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Dear Esteemed Readers, Authors, and Colleagues,

I hope this letter finds you in good health and high spirits. It is my distinct pleasure to address you as the Editor-in-Chief of Integrative Omics and Applied Biotechnology (IIOAB) Journal, a multidisciplinary scientific journal that has always placed a profound emphasis on nurturing the involvement of young scientists and championing the significance of an interdisciplinary approach.

At Integrative Omics and Applied Biotechnology (IIOAB) Journal, we firmly believe in the transformative power of science and innovation, and we recognize that it is the vigor and enthusiasm of young minds that often drive the most groundbreaking discoveries. We actively encourage students, early-career researchers, and scientists to submit their work and engage in meaningful discourse within the pages of our journal. We take pride in providing a platform for these emerging researchers to share their novel ideas and findings with the broader scientific community.

In today's rapidly evolving scientific landscape, it is increasingly evident that the challenges we face require a collaborative and interdisciplinary approach. The most complex problems demand a diverse set of perspectives and expertise. Integrative Omics and Applied Biotechnology (IIOAB) Journal has consistently promoted and celebrated this multidisciplinary ethos. We believe that by crossing traditional disciplinary boundaries, we can unlock new avenues for discovery, innovation, and progress. This philosophy has been at the heart of our journal's mission, and we remain dedicated to publishing research that exemplifies the power of interdisciplinary collaboration.

Our journal continues to serve as a hub for knowledge exchange, providing a platform for researchers from various fields to come together and share their insights, experiences, and research outcomes. The collaborative spirit within our community is truly inspiring, and I am immensely proud of the role that IIOAB journal plays in fostering such partnerships.

As we move forward, I encourage each and every one of you to continue supporting our mission. Whether you are a seasoned researcher, a young scientist embarking on your career, or a reader with a thirst for knowledge, your involvement in our journal is invaluable. By working together and embracing interdisciplinary perspectives, we can address the most pressing challenges facing humanity, from climate change and public health to technological advancements and social issues.

I would like to extend my gratitude to our authors, reviewers, editorial board members, and readers for their unwavering support. Your dedication is what makes IIOAB Journal the thriving scientific community it is today. Together, we will continue to explore the frontiers of knowledge and pioneer new approaches to solving the world's most complex problems.

Thank you for being a part of our journey, and for your commitment to advancing science through the pages of IIOAB Journal.

Yours sincerely,

Vasco Azevedo

***Vasco Azevedo**, Editor-in-Chief*
Integrative Omics and Applied Biotechnology
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ARTICLE

A SECURE GA APPROACH IN TREE BASED MUTICAST NETWORK

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ABSTRACT

Multicast routing is the process of sending data from one or more sources to many destinations. In MANET, structure of the network may change frequently due to the movement of the nodes. Hence routing affords multifarious issue which has led to development of many diverse routing protocols for MANETs. To achieve high efficiency, it is mandatory to minimize path delay due to blocking, and the cost of the path tree to reach destinations. Multicast Tree Optimization (MTO) problems are usually difficult to solve and are known as NP-Complete problems. The Genetic Algorithm (GA) has been proven to be an efficient technique for solving the MTO, because of its well defined chromosomes and genetic operators, which are the key characteristics of the GA to determine its performance. GA is a heuristics combination, which depends on an actual state of the network and will select paths in such a way to maximize the routing metric. The security metric is also including using genetic algorithm to prevent from security attacks. A proposed work leverages the advantages of Newton's interpolation method to implement the key chaining for MANET. The simulations are carried out for the different parameter such as control overhead, end to end delay, packet delay and average node density. With the performance enhancement and comparison are performed through extensive simulation. It is proved to be an efficient encoding scheme of the reconstruction of the multicast tree topology and the simulation results demonstrate the effectiveness of the sGenMAODV compared to the MAODV protocol.

KEY WORDS
MANET, Multicasting, path tree, Genetic Algorithm, key chaining

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INTRODUCTION

Recently Multicasting routing has various protocols proposed, in this way many multicast protocols have been Evaluated and proposed. MANET multicast protocols can be characterized by how they proliferate information as mesh-based or tree-based [1]. While tree-based conventions spread information over a tree traversing all multicast bunch individuals, in mesh based conventions a subset of organization hubs (mesh) is answerable for sending information to all multicast recipients. A few of the current routing convention are Protocol for Unified Multicasting through Announcements (PUMA), Core Assisted Mesh Protocol (CAMP) Forwarding Group Mesh Protocol (FGMP), Dynamic Core-Based Multicast Routing Protocol (DCMP) and most usually utilized On-request Multicast Routing Protocol (ODMRP) are protocols of mesh based conventions[2]. Multicast Protocols, for example, Multicast Ad-hoc On demand Distance Vector (MAODV) are tree based conventions, In this multicast routing, Increasing traffic load varieties cause confined connection link congestion, and optimizing the route that bring about potential execution issues. Quality of Service (QoS) based multicast directing and different issues identified with Steiner trees.

Genetic Algorithms are search based algorithm reliant on natural evolution models. The Search space includes population of individuals' nodes from which it represents the best possible routes. The fitness value is assessed for each route in order to achieve optimal route from many possible routes. The methodology of the GA approach is to investigate the pursuit search space and to find a superior ideal solution for the problem definition. The accomplishment of the calculation is ascribed to different components such as robustness, advance search capability, capacity to join with other heuristic methodology, for example, discrete or continuous search space and linear or non-linear constraints,

Route optimizing is significant factor for designing route traffic that are utilized to localized congestion, forward data packets and routing tables need to building in a optimize manner. This incorporates packet loss; packet delay and other link utilize values within the nodes. The fundamental point is to have minimized the cost of the route and effective linkage in the network. The current methodology manages NP complete issue in which communication through the multicast tree take place through packets. In this paper manages strategy for getting secure path exchange, latency, control overhead that respects advance optimize routes and secure way trade through Newton's interpolation method for secure key exchange and Genetic Algorithm for QoS prerequisites utilization.

