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Analysis and Comparison of an Energy Efficient Clustering Approach using ICPM Protocol and Compare with CPM Protocol in WBAN

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Abstract

Aim: The main aim of this research is to minimize the energy consumption of the sensor nodes in Wireless Body Area Network (WBAN) for green communication in smart health care systems using Improved Continuous Passive Motion (ICPM) protocol and compared with Continuous Passive Motion (CPM) protocol in WBAN. **Materials and Methods:**In this research energy efficient centralized green communication in a health care system is achieved using cluster based WBAN routing. In this scheme the cluster head (CH) and Innovative Commander Node (ICN) is selected using various parameters such as distance, residual energy, transmission and reception count. In this work there are two groups in which each group has 20 sample sizes collected by varying number of rounds and it was calculated by calculator. Net with pre-test power of 80% (G-power). To evaluate the effectiveness of the Enhanced ICPM protocol in terms of Lifetime, energy consumption, throughput and delay. **Results:** Energy Consumption and throughput has statistically significant value ($p<0.05$) from the SPSS results. The output obtained by the ICPM protocol has better performance when compared to the CPM protocol in terms of2.47% lower energy consumption, and 4.47% higher throughput. **Conclusion:** From the independent statistical T-test and experiment's results the proposed ICPM protocol has efficient routing when compared to CPM protocol.

Keywords: Green communication, Routing, Cluster head, Distance, Residual energy, Healthcare systems, Innovative Commander Node, WBAN.

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INTRODUCTION

To improve the quality of life, a WBAN has been specifically intended for medical care observation (Olatinwo, Abu-Mahfouz, and Hancke 2021). To plan of this kind of remote organization is to give wellbeing related administrations that objectives the overall prosperity of people by consistently observing basic crucial signs, including the heartbeat, breath, temperature, circulatory strain similar to the electromyography (EMG), electroencephalogram (EEG) and electrocardiogram (ECG) (L, Liya, and Arjun 2020), and (Wang, Jiang, and Chen 2014) detailing the acquired estimations distantly to committed doctors and medical clinics through correspondence advances, diminishing medical clinic visits in an expense effective way, and limiting the rate of (Lau and Kwok 2006) and (Arboleda, Aedo, and Rivera 2016) hospitalization. The smart healthcare systems use green communication. to monitor the vital signs of patients in real-time with the least energy consumption. Because of their patient-centric approach, these systems have found their applications in hospitals, nursing care, and in-home patient monitoring.With the outbreak of various chronic diseases, e.g., COVID-19, the role of smart healthcare systems for its mitigation and control cannot be ignored (Hasan et al. 2020) and (Wang, Jiang, and Chen 2014).

Mostly 80 articles were published in the IEEE access and 83 articles in the Science directly related to the Cluster based routing protocol using WBAN for various health Applications. IoT technology may be fused with WBANs to shape a WBAN-enabled IoT era for greater functionalities and new use cases. Such structures aren't best appropriate for healthcare systems, however additionally have capabilities to autonomously perform technique manipulation and decision-making capabilities with or with no human intervention (L, Liya, and Arjun 2020) and ("Network Lifetime Enhancement in WSN Using Fuzzy Based Clustering Algorithm" 2020). These structures encompass intelligent, miniature size, and low-strength IoT biosensor gadgets which can be located inside, round or worn on the human frame to monitor, diagnose, and deal with sufferers that suffers from

persistent diseases, which includes cancer, diabetes, obesity, myocardial infarction, stroke, and different styles of diseases, in a continuing manner, in addition to speak sensory fitness records to healthcare systems, which includes precise hospitals, via get admission to point (AP) or base station (BS) nodes in body area (Shakir et al. 2016) and (Aslam et al. 2017).Our team has extensive knowledge and research experience that has translate into high quality publications(Bhansali et al. 2021; Jayanth et al. 2021; Sudhakar, Ravel, and Perumal 2021; Sathiyamoorthi et al. 2021; Deepanraj et al. 2021; Raju et al. 2021; Arun Prakash et al. 2020; Kamath et al. 2020; Shanmugam et al. 2021; Rajasekaran et al. 2020; Adhinarayanan et al. 2020; Rajesh et al. 2020; Aurtherson et al. 2021)

