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Solar Thermoelectric based Portable Refrigerator

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ABSTRACT: Vehicular Network uses moving vehicles as nodes and forms a network. Each vehicle acts as a wireless router and may exchange data between them. Sometimes there is need for downloading a large file. Previously, all vehicles downloaded the files from the access points. Download seems to be continued even if the vehicle is moving by using multihop forwarding. This resulted in low data rate. To speed up the download and increase the data rate cooperative download was introduced. It follows carry & forward mechanism. Here the file to be downloaded is divided into chunks and are transmitted to multiple vehicles (carry). Then the vehicles transmit those packets to the destination vehicle (forward) during their travel. The vehicles operate cooperatively and download the file with high data rate without the involvement of access point during the whole transmission. Suppose there is packet losing due to collision, the vehicle will send request to the AP regarding the retransmission of the packet. During retransmission, if the vehicle goes out of coverage area of AP, then again the packet loses and retransmissions need to be done again and again. DC-ARQ (Delayed Cooperative ARQ) is introduced for minimizing the number of retransmissions and obtaining the lost packet. Here a group of vehicles are selected as DC-ARQ cooperators based on the hello protocol. When the vehicle goes out of coverage area and needs the lost packet, they will get the packets from the DC-ARQ coordinator thus reducing the number of retransmissions.

KEYWORDS: Vehicular networks, cooperative own loading, delay to lerant networking, carry & forward transmission.

I. INTRODUCTION

Vehicle traveling within cities and along highways are regarded as most probable candidates for a complete integration into mobile networks of the next generation. Vehicle-to-infrastructure and vehicle-to-vehicle communication could indeed foster a number of new applications of notable interest and critical importance, ranging from danger warning to traffic congestion avoidance. It is, however, easy to foresee that the availability of on board communication capabilities will also determine a significant increase in the number of mobile users regularly employing business and infotainment applications during their displacements. As a matter of fact, equipping vehicles with WiMAX/LTE and/or WiFi capabilities would represent a clear invitation for passengers on cars or buses to behave exactly as home-based network users. The phenomenon would thus affect not only lightweight services such as web browsing or e-mailing, but also resource-intensive ones such as streaming or file sharing.

In the paper,focusis on one of the latter tasks, namelythe download of large-sized files from the Internet. More precisely, we consider a urban scenario, where users aboardcars can exploit roadside Access Points (APs) to access the servers that host the desired contents. We consider that the coverage provided by the roadside APs is intermittent: thisis often the case, since, in presence of large urban, suburban,and rural areas, a pervasive deployment of APs dedicatedto vehicular access is often impractical, for economic and technical reasons. We also assume that not all on-boardusers download large files all the time indeed, one canexpect a behavior similar to that observed in wirednetworks, where the portion of queries for large contentsis small . As a result, only a minor percentage of APs issimultaneously involved in direct data transfers to downloadercars in their respective coverage area, and themajority of APs is instead idle.Within such a context, we study how opportunisticvehicle-to-vehicle communication can complement theinfrastructure-based connectivity, so to speed up the downloadprocess. We exploit the APs inactivity periods totransmit, to cars within range of idle APs, pieces of the databeing currently downloaded by other vehicles. Cars thatobtain information chunks this way can then transport thedata in a carry&forwardfashion and deliver it to thedestination vehicle, exploiting opportunistic contacts with it,as in Fig. 1. We remark that the concept of cooperativedownload in vehicular networks has been already proposedfor highway environments: however, unlike what happensover unidimensional highways, urban/suburban roadtopologies present multiple route choices that make it hard to predict if vehicles will meet; moreover, the presence of traffic lights, stop and yield signs renders cars contact timings very variable. The set of IEEE 1609 standards have been developed to enhance IEEE 802.11 standards for supporting wireless communication both between vehicles (V2V) and between vehicles and the roadside infrastructure (V2I). These are also commonly known as dedicated short range communications (DSRC) schemes. In particular IEEE 1609.2 addresses security within WAVE communications. The standard dictates that confidentiality, authenticity, and integrity must be provided within WAVE communications.

II.COOPERATIVE DOWNLOAD

Let us first point out which are the major challenges in the realization of a vehicular cooperative download systemwithin complex urban road environments. With reference to the transfer model proposed in the twomain problems:

Selection of the carrier(s):
contacts between cars inurban/suburban environments are not easily predictable.Idle APs cannot randomly or inaccurately select vehicles to carry data chunks, or the latter risks to be never delivered to their destinations. Choosing the right carrier (s) for the right downloader vehicle.

Scheduling of the data chunks:
determining which parts of the content should be assigned to one ormultiple carriers, and choosing in particular thelevelof redundancy in this assignment, plays a major rolein reducing the probability that destination vehicles never receive portions of their files.The selection of carriersat the APs, proposing to leverage historical informationon large-scale traffic flows to drive datatransfers decisions.

2.1 Carriers Selection

The first problem we address is thatthe selection of data chunk carriers at APs that are idle, i.e., that are currently not transferring data directly to vehicular downloaders. As previously discussed, these APs can opt to employ their spare airtime to delegate, to mobile users within range, portions of files being downloaded. Taking such a decision means to answer to two questions:

1) which, among the vehicles in range of an idle AP, should be picked as carriers and
2) which of the downloaders should these carriers transport data .

The key to the answers is to know in advance whether (and possibly when) one or more cars currently within coverage of an AP will meet a specific downloader vehicle,so to perform the selection that maximizes the download rate. Also, by choosing carriers depending on their future contacts, the destination of the data becomes constrained to the elected carriers, and the second question above is inherently solved along with the first one. However,assuming that the roadside infrastructure has perfect knowledge of the future route of each user is unrealistic, other than raising privacy issues. At the same time, the movement of individual vehicles over urban road topologies cannot be easily predicted as in unidimensionalhighways.We then adopt a probabilistic approach, by leveraging the fact that large-scale urban vehicular flows tend to follow common movement patterns. More precisely, the solution we propose leverages contacts maps, that are built by exploiting historical data on contacts between car flows, and then used to estimate the meeting probabilitybetween downloaders and candidate data carriers.

