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Searching a Quality of Service (QoS) routing protocol adapted to the ad hoc classroom network of the New Generation of Digital Open Universities (DOUNG)

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Abstract

To extend the DOUNG [1][2] capacities, its network have been improved by including a Wi-Fi extension which leads to an ad hoc area. In this perspective, recent works highlights the Quality of Service (QoS) gains obtained from the ad hoc network by diversifying the routing protocols. A first contribution [3] shows the QoS level obtained by associating the SCTP (Stream Control Transport Protocol) at the transport layer and DSR (Dynamic Source Routing) at network layer. Then, the DSR is replaced by the AODV (Ad hoc On-Demand Distance Vector protocol) in [4], and by OLSR (Optimized Link State Routing) in [5]. This paper capitalizes the achievements of previous works in addition to new results obtained with DSDV (Destination Sequenced Distance-Vector). We carry out a comparative study of this range of protocols and determine the most suitable for the context of the DOUNG.

Keywords: Distance learning, DOUNG, ad hoc classroom networks, QoS, DSR, AODV, OLSR, DSDV

1. INTRODUCTION

The multiplication of learner's devices offers a real opportunity for DOUNG to considerably extend the architecture of its network while respecting the requirements of QoS for real time traffic. The new architecture extends the network with a Wi-Fi antenna to which is federated an ad hoc network. It is a freely associating of nodes which needs to consider its stable nature even if each mobile node is keeping its freedom of communication, autonomy, independence of movement and participation in routing information. Among many parameters of this architecture, it was necessary to resolve the problem of choosing a routing protocol adapted to this context and which guarantees a better level of QoS.

Many routing protocols are available and need to conduct a comparative study according to the QoS level in the context of real-time traffic. The previous results of DSR, AODV and OLSR are capitalized in this paper by adding the DSDV. Therefore, after a reminder on the classroom wireless network, the QoS problem is raised by highlighting the synchronization time between teacher and learner and the amount of data available in buffers. To find the routing protocol adapted to the classroom, the DSDV is presented and the new scenario is evaluate by simulation with cross analysis of all the QoS parameter curves.

I. The classroom wireless network

In the extended DOUNG architecture, the classroom is made up of mobile devices with multimedia capabilities forming a coherent whole by spontaneous concentration of the learners. The first wireless network deriving from the Wi-Fi antenna is referenced as LAN1 and the second constituting the ad hoc zone is designated as LAN2. This last network offers a cost-free extension with a compromise related to the tolerable limits of the QoS parameters values which make possible to follow the course synchronously. It is to limit the proliferation of the costly Wi-Fi antennas in terms of deployment. The state of degradation of the desired level of QoS parameters therefore remains the main objective to be assessed. This leads to the idea of carrying out a comparative study of DSR, AODV, OLSR and DSDV to measure their difference in QoS gains. Indeed, many recent works [6] have been conduct for the cross analyze of some parameters of these protocols, given them a particular research interest.

II. The nature of communication despite the diversity of devices

The Communication between learner devices is made possible by the standard application environment of the DOUNG despite their architectural difference and their mode of operation. Indeed, this environment involves standard applications classified in five (5) categories in document [1]. The category 1 is composed of the course production applications in the multimedia format for the recorded audio/video streams. It covers word processing applications, spreadsheets, pdf file generators. The Category 2 is for applications that make the course available whose standard web server has been preferred to transcend the hardware and software differences of the devices. The use of a browser and adequate protocols allows any device to connect and retrieve hypertext and multimedia information. The web server offers the advantage of its multifunctional character with the service of web pages, the access to multimedia content, the downloading by the means of ftp, the archives researching and so on. Category 3 is for retrieving teaching applications by the learners. It includes web clients and browsers also constituting the category 4 grouping together the tools for viewing the courses by the learner. Finally, category 5 is for dialogue between teacher and learners