From this literature review the cluster head alone is not enough to achieve efficient cluster based routing and also in the conventional methods CH selection parameters are residual energy, node distance, hop count, but these parameters are not enough to select the efficient cluster head, hence ICPM protocol is proposed to minimize the energy consumption of the sensors in WBAN by using efficient CH (Cluster Head) and ICN (Innovative Commander Node). Both CH and ICN are selected using various parameters such as distance, residual energy, transmission and reception count.

Materials And Methods

This research work was done in the sensors lab in the Department of Biomedical Engineering at Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, Tamilnadu, India. Two groups are required for this study. Group one consists of Proposed ICPM protocol and group two represents CPM protocol (Olatinwo, Abu-Mahfouz, and Hancke 2021). The sample size was calculated by using a sample size calculator finding the mean and standard deviation. The sample size was 20 per group 80% of the pre-test power (G-power) used for this study. A PC with Ubuntu OS by VMware workstation and NS2 simulator software was used for execution of the project. The ns run command was given to execute the code in TCL script.

Icpm Protocol

In ICPM both CH and ICN (Innovative Commander Node) are selected using various parameters such as distance, Residual energy, transmission and reception count. The various steps involved in the CN and ICN selection process are described below.

Step 1: All the sensor isolated nodes are deployed in various places in a human body and clusters are formed.

Step 2: All the nodes in this scheme posses various states such as idle, sleep, Awake and active, and also performs the transitions between these states.

Step 3: CH and ICN are selected using various parameters such as distance, residual energy, transmission and reception count.

Step 4: The node which contains the highest value is selected as CH as well as ICN.

Step 5: The CH used the TDMA scheduling scheme to collect various information from the cluster member using various states of the nodes.

Step 6: The CH searches the nearest ICN node to route the information to the destination.

Cpm Protocol

In comparison CPM protocol used proximity distance, residual energy of the isolated nodes based probability for efficient routing. The based rules are used to select the super cluster-head among the cluster-head to route the information from the cluster-head to the base station.

Statistical Analysis

The statistical analysis was carried out using the SPSS tool. The significance is calculated using an independent T-test. It was performed for the two dependent variables such as energy consumption and throughput. The independent variables are distance and speed. Using the SPSS software the standard deviation, standard error of mean were also calculated (McCormick and Salcedo 2017).

Results

Table 1 shows experimental results data analysis of the proposed ICPM protocol under varying number of rounds and time with reference to throughput. Experimental results of Proposed ICPM protocol under varying number of rounds (0 to 12000) in terms of packet delivery ratio (achieved highest value 8.1 when the number of rounds is 12000 and achieved lowest value 0.6 when the number of rounds is 600).

Table 2 shows experimental results data analysis of the proposed ICPM protocol under varying number of rounds and time with reference to residual energy. Experimental results of Proposed ICPM protocol under varying number of rounds (0 to 12000) in terms of packet delivery ratio (achieved highest value 6.1 when the number of rounds is 600 and achieved lowest value 1.7 when the number of rounds is 12000).

Table 3 shows group statistical analysis of Proposed ICPM protocol and PCM protocol. Throughput Mean value is 0.59526 in ICPM protocol and Throughput Mean value of CPM protocol is 5.0350. The standard deviation value of energy consumption is high in CPM protocol i.e. 2.35451 and throughput has a low standard deviation value of 0.25204.
Table 4 shows the independent sample T-test calculation of Proposed ICPM protocol and comparison of CPM protocol. The energy consumption, lifetime, throughput are statistically significant ($p<0.05$).

Discussion

Comparison of energy efficiency of enhanced ICPM protocol and CPM protocol is studied. The number of rounds of the proposed protocol is varied from 0 to 12000. The energy consumption is minimized by 2.47% as shown in Fig. 1. The throughput increased by 4.47% in enhanced ICPM protocol with CPM protocol under varying number of rounds as shown in Fig. 2.
Figure 3 shows the bar chart representation of ICPM protocol and CPM protocol in terms of throughput and ICPM achieved 4.47% higher throughput when compared with CPM protocol.
Figure 4 Bar chart representing the comparison of ICPM protocol and CPM protocol in terms of energy consumption and ICPM achieved 2.47% lower energy consumption when compared with CPM protocol.
By Independent sample t-test calculation the energy consumption and throughput is statistically less significant ($p<0.05$) by SPSS software. Optimized ICPM protocol has better performance in efficient routing when compared with CPM protocol with reference to the simulation results.
Modification made in this research is that the CH and ICN are selected using various parameters such as distance, residual energy, transmission and reception count. (Karl and Willig 2007) and ("Network Lifetime Enhancement in WSN Using Fuzzy Based Clustering Algorithm" 2020) have similar research which uses the CPM protocol to improve the performance of the network routing in WBAN. (Arboleda, Aedo, and Rivera 2016; Lin, Yen, and Lin 2009) opposes the methodology.The main limitation of this work is the ICPM is if the size of the network increases, the number of cluster members increases which causes more redundant messages in the network, hence the packet delivery ratio in the network decreases and also due to the multiple function the cluster head nodes consumes more energy. In Future the security of the routing protocol needs to be improved by using the cryptographic techniques with movable sink scenarios.

Conclusion

The cluster based routing protocols are used to minimize the energy consumption and also improves the packet delivery ratio in the green communication using WBAN. The proposed ICPM protocol has better simulated outputs when compared to CPM protocol in terms of energy is minimized by 2.47% and throughput increased by 4.47%.

Declaration

Conflict of Interests
No conflict of interest in this manuscript.
Author Contribution
Author MK was involved in Methodology creation, simulation, data collection, data analysis, Manuscript writing. Author CS was involved in conceptualization, guidance and critical review of manuscript.
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References

