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Belarusian State University of
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Wei
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ROUTING ALGORITHMS IN THE MOBILE AD-HOC NETWORKS

Abstract
for a Master's Degree
in the Specialty 1-45 80 01 Infocommunication Systems and Networks

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INTRODUCTION

Ad-hoc networks were initially developed for military applications. Over more than 40 years of research, their use has expanded to local area communication networks, personal wireless mobile communication, and other civilian fields. Experts predict that Ad-hoc networks will become a core component of future mobile communication technology. Due to node mobility in mobile Ad-hoc networks (MANET), there is no fixed topology, rendering traditional Internet routing protocols unsuitable. Therefore, suitable routing algorithms are needed to address routing issues in Ad-hoc networks, making the optimization of routing protocols in MANET a key research focus.

MANET face significant challenges due to node mobility and network topology instability, leading to issues like signal weakening, packet loss, and code errors. To address these challenges and improve network reliability and performance, this paper discusses the integration of error correction coding methods to handle communication errors and packet loss. By implementing these error correction technologies, data integrity and reliability can be enhanced, boosting the performance and stability of mobile Ad-hoc networks.

The aim of the study was to compare the performance of different network protocols, including BATMAN-ADV, Babel, BMX6, BMX7, CJDNS, OLSR, and Yggdrasil. and investigate the potential benefits of incorporating 2D error correction coding to enhance performance. Provides reference for introducing correction codes into network protocols in the future. The dissertation addressed the following tasks:

1 Ensure compatibility and develop scripts to facilitate installation and benchmarking of network protocols.

2 Implement various mobile AD hoc network protocols such as BATMAN-ADV, OLSR, and Babel on the Linux platform.

3 Write some scripts to de-link and compare the packet arrival rate and throughput of these protocols when network nodes change and move in the same network topology. Analyze different protocols for which environment to achieve better performance.

4 Two different techniques of 2D error correcting codes and product codes are applied, including an iterative decoding method for 2D Hamming product codes and an improved hard decision iterative decoding method for 2D SEC-DED codes.

5 To evaluate their impact on improving the performance of network protocols, and provide reference for how to incorporate error-correcting codes into network protocols to improve their overall performance in the future.

GENERAL DESCRIPTION OF WORK

Relevance of the subject

The work corresponds to paragraph 1 «*Digital information and communication and interdisciplinary technologies, production based on them*» of the State Program of innovative development of the Republic of Belarus for 2021–2025. The work was carried out in the educational institution Belarusian State University of Informatics and Radioelectronics.

The aim and tasks of the work

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Personal contribution of the author

Mobile Ad-hoc networks, including BATMAN-ADV, Babel, BMX6, BMX7, CJDNS, OLSR, Yggdrasil performance evaluation, and two 2D correction coding applications. It consists in the scientific substantiation of names algorithms (methods, software tools, etc.), setting and conducting experiments to study characteristics, assessing the efficiency of the developed algorithms, processing and analyzing the obtained results, formulation of conclusions.

Testing and implementation of results

The main provisions and results of the dissertation work were reported and discussed at: Information transfer and processing technologies, proceedings of the international scientific and technical seminar (2023), International scientific and technical seminar "Technologies of information transmission and processing" (Minsk, April, 2024) and 60th scientific conference of graduate students, undergraduates and students (Minsk, March, 2024).

Author's publications

According to the results of the research presented in the dissertation, 3 author's works was published, including: 3 articles and abstracts in conference proceedings.

Structure and size of the work

The dissertation work includes an introduction, an overview of related work, proposed algorithms, experimental results, conclusion, and bibliography.

The total volume of the thesis work is 90 pages, including 89 pages of text, 42 figures, 1 table, a list of bibliographic sources used, and a list of author's publications on the topic of the thesis.

Plagiarism

An examination of the dissertation «*Performance analysis of routing protocols in mobile ad-hoc networks and application of two-dimensional product code*» by Wei Zijian was carried out for the correctness of the use of borrowed materials using the network resource «Antiplagiat» (access address: https://antiplagiat.ru) in the online mode 25.05.2024. As a result of the verification, the correctness of the use of borrowed materials was established (the originality of the thesis is 85.83 %)

SUMMARY OF WORK

Mainly tests and analyzes the performance of routing protocols in mobile Ad-hoc networks, and discusses the application of two-dimensional product codes in communication systems.

In the first chapter, the background and research significance of mobile Ad-hoc networks are introduced, and the existing problems in mobile Ad-hoc networks are pointed out. This paper summarizes the research status of routing protocols in mobile Ad-hoc networks, and discusses the characteristics, research hotspots and application directions of wireless Ad-hoc networks. The architecture of mobile Ad-

hoc network is also introduced. Through the research of this chapter, we have a deep understanding of the background of mobile Ad-hoc networks and the research status of routing protocols.

Considered several protocols, including Babel, BATMAN-ADV, BMX6, BMX7, CJDNS, OLSR1, OLSR2, and Yggdrasil protocols. According to plane, cluster, active and passive route differentiation, as show in figure 1. Through the detailed analysis of the characteristics, advantages and limitations of these protocols.

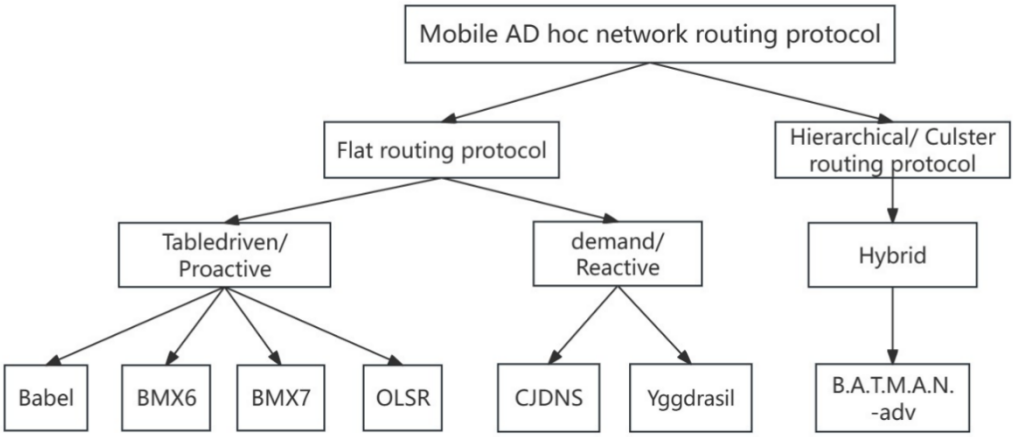

Figure 1 – Ad-hoc network protocol

Chapter 2 mainly discusses the routing protocols of mobile Ad-hoc networks, including BATMAN-ADV, OLSR and Babel. For example, as shown in Figure 2, the OGM package of batman-adv floods. Through the research of these routing protocols, it can provide reference for selecting routing protocols suitable for specific mobile Ad-hoc network scenarios.

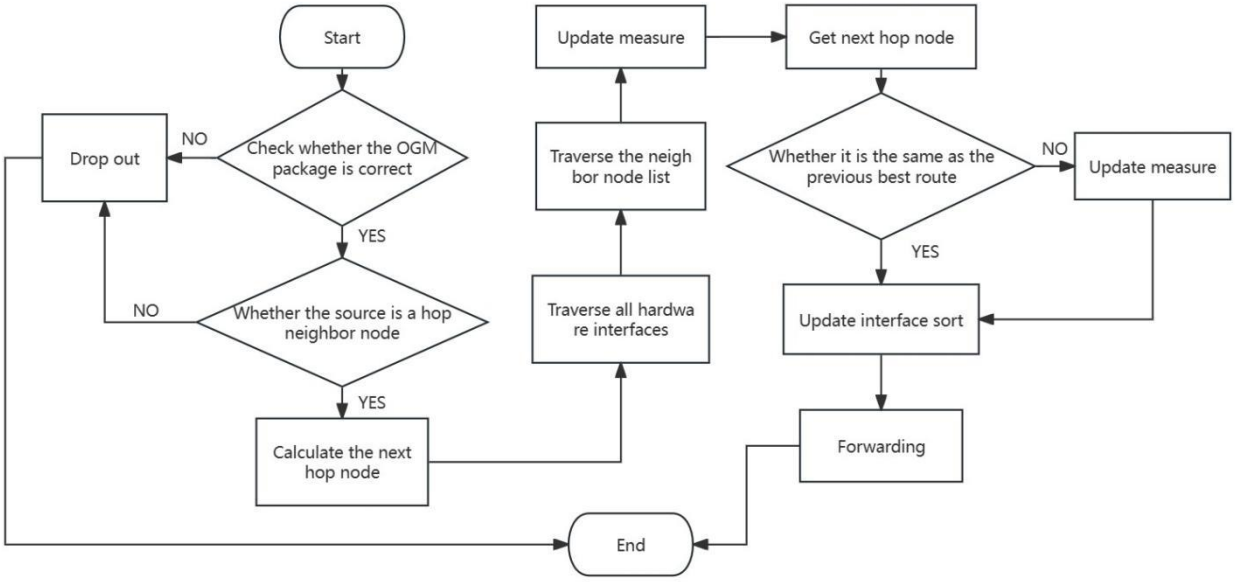

Figure 2 – Operation when a node receives an OGM packet

The third chapter focuses on the performance testing of routing protocols. This includes maximum node testing, connectivity testing, convergence testing, and mobility testing, show in figure 3-6. Through these tests, the performance of different routing protocols in different scenarios is evaluated, which provides a reference for practical application and network design.

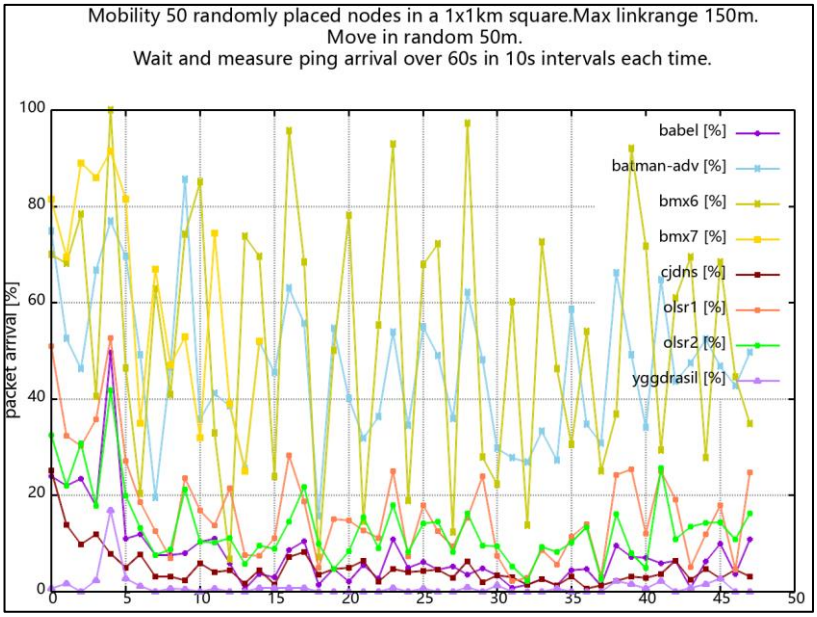

Figure 3 – Each step of node arrival

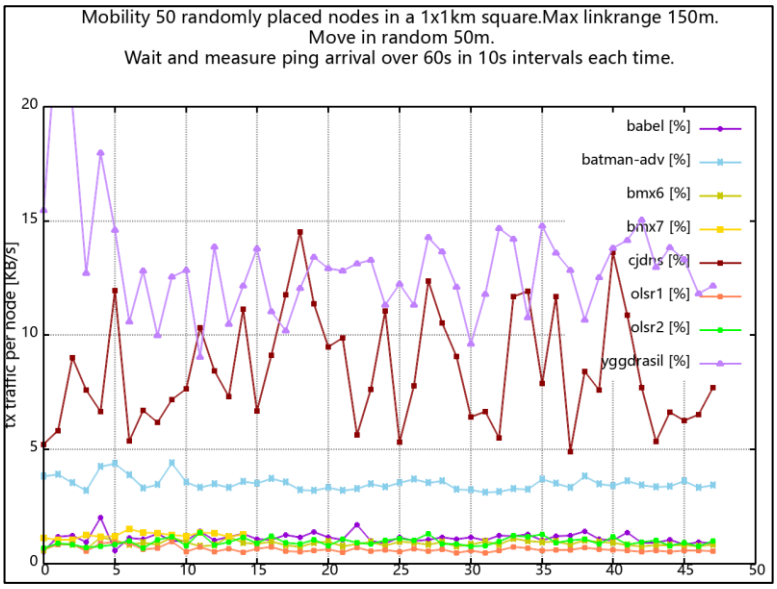

Figure 4 – Each step of node arrival and speed

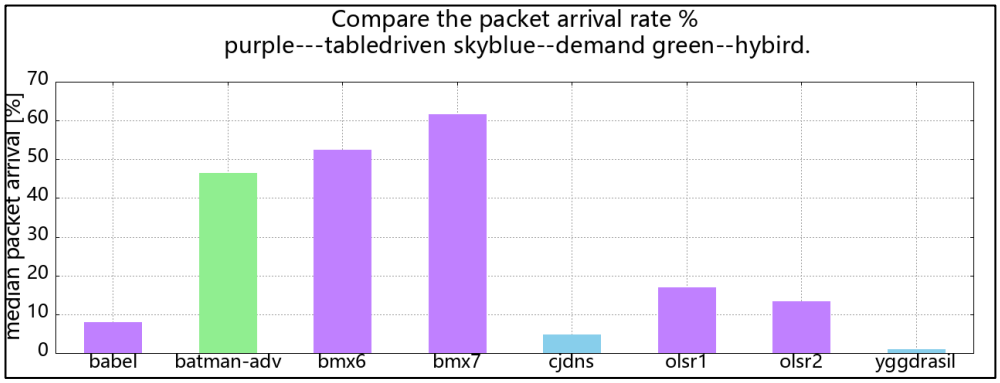

Figure 5 – Data of protocol arrival

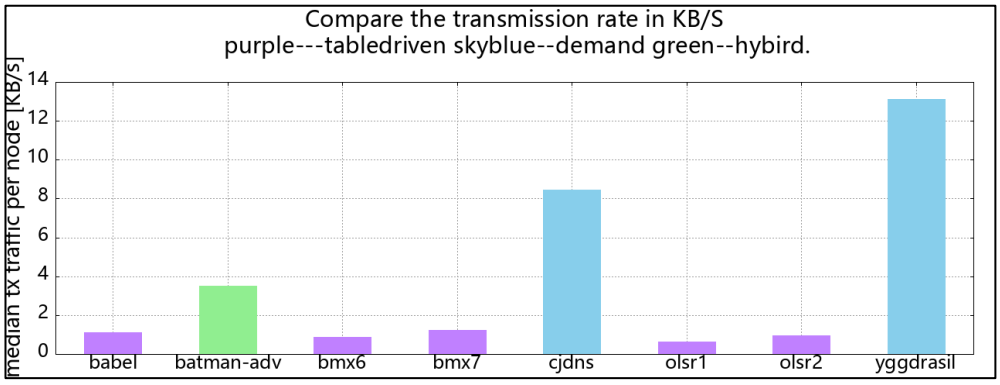

Figure 6 – Data of protocol speed

Chapter 4 discusses the application of two-dimensional product code in communication system. The iterative decoding methods of 2D Hamming product

code and 2D SEC-DED code are introduced, and an improved iterative decoding method of hard decision is proposed. The application of these codes is realized through JavaScript, and the performance analysis is carried out. 2D product code development and application show in figure 7.

Figure 7 – Algorithm processing in JavaScript

Current 2D product coding schemes can serve as a starting point, but there is still room for improvement in performance and efficiency. Future work should focus on designing new coding algorithms, improving the parameter Settings of existing algorithms, or adopting hybrid coding schemes to further improve coding efficiency

and fault tolerance. For example, coding schemes based on neural networks can be explored, using deep learning methods to improve the efficiency of encoding and decoding. In addition, the use of other types of codes, such as beamforming codes, is also a worthwhile direction to adapt to different network environments and application needs.

Consider energy consumption and latency, Ad-hoc networks typically operate in resource-constrained environments, so power consumption and latency are key metrics. Future work should further investigate how to take energy consumption and delay into account in 2D product coding. Energy-optimized coding schemes can be designed to reduce energy consumption by reducing the computational complexity of encoding and decoding or reducing the communication overhead. In addition, exploring how to reduce latency in the process of encoding and decoding to improve real-time and responsiveness is also an important research direction.

CONCLUSION

Contributions and innovations of this thesis

In this paper, the mesh networking protocol in wireless Ad-hoc networking is compared and evaluated comprehensively. The researchers considered several protocols, including Babel, BATMAN-ADV, BMX6, BMX7, CJDNS, OLSR1, OLSR2, and Yggdrasil protocols. Through the detailed analysis of the characteristics, advantages and limitations of these protocols, readers are provided with the basis for in-depth understanding of each protocol.

Mainly tests and analyzes the performance of routing protocols in mobile Ad-hoc networks, and discusses the application of two-dimensional product codes in communication systems. Here is a summary of each chapter:

In the first chapter, the background and research significance of mobile Ad-hoc networks are introduced, and the existing problems in mobile Ad-hoc networks are pointed out. This paper summarizes the research status of routing protocols in mobile Ad-hoc networks, and discusses the characteristics, research hotspots and application directions of wireless Ad-hoc networks. The architecture of mobile Ad-hoc network is also introduced. Through the research of this chapter, we have a deep understanding of the background of mobile Ad-hoc networks and the research status of routing protocols.

Chapter 2 mainly discusses the routing protocols of mobile Ad-hoc networks, including BATMAN-ADV, OLSR and Babel. The working principle and characteristics of these protocols are introduced in detail, and their performance in mobile Ad-hoc networks is compared. The research of these routing protocols can

provide reference for selecting routing protocols suitable for specific mobile Ad-hoc network scenarios.

The third chapter focuses on the performance testing of routing protocols. This includes maximum node testing, connectivity testing, convergence testing, and mobility testing. Through these tests, the performance of different routing protocols in different scenarios is evaluated, which provides a reference for practical application and network design.

Chapter 4 discusses the application of two-dimensional product code in communication system. The iterative decoding methods of Hamming product code and 2D SEC-DED code are introduced, and an improved iterative decoding method of hard decision is proposed. The application of these codes is realized through JavaScript, and the performance analysis is carried out.

Finally, in the conclusion part, the whole research is summarized comprehensively, and some prospects for future research are put forward.

In summary, this study evaluates and analyzes the performance of mobile Ad-hoc networks through the study of routing protocols and two-dimensional product codes in mobile Ad-hoc networks, and puts forward some improvement and future research directions. These research results have important guiding significance for the design and optimization of mobile Ad-hoc networks.

Further research work

Current 2D product coding schemes can serve as a starting point, but there is still room for improvement in performance and efficiency. Future work should focus on designing new coding algorithms, improving the parameter Settings of existing algorithms, or adopting hybrid coding schemes to further improve coding efficiency and fault tolerance. For example, coding schemes based on neural networks can be explored, using deep learning methods to improve the efficiency of encoding and decoding. In addition, the use of other types of codes, such as beamforming codes, is also a worthwhile direction to adapt to different network environments and application needs.

Consider the network topology and load, current research may not fully consider the coding performance under different network topologies and load conditions. Future work should further explore coding schemes under different network topologies (such as star, mesh, etc.) and investigate their robustness under high load conditions. By carrying out simulation experiments, simulating various network topologies, and observing the transmission effects of coding schemes under different loads, we can better understand the applicability of coding schemes in actual Ad-hoc scenarios, and provide targeted optimization methods.

Consider energy consumption and latency, Ad-hoc networks typically operate in resource-constrained environments, so power consumption and latency are key

metrics. Future work should further investigate how to take energy consumption and delay into account in 2D product coding. Energy-optimized coding schemes can be designed to reduce energy consumption by reducing the computational complexity of encoding and decoding or reducing the communication overhead. In addition, exploring how to reduce latency in the process of encoding and decoding to improve real-time and responsiveness is also an important research direction.

LIST OF AUTHOR'S PUBLICATIONS

A – 1 Y. Wang. Research on wireless Ad-hoc network technology / Y. Wang, P. Zeng, Z. J. Wei // Технологии передачи и обработки информации: материалы Международного научно-технического семинара, Минск, март-апрель 2023 г. / Белорусский государственный университет информатики и радиоэлектроники; редкол.: В. Ю. Цветков [и др.]. – Минск, 2023. – С. 113–116.

A – 2 Z. J. Wei. BATMAN-ADV, An Energy-Efficient Wireless Routing Protocol for Dynamic / Z. J. Wei, Y. Wang, P. Zeng // Технологии передачи и обработки информации: материалы Международного научно-технического семинара, Минск, март-апрель 2024 г. / Белорусский государственный университет информатики и радиоэлектроники; редкол.: В. Ю. Цветков [и др.]. – Минск, 2024. – (in publishing).

A – 3 Z. J. Wei. BATMAN-ADV, An Energy-Efficient Wireless Routing Protocol for Dynamic / Z. J. Wei, Y. Wang, P. Zeng // 60-я научная конференция аспирантов, магистрантов и студентов, Минск, 11-15 марта 2024 года / Белорусский государственный университет информатики и радиоэлектроники; – Минск, 2024. – (in publishing).