International Journal of Multidisciplinary Research and Growth Evaluation.

Research solutions for IoT applications in the construction of intelligent logic programming devices for measurement and control systems

Le Ngoc Giang [1*], Nguyen Van Hieu [2], Phan Hien [3]
[1] Department of Metrology, Faculty of Fundamental Technical, AD-AF Academy of Vietnam, Vietnam
[2] Department of Technical, Inspection and Repair Station for Measuring Devices, AD-AF Academy of Vietnam, Vietnam
[3] Department of Radar, Faculty of Fundamental Technical, AD-AF Academy of Vietnam, Vietnam

* Corresponding Author: **Le Ngoc Giang**

Article Info

ISSN (online): 2582-7138
Volume: 04
Issue: 01
January-February 2023
Received: 06-01-2023;
Accepted: 27-01-2023
Page No: 425-430

Abstract
This article is aimed at researching IoT technology and specific applications. On that basis, build an intelligent logic programming device capable of performing automation, measurement, and control problems in today's technology trend. From there, giving simple instructions and helping users easily realize their control measurement problems in a completely new, intuitive, and effective way.

DOI: https://doi.org/10.54660/.IJMRGE.2023.4.1.425-430

Keywords: Internet of Things -IoT, measurement, control, intelligent logic programming devices

1. Introduction

The fourth industrial revolution created the trend of automation in all fields. The emergence of Internet of Things (IoT) devices is changing the way people communicate, operate, do business, work, play, and stay connected. In 2018, IoT technology exploded in Vietnam, and many companies are focusing on developing smart technology solutions and products based on the IoT platform. The 4.0 technology revolution and IoT are no longer strange to the Vietnamese community and the world. It has become essential to the economy of every country, especially developing countries like Vietnam. According to IDC, the world spent $1.3 trillion on the Internet of Things in 2019. By 2020, Gartner predicts that the added value of the Internet of Things will be $1.9 trillion. McKinsey estimates that the impact of the Internet of Things on the global economy will be $11 trillion by 2025. By 2021, IoT subscribers are expected to reach 9.1 billion.

With the wave of IoT technology spreading strongly around the world, Vietnam is also undergoing major changes with this development. Vietnamese IT companies with strong innovation and invention capabilities are boldly investing in IoT and advanced new technologies today.

The Industrial Revolution 4.0 has had a huge impact on Vietnam. Of the many diverse challenges we face today, the biggest and most important is embracing and shaping new technological revolutions. In the areas of military, defense, IoT, and Industrial Revolution 4.0, it has and will continue to have a strong and comprehensive impact, bringing higher development steps and greater challenges. Many new achievements in scientific research and technological development have been widely applied to create a new generation of weapon systems and technological equipment such as energy weapons, biological genes, and combat robots, ...with outstanding features that represent a leap in quality.

The age of new technology-the technology of connectivity and intelligent processing—demands that measurement and control devices be constantly developed to meet its needs. In some respects, previous sets of measurements and controls no longer meet today's requirements. Therefore, it requires us to have intelligent measurement and control sets capable of solving practical problems and responding to the times. On that basis, the article poses the problem of "research solutions for IoT applications in the construction of intelligent logic programming devices for measurement and control systems."

2. IoT and intelligent control measuring devices

The world has gone through three industrial revolutions with leaps and bounds in science and technology and is now entering the fourth industrial revolution. According to Gartner, the industrial revolution 4.0 comes from the concept of "Industrie 4.0" in a German government report in 2013. "Industrie 4.0" connects embedded systems and smart manufacturing facilities to create digital convergence between industry, business, and internal processes. At the heart of Industry 4.0 is the unified use of hardware, robotics, and massive computing capabilities to extend information technology, with the intersection of advanced technologies such as cloud computing, the Internet of Things, artificial intelligence (AI), virtual reality (VR), augmented reality (AR), big data mining, wireless mobile technology (WiFi), quantum information technology, nanotechnology, etc.

IoT is part of the "4.0" revolution, is very close, and is becoming increasingly popular in Vietnam. The Internet of Things refers to objects that can be tracked and exist in an integrated, interconnected architecture: the Internet of Things.

As Internet-connected automation is widely used in many industries, the IoT is expected to generate large amounts of data from multiple sources, leading to rapid data aggregation, increased demand for storage, and more efficient processing of that data.

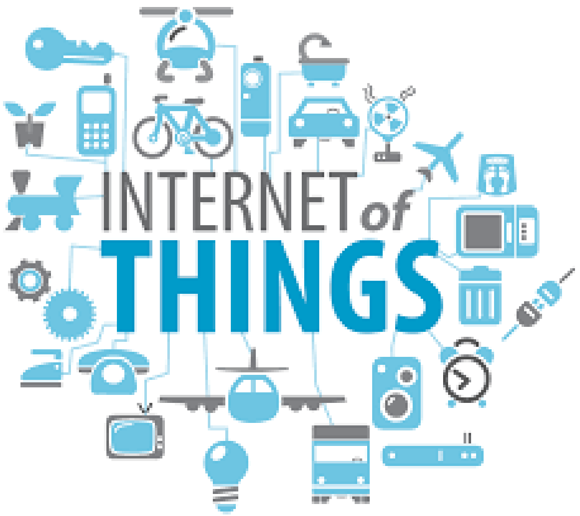

Fig 1: The Internet of Things

An IoT system allows users to go deeper into automation, analytics, and integration. It helps improve vision, accuracy, sensitivity, connectivity, and robotics technology for maximum efficiency. IoT systems develop, exploit software advancements, reduce costs when building hardware, and take advantage of modern technologies. These innovations change the way products, services, social, and economic production work and affect politics as well. The most important issues of IoT systems include artificial intelligence, connectivity, sensors, and small but highly mobile devices, which are briefly described as follows:

- AI (artificial intelligence): The IoT system is basically understood to make every device smart. It enhances every aspect of life with the data it collects through artificial computing algorithms and networking. A simple example is your rice container. When the rice is running low, the system automatically places a new order with the supplier.
- Connectivity: as a basic feature of the IoT, device networks are becoming increasingly popular. Many device networks are getting smaller, cheaper, and more tailored to the realities and needs of users.
- Sensors: IoT would lose its importance without sensors. Sensors act as a tool to help the IoT move from a network of passive devices to a network of active devices. At the same time, it can interact with the real world.
- Active Engagement: Today, most interactions with connected technologies happen passively. IoT is expected to bring positive systems in terms of content, products, and cohesive services.
- Small devices: As expected, devices are increasingly optimized for accuracy, scalability, and flexibility. It is designed to become smaller, cheaper, and more efficient over time.

The instrumentation and control units used to be one giant cabinet, full of relays and wires working together to control the machine. Overcoming that drawback, a programmable logic controller (PLC) was born. It allows flexible implementation of logic control algorithms through a programming language. PLC was developed in the 1960s and 1970s in developed countries. It is a programmable control logic that replaces the traditional relay control system. It creates a flexible control system that can combine delay timing as an alternative to timing relays, count, and perform computational functions. Today's PLC is strongly developed both in the field of industrial and civil electrical measurement and control. Basically, a PLC can be considered a microcomputer because it has all the parts, such as hardware, program parts, and software. However, the internal hardware structure is simple, and the memory capacity is much smaller compared to computers.

The trend toward IoT and industry 4.0 requires greater changes in programmable control and measurement devices. Based on the development of embedded devices and the foundation of IoT applications, the research team proposes to build intelligent measurement and control devices with the following advantages:

- High measurement and control performance: The development of microprocessor technology and embedded technology creates chips capable of high-speed, complex processing, intelligent control and measurement algorithms, digital signal processing capabilities, etc., which are common problems in today's measurement and control systems. However, the size is compact and energy-saving.
- Flexible in configuration, capable of intelligent measurement and control: Large area measurement and control systems, widely applied General Purpose Input/Output (GPIO) technology. The user can set a pin as input or output. The output of the smart processing device, in addition to the results from the basic input and delay pins, also has the ability to intelligently on/off

according to the set time, according to the external event or pulse width control (PWM)). Those are problems in the 4.0 era. Thereby, it is flexible in solving many different measurement and control problems, meeting the diversity, needs, and creativity of users.

- Multi-system connectivity: in the IoT, it is necessary to connect systems to exchange information with each other. IoT requires measurement and control systems to collaborate on a deeper level. Not only do individual PLCs need to cooperate with each other, they also need to work more closely with other systems, both internally and externally.
- Capable of distributed control: today, we use more and more distributed measurement and control systems at the machine level.
- Multilingual support: IoT development projects are coming to many technology companies around the world. Currently, there are only about 300,000 developers involved in the Internet of Things, but by 2020, the world will need 4,5 million developers. With today's hardware platforms, embedded systems with applications can easily design IoT systems. Not long ago, the choice of programming language was determined by the hardware platform. Many modern platforms are based on open source standards and can support multiple languages, allowing greater flexibility in interoperability.

3. Building IoT-controlled measuring devices

3.1. Device selection

Based on the above analysis, the team tested and selected an embedded device based on the Raspberry Pi board. Especially noteworthy is the Raspberry Pi 3 Mode B$^+$. It's a fairly popular version that is expected to be in production until January 2026. The Raspberry Pi Foundation created the Raspberry Pi, aims to build a system that many people can use in many custom operations.

Fig 2: Raspberry Pi 3 Model B+

The Raspberry Pi board is researched and developed by Sony, Qsida, and Egoman and is distributed mainly by Element14, RS Components, and Egoman. The Raspberry Pi is built around the Broadcom BCM2837 SoC processor, which is the most popular ARM chip line on mobile phones today. This processor includes a CPU, GPU, audio/video processor, and other features… all integrated into the chip and using low power. The Raspberry Pi board does not completely replace a desktop or laptop system. However, Raspberry Pi is a versatile support device that integrates many pieces of hardware to be able to develop electronic systems, automatic measurement and control, calculation systems, and low-cost but durable operation that saves energy.

Configuration: The Raspberry Pi 3 Model B+ version uses Broadcom BCM2837B0, a Cortex-A53 (ARMv8) 64-bit SoC @ 1.4GHz processor speed, equipped with 1GB LPDDR2 SDRAM memory that can take care of tasks like FullHD video playback or input/output control services.

Operating system and software: Because it is built on an ARM chip, Raspberry Pi is compatible with many open-source operating systems, and there are more than 80 Linux-based distributions suitable for the Raspberry Pi, from Raspbian, PiDora, and ArchLinux to Linutop and PiBang.

3.2. System software design tool

The article uses the Node Red programming tool to connect hardware devices, application programming interfaces (APIs), and online services in new and intuitive ways. It provides a browser-based editor that makes it easy to connect threads together using a series of buttons in the tool panel. Node-RED supports JavaScript functions, which can be built right into a text editor.

In addition, many built-in libraries allow saving functions, templates, or useful flows for reuse. Node-RED is built on Node.js, which is a software system designed to write scalable internet applications, especially web servers, taking full advantage of the paradigm. This makes it ideal for running on the outer layer of the network, on low-end hardware, as well as in the cloud. With over 225,000 modules in Node's package repository, it's easy to expand the range of tool panel nodes as new features need to be added. Streams created in Node-RED are stored in the form of JSON (JavaScript Object Notation), which is a type of data that follows a certain rule that most programming languages can read today and can be easily imported and exported to share information over the network.

With the application of IoT in measurement and control, it is great to have a flexible and online development tool, and Node-RED is the effective choice. Node-RED is a free and open-source tool created by Nick O'Leary and Dave Conway-Jones of IBM Emerging Technologies. This tool is built with the goal of simplifying the programming components. It uses visual programming that allows the programmer to connect blocks of code (called nodes) to perform a task. Nodes that are connected together are called "flows." Using Node-RED is a new way to "code" a program with a simple, intuitive "drag-and-drop" approach. This is considered a trend for the future programming of IoT projects.

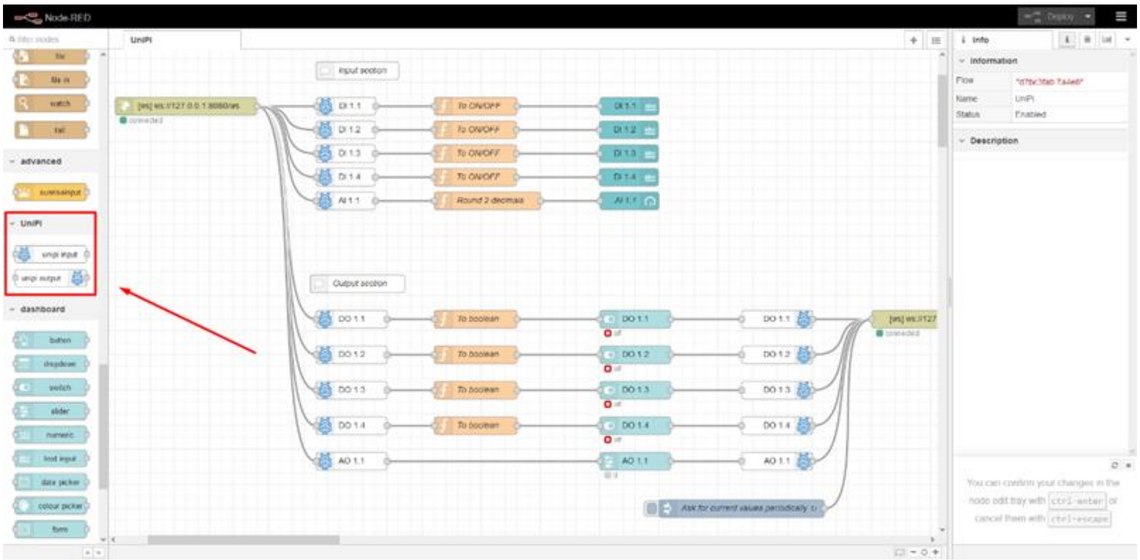

Fig 3: Interactive interface on Node-RED

Node-RED is a quality solution because

- Node-RED is open source and developed by IBM.
- Node-RED perfectly supports the Raspberry Pi.
- Node-RED is so easy to use that we can spend more time doing amazing things instead of spending countless hours coding.
- Node-RED allows you to prototype complex home automation systems quickly.

With Node-RED, we can: Access the RPi GPIO. Establish MQTT connections with other boards (Arduino, ESP8266, etc.). Create a responsive graphical user interface for your project. Communicate with third-party services (IFTTT.com, Adafruit.io, ThingSpeak, etc.). Create events that trigger over time. Store and retrieve data from the database.

3.3. Construction and usage

Runs on Raspberry Pi: If you are using Raspbian, you must have a minimal version of Raspbian Jessie or Raspbian Buster, which is the currently supported version. Install Node-RED: You can easily find a canonical script to install Node.js, npm, and Node-RED onto the Raspberry Pi once Raspbian has been installed. You can use the script shell file. In addition, the upgrade when there is a new release is also done easily. Run the scripted script: > bash sudo apt-get install build-essential to make sure npm can build any binary modules that need to be installed. This script will:

- Remove prepackaged versions of Node-RED and Node.js.
- Install the current LTS Node.js release using NodeSource.
- Install the latest version of Node-RED using npm.
- Set up Node-RED to run as a service and provide a script to work with the service.
- Node-RED has also been packaged for Raspbian repositories and appears in the "Recommended Software" list. Once Node-RED is running, you can access the editor through the browser.

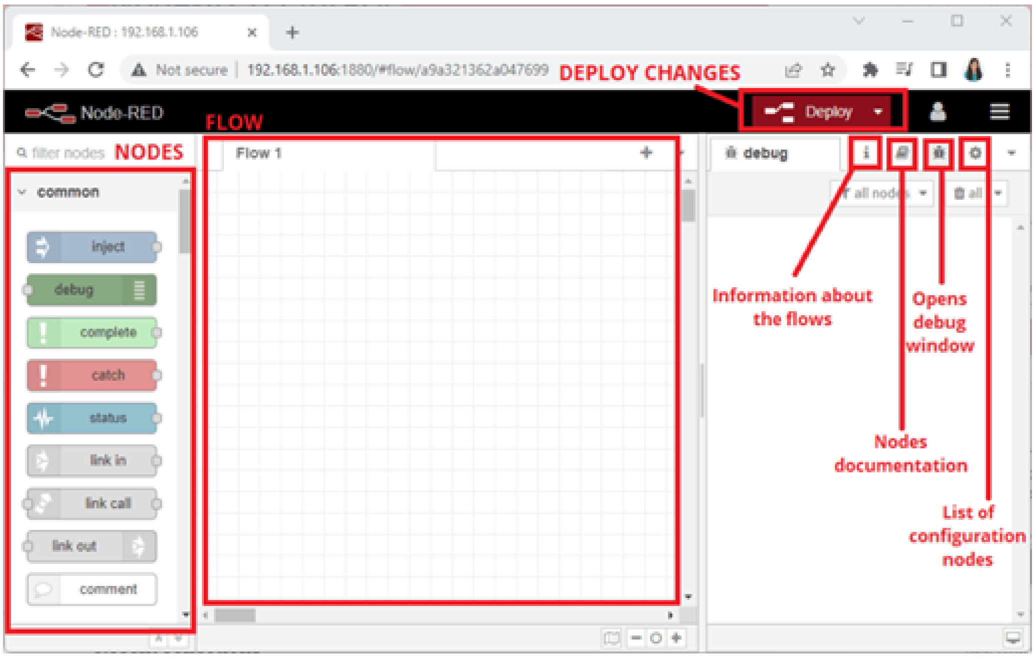

Fig 4: Node-RED Development Interface with Raspberry

There are eight main note types in the default settings in Node-Red: inputs, outputs, functions, social, storage, analysis, advanced, and Raspberry Pi. Method for creating a basic flow in programming:

- Add an Inject Button: The Inject button is dragged into the workspace from the node list panel. Open the sidebar and select the Info tab. Select the newly added "Inject" button to view information about its properties and a description of it.
- Add a debug node: The Debug button enables you to display any message in the debug bar. It displays the message by default, but it can also display the entire message object.
- Add a node function: The function node contains one or more functions that process the input message and output the resulting message to the next node in the stream. Functions can be preconfigured in the node or directly coded by the user in java script.

Connect the 3 nodes together and press "deploy." Click on the small square on the "Inject" node. Observe the debug window to see information about the time when the Inject button is pressed.

3.4. Build expansion modules for Pi

Control pins on the Raspberry Pi 3 B+:

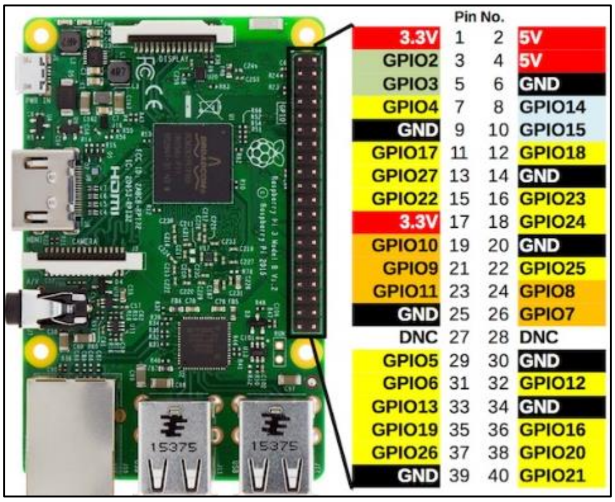

Fig 5: Layout of GPIO Pins on the Pi 3 B+

On the Raspberry Pi 3 B+, in addition to the interfaces for connecting in/out such as audio/video, network, and USB, the important resource is 40 GPIO pins in the form of a slot. GPIOs, in addition to a few mandatory features (GDN, 3V, 5V, etc.), mostly allow soft configuration to be able to: receive input signals; open/close control; control PMW; or connect interface ports for expansion according to standard Rs-232 and Rs-485.

Thus, through this slot, we can easily design an expansion and combination circuit for the Raspberry Pi. In the research article, the expansion circuit is designed to ensure the following criteria:

- Apply 5V/1.5A power to the Raspberry Pi board.
- The mixer circuit measures 08 analog input signals.
- 08 output circuit, optically isolated on/off mode (to protect the main circuit).
- A circuit connects 02 PWM outputs for power control.
- RS-4.85 extension adapter circuit for sending measurement and control system parameters to a PC.