2.2 Chunk Scheduling

The selection of a destination for the carry&forwardtransfer, jointly with the associated local carriers, an AP must decide on which portion of the data the downloader is interested in is to be transferred to the carriers. At last,we assume that each content is divided into chunks, i.e.small portions of data that can be transferred as a single block from the AP to the carriers, and then from the latter to the destination. Since a same chunk can be transferred by one or multiple APs to one or more carriers, the chunk scheduling problem yields a trade-off between the reliability(i.e., the probability that a downloader will receive at least one copy of a chunk) and the redundancy (i.e., how many copies of a same chunk are carried around the road topology) of the data transfer.

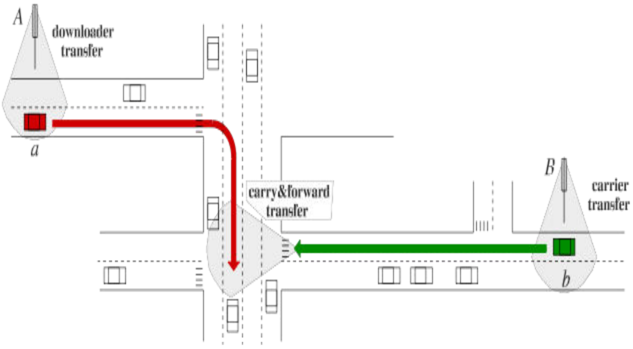

Fig. 1. Vehicle a downloads part of some content from AP A. The idle APB delegates another portion of the same content to a vehicle b. When bencounters a, vehicle-to-vehicle communication is employed to transfer to a the data carried by b.

III. PROPOSED STRATEGY

3.1 Vanet scenario

The suitable mechanisms for detecting in-rangeAP,association and authentication of vehicles reaching agiven AP must be provided. Those mechanisms can have a major importance on the overall performance, but are not specific of the use or not ofcooperation,and thus we leave them out of the scope of this paper.It can be assumed, for example that vehicles are equipped with WAVE (Wireless Access in Vehicular Environments) IEEE 802.11p cards. WAVE architecture provides mechanisms to access WAVE Base Stations (APs) in vehicular networks.

On the current implementation of the prototype used for the testbed we use 802.11 technology, we have not considered security issues and the association with the AP has been made very simple, the AP is continually transmitting numbered packets addressed to each car in the experiment and a vehicular node is considered associated with the AP in the moment it receives a packet from the AP (it enters into the coverage area).

Nodes are operating in this phase while they are onthe coverage area of the AP. During this phase, nodes will request the information blocks to be downloaded and the AP will transmit them to the vehicular nodes. In our prototype, the exact request mechanism is not implemented, and this phase starts with the reception of the first packet from the AP and finishes when no packets have

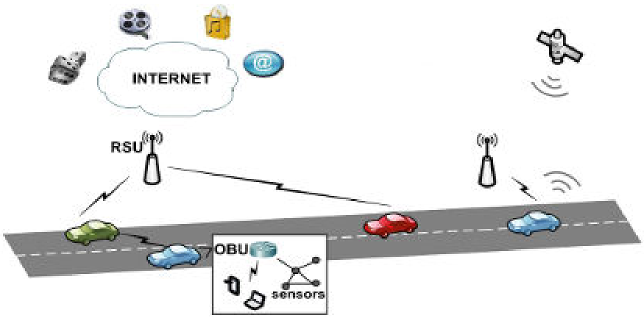

Fig:2 System architecture of vanet

been received for a given time period.While in this phase, vehicular nodes receive datafrom the AP. Each car receives its data but also buffersthe packets addressed to other cars in the platoon that consider it as cooperator.

3.2 Vehicular Cooperation

The cooperation relationshipis established through the exchange of HELLO messages broadcasted periodically by the vehicular nodes. The first function of a HELLO message sent by a node x is to allow other nodes to know about the presence of x. Other vehicular node y in the platoon will add x to its list of cooperators (if x is not already a cooperator of y) when receiving this HELLO message. The second function of a HELLO message sent by a node x is to notify other nodes about the fact that they have to act as cooperators of x. For this second function, each HELLO message contains the list of cooperators of the sending node. In our example, thenext HELLO message sent by y will contain x in the list of cooperators. In this way, x will be aware of the fact that y considers it as cooperator and will act accordingly (buffering packets addressed to y for a later possible cooperation). The list of co-operators contained in the HELLO messages also indicates the order in which cooperators should act in the Cooperative-ARQ phase: this is to avoid collisions; when a node requests a packet to its cooperators, each cooperator will wait a fixed back-off depending on this assigned order, before sending the packet. Note that we do not focus on the cooperators selection algorithm, so this is left out of the scope of this document. In our work, only one hop neighboring nodes can be selected as cooperators, although other schemes can be envisioned.

In the considered scenario, data flow is always from the AP to the vehicular nodes, and no retransmissions are used. We avoid retransmissions at the hope that other cars in the platoon (i.e. cooperators) will receive packets incorrectly received by the destination and will help it in the Cooperative-ARQ phase, without the need of wasting the useful time in coverage with theAP in retransmissions. In this way the channel can be used by the AP to transmit as much new data addressed to the cars as possible, thus reducing the downloading time and increasing the effective data rate. Of course, a retransmission scheme (possibly adaptive with respect to the number of cooperators) would be needed in a real system, but the study of that is left for future work.

3.3 Cooperative-ARQ

When the cars leave the AP range, they enter intothe Cooperative-ARQ phase. In our prototype this phase starts when the timeout from the last received packet from the AP expires (5 seconds in the current implementation). At this point, every node checks which packets it has failed to receive correctly from the AP and starts to request them to other vehicular nodes (i.e. to its cooperators), in an attempt to recover all packets from the first to the last received from the AP. The process is the following:

(i) A node x broadcasts a REQUEST packet for each packet that is has failed to receive from the AP.
(ii) When receiving this REQUEST, each cooperator of x will check if it has the requested packet buffered (it has received the packet correctly from the AP in the previous phase).
(iii) If it has the packet, it will wait a fixed time depending on the order of cooperation assigned by x through the

HELLO messages as explained on previous subsection, and will send the packet to x (unless other co-operator sends it before).