Mathematical analysis and process

In Genetic Algorithms are search based algorithm reliant on nature of evolution process it represents the best possible routes. Each time it produces new offspring through probability which is relative to the nature of the comparing arrangement. In every generation, strings that represent to arrange with great properties to have a higher opportunity to get by the others. The crossover picks a couple of strings, which splits up their quality grouping indiscriminately places, and exchange the hereditary data. The mutation process represents new hereditary material by randomly choosing and changing straightforward genes.

If the size of population and also, in every algorithm the best generation are set to 100 and 1000 separately and the parameters for the computation of the proposed algorithms are set to mutation probability Pm = 0.05 to 0.1 and crossover probability Pc = 0.4 to 0.5.

Shortest path trees (SPTs) and multicast trees (MCTS)

The two principle way to deal with optimizing the multicast routing issues is Shortest Path Trees (SPTs) and Minimum Cost Trees (MCTs). A undirected spanning tree G = (V, E), V = {v1,v2,v3, … .vn} is the vertex set , and the E = {e1,e2,e3, … em} is a set of edges that is associations between these vertices of G. Let W = {w1,w2,w3, … wm} stands to the weight or cost of each edge and confined to be a positive number. The objective of SPT calculations is to build a minimum cost shortest path in the multicast tree from the sender to its recipients

The MCT approach means that the complete expense of the multicast tree is need to reduce. MCT approach also depends on the base Steiner tree issues, which is NP-Complete. The cost tree with minimum edge can be found by arranging all the weight in the ascending order, choosing each edge in turn and, going along with it to the tree, when it doesn't make a cycle. here involved less number of forwarding nodes while compare to SPTs

METHOD

This technique is to find the minimum cost multicast trees with best the fitness value. The problem or issue is to encode into a set of chromosomes (strings), and each string in multicast tree will be allocate a fitness value. Here in this paper we are utilizing protocol named Multicast Ad-hoc On-demand Distance Vector (MAODV) protocol, which is tree base multicast routing protocol.

In MANETs, designing a multicast routing protocol is a challenging task due to its limited link, path constraints and node mobility. A new dimension to the multicast routing problem is the construction of a optimized tree structure or minimum cost tree that supports QoS characteristics such as delay, jitter, throughput, etc. which are the essential requirements for modern multimedia applications in multicast communication. Multicast Tree Optimization (MTO) problems are usually difficult to solve. The GA has been an efficient procedure for giving solution to MTO, because of its well defined chromosomes and genetic operators, which are the key characteristics of the GA to determine its performance.

In MAODV, it utilizes a tree based path, which contains a bunch of relay nodes to convey information in form of data packets conveyed by the source to multicast recipients. This set of relay nodes are selected by the MAODV itself between the source and the receiver. Nonetheless, these trees are not ideal as far as number of sending or forwarding nodes which are chosen, acquiring a higher control message overhead, which, in turn, reduces the data delivery. The concept of minimum cost trees is to attempt to lessen the expense of the multicast tree by decreasing the quantity of connections(links) which are needed to associate from sources and destinations. This is needed by choosing joins in the tree which are valuable to countless receivers. The issue of finding a multicast tree with minimum cost is notable as the Steiner tree issue; to achieve this, a new encoding scheme sequence and topology encoding is introduced. It is proved to be an efficient encoding scheme of the recreation in topology of multicast tree and the simulation results show the improvement of the GenMAODV compared with the MAODV convention.

Basis for genmaodv

The augmentation of multicast is Ad-hoc On-demand Distance Vector Protocol (AODV). In each multicast group a tree structure and the group member is coordinated that first develops the tree with the group leader, and in order to broadcast Group Hello (GREP) messages periodically, need to maintain group tree in the network. Here, every node maintains has three tables,

1. unicast route table
   In this table, it stores the location of the next hop for unicast traffic.
2. multicast route table
   In this table, for each multicast group, it stores the next hop information for the tree structure. Like group leader or group member, every node in the group should maintain to keep up its own identity and associate with either downstream or upstream direction.
3. Group route table
   In this table, it stores the next hop address of group leader and towards the group leader.

The detecting of broken links on the active nodes, route to multicast node can be process in MAC layer. Each node will check to find the next hop information in order to forward packets in the multicast tree through multicast route table. For multicast tree construction RREQ, RREP and MACT messages are used. Initially a node sends a join flag RREQ-J when needs to join the multicast group or when it is not a tree member. It makes an entry and identify node in the multicast route table.

Multicast Route Activation (MACT) is utilized for joining a branch to the tree. Subsequent to sending RREQ-J the source node stay for a particular time RREP-J. If received it, sends MACT-J towards upstream node and adds the address of new next hop information to the multicast routing table. If not received any RREP-J, the mentioning source node turns into the group leader to keep up the gathering number (sequence) and tree structure. Multicast tree support incorporates Periodic Group-Hello Propagation, Neighbor Connectivity Maintenance, Group Leader Selection, Membership Revocation and Tree Merge.

