

Application of Computer Network Technology in Ship Communication System

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Abstract: With the rapid growth of international trade and shipping, ships are the main mode of transportation connecting various parts of the world. Therefore, the reliability and effectiveness of communication systems on ships are very important. As an important means of modern communication, computer networks have been increasingly applied in ship communication. This article introduces the current situation, advantages, and existing problems of the application of computer networks in ship communication, and proposes corresponding solutions. Introduced the basic concepts of network and communication, laying a solid theoretical foundation for the subsequent analysis. An analysis was conducted on the current composition and requirements of ship communication, pointing out its existing problems and future development trends. This article provides a detailed discussion on the current development trend of ship communication from several perspectives, including remote communication of ships, optimization of internal communication of ships, efficient integration of ship shore communication, innovation of communication signal processing technology, and development of comprehensive communication terminals.

Keywords: Computer network, ship, communication system.

1. Introduction

With the rapid development of the global shipping industry and the continuous progress of shipbuilding, communication on the ocean has become increasingly important. The ship communication system is the key to ensuring the safety of ship navigation, managing ships, and transportation scheduling, and puts forward higher requirements for the efficiency, reliability, and safety of communication. The existing data transmission technology on ships is constrained by factors such as data transmission speed, coverage area, and anti-interference ability, making it difficult to meet the needs of modern ships. With the development of computer network technology, ship communication systems have also made great progress, improving the communication capabilities of ships and laying a solid foundation for achieving intelligent management of ships. This article conducts a more in-depth study on the application of computer network technology in ship communication from the aspects of basic technology status and requirements, specific application field challenges and development trends.

2. Overview of Computer Networks and Communication Systems

2.1. Computer Networks

Computer network is a technology that connects computing devices distributed in multiple locations through multiple hardware devices, communication protocols, etc., for information transmission and resource sharing. Its characteristics determine that it is an indispensable and important component of modern ship communication systems. Computer network technology has the characteristics of high data transmission efficiency, diverse data types, large data volume, and strong real-time performance. In terms of ship navigation, monitoring, and management, real-time acquisition and transmission of key information such as ship navigation, monitoring, and management can achieve

functions such as ship navigation, monitoring, and management, improving the safety and efficiency of ship navigation. Computer network technology utilizes standardized communication protocols such as TCP/IP to ensure stable and secure transmission of data over the network. These communication protocols ensure the reliable and secure transmission of data, avoiding data loss and tampering. The data transmission of the ship communication system is a crucial link, and any errors that occur during the data transmission process can have serious consequences. Computer networks also have the ability to dynamically construct networks, which can adjust the structure of the network based on the movement of ships and changes in the topology of the network. This flexible network structure allows ships to adjust network connections at any time during their voyage to ensure stable communication system operation [1]. No matter where the ship navigates, it can maintain communication with the outside world and obtain the necessary information and resources. The use of firewalls and encryption technology ensures the integrity and confidentiality of data transmission. This high security ensures that the ship communication system is not subject to illegal interception and interference, safeguarding the personal safety of the ship and crew, as well as ensuring the transmission of sensitive information. Computer network technology has become an important supporting technology for modern ship communication due to its high data transmission efficiency, standardized communication protocols, flexible network structure, and secure reliability.

2.2. Communication System

As an important component of maritime navigation equipment, communication systems play a crucial role in the process of maritime navigation. It includes information exchange between ships and shore based, ships and ships, as well as information exchange between ships and their affiliated units. The modern ship communication system adopts various communication methods such as satellite,

radio, and mobile communication, ensuring the reliability of communication for ships under various harsh navigation conditions. These communication systems not only need to provide voice communication functions, but also need to meet the real-time transmission requirements of various types of information such as data, images, and videos. The emergence of the Internet of Things has led to the development of intelligent and automated communication systems for ships, which are interconnected with various sensors and actuators on board to achieve real-time monitoring and effective management of ships. In the design process of the communication system, high anti-interference ability and high stability communication devices and technologies were selected based on the working environment characteristics of the ship, as well as harsh conditions such as electromagnetic interference and weather changes at sea. In order to ensure continuous and reliable communication, communication systems are generally equipped with backup devices [2]. Once the main communication link fails, fast communication can be carried out through the backup link, so that communication inside and outside the ship is not interfered with.