III. QoS problem in the wireless network

Many parameters highlighted in document [2] allow to measure the level of QoS required in the DOUNG operation. To use the comparative approach of routing solutions such as that carried out in documents [3] and [4], we consider the same criteria and the same parameters as well as the network architecture subdivided into two contiguous areas. Indeed, apart from the optimization of resources, the additional gain expected in this ad hoc extension is to encourage a large influx of learners for synchronous course access. This gain can only be obtained if the QoS parameters continue to display tolerable values when the learners are crowded. For this, we assess (1) the synchronization delay between teacher and learner and (2) the amount of data available in the buffers for avoiding an interruption to occur during the real-time traffic. With the achievements of previous works and the results of DSDV, it is then possible to carry out at least two crossings by first considering the criterion of their proactive and reactive nature. In this case, DSR and AODV constitute the reactive group crossed with OLSR and DSDV for the proactive group. It is also possible to classify the protocols according to the criterion of their routing algorithm with on one side AODV and DSDV based on the distant vector and on the other side, OLSR in the category of link state algorithm.

III.1. The synchronization delay between teacher and learner

When using DSDV, we measure the level its contribution on the synchronization delay defined as the shift of the time between two important instants. On one side, ST_s is the instant at which the camera multimedia stream enters into the buffer of the DOUNG server SB (Server Buffer). On the other side, the instant ST_{vi} ($i = 1, 2$) is the time at which the same flow reaches a learner of a given area. ST_{v1} with $i = 1$ is that of the antenna and ST_{v2} with $i = 2$ is that of the ad hoc network. We consider the two additional parameters DG_1 and DG_2 indicating the overall delays in the acquisition of multimedia streams respectively for the antenna and the ad hoc areas. All are calculated by considering T_δ the transfer time of δ bits which are required by the learner applications before starting the video. Specifically, the DG_2 and ST_{v2} parameters allow the DOUNG to set the S_{DOUNG} tolerance threshold. It is a limit that a less value indicates the degradation which compromises the real time service. To achieve this goal, we consider the parameter TTL_{max} indicating the maximum lifetime of a multimedia stream in the buffer SB. The relations between these parameters are set as follow:

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

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

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

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

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

III.2. Amount of data available in the buffer zones

The comparative approach of the QoS results is conduct by considering the parameters Q_s, Q_{r1} and Q_{r2} indicating the quantity of data available in the SB and CB (Client Buffer) according to the learners area. With DSDV at the network layer, we determine the new contribution expected on these parameters. Specifically, Q_s indicates the amount of data available in the SB at the given time CT (Current Time), Q_{r1} indicates that of the CB of the LAN1 learner and Q_{r2} for the LAN2 learner. For the formulas of calculating these parameters, two basic information are considered. These are T_v the frame rate of the camera and TTL_{max} the maximum duration of a multimedia stream in the SB buffer. Formulas are as follows:

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

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

The inequality (7) indicates that Q_{r2} is the determining parameter for measuring the QoS level of the overall system. In other words, if the amount of information available in the ad hoc learners' buffer is great, less is the risk of disruption of the synchronization for following the course alive. The three parameters of equation (7) are again measured in this paper under the influence of two conditions. The first condition is that of the increasing number of learner's mobile devices. The second condition is linked to the use of the DSDV routing protocol which differs from the other protocols already evaluated.

IV. Overview of DSDV protocol

The DSDV [7][8][9] protocol operates by using the classic Bellman-Ford routing algorithm and is applied in our case to the routing of information in the classroom ad hoc network. Any learner device that implements the DSDV maintains a routing table containing all the classroom reachable destinations. In its operation, a DSDV node periodically transmits its routing table to its neighbors. This transmission also takes place when the network topology changes significantly. However in the LAN2, the expected behavior leads to a relative stability of the network, thus greatly limiting the exchanges of the routing tables due to changes in the topology. A gain of QoS is therefore expected through the avoidance of this activity which generates additional traffic especially in the case of the use of the "full-dump". It is strongly expected that the node will be limited to the use of the incremental update. Indeed in the case of the "full-dump", a DSDV node sends to all of its immediate neighbors its full routing table. In contrast, the "incremental" option only allows it to transmit the entries whose sequence numbers have been changed. This last residual activity expected to be more frequent due to the stability of LAN2 therefore avoids great additional traffic disruptive to the delivery of the real time video stream. Generally, the great mobility of the nodes generates frequent topology changes leading the DSDV protocol to resort to "full-dump" repeatedly. Another favorable mechanism concerns the limit which imposes the delay of the transmission of the routing table entries to avoid updates when better routes are discovered very early.

