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A STUDY ON THE APPLICATION OF NETWORK CODING IN VANET

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INTRODUCTION

Most of the P2P or the peer-to-peer system of sharing file (as in Gnutella, BitTorrent) get developed by means of targeting wired mode of IP networks and therefore work hardly as per the determined intention in case of mobile ad hoc networks (MANETs) without following modification. In current research, various P2P schemes are targeting MANET, in a way, MANET-optimized version of the currently available P2P schemes and clean-slate designs, were proposed.

This paper concentrates in investigating issues related to the process of running BitTorrent that is under type P2P systems for sharing file, i.e., for the file swarming protocols, in terms of vehicular ad hoc networks (VANETs), where MANETs comprises of trucks, cars, or any kind of vehicles on road. We consider it very specifically, and interested more in VANETs as VANETs turned up to be imminent reality. In reference to near future, all kinds of vehicles get equipped with the process of wireless connectivity as well as devices [4] enabling communications along with roadside objects added by other vehicles. Development as well as deployment over VANETs gets driven basically through demands related to navigation safety (as in VANET being used as a reliable communication channel in terms of virtual tail lamp signals among vehicles that stand in supplement to conventional visual tail lamp system), yet emerging VANETs being expected towards operational aspects related to the wireless LAN grade bandwidth (as up to 27Mbps within standard of DSRC [4]), therefore permitting further applications spanning in various different fields from office-on-wheels to the entertainment, sharing of P2P file, extensions of Internet, etc.

MANET (being under VANET) as a featured approach through highly dynamic topology gets noted as most MANET P2P protocols try to address issues led by topology dynamics by cross-layer optimization. As a matter of fact, protocols of P2P are encumbered through different modes of features related to VANETs.

At the foremost level, the wireless channel remains prone to error. In case the protocol gets designed without keeping the errors under consideration, the respective protocol performance in the process of real deployment remain degraded in a serious way. As for instance, TCP connections in general die out within multihop networks added by the lossy channel, yet many of P2P protocols are assumed simply in terms of offers by TCP that

stand as a significant sort of reasonable bandwidth. Density related to the user demands to get considered simultaneously. In case of an urgent ban scenario, VANETs are liable to get scaled till 10000s of nodes, added by the theoretical modes, all related to nodes that are subject to get applicable for the users running P2P protocols. Even in case of cross-layer optimization, there is no room for conventional MANET routing protocols that gets expected towards the process of supporting this kind of big networks. Possible mode of non-cooperative nodes carries other kind of concern. Many MANET protocols get designed in accordance to the determined assumption for node co-operativeness. Multihop routes are subject to get established as many nodes are in the way to serve in the form of relays for meeting the demands of the data sender. In case of MANET built or the maintenance or gaining ownership by single entity, like military tactical network or otherwise the wireless mesh network, nodes, there is the room for being easily forced towards cooperate in terms of attaining common kinds of goal (as in the process of offering communication infrastructure). However, in VANETs there is every possibility whereby the nodes get operated through different entities in context of their personal good added by the instance whereby the approach may not remain liable to force every node towards the process of cooperating each other.

Eventually, IP addressing remains non-trivial within the context of VANETs. There is no clear statement regarding the way every node being assigned within an IP address in VANETs. Further, DSRC [4], a kind of PHY/MAC standard gets expected towards the application of future, whereby VANETs define usages related to random MAC address, in the process of addressing privacy protection that violates unique and static MAC address statement that all sort of MANET routing protocol being created in e form of atop.

