Advances in Wireless and Mobile Communications.
ISSN 0973-6972 Volume 13, Number 1 (2020), pp. 23-33

http://www.ripublication.com

Quality of Service evaluation by using Optimized Link State Routing (OLSR) in the classroom ad hoc network of the New Generation of Digital Open Universities (DOUNG)

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Abstract

The DOUNG classroom capacity has been improved in recent work [1] by the way of technology evolution that brings to the advent of a wide range of electronic devices such as computers, laptops and telephone cells. That recently numeric Open University model initially defined in [2] was improved in [1] in order to extend its geographic covering area for the need of its lectures delivery. The Quality of Service (QoS) level that can be reached has been evaluated in [1] with many remaining ad hoc network challenges. Even if the classroom ad hoc network is relatively stable, the choosing of the adapted routing protocol problematic remains. Thus in this paper, we are providing new results by using the differentiation criterion of the link state algorithm on which the OLSR (Optimized Link State Routing) protocol is based. For a further comparative analyze to determine the routing protocol adapted to the DOUNG context, AODV (Ad hoc On-Demand Distance Vector) used in document [3] is replaced by OLSR. New simulations are run and new curves are produced and discussed.

Keywords: Distance education, DOUNG, classroom ad hoc network, QoS, OLSR

1. Introduction

The document [1] highlights a new frame that improves considerably the DOUNG infrastructure through the opportunity given by the great density of learner electronic devices. The extended architecture uses a Wi-Fi antenna with an ad hoc network in which nodes keep their independence in terms of mobility, function and routing information. Therefore, a remaining challenge belongs to the choice of a routing protocol under the main constraint of the real time traffic which success imposes to get “good” values of QoS parameters.

The selection of a routing protocol and the QoS guarantee are discussed in this paper within first, the description of the wireless classroom network before presenting the QoS parameters to study. The contribution of the SCTP (Stream Control Transport Protocol) protocol at the transport layer is also discussed with at network layer, OLSR based on the link state algorithm. New simulations are run to establish the contribution of OLSR within the values of the selected QoS parameters. Curves are produced as final result and are interpreted.

II. The classroom wireless network characteristics

The classroom wireless network is composed of learner’s mobiles devices in the model of diversity. In spite of their differences in hardware and function, the using of the Wi-Fi access with standards protocols and web services offered by the DOUNG make easy their federation in a uniform set being an operational wireless network. The classroom considered in this paper is having spontaneous concentration of mobiles devices with multimedia activity capacities. To extend its network in this case, the DOUNG makes available a Wi-Fi antenna that create a first wireless network with infrastructure called LAN1. After, the learner’s devices far from the antenna operate by using their wireless interface and create an ad hoc network called LAN2. The system extends the course delivery without additional means in the limit of favorable values of the QoS parameters. By avoiding to use many Wi-Fi antenna, the less coasts ad hoc network increase the DOUNG capacities and remains benefit until the QoS parameter values will not switch from "good" to "bad" level. The figure below illustrates the architecture given by LAN1 and LAN2 in the classroom.

