STATIC PIPELINE NETWORK PERFORMANCE OPTIMISATION USING DUAL INTERLEAVE ROUTING ALGORITHM

SIVA KUMAR SUBRAMANIAM[1*], SHARIQ MAHMOOD KHAN[2], ANHAR TITIK[3] AND RAJAGOPAL NILAVALAN[4]

[1]Advance Sensors & Embedded Controls System (ASECS), Centre for Telecommunication Research & Innovation (CeTRI), Faculty of Electronic & Computer Engineering, Universiti Teknikal Malaysia Melaka, Malaysia.
[2]Department of Computer Science & Information Technology, NED University of Engineering & Technology Karachi, Pakistan.
[3,4]Department of Electronic & Computer Engineering, College of Engineering, Design & Physical Sciences, Brunel University London, United Kingdom.

[*]Corresponding author: siva@utem.edu.my

(Received: 1st April 2017; Accepted: 7th Feb 2018; Published on-line: 1st June 2018)

https://doi.org/10.31436/iiumej.v19i1.841

ABSTRACT: In the recent years, there is an increasing demand on multi-hop wireless sensor networks (WSN) especially for remote condition and integrity monitoring of oil and gas pipelines. The sensing points are connected through WSN points, known as a wireless communication medium, between the remotely measured locations on a pipeline and a centralised monitoring station, located some distance away. Generally, WSN deployment on a multi-hop linear topology has critical factors that contribute towards overall degrading of network performance proportional to the number of nodes. This is especially true in highly dense networks. In general, such a drawback contributes towards poor network reliability, low network capacity, high latency, and inequality with snowballing effect, increasing in the direction of the destination node. This paper introduces the Dual Interleaving Linear Static Routing (DI-LSR) for a multi-hop linear network with high reliability and efficiency to significantly enhance the overall network performance of a pipeline network. The DI-LSR was tested and analysed according to IEEE 802.11 standard in a various simulation environment for future real-time deployment in a pipeline network.

ABSTRAK: Sejak beberapa tahun kebelakangan ini, terdapat permintaan yang drastik pada rangkaian multi-hop sensor wayarles (WSN) terutamanya bagi pemantauan jarak jauh dan integriti saluran paip minyak dan gas. Kesemua unit pengesan antara lokasi disambung melalui satu saluran WSN yang dikenali sebagai medium komunikasi wayarles dan diukur ke stesen pemantauan berpusat. Penempatan WSN pada topologi linear multi-hop mempunyai faktor-faktor penyumbang kepada penurunan prestasi keseluruhan rangkaian yang berkadar dengan jumlah bilangan nod dalam rangkaian yang padat. Secara umum, kelemahan ini adalah penyumbang kepada kebolehpercayaan rangkaian, kapasiti rangkaian rendah, respon rangkaian tinggi dan faktor pendorong kesan ketidaksamaan terhadap nod destinasi. Kajian ini memperkenalkan Dual interleaving Linear Static Routing (DI-LSR) iaitu algoritma jalinan komunikasi cekap bagi mencapai peningkatan ketara keseluruhan prestasi dalam saluran paip rangkaian. DI-LSR telah diuji dan dianalisa dalam pelbagai persekitaran simulasi mengikut piawaian IEEE 802.11 bagi mengatur kedudukan pada masa depan saluran paip rangkaian.

KEYWORDS: *multi-hop linear topology; static routing; IEEE 802.11; pipeline; WSN*

1. INTRODUCTION TO WSN ON OIL AND GAS PIPELINES

The multi-hop WSN has been vastly used for oil and gas pipeline condition monitoring from a centralized location. The WSN plays a major role as a communication medium in relaying real-time happenings from sensing points placed throughout the pipelines. In general, a network of pipelines is known as the safest shipping and most cost-effective medium [1] in the oil and gas industry, which is still at risk of physical damage or hazardous accidents [2-4]. In recent years, numerous studies have indicated a series of failures in pipeline transportation yet, when compared to railroad transportation, the percentage of reported incidents or accidents are still very low [1]. Pipeline accidents (unpredictable) that lead to oil leaks would result in irregular temperature readings beneath the pipe, whereas a ruptured gas line causes a temperature decrease above the pipe. Hence, continuous monitoring of both temperature and pressure on oil and gas pipelines would prompt the process of detecting leaks or ruptured pipes, which would enable faster response to any new accidents that could be a threat to the surrounding environment [2, 5, 6].

2. STATIC PIPELINE NETWORK: CHALLENGES AND LIMITATIONS

The three common key features in a WSN deployment on oil and gas pipelines are: (1) data reliability, (2) network scalability, and (3) long-term robustness in the all-weather environment of the application. The sustainability of a multi-hop linear WSN is often related to the overall performance of a network over long-term usage. Due to the linear geographical layout of oil and gas pipelines, major limitations on overall network performance result in unfeasible WSN deployment on a highly dense network [7, 8]. In any WSN context, the limitation factors can be categorized as the (1) transmission and carrier sensing range between nodes, (2) queue length, usually referred at a certain node in the network, (3) network capacity to handle the generated data packets, (4) energy consumed in the network and (5) bandwidth allocation. In a conventional static multi-hop linear network, the source node is not only limited to detecting anomalies on pipelines but also as an intermediate node that is required to transfer bi-directional packets throughout the network. Thus, the data and control packet accumulation at a certain node would result in a bottleneck state and further create node starvation in the network.