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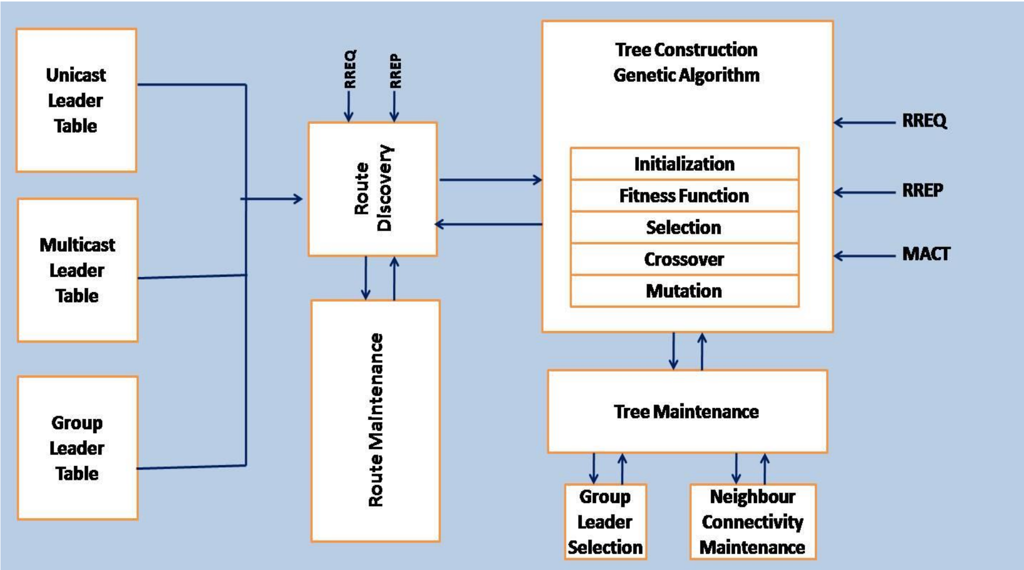

Fig. 1: Architecture of GA optimize with MAODV routing protocol.

The group leader should intermittently broadcast Group Hello message (GRPH) to the whole network to indicate the existence of the group and its status. group leader table is updated all the nodes as well as the route reaching towards the GRPH message. when the downstream node of a connection in the tree understands that the connection is broken by not accepting any transmission messages from that neighbor. Tree neighbor availability is repaired and maintained.

If a connection link breakage is recognized, the downstream hub erases the next hop information in its multicast route table and sends RREQ-J to locate another branch. If requesting source node to change its group information with the help of local repair message, then at this point GRPH is send with an update flag GRPH-U to its downstream node. Where next hop information will get data packet informing to the source node to start a new discovery. Thus, to setup a multicast tree for an unidentified multicast group, the group leader request its group members through broadcasting RREQ/RREP control messages to the whole network. Every node receiving these messages chooses one with the optimal route.

Secure GA Model

This procedure is to discover the minimum cost multicast tree with best the fitness value[4]. The issue is encoded into a bunch of strings (chromosomes), and each string speaks to a multicast tree and is relegated a wellness fitness value. The development of an advanced or optimized route in the MAODV with a base number of sending nodes is done in the accompanying way.

Initial Population

In the MAODV, the nodes in the organization structure a tree, and the quantity of spanning trees on a total chart of 'n' hubs is nn-2 as indicated by Prufer's verification of Cayley's hypothesis..

Encoding

This part presents an encoding plan used to improve the directing proficiency in a GA. In the GA, the main basic task is to encode trees, Generally, the encoding plans, use edge encoding, vertex encoding, and both edge and vertex encoding. However, the GA dependent on these encoding plans doesn't save area; while transforming one component of its vector causes a radical change in its individual tree topology. The encoding plan is called topology encoding and the related with crossover and mutation.

Fitness Function Evaluation and Selection

The Fitness function is estimated by how well the chromosome finds an answer. Just a fitter chromosome yields offspring in the future. The sub chart of G can be communicated utilizing a vector x = {x1, x2, x3, ... xm} where every component xi can be characterized as follows

$$x_i = \begin{cases} 1 \; if\ edg\ e_i\ is\ selected\ in\ the\ subgrapgh \\ 0 \; otherwise \end{cases}$$

In a graph G, consider the set of spanning tree is T. the evaluation can be devised as

$$f(x)_{min} = \sum_{i=1}^{\infty} \{w_i x_i | x \epsilon T\}$$

Where w = {w1, w2, w3.............. wm} represents the cost of each edge.
m=Number of nodes in the sub network.
The cycling cycle proceeds until either multicast tree with minimum cost is found or iterations is reached to the maximum extend. This method applies repeatedly until the selected parent node is reproduced.

Crossover

The crossover operator modifies the chosen components to form new segments to be assessed in the future generations. The plan of operators in this encoding scheme is significant, in light of the fact that GA will applied to enhance adequacy and effectiveness. The encoding plan utilize here, contains two chromosomes; the operators for this encoding are more confounded than those for single chromosome codes.

Mutation

Mutation is a important operator in genetics used to keep up hereditary variety from one age of a populace of chromosomes to other. The exemplary illustration of a mutation includes probability of changing a sequence of a bit from its original state. This arbitrary variable tells whether a specific bit sequence will be changed. It accomplishes a decent territory so just a little change happens in the nodes on the tree after crossover. The reason for change in a hereditary calculation is to permit the calculation to dodge neighborhood minima by keeping the number of inhabitants in chromosomes from getting excessively like one another. At the point when a change happens, a vertex is arbitrarily chosen on the tree and another tree(new) is developed there.

Key chaining

During the process of selection, unauthorized node can intervene and disturb the whole network by passing incorrect information, blocking the content and other services partially or completely. Key chaining is one of the important security framework for network building, other framework are Security association and Distributed Key management [9].

In this Key Chaining method, Network interpolation is used that is based on interpolating polynomial degree and recognized by Lagrange formulae. Newton's forward difference and Newton's backward difference are the two types of interpolation method that support data that one can slowly build the help information without re figuring what is now registered.

The Forward difference method helps in to determine new routes in all best way to it reaches destination node. This method updated with key share generated using the interpolation method that all are encrypted by intermediate nodes values that cannot be viewed by other nodes. These asymmetric key shares from the Newton's forward table which are used to generate polynomial functions.