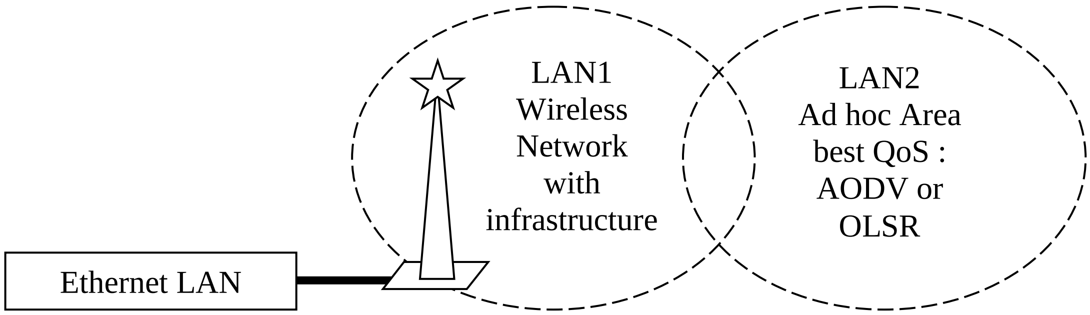

Figure 1: LAN1 and LAN2 positions in the classroom

III. Transport layer contribution

The model put under test uses a protocol stack composed of SCTP [4] at the transport layer. SCTP is a reliable transmission protocol with ordered data delivery that operates with stream and association concepts. For their definition, the stream is a sequence of messages that are to be transmitted in order while the association regroups many streams in which, each stream endpoint is identify by a list of transport addresses (@IP + port). SCTP protocol develops many functions including the data transfer with acknowledgement and without duplication, the data fragmentation, the message delivery in order within streams with also the individual message delivery according to their arrival sequence. Even grouped, the transferred streams are independent to avoid that the failure of one impacts the others. SCTP offers network layer error tolerance with multi–domiciliation. It performs the congestion avoidance, the flooding and attack overcoming, the starting of an association before transferring data, the end of an association, the data send error and the path failure management.

IV. Network layer contribution

IV.1. Differentiation criterion

The need of conveying information through the DOUNG LAN2 brings to the using of a free collaboration between individual learner devices. Particularly in the case of proactive protocols, every node maintains a routing table showing the destinations available in the network. By not considering their proactive or reactive nature, it is possible to use the differentiation criterion of their main algorithm. Instead of DSR (Dynamic Source Routing) [5] or AODV [6] previously used, we choose here to evaluate the QoS gains that can be obtained with OLSR based on the link state algorithm deriving initially from the wired network. In fact, according to many points, the DOUNG LAN2 is not far from the wired network, notably for the stability of its topology, by the low speed mobility with very long break time during which the learners are mostly concentrated to follow the teacher instead of changing their position. With a “good” QoS level, the ad hoc network brings the DOUNG to not mobilize additional means if not the capacity of its server to support real time traffic broadcasted towards a great number of learners.

IV.2. Link state illustration with OLSR

The OLSR [7][8][9] protocol is designed to operate according to the nodes mobility in the ad hoc network, particularly in the case of dense network having low mobility as our classroom ad hoc network. It produces shortest path with the link state algorithm optimization by using the Multipoint Relay (MPR) concept that avoids a node to broadcast its periodic traffic towards all its immediate neighbors. The MPR principle is based on the rule allowing a node to choose a minimal subset of symmetric one-hop neighbors that can reach all the two-hop neighbors. The selected subset helps to perform an efficient diffusion with minimizing the bandwidth consumption and avoiding the broadcasting of periodic control messages in the entire network. In the classical diffusion, a node retransmit every new message toward its immediate neighbors. But the MPR optimization adds a condition: the retransmission is triggered only if the message is recent and if the receiving node is considered by the sender as its MPR. A node N1 that is not the MPR of N2 will not broadcast the N2 messages.

OLSR performs two main operations consisting to the neighbor's discovery with periodic Hello message emission (to choose the MPR) and the diffusion of TC (Topology Control) message by every MPR. Hello message offers many functions such as bringing a receiving node N to update its immediate neighbor table with their type of link. It allows also to determine the other nodes that select N as their MPR and makes easy the deducing of the MPR-set. MPR nodes ensure topology control with the periodic broadcasting of TC messages toward their MPR-set for the building of the topology and the routing tables. OLSR uses the IP packet to send its control messages and gives the optimal path in number of hop. Therefore if the using of MPR is adapted to large network and is less efficient for small network, the contribution of that protocol in our case is to allow the LAN2 to become as large as possible, in order to avoid the attendance of learner becoming a barrier for following the course alive.

V. QoS level indicator parameters

The QoS problematic in the wireless networks of the DOUNG classroom is enforced by the influence of routing protocols. We put here under test the OLSR protocol. New QoS gains are expected since using this protocol is assumed to be favorable to the large dimension of the classroom ad hoc network. Thus, allowing the attendance of learners to increase significantly during the session of a course alive is the expected contribution being evaluated by simulation. The QoS parameters [10] that are used for this need are defined by (1) the synchronization delay between the teacher and the learners and (2) the amount of data available in the buffers for the continuity of the course synchronization without interruption.

V.1. The synchronization delay between teacher and learner

The synchronization delay is define as the shift of the time from the instant ST_s at which the camera multimedia stream is introduced in the buffer SB (Server Buffer) of the DOUNG and the instant ST_{vi} (i=1,2) at which it reaches a learner dependently to his zone. In the LAN1, "i=1", the instant is ST_{v1}, in the LAN2, "i=2", the instant is ST_{v2}.

