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An implementation of toll road smart lamps as Indonesia's green energy solution

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ABSTRACT
The Lighting is very much needed in various areas of life today, both for individuals and the living environment. Considering that roads are places that we always pass, this requires lighting in various sectors, including steep roads that must be equipped with maximum lighting. We often know that many accidents occur, one of which is caused by the lack of lighting on the side of the road. Seeing this and considering technological developments, an intelligent system based on Arduino UNO was created which was able to overcome this problem. With Arduino UNO, LDR Light Sensor, and IR Sensor, this intelligent system is able to turn on the lights automatically for road users, thus this tool will be able to reduce the problem of accidents that often occur on the road, and is also able to provide a sense of security and comfort for drivers.

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INTRODUCTION

In the era of 4.0, the development of the globalization era has a significant impact on increasing the need for electrical energy consumption. The increasing needs encourage the need for the latest alternative energy sources, one of which is the utilization of solar energy or Solar Energy. Solar Cell plays an important role in converting solar energy into electrical energy. Solar cell technology is a semiconductor area that is able to absorb photons from sunlight and convert them into electricity. Solar cells are widely used in various applications, including street lights.

Although solar cells have become a sustainable energy solution, many street lights are still controlled manually. In other words, human intervention is still required to turn the lights on and off. Therefore, it is necessary to design a control system for street lights to automate the process of setting lights on and off, so that it can be more efficient and environmentally friendly.

Light sensors may not operate optimally in automation in case of interruptions due to weather changes. Therefore, a backup mechanism using a timer is required. The utilization of the timer aims to allow the lights to automatically turn on and off when the sensor experiences interference, so that the automation process continues despite the obstacles.

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The main purpose of the device created is as an energy source in the street light automation system. The focus of this paper is on making "Automatic Street Lights Using Solar Cell Based on ATmega8535". This system is designed to turn on street lights automatically without human intervention, while controlling battery charging automatically using a charger controller. The control circuit and data processing are implemented through the ATMega8535 microcontroller.

The benefit of this paper lies in the device's ability to effectively illuminate street lights without the need for human intervention. The system can automatically regulate the life and death of the lights, providing an efficient and sustainable solution in the use of electrical energy in street lights.

Public street lighting (PJU) is a lamp used for street lighting at night so that it makes it easier for road users to see at night, so as to improve traffic safety and security. and where PLTS is one of the power plants that is very simple and easy to install at home, so PLTS is one of the means to meet the needs of the community for electricity which is very environmentally friendly because it utilizes sunlight. PLTS is often also called Solar Photovoltaic, or Solar Energy. Sunlight is one of the potential alternative energy sources and has considerable prospects for development, because the sun will never run out and can be utilized as a power plant.

For the wider community, public road lighting is a lamp used to illuminate roads at night so that drivers can see more clearly the road they are going to travel at night. Street lighting can improve traffic safety and security of road users. Street lighting is also used as lighting on toll roads. Toll roads are facilities that are currently very much needed by the community. The increasing number of toll road users means the need for good road lighting that meets the standards on the toll road. Toll road lighting in the Semarang area usually uses SON-T and LED lamps. The road lighting needed by road users is lighting that does not provide excessive glare and is useful for clarifying views, providing a feeling of safety and comfort when driving at night. Not only designing in terms of good lighting, but also looking at it from an effective and economical perspective. Currently, there are still many LPJU which are still inadequate or do not comply with street lighting standards. There are factors that influence the level of lighting and the quality of street lighting, namely the volume of traffic in the form of vehicles such as private cars and trucks, road condition factors from road intersections and the width of the road. Pavement texture factors and pavement types influence the reflection of lighting.

The Medan – Kualanamu Toll Road in 2017 has become an inner-city toll road. Therefore, it is necessary to add road lighting at several points for the safety of toll road users. So it is necessary to design street lighting on the Lubuk Pakam - Sei Rampah toll road, especially at KM 60 (1800) - KM 63 (1800) in order to obtain good, effective, economical and in accordance with standard road lighting. Due to the use of SONT lamps which still have deficiencies in energy efficiency (power) and the design of these street lighting lamps uses LED generator lamps.