In order to offer remedy to such issues noted above, we are considering holistic approach. In an another way, rather than solving every kind of issue on separate provisions, as in case of independent problem, we have designed entirely newer mode of protocol for the purpose of addressing all kinds of issues at a time. Since we have noted that application of MANET routing protocols within VANETs offer rise towards the most of the problems. The very important argument related to this particular paper is about the swarming file for the protocols within VANETs that live without MANET routing protocols. In reference to our design, we are liable to resort towards single-hop communication. The instances of Multihop routes never gets used and therefore are without any need for maintained aspects that are explicitly noted by any kind of layer within protocol stack. Instead, multihop communication remains implicit. We hereby restrict logical peers, which are nodes in

exchange of file pieces, towards the physical neighbors, but the respective data remains propagated by (overlay) network of various peers in reference to common interest, that remain as the basic concept towards the P2P file operation under the system of sharing. The very important problem here is the process of restricting logical peers towards physical neighbors within VANETs. However, is reference to the connectivity within peers, it remains hard for node to derive peers following common kind of interest. Though there are some peers found in this context, yet there seemed to be no guarantee that all those peers comprises of useful data. Core ingredients related to our design are coding of network and necessary mobility that can assist propagation of data (as in [2, 14]). There are 2 procedures that are enabling our design in terms of maintaining enough mark of connectivity within peers along with low overhead like that of the users downloading files within very less possible time, rather than determined case that comprises of current protocols.

Through the network coding, we hereby refer towards the performance notion for coding operations related to the contents related to the packets throughout respective network. This is a kind of notion that is in general subject to remain attributive towards Ahlswede et al. [1], showing utility related to the network coding menat for multicast. Research led by Ahlswede et al. get followed by some of the other kind of work led by Koetter and M´edard [8] and are with the provision to show codes along with simple as well as linear structure that are sufficient in terms of attaining capacity meant for multicast connections within lossless, necessary wireline networks. As a result, Ho et al. [6], who pioneered random mode of construction over the linear codes, remain sufficient. It is the utility related to such random mode of linear code that is subject to remain wired P2P mode of file sharing systems and in no time gets realised for its activities [5]. The contribution made by us is in this particular lineage that assisted in realising utility meant for random linear code, for the first time in context of P2P file sharing systems within mobile networks. Our work as well as [5] being same, both remain applicable in a very random linear code related towards P2P file sharing systems. Still, the proposed protocol as in [5] remain under the non-expected mode towards work managed properly within VANET that is same as other wired P2P protocols since the condition as mentioned above. The remaining part of this research paper gets organized in the following manner. Section 2 is meant to illustrate our network that is responsible for coding in accordance to file swarming protocol added by the provision to evaluate protocol by simulation within Section 3. The following Section 4 is liable to presents related work and, lastly the Section 5 is for concluding the entire paper.

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2. NETWORK CODING BASED FILE SWARMING PROTOCOL

A node that is liable to intend n terms of sharing a file, seed node, is liable to create as well as broadcast its 1-hop neighbor under the illustration of the file. In the same way, towards torrent file within BitTorrent protocol, that stand as an illustration comprising of aspects like identification name, number, name, pieces, etc. We hereby simply assume every file being uniquely identified in context of identification number (or the fileid) in the phase where every node remain interested within respective file added by the venture to complete downloading.

At notable seed node, there is a file F that gets divided into n pieces termed as $\mathbf{p}_1, \mathbf{p}_2, \cdots, \mathbf{p}_n$. In context to our protocol, there are nodes referred for the purpose of exchanging coded frames rather than file pieces. We hereby define a kind of coded frame as c that stands in linear combination with the file piece $\mathbf{p}_k$'s. That is, $\mathbf{c} = \sum_{k=1}^{n} e_k \mathbf{p}_k$ where e_k has been noted for representing certain element within some kind of finite field F that is meant for every kind of arithmetic operation. File piece p's along with coded frame c's are considered as vectors over the state of F. In any occasion, when the seed node gets requested towards exchange of a coded frame, respective code transmits newly generated coded frame c along with the aspects in terms of generating c, where every e_k gets drawn in a random way from F, thus the name random linear coding. In case of header related to the coded frame, respective encoding vector $\mathbf{e} = [e_1 \ \ldots \ e_n]$ gets store for the later decoding. This entire paper for us is about abusing lowercase boldface letters in order to denote frames, vectors, or packets, added by uppercase letters in terms of denoting matrices, italics for the purpose of denoting variables or otherwise fields within packet header.