V. Evaluation of QoS parameters by simulation

V.1. Description of scenarios

The protocol stack uses SCTP at the transport layer with 1500 bytes of segments size. IP and DSDV are at the network layer and the IEEE 802.11 protocol is deployed at the lower layers. The environment is provided by ns-2. In the scenario, a CBR traffic source represents the Wi-Fi antenna which sends a data stream towards the nodes in the LAN1 and LAN2. For this traffic, the inter-arrival time of messages during peaks is fixed at 0.1 seconds. We evaluate the QoS gains of the DSDV protocol through the parameters ST_{v1}, ST_{v2}, Q_s, Q_{r1} and Q_{r2}. ST_{v1} helps to determine the synchronization evolution of the LAN1 learner. Likewise, ST_{v2} is assessed for the LAN2 learner. The parameters Q_s, Q_{r1} and Q_{r2} are evaluated as main indicators of the amount of information available at a given time CT in the buffers. The contribution of the DSDV protocol is measured trough its ability to support the evolution of the number of learners in the LAN2 while allowing the system to maintain the conditions for achieving a good QoS at a value greater than or equal to the S_{DOUNG} threshold.

V.2. Basis for interpretation of results

After the simulations, we produce curves presenting on the horizontal axis, the values 10, 15, 20, 25, 30, 35, 40, 45 and 50 giving the evolution of the number of nodes placed randomly in the LAN1 and LAN2. The obtained trace files allow to calculate the average values of each QoS parameter and to draw the curves before analyzing and explaining the results. A fairly slow movement of nodes is set with 25 ms of the break time. The area is partitioned with 1/3 (antenna) and 2/3 (ad hoc) of the 1500 x 300 size of the simulation surface. The position of the Wi-Fi antenna is fixed on the middle of the left border. By performing 150 seconds of the simulation, each node adopts the same movement speed between [1m/s, 10m/s] with the RWP (Random Way Point) model.

V.3. Cross analysis of attendance curves/synchronization delay

In this paper, we are crossing the previous results obtained from the DSR, AODV and OLSR protocols with the DSDV results. Firstly, the SCTP/DSDV stack results are used to explain the obtained contribution. The QoS parameters studied always remain the synchronization delay and the size of the buffer when the ad hoc network is subject to an increasing learner attendance. The stability of the classroom network stills being a favorable factor allowing the consolidation of intuitive results and mathematical models. The DSDV curve below shows the evolution of the average time of the learner synchronization from LAN1 and LAN2. If the DG_1 parameter of LAN1 is always on the abscissa axis and displays an immediate synchronization due to the proximity of the wireless antenna, the evolution of the LAN2 parameter is different. Indeed, this parameter undergoes an oscillation between the limits from 10 to 40 before having a significant evolution in the remaining part. As in the case of the AODV protocol also based on the same distant vector algorithm, the peaks observed reflect the resumption of periodic activities. They greatly handicap the use of the bandwidth for the benefit of the multimedia flow and therefore lead to an extension of the synchronization period. The moments of decline in these activities remain more favorable by allowing the curve of LAN2 to approach that of LAN1. Thus, the use of periodic activities for the creation or updating of routing tables is added to the step-by-step propagation in the network and constitute the main factors unfavorable to the synchronization of LAN2 learners.