To measure the network capacity of allowing a synchronous course access mode, it is important to consider the two additional parameters DG_1 and DG_2. They are used to calculate the global delay of multimedia stream acquisition by a learner. DG_1 is used for the learner in LAN1 and DG_2 for the LAN2. They are calculated by using T_δ showing the extension of the synchronization delay at the learner side during the transfer of δ bits required by the application before playing the course video. The DOUNG has to set the value of a QoS threshold called S_{DOUNG} from which the QoS allow to follow a course in real time. For that purpose, TTL_{max} is defined as the maximal duration of a multimedia flow in SB. The equations below give the relations established between all the previous parameters:

$ST_s < ST_{v1} < ST_{v2}$ (1)

$DG_1 = ST_{v1} + T_\delta$ (2)

$DG_2 = ST_{v2} + T_\delta$ (3)

$S_{DOUNG} < TTL_{max}$ (4)

$DG_2 >= S_{DOUNG}$ (5) for good level of the far learners QoS value

V.2. The amount of data available in the buffers

The QoS required when following the DOUNG course alive depends widely to the amount of data available in the buffers SB and CB (Client Buffer by anticipation windows). Let assume Q_s, Q_{r1} and Q_{r2} being the indicator parameters at CT (Current Time) defined by:

Q_s is the amount of data available in the buffer SB at the given instant CT.

Q_{r1} is the amount of data available at the given instant CT in the LAN1 learner CB.

Q_{r2} is the amount of data available at the given instant CT in the LAN2 learner CB.

Let consider T_v as the camera bit rate and TTL_{max} as the maximal duration of a multimedia stream in SB, the relations below are set between these QoS parameters:

$Q_s = T_v * TTL_{max}$ (6)

$Q_{r2} < Q_{r1} < Q_s$ (7)

VI. QoS Parameters evaluation by simulation

To evaluate the influence of OLSR over ST_{vi}, Q_s, and Q_{ri} (i=1,2), we use a protocol stack composed of SCTP at the transport layer and IP [RFC0791] at the network layer. The protocol stack uses the 802.11 protocols for lower layers. Ns–2 is used for the simulation with a traffic source representing the Wi-Fi antenna that initiates a Constant Bit Rate (CBR) toward the learners of LAN1 and LAN2. The inter-arrival time of messages during peak is set to 0.1 second. The SCTP protocol generates 1500 bytes for segments size.

VI.1. Description of scenarios

The goal of the simulations is to analyze the influence of OLSR over the SB and CB buffer size and over the synchronization delay. We evaluate the values of the parameters ST_{v1} for the synchronization of a learner in the LAN1 and ST_{v2} for the learner of LAN2. Also, we evaluate the values of the parameters Q_s, Q_{r1} and Q_{r2}

showing the amount of data available at the given instant CT in the buffers of respectively the DOUNG, the LAN1 and the LAN2 learners. The results to be extracted from traces file allow to determine the contribution OLSR and the capacity of the ad hoc architecture to support the real time traffic without no early interruption of the QoS conditions below the threshold S_{DOUNG}.

VI.2. Results interpretation Basis

The curves are drawn as incoming results with horizontal axis shown the increasing number of nodes in LAN1 and LAN2 within the following values: 10, 15, 20, 25, 30, 35, 40, 45, 50. The average results are calculated for each QoS parameter from the traces file. Then after, we give the interpretation of the curves evolution. The nodes speed is consider low in the interval of [1m/s, 10m/s] with break time set to 25 ms and mobility direction chosen in the LAN1 and LAN2 areas. The global simulation area dimension is set to 1500 x 300 which is divided in two zones with LAN1 beginning from the left border and having 1/3 of the global area while LAN2 takes the remaining 2/3. The antenna position is set to the middle of the left border. The average QoS values are calculated within TTL_{max} set to 10 ms. The simulations duration is set to 150 seconds with the RWP (Random Way Point) mobility model.

VI.3. Curves of the attendance/synchronization delay ratio

To resolve the problem of determining the routing protocol adapted to the context of the DOUNG, the process requires the multiplication of cases to be studied by varying the protocols available according to specific differentiation criterion. If the first two approaches in [1] and [3] use SCTP/DSR and SCTP/AODV protocol stacks, the present paper introduces an additional criterion and a variant stack using the OLSR protocol at the network layer. The main differentiation criterion used in [3] is linked to the distant vector algorithm of the AODV protocol unlike the DSR which does not use a standard algorithm. This choice was made while keeping the two protocols of the same reactive group. The new differentiation criterion introduced in this paper consists of evaluating the same QoS parameters using OLSR as a proactive routing protocol based on the link state algorithm. Therefore, with a different behavior in terms of routing information, new results are expected in order to consolidate the previous observations confirming the intuitive approach and the mathematical models.