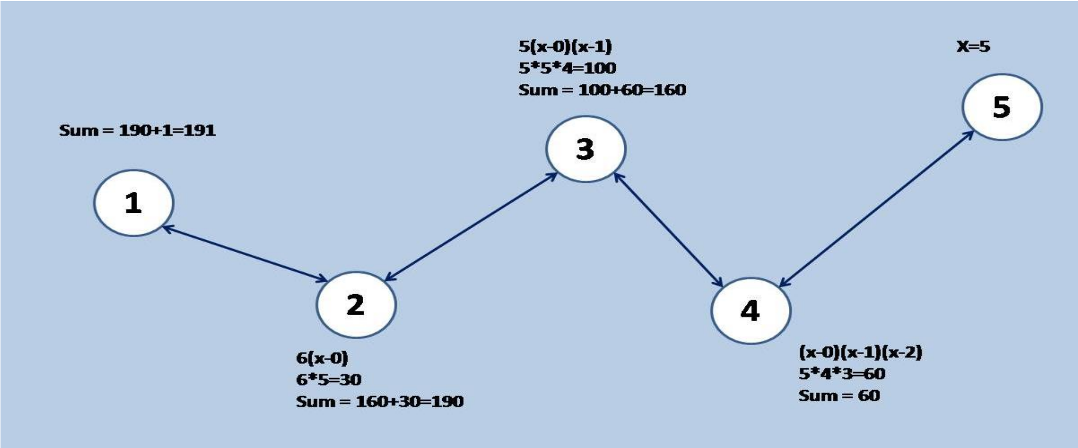

Fig. 2: Secure Key chaining in GenMAODV.

The objective hub begins key affixing in the wake of accepting a forward method, in reverse methods refreshed with key offers table backward request. The key offers are scrambled by open keys of separate middle nodes. These qualities are contrasted and old qualities from node table and calculation is summoned to refresh way and to give the symmetric key to source node.

The [Fig. 2] shows key share principle that share encrypted values among the intermediate nodes. The Values generate from key share compared with old values key shares table and updates path till it reaches to source node.

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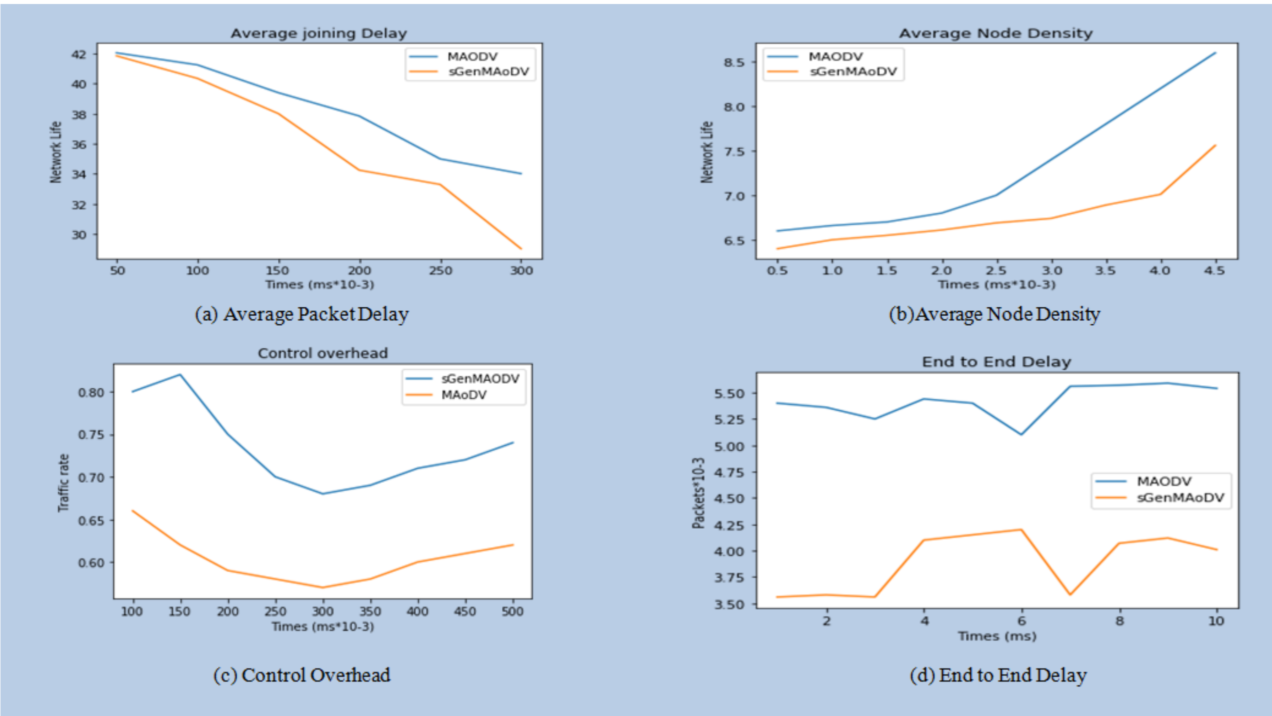
Key chaining calculation

Stage 1: Generate a retrogressive backwards method with key offers as surrendered
Stage 2: Generate a polynomial capacity with the assistance of gathered key shares.1 + 6(x-0) + 5(x-0)(x-1) + 1(x-0) (x-1)(x-2) + 0(x-0)(x-1)(x-2)(x-3) x3 + 2x2 + 3x + 1
Stage 3: Calculate f(x) for a given random estimation of x
Stage 4: For example, on the off chance that x=5, at that point f(x)=191
Stage 5: Encrypt x by utilizing the public key of source hub
Stage 6: Send in reverse subterranean node to source hub
Stage 7: Compare key offers an incentive at every single intermediate node.
Stage 8: on the off chance that qualities are equivalent, at that point assess conditions at intermediate Nodes
Stage 9: For example, Node (hub) 4 [Fig. 2] value= (x-0)*(x-1-)*(x-2) =5*4*3=60.
Step10: Calculate sum=sum + value
Step11: Encrypt aggregate by utilizing the public keys of individual middle hubs.
Step12: Repeat ventures from 8 to 11 to calculate complete sum.
Step13: Deliver whole to source hub

Thus with the help of random generated value 'x' and its sum carried out till the source hub by backward method. The amount of all middle qualities should be equivalent to symmetric key qualities that are created straightforwardly by source hub. Essentially the proposed work centers around way based key rather than a solitary hub.

RESULTS AND DISCUSSION

In this paper, Performance is simulated using NS-2.34 software which is most open source simulator for research. This Simulator consist of backend c++ code and for accessing need TCL scripting language. Along with this patch of MAODV and Genetic Algorithm generic code is added. Simulation results show two protocols MAODV and sGenMAODV subjects to multicast group and mobility. In this paper, the senders are chosen at random from the multicast group. The number of sources and receivers are set as five and twenty respectively, in all simulations except when varying the multicast group size. The GA parameters for the computation of the proposed algorithms are set to mutation probability Pm = 0.05 to 0.1 and crossover probability Pc = 0.4 to 0.5. Continuous and efficient path is obtained and the data is transmitted without any delay and with very high delivery ratio. Results show that sGenMAODV has a high success rate packet delivery ratio, low latency when compared with MAODV and sGenMAODV protocols. Results show that sGenMAODV performs better than existing protocol MAODV, more than 90 nodes are formed to compare the performance of the two protocols.



(a) Average Packet Delay (b)Average Node Density (c) Control Overhead (d) End to End Delay

Fig. 3: Simulation results graph of average packet delay, Average Node density, Control overhead and end to end delay.

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Average packet delay

In this simulation, average packet delay is sum of times taken by the successful data packets to travel from their sources to destination divided by the total number of successful packet. The average packet delay is measured in seconds. In [Fig. 3a] shows the comparison of two protocols using NS-2 simulator and shows that average delay of SGenMAODV is less when compared to protocol MAODV.

Average node density

In this Simulation, the node density impacts routing evaluations since it determines, together with the mobility model, how many neighbors a node has. In [Fig. 3b] shows the average node density of sGenAODV is reduced when compared to other protocol.

Control overhead

In this simulation, the control overhead is calculated as total number of control packets needed to establish a stable route from source to the multicast receiver. In [Fig. 3c] the control overhead of sGenMAODV is improved when compared to MAODV protocol.

Average end-to-end delay

In this Simulation, End-to-end delay is calculated the time taken for a packet to traverse across a network from source to destination. It is average time of the whole network passing a packet. In [Fig. 3d] shows that the End to End delay of sGenMAODV is reduced when compared to MAODV protocol. This signifies how proficient the fundamental directing calculation is, on the grounds that delay basically relies upon optimality of way picked

CONCLUSION

In Tree based multicasting is a challenging task due to its limited link, path constraints and node mobility. MAODV is the tree based existing routing protocol which contains a bunch of relay nodes to convey information in form of data packets conveyed by the source to multicast recipients. Genetic based with secure key exchange makes MAODV more optimal. The simulation results show that sGenMAODV provides better results for average delay, average end-to-end delay, control overhead, average node density in different node speeds and also for different number of nodes. Genetic Algorithm find the solution space in getting of optimal route and newton's interpolate method helps in key chaining mechanism for secure communication. Thus sGenMAODV protocol provides enhance communication when compared to existing protocol MAODV

CONFLICT OF INTEREST
None.

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ARTICLE

IONIC SALTS ENHANCE THE PERFORMANCE OF MICROBIAL FUEL CELL

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ABSTRACT

Background: World is currently facing energy crisis due to the rapid exhaustion of the fossil fuel based energy sources, and are also major cause of Greenhouse Gas emissions which are known to be the cause of detrimental global warming, thus the current surge in search of alternative energy such as biofuels. Microbial fuel cells (MFCs) are biofuels based on electrochemical process that use microorganisms to generate current by direct or mediated electron transfer to electrodes. Despite the promise of MFC as future alternative energy, it suffers some setbacks including high production cost, low voltage generation. Improving the performance of MFC, require our comprehensive understanding of operational parameters of the fuel cell. In this study, the influence of different types of ionic salts (KCl, NaCl, NaOH and KOH) bridges on MFC performance operated using wastewater samples was studied. Methods: A two chambered microbial fuel cell was constructed, and the ionic salts bridge was fabricated 5g of salt in 0.02g/ml nutrient agar to form the bridge. Results: The results recorded shows that highest MFC power density (10.12 mW/m²) was found in MFC with KCl salt bridge and lowest (1.32mW/m²) was observed in MFC operated with NaOH salt bridge. In the same vain, corresponding maximum voltage (447mV) and lowest (110mV) were observed in MFC operated with salt bridges of KCl and NaOH, respectively. Conclusion: The study has demonstrated the importance of salt bridge optimization which is central in improving MFC performance, increased yield and production cost reduction for wider deployment.

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INTRODUCTION

KEY WORDS
Biofuel, Bioelectricity, MFC, MEC, BES, Microbial fuel cell

One The current global energy crisis due to the rapid exhaustion of the fossil fuel based energy sources and production instability, insecurity with coupled with emission of greenhouse gas has called for legislations and directives such as the Kyoto Protocol with the goal of reducing greenhouse gas emissions by at least 18% below the 1990 levels by the year [1]. The current logarithmic global population growth has incurred increase in industrial activities consequently, warranting the recent surge in energy consumption thus, resulting in environmental pollution and economic difficulties as well as epileptic power supply. Additionally, the current insecurity that exists in the oil producing nations has resulted in dwindling gas supply to power stations due to vandalism of the oil pipelines. This warranted the renewed research interests on sources of alternative energy [2-4]. On this note, advances in renewable energy research have led to the production of clean and sustainable energy such as biofuels from microalgae [5, 6], and biofuel from biomass [7]. Other research scenario, studied the technology involve in reactor design for biofuel production, specifically biodiesel [8].

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Ever since the reported electron shuttling ability of some bacteria by MC Potter in 1911[9], research on the electrogenesis of certain bacteria using waste and renewable biomass has gained impetus [10, 11]. Bioelectricity is a renewable bioenergy produced from biofuel microbial cells thus described as microbial fuel cell (MFC). This particular fuel cell is a bio electrochemical system that has the ability to harness electrons produced from metabolic activities of microorganisms, thus generating electrical current [12]. Typical MFC consists of anode and cathode compartments separated by a proton exchange membrane in a double-chambered setup [10]. Nafion™ and Zirfon are some examples of proprietary proton exchange membranes commonly used in MFC. The system functions when microbes in the anodic chamber oxidize the added substrate and generate electrons and protons via bioredox reaction, thus producing carbon dioxide as an oxidation product. However, there is no net carbon emission because the carbon dioxide in the biomass originally comes from the atmosphere. The electrons are absorbed by the anode and are transported to the cathode through an external circuit, whereas the generated protons cross the proton exchange membrane, and enter the cathode chamber where they combine with oxygen to form water [13]. The generation of electric current is made possible by keeping microbes separated from oxygen or any other end terminal other than the anode and this requires anaerobic anodic chamber. The most obvious use of the MFC is to generate electricity. They can be utilized in rural and urban sectors [14]. Though the electricity produced in fuel cells is not that efficient in small scale but large scale can be efficient, especially when coupled with water treatment process. Low power wireless systems can also be powered using MFC [15]. There has been reported study of using MFCs utilizing body glucose as carbon source to power medical implants [16-18]. In developed countries, MFCs are used in wastewater treatment and most beneficial is that with the treatment, one can actually harness the electricity as well. It produces lesser solid waste from the process, and the electricity produced can be used in aerating the sludge so it can be a self-powered treatment facility. This reduces the cost of electricity generation. Unlike conventional water treatment process, the MFCs combined process is reported to completely break down most of the acetate to carbon dioxide and water [19].

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The microbial fuel cell is now seen as a cost effective development solution for developing countries. Reports from international organizations argue that renewable energy is on its way to become more affordable than fossil fuels [13]. Whilst significant literature is available on the power produced in MFC, its low power generation and high production cost remained major causes of concern hence, limiting its large-scale applications [12]. For example, Nafion membranes are well studied for their application in MFCs [20]. Nafion is reported to exhibit high ionic conductivity (10− 2 S cm − 1), unfortunately very costly at estimated $ 780/m^2 [21]. Although new proton exchange membranes were introduced into the market, but still not cost effective, and this is major consideration. Another cost effective alternate method for proton transfer is the use of salt bridge which connects the anode and cathode chambers and is made of agar and ionic salt.

Previously, we have reported on the enhancement of microbial fuel cell performance by anode nanocomposite modification [12]. In the same vain, this research investigated the effect of ionic salts in agar salt bridge on the enhancement of electro-generation of MFC. It is expected that the research will portray the importance of salt bridge optimization on improve the efficiency of MFC.

MATERIALS AND METHODS

Materials

Ionic salts used (NaCl, KCl, NaOH and KOH) were purchased from Sigma Aldrich Germany and were of analytical grades. PVC pipes and plastic containers were purchased from utility store.

Methods

Sample collection

Samples of municipal wastewater effluent were collected from different location within Dutse metropolis, Jigawa State, Nigeria in a sample container and were taken to the Microbiology laboratory, Federal University Dutse.

Fabrication of salt bridge

A fixed concentration (2M) of salt (NaCl, KCl, NaOH or KOH) was used in the bridge unless stated otherwise. The salt bridge was prepared by dissolving the respective ionic salt each in preheated 10% agar in 300ml deionized water and allow to stand over time to have viscous molten agar, thereafter, it was cast into pvc pipes (15 cm length; 5cm diameter) and allowed to solidified. The salt-agar casted pvc pipe was used as a connecting horizontal bridge between the anode and cathode chambers [Fig. 1]. Based on the type of the ionic salt used, salt bridges prepared using NaCl, KCl, NaOH, and KOH were herein designated as MFC1, MFC2, MFC3, and MFC4, respectively.

Fig. 1: A double chambered MFC consisting of an anaerobic chamber (anode; left) and aerobic chamber (cathode; right) connected by pvc pipe salt bridge.

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Electrode preparation

Rectangular iron mesh with total surface area of 32cm^2 was used as electrode and copper wires were attached to the mesh using a soldering iron to make the electrodes and their connector to external circuit.

MFC construction and operation

Transparent plastic container of 5L capacity and 4L working volume was used as the anode and cathode chambers, respectively [Fig. 1]. A circular hole was made on the side of the two plastic large enough for the salt bridge to fit in. The salt bridge was inserted on both holes made at the side of the chambers and sealed with epoxy glue. A single hole was bored on the cover lid of the anode chamber for the electrode connector, where two holes were bored on the cover lid of the cathode chamber for electrode and aeration Spurger tube. Wastewater sample was poured into the anode chamber and electrode was inserted. On the other hand, distilled water as poured into the cathode chamber and the cathode electrode inserted too and covered. The spurging tube was inserted into the cathode chamber and Oxygen was spurged into the cathode chamber using electric aquarium pump at 1.6 L/min. Sugar solution (40 g/L) was added to the anode chamber to enrich the mixed bacterial consortia in the wastewater effluent sample. Then volt meter was connected to the positive and negative terminal of the microbial fuel cell to display the readings [Fig. 1]. The circuit was completed with a fixed load of 1000 Ω, and the setup was monitored at time intervals. The anodic medium was replaced if the voltage was below 60 mV. Results were recorded in milli voltage (mV) at intervals using Multi-meter (Kusam meco model R 33275 china).

Numerical calculations

Current (i) was calculated according to Ohm's law at a resistance (R) from the voltage (V) according to Eq. (1), normalized by the anode surface area as described somewhere else [20]:

$$i = \frac{V}{R} \qquad Eq.(1)$$

Generally, the overall performance of an MFC is evaluated through power output and current density. The current density (CD) and power (P) were calculated according to Eq. (2) and Eq. (3), respectively

$$CD = \frac{V}{A_{an}R} \qquad Eq.(2)$$

$$P = iV \qquad Eq.(3)$$

But since the voltage is measured across a fixed external resistor (R), while the current (i) is calculated from Ohm's law. Thus, relating Eq. (3) to Eq. (1), power is usually calculated as presented in Eq. (4)

$$P = \frac{V^2}{R} \qquad Eq.(4)$$

It has been reported that in order to compare the power output of different MFC, the power is often normalized to some characteristic of the reactor [8]. Since anode is where the biochemical reaction occurs in MFC, the power output is usually normalized to the projected anode surface area because the anode [8]. The power density (PD) is therefore calculated on the basis of the area of the anode (Aan) according to Eq. (5)

$$PD = \frac{V^2}{A_{an}R} \qquad Eq.(5)$$

The polarization curve was obtained by plotting the graph of the voltage obtained against the current density (mA m−2).

RESULTS AND DISCUSSIONS

Type of ionic salt bridge as a function of MFC cell voltage and power density

The type of ionic salt used in agar bridge play an important role on the transport of proton (H^+) ions. The effect of type of agar salt bridge on the MFC performance was studied [Fig. 2]. Different ionic salts (KCl, NaCl, NaOH and KOH) were tested. Generally, in both salt bridges, a linear increase in voltage generation with corresponding increase in power density to a maximum level was observed over time, thereafter the MFC voltage and power density start to decrease gradually [Fig. 2]. The MFC power density was found to be substantially higher (10.12 mW/m^2) =when KCl salt bridge was used compared to that with NaCl salt bridge (9.21 mW/m^2). In the same vain, corresponding maximum voltage of 447mV and 380mV were observed in MFC operated with KCl and NaCl, respectively.

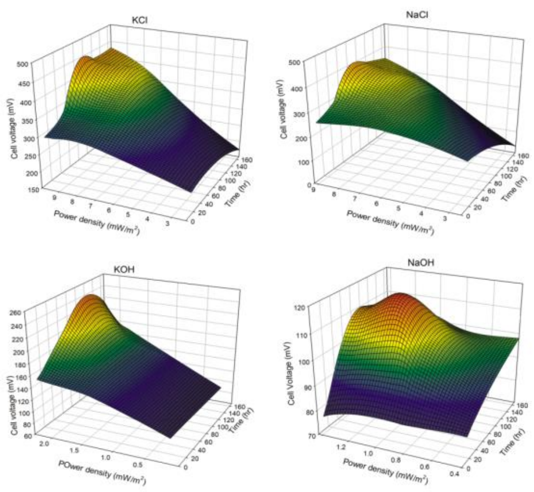

Fig. 2: Response surface plot displaying the type of ionic salt bridge as a function of Cell voltage and power density in MFC.

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This observation was found to be in good agreement with previous reports on increase in higher voltage in KCl (823mV) compared to NaCl with 713 mV [21]. It was also found to be in accord with reported observation by Parkash [7]. The observed higher performance of potassium salt over that of sodium could be attributed to the lower ionization energy of potassium, and reported higher transfer rate of K^+ (0.49) in water compared to 0.4 for Na^+ [21, 22]. Similarly, KOH and NaOH salt bridges displayed 2.29 mW/m2 and 1.32 mW/m^2, with cell voltage of 238mV and 110 mV, respectively. When compared to chloride (Cl^-) associated salts (KCl, NaCl), the observed low MFC performance of hydroxyl (OH-) associated salt (KOH, NaOH) could be due to fact that OH is a strong conjugate base thus making it a poor leaving group, thus difficult to be ionized and transport protons. For example, the PKa for KCl is -7 and that of KOH is 15.7, which indicates the readiness of chlorine to leave compared to the hydroxyl moiety.

Effect of salt concentration in agar on MFC current density

Salt molar concentration in MFC salt bridge is critical in facilitating proton transfer due to its dissociated ions. The effect of different salt concentrations (0.5M to 7M) on MFC current density was studied (Fig. 3). Initial gradual increase in current density from 0.5M to 1M was observed in all the studied MFC samples. Highest current density occurred at 1M concentration in both salt bridges samples. However, MFC operated with KCl salt bridge was found to exhibit highest current density (2.81×10-2 mA/m^2) and lowest current density (6.17×10-3 mA/m^2) was produced by MFC NaOH salt bridge [Fig. 3]. Parkash [7] reported similar observation of highest MFC performance at 1M salt concentration in KCl and NaCl bridges. The researchers further observed a decrease in cell current with increase in molar centration of the salt. In the same vain, optimum molar concentration for KCl salt bridge was reported to be 1M which delivered maximum voltage of 1056 mV [21]. In another research, 1M NaCl concentration was found to produced highest current (256μA) compared to 62 μA been the lowest produced by the MFC when operated by 9M NaCl [23]. Similarly, increase in MFC performance in terms of power density with increasing salt concentration from 1% to 5%, thereafter, a gradual decrease in power and current was reported [18]. It has been reported that increasing the concentration of salt in agar bridge enhances the transfer of protons from the anode chamber to the cathode, at the same time reduces the activation loss [18]. The observed decrease in current generation while increasing the molar concentration of the salt could be due to reported microbial cells dehydration in higher salt concentrations, which resulted in slower electron and proton transfer, thus causing drastic increase in internal resistance [24].

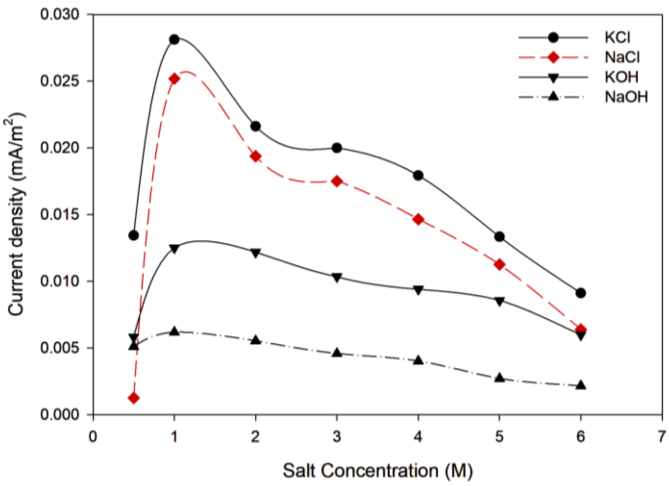

Fig. 3: Effect of salt concentration in agar on MFC current density.

Effect of operation time on Current generation in MFC operated with different ionic salt bridge

The effect of operation time on MFC current generation was studied using different agar-salt bridges [Fig.4]. In all the MFC tested, gradual increase in current generation with increasing time to a maximum level was observed, with salts of potassium having higher generation compared to that of sodium. The current generation was however observed to gradually decrease after the optimum time. In MFC with salt of potassium (KCl, KOH) bridges, optimum current generation of 0.45mA and 0.20mA was observed at 120hrs and 96hrs of operation, respectively. On the other hand, the performance of MFC with salts of sodium bridges (NaCl, NaOH) in terms of current generation was observed to be below that of MFC with potassium salts. In MFC with NaOH salt bridge, the current generation reach optimum level early and decline progressively [Fig. 4].

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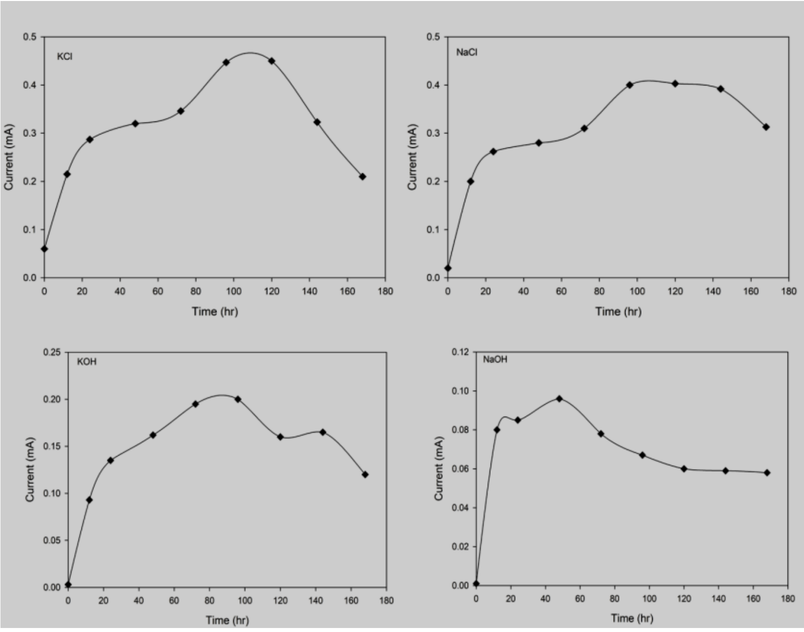

Fig. 4: Operation time as a function of cell current in MFC operated with different ionic salt bridge.

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The general decrease in current generation with prolong operation time could be as a result of ohmic polarization [8]. Equally, the observed high current generation in potassium salt could be due to the same reason mentioned earlier i.e. low ionization energy and higher ion transfer of potassium in comparison to sodium. The progressive decline of current generation in MFC with NaOH could be akin to the strong conjugate nature of the hydroxyl group. Our observation of gradual decrease in current generation after attaining optimum level in MFC over time was in accord with previous literatures [7, 18, 23, 25].

CONCLUSION

In this study we analyzed the effect of different agar- salt bridges and the ionic salt concentration on the performance of a two-chamber MFC. Optimum performance was observed when the MFC was operated with 1M salt concentration in the bridge. Salt of potassium perform better compared to that of sodium probably due to lower ionization energy of the potassium. Accordingly, chloride is known to be poor conjugate base, thus ready to leave the group allowing for proton capture and its subsequent transport. Thence, ionic salts containing chloride exhibit higher performance than those with hydroxyl group. Highest power density (10.12 mW/m^2) and corresponding cell voltage (447mV) were observed in MFC operated with KCl salt bridge. This study has demonstrated the importance of salt bridge in optimizing the performance of MFC.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this paper.

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This work was carried out in the Department of Microbiology and Biotechnology, Federal University Dutse, Jigawa State, Nigeria.

FINANCIAL DISCLOSURE

None.

AUTHOR CONTRIBUTION

GAM: Experimental design, research execution and Statistical analyses; SFB, MM, HY, R MA, GR: Sample and data collection; ZM: Bio electrochemical and Statistical analyses

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