Referring to the IEEE 802.11 standard, a series of impending factors in terms of performance can be related to the unpopularity of a multi-hop linear topology when associated with other topologies [9-11]. The three most common factors in a static multi-hop linear network are; (1) limited scalability that (2) contributes towards passive nodes in the network due to the data accumulation factor at a specific node in the network (commonly close to the destination node). Apart from that, (3) wastage of network resources due to competitive data transfer in a large network with a high data rate is a waste of the network allocation, especially of energy usage. Technically, with the proposed routing algorithm, these factors can be manipulated with a tailored and improved routing algorithm based on the nature of the application such as the pipeline network, particularly in enhancing the overall network performance [12].

3. INTRODUCTION AND BACKGROUND WORKS IN PIPELINE NETWORK

Generally, oil and gas pipelines can be categorised as a fixed infrastructure that is commonly stretched over an extensive distance from one point to another. This is the concept of chain communication over a series of intermediate nodes between detection points (sensing nodes) to the centralised monitoring station (receiving node) in order to transfer data as required by the user [13, 14]. The static WSN comprises a sequence of source nodes (sensing points) that operate as hosts when changes are detected on a sensor and also act as routers in a communication path towards a destination node. In general, a data packet generated at the source node requires a navigated wireless communication path to successfully transmit the data packet to a designated receiver node (destination). The route discovery or route identification on a multi-hop linear network among source nodes (multiple nodes) to a destination node (usually one located at the end of the network) is accomplished with a sequence of broadcast packets referred to the used routing protocol characteristic. The four common routing protocols are; (1) reactive routing protocol also known as the on-demand routing protocol, (2) the proactive routing protocol also known as the table-driven protocol, (3) the hybrid routing protocol (a combination of both reactive and proactive protocols), and (4) manual routing protocols [15, 16]. All these routing protocols are different in nature and have a unique process flow with respect to the route discovery and data transfer process, which in turn has significant implication when applied in a wireless network.

The Ad hoc On-Demand Distance Vector (AODV) is the most common and popular reactive routing protocol [16-18]. The route search or identification is completed based on demand and real-time changes in a network. The newest route to a destination node is identified from a sequence of numbers at the destination. In a scenario with two nodes located in a transmission radius (range in meter), the node has the possibility to bypass the next immediate node based on the circumstances and real-time changes in the network. Another on-demand routing protocol that has a similarity to AODV is the Dynamic Source Routing (DSR) [16, 18] where sender and receiver node route navigation is incorporated with transmitted data packets. The route to a designated destination node is generated by referring to the accumulated route information that is temporarily stored in all the nodes. The drawback of DSR is higher overhead that makes it unreliable for long range multi-hop linear communication. The Destination-Sequence Distance-Vector routing protocol (DSDV) is a common proactive routing protocol [14, 17, 18]. There is a minimum delay between the route identification and route setup process in DSDV for an accessible path to a receiver node. The major drawback with DSDV is that frequent routing table updates are required throughout the active period of the network, referred to as a dynamic changing environment in the network. Hence, this results in a network that consumes higher energy cost as well as bandwidth allocation even in an idle network state. A table-driven routing protocol that has similarities with DSDV routing protocol is Optimised link-state routing (OLSR) [16], which identifies the routing path to a receiver node from recognized paths prior to data packet transmission. Thus, the accessible path to a designated node requires zero duration in the route discovery process. The drawback of OLSR is the higher routing overhead.

Fixed routing path (FRP) is a static manual routing algorithm that is efficient with suppressed broadcast related packets for a pre-calculated optimal shortest path [19, 20]. The multi-hop routing algorithm takes into account all possible paths between nodes in a network with the shortest path. The data merging technique prior to transmission to the receiver node through a specific cluster head on a multi-tier cluster-based topology is designed to reduce actual data packet transmission in a wireless network [21, 22]. The Power-Efficient Node Placement Scheme (PENPS) is based on optimisation of node and distance to diverse route loss parameters on a linear WSN [23]. A hierarchical node arrangement that segregates nodes into three groups with specific tasks assigned at each level in the network. The basic sensor nodes at the lowest level of the network communicate the data packets to the next level, which is the data relay nodes, before sending the data packets to the data dissemination nodes in a linear network [13]. The author in [24] introduces the flat data collection algorithm for wireless nodes that respond to unplanned data packets in a network. The data packet is then forwarded to a node with minimum waiting time in the neighbouring nodes.

In any wireless network, routing protocols are associated with network performance, which is a crucial factor that reflects on various wireless measures. The most important measure in any routing protocol is the link stability between nodes, wherein a link failure state contributes to the loss of data packets in the network. A wireless node generates broadcast-related packets in a periodic cycle (time interval) to all its neighbouring nodes that are in its transmission/communication range to ensure their presence. This process also ensures and helps the nodes to retain the existing route or to identify new routes in the network. Hence, this process creates an overwhelming rate of broadcast along with control packets in a wireless network. A simple data accumulation factor on a series of nodes is as shown in Eqn. (1) where the shared network allocation towards a receiver node located at the end of a certain network.

$$NTP = \left[\left(DP_j + CP_j\right) + \sum_{k=j+1}^{n}(DP_k + CP_k)\right] \leq IfQlen_j \qquad (1)$$

where total bi-directional packets are described as *NTP* for *n* number of source nodes, DP_j is the total data packets and CP_j is the total control packets at node *j* with $1 \leq j \leq n$ with $IfQlen_j$ is the default queue size set at 50 packets in a network. While DP_k is the total data packets and CP_k is the total control packets at neighboring node *k*.