The link state algorithm creates a different organization of the network, but like the distant vector, it leads to the using of residual activities. It is used by the OLSR protocol which proposes an optimization avoiding a "wild" broadcast by the election of MPR nodes. This variation allows to expect that the knowledge of the architecture of the classroom ad hoc network and its stability impose a strong limitation of residual activities. It leads to a reduction in the overhead favorable to the using of the bandwidth for the transmission of the multimedia stream, which is restrictive in terms of transmission delay and greedy in size of the data to be transported. The OLSR protocol performs several time and bandwidth consuming activities, in particular, (1) determining the neighbors by periodically sending the Hello message and (2) broadcasting the TC message by the MPRs. These main activities generate (3) the creation and updating of the neighborhood table and the construction of (4) the MPR-set list, (5) the topological table and (6) the routing table.

The previous activities of the OLSR protocol are explanatory factors for the results displayed on the two curves in the figure below. These curves are established with the average values of the two QoS parameters considering the evolution of the learner's attendance. The DG1 parameter measures the synchronization progress of a LAN1 learner while the DG2 parameter relates to the LAN2 learner. With immediate synchronization for the LAN1 and an explicit delay for the LAN2, the behavior observed therefore remains in line with expectations as in the case of SCTP/AODV and SCTP/DSR stacks. It confirms the intuitive results and the mathematical models developed.

The multiple functionalities implemented by OLSR explain the obtained results since they are used in LAN2 to route the multimedia stream toward the various nodes of the network. The evolution of the DG2 curve is both influenced by the six mechanisms previously presented in addition to that of propagation. The result is the time consumed and cumulated for the remote nodes that triggers an extension of their synchronization delay. Indeed, as translated by the figure below, the evolution of the LAN2 curve presents values far from the abscissa axis on which the LAN1 curve is plotted, characterized by an immediate transmission with a zero DG1 delay. The first stage of this curve has a rapid evolution for a small number of learners, between the limits of 10 to 25. However, it tends to stabilize with a less marked fluctuation for the significantly higher attendance values. The explanation of this appearance is linked to the various factors mentioned above. In particular, the influx of learner results in a strongly meshed network architecture characterized by the availability of numerous paths from one point to another. These conditions are likely to lead to the limitation of the OLSR overhead generation by letting the MPR principle to become efficient. In addition, the stability of the classroom produces fewer update events which leads to a decrease in the frequency of periodic activities (3), (4), (5) and (6) even if the activities (1) and (2) continue at a less restrictive pace. The result is a reduction in the consumption of network resources that can be allocated to real-time multimedia traffic. These factors lead to a stabilization of the DG2 curve evolution which tends to decrease after having peaked around the attendance of 35. This pace reflects the expected behavior of the OLSR protocol favorable to large networks. Across the exploitation of the network stability, it slows down its residual activities with the consequence of freeing up more bandwidth for multimedia traffic. However, this observation deserves to be consolidated to determine the limit of this adaptation of the protocol to the context of the DOUNG classroom network.