This process will be repeated for each missing packet. When the final of the list of missing packets is reached, the vehicular node will start again from the beginning of the actualized (shorter) list of missing packets. A node stops to issue requests of missing packets when it has recovered all of them or when it enters in range of a new AP, meaning that it comes into reception mode (Reception phase of the protocol operation), and the whole cycle starts again.Note that the operation in this phase can be optimized in many aspects. For example, one optimization that arises directly is to include in the REQUEST messages all the missing packets, instead of sending a REQUEST for each one. In this way,although it could have some similarities, the cooperation would not behave as epidemic routing in which nodes carry and forward packets for other nodes. Cooperative-ARQ objective is to improve performance given that the neighborhood of a node has received packets directed to that node.

IV. EXPERIMENTAL SETTINGS

A performance evaluation of the proposedmechanism has been performed using a real implementation. The tests were performed in the urbanscenario depicted in Figure 3. The AP was located in the position marked as AP in Figure 3 and consisted in a desktop PC equipped with a Proxim external PCI wireless antenna located in an office in the first floor of the building. The antenna was located on the window of this office.

Figure 3. Map of the testbed

On the other hand, three mobile vehicular nodeswere used, consisting of three laptops (Toshiba Satellite Pro A120 model) equipped with Cisco Aironet AIR-CB21AG-E-K9 802.11a/b/g PCMCIA wireless adapters, each of them transported by a car.

The three cars followed the path marked with the whitearrows in Figure 3 all together at an average speed of about 20 Km/h. for a total number of 30 rounds. Wehave named them as Car 1 (the first), Car 2 (the car inthe middle) and Car 3 (the last).

The implementation of the mechanism was doneusing Click Modular Router and all the cards werecontrolled by a MadWiFi driver in monitor modeand with retransmissions disabled. All transmissions(i.e. AP to Car, Car to Car) were performed using802.11g at 1Mbps.

The AP transmitted three different data flowsaddressed to each car on the experiment consisting of 5ICMP Echo Request messages per second with anICMP payload of 1000 bytes, each one. During theexperiments we captured all the received traffic oneach laptop for its analysis and post-processing toobtain the results exposed in next section.

We have performed the tests on an urban scenariofor its easiness of deployment in contrast to a highwayscenario. Of course, losses will be lesser than thereported in because of the speed of vehicular nodesand the lower data rate we employ for the tests.However, this simple scenario allows us to show howcooperative techniques and more precisely,Cooperative ARQ can help on the improvement ofthese kinds of networks.

V. EXPERIMENTAL RESULTS

Firstly, we present in Table 1 the average values onpacket losses obtained along the 30 rounds performedon the experiment. Together with the mean absolutevalues, we show the percentages of losses without andwith the cooperative ARQ mechanism.

Table 1. Average values on the number of packets received and lost in the three cars.

Car		Txby the AP	Lost before coop.	Lost after coop.
1	Mean	130.4	30.5 (23.4%)	13.7 (10.5%)
	Std.Dev.	17.7	12.9	9.1
2	Mean	143.0	38.4 (26.9%)	24.8 (17.3%)
	Std.Dev.	18.6	12.4	11.8
3	Mean	121.4	34.7 (28.6%)	19.1 (15.7%)
	Std.Dev.	17.2	15.5	14.4

As can be seen in Table 1, all three cars present animprovement on the reliability on the link between the AP and themselves. Especially striking is the case of car 1, where a reduction of more than 50% in the number of lost packets is achieved. It seems strange that the poorer results are obtained for car 2. This fact,however, can be explained, as we will see, by the environment and by the different behavior of the three cars along the experiment (distances between them, etc.). In other tests, not shown here, car 2 normally achieved the best performance. This is a normal result as car 2 is the car located in the middle of the platoon and can benefit from the cooperation coming from car 1 on the first range of packets it should have received from the access point while entering the coverage area and from the cooperation of car 3 on the last packets that it should have received while leaving the coverage area.

Now that we have seen the mean values obtained on the experiment, let us focus into the details to explain them and study the probabilities of reception of packetson the different cars. In Figure 3 the probability of reception for the three different cars of packets addressed to car 1 is shown. Three different packet reception regions can be defined: Region I corresponds to car 1 being at the beginning of the AP coverage area while cars 2 and 3 are just entering it. Region II corresponds to the car 2 and/or car 3 on the coverage area together with car 1. In Region III, car 1 is leaving the coverage area while car 2 and/or 3 are still there.

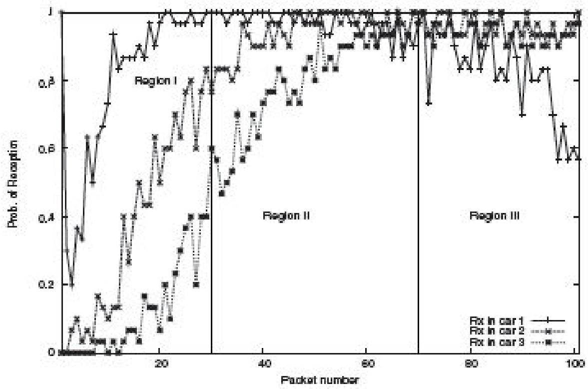

Figure 4. Probability of reception in packets addressed to car 1

Figure 4 depicts how, when car 1 is entering thecoverage area (Region I), its probability of reception ismuch better of that in car 2 and even better comparedwith that in car 3, which implies that car 1 will receivelittle cooperation from 2 and 3 for this range ofpackets. When car 1 starts to leave the coverage area(Region III), however, we can see how both car 2 andcar 3 have higher reception probability, suggesting thatcar 1 will benefit from cooperation for this range ofpackets. It is also important to note that, while onRegion I of the figure, car 2 and car 3 perform quitedifferent, on Region III their probabilities of receptionare almost the same. We argue that this is because ofthe behavior of the different drivers. The fact is that thedriver in car 2 was the least experienced, thus meaning that at corner marked as C on Figure 2, car 3 became very close to car 2 in almost all rounds, making their reception conditions on the street before the corner (after turning to the right on corner C) quite similar.

Figure 5 presents the same results but for car 2. We can observe on Region I of Figure 3 (first packets) that, as expected, car 1 has better reception conditions, so car 2 will benefit from cooperation coming from car 1.For the last packets (Region III of the figure) a better reception probability on car 3 was expected. However, due to the pattern on the cars’ movement explained before, this is not the case and the reception condition for car 2 and 3 are almost the same.