3. The Current Status and Requirements of Ship Communication Systems

3.1. Composition of Ship Communication System

At present, the ship communication system has developed to a highly complex and multifunctional level, including various communication requirements between ships, ships on shore, ships between ships, and ships inside ships. The first GMDSS is a global communication system established by IMO to ensure maritime safety. The system utilizes various communication methods such as satellite communication and high-frequency radio communication to ensure that ships can send distress signals in a timely manner and receive rescue messages in the event of a maritime accident. The GMDSS system can transmit the distress signal of a ship to the coastal rescue center and neighboring ships in case of sudden events such as severe weather or mechanical failures, and transmit the specific location and related basic information of the ship to the coastal rescue center and neighboring ships. The GMDSS system is one of the key technologies to ensure the safety of ship navigation and plays an irreplaceable role. The second AIS system is a short-range wireless communication system suitable for ships to ships and ships to shore. Through the AIS system, ships can exchange information such as position, speed, and heading with each other, and also obtain information such as position, speed, and heading from neighboring ships. The AIS system has a good role in assisting navigation and preventing conflicts. The AIS system can also dynamically monitor and track ships, providing a basis for port supervision and maritime law enforcement work. The AIS system generally includes a very high frequency radio communication module, a global positioning system positioning module, and an information processing module. The real-time and accuracy of AIS system have a significant impact on improving the navigation safety of ships. The third generation satellite communication is an important component of ship remote communication [3]. By using satellite communication technology, ships can send voice,

video, multimedia and other information to shore and other ships, thus achieving remote communication between ships and shore and other ships. Internationally renowned satellite communication companies such as Inmarsat and Iridium have established global satellite communication networks for various ships sailing at sea, providing support for emergency rescue, remote diagnosis, and receiving meteorological information for various ships sailing at sea. Satellite communication has become an essential communication method in maritime navigation due to its reliable performance and large coverage area. Fourthly, the onboard communication system is mainly designed to achieve communication and management functions within the ship, including daily communication among crew members, command transmission, and emergency reporting. These systems typically include devices such as broadcasting systems, walkie talkies, internal telephone networks, etc., which ensure effective transmission and reception of information during the operation of the vessel. The captain can transmit the navigation plan and safety notice to the crew through the wireless device, and the engineer can communicate the operation status of the device in real-time with the employees in the cabin through the wireless pager [4]. The stability and timeliness of the internal communication system of a ship will affect the overall efficiency and safety of the ship.

3.2. Requirements for Ship Communication Systems

With the rapid development of modern maritime industry, ships are traveling farther and farther at sea, their operations are becoming more and more complex, and the demand for communication is also increasing. Traditional communication systems have significant deficiencies in real-time performance, stability, universality, and global coverage, making it difficult to meet the needs of modern ships. In order to ensure timely transmission of navigation, weather, distress and other information, and to prevent danger to navigation caused by changes in weather conditions and unexpected events, ship communication systems should have strong data transmission capabilities. At the same time, the complexity and uncertainty of the marine environment require communication systems to have good anti-interference and stability, and adopt redundancy and protection measures to ensure reliable operation under harsh weather conditions. The ship communication system should have multiple functions such as navigation, cargo monitoring, crew communication, and remote fault diagnosis, and be combined with automatic control devices and IoT technology to achieve intelligent management. As the distance traveled by ships continues to increase, especially in remote ocean and polar marine environments, the requirements for communication are becoming higher and higher. Satellite communication must be relied upon to ensure signal stability and bandwidth requirements. At the same time, cross-border communication standards must be established to connect communication between countries and regions, in order to better meet the needs of international transportation.

4. The Current Application Status of Computer Network Technology in Ship Communication Systems

4.1. Applications in Remote Communication Systems

Satellite communication has become the main means of long-distance communication for ships, combined with computer and network technology, making the role of satellite communication even more powerful. By utilizing satellite communication, ships can effectively connect to shore based communication networks and engage in remote voice, video, and data communication. The satellite network of the International Maritime Satellite Organization (Inmarsat) combines TCP/IP protocol with maritime information transmission technology to achieve global communication for ships, enabling real-time communication between ships and shore in any water area. This fusion can ensure real-time information and high-quality multimedia data transmission, meeting the needs of ship navigation, cargo monitoring, personnel communication, and other aspects [5].