The multi-hop linear topology is an important communication architecture on an extended range pipeline network. Due to the unique geographical terrain and data accumulation factor in a single path, communication contributes to the occurrence of nodes without data transmission opportunity (passive nodes) between the sender and a receiver node [19, 20]. Most of the traditional dynamic and hybrid routing protocols have different characteristics from network initialization to a route discovery process [12, 21, 22]. One of the crucial factors in a multi-hop linear communication is queue overwhelming from both data and control packets that lead to a bottleneck point in the network. Such factors in routing protocols are often related to frequent communication link instability. Link instability will trigger a route maintenance procedure at a certain point in the network and increase the consumption of network resources, which will eventually contribute to underperformance of network characteristics. This would result in an increasing number of passive nodes or node failures (due to limited power), which is a waste of network resources and allocation that subsequently degrades the overall network performance [17]. The issues with higher routing overhead, queue overwhelming, frequent updates on route and passive nodes, drives the research motivation to the development of a static routing algorithm. This can eliminate broadcast related routing overhead, predefine routing path, reduce the effects of queue overwhelming and eventually enhance the overall network performance.

4. DUAL INTERLEAVING TECHNIQUE IN MULTI-HOP LINEAR NETWORK

The Dual Interleaving Linear Static Routing (DI-LSR) is designed for a multi-hop linear network to enhance overall network performance compared other routing algorithms, as discussed in Section 3. The predefined dual routing path (*odd* and *even*) concept introduced in DI-LSR would improvise the overall network performance, particularly on the network capacity and issues with passive nodes. A simple seven node arrangement, as proposed in DI-LSR, with three source nodes on each path to a single destination node in a predefined route is shown in Fig. 1. Node placement or arrangement in a multi-hop linear topology plays a major role in the establishment of a sustainable communication between a sensing and a receiver point. Connectivity is often highlighted with node placement as one of the affecting factors on optimisation issues in any multi-hop linear network. Referring to Fig. 1, nodes are arranged in *d* distance (uniform interval) where *2d* distance is the maximum transmission range. The concept of predefined dual routing path ensures that bi-directional flow of both data and control packets are always in a specific path between a sensing point (source nodes) and receiver point (sink node) in a pipeline network. This essentially splits the overwhelming queue factor into two, further improving the data flow rate towards the destination node.

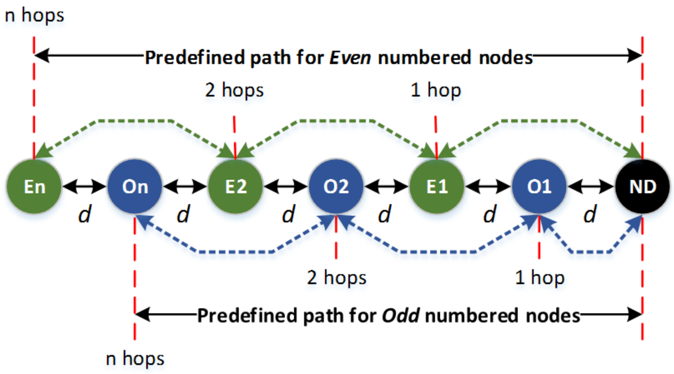

Fig. 1: DI-LSR with source nodes (*On*/*En*) and a single destination node (*ND*).

The eliminated broadcast packets in DI-LSR reduces the routing table generating time to near-zero, since the network is always in a known state with the available nodes in the network at the first active period. In a conventional multi-hop linear network, a single routing table is generated for all nodes that are partially/fully kept in all nodes. These routing table entries are updated periodically based on the characteristic of the routing protocol used that is time-consuming as well as energy-consuming, to support the broadcast packets. Unlike a standard routing protocol, the DI-LSR generates two routing tables; (1) forward for *odd* and *even* as described in Fig. 2 and (2) reverse routing table that retains all source node entries at the destination node with the respective routing path as described in Fig. 3.

The routing process in DI-LSR starts at the initialization state with no broadcast and hello packets where all nodes in the network are presumed to be at a prefixed position in a standby state at all times. The DI-LSR is designed for an ideal network environment without expected changes in the network active period, thus, no routing table updates are expected at any time. The routing table in DI-LSR is generated based on the *odd* and *even*

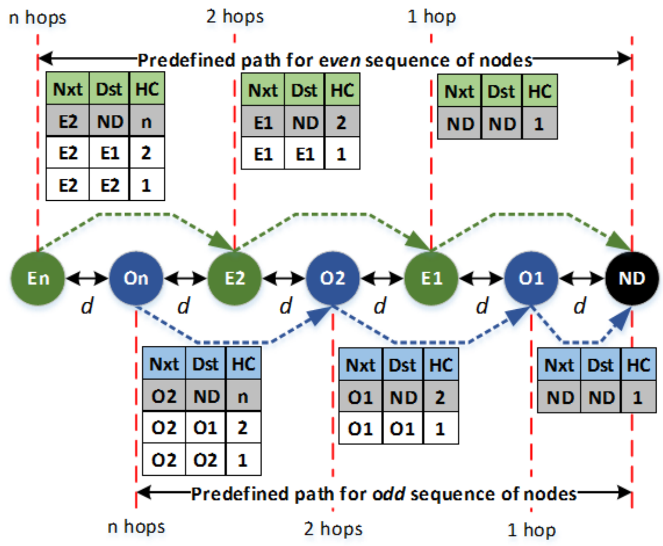

Fig. 2: Forward path routing table in DI-LSR.

