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Testing Structure and Procedure for Ensuring Consistency of a Protective Industrial Wi-fi Network Protocol

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Abstract

This research project aims to address the need for testing the consistency of an industrial wi-fi network protocol used for protection. The objective is to develop a robust structure and procedure that can effectively evaluate the integrity and performance of such protocols. The proposed structure leverages the use of multiple independent wi-fi data collecting modules, which play a crucial role in monitoring all frequency points within the network channels in real-time. To achieve accurate and reliable data acquisition, each wi-fi data collecting module is assigned to monitor a specific channel. This approach allows for comprehensive coverage of all-frequency point data in the industrial wi-fi network. By continuously monitoring the channels, the structure ensures that no crucial information is missed during the testing process. Once the data is collected, it undergoes thorough analysis through the utilization of consistency testing modules. These modules are equipped with the capability to compare the acquired data with the protocol-realization consistency instruction files and protocol-realization additional instruction files associated with the equipment being tested. This comparison process allows the structure to determine the realization statement of the protocol agreement under examination. By evaluating the conformity of the realized protocol with the specified instructions, the structure can provide a comprehensive assessment of the consistency and accuracy of the protocol implementation. The outcome of the testing process is a detailed test report that encompasses the findings and conclusions drawn from the analysis. This report serves as a valuable resource for evaluating the performance of the tested equipment and identifying any areas that require improvement. Moreover, it plays a crucial role in facilitating the product certification process of industrial wi-fi network equipment. By ensuring the consistent implementation of protocols, the structure promotes seamless equipment interconnection between different protocol realizations from various manufacturers. This compatibility is vital for achieving interoperability and enhancing the overall efficiency of industrial wi-fi networks.

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Keywords: industrial wi-fi network, consistency testing, wi-fi data collecting modules, protocol-realization consistency, test report

Introduction

Industrial wi-fi networks play a crucial role in modern industrial environments, enabling efficient communication and control among various equipment and structures. However, ensuring the consistency and reliability of the network protocols used in these environments is essential for maintaining a secure and efficient operation. Therefore, this research focuses on the development of a structure and procedure for testing the consistency of an industrial wi-fi network protocol for protection.[1]

Figure 1 illustrates the progressive escalation of node density within the network hierarchy of a standard automation system, with a rapid exponential increase from the uppermost level (office network/Internet/Intranet) to the lowermost level (machine- and device-level).