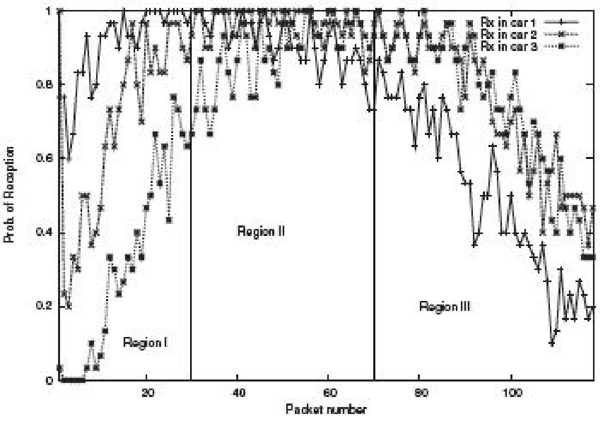

Figure 5. Probability of reception in packets addressed to car 2.

On Figure 6 we can observe how, when car 3 is entering into the coverage area (Region I), both cars 1 and 2 experience better packet reception probabilities, making them good cooperators. When car 3 is leavingthe coverage area (Region III), however, car 1 has very worst reception conditions as it is almost out of the coverage area.

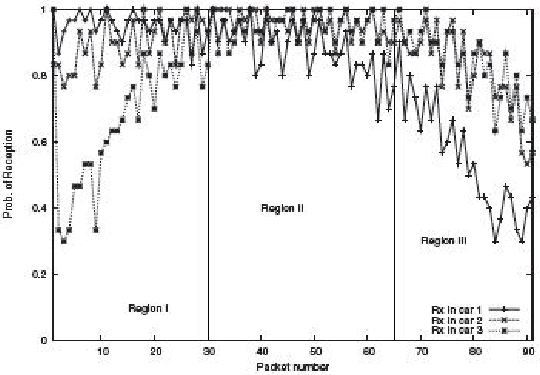

Figure 6. Probability of reception in packets addressed to car 3.

The next figures (Figures 7, 8 and 9) presentinteresting results taking a different approach. In themthe probability of correct reception using C-ARQ (i.e.after cooperation) is compared with the jointprobability of reception of the different packets in car1, 2 or 3 in order to establish if the C-ARQ mechanismimplemented and tested works properly and theeffectiveness of it. In all the figures, the two curves arealmost coincident indicating that the protocol worksalmost optimally in the sense that the destination car isable to recover all the packets that have been receivedin any of the cars in the platoon. Let us focus now onFigure 7 and analyze it in conjunction with Figure 4.As can be seen, the curve in Figure 6 for Region I hasthe same shape of the Rx in car 1 curve in Region I inFigure 4. This is because in this case all receivedpackets were received directly by car 1. In Region II,car 1 experiences very good reception conditions, so itwill not need cooperation for this range of packets. Forpackets between 60 and 100 (Region III), however, itcan be seen on Figure 3 how the probability ofreception in car 1 decreases greatly (it is leaving thecoverage area). But, thanks to C-ARQ, it is able torecover most of the packets helped by car 2 and 3: notethat the shape of Region III of Figure 7 is almostcoincident with the Rx in car 2 and Rx in car 3 curvesin Region III of Figure 4. Here is the key idea behindthe mechanism: it exploits the diversity that can beachieved thanks to the different cars on a platoon andperforms as well as a virtual car which uses the better reception conditions of all of them.

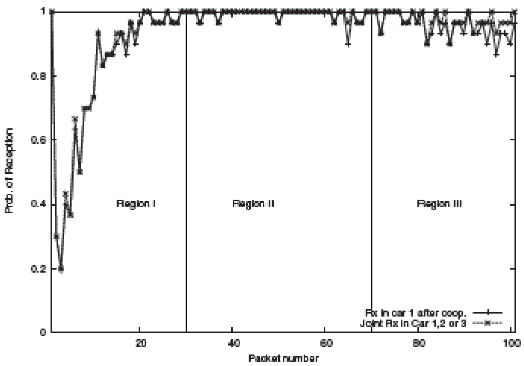

Figure 7. Probability of reception with C-ARQ in car 1.

A similar analysis can be done for Figure 8 and using Figure 5 for comparison purposes. We can see how the reception in car 2 after the cooperation phase in Figure 8 for Region I performs more or less like car 1 in Figure 5, which means that car 2 has benefit greatly from cooperation coming from car 1.

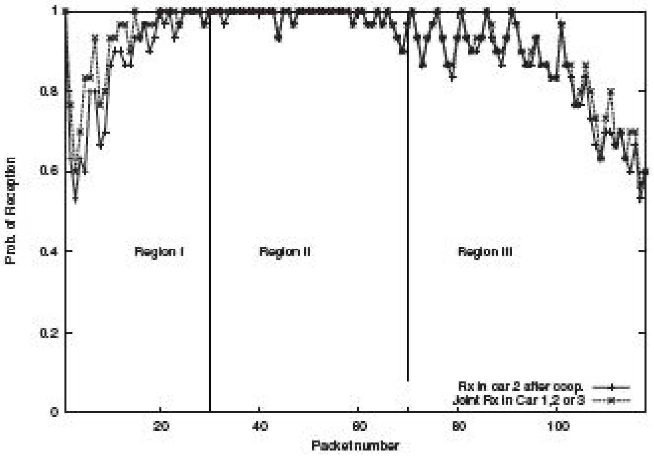

Figure 8. Probability of reception with C-ARQ in car 2.

On Figure 9 it can be seen how car 3 benefits from cooperation for the first 30 packets range. For the last packets, little cooperation can be used, as long as car 3 is the last car in leaving the coverage area.

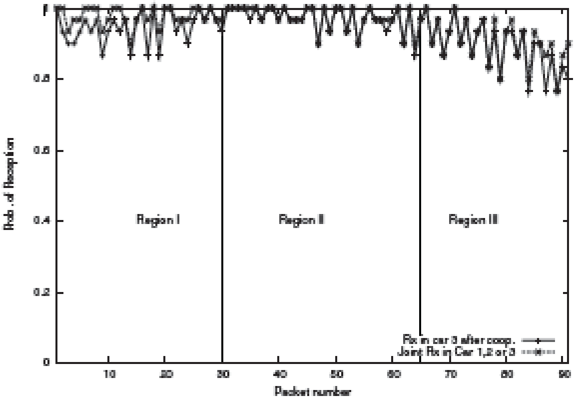

Figure 9. Probability of reception with C-ARQ in car 3.