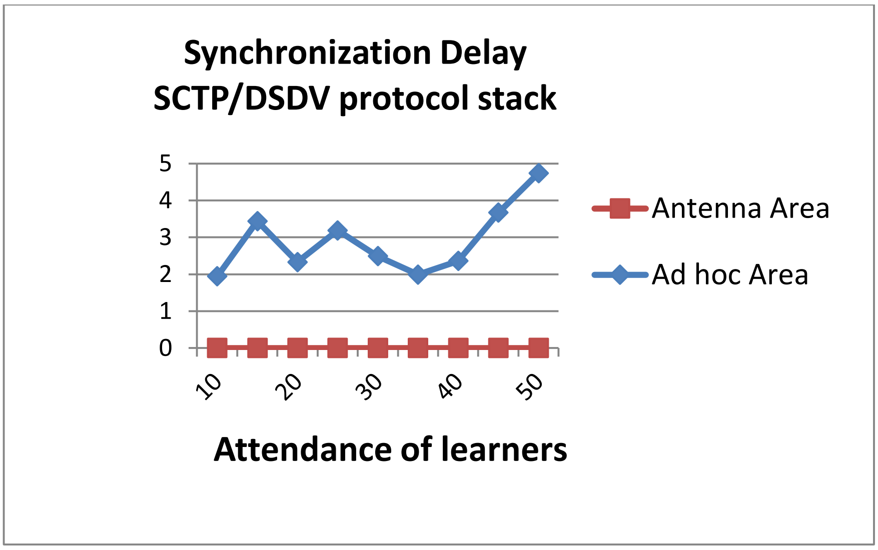

Figure 2: Ratio of attendance over synchronization delay of the SCPT/ DSDV stack

The crossing of the results obtained in the cases of the various protocols studied is carried out through the figure below. These include QoS gains obtained with DSR, AODV, OLSR and DSDV protocols used in turn in the classroom ad hoc network. For each case, the synchronization period was evaluated here based on the increasing attendance of learners. Thus, the four curves give a clearer indication of each contribution level. It emerges from this comparative study that the DSR protocol gives more satisfactory results close to the abscissa axis. It is followed by AODV, then OLSR and finally DSDV. If around the attendance point of 50 the DSR experiences an evolution and AODV a decrease which means that the two curves almost meet, the difference between these two protocols is clearly marked by the previous values. The explanation holds periodic activities which disadvantage AODV based on the distant vector algorithm with its exchanges between adjacent routers while DSR is favored by the absence of these bandwidth consuming and blocking activities. Between 10 and 15, AODV and OLSR initiate a start with almost identical values. However with the evolution of the affluence, OLSR subjected to the constraint of the network organization knows an evolution which dissociates the two curves for the remaining values. The explanation is mainly due to the weight of the periodic activities carried out by the two protocols with a high weight in the consumption of resources for OLSR and a lower weight for AODV. This same parameter demonstrates the level of the distance from DSDV where the non-optimized diffusion unlike the OLSR leads to the extension of the delays. They are having significantly higher levels apart from the weakening of the curve for the attendance of 35. We note the proximity of the two curves for attendance of 30 and 40. These results bring to the election of the DSR protocol in the studied configuration of the DOUNG classroom for its absence of periodic activity unfavorable to the synchronization of the learners and for its efficiency in exploiting the stability of the network in order to convey the multimedia data.