1. Adhinarayanan, Rajesh, AravindhRamakrishnan, GopalKaliyaperumal, Melvinvíctor De Poures, Rajesh Kumar Babu, and DamodharanDillikannan. 2020. "Comparative Analysis on the Effect of 1-Decanol and Di-N-Butyl Ether as Additive with diesel/LDPE Blends in Compression Ignition Engine." Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, June, 1–18.
2. Arboleda, Jose, Jose Aedo, and Fredy Rivera. 2016. "Wireless System for Supporting Home Health Care of Chronic Disease Patients." 2016 IEEE Colombian Conference on Communications and Computing (COLCOM). https://doi.org/10.1109/colcomcon.2016.7516401.
3. Arun Prakash, V. R., J. Francis Xavier, G. Ramesh, T. Maridurai, K. Siva Kumar, and R. Blessing Sam Raj. 2020. "Mechanical, Thermal and Fatigue Behaviour of Surface-Treated Novel Caryota Urens Fibre–reinforced Epoxy Composite." Biomass Conversion and Biorefinery, August. https://doi.org/10.1007/s13399-020-00938-0.
4. Aslam, Nelofar, Kewen Xia, Muhammad Haider, and Muhammad Hadi. 2017. "Energy-Aware Adaptive Weighted Grid Clustering Algorithm for Renewable Wireless Sensor Networks." Future Internet. https://doi.org/10.3390/fi9040054.
5. Aurtherson, P. Babu, Bhanu Teja Nalla, Karthikeyan Srinivasan, Kulmani Mehar, and Yuvarajan Devarajan. 2021. "Biofuel Production from Novel Prunus Domestica Kernel Oil: Process Optimization Technique." Biomass Conversion and Biorefinery, May. https://doi.org/10.1007/s13399-021-01551-5.
6. Bhansali, Karan J., Kamlesh R. Balinge, Subodh U. Raut, Shubham A. Deshmukh, M. Senthil Kumar, C. Ramesh Kumar, and Pundlik R. Bhagat. 2021. "Visible Light Assisted Sulfonic Acid-Functionalized Porphyrin Comprising Benzimidazolium Moiety for PhotocatalyticTransesterification of Castor Oil." Fuel 304 (November): 121490.
7. Deepanraj, B., N. Senthilkumar, D. Mala, and A. Sathiamourthy. 2021. "Cashew Nut Shell Liquid as Alternate Fuel for CI Engine—optimization Approach for Performance Improvement." Biomass Conversion and Biorefinery, February. https://doi.org/10.1007/s13399-021-01312-4.
8. Hasan, Khalid, Khandakar Ahmed, Kamanashis Biswas, Md Saiful Islam, A. S. M. Kayes, and S. M. Riazul Islam. 2020. "Control Plane Optimisation for an SDN-Based WBAN Framework to Support Healthcare Applications." Sensors 20 (15). https://doi.org/10.3390/s20154200.
9. Jayanth, BellappuVenkat, Melvin Victor Depoures, GopalKaliyaperumal, DamodharanDillikannan, DilipsinghJawahar, KumaranPalani, and Ganesha Prasad MeravanigeeShivappa. 2021. "A Comprehensive Study on the Effects of Multiple Injection Strategies and Exhaust Gas Recirculation on Diesel Engine Characteristics That Utilize Waste High Density Polyethylene Oil." Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, June, 1–18.
10. Kamath, Manjunath, Subha Krishna Rao, Jaison, Sridhar, Kasthuri, Gopinath, Sivaperumal, and ShantanuPatil. 2020. "Melatonin Delivery from PCL Scaffold Enhances Glycosaminoglycans Deposition in Human Chondrocytes – Bioactive Scaffold Model for Cartilage Regeneration." Process Biochemistry 99 (December): 36–47.
11. Karl, Holger, and Andreas Willig. 2007. Protocols and Architectures for Wireless Sensor Networks. John Wiley & Sons.
12. Lau, Vincent K. N., and Yu-Kwong Ricky Kwok. 2006. Channel-Adaptive Technologies and Cross-Layer Designs for Wireless Systems with Multiple Antennas: Theory and Applications. John Wiley & Sons.