VI. CONCLUSIONS AND FUTURE WORK

Thus the system is proposed to recover packet losses due to the harsh physical conditions and carry and forward mechanism is to improve throughput and total transfer delay DC-ARQ (Delayed Cooperative ARQ) is introduced for minimizing the number of retransmissions and obtaining the lost packet.

Many questions are left for future work and remain as open issues.Retransmissions schemes for these kinds of systems need also to be studied. Moreover, we have indicated how the way in which vehicular nodes request the lost packets to their cooperators can be optimized but the behavior of this approach needs to be studied. Even more important is to study how the presented loss reduction can reduce the number of APs that a vehicular node needs to visit to download a file or how it can allow to increment the bit rate used by the APs.

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REFERENCES

1. Annan, S. Das, G. Pau, M. Gerla, and M.Y. Sanadidi, “Co- Operative Downloading in Vehicular Ad-Hoc Wireless Networks,” Proc. Second Ann. Conf. Wireless Network Systems and Services (WONS ’05), Jan. 2005.
2. C.Nagarajan and M.Madheswaran - ‘Stability Analysis of Series Parallel Resonant Converter with Fuzzy Logic Controller Using State Space Techniques’- Taylor &Francis, Electric Power Components and Systems, Vol.39 (8), pp.780-793, May 2011. DOI: 10.1080/15325008.2010.541746
3. S.Thirunavukkarasu, C. Nagarajan, 2024, “Performance Investigation on OCF and SCF study in BLDC machine using FTANN Controller," Journal of Electrical Engineering And Technology, Volume 20, pages 2675–2688, (2025), doi.org/10.1007/s42835-024-02126-w
4. B.B. Chen and M.C. Chan, “MobTorrent: A Framework for Mobile Internet Access from Vehicles,” Proc. IEEE INFOCOM, Apr. 2009.
5. F. Malandrino, C. Casetti, C.-F. Chiasserini, and M. Fiore, “Content Downloading in Vehicular Networks: What Really Matters,” Proc. IEEE INFOCOM, Apr. 2011.
6. J. Zhao and G. Cao, “VADD: Vehicle-Assisted Data Delivery in Vehicular Ad Hoc Networks,” Proc. IEEE INFOCOM, Apr. 2006.
7. K. Fall, “A Delay-Tolerant Network Architecture for Challenged Internets,” Proc. ACM Sigcomm, Aug. 2003.
8. O. Trullols-Cruces, J. Morillo, J. Barcelo-Ordinas, and J. Garcia- Vidal, “A Cooperative Vehicular Network Framework,” Proc. IEEE Int’l Conf. Comm. (ICC ’09), June 2009.
9. S. Yoon, H.Q. Ngo, and C. Qiao, “On ‘Shooting’ a Moving Vehicle with Data Flows,” Proc. IEEE Mobile Networking for Vehicular Environments (MOVE ’07), May 2007
10. Y.Ding,C.Wang,andL.Xiao,“A Static-Node Assisted Adaptive Routing Protocol in Vehicular Networks,” Proc. Fourth ACM Int’l Workshop Vehicular Ad Hoc Networks (VANET ’07), Sept. 2007.
11. K.Prakashraj, G.Vijayakumar, S.Saravanan and S.Saranraj, “IoT Based Energy Monitoring and Management System for Smart Home Using Renewable Energy Resources,” International Research Journal of Engineering and Technology, Vol.7, Issue 2, pp.1790-1797, 2020.
12. J Mohammed siddi, A. Senthil kumar, S.Saravanan, M. Swathisriranjani, “Hybrid Renewable Energy Sources for Power Quality Improvement with Intelligent Controller,” International Research Journal of Engineering and Technology, Vol.7, Issue 2, pp.1782-1789, 2020.
13. T.R. Vignesh, M.Swathisriranjani, R.Sundar, S.Saravanan, T.Thenmozhi,” Controller for Charging Electric Vehicles Using Solar Energy”, Journal of Engineering Research and Application, vol.10, Issue.01,pp.49-53, 2020.
14. G. Poovarasan, S. Susikumar, S. Naveen, N. Mohananthini, S. Saravanan,” Study of Poultry Fodder Passing Through Trolley in Feeder Box,” International Journal of Engineering Technology Research & Management, vol.4, Issue.1, pp.76-83, 2020.
15. M.Revathi, S.Saravanan, R.Raja, P.Manikandan,” A Multiport System for A Battery Storage System Based on Modified Converter with MANFIS Algorithm,” International Journal of Engineering Technology Research & Management, vol.4, issue 2, pp.217-222, 2020.
16. D Boopathi, S Saravanan, Kaliannan Jagatheesan, B Anand, “Performance estimation of frequency regulation for a micro-grid power system using PSO-PID controller”, International Journal of Applied Evolutionary Computation (IJAEC), Vol.12, Issue.4, pp.36-49, 2021.
17. V Kumarakrishnan, G Vijayakumar, D Boopathi, K Jagatheesan, S Saravanan, B Anand,” Frequency regulation of interconnected power generating system using ant colony optimization technique tuned PID controller”, Control and Measurement Applications for Smart Grid: Select Proceedings of SGESC 2021, pp..129-141.
18. G Vijayakumar, M Sujith, S Saravanan, Dipesh B Pardeshi, MA Inayathullaa," An optimized MPPT method

for PV system with fast convergence under rapidly changing of irradiation", 2022 International Virtual Conference on Power Engineering Computing and Control: Developments in Electric Vehicles and Energy Sector for Sustainable Future (PECCON), pp.1-4.