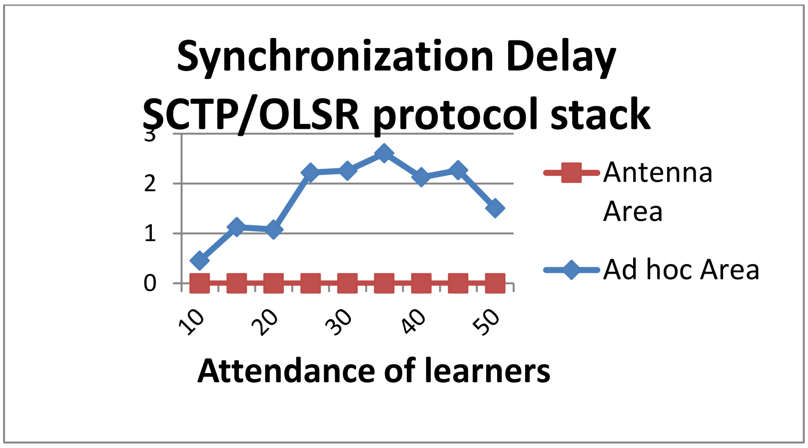

Figure 3: Ratio of attendance over synchronization delay of the SCPT/OLSR stack

VI.4. Curves of the attendance/learner buffers size ratio

With the SCTP/OLSR stack, we also calculate the average value of the buffers size according to the evolution of the learner's attendance. The obtained trace files are used to draw the three curves of the parameters Q_{r2}, Q_{r1} and Q_s in the figure below which confirm the intuitive approach and the mathematical models. With the value of TTL_{max} fixed at 10 ms, the average values of these parameters are calculated. As for the previous cases, the LAN1 buffers evolve synchronously to the server's with some exceptions which constitute points of dissociation of the two curves. This is the proximity effect which favors learners in this area with no delay in the transmission of multimedia data. Unlike, the observation shows the deterioration of the ad hoc area buffer sizes with a significant difference causing a break in synchronization for the attendance of 40 and 50 while the values of the two near areas meet at these points. OLSR thus demonstrates a major handicap in this scenario evaluated with an absence of correlation according to the evolution of the learner attendance. Indeed, the ad hoc part remained largely on the sidelines of a substantial buffer size allowing synchronous course access. This behavior is different from that observed for LAN1. In this area, the size of the buffer has remained directly linked to the traffic growth and the evolution of the number of learners. For example, from a starting rate of 4000 and 5000, the two buffers close to each other reached the common value of 12000 almost without much variation in the difference of their size during this evolution.

The first conclusion to deduce from these results is related to the non-adaptation of the OLSR protocol to this small classroom network despite the slowdown in certain residual activities. The level of the parameter for measuring the amount of data available in the buffer is insufficient. It can be conceded that by significantly changing the attendance of learners, different and better results are likely to be obtained. The previous paragraphs concede that this protocol consumes a significant amount of time to organize the network with MPR nodes election. It is only suitable for large networks and is less effective for small networks. The basis of the comparison with the other protocols used in the present case is therefore unfavorable to OLSR. As a reminder, LAN2 is subject to the negative influence of factors which combine, including the step-by-step propagation and the significant weight of the functionality of the OLSR protocol with its residual activities from (1) to (6). As previously, even slowed down by the stability of the classroom ad hoc network, these activities are consuming time and bandwidth. So, many packets are therefore constantly in transit and whose propagation is slowed down to the point of causing their TTL_{max} to expire, an event that triggers a break in sequence and synchronization. Aggravating factors that add additional delays come from the routing structure updates, the retransmissions or the reorganization of the network during specific events that occur in the classroom.

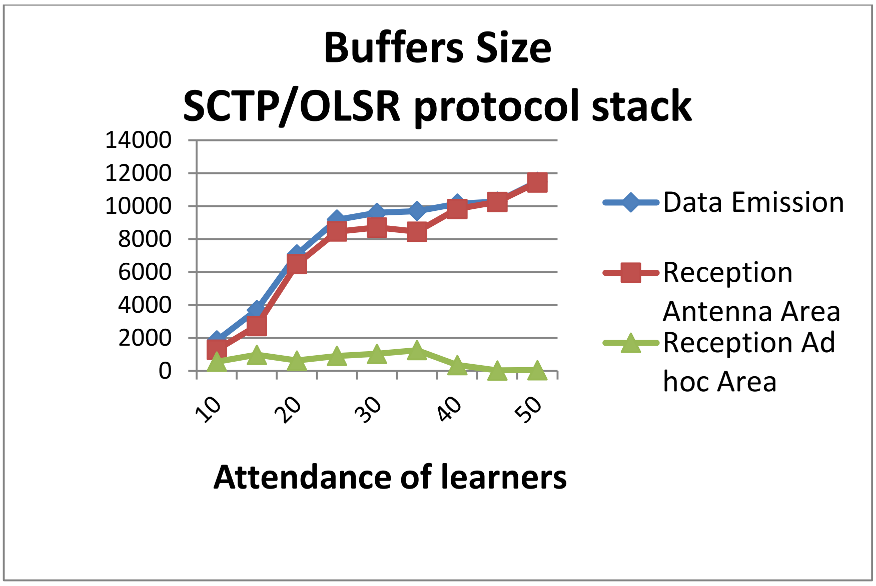

Figure 4: Ratio of attendance over buffer size of the SCPT/OLSR stack

Conclusion

In this paper, the architecture of the DOUNG is again tested by assessing the level of QoS parameters. Indeed, given the multiplicity of routing protocols, a new evaluation is run using the OLSR protocol at the network layer. In this new configuration, the nature of the standard algorithm is the criterion put forward in differentiating the behavior of the all studied protocols. The previous AODV is based on the distant vector algorithm while OLSR uses the link state. The weight of the optimization introduced by the OLSR was measured with its organization of the network into MPR nodes and with its regular activities.