13. Lin, Frank Yeong-Sung, Hong-Hsu Yen, and Shu-Ping Lin. 2009. "A Novel Energy-Efficient MAC Aware Data Aggregation Routing in Wireless Sensor Networks." Sensors 9 (3): 1518–33.
14. L, Liya M., M. L. Liya, and D. Arjun. 2020. "A Survey of LPWAN Technology in Agricultural Field." 2020 Fourth International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC). https://doi.org/10.1109/i-smac49090.2020.9243410.
15. McCormick, Keith, and Jesus Salcedo. 2017. SPSS Statistics for Data Analysis and Visualization. John Wiley & Sons.
16. "Network Lifetime Enhancement in WSN Using Fuzzy Based Clustering Algorithm." 2020. International Journal of Innovative Technology and Exploring Engineering. https://doi.org/10.35940/ijitee.d2104.029420.
17. Olatinwo, Damilola D., Adnan M. Abu-Mahfouz, and Gerhard P. Hancke. 2021. "A Hybrid Multi-Class MAC Protocol for IoT-Enabled WBAN Systems." IEEE Sensors Journal. https://doi.org/10.1109/jsen.2020.3037788.
18. Rajasekaran, S., D. Damodharan, K. Gopal, B. Rajesh Kumar, and Melvin Victor De Poures. 2020. "Collective Influence of 1-Decanol Addition, Injection Pressure and EGR on Diesel Engine Characteristics Fueled with diesel/LDPE Oil Blends." Fuel 277 (October): 118166.
19. Rajesh, A., K. Gopal, De Poures Melvin Victor, B. Rajesh Kumar, A. P. Sathiyagnanam, and D. Damodharan. 2020. "Effect of Anisole Addition to Waste Cooking Oil Methyl Ester on Combustion, Emission and Performance Characteristics of a DI Diesel Engine without Any Modifications." Fuel 278 (October): 118315.
20. Raju, P., K. Raja, K. Lingadurai, T. Maridurai, and S. C. Prasanna. 2021. "Glass/Caryota Urens Hybridized Fibre-Reinforced nanoclay/SiC Toughened Epoxy Hybrid Composite: Mechanical, Drop Load Impact, Hydrophobicity and Fatigue Behaviour." Biomass Conversion and Biorefinery, March. https://doi.org/10.1007/s13399-021-01427-8.
21. Sathiyamoorthi, Ramalingam, Gomathinayakam Sankaranarayanan, Dinesh Babu Munuswamy, and Yuvarajan Devarajan. 2021. "Experimental Study of Spray Analysis for Palmarosa Biodiesel-diesel Blends in a Constant Volume Chamber." Environmental Progress & Sustainable Energy 40 (6). https://doi.org/10.1002/ep.13696.
22. Shakir, Mustafa, Obaid Ur Rehman, Mudassir Rahim, Nabil Alrajeh, Zahoor Ali Khan, Mahmood Ashraf Khan, Iftikhar Azim Niaz, and Nadeem Javaid. 2016. "Performance Optimization of Priority Assisted CSMA/CA Mechanism of 802.15.6 under Saturation Regime." Sensors 16 (9). https://doi.org/10.3390/s16091421.
23. Shanmugam, Rajasekaran, DamodharanDillikannan, GopalKaliyaperumal, Melvin Victor De Poures, and Rajesh Kumar Babu. 2021. "A Comprehensive Study on the Effects of 1-Decanol, Compression Ratio and Exhaust Gas Recirculation on Diesel Engine Characteristics Powered with Low Density Polyethylene Oil." Energy Sources, Part A: Recovery, Utilization, and Environmental Effects 43 (23): 3064–81.
24. Sudhakar, M. P., Merlyn Ravel, and K. Perumal. 2021. "Pretreatment and Process Optimization of Bioethanol Production from Spent Biomass of GanodermaLucidum Using Saccharomyces Cerevisiae." Fuel 306 (December): 121680.
25. Wang, Zhihua, Hanjun Jiang, and Hong Chen. 2014. "WBAN Transceiver Design." CMOS IC Design for Wireless Medical and Health Care. https://doi.org/10.1007/978-1-4614-9503-1_4.