19. VM Geetha, S Saravanan, M Swathisriranjani, CS Satheesh, S Saranraj, "Partial Power Processing Based Bidirectional Converter for Electric Vehicle Fast Charging Stations", Journal of Physics: Conference Series, Vol.2325, Issue.1, pp.012028, 2022.
20. M Santhosh Kumar, G Dineshkumar, S Saravanan, M Swathisriranjani, M Selvakumari, "Converter Design and Control of Grid Connected Hybrid Renewable Energy System Using Neuro Fuzzy Logic Model", 2022 Second International Conference on Computer Science, Engineering and Applications (ICCSEA), pp.1-6, 2022.
21. C Gnanavel, A Johny Renoald, S Saravanan, K Vanchinathan, P Sathishkhanna, "An Experimental Investigation of Fuzzy-Based Voltage-Lift Multilevel Inverter Using Solar Photovoltaic Application", Smart Grids and Green Energy Systems, pp.59-74, 2022.
22. V Kumarakrishnan, G Vijayakumar, D Boopathi, K Jagatheesan, S Saravanan, B Anand, "Optimized PSO technique based PID controller for load frequency control of single area power system", Solid State Technology, Vol.63. Issue.5, pp.7979-7990, 2020.
23. G. Poovarasan, S. Susikumar, S. Naveen, N. Mohananthini, S. Saravanan, "Implementation of IoT Based Poultry Feeder Box", International Journal of Innovative Research In Technology, Vol.6, Issue.2, pp.33-38, 2020.
24. N.Gokulnath, B.Jasim Khan, S.Kumaravel, Dr.A.Senthil Kumar and Dr.S.Saravanan, "Soldier Health and Position Tracking System", International Journal of Innovative Research In Technology, Vol-6 Issues 12, pp.39-45, 2020.
25. P.Navaneetha, R.Ramiya Devi, S.Vennila, P.Manikandan and Dr.S.Saravanan, " IOT Based Crop Protection System against Birds and Wild Animal Attacks", International Journal of Innovative Research In Technology, Vol-6 Issues 11, pp.133-143, 2020.
26. K. Punitha, M. Rajkumar, S. Karthick and Dr. S. Saravanan, " Impact of Solar And Wind Integration on Frequency Control System", International Research Journal of Engineering and Technology, Vol 7 Issue 3, pp.1357-1362,2020.
27. A.Arulkumar, S.Balaji, M.Balakrishnan, G.Dineshkumar and S.Saravanan, "Design And Implementation of Low Cost Automatic Wall Painting Machine" International Journal of Engineering Technology Research & Management, Vol-4 Issues 03, pp.170-176, 2020.
28. V.Periyasamy, S.Surya, K. Vasanth, Dr.G.Vijayakumar and Dr.S.Saravanan, "Design And Implementation of Iot Based Modern Weaving Loom Monitoring System" International Journal of Engineering Technology Research & Management, Vol-4 Issues 04, pp.11-18, 2020.
29. M.Yogheshwaran, D.Praveenkumar, S.Pravin, P.M.Manikandan and Dr.S.Saravanan, "IoT Based Intelligent Traffic Control System" International Journal of Engineering Technology Research & Management, Vol-4 Issues 04, pp.59-63, 2020.
30. R.Pradhap, R.Radhakrishnan, P.Vijayakumar, R.Raja and Dr.S.Saravanan, "Solar Powered Hybrid Charging Station For Electrical Vehicle" International Journal of Engineering Technology Research & Management, Vol-4 Issues 04, pp.19-27, 2020.
31. S.Shenbagavalli, T.Priyadharshini, S.Sowntharya, P.Manikandan and Dr.S.Saravanan, "Design and Implementation of Smart Traffic Controlling System" International Journal of Engineering Technology Research & Management, Vol-4 Issues 04, pp.28-36, 2020.
32. M.Pavithra, S.Pavithra, R.Rama Priya, M.Vaishnavee, M.Ranjitha and S.Saravanan, "Fingerprint Based Medical Information System Using IoT" International Journal of Engineering Technology Research & Management, Vol-4 Issues 04, pp.45-51, 2020.
33. A.Ananthan, A.M.Dhanesh, J.Gowtham, R.Dhinesh, G.Jeevitha and Dr.S.Saravanan, "IoT Based Clean Water Supply" International Journal of Engineering Technology Research & Management, Vol-4 Issues 03, pp.154-162, 2020.
34. R.Anbarsan, A.Arsathparvez, K.S.Arunachalam, M.Swathisriranjani and Dr.S.Saravanan, "Automatic Class Room Light Controlling Using Arduino" International Journal of Engineering Technology Research & Management, Vol-4 Issues 03, pp.192-201, 2020.
35. S.Karthikeyan, A.Krishnaraj, P.Magendran, T.Divya and Dr.S.Saravanan , "The Dairy Data Acquisition

System" International Journal of Engineering Technology Research & Management, Vol-4 Issues 03, pp.163-169, 2020.
36. M.Amaran, S.Mannar Mannan, M.Madhu, Dr.R.Sagayaraj and Dr. S.Saravanan, "Design And Implementation of Low Cost Solar Based Meat Cutting Machine" International Journal of Engineering Technology Research & Management, Vol-4 Issues 03, pp.202-208, 2020.
37. N.Harish, R.Jayakumar, P.Kalaiyarasan, G.Vijayakumar and S. Saravanan, "IoT Based Smart Home Energy Meter" International Journal of Engineering Technology Research & Management, Vol-4 Issues 03, pp.177-183, 2020.
38. K.Subashchandrabose, G.Moulieshwaran, M.Raghul, V.Dhinesh and S.Saravanan, "Design of Portable Sanitary Napkin Vending Machine", International Journal of Engineering Technology Research & Management, Vol-4 Issues 03, pp.52-58, 2020.
39. D.Hemalatha, S.Indhumathi, V.Myvizhi and S.Saravanan, "Design and Implementation of Intelligent Controller for Domestic Applications", International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.4-7, 2023.
40. S. Divyasri, E. Indhu, M. P. Keerthana, M. Selvakumari and S. Saravanan, "Gas Cylinder Monitoring System using IoT", International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.67-71, 2023.
41. J.Arul, R.Balaji, S.Jeyamoorthy, M.Manipathra, R.Sundar and S.Saravanan, "IoT based Air Conditioner Control using ESP32", International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.48-52, 2023.
42. Vundel Munireddy, J.Prahathesvaran, C.R.Thirunavukarasu, M.Santhosh Kumar and S.Saravanan, "IoT Based Charge Controller for Direct Fast Charging of Electric Vehicles Using Solar Panel", International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.77-81, 2023.
43. D.Monish Kumaar, K.Akash, S.Aswinkumar, S.Saravanan and R. Sagayaraj, "IoT based Industry Surveillance and Air Pollution Monitoring using Drones", International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.14-18, 2023.
44. T.Silambarasan, R.Surya, J.Pravinkumar, R.Sundar and S Saravanan, "IoT based Monitoring System For Sewage Sweeper", International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.88-93, 2023.
45. R.Aravinthan, Alwin.Augustin, P.Divagaran, S.Saravanan and P.Manikandan, "IoT Based Power Consumption and Monitoring System", International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.43-47, 2023.
46. S.Partheeban, S.Sundaravel, S.Umapathi, R.Sagayaraj and S.Saravanan, "IoT based Safety Helmet for Mining Workers", International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.116-120, 2023.
47. K.Eswaramoorthi, R.Manikandan, R.Balamurugan, C.Ramkumar and S.Saravanan, "Smart Parking System using IoT", International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.53-57, 2023.
48. S.Nirmalraj, C.Pranavan, M.Prem and S.Saravanan, "Smart Trolley With IoT Based Billing System", International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.111-115, 2023.
49. V.Gunasekaran, M.Gowtham , S. Anbubalaji, S.Saravanan and R.Prakash, "Solar based Electric Wheel Chair", International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.8-13, 2023.
50. P Thava Prakash, P.Venketesan, D.Vignesh, S.Prakash, S.Saravanan, "Design of Low Cost E-Bicycle using Brushless DC Motor with Speed Regulator", International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.148-153, 2023.
51. D.Tamilarasan, V.S.Vairamuthu, Y.Vasanth, K.Umadevi, S.Saravanan, "GSM based Agricultural Motor Control", International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.172-177, 2023.
52. P. Vimal, S.Veerasigamani, R.Srihari, C.S.Satheesh, S.Saravanan, "IoT Based Optimal Power Management System For Smart Grid", International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.160-165, 2023.

