in Fig. 4.

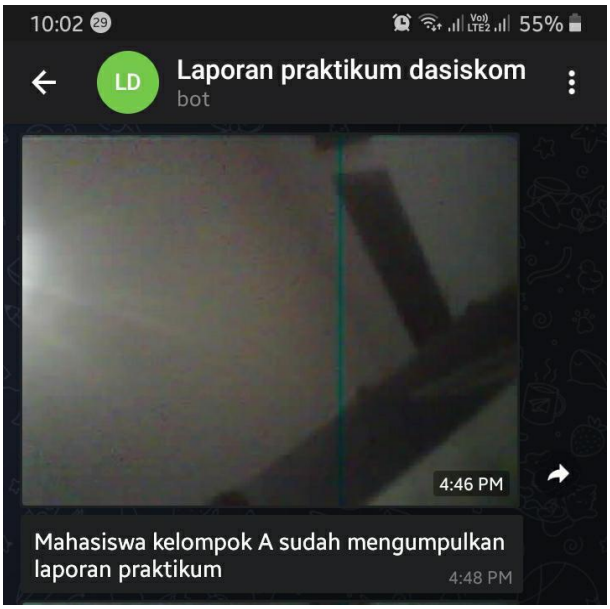
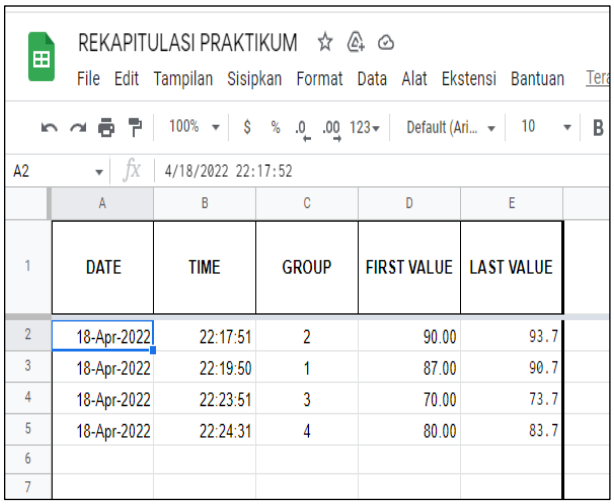


Fig 5. Telegram Display

In Fig. 5, there is a display of Telegram on the mobile screen when the report has been entered.



	A	B	C	D	E
1	DATE	TIME	GROUP	FIRST VALUE	LAST VALUE
2	18-Apr-2022	22:17:51	2	90.00	93.7
3	18-Apr-2022	22:19:50	1	87.00	90.7
4	18-Apr-2022	22:23:51	3	70.00	73.7
5	18-Apr-2022	22:24:31	4	80.00	83.7
6					
7					

Fig. 6. Google Spreadsheet Display

Fig. 6 describes a display of Google Spreadsheets when the report has been entered.

III. Result and Discussion

III. 1. Result of tool realization

The following are the results of the tool realization. Fig. 7 is the result of realizing the Tool. Components of the tool will be described by numbering as follows; 1. An arduino Mega, 2.LCD, 3. RFID, 4. NodeMCU, 5. relay, 6. ESP32 Cam, 7. UV lamp, 8. Solenoid door lock, 9. RFID tag and card.

Fig 7. Result of tool realization

How to use this tool is as follows.

1. Students put RFID Tags on RFID Sensors.
2. Next, the tool will verify the RFID TAG.
3. The Selenoid on the tool door will open if the RFID is verified correctly. At the same time, the ESP32-CAM takes students' photos to be sent to laboratory assistants' Telegram and Google Spreadsheets along with group information and report collection time.
4. Students place the report into the tool.
5. The Selenoid on the door will close after students enter the report within 30 seconds.
6. UV Sterilizer will be on to sterilize report.
7. The tool can be re-used.

III. 2. Tool testing

Testing was done by comparing the tool measurement result that was made with standard tools that were commonly used. In addition, there was testing by taking the results of the actual condition and real-time

Calculations were done using several formulas, including.

$$\text{Deviation} = (nSensor - nMeasure) \quad (1)$$

which is the deviation formula [16];

$$Average\ Value = \mu = \frac{x_1+x_2+x_3+x_4+x_5}{n} \quad (2)$$

which is the average value formula[17]; standard deviation formula [16][18].

$$\sigma = \sqrt{\frac{\sum_{i-1}^{x}(x_i-\mu)^2}{n}} \quad (3)$$

and, formula percentage accuracy and percentage error can be expressed below.

$$\%\ Accuracy = \{1 - \left|\frac{Yn-Xn}{Xn}\right|\} \times 100\ \% \quad (4)$$

$$\%\ Error = \{\left|\frac{Yn-Xn}{Xn}\right|\} \times 100\ \% \quad (5)$$

III. 3. 12 Volt power supply testing

Table IV indicates the results of ten times 12 Volt power supply testing using a multitester. This Test obtained a deviation of 0.00 and 100% accuracy, and it can be concluded that the voltage of 12 volts used in this tool is accurate. This 12 Volt voltage will be used to activate the solenoid and become a stepdown source to provide supply to the control circuit.

TABLE IV
12 VOLT POWER SUPPLY TESTING

Testing to -	Voltage needed (V)	Multimeter (V)	Deviation (V)	Accuracy (%)
1	12	12	0	100
2	12	12	0	100
3	12	12	0	100
4	12	12	0	100
5	12	12	0	100
6	12	12	0	100
7	12	12	0	100
8	12	12	0	100
9	12	12	0	100
10	12	12	0	100
Average	12	12	0	100

III.4. A 5 volts power supply testing

Table V demonstrates the testing of a 5 volts power supply using multi-tester by ten times test and obtained the deviation of 0 volts and 100% accuracy. It can be concluded that the 5 volts voltage used in this tool is accurate.

III.5. Testing of WiFi connection to NodeMCU ESP8266

In table VI, the test results were obtained from ten times WiFi connection to NodeMCU ESP8266 testing with a waiting time of 4 seconds and 5 seconds. The conclusion of the testing is that NodeMCU ESP8266 can be connected to WiFi at medium speed.

TABLE V
5V POWER SUPPLY TESTING

Testing to -	Voltage needed (V)	Multimeter (V)	Deviation (V)	Accuracy (%)
1	5	5	0	100
2	5	5	0	100
3	5	5	0	100
4	5	5	0	100
5	5	5	0	100
6	5	5	0	100
7	5	5	0	100
8	5	5	0	100
9	5	5	0	100
10	5	5	0	100
Average	5	5	0	100

TABLE VI
TESTING WIFI CONNECTION TO NODEMCU ESP8266

Testing to-	Wifi ESP 8266		Speed
	Condition	Waiting Time (s)	
1st Test	Connected	5	Medium
2nd Test	Connected	5	Medium
3rd Test	Connected	4	Medium
4th Test	Connected	5	Medium
5th Test	Connected	4	Medium
6th Test	Connected	5	Medium
7th Test	Connected	4	Medium
8th Test	Connected	5	Medium
9th Test	Connected	5	Medium
10th Test	Connected	4	Medium

III.6. Testing of Wifi connection to ESP32-CAM

Table VII shows testing WiFi connection to ESP32-CAM by ten times. From the testing result, it was obtained the results of connection with a waiting time of 4 seconds and 5 seconds. The conclusion of this testing is WiFi speed connection to ESP32-CAM is medium.

In Table VII, it can be seen that in ten trials of Wifi connection to ESP32-CAM, all of them were successfully connected properly. Connection time is in the range of 4 to 5 seconds. The data transfer rate for all test connections is medium speed.

The results of this test indicate that the Wifi connection has been running normally, so that the built device can be used properly.

TABLE VII
TESTING WIFI CONNECTION TO ESP32-CAM

Testing to-	Wifi ESP32-CAM		Speed
	Condition	Waiting Time (s)	
1st Test	Connected	4	Medium
2nd Test	Connected	5	Medium
3rd Test	Connected	4	Medium
4th Test	Connected	5	Medium
5th Test	Connected	4	Medium
6th Test	Connected	5	Medium
7th Test	Connected	4	Medium
8th Test	Connected	5	Medium
9th Test	Connected	4	Medium
10th Test	Connected	4	Medium

III. 7. Solenoid Door Lock Testing

Table VIII reveals the results of solenoid testing with ten times testing. From the testing result, it can be concluded that the instruction with realization is appropriate. The results of the equipment testing as shown in Table VIII that there is a good consistency of results.

TABEL VIII
SOLENOID DOOR LOCK TESTING

Testing to-	Selenoid		Description
	Command	Realization	
1st Test	HIGH	HIGH	Appropriate
2nd Test	LOW	LOW	Appropriate
3rd Test	HIGH	HIGH	Appropriate
4th Test	LOW	LOW	Appropriate
5th Test	HIGH	HIGH	Appropriate
6th Test	LOW	LOW	Appropriate
7th Test	HIGH	HIGH	Appropriate
8th Test	LOW	LOW	Appropriate
9th Test	HIGH	HIGH	Appropriate
10th Test	LOW	LOW	Appropriate

III. 8. RFID Testing

From the RFID testing in the table IX, the results of ten times RFID card testing registered with serial monitors are appropriate. The results of the equipment testing as shown in Table IX that there is a good consistency of results. The registration number and serial monitor of the RFID code are all detected as appropriate. This indicates that the equipment has been working properly.

TABLE IX
RFID TESTING

Testing to-	RFID Code		Description
	Registered	Serial Monitor	
1st Test	51 2D C2 27	51 2D C2 27	Appropriate
2nd Test	E5 F1 A6 AC	E5 F1 A6 AC	Appropriate
3rd Test	D5 89 AF AC	D5 89 AF AC	Appropriate
4th Test	40 9A A8 1B	40 9A A8 1B	Appropriate
5th Test	52 2D C2 27	52 2D C2 27	Appropriate
6th Test	E5 F1 A6 AC	E5 F1 A6 AC	Appropriate
7th Test	D5 89 AF AC	D5 89 AF AC	Appropriate
8th Test	41 9A A8 1B	41 9A A8 1B	Appropriate
9th Test	51 2D C2 27	51 2D C2 27	Appropriate
10th Test	E5 F1 A6 AC	E5 F1 A6 AC	Appropriate

III. 9. UV Sterilizer Testing

In Table X, UV Sterilizer experiment has been tested ten times with test results in line between the command and UV Sterilizer realization. The results of the equipment testing as shown in Table X that there is a good consistency of results. The command and realization of the UV sterilizer testing are all detected as appropriate. This indicates that the equipment has been working properly.

TABLE X
UV STERILIZER TESTING

Testing to-	UV Sterilizer		Description
	Command	Realization	
1st Test	HIGH	HIGH	Appropriate
2nd Test	LOW	LOW	Appropriate
3rd Test	HIGH	HIGH	Appropriate
4th Test	LOW	LOW	Appropriate
5th Test	HIGH	HIGH	Appropriate
6th Test	LOW	LOW	Appropriate
7th Test	HIGH	HIGH	Appropriate
8th Test	LOW	LOW	Appropriate
9th Test	HIGH	HIGH	Appropriate
10th Test	LOW	LOW	Appropriate

III. 10. ESP32-CAM Testing

Table XI shows ten tests on ESP32-CAM and obtained results that camera ESP32-CAM could conduct photo commands properly.

TABLE XI
ESP32-CAM TESTING

Testing to-	ESP32-CAM		DESCRIPTION
	INPUT	OUTPUT	
1st Test	HIGH	PHOTO	Success
2nd Test	HIGH	PHOTO	Success
3rd Test	HIGH	PHOTO	Success
4th Test	HIGH	PHOTO	Success
5th Test	HIGH	PHOTO	Success
6th Test	HIGH	PHOTO	Success
7th Test	HIGH	PHOTO	Success
8th Test	HIGH	PHOTO	Success
9th Test	HIGH	PHOTO	Success
10th Test	HIGH	PHOTO	Success

III. 11. Telegram Testing

Table XII shows the results of ten times Telegram application testing with 3 second waiting time to send notifications. From the testing, the conclusion is that the speed of sending the notification is medium. It can be observed in Table XII that from ten tests, the results obtained are always consistent which indicates that the equipment has worked well.

TABLE XII
TELEGRAM TESTING

Testing to-	Telegram		Speed
	Condition	Waiting Time (s)	
1st Test	Send	3	Medium
2nd Test	Send	3	Medium
3rd Test	Send	3	Medium
4th Test	Send	3	Medium
5th Test	Send	3	Medium
6th Test	Send	3	Medium
7th Test	Send	3	Medium
8th Test	Send	3	Medium
9th Test	Send	3	Medium
10th Test	Send	3	Medium

III. 12. Google spreedshet Testing

In table XIII, the results of ten times Google Spreadsheet testing with a waiting time of 3 seconds. From the testing, the conclusion is that the speed of sending the notification is medium. It can be observed in Table XIII that from ten tests of google spreadsheet, the results obtained are always consistent which indicates that the equipment has worked well.

TABLE XIII
GOOGLE SPREADSHEET TESTING

Testing to-	Google spreadsheet		Speed
	Condition	Waiting Time (s)	
1st Test	Send	3	Medium
2nd Test	Send	3	Medium
3rd Test	Send	3	Medium
4th Test	Send	3	Medium
5th Test	Send	3	Medium
6th Test	Send	3	Medium
7th Test	Send	3	Medium
8th Test	Send	3	Medium
9th Test	Send	3	Medium
10th Test	Send	3	Medium

IV. Conclusion

Based on the test result that has been conducted, it can be concluded that:

1. Normal power supply testing and no voltage drop either when the device is on standby or when the device is operating. The average percentage of voltage accuracy of 12 volts is 100%, and the voltage of 5 volts is 100%
2. RFID testing was conducted eight times with eight different RFID cards. RFID testing takes place optimally, and RFID card codes can be read well.
3. Internet connection testing runs optimally, and the tool can connect so that Telegram notifications and Google Spreadsheets can be sent with the average delay needed to connect of 4.5 seconds.

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