TABLES AND FIGURES

Table 1. Experimental results of proposed ICPM protocol compared with CPM under varying number of rounds (0 to 12000) in terms of throughput (achieved highest value 8.1 when the number of rounds is 12000 and achieved lowest value 0.6 when the number of rounds is 600).

No of rounds	ICPM	CPM
600	0.6	0.4
1200	1.2	0.8
1800	2.2	0.02
2400	2.8	0.23
3000	3.2	0.29
3600	3.8	0.36
4200	4	0.38
4800	4.6	0.44
6300	5	0.49
5400	5.3	0.05
6000	6	0.59
6600	6.7	0.64
7200	7.3	0.07
7800	7.5	0.73
8400	7.8	0.76
9600	8	0.75
10200	8.1	0.74
10800	8.1	0.73
11400	8.1	0.72
12000	8.1	0.71

Table 2. Experimental results of ICPM protocol under varying number of rounds (0 to 12000) in terms of throughput (achieved highest value 6.1 when the number of rounds is 600 and achieved lowest value 0.08 when the number of rounds is 12000).

No of rounds	ICPM	CPM
600	6.1	7
1200	6	6.9
1800	5.7	6.4

2400	5.2	6.3
3000	5.1	5.9
3600	4.3	5.3
4200	4.2	5.1
4800	4	4.8
6300	3.9	4.5
5400	3.2	4.2
6000	3.1	3.4
6600	3	3.2
7200	2.9	3.1
7800	2.8	2.9
8400	2.5	1.8
9600	2.1	1.2
10200	2	0.07
10800	1.9	0.06
11400	1.8	0.06
12000	1.7	0.08

Table 3. Group statistical analysis of Proposed ICPM protocol and PCM protocol. Throughput Mean value is 0.59526 in ICPM protocol. Throughput mean value is 5.0350. The standard deviation value of Energy Consumption is high in CPM protocol i.e. 2.35451 and throughput has a low standard deviation value of 0.25204.

	GROUP	N	MEAN	STD.Deviation	STD.Error.Mean
Throughput	ICPM	20	5.0350	2.66207	.59526
	CPM	20	.4855	.27076	.06054
Energy Consumption	ICPM	20	3.4000	1.12718	.25204
	CPM	20	3.5435	2.35451	.52648

Table 4. Independent sample T-test calculation of ICPM protocol and CPM protocol. The energy consumption and throughput are statistically significant ($p<0.05$).

		Levene's Test for Equality of variances		T-test for Equality of Means							
						Significance				95% Confidence interval of the difference	
		F	Sig.	t	df	One- sided p	Two- sided p	Mean differen - ce	Std. Error differ - ence	Lower	upper
Throughput	Equal variances assumed	46.772	<.001	7.604	38	<.001	<.001	4.549507	.59833	3.33825	5.76075
	Equal variances not assumed			7.604	19.393	<.001	<.001	4.549507	.59833	3.29890	5.80010
Energy Consumption	Equal variances assumed	13.417	<0.01	-.246	38	.404	.807	-.14350	.58371	-1.32515	1.03815
	Equal variances not assumed			-.246	27.274	.404	.808	-.14350	.58371	-1.34060	1.05360

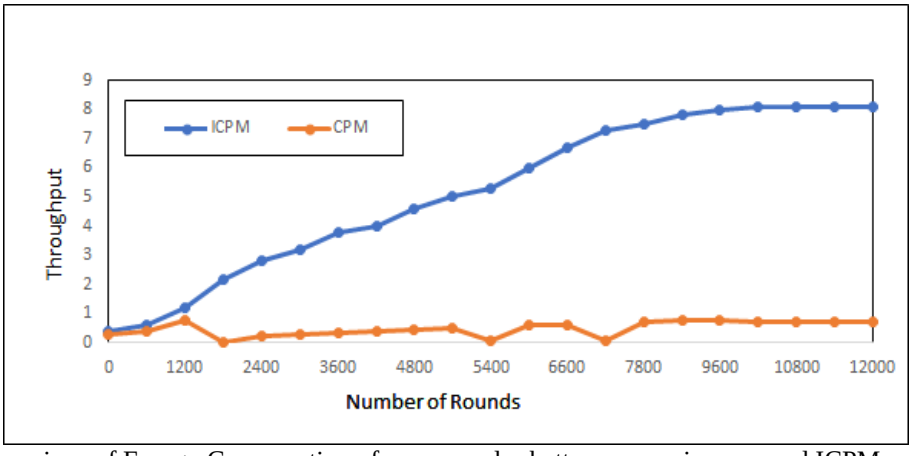

Fig. 1. Comparison of Energy Consumption of sensor nodes battery power in proposed ICPM protocol with compared CPM protocol. Under varying numbers of rounds the energy consumption is minimized by 4.47%.