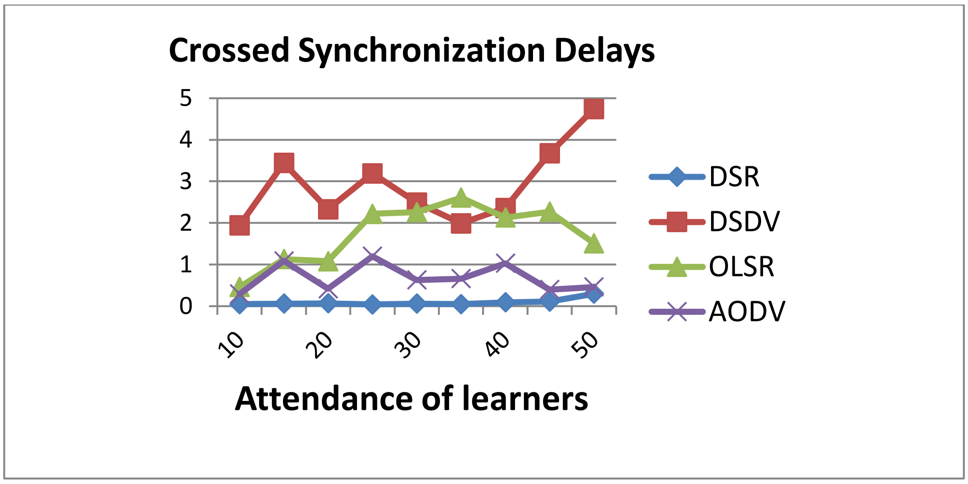

Figure 3: Crossing of the curves of attendance over synchronization delay

V.4. Cross analysis of the influx/size curves of the buffer zones

For this ratio, DSDV results are firstly presented in the curves of the figure below before performing the cross-analyze. Simulations confirm the mathematical models and the intuitive approach. We set the value of TTL_{max} at 10 ms and calculate the average values of Q_s, Q_{r1} and Q_{r2}. In the figure below, the curves of the first two parameters evolve with the same amount of information outside the point of attendance 40 which causes their slight difference. This derives from the proximity of the two areas where the transmission is immediate thus facilitating the real time traffic. Unlike and as in other cases, the evolution of LAN2 buffer curve remains weak even if it experienced a timid growth over the attendance evolution. The size remained below 2000 until attendance of 40, which weakens the multimedia traffic constraining in time and size of data to be transferred. The shape of the LAN2 curve is explained by the functioning of the DSDV and the impact of propagation through the network that cause delays in data transmission. Whether it is a "full-dump" or the "incremental" option, the DSDV carries out periodic activities to update the routing tables and these activities have the effect of network time and resources consumption, blocking the progression of high traffic. These activities keep certain regularity by avoiding the oscillations which translate instants of starting and stopping the overhead production.

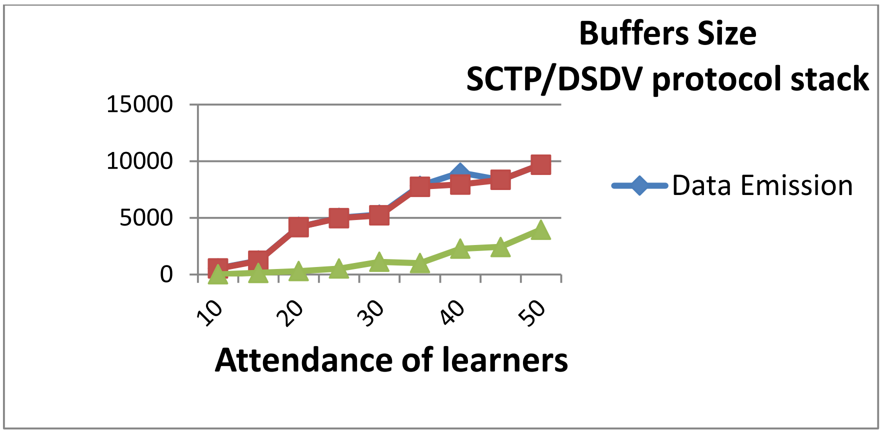

Figure 4: Ratio of attendance over buffer size of the SCPT/ DSDV stack

Since the values of the buffers are different following the amount of traffic that is not the same from one simulation to another, we convert all the results using the percentage of data transferred by each protocol according to the amount of data issued by the CBR source. This helps to determine the effectiveness of DSR, AODV, OLSR and DSDV. Their results are crossed when producing the curves in the figure below showing the QoS gains obtained for the buffers size of the classroom ad hoc network. For each case, the Q_{r2} parameter is evaluated as a function of the increasing attendance of learners. It emerges from this comparative study that the DSR protocol offers better buffer sizes as a percentage of the data transmitted, which potentially favors the option of synchronous course monitoring by learners. The other protocols present mixed results with the ad hoc network buffers oscillating below 40% of the proximity rate of that of the DOUNG server. The only initial point with an influx of 10 is unfavorable to DSR, which has a rate less than 20%, while OLSR and AODV go up to 30%. This is explained for the DSR by the absence of path in an overly ventilated network leading to the failure of the route discoveries for destinations out of range of the neighbors radio signal. Despite this starting point where the DSDV rate remained low, the trend in attendance is unfavorable to OLSR while the AODV and DSDV curves overlap with a few small variations. They hover around the 40%

mark while the DSR protocol offers a rate of 80%.

