Perancangan dan Analisis Sistem Adaptif Transmisi multi-path Protokol pada Jaringan Sensor Nirkabel Bawah Air untuk IKN smart city berbasis Algoritma Reinforcement Learning dan Klasterisasi K-Means

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**Abstract**—A good abstract is a stand-alone summary of the paper, and should summarize the key components of the manuscript. Generally, the abstract should be concise and informative within 150-250 words. The abstract should briefly state the purpose of the research, the materials and method, the principal results, and the major conclusions. As an abstract is a separate section, it should be a self-containing text (no abbreviations, no references, no URLs, no undefined concepts, etc.). *[[1]](#footnote-1)*

**Keywords**—first term, second term, third term, fourth term, fifth term, sixth term, seventh term

# Introduction

WSN telah merevolusi metode pengumpulan dan monitoring data dalam berbagai bidang seperti tatisti, otomotif, militer, pertanian, dan medis. Meningkatnya teknologi manufaktur mendukung pengembangan sensor WSN, salah satu dari system penerapan tersebut adalah tatis IoUT yang diterapkan melalui floating buoy atau anchor buoy untuk pengambilan data suhu, salinitas, tekanan, dan Cahaya [1]–[3]. Permasalahan utama yang terjadi pada UWSN adalah atenuasi, interferensi, serta noise yang disebabkan oleh tatis lingkungan dan aktivitas manusia [4]. Protokol routing memainkan peranan penting dalam mengendalikan proses transmisi, agregasi serta integrasi data, yang berperngaruh pada reabilitas, latensi serta efisiensi energi dari UWSN. Selain itu, strategi deployment dari UWSN memiliki pengaruh terhadap skalabilitas serta lifespan dari UWSN [5]. Sehingga, desain tatisti routing serta strategi deployment menjadi krusial dalam perancangan arsitektur UWSN.

Protokol routing WSN secara garis besar dapat dibagi menjadi tiga jenis yakni flat, hierarchical, dan location-based. Pada hierarchical-based protocol terdapat tahapan seleksi cluster head (CH) node tatis proses pembacaan dilakukan oleh node dengan energi rendah sedangkan pemrosesan serta transmisi data di bebankan pada node dengan energi tinggi, sehingga lifetime, sehingga skalabiltias serta efisisensi energinya lebih unggul ketimbang tatisti flat dan location-based [6]. Salah satu contoh dari hierarchical-based protocol adalah Low Energy Adaptive Clustering Hierarchy (LEACH). Pemilihan CH yang di dasarkan atas probabilitas random serta single-hop transmission pada transmisi data antara CH dengan base station menjadikan penerapan LEACH tidak ideal pada large network [7]. Meningkatnya kemajuan artificial intelligence (AI), telah mendukung perkembangan kemajuan dari protocol routing, salah satunya dengan penggunaan reinforcement learning dalam menentukan rute optimum serta penggunaan unsupervised learning dalam proses seleksi node. Penggabungan kedua metode tersebut dalam membentuk tatis transmisi adaptif yang mampu menentukan rute optimum UWSN berdasarkan informasi yang diperoleh dari data dan pola yang diidentifikasi. Hal ini akan meningkatkan adaptabilitas dan efektivitas dari tatis UWSN dalam menghadapi tantangan serta permasalahan pada transmisi bawah air.

# Literature Review

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| REF. | *Coverage* | *Scalability* | *Energy Efficiency* | *Load Distribution* |
| [8] | Low | Low | Low | Low |
| [9] | Low | Moderate | Moderate | Moderate |
| [10] | High | High | High | High |
| [11] | Low | Low | Moderate | Low |
| [12] | High | Low | Moderate | High |
| [13] | Low | High | High | High |
| Proposed method | High | High | High | High |

# Materials and Methods

Penelitian ini dilakukan melalui pendekatan mix-method dengan menggabungkan pendekatan kuantitatif melalui analisis numerik dan tatistic serta pendekatan kualitatif dalam menginterpretasi aspek-aspek yang mempengaruhi hasil dari simulasi dan komparasi. Metode sampling dilakukan secara eksperimental berbasis simulasi melalui pemodelan matematik untuk mensimulasikan lingkungan bawah air yang didasarkan atas parameter-parameter yang ditetapkan. Proses iterative sampling dilakukan untuk menganalisis performa energi konsumsi dan node failure pada selang waktu berbeda.

Penelitian ini mengusulkan pendekatan artificial intelligence (AI) berbasis RL dengan Q-Learning dalam penentuan jalur transmisi optimum, klasterisasi K-Means untuk pemilihan cluster head (CH), serta penggunaan multi-layer trilateration dalam meningkatkan coverage, network lifetime, reabilitas serta efisiensi energi konsumsi dari UWSN.