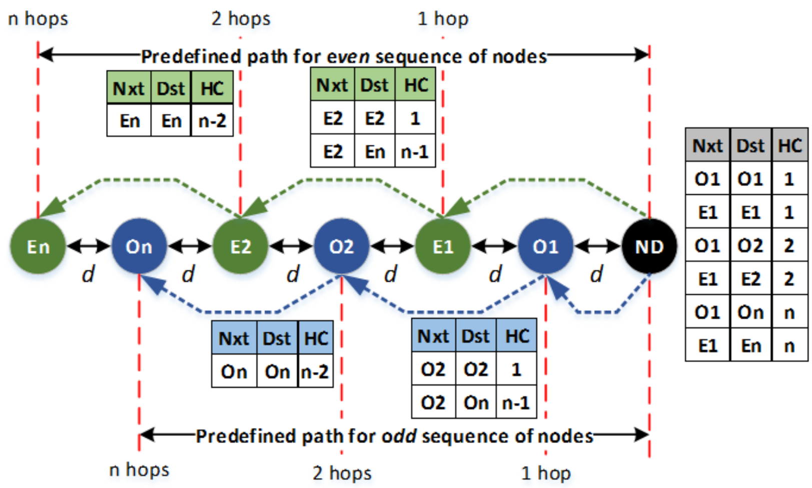

Fig. 3: Reverse path routing table in DI-LSR.

sequence of nodes in the network. The DI-LSR generates two bi-directional *odd* and *even* route between source to a destination node as shown in Fig. 4.

The flow of packets (data and control packets) in both source and a destination nodes in DI-LSR is restricted on a dedicated path without path crossing possibilities. There is a standard queue limitation as in any routing protocol as mentioned in Table I. The concept of queue limitation and data accumulation factor on both *odd* and the *even* path is as described in Eqn. (2) and Eqn. (3) respectively.

$$TPO = \left[\left(DPO_j + CPO_j\right) + \sum_{k=j+1}^{nn}\left(DPO_k + CPO_k\right)\right] \leq IfQlenO_n \tag{2}$$

where *TPO* is the total packets for a *nn* number of nodes (*odd*), DPO_j is the total data packets and CPO_j is the total control packets at node *j* with $1 \leq j \leq nn$ with $IfQlenO_n$ as the queue length in the network. While DPO_k is the total data packets and CPO_k is the total control packets at neighbouring node *k*.

$$TPE = \left[\left(DPE_j + CPE_j\right) + \sum_{k=j+1}^{nn}\left(DPE_k + CPE_k\right)\right] \leq IfQlenE_n \tag{3}$$