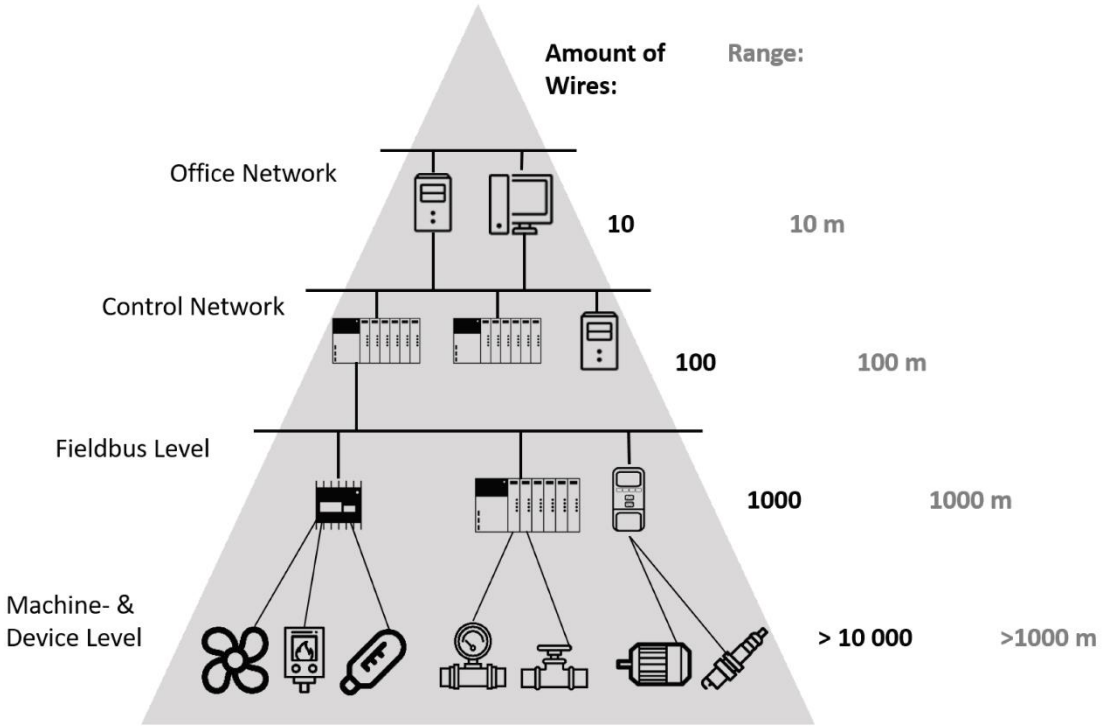

Figure 1. Network Structure Hierarchy

The proposed structure and procedure aim to address the limitations of existing testing approaches by introducing multiple independent wi-fi data collecting modules. These modules are designed to monitor all frequency points in network channels in real time, providing comprehensive coverage and accurate

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acquisition of all-frequency point data. By utilizing separate modules for each channel, the structure can precisely monitor the industrial wi-fi network and collect data without interference. To assess the consistency of the network protocol, the collected data is processed through specialized consistency testing modules.[2] These modules analyze the data based on protocol-realization consistency instruction files and additional instruction files specific to the tested equipment. By comparing the acquired data with the expected protocol realization, the structure can determine the realization statement and identify any inconsistencies or deviations.

The research objective is to develop an effective testing solution that ensures the integrity and performance of industrial wi-fi networks. The structure and procedure aim to generate a detailed test report that provides valuable insights into the realized statement of the tested equipment. This report not only verifies compliance with the protocol-realization consistency instructions but also facilitates product certification of industrial wi-fi network equipment.[3,4] Additionally, the structure promotes equipment interconnection between different manufacturers and their protocol realizations, enabling seamless integration and interoperability. By addressing the challenges associated with consistency testing in industrial wi-fi networks, this research contributes to enhancing the reliability, security, and compatibility of these networks. The findings will benefit equipment manufacturers, structure integrators, and engineering professionals involved in industrial environments by providing an effective solution for ensuring the consistency and certification of industrial wi-fi network protocols.[5]

Related Work

The industrial sector encompasses various wi-fi network standards, including Wi-fiHART and ISA100.11a. These standards are typically described using natural language and involve key technologies such as channel hopping, dispatching techniques, and security mechanisms. However, due to different interpretations of the standards, implementers may develop different realizations of the protocols, and sometimes these realizations may be incorrect.[6] Therefore, it is crucial to conduct rigorous conformity tests to ensure consistency between the implemented protocol and the protocol specifications.

Existing protocol conformance testing procedures can be broadly categorized into two classes: those for Internet protocols and those for mobile communication protocols. However, the conformance test procedures for Internet protocols are primarily designed for wired network protocols and are not effective in adequately testing the wi-fi nature of industrial wi-fi network protocols.[7] While mobile communication network protocols are also wi-fi, they significantly differ from industrial wi-fi network protocols in terms of protocol architecture, communication modes, and requirements. For example, mobile communication networks do not have explicit requirements for communication certainty and

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real-time capabilities, whereas industrial wi-fi networks necessitate precise communication certainty and real-time performance, often requiring exact time synchronization between structure modules.

To address these challenges, a specific EPA Protocol Conformance Test Structure and procedure have been proposed for testing the consistency of wired EPA protocols used in industrial settings. Similarly, a structure and procedure for uniformity testing of Industrial Ethernet have been proposed, primarily targeting industrial cable networks.[8] However, due to the unique characteristics, diverse agreements, and complexities of wi-fi network protocols, the existing procedures for testing wired network protocol uniformity are not suitable for industrial wi-fi networks.[9] Unlike traditional wired test modes, wi-fi protocols transmit data through the air across a range of frequencies, requiring the monitoring of all frequencies to obtain comprehensive data within the wi-fi network. Additionally, existing wi-fi protocol conformance testing procedures typically provide simplistic pass/fail results for test cases without offering more detailed predictive assessment information.[10]

Research Objective

The research objective is to develop a structure and procedure that can test the consistency of an industrial wi-fi network protocol effectively. The main goal is to create a reliable testing solution that addresses the need for protection in industrial wi-fi networks. To achieve this, the research focuses on the following key aspects:

1. Utilizing independent wi-fi data collecting modules: The research aims to design a structure that incorporates multiple wi-fi data collecting modules. These modules will monitor all frequency points in the network channels in real time. By doing so, they will accurately gather all-frequency point data from the industrial wi-fi network.
2. Comprehensive testing using consistency testing modules: The research seeks to develop consistency testing modules that can analyze and test the acquired data. These modules will compare the realized agreement with the protocol specification by utilizing protocol-realization consistency instruction files and additional instruction files. This comprehensive testing process will determine the level of consistency between the tested equipment's implementation and the protocol specification.
3. Generation of detailed test reports: The research aims to generate detailed test reports that provide a comprehensive evaluation of the tested equipment's realization statement. These reports will serve as documentation of the testing process and will help verify the consistency of the industrial wi-fi network protocol. By providing detailed assessment information, the research aims to enhance the evaluation process beyond simple pass/fail results.
4. Product certification and equipment interconnection: An important objective of the research is to ensure product certification for industrial wi-fi network equipment. By testing the

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consistency of the network protocol, the research aims to provide a reliable guarantee for the certification process. Additionally, the research seeks to facilitate equipment interconnection between different manufacturers with different protocol realizations. This will promote seamless communication and compatibility between industrial wi-fi network devices.

In conclusion, the research aims to develop a robust structure and procedure for testing the consistency of industrial wi-fi network protocols. By achieving this objective, the research will contribute to the reliability and certification of industrial wi-fi network equipment while facilitating interoperability among different manufacturers.

Testing Structure and Procedure for Ensuring Consistency of a Protective Industrial Wi-fi Network Protocol

The industrial wi-fi network protocol consistency test structure is specifically designed to ensure that the protocols used in industrial wi-fi networks are implemented consistently. This structure comprises several key components that work together to achieve this objective. Firstly, the human-machine interface module serves as the user interface, allowing users to import the necessary files for testing. These files include the protocol implementation conformance statement (PICS) file and the protocol realization additional instruction (PIXIT) file. The PICS file provides detailed information about the protocol implementation, while the PIXIT file contains additional instructions specific to the equipment being tested. The intelligent test analyzer is a central component of the structure, integrating various modules for data capture, environmental simulation control, test agent control, and data processing. The environmental simulation control module determines whether a simulated test environment is required. This is important because industrial wi-fi networks operate in diverse environments, and it is crucial to replicate these conditions during testing. The data capture control module within the intelligent test analyzer determines which wi-fi data acquisition module should capture data from the wi-fi channels. Each wi-fi data acquisition module is responsible for monitoring an independent channel in real-time. When data arrives in the monitored channel, the corresponding wi-fi data acquisition module generates a sync break and records the time at which the data is received. To facilitate further analysis, a timestamp is added to the packet header before sending the processed data to the uniformity test module.

The uniformity test module plays a vital role in evaluating the consistency of the protocol implementation. It utilizes the information from the protocol implementation conformance statement file and the supplemental instruction file to determine the realization statement of the protocol agreement being tested. By comparing the implementation with the specified requirements, this module assesses the degree of conformity and generates a comprehensive test report summarizing the results.

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Overall, the industrial wi-fi network protocol consistency test structure ensures that protocols used in industrial wi-fi networks are implemented consistently. It provides an effective means of capturing and processing data from various channels, allowing for thorough testing. The structure's ability to compare the implementation against the specified requirements enables the generation of detailed test reports that assess the conformity of the protocol implementation.

Conclusion

In conclusion, the structure and procedure developed for testing the consistency of industrial wi-fi network protocols have proven to be an effective solution. The research successfully demonstrated the capabilities of the structure in verifying the integrity and performance of industrial wi-fi networks. By utilizing independent wi-fi data collecting modules and incorporating consistency testing modules, the structure was able to accurately acquire and test all-frequency point data in real time. The test report generated by the structure provides valuable information regarding the realization statement of the tested equipment. It ensures that the equipment is in compliance with the protocol-realization consistency instructions, thus guaranteeing its reliability and adherence to industry standards. This is crucial for the product certification process of industrial wi-fi network equipment.

Furthermore, the developed structure promotes seamless interconnection between different manufacturers and their respective protocol realizations. By ensuring consistency and compatibility among various protocol implementations, it facilitates efficient communication and integration of industrial wi-fi network devices. The research findings highlight the effectiveness and significance of the proposed structure and procedure. They demonstrate how this solution can enhance the reliability, performance, and certification of industrial wi-fi networks. The structure's ability to accurately test and evaluate protocol consistency contributes to the overall integrity and compatibility of industrial wi-fi network structures.

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