53. S.Abimanyu, P.Jagadheeswaran, S.Jaganath, K.Sanjay, R.Sivapranesh, K.Velmurugan, N.Mohananthini, C.S.Satheesh, S.Saravanan, “Portable Solar Tree”, International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.154-159, 2023.
54. M.Karthikeyan, S.Bilalahamad, V.A.Chandru, V.Deepika and S.Saravanan, “Design and Development of IoT based Motor Starter”, International Journal of New Innovations in Engineering and Technology, Vol.22, Issue.3, pp.178-183, 2023.
55. R.Anbarsan, A.Arsathparvez, K.S.Arunachalam, M.Swathisriranjani and S.Saravanan, “Automatic Class Room Light Controlling Using Arduino” International Journal of Engineering Technology Research & Management (IJETRM), Vol-4 Issues 03, pp.192-201, 2020.
56. S.Karthikeyan, A.Krishnaraj, P.Magendran, T.Divya and S.Saravanan , “The Dairy Data Acquisition System” International Journal of Engineering Technology Research & Management (IJETRM), Vol-4 Issues 03, pp.163-169, 2020.
57. N.Harish, R.Jayakumar, P.Kalaiyarasan, G.Vijayakumar and S. Saravanan, “IoT Based Smart Home Energy Meter” International Journal of Engineering Technology Research & Management (IJETRM), Vol-4 Issues 03, pp.177-183, 2020.
58. G. Poovarasan, S. Susikumar, S. Naveen, N. Mohananthini, S. Saravanan,” Study of Poultry Fodder Passing Through Trolley in Feeder Box,” International Journal of Engineering Technology Research & Management, vol.4, Issue.1, pp.76-83, 2020.
59. A.Ananthan, A.M.Dhanesh, J.Gowtham, R.Dhinesh, G.Jeevitha and S.Saravanan, “IoT Based Clean Water Supply” International Journal of Engineering Technology Research & Management (IJETRM), Vol-4 Issues 03, pp.154-162, 2020.
60. Ram Kumar C, Saravanan S, and Nagarajan C,“Hybrid LSTM and Deep Reinforcement Learning for Autonomous Battery Health Optimization in Electric Vehicles”, Electrical Power Systems Research, Vol-253 Issues 112535, ISSN No:0378-7796,2025.
61. Gopinathan, V. R. (2024). Real-Time Fault-Tolerant Multi-Cloud Database Architectures for High Availability Applications. International Journal of Future Innovative Science and Technology (IJFIST), 7(4), 13148.
62. Chandra, S., Rengarajan, A., Sahoo, G. S., & Sharma, S. (2023, December). Identifying Neuronal Damage and Plasticity by Analyzing Changes in Diffusion Tensor Imaging. In International Conference on Data Science, Machine Learning and Applications (pp. 433-438). Singapore: Springer Nature Singapore.
63. Sugumar, R. (2025). Federated AI in Offline-First Mobile Health Architectures for Privacy-Preserving Clinical Intelligence. International Journal of Science, Research and Technology, 8(4), 14589-14600.
64. Murugeshwari, B., Rajalakshmi, S., & Sudharson, K. (2023). Hybrid Approach for Privacy Enhancement in Data Mining Using Arbitrariness and Perturbation. Computer Systems Science & Engineering, 44(3).
65. Pandey, V. K., Mishra, S., Rengarajan, A., Savita, & Roomi, M. M. (2024, March). Enhancing Weather Forecasting with Machine Learning Techniques. In International Conference on Renewable Power (pp. 147-156). Singapore: Springer Nature Singapore.
66. Soundappan, S. J. (2025). Next Generation AI Enabled Holistic Cognitive Platform for Secure Cloud Network Intelligence Enterprise Systems and Digital Trust Optimization. International Journal of Computer Technology and Electronics Communication, 8(5), 11534-11542.
67. Mathew, A. (2022). Leveraging Big Data Analytics to Power AI and ML (Machine Learning) Automation. Educational Research (IJMCER), 4(5), 131-134.
68. Sugumar, R. (2024). AI-Augmented Quality Engineering for Performance Optimization and Test Orchestration in Distributed Systems. International Journal of Science, Research and Technology, 7(5), 12835-12846.
69. Akila, R. (2024). A deep reinforcement learning approach for optimizing inventory management in the agri-food supply chain. J. Electrical Systems, 20(4s), 2238-2247.
70. Mahendran, M., Anbazhagan, K., Pavithran, G., Nivas, A., & Pandey, S. D. (2022). Earthquake Damage Prediction using Machine Learning. Grenze International Journal of Engineering & Technology (GIJET), 8(1).
71. Gopinathan, V. R. (2025). Enterprise AI Frameworks for Financial Data Engineering Behavioural Analytics and Intelligent Cloud Solutions. International Journal of Research Publications in Engineering, Technology and Management (IJRPETM), 8(4), 12499-12506.

