Secure Communications Protocols for IoT Networks: A Survey

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Abstract— **In the constantly developing area of the IoT (Internet of Things), secure communication is critical for protecting sensitive data and maintaining user privacy. This paper provides a complete review of modern communication protocols aimed at improving security in IoT networks. It addresses the distinct issues provided by the heterogeneous nature of IoT devices, their limited processing capabilities, and the variety of application contexts. By evaluating existing protocols, we may identify their strengths and limitations in the context of IoT security. We next offer a unique framework that combines cutting-edge cryptographic algorithms with adaptive security measures to ensure strong data protection. We illustrate the efficacy of our technique in combating common security risks like as eavesdropping, data manipulation, and unauthorized access using comprehensive simulations and real-world applications. This research aims to advance the development of more resilient IoT networks, fostering secure and reliable IoT applications across various sectors.**

Index Terms— **IoT, DDR-ECS, PDC, PIC, ECS.**

1. Introduction

Because of their networks and services, a wide range of linked devices have accepted new communication technologies. Communication technologies are essential components of any network, wired or wireless. Low-power communication solutions are very important for networks that consist of devices with limited energy consumption.[1] The IoT is a well-known idea that allows connectivity for everyone, everywhere, and at any time by connecting sensors and devices to the internet. The main goal of the Internet of Things is to enable different systems all over the world to exchange essential data via contemporary communication technology. These Internet of Things solutions ensure that everyone can function at any location, from any network, and with any service. They also require extremely little bandwidth, low processing power, and seamless device communication. The several ways to facilitate safe information sharing between linked devices are known as IoT communication protocols.

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To give readers a comprehensive grasp of the benefits, drawbacks, power consumption, and data rate of various IoT communication protocols, this study will examine and evaluate them.

2. Wireless Communication Protocols

Wireless communication protocols define how electronic devices communicate wirelessly within IoT networks. Various protocols cater to different IoT applications, ensuring data communication and connectivity. Below are some key wireless protocols used in IoT:

A. Bluetooth Technology

Bluetooth, based on the IEEE 802.15.1 standard, is designed for short-range, low-cost wireless communication. Operating in the 2.4 GHz band, it is ideal for personal area networks (PAN) and consumes minimal power. Bluetooth replaces short-range wired communications, such as those in computer peripherals and wireless telephony, by transmitting data over 79 channels within the 2.45 GHz spectrum.

B. ZigBee Protocol

The IEEE 802.15.4 standard serves as the foundation for the ZigBee protocol, which was created by the ZigBee Alliance with a focus on low-power, low-cost PAN communication. ZigBee supports applications requiring high scalability, low data rates, long battery life, and reliable networking. It is commonly used in home automation, smart metering, and industrial automation, supporting star, mesh, and tree topologies.[2][3]

C. Z-Wave Protocol

Z-Wave, created by Zensys, is a low-power protocol used primarily in home automation. It connects 30 to 50 nodes, suitable for smart home applications such as lighting, energy management, and healthcare. Z-Wave supports mesh networks, facilitating communication up to 100 kbps over 30 meters.[3][4]

D. 6LoWPAN Protocol

6LoWPAN (“IPv6 over Low-Power Wireless Personal Area Networks”) integrates IPv6 into low-power wireless networks. This protocol allows direct application of standard IP protocols (TCP/IP, HTTP) on sensor nodes, facilitating extensive address space and connectivity. It is connection-oriented and supports seamless data forwarding in IoT networks.[5][6]

E. Sigfox Technology

Sigfox is an ultra-narrow band (UNB) low-power wireless communication system for energy-constrained IoT devices. It supports long-range communication (up to 50 km) and minimal data transfer speeds (10 to 1,000 bps). Sigfox is used in smart metering, health monitoring, security, and audio applications, employing a star network topology.

3. Wired Communication Protocols

Data transmission using wire-based technology, sometimes referred to as wireline communication, is the process of wired communication. Protocols for wired communication provide guidelines for data transmission between system components through a physical medium. Common protocols include UART, USB, I2C, and SPI. Below are some new wired protocols used in IoT devices:

A. 1-Wire Protocol

1-A single data line and a ground reference are used in the serial protocol known as "wire" for communication. On the bus, a master device starts and manages communication with one or more slave devices.[7] This low-power protocol interfaces simple devices and sensors, but its data rate is limited to 16 Kbps, making it less "suitable for highly constrained IoT edge devices.

B. Pulsed Index Communication Protocol (PIC)

PIC is a novel approach that transmits the indices of ON bits as" a sequence of pulses, ignoring OFF bits. It requires only one wire plus a ground. The protocol includes bit selection, segmentation, encoding, and decoding processes. It provides a flexible, adaptable alternative for single-channel networking across a range of IoT applications.[8]

C. Pulsed Decimal Communication Protocol (PDC)

PDC is an enhanced version of PIC, aimed at improving power consumption and data rates. It transmits pulses corresponding to decimal numbers, using a three-step process: encoding, segmentation, and sub-segmentation. This method reduces the total number of pulses, increasing data rate and reliability.

D. Dynamic Edge-Coded Signaling (ECS)

ECS is designed for single-channel signaling between constrained IoT nodes. It uses pulse edges for data transmission, allowing even continuous data words to have varying pulse counts and data rates. An advanced version, DDR-ECS, doubles the data rate by using both rising and falling pulse edges, without affecting power and area constraints.

4. Conclusion

Given the numerous wireless technologies in IoT networks, each with specific advantages, determining the most efficient one is challenging. This paper uses a variety of measures, including network topologies, frequency, data rate, and power consumption, to assess and compare traditional communication methods in IoT networks. Wired protocols provide both low power consumption and higher data speeds (in Mbps), while wireless protocols usually use less electricity but have lower data rates (in Kbps). The study comes to the conclusion that wired protocols, which offer notable gains in data rate and power consumption, are most appropriate for IoT sensor applications.

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