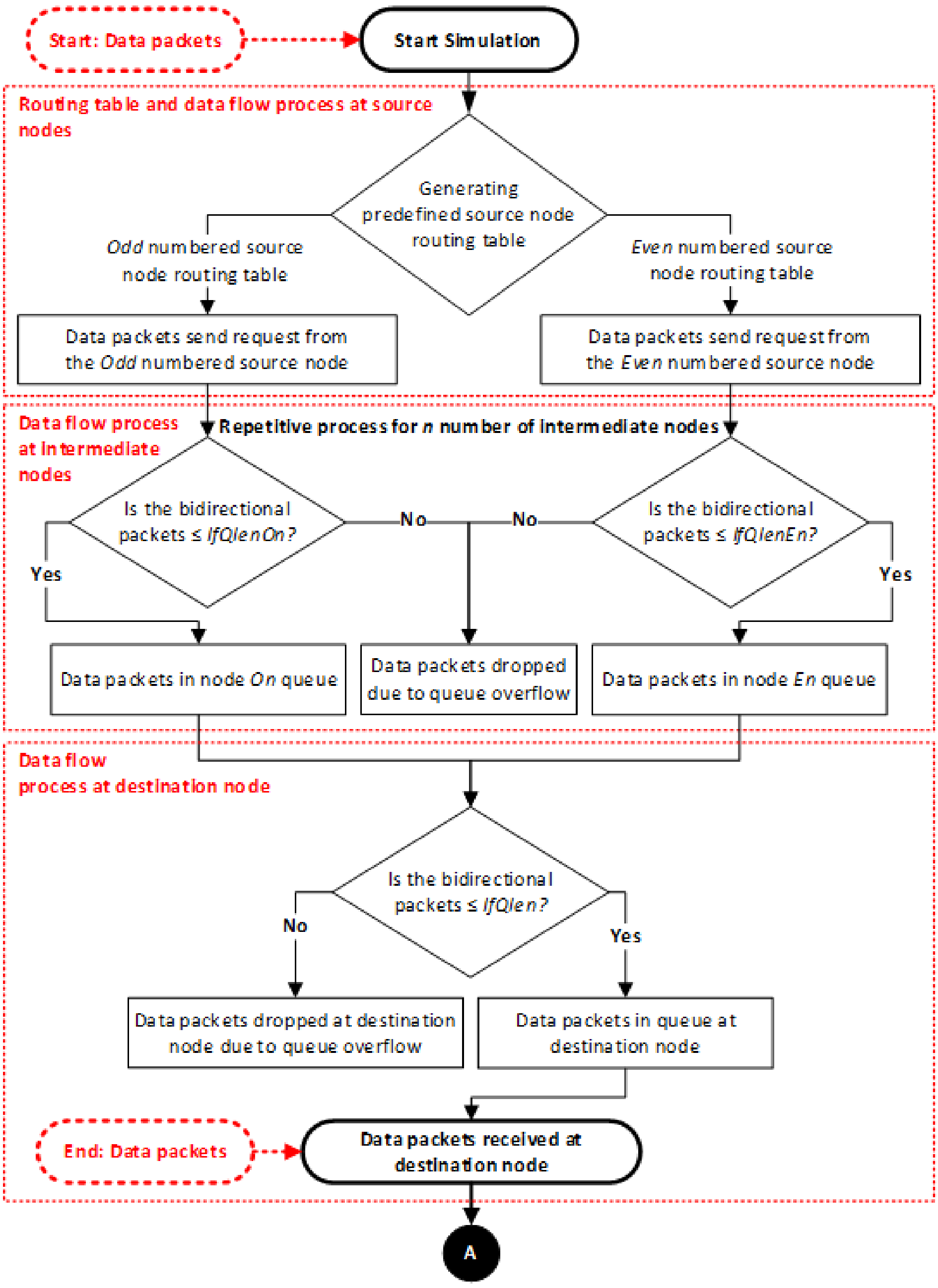

Fig. 4: Process flow of data packets in DI-LSR.

Where *TPE* is the total packets for a *nn* number of nodes (*even*), DPE_j is the total data packets and CPE_j is the total control packets at node *j* with $1 \leq j \leq nn$ with $IfQlenE_n$ as the queue length in the network. While DPE_k is the total data packets and CPE_k is the total control packets at neighbouring node *k*. Any incoming data packets at an intermediate node where the queue length > $IfQlenO_n/IfQlenE_n$ is discarded at this point. With the proposed dual path technique and low routing overhead routing algorithm further reduce the effect of routing overhead hence allocates more bandwidth for data packets. The end source nodes in *odd* and the *even* path will be connected to the destination node with the same queue limitation. The data accumulation factor at a destination node is as described in Eqn. (4).

$$NTP = TPO + TPE \leq IfQlen \tag{4}$$

where *NTP* is the network total packets at the destination for *n* number of nodes which could be *odd/even* and the value of *TPO/TPE* is from Eqn. (3/4). The proposed routing algorithm designed with a dual interleaving technique would add great performance enhancement when implemented in a pipeline network compared to any conventional routing algorithm. One of the key features of DI-LSR is the reduced basic control packets especially broadcast packets as the nodes in the network is permanently fixed. With limited control packets, DI-LSR enables a significant increase in data packet transfer rate as desired in any wireless network.

5. SIMULATION SETUP

In all simulation setups using Network Simulator 2 (NS2) [25], DI-LSR was compared with a reactive routing protocol (AODV), a proactive routing protocol (DSDV), and a manual routing algorithm (FRP) for performance comparison. The results are from an average value of five runs with different seed number (1-10) over 500 seconds (simulation duration) with all nodes in a fixed location. The data size is set at 512 bytes at a rate of 1 packet/sec with a random start time generated between 0 – 2 seconds. The agent type used in the simulation is Transmission Control Protocol (TCP) and traffic type is Constant Bit Rate (CBR). Table 1 indicates the basic predefined simulation settings in NS2.

Table 1: NS2 simulation parameters

Parameters	**Value**
Channel type	Wireless channel
Radio propagation model	Two Ray Ground
MAC type	802.11
Interface queue type	DropTail/PriQueue
Source nodes	12, 24, 36, 48, 60, 72, 84, 96, 108, 120
Destination node	1
Max packet in ifqlen	50 (packets)
RX Thresh/CS Thresh	100 meters/125 meters

6. SIMULATION RESULTS

In all the simulation environment, the DI-LSR was tested and evaluated along with AODV, DSDV and FRP on the following wireless metrics:

6.1 Packet Delivery Ratio

The most fundamental and crucial parameter measured in any wireless network is the packet delivery ratio that indicates the rate of receiving data packets over send data packets [10, 13, 14]. The packet delivery ratio in Fig. 5 for all compared routing protocols is in reverse proportion to the increasing number of source nodes. Referring to Fig. 5, at low network densities with 12 source nodes, the packet delivery ratio is almost at the same rate among all routing protocols due to the small network size. The packet delivery ratio of DI-LSR with the technique proposed in section 4 outperforms all the other routing protocol with varying numbers of source nodes in the simulated environment. The implementation of the predefined dual routing path (splits the traffic into two paths) enables better data flow towards the destination node than other routing protocols. Creating two interleaving individual paths accommodates more data on the queue as well as promotes a better data transfer rate when compared to the traditional routing protocols in the simulation. The packet delivery ratio rate, in percentage (%), gives a brief understanding of the successfulness of packets received rather than the actual number of packets received. Thus, further performance factors can be visualized in the following results.