72. Kondalsamy, P., & Kaliappan, K. (2025). An Optimal Prediction of Leaf Disease Based on Hybrid Deep Learnings and Metaheuristic Technique. Traitement du Signal, 42(1), 363.
73. Deivendran, P., Babu, P. S., Malathi, G., Anbazhagan, K., & Kumar, R. S. (2023). Emotion Recognition for Challenged People Facial Appearance in Social using Neural Network. arXiv preprint arXiv:2305.06842.
74. Sugumar, R. (2025). Unified AI Framework for Predictive Data Engineering and Real Time Prescription and Billing Systems. International Journal of Advanced Engineering Science and Information Technology (IJAESIT), 8(5), 17261.
75. Vekariya, V., Kumar, S., & Rengarajan, A. (2024). A distinctive and smart agricultural knowledge-based framework using ontology. In Sustainability in Digital Transformation Era: Driving Innovative & Growth (pp. 207-213). CRC Press.
76. Gopinathan, V. R. (2025). Software engineering practices for AI-driven systems: From development to deployment (MLOps perspective). International Journal of Science, Research and Technology, 8(1), 13493-13500.
77. Mathew, A. R. (2022). Threats and protection on E-sim: a prospective study. Novel Perspectives of Engineering Research, 8, 76-81.
78. Naveena, S., & Kavitha, K. (2025). Gossypium herbaceum: Folium disease identification and classification using Efficient Net-Coordinate Convolutional Neural Network (EcoNet). Engineering Applications of Artificial Intelligence, 152, 110701.
79. Rengarajan, A., Mishra, A., Kulhar, K. S., Shrivastava, V. P., & Alawneh, Y. J. J. (2024, March). Role of Deep Reinforcement Learning in Mitigating Cyber Security Issues: A Review. In International Conference on Renewable Power (pp. 37-48). Singapore: Springer Nature Singapore.
80. Achari, A. P. S. K., & Sugumar, R. (2024, November). Performance analysis and determination of accuracy using machine learning techniques for naive bayes and random forest. In AIP Conference Proceedings (Vol. 3193, No. 1, p. 020199). AIP Publishing LLC.
81. Mathew, A., & Alex, H. (2022). Detect & protect-medical device cybersecurity. Curr. Overview Sci. Technol. Res, 1, 60-68.
82. Sammy, F., Chettier, T., Boyina, V., Shingne, H., Saluja, K., Mali, M., ... & Shobana, A. (2025). Deep Learning-Driven Visual Analytics Framework for Next-Generation Environmental Monitoring. Journal of Applied Science and Technology Trends, 114-122.
83. Anbazhagan, K. (2024). Trustworthy and Adaptive AI Systems for Enterprise Analytics Cybersecurity and Decision Optimization Using API-First and Cloud-Native Architectures. International Journal of Technology, Management and Humanities, 10(03), 65-74.
84. Mathew, A. (2021). Deep reinforcement learning for cybersecurity applications. Int J Comput Sci Mob Compu, 10(12), 32-38.
85. Dhinakaran, D. (2022). Joe Prathap P. M, Selvaraj D, Arul Kumar D and Murugeshwari B," Mining Privacy-Preserving Association Rules based on Parallel Processing in Cloud Computing,". International Journal of Engineering Trends and Technology, 70(3), 284-294.
86. Karthika, K., Anusha, K., Kavitha, K., Harshadha, R., Dharshini, D. S., & Sundhar, N. A. (2025, April). Frequency Reconfigurable Antenna using Advanced Materials: A Study. In 2025 3rd International Conference on Advancements in Electrical, Electronics, Communication, Computing and Automation (ICAECA) (pp. 1-6). IEEE.
87. Thavamani, C., & Rengarajan, A. (2024). Clustering related behaviour of users by the use of partitioning and parallel transaction reduction algorithm. International Journal of Advanced Intelligence Paradigms, 29(2-3), 122-132.
88. Sugumar, R. (2025). Unified AI Framework for Predictive Data Engineering and Real Time Prescription and Billing Systems. International Journal of Advanced Engineering Science and Information Technology (IJAESIT), 8(5), 17261.
89. Soundappan, S. J., & Sugumar, R. (2016). Optimal knowledge extraction technique based on hybridisation of improved artificial bee colony algorithm and cuckoo search algorithm. International Journal of Business Intelligence and Data Mining, 11(4), 338-356.

90. SakthiPreetha, A., Kavitha, K., Karthika, K., & Manohari, R. G. (2025, April). A Novel Metasurface-Embedded Antenna for WBAN Communications. In 2025 3rd International Conference on Advancements in Electrical, Electronics, Communication, Computing and Automation (ICAECA) (pp. 1-4). IEEE.
91. Murugeshwari, B., Selvaraj, D., Sudharson, K., & Radhika, S. (2023). Data Mining with Privacy Protection Using Precise Elliptical Curve Cryptography. Intelligent Automation & Soft Computing, 35(1).
92. Gopinathan, V. R. (2025). Software engineering practices for AI-driven systems: From development to deployment (MLOps perspective). International Journal of Science, Research and Technology, 8(1), 13493-13500.
93. Anbazhagan, K., Kumar, R., Thilagavathy, R., & Anuradha, D. (2024, March). Shortest Job First with Gateway-based Resource Management Strategy for Fog Enabled Cloud Computing. In 2024 4th International Conference on Data Engineering and Communication Systems (ICDECS) (pp. 1-6). IEEE.
94. Kannadhasan, S., Vasuki, S., Kavitha, K., Karthikeyan, P., & Usha, S. G. A. (Eds.). (2025, April). Preface: Role of Artificial Intelligence and IoT in Engineering, Technology & Science [ICRAETS 2024]. In AIP Conference Proceedings (Vol. 3258, No. 1, p. 010001). AIP Publishing LLC.
95. Dhinakaran, D., Prathap, P. J., Selvaraj, D., Kumar, D. A., & Murugeshwari, B. (2022). Mining privacy-preserving association rules based on parallel processing in cloud computing. International Journal of Engineering Trends and Technology, 70(3), 284-294.