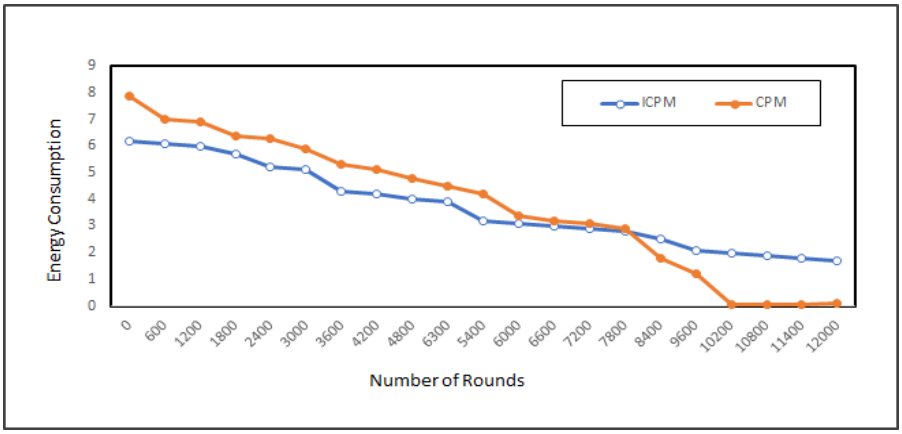

Fig. 2. Comparison of Energy Consumption of sensor nodes battery power in proposed ICPM protocol with compared CPM protocol. Under varying number of rounds the energy consumption is minimized by 2.47% due to the Innovative node bandwidth parameter for efficient cluster head selection which reduces the node energy consumption.

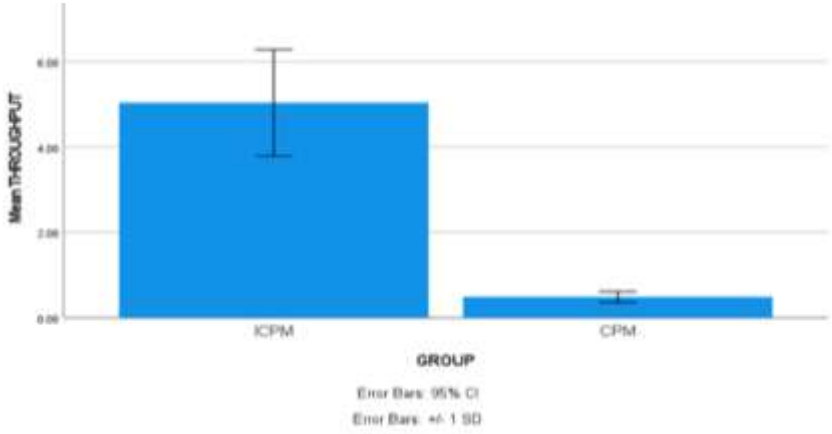

Fig. 3. Bar chart representing the comparison of ICPM protocol and CPM protocol in terms of throughput and ICPM achieved 4.47% higher throughput when compared with CPM protocol. X Axis: Mean throughput of detection ± 1 SD.

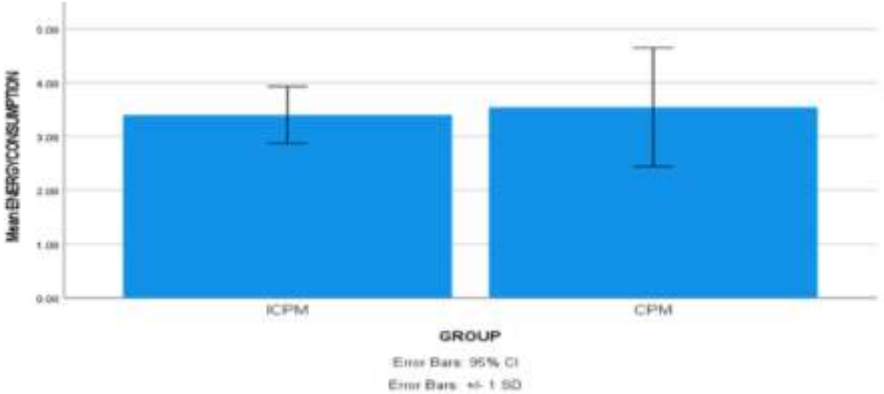

Fig. 4. Bar chart representing the comparison of ICPM protocol and CPM protocol in terms of energy consumption and ICPM achieved 2.47% lower energy consumption when compared with CPM protocol. X Axis: Mean energy consumption of detection ± 1 SD.