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Figure 1. Lubuk Pakam – Sei Rempah Toll Road

The technology used for public road lighting on toll roads automatically reduces crime and accident rates on toll roads where currently lighting is very inadequate, lighting on Medan toll roads is approximately 1,125 points that need to be installed. Now the Medan Marga Service is facing serious problems related to inadequate toll road lights, even the capital city of North Sumatra province is now entering a stage of progress in infrastructure development, in line with the high rate of toll road construction in North Sumatra amidst limited lighting facilities on newly built toll roads.

Lighting is needed by public road users to recognize an object visually. Public street lighting is created to make it easier and help people to see objects on the road at night or in dark conditions. A city without street lights will be like a dead city, and there will likely be many cases of crime, traffic accidents, and will have a negative impact on the social life of the city at night. A city with good street lighting will make the face of the city better, prettier and more beautiful. Apart from that, it has a better impact on the social life of city residents.

One of the urban infrastructure developments is the construction and installation of public street lighting. In implementing the construction of public street lighting, good planning is required, so that the installation of public street lighting has high efficiency, has sufficient lighting strength and low operational costs.

One way to achieve this goal is to choose the right type of lamp, which will be used as public street lighting. And the intensity of public street lighting must comply with the provisions so that public street lighting can operate properly. Toll roads are a very valuable need for society, especially public transportation and private car drivers, so it is very easy for people to travel between cities within the province.

Figure 2. Uneven Toll Road Conditions

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Due to the lack of lighting on toll roads, based on previous research, road lighting is regulated by PJU officers whose work is very simple and inefficient. So the researcher's idea arose to design an automatic public road lighting simulation tool on toll roads. Based on the description above, the researcher will design an "Automatic Simulation of Public Street Lighting on Toll Roads". Below shows a picture of uneven road posture.

Literature Review

Public Street Lighting

The development of a region is characterized by an increase in the rate of population growth and activity. Increased population activity often leaves problems for area managers, because it is often not balanced with improvements in facilities and infrastructure that support the increase in population activity. One of the important infrastructure support facilities is electrical energy. Electrical energy is managed nationally by the state electricity company (PLN).Identify existing problems and face them to reduce wasteful electrical energy expenditure. Analyze the automatic sensor system in lighting lamps currently used. Analyze the type of lighting used to determine the design of the sensor that will be installed or used. Identifying the need for freeway driver satisfaction based on energy savings.

This lighting can provide a bright effect like during the day, so that the number of accidents caused by ignorance of road users due to potholes and the lack of lighting will be even more depressed. By implementing smart public street lighting, it can reduce the use of electrical energy because smart public street lighting uses solar panels as an energy source obtained from converting solar heat into electrical energy which is then stored in batteries.

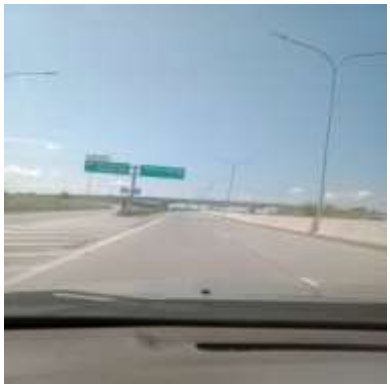

Figure 3. Public Street Lighting

Public street lighting is lighting that is public in nature (for the common good) and is usually installed on roads or in certain places such as parks and other public places. Public Street Lighting (PJU) In English, street lighting or road lighting is a light source installed on the side or road section which is lit every night, the lighting can be done automatically.

Microcontroller

A microcontroller is a functional computer system on a chip. It contains a processor core, memory (a small amount of RAM, Program Memory, or both), and input and output equipment (Hanafi, 2015). In other words, a microcontroller is a digital electronic device

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that has input and output as well as control with programs that can be written and deleted in a special way. The way a microcontroller actually works is reading and writing data. Just as an example, imagine yourself when you start learning to read and write, when you can do that you can read anything, be it books, short stories, articles, and so on, and you can also write things otherwise. Likewise, if you are adept at reading and writing data then you will be able to program an automatic control system using a microcontroller according to your wishes.

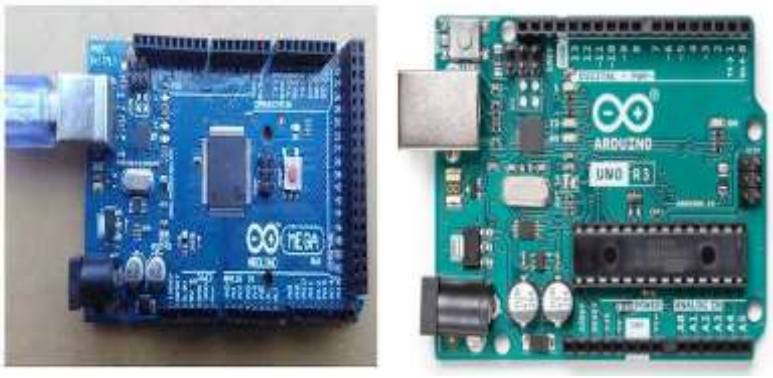

Figure 4. Microcontroller

A microcontroller is a computer containing a chip that is used to control electronic equipment, which emphasizes efficiency and cost effectiveness. Literally it can be called a "small controller" where electronics that previously required a lot of supporting components such as IC, TTL, and CMOS can be reduced/minimised and finally centralized and controlled by the ATMega328 microcontroller below. (Hanafi, 2015).

The ATMega328 is a microcontroller produced by ATMEL which has a Reduced Instruction Set Computer (RISC) architecture, where each data execution process is faster than the Complete Instruction Set Computer (CISC) architecture. This microcontroler has several features, including:

a. Speed reaches 16MIPS with a 16MHz clock.
b. 32KB flash memory and the Arduino has a bootloader which uses 2KB of flash memory as a bootloader
c. Has 1KB EEPROM (Electrically Erasable Programmable Read Only Memory) as semi-permanent storage because EEPROM can still store data even if the power supply is turned off.

Arduino is an electronic kit or open source electronic circuit board which contains the main component of a microcontroller chip with an Automatic Voltage Regulator (AVR) from the Atmel company. Arduino Uno R3 is a microcontroller in the form of a chip or integrated circuit (IC) that can be programmed using a computer. The purpose of embedding a program in a microcontroller is so that the electronic circuit can read input, process the input and then produce the desired output. So the microcontroller acts as the "brain" that controls the input, process and output of an electronic circuit.

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The function of using Arduino Mega is that it is very suitable for creating projects where the space capacity in the circuit is large. The larger memory capacity compared to other Arduinos makes this Arduino Mega suitable for projects that use many modules at once. Arduino provides 20 I/O pins, consisting of 6 analog input pins and 14 digital input/output pins. The 6 analog pins themselves can also be used as additional digital outputs apart from the 14 pins that are already available. To change the analog pin to digital, just give it the description 0-13, so to use the analog pin to become a digital output, the analog pin in the board description 0-5 is changed to pin 14-19 to function as digital output pin 14-16 (Hanafi, 2015).

METHOD

The author conducted research on weekends or when the author came home from work. Research and writing of the thesis were carried out at the writer's house or residence, precisely on Jalan Mangaan 1 Link. IV Mabar Hilir No.378 Medan Deli District, North Sumatra.

Figure 5. Research Place Based on Google Maps

To obtain research results from simulations of public street lighting on toll roads automatically, materials and equipment are needed to support this research. The equipment and materials used in the assessment are as follows.