After designing the circuit and integrating it with the Raspberry Pi board that has been installed with the operating system and the Node-Red application developer, we have a versatile measurement and control kit: There are 08 analog inputs for measuring signal in the +/- 12V range, 08 due outputs, 02 ao outputs, and an RS-485 connection port. The application of this measurement and control suite in real applications is completely self-built by users directly through Node-Red's intuitive drag-and-drop programming interface.

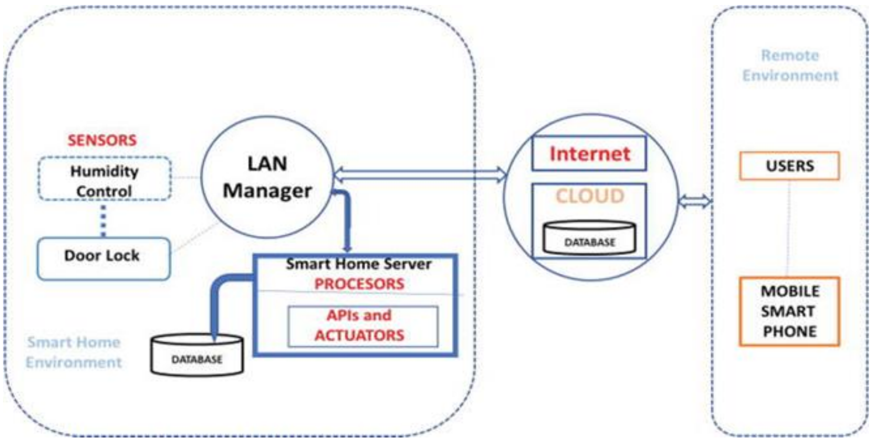

Fig 6: Hardware design module of the IoT control measurement system

4. Conclusion

In this article, we have researched and built an intelligent logic programmer that supports IoT using the Raspberry Pi embedded board.

- Provides a foundation for choosing hardware devices and open-source operating systems.
- Design additional hardware circuitry to handle the I/O.
- Integrates logic processing software with measurement and control interfaces.
- Instructions for setting up some basic applications based on already-built devices.

This research has demonstrated the ability to synergize open-source hardware and software to create intelligent processing devices. This measurement and control unit allows for good operation in the local area network, ensuring safety and security. When necessary, it can be easily configured to open the port for control and measurement from the Internet.

Some development directions:

- On this principle, it is possible to build measurement and control sets with a larger number of inputs and outputs for broader measurement and control problems.
- It is recommended to research and build specialized measuring and control units with network connections to coordinate with measurement and control logic devices via MQTT.

5. References

1. G Parmar, S Lakhani, M Chattopadhyay. An IoT based low cost air pollution monitoring system, 2017 International Conference on Recent Innovations in Signal processing and Embedded Systems (RISE), Bhopal, India, 2017. DOI: 10.1109/RISE.2017.8378212.
2. Le Ngoc Giang, Vương Thuy Linh, Phuong Nhat Minh. Research and application of IoT technology for food warehouse monitoring. International Journal of Multidisciplinary Research and Growth Evaluation. 2022; 03(06):662-668, DOI: 10.54660/anfo.2022.3.6.20.
3. Karim Yaghmour, O'Reilly. Building Embedded Linux Systems, 2003, ISBN: 0-596-00222-X.
4. RM Varaprasad, K Srujan Raju, G Vishnu Murthy, B Kavitha Rani. Configure and management of internet of things, in Data Engineering and Communication Technology, 2022, 163-172, Springer, Berlin, Germany, 2020.
5. F Bahar, F Firouzi, K Chakrabarty. *Healthcare IoT*, in Intelligent Internet of Things, Springer, Berlin, Germany, 2020, 515–545.
6. B Alexandre, D Lavino-Junior, M Sime, L Encarnação, T Bastos-Filho. A human–machine interface based on eye tracking for controlling and monitoring a smart home using the internet of things, Sensors. 2019; 19:859.
7. LY Mano, BS Faiçal, LHV Nakamura, *et al*. Exploiting IoT technologies for enhancing Health Smart Homes through patient identification and emotion recognition, Computer Communications. 2016; 89-90:178-190.
8. TN Dang, LTH Le, An improvement of remote control panel for numerous electrical devices in smart homes using RF and wifi, International Journal of Online and Biomedical Engineering (iJOE). 2019; 15(15):127-133.