A node is subject to learn of file from the process of receiving illustrations about the file that gets transmitted from neighbors. In case, node derives file in an interesting way, it is liable to broadcast a request that comprises of fileid of respective file. As such request gets received, each node with any piece of file or coded frame related to the requested file is subject to respond with newly-generated coded frame. A node is regular in sending requests to the neighbours in terms of sending coded frames, till it can collect n coded frames comprising encoding vectors that stand linearly independent to each other.

Whenever the request has been made, every node, not only the seed node; there is always the room to generate on-the-fly added by the act of transmitting newly coded frame. Code generation over non-seed nodes remains through same approach that comprises the seed node with an undergoing aspect for generating coded frame, which is subject to generate random linear combination in the coded frames, which are available within local

memory. It is necessary to note that though frames related to local memory get coded, there is also the re-encoded frame $\acute{c} = \sum_{k=1}^{rnk} \acute{e}_k \mathbf{c}_k$ that gets tagged along with encoding vector $\acute{e} = \sum_{k=1}^{rnk} \acute{e}_k \mathbf{e}_k$ where $\mathbf{c}_k$ and $\mathbf{e}_k$ which gets the coded frame within local memory as well as encoding vector that gets prefixed towards $\mathbf{c}_k$ in a respective way. rnk is noted as the number related to $\mathbf{c}_k$'s as noted in local memory. As the encoding, every $\acute{e}_k$ gets drawn uniformly from F.

In order to recover n pieces of file $\mathbf{p}_1, \mathbf{p}_2, \ldots, \mathbf{p}_n$, is about a node that needs to get collected more than respective n coded frames that are subject to carry encoding vectors which linearly remain independent to each other. Let $\mathbf{c}_k$ remain as coded frame, where $\acute{e}_k$ is subject to encode vector which is prefixed towards $\mathbf{c}_k$, and $\mathbf{p}_k$ being a piece of file for the purpose of decoding and recovering, following k = 1, ..., blocksize. Moreover, let us consider $\mathbf{E}^\intercal = [\mathbf{e}_1^\intercal \ldots \mathbf{e}_{blocksize}^\intercal]$, $\mathbf{C}^\intercal = [\mathbf{c}_1^\intercal \ldots \mathbf{c}_{blocksize}^\intercal]$, and $\mathbf{P}^\intercal = [\mathbf{p}_1^\intercal \ldots \mathbf{p}_n^\intercal]$ that comprises of the superscript T denoting transpose operation, followed by the act of conceptually noted P = $\mathbf{E}^{-1}\mathbf{C}$, that is liable to obtain pieces of original file. Note here that all the $\mathbf{e}_k$'s is subject to remain linearly independent in order to get invert E.

Added to the seed node of a particular file, there is every node comprising any count of coded frame of respective file along with willingness to share the similar aspects on a periodic manner, especially for the purpose of broadcasting (in very low rate) towards 1- hop neighbors' file illustration. In case of a node having multiple files in order to share, relevantly multiple illustrations that are packed in least possible number of packets carrying all of them as well as are further transmitted.

A request related to coded frames can be accompanied through the nullspace vector that stands as a vector within respective nullspace spanned through all the encoding vectors structured for the frames, relevantly stored within local memory of particularly requested node. On reception of this kind of request, respective node transmits coded frame, only in case there is the availability of local memory with a frame for encoding vector, which is never noted for orthogonal towards nullspace vector attained with respective request. Every single node remains promiscuously listens towards the packets, which a node attains on the basis of determined packet, even in case the node never stands for the designated receiver, in a way that eh same can imply the same, especially when the instance get possible. A node is always subject to overhear packets that can carry coded frames and further are subject to treat overhead ones, since the coded frames stand transmitted particularly towards the node. In case of an overheard

coded frame, there is the room for linearly independent for the coded frames within local memory, followed by stored node.

As every transmission gets MAC or link layer broadcasting, there is a small rate of random amount for waiting span of time prior to every transmission, termed as broadcast jitter which is applied towards the reduction of collisions. Without the participation of broