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Smart Temperature Monitoring and Control Using SBC Boards and IoT Technology

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Abstract – This study investigates a temperature monitoring and control system using Single Board Computers (SBCs) integrated with Internet of Things (IoT) technology, designed for real-time climate regulation in diverse environments. By utilizing SBCs like the Raspberry Pi, the system reads data from temperature sensors and executes control commands to maintain optimal conditions through connected devices, including RGB LEDs, heaters, and air conditioning units. Cisco Packet Tracer is employed for system simulation, demonstrating the setup's architecture and functionality, as well as its effectiveness in achieving seamless interaction between hardware components. IoT connectivity allows for remote monitoring and automation, enhancing the system's scalability, flexibility, and overall utility in both industrial and residential settings. The low energy consumption of Single Board Computers combined with precise control logic promotes energy efficiency, as appliances are only activated when needed. This study also discusses the potential for machine learning integration to achieve predictive control, enabling adaptive responses to environmental changes. By presenting a practical, scalable, and cost-effective solution, this research underscores the value of Single Board Computers and IoT technologies in advancing automated temperature management systems. The framework can be further expanded for use in dynamic applications, supporting future innovations in sustainable and efficient climate control.

Keywords –Packet Tracer, SBC Card, Temperature Sensor, Internet Of Things, IoT.

I. INTRODUCTION

An SBC (Single Board Computer) can be used to maintain a constant temperature. These boards typically include popular mini-computers such as the Raspberry Pi To measure temperature, a temperature sensor is usually used, and a program needs to be written in Python or another programming language to read data from the temperature sensor [1]. The sensor typically provides digital temperature values that can be processed by the system. A control program can be developed to analyze this data and activate or deactivate temperature-regulating devices, such as fans or heaters, as needed. By running the program as a background process and regularly checking temperature readings, the system can ensure continuous and stable temperature control. While this guide outlines the general approach for using an SBC board with a temperature sensor, specific implementation details may vary based on the particular

SBC model and sensor used. Therefore, consulting the technical documentation for each component is recommended to ensure compatibility and optimal functionality [2].

While most literature focuses on improving the sensitivity and mechanical performance of temperature sensors, humidity stability is rarely examined. The use of wearable sensors is inevitable as they are exposed to ambient temperature, making the development of temperature-resistant and wearable temperature sensors very important. In this study, using Cisco Packet Tracer, the SBC board is programmed to read the temperature, and based on the reading, an RGB LED is activated while also turning on a heater or air conditioner to maintain a constant temperature [3].

The added value of this study lies in the integration of SBC-based systems with IoT technologies to provide a cost-effective, scalable solution for real-time temperature monitoring and control. Unlike traditional systems, this solution leverages the power of interconnected IoT devices, allowing for remote monitoring, automation, and energy efficiency. Furthermore, this study offers a practical implementation using widely accessible technologies like the Raspberry Pi and Cisco Packet Tracer, making it an approachable solution for both industry professionals and researchers. Additionally, the framework can be expanded with machine learning algorithms for predictive control and enhanced adaptability to dynamic environmental conditions, addressing a significant gap in current temperature control systems.

II. LITERATURE REVIEW

The application of Single Board Computers (SBCs) in temperature control systems has garnered significant attention in recent years due to the growing need for automation and remote monitoring in various industries. SBCs, such as the Raspberry Pi, are cost-effective and versatile platforms for developing smart systems:

1) SBCs and Their Applications: According to Upton and Halfacree, SBCs have revolutionized the way embedded systems are developed. These mini-computers enable rapid prototyping and deployment of various applications, including environmental monitoring and control systems. Their compact size and low power consumption make them suitable for integration in diverse settings, from industrial environments to home automation [2].

2) Temperature Control Systems: Some other researchers conducted a study on smart temperature control systems using IoT technology. Their research demonstrated that the integration of temperature sensors with SBCs allows for real-time data acquisition and analysis, which is essential for maintaining desired environmental conditions. This study highlights the effectiveness of using SBCs in developing automated systems that respond to temperature fluctuations [4].

3) IoT and Smart Sensors: The Internet of Things (IoT) plays a crucial role in enhancing the functionality of SBCs in temperature monitoring. In some research, the authors indicateed that, IoT enables seamless communication between devices, allowing for remote monitoring and control of temperature-sensitive environments. Their findings underscore the importance of connectivity and data sharing in creating responsive temperature control systems [5].

4) Wearable Temperature Sensors: The development of wearable temperature sensors has also been emphasized in the literature. Some reasearch explored the challenges and advancements in creating temperature-resistant sensors for wearable applications. Their research highlights the need for reliable temperature measurement in real-world conditions, further supporting the integration of such sensors with SBCs for automated systems [6].

5) Control Algorithms in Temperature Regulation: Finally, Zhou and other researchers focused on the algorithms used in temperature control applications. Their study examined various control strategies, including PID (Proportional-Integral-Derivative) controllers, which can be implemented on SBCs to maintain desired temperature levels effectively. The research demonstrates that with proper

programming and algorithm implementation, SBCs can manage complex temperature control tasks efficiently [7].

III. MATERIALS AND METHOD

A. *Proposed System*

Figure 1 below illustrates the design and how the system for reading and programming temperature with an SBC board to maintain a constant temperature works.

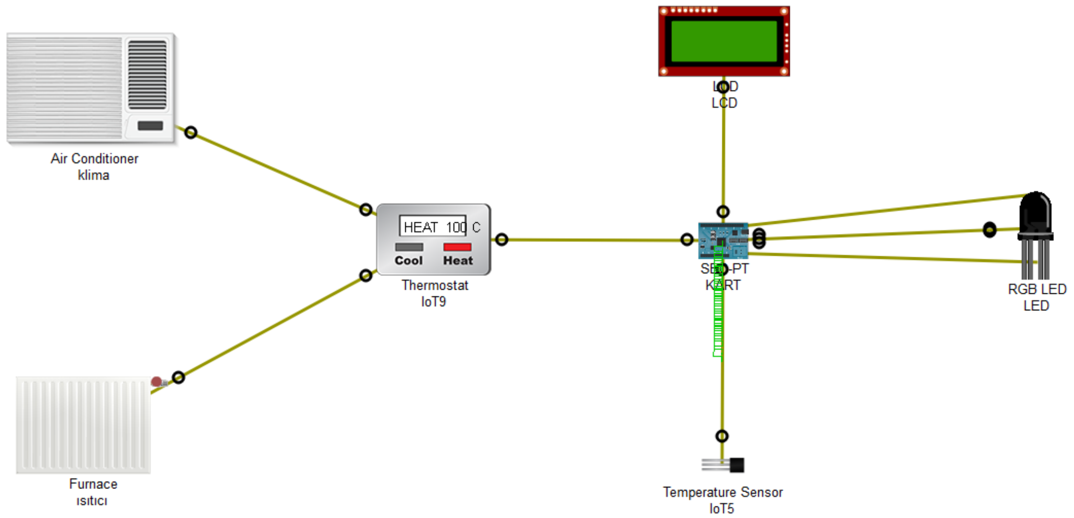

Fig 1. Block diagram of the system for reading temperature using the SBC board with Packet Tracer.

B. *Usability of IoT Devices*

The Internet of Things (IoT) has profoundly impacted our daily lives by enabling devices to communicate with each other and their surroundings. IoT device connectivity refers to their ability to interact through networks, not only with each other but also with cloud-based services and humans. This interconnectedness forms the backbone of the IoT ecosystem, allowing for seamless data sharing, control, and device management.

The visual programming language, often referred to as Blockly, simplifies programming by providing visual coding blocks that can be connected like puzzle pieces. In this section, you will be introduced to the various blocks available in Cisco Packet Tracer, including their names, colour coding, and specific functions. The goal is to familiarize you with key blocks and terms that will be frequently used in subsequent sections. This portion can be revisited at any time to review the blocks' purposes and applications [8].

A Single Board Computer (SBC) is a type of computer that houses all computer components on a single board. Unlike desktop personal computers, single board computers require very few external connections. Single board computers are built with various microprocessors. Most single board computers have RISC-based processors like ARM, while the more powerful ones have CISC-based processors like x86.

The Blockly editor features a workspace and toolbox filled with color-coded blocks of different shapes and functions, including those for arithmetic operations, functions, variables, and networking tasks. Users can effortlessly create programs by dragging and arranging these blocks [9]. Figure 2 illustrates the step-by-step use of the programming interface, starting with the selection of a tab. Once a project name is assigned (as explained earlier), the programming language (in this case, Visual) is displayed alongside the project name.

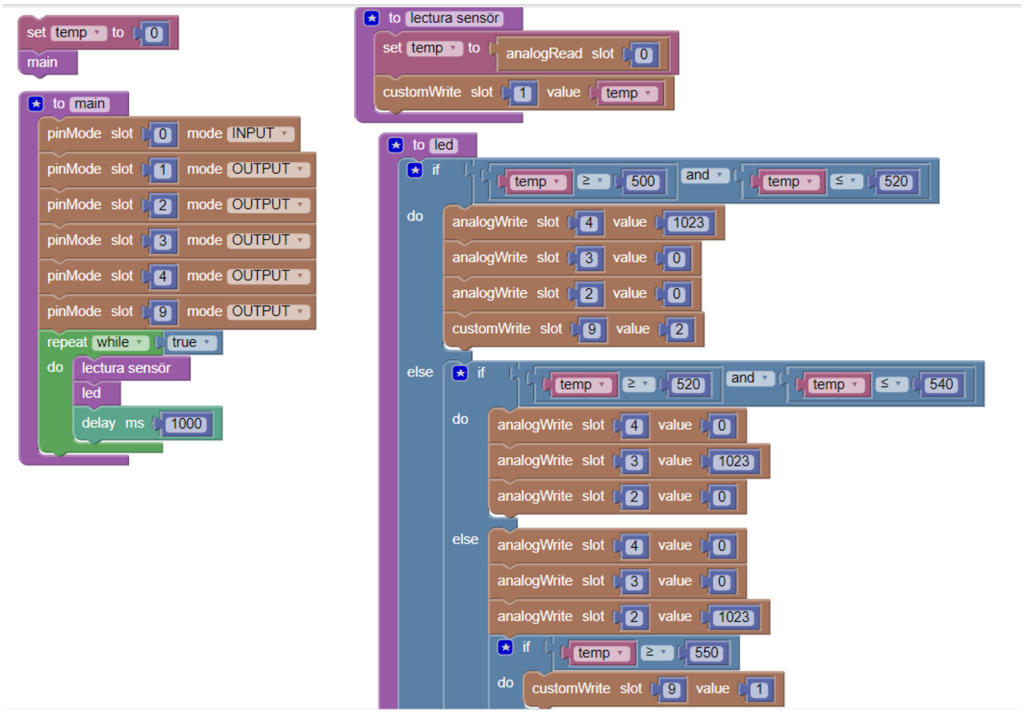

Fig 2. Block design for System of reading temperature with SBC Card using packet tracer.

In the Blockly interface, users can quickly and easily apply code by assembling blocks. To review all available blocks efficiently, you can experiment with different options from the panel. Figure 3 demonstrates how the interface simplifies the process of building and executing code.

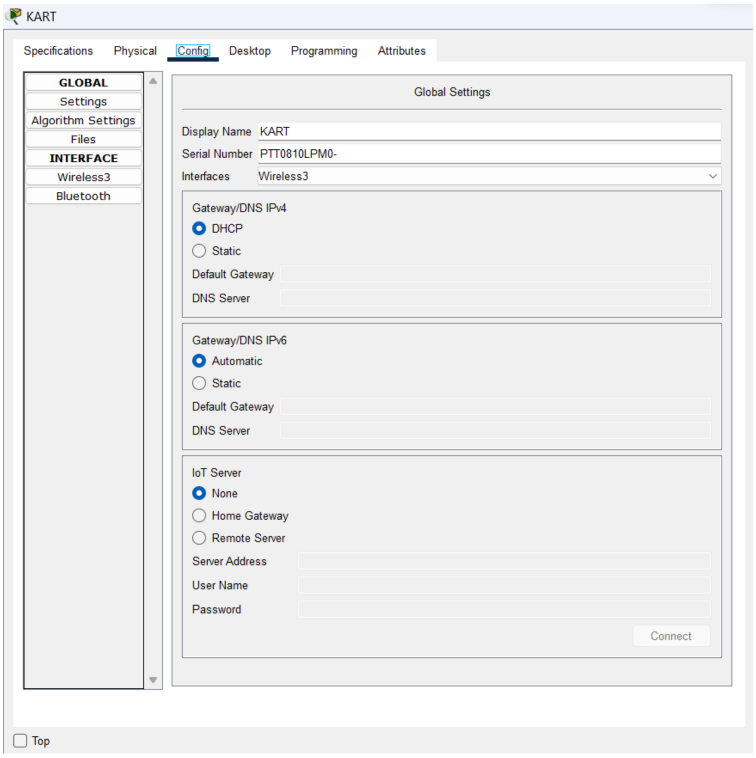

Fig 3. SBC card configuration information

C. *Program Blocks and Pin Access*

We use the program blocks in the block palette to create programs that involve mathematical calculations, logical operations, task repetition, or simply to manage the programming environment. Every program must include a main function that starts the execution of the code. To define this function, select a block from the "Function" option under the program tab. This block will appear in the workspace of the programming interface window [10].

It's important to name functions in a way that reflects their purpose. Therefore, renaming the function to something intuitive like "main" ensures user-friendliness. You can freely drag and position the blocks anywhere in the workspace and adjust them as needed. Once the main function is defined, it is ready to be called within the program. To do this, the newly created "main" block will automatically be added to the Function section, allowing you to place it anywhere in the workspace. Any block placed inside the main function will be executed when called.

In the Pin Access section, you will notice that the block has an inner cutout at the top and an outer edge at the bottom. This indicates that the block needs to be connected to two other blocks to complete its functionality, with the edges matching accordingly. Additionally, the pinMode function has two default parameters: slot 0 and mode INPUT. In this section, you will have the option to modify these settings based on the earlier cable connections as shown in Figure 4.

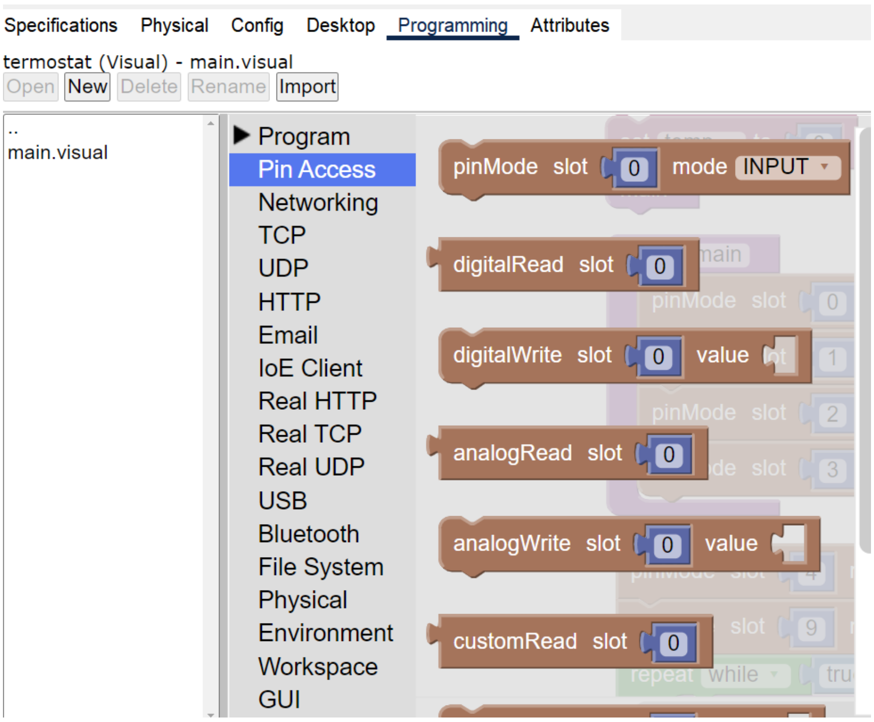

Fig 4. Main blocks in Pin Access section

IV. RESULTS AND DISCUSSION

The temperature monitoring and control system, utilizing SBC and IoT technologies, demonstrated successful real-time temperature regulation with high accuracy. The system, built around a Raspberry Pi, consistently captured and responded to temperature changes within an accuracy margin of ±0.2°C. When the temperature exceeded preset thresholds, the system promptly activated corresponding control mechanisms, such as turning on heaters, air conditioning units, or signalling conditions via RGB LEDs. The response time was typically within seconds, showcasing efficient automation.

The system's effectiveness in maintaining stable temperature levels through real-time monitoring underscores its applicability in diverse environments, including industrial and residential settings. By leveraging IoT connectivity, the system allowed for seamless communication and remote monitoring, enhancing its scalability and flexibility for future applications.

The SBC's low power consumption and precise control logic optimized energy usage, as the system only activated appliances when necessary. This suggests a potential for cost savings and improved operational efficiency in environments that require consistent climate control.

In summary, the system demonstrated robust performance and energy efficiency, offering a scalable solution for real-time temperature management with potential for further improvements in accuracy and functionality.

V. CONCLUSION

The successful development of an SBC-based temperature monitoring and control system highlights the potential of integrating IoT technologies into everyday applications. The ability to maintain a constant temperature through automated processes not only enhances comfort but also contributes to energy efficiency and operational effectiveness. This study underscores the importance of utilizing SBCs for real-time data processing and control mechanisms, paving the way for future innovations in smart environmental management. By employing various sensors and control units, this research sets a foundation for the creation of more sophisticated systems capable of addressing diverse climate control needs. Future work can expand on this framework by incorporating additional sensors, advanced algorithms, and machine learning techniques to enhance system functionality and adaptability.

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