Automatic Toll Road Design Simulation Materials

The materials used to automatically simulate public road lighting on toll roads are:

a. Mcb
   Mcb is used in the simulation of public road lighting on toll roads automatically as a safety measure for overloading the components used.
b. Relays
   Relays are used as disconnect switches and light connectors in toll road design simulations.
c. TimeSwitch
   In the automatic toll road design simulation, the timestich component is used as an automatic timer to turn on the lights in the toll road design simulation.
d. Electric socket

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https://ejournal.seaninstitute.or.id/index.php/InfoSains

In toll road design simulations, sockets are automatically used to distribute electrical energy to the design simulation load on the toll road.

e. Adapter
The adapters in my device are 12 v and 24 v adapters, where the 12 v adapter is used to turn on the LED lights and the 24 v adapter functions to turn on components in the form of Arduino relays and others.

f. UPS (Uninterruptible Power Supply)
UPS is an electronic device that is used to provide backup electricity for computers, data centers, and other important things used in automatic toll road design simulations

g. Infrared Sensor
Infrared sensors are useful for turning lights on and off,as a medium for data communication between the receiver and transmitter in automatic toll road design simulations.

h. LCD 16x2 (Liquid Crystal Display)
Used to display sensor data in toll road design simulations automatically.

i. Relay Switch
Relay switches are used to automatically connect and disconnect voltage in design simulations on toll roads.

j. Jumper Cables
Jumper cables are used to connect a series of components to each other or separately in automatic toll road design simulations.

k. Plywood Board
Plywood boards are used to place simulation tools and materials used in automatic toll road design simulations.

l. UBEC (Universal Battery Eliminated Circuit)
This tool is usually used to reduce the voltage from the 6V-23V input to 5V and 6V by automatically selecting the jumper on the BEC unit in toll road design simulations.

Automatic Toll Road Design Simulation Tool

The tools used to simulate public road lighting in this automatic toll road design simulation are:

a. Solder & Tin
Solder is used to connect the component legs with copper lines on the microcontroller circuit board in automatic toll road design simulations

b. Drill and Drill Bits (3mm, 6mm)
The drill is used to automatically drill holes in plywood, PCB and acrylic boards in toll road design simulations.

c. Ruler
A ruler is used to measure PCB boards, acrylic and plywood in automatic toll road design simulations.

d. Pliers

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Pliers are used to cut or strip cablesor cutting component legs in toll road design simulations automatically.

e. Screwdriver
Screwdrivers are used to open or tighten bolts or screws on various objects in toll road design simulations automatically.

RESULT AND DISCUSSION

The process of testing the tools that have been worked on will determine the success or failure of the tools that have been worked on. After testing, it can be seen whether the tool that has been worked on has an error or needs repairs. In each test, measurements are taken which will later be used to analyze hardware and software as well as other supporting components.

System Implementation

After the system requirements that have been prepared have been met, the next stage is to design and build the system that will be created. Arduino Mega in the design of this tool is the initial part as a control system for Infrared sensor input and LED output which is connected to Arduino

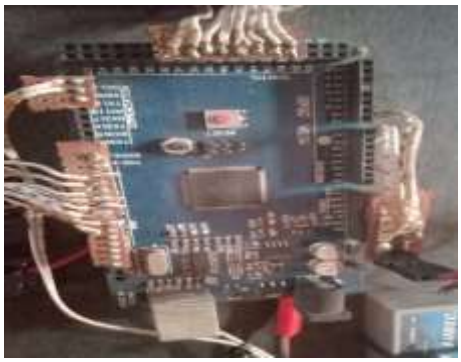

Figure 6. Arduino Mega circuit

In Figure 6, it can be seen that the Arduino minimum system is connected to other parts such as the Arduino data cable. In the Arduino minimum system, there is an indicator light which is used to find out whether the circuit is working or not.

Arduino Mega System Series

The Arduino module in this research functions as a control for all systems to regulate traffic safety from traffic jams when trains pass. The Arduino used in this research is Arduino Mega.