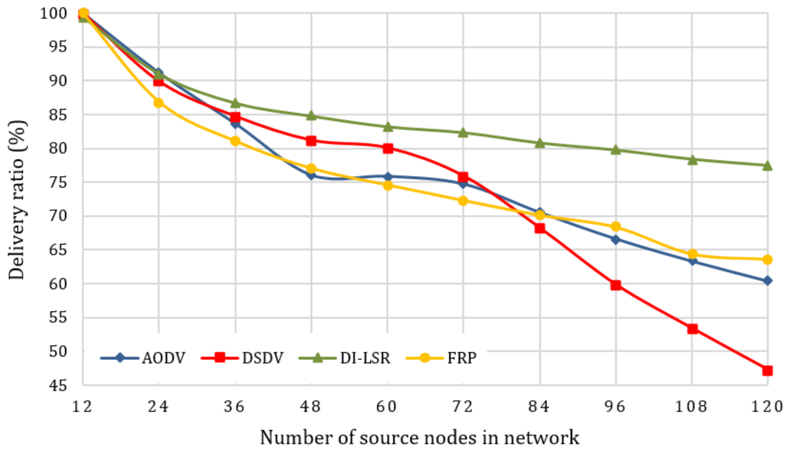

Fig. 5: Graph of packet delivery ratio (%) versus the number of source nodes.

6.2 Throughput

The average throughput value from all source nodes in the network [10, 22] can be described as the network capacity to handle a specific data size in a given duration. The performance in a WSN is the ability to achieve higher throughput within the available network resource, which is a desirable goal in any network. The throughput results presented in Fig. 6 are measured from a small network size of 12 source nodes to a large network size of 120 source nodes. Figure 6 shows that DI-LSR outperforms all the other compared routing protocols. The curve pattern of throughput is almost the same as DI-LSR with a significant difference between 24.12 Kbps to 43.73 Kbps in the varying number of source nodes compared to the other routing protocols. The DI-LSR routing algorithm enhances the data rate among source nodes placed in dual interleaving path with more room to accommodate the generated data on the outgoing queue within the available network resources. The amount of data transferred in a specific duration is critical in a pipeline network for the monitoring station personnel to visualize the integrity of pipelines. Moreover, with a small difference in the packet delivery ratio as shown in Fig. 5, the DI-LSR has a significant impact on throughput for the simulated scenario that makes it a more desirable choice for a multi-hop linear wireless network.

6.3 End-to-End Delay

End-to-end delay is the average value of total time taken to transmit data over all the flows in the network [10, 13]. Referring to Fig. 7, the end-to-end delay in DI-LSR is fairly low when compared to the received data rate at the destination node. Generally, the end-to-end delay in a multi-hop linear network has a corresponding effect on received data rate and network fairness measured in the fairness index. Therefore, the steady increase in end-to-end delay with DI-LSR is proportional to the varying number of source nodes (distance between the source and destination nodes increases) in the network, higher packet delivery ratio and throughput rate. The higher throughput rate as shown in Fig. 6 using DI-LSR justifies the reasons for the higher end-to-end delay in Fig. 7. To reduce the end-to-end delay to a reasonable rate, controlling the number of generated packets in the network will be applicable as a short-term solution in a multi-hop linear topology.

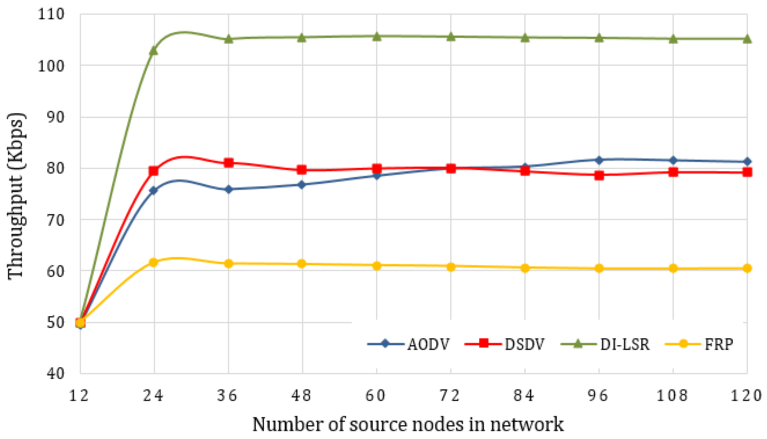

Fig. 6: Graph on throughput (Kbps) versus the number of source nodes.

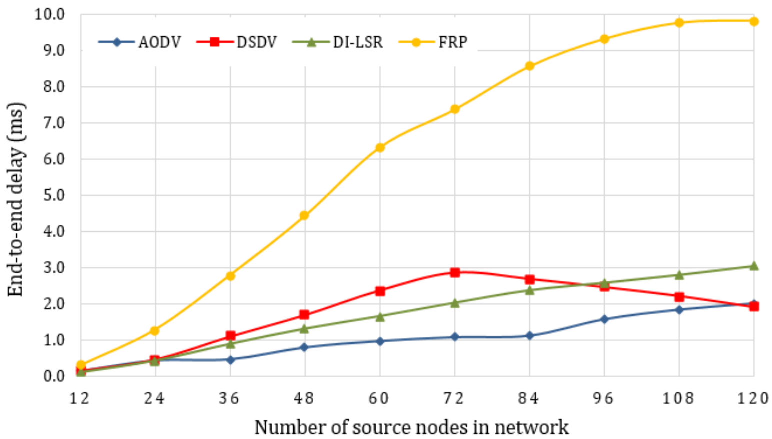

Fig. 7: Graph of end-to-end delay (ms) versus the number of source nodes.

6.4 Fairness Index

Fairness or data transfer equality in a multi-hop linear topology is a crucial factor from the perspective of network stability and scalability. The scalar measurement of resources (data packets) allocation discrimination among all source nodes [22] is known as the throughput fairness index. Achieving the optimum throughput fairness index is a challenging task for the routing algorithm in multi-hop linear wireless networks, particularly in a large scale implementation. In a small size linear network, fairness is hardly visible as shown in Fig. 8. The result of the fairness index indicated that a network with DI-LSR has a reasonable rate of equality in the network when compared to AODV, DSDV and FRP. The throughput fairness index of DI-LSR outperforms all the other routing protocols with a significant difference of 0.2711 to 0.3735 in all simulated environments. A network with DI-LSR has a better data flow and transmission opportunity among source nodes in the proposed dual path instead of a single path as in a traditional multi-hop linear network. With a reasonable rate of throughput fairness index and higher throughput capacity ensures a network with DI-LSR to achieve a fair network allocation with optimum performance. The fairness index can be further improved by controlling the number of generated packets and the TCP delayed acknowledgement method.

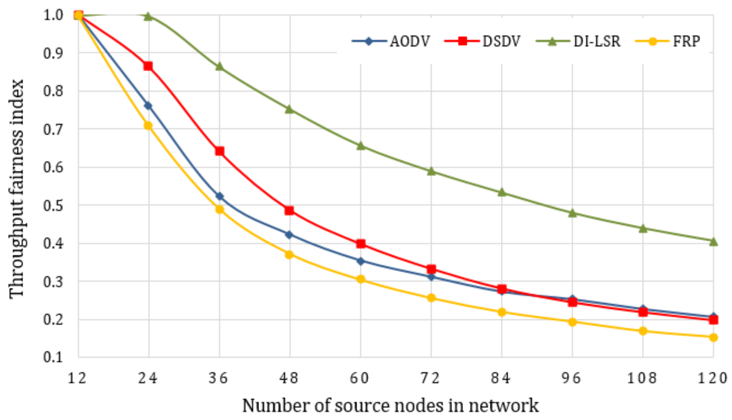

Fig. 8: Graph of throughput fairness index versus the number of source nodes.

6.5 Consumed Energy

The energy consumption per-packet is as shown in Fig. 9, which indicates DI-LSR and other routing protocols have a constant increase of network energy with the increasing network size. The energy consumption per-packet increase factor in DI-LSR is due to the data amplification rate and increasing distance between a source and a destination node in all simulated environments that is higher when compared to other routing protocols. Based on the number of data packets received and the throughput fairness index, DI-LSR has a fair use of energy when compared to all the other routing protocols shown in Fig.9. The energy consumption in a network is relatively related to the network capacity and equality among source nodes as shown in Fig. 6 and Fig. 8, respectively. Theoretically, the energy consumption is proportional to the network size in a multi-hop linear topology due to the increasing distance between a source and the destination node.

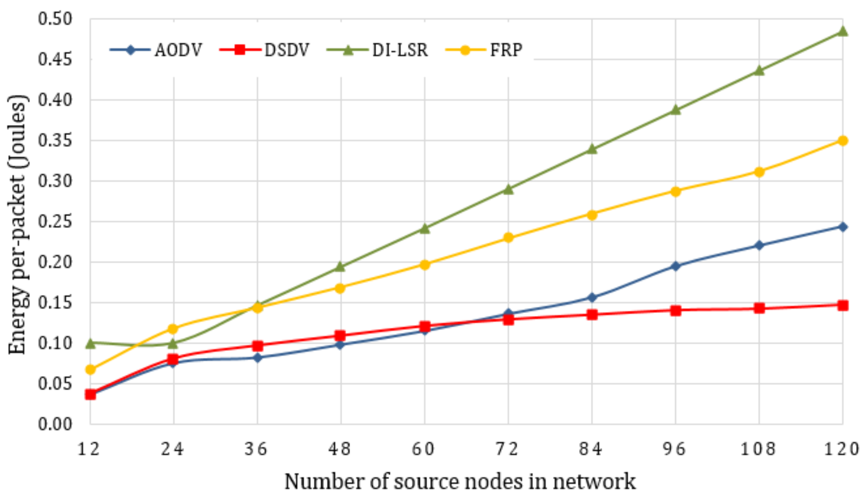

Fig. 9: Graph of energy per-packet (Joules) versus the number of source nodes.

6.6 Normalised Routing Load

The effect of varying the number of source nodes increases the routing overhead in the network for all compared routing protocols as shown in Fig. 10. The routing overhead in a network with the implementation of DI-LSR is relatively lower when compared in terms of received data packets among the other routing protocols between a low network density with 12 source nodes to a larger network density with 120 source nodes. With a reduced rate of control packets, particularly with broadcast related packets, help to reduce the control packet traffic in a network especially with an increasing number of source nodes in a network. The lower routing overhead reduces queue overflow and enables better network resources allocation for data packet transmission between a source and a destination node. A routing algorithm with lower routing overhead is a viable solution for a long-range multi-hop linear architecture such as the pipeline network.