Without yet leading to the cross-analyze step, the obtained results give the OLSR contribution. Therefore, by changing the influx of learners to measure the QoS parameters related to both the synchronization delay and the size of the buffer, it emerged that the OLSR protocol is negatively influenced by several identified factors.

Its adaptation to the case of large networks is also disadvantaged by the ceiling on the number of learners chosen in the present context of the simulations carried out. Even if this choice avoids a promiscuity of the nodes which is unsuitable for the necessary aeration of the network putting the routing protocols under the test of the path search, and even if the projection and the scaling lead a simulated node to represent several other nodes of the real case, the complementary work expected consists in significantly increasing the number of learners to evaluate the OLSR mechanisms of the management of these large networks. It is also useful to carry out a cross-analyze of these results with those of other routing protocols in a complementary work.

References

[1] I. G. Noura, M. I. Tiado, H. G. Souleymane, C. I. Hussein, H. M. Mahamadou, “Quality of Service Evaluation by Simulation in the classroom ad hoc network for the New Generation of Digital Open Universities (DOUNG)”, IJNCE-International Journal of Networking & Computer Engineering, July 2020

[2] M. Issoufou Tiado, H. Saliah-Hassane, "Cloud-Computing based architecture for the advent of a New Generation of Digital Open Universities in m-learning", ICEER13 Proceedings, pp 572-579, July 2013, www.labader.org

[3] I. G. Noura, M. I. Tiado, H. G. Souleymane, C. I. Hussein, H. M. Mahamadou, “Quality of Service evaluation by using Ad hoc on Demand Distant Vector (AODV) in the classroom ad hoc network of the New Generation of Digital Open Universities (NG-DOU)”, AWMC - Advances in Wireless and Mobile Communications, July 2020

[4] H. M.Tahir, A. Said, M. A. A. Seman, S. N. Shelena, M. S. Selan, S. H. Abdi, "PERFORMANCE COMPARISON OF SCTP AND UDP OVER MOBILE AD HOC NETWORKS", IJCSI International Journal of Computer Science Issues, Vol. 9, Issue 4, No 2, July 2012, ISSN (Online): 1694-0814, www.IJCSI.org

[5] K. M. Khabir, S. Siraj, A. Habib, T. Hossain, A. R. Ahad, "A Study on DSR Routing Protocol in Adhoc Network for Daily Activities of Elderly Living", 7th International Conference on Informatics, Electronics & Vision, 2018, Fukuoka, Japan

[6] M. A. Zant, A. Yasin, "Avoiding and Isolating Flooding Attack by Enhancing AODV MANET Protocol (AIF_AODV)", Hindawi, Security and Communication Networks, Volume 2019, Article ID 8249108, March 2019, https://doi.org/10.1155/2019/8249108

[7] P. Kumar, S. Verma, "Implementation of modified OLSR protocol in AANETs for UDP and TCP environment", Journal of King Saud University – Computer and Information Sciences journal homepage: www. sciencedirect.com, July 2019

[8] O. Barki, Z. Guennoun, A. Addaim, "Improving the selection of MPRs in OLSR protocol: a survey of methods and techniques", International Journal of

Electrical and Computer Engineering (IJECE), Vol. 10, No. 1 , February 2020, pp. 288~295, ISSN: 2088-8708, DOI: 10.11591/ijece.v10i1 .pp288-295, http://ijece.iaescore.com/index.php/IJECE

[9] Alamsyah, K. E. Purnama, E. Setijadil, M. H. Purnomo, “MPR selection to the OLSR quality of service in MANET using minmax algorithm”, International Journal of Electrical and Computer Engineering (IJECE), Vol. 9, No. 1, Feb 2019, pp. 417~425, ISSN: 2088-8708

[10] I. G. Noura, M. I. Tiado, H. M. Mahamadou, “Communicating vessels model for the Intelligent Monitoring System of the service guarantee in the New Generation of Digital Open Universities”, AWMC - Advances in Wireless and Mobile Communications, Mars 2020