The equipment needed to carry out this test is:

- Minimum Arduino Mega System
- Arduino Mega data cable
- Arduino IDE software

steps for testing the Arduino circuit are as follows:

- Open the Arduino IDE application

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https://ejournal.seaninstitute.or.id/index.php/InfoSains

- Next, the initial display "sketch_xxxxxx" will appear automatically.
- Typed the program listing for Arduino testing.
- If there are no errors, then click the Upload icon or Ctrl+U. It can be seen in figure 4.3. under :

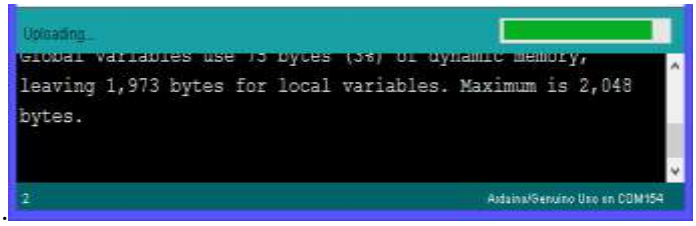

Figure 7. Process of Uploading Programs from Computer to Arduino

Analysis of Program Results:

When testing the Arduino Mega circuit, you don't need to add another circuit, you just need to use the built-in LED on the Arduino Mega. In writing the program, it is only a program to turn the LED on and off automatically with a delay (time). The following is a listing of this Arduino testing program:

```
void setup() { pinMode(LED_BUILTIN,OUTPUT);}
void loop() { digitalWrite(LED_BUILTIN,
HIGH);delay(1000);digitalWrite(LED_BUILTIN, LOW);delay(1000);}
```

In the program listing above, the void setup() function is an Arduino program command that will be read once. Meanwhile, void loop () is a command function that will be read repeatedly. On pin Mode (LED_BUILTIN,OUTPUT); is to declare pin 13 (built in led) as digital output, delay (1000); is to express the delay time in milliseconds which means 1000 ms = 1 second, while digital Write (LED_BUILTIN,HIGH); is to give a HIGH or 1 value to PIN 13 (ledbuiltin) and digital Write LED_BUILTIN,LOW); is to give a LOW or 0 value to PIN 13 (built in LED).

Testing Arduino Mega System with LCD

In testing the Arduino Mega circuit connected to the LCD, it is necessary to call library#include<Liquid Crystal.h>and also "Liquid Crystal lcd(8, 13,9,4,5,6,7);" which functions to add functions -The program function displays characters on the LCD. Then “lcd.begin(16,2);” is a program listing for setting the LCD address and LCD size, number of rows and columns according to the LCD used. Because what is used is a 16x2 character LCD, makalcd_begin(16,2);.

To write "--LCD TEST--" on the top line, write the command "lcd.setCursor(0,0);lcdprint("--TEST LCD--");" which means writing the characters "--LCD TEST--" starting from the first column and first row (0,0). The number 0 represents the beginning of the column and the beginning of the row. If you want to write on the second line, use the command “lcd set Cursor(0,1); lcdprint("01234@#$%&QWERTY"); The overall program listing output results are shown in Figure 4.4. as follows :

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Figure 8. Photo of Test Results with LCD

Infrared Sensor Testing

In principle, the way an infrared sensor works is the same as a button and the programming is almost the same, the only difference is the trigger of the button the. The way this infrared sensor works is that when the car passes the sensor it will activate and connect the button to the Arduino. The following is a picture of the infrared sensor installation on Arduino in the picture below:

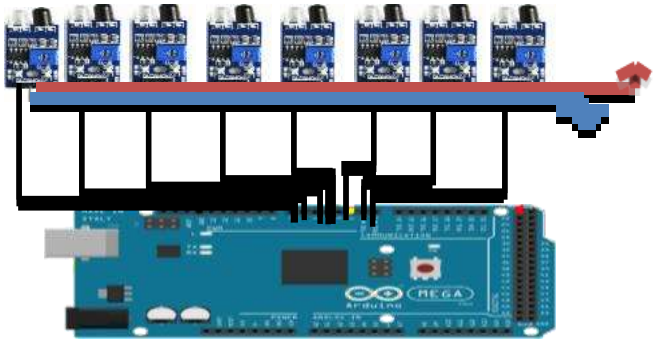

Figure 9. Installation of infrared sensors on Arduino

The picture above shows that the combination of pins 0, 1, 2, 3, 4, 5, 6 and 7 on the Arduino Mega is used as input from the infrared sensor. These eight sensors will later be tested with 1 LED that is built-in on the Arduino Mega. When the infrared sensor has an object in front of it, the pin will go "LOW", but when it doesn't detect an object the pin will float, this can sometimes cause errors. The resistor function is important. A resistor will be installed between the Arduino pin and +5V, so that when the sensor is not active the pin will be connected to +5V via a resistor and the pin will be "HIGH". This is called a pull-up resistor, because the resistor pulls the pin up at +5V. The infrared sensor already has its own resistor in the module, and has a digital output in the form of values 0 and 1 or in the Arduino program listing it is called "HIGH" and "LOW". The final result of this test is that each sensor that detects objects passing in front of it will send signal to Arduino, then Arduino will turn on the LED and if the sensor does not detect an object then the LED will turn off.

Relay Module Testing

Relays are a type of switch which operates based on electromagnetic principles which are used to move torque contacts to connect the circuit indirectly. The closing and opening of the contactor is caused by the magnetic induction effect produced by the

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inductor coil which is carrying an electric current. The difference with a switch is that the movement of the contactor on the switch for on or off conditions is done manually without the need for electric current, whereas relays require electric current. The following is a picture of the installation of a 4 channel toll road light relay. This overall tool testing is a combination of tests for each input and output part that have been carried out previously. Equipment needed to carry out this test:

- Minimum Arduino Mega System
- Arduino Mega data cable
- 2 4 Channel Relay Modules
- 12 volt 2 Ampere adapter
- 12 volt Led light
- Arduino IDE software

The following is a picture of the relay module installation on Arduino, namely:

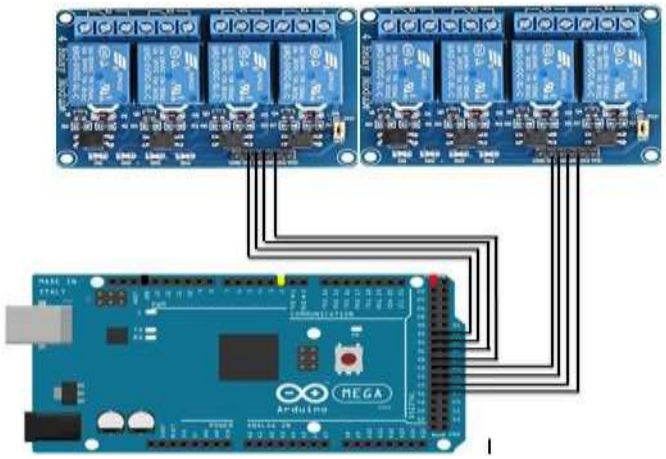

Figure 10. Relay Module Installation on Toll Lights

This test was carried out to measure the voltage produced from the LM7805 voltage regulator. The regulator changes the voltage from the power supply to 5 VDC for the overall working voltage of the device. The following are the results of the comparison of voltage measurements, shown in table 4.1:

Table 1. 5 VDC Voltage Regulator Test Results

No. Testing	Measurement Results (Volts)	Error (Volts)
1	5.1	0.1
2	5.1	0.1
3	5.1	0.1
4	4.9	0.1
5	5	0
6	4.8	0.2
7	5.1	0.1
8	5	0
9	5.2	0.2

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No. Testing	Measurement Results (Volts)	Error (Volts)
10	4.9	0.1
	∑ Error	1
	Average Error	0.1

Source: Author, 2023

Based on the data from the table above, it is concluded that *The error between the normal voltage and the 5VDC regulator voltage has a total error difference of ± 1 Volt in 10 tests (n) or an average error of 0.1 Volt.*

CONCLUSION

From the design of the Automatic Public Street Lighting Simulation Tool on Toll Roads, testing and analysis were then carried out so that the following conclusions were obtained: In designing this tool, it uses an infrared sensor, the principle of which works as a distance sensor but does not have a long range. From the tests that have been carried out, every sensor that the car passes through can detect at a distance of 2cm and not too far. In the tool testing that was carried out, the author used a 12 volt DC lamp, to save design space and efficiency in the layout of the prototype that had been made. In the application of this tool, it can be used on one-way roads. This is only due to the limited range of the sensor.

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