In the maritime mobile communication network, real-time dynamic adjustment of the channel is required due to the frequent changes in the position of ships. On the basis of computer networks, a routing protocol DSR (Dynamic Source Routing Protocol) based on dynamic source routing is proposed. It can select the optimal communication line in the shortest possible time according to the actual situation of the network, effectively reducing data latency and packet loss rate. By utilizing dynamic routing technology, the system is able to quickly respond to the positioning and communication requirements of ships, ensuring effective information transmission. Especially in the case of collaborative communication among multiple ship groups, it has broad application prospects and provides technical support for the information management of ship groups.

The introduction of IoT technology in remote monitoring of ships has improved the level of intelligence in ship monitoring. By installing sensors on important devices on the ship, the working conditions of important devices such as engine performance, cargo hold temperature, and humidity can be collected in real time through a computer network. This information is then transmitted to the onshore management center, where personnel can remotely monitor the working conditions of the ship, thereby implementing preventive maintenance on important devices and reducing the risk of equipment failure. With the support of IoT technology, the operational efficiency of ships has been greatly improved, while also reducing losses caused by accidents.

4.2. Optimization of Ship's Internal Communication System

As an advanced technology, it is widely used in the cabin monitoring and control systems of modern ships. This method utilizes efficient data collection and wireless communication between nodes to achieve real-time monitoring of various facilities on ships. Real time monitoring of engine temperature, fuel condition, and steering mechanism operation through Zigbee network, and sending the monitoring results to the host. When a malfunction is detected in a certain device, an alarm can be triggered in a timely manner to ensure the safety of the ship. The low-power

characteristics of Zigbee technology make it particularly suitable for energy limited environments such as ships, and thus significantly improve the use of energy. CAN bus is an effective fieldbus that plays a crucial role in communication within ships. By utilizing CAN bus technology, real-time communication and data sharing can be achieved among various instruments inside ships such as aircraft, radar, and surveillance cameras. By utilizing CAN bus technology, obstacles detected by radar can be quickly transmitted to the autonomous navigation system of the car, achieving intelligent navigation of the vehicle. The high reliability and good anti-interference performance of the system make it perform well in complex environments. It provides an effective information exchange platform for various devices on the ship, ensuring that the ship can operate normally under different environmental conditions. By adopting the above-mentioned advanced technologies, the operational efficiency of the ship has been greatly improved, and the safety performance of the ship has been enhanced [6].

4.3. Efficient Integration of Ship Shore Communication

A data bridge is a device that seamlessly connects ships with onshore equipment for data exchange. This system realizes real-time transmission of important data such as navigation, weather, and cargo status to the port control center during the navigation process of the ship, achieving comprehensive monitoring of the ship's condition. Data bridge technology can not only achieve one-way transmission of data, but also two-way transmission of data. In other words, onshore managers can transmit commands to the ship, thereby achieving remote control and management of the ship. The application of this system greatly improves the efficiency and reliability of ship shore communication, achieving real-time and smooth information exchange between ships and shore.

By establishing an online collaboration platform, communication between ships and onshore command centers can be strengthened. On this basis, onshore managers can monitor important information such as the position, speed, and heading of ships in real-time. Real time acquisition of this information can improve the efficiency of ship transportation and achieve optimization of ship transportation. When multiple ships are sailing in a certain waterway at the same time, using a collaborative platform to coordinate the speed and route of each ship can reduce conflicts between ships and improve waterway utilization. This cooperative based business model not only greatly improves operational efficiency, but also effectively reduces the failure rate of ships and ensures their safe navigation.

4.4. Innovation in Communication Signal Processing Technology

Wavelet analysis, as a highly effective signal processing method, has played a significant role in the processing of marine telecommunications signals. The use of wavelet analysis technology can effectively denoise and improve the quality of the signal. The electromagnetic interference and multipath effects in the marine environment have a significant impact on wireless communication systems, leading to a decrease in their performance. The wavelet method, due to its strong denoising ability, can effectively improve the accuracy and integrity of data processing. Especially in long-distance satellite communication and wireless communication, this technology has played a very good role and is a strong

technical support for these two aspects.