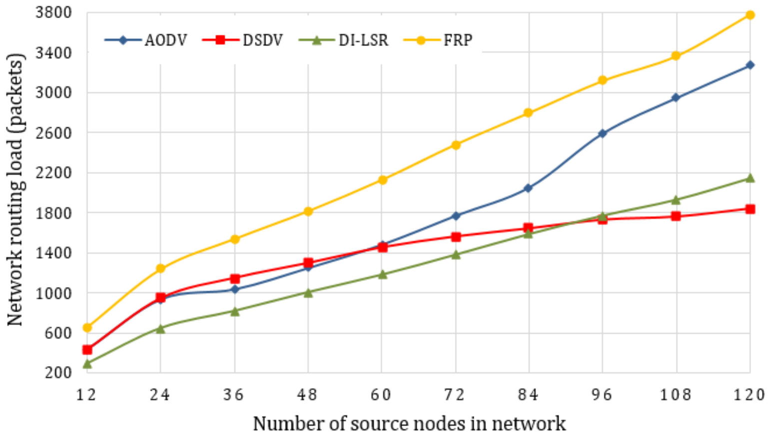

Fig. 10: Graph of network routing load versus the number of source nodes.

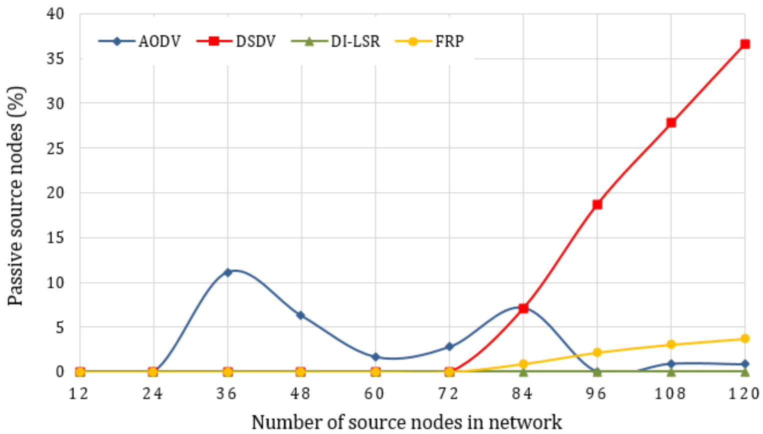

Fig. 11: Graph of passive nodes (%) versus the number of source nodes.

6.7 Passive Nodes

Passive nodes are known as the nodes in a certain network without the opportunity to successfully send data packets to a destination node. The passive nodes are a result of inequality or bias sharing of the network resources that are undesirable in a multi-hop linear topology. A network with DI-LSR has no issues with passive nodes in all simulated environments whereas the other routing protocols have an incrementing factor on passive nodes with the increasing number of source nodes as shown in Fig. 11. A routing protocol that requires broadcast packets contributes towards a higher number of passive nodes due to overwhelming of the queue and uncontrolled data packet flow as shown in Fig. 11. The fluctuation rate of passive nodes is due to the characteristic of a routing protocol that changes in real-time during the simulation based on the data or traffic pattern in the data path that can be corrected with a modification of the data packet transmission rate. Generally, such a network state contributes to waste of network resources, poor delivery ratio, lower throughput rate and can lead towards communication termination that may lead to a certain point in a network due to a single point failure factor in a multi-hop linear topology.

7. CONCLUSION

The outcome of the implementation of the DI-LSR in a pipeline network has emphasized optimization towards the overall network performance in a scalable linear network. The proposed DI-LSR features a beaconless routing algorithm that reduces the network routing load which is a crucial factor in a multi-hop linear wireless architecture. The predefined *odd* and *even* path further enhances the overall network performance with better network allocation to eliminate issues with passive nodes. Simulations to remake a pipeline network were executed to evaluate the proposed DI-LSR in varying network densities that result in a significant level of enhancements in reliability (packet delivery ratio), latency (end-to-end delay), and responsiveness (passive nodes) that has critical implication to the sustainability of a pipeline network.

8. FUTURE WORK

The overall performance enhancement with DI-LSR has functional implications mainly in network capacity and fairness at this state of research that is a common limitation in a multi-hop linear topology, especially with a single destination node. This factor can be further analysed to optimise both performance and fairness using DI-LSR. Hence on the next stage of work, the DI-LSR is proposed to be implemented on a cluster-based topology to further improve the network capacity as well as dealing with passive nodes in the long run. Whereas the network equality issues can be improvised with a model of TCP delayed acknowledgement that can be incorporated with DI-LSR to optimise fairness in a network. The performance and fairness are often related to the energy consumption on a network. Thus, an efficient energy model will add benefit for the implementation in a remote location especially with a non-infrastructure setup.

ACKNOWLEDGEMENT

This work is part of a research project entitled Analysis and implementation of an IoT based remote monitoring of oil and gas pipelines, grant no. PJP/2018/FKEKK (5B)/S01618 funded by Universiti Teknikal Malaysia Melaka. The authors would like to thank Ministry of Higher Education - Malaysia, Universiti Teknikal Malaysia - Melaka and Brunel University- London for their financial support, lab facilities, sincere encouragement and assistance.

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