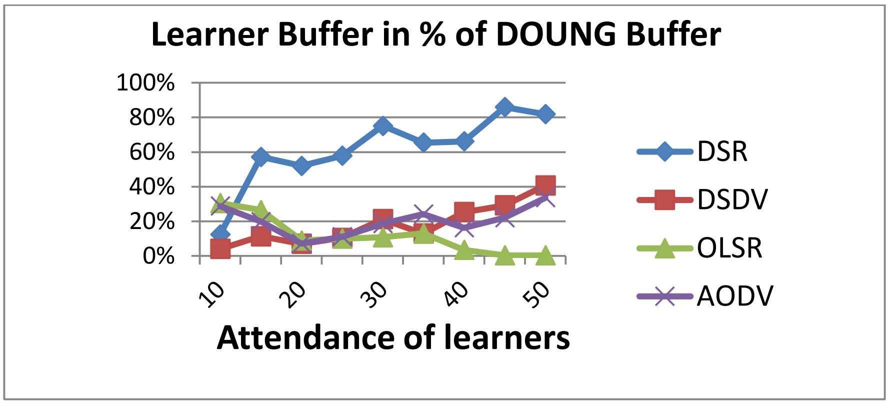

Figure 5: Crossing of the curves of attendance over buffer size

VI. Evolving the lecture delivery technique

Among the lessons to be drawn, there is the method to be used in distance education to resolve the problem of data loss. As this loss is frequent in the ad hoc network, it is therefore necessary to avoid a degradation of the transmission that compromises the understanding of the teacher's message. The resolution of this problem requires considering the nature of the flow of data transmitted. Indeed, more than the video itself, two key elements are most important for understanding the message. This is the teacher's explanatory voice and the entire contents of the blackboard fully displayed. From this consideration, the main recommendation is to transmit the image of the blackboard serving as support in a model of display for a good period. For example, the rate of one minute of display is suggested. Since this content remains static for this duration, its successful prior transmission allows to fill the holes linked to the loss of some voice sequences. In this case, its content allows the learner to compensate the lost message. By simple projection for the case of a minute of the blackboard display, with 40% for AODV and DSDV, 24 seconds of the voice out of 60 may be available and 100% of the content of the blackboard while the DSR offers in the same case, 48 seconds of the voice on 60 and 100% of the content of the blackboard. The quality of the content of the blackboard therefore becomes a determining factor for the success of using the ad hoc network in the DOUNG classroom and for facilitating the understanding of the teacher's message.

Conclusion

The contribution of this paper lies in several areas in the logic of finding the most suitable routing protocol in terms of QoS in the context of the DOUNG. In this study as in the previous, the first parameter considered concerns the synchronization delay as a function of the increasing learner attendance. The second parameter concerns the evolution of the size of the buffers according to the same presence of the learners.

The DSDV protocol was studied as the fourth alternative after DSR, AODV and OLSR. It uses the distant vector as AODV and unlike OLSR based on the link state. Conversely, it belongs to the category of proactive protocols like OLSR and unlike AODV which is reactive. It again consolidates the achievements of the previous cases, confirming the intuitive approach and the mathematical models. Through the comparative study and the crossing of all the results, this paper highlights the adapted nature of the DSR in the context of the DOUNG for the best values of the two studied QoS parameters that it provides. However, given that the ad hoc part of the classroom network experiences information loss which avoids reaching the 100% threshold for all parameters, a solution to data loss in this network is proposed to avoid compromising the understanding of the teacher's message. The reinforcement of these results with greater learner influx is a perspective of the present work.

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