Intelligent anti-interference technology is a dynamic selection of spectrum and channel that effectively improves the anti-interference performance of ships during maritime navigation. Dynamic channel selection technology can adaptively select different transmission channels under different real-time communication conditions, effectively avoiding different interference frequency bands and ensuring smooth communication. This technology can effectively handle different types of interference and improve communication quality. Spectrum analysis can detect interference sources and determine their exact location and strength based on their spectral characteristics. In order to ensure stable and reliable communication when interference is detected, the system can avoid interference by adjusting the frequency or switching the transmission channel. This comprehensive intelligent anti-interference technology can maintain high communication efficiency and good communication stability of the entire communication system in the complex and changing environment at sea.

4.5. Development of Multi functional Communication Terminals

The application of the system on ships is increasing, integrating multiple functions such as data acquisition, data processing, and data transmission, making it a key node in ship communication. This multifunctional communication terminal is a communication device suitable for both inside and outside ships, which can support multiple communication protocols. Multiple monitoring devices such as radar, autopilot, AIS, etc. can be connected to this embedded communication terminal to achieve comprehensive processing and transmission of data from multiple monitoring devices, thereby achieving monitoring of multiple monitoring devices. The terminal has implemented real-time monitoring and intelligent alerts for ships, ensuring their normal navigation. Due to the use of edge computing technology, mobile communication terminals can, to a certain extent, achieve local processing of data, thus reducing the dependence on remote servers, shortening communication time, and accelerating response speed [7]. This terminal device adopts a modular structure, which can be flexibly expanded according to the needs of the ship, and has good applicability and operability.

5. Challenges of Applying Computer Network Technology to Ship Communication Systems

5.1. Network Adaptation Challenges in Complex Environments

The complex environment requires high adaptability of the network, which is currently the biggest problem encountered in ship communication. The marine environment is constantly changing, including waves, winds, temperature fluctuations, salt spray, and various other factors that can affect the operation and stability of network devices. When sailing at sea, the position, speed, direction, etc. of ships will change, which makes the network's adaptation more difficult. How to ensure that network devices can operate normally in extreme environments is an urgent issue that needs to be addressed.

Ship communication involves various communication devices such as radar, satellite, and radio, and the

communication protocols and technical specifications used by each communication device are different. How to connect multiple devices to each other in a complex environment and ensure correct data transmission is also an important issue. Especially in areas with high ship density, there are significant threats such as network interference and collisions, and smarter and more effective adaptive strategies must be adopted.

5.2. Data Transmission and Security Challenges

Safe and reliable data transmission is the key to ship communication. When ships navigate at sea, they often encounter many difficulties in transmitting information due to their remote geographical location. The marine environment is complex and ever-changing, with many uncertain factors that can cause instability in data transmission, thereby greatly affecting the reliability and quality of communication. The information transmitted in the ship communication system usually includes important information such as ship location, navigation status, and cargo information. If there is leakage, interference, or other situations, it will bring great harm to the navigation and safety of the ship. Researchers are also constantly researching various new technologies and methods to improve the security and reliability of data transmission. Advanced encryption techniques can be used to encrypt data to ensure that it will not be stolen or tampered with during transmission. Redundant transmission mechanisms can also be used to increase the reliability and integrity of data through multiple transmissions and checks. Establishing firewalls and intrusion detection systems to enhance the security of ship information systems is also an effective way to ensure information security [8].

5.3. Limitations on Energy Consumption and Resource Constraints

The limitations of energy and resources are an undeniable factor in ship communication. In the marine environment, the energy supply of ships is very limited, and the energy consumption and utilization efficiency of ship communication systems are a very worthwhile research topic. The software and hardware resources of ship communication equipment are also limited. How to effectively utilize existing communication networks and achieve optimal configuration under resource constraints is also a challenge facing researchers. It is necessary to research, develop, and apply various advanced energy-saving, efficient, and environmentally friendly technologies and means in order to achieve the goal of energy conservation, environmental protection, and high efficiency in the entire ship communication system, and to achieve sustainable development of the ship communication system. Reduce the overall energy consumption of the communication system by using energy-efficient hardware devices and energy management systems. From the perspective of resource constraints, researchers can effectively share and allocate hardware resources among research subjects through virtual reality, cloud computing, and other means, thereby achieving better research results.

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