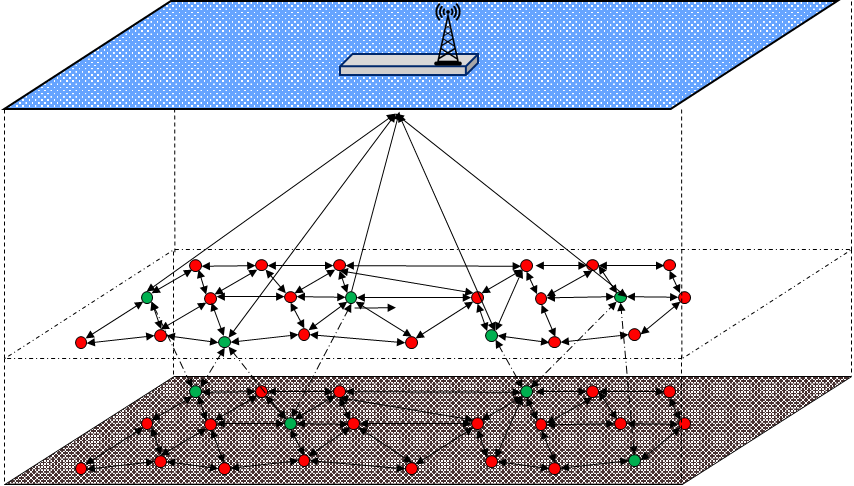


Fig. 1. Note how the caption is centered in the column

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# Proposed Method

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# Result and Discussion

A well-presented results section coupled with a convincing discussion will definitely prove the novelty and importance of your study. It should provide a concise and precise description of the experimental results, their interpretation, as well as the experimental conclusions that can be drawn.

## Figures and Tables (Subsection Level 2)

Figures and tables should be inserted in the main text in

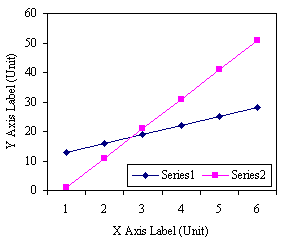


Fig. 1. Note how the caption is centered in the column.

To figure axis labels, use words rather than symbols. Do not label axes only with units. Do not label axes with a ratio of quantities and units.

Color figures will be appearing only in online publication. All figures will be black and white graphs in print publication.

TABLE I. Type Sizes for Final Papers

| Type size | Appearance | | |
| --- | --- | --- | --- |
| Regular | Bold | Italic |
| 6 | Table caption1, table superscripts |  |  |
| 8 | Section titles, tables, table names, first letters in table captions, figure captions, footnotes, text subscripts, and superscripts |  |  |
| 9 | References, authors’ biographies | Abstract |  |
| 10 | Authors’ affiliations, main text, equations, first letters in section titles |  | Subheading |
| 11 | Authors’ names |  |  |
| 24 | Paper title |  |  |

1 Tables may have a footer.

### Subsection (Level 3)

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#### Subsection (Level 4)

Here is the content of Subsection (Level 4).

## References

Number citations consecutively in square brackets [1]. No punctuation follows the bracket [2]. Use “Author’s last name [3]” at the beginning of a sentence.

In the reference list, give all authors’ names; use “et al.” if there are more than three authors. Papers that have not been published, even if they have been submitted for publication, should be cited as “unpublished” [4]. Papers that have been accepted for publication should be cited as “in press” [5]. In a paper title, capitalize the first word and all other words except for conjunctions, prepositions less than seven letters, and prepositional phrases.

For papers published in translated journals, please give the English citation.

For on-line references a URL and time accessed must be given.

## Footnotes

Number footnotes separately in superscripts 1, 2, …. Place the actual footnote at the bottom of the column in which it was cited, as in this column. See first page footnote for an example.

## Abbreviations and Acronyms

Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Do not use abbreviations in the title unless they are unavoidable.

## Equations

Equations should be centered in the column. The paragraph description of the line containing the equation should be set for 6 points before and 6 points after. Number equations consecutively with equation numbers in parentheses flush with the right margin, as in Eq. (1). Italicize Roman symbols for quantities and variables, but not Greek symbols. Punctuate equations with commas or periods when they are part of a sentence, as in

 (1)

Symbols in your equation should be defined before the equation appears or immediately following.

## Other Recommendations

Use either SI (MKS) or CGS as primary units. (SI units are encouraged.) If your native language is not English, try to get a native English-speaking colleague to proofread your paper.

# Conclusion

The 'conclusions' are a key component of the paper. It should complement the 'abstract' and is normally used by experts to value the paper's engineering content. A conclusion is not merely a summary of the main topics covered or a re-statement of your research problem, but a synthesis of key points and, if applicable, where you recommend new areas for future research.

##### Appendix A Appendix Title

Appendixes, if needed, is numbered by A, B, C... Use two spaces before Appendix Title. In the appendices, Figures, Tables, etc. should be labeled starting with “A”—e.g., Figure A1, Figure A2, etc.

##### Conflict of Interest

Please declare whether or not the submitted work was carried out with a conflict of interest. If yes, please state any personal, professional or financial relationships that could potentially be construed as a conflict of interest. If no, please add "The authors declare no conflict of interest".

##### Author Contributions

Please state each author's contribution to this work, it can be up to several sentences long and should briefly describe the tasks of individual authors. e.g., AB conducted the research; CD analyzed the data; AB wrote the paper; ...; all authors had approved the final version.

##### Funding

Please add funding information here, e.g., this research was funded by NAME OF FUNDER, grant number XX. If there is no funding, this section can be removed.

##### Acknowledgment

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##### References

[1] J. Trevathan *et al.*, “SEMAT — The Next Generation of Inexpensive Marine Environmental Monitoring and Measurement Systems,” *Sensors 2012, Vol. 12, Pages 9711-9748*, vol. 12, no. 7, pp. 9711–9748, Jul. 2012, doi: 10.3390/S120709711.

[2] C. A. Pérez, M. Jimenéz, F. Soto, R. Torres, J. A. López, and A. Iborra, “A system for monitoring marine environments based on wireless sensor networks,” *OCEANS 2011 IEEE - Spain*, 2011, doi: 10.1109/OCEANS-SPAIN.2011.6003584.

[3] D. Pompili, T. Melodia, and I. F. Akyildiz, “Three-dimensional and two-dimensional deployment analysis for underwater acoustic sensor networks,” *Ad Hoc Networks*, vol. 7, no. 4, pp. 778–790, Jun. 2009, doi: 10.1016/J.ADHOC.2008.07.010.

[4] D. Bradley, “ Handbook of Underwater Acoustic Engineering ,” *J Acoust Soc Am*, vol. 120, no. 5, pp. 2393–2393, Nov. 2006, doi: 10.1121/1.2354068.

[5] D. Zeng, X. Wu, Y. Wang, H. Chen, K. Liang, and L. Shu, “A Survey on Sensor Deployment in Underwater Sensor Networks,” *Communications in Computer and Information Science*, vol. 418 CCIS, pp. 133–143, 2014, doi: 10.1007/978-3-642-54522-1\_14/COVER.

[6] M. Haque, T. Ahmad, and M. Imran, “Review of Hierarchical Routing Protocols for Wireless Sensor Networks,” *Lecture Notes in Networks and Systems*, vol. 19, pp. 237–246, 2018, doi: 10.1007/978-981-10-5523-2\_22/COVER.

[7] I. Daanoune, B. Abdennaceur, and A. Ballouk, “A comprehensive survey on LEACH-based clustering routing protocols in Wireless Sensor Networks,” *Ad Hoc Networks*, vol. 114, p. 102409, Apr. 2021, doi: 10.1016/J.ADHOC.2020.102409.

[8] H. H. Rizvi, S. A. Khan, and R. N. Enam, “Clustering Base Energy Efficient Mechanism for an Underwater Wireless Sensor Network,” *Wirel Pers Commun*, vol. 124, no. 4, pp. 3725–3741, Jun. 2022, doi: 10.1007/S11277-022-09536-X.

[9] K. G. Omeke *et al.*, “DEKCS: A Dynamic Clustering Protocol to Prolong Underwater Sensor Networks,” *IEEE Sens J*, vol. 21, no. 7, pp. 9457–9464, Apr. 2021, doi: 10.1109/JSEN.2021.3054943.

[10] S. He, Q. Li, M. Khishe, A. Salih Mohammed, H. Mohammadi, and M. Mohammadi, “The optimization of nodes clustering and multi-hop routing protocol using hierarchical chimp optimization for sustainable energy efficient underwater wireless sensor networks,” *Wireless Networks*, 2023, doi: 10.1007/S11276-023-03464-9.

[11] P. Feng, D. Qin, P. Ji, M. Zhao, R. Guo, and T. M. Berhane, “Improved energy-balanced algorithm for underwater wireless sensor network based on depth threshold and energy level partition,” *EURASIP J Wirel Commun Netw*, vol. 2019, no. 1, Dec. 2019, doi: 10.1186/S13638-019-1533-Y.

[12] T. Hu and Y. Fei, “QELAR: A Machine-Learning-Based Adaptive Routing Protocol for Energy-Efficient and Lifetime-Extended Underwater Sensor Networks,” *IEEE Trans Mob Comput*, vol. 9, no. 6, pp. 796–809, Jun. 2010, doi: 10.1109/TMC.2010.28.

[13] N. Subramani, P. Mohan, Y. Alotaibi, S. Alghamdi, and O. I. Khalaf, “An Efficient Metaheuristic-Based Clustering with Routing Protocol for Underwater Wireless Sensor Networks,” *Sensors 2022, Vol. 22, Page 415*, vol. 22, no. 2, p. 415, Jan. 2022, doi: 10.3390/S22020415.

1. Manuscript received xx xx 2023; revised xx xx 2023, accepted xx xx 2023. [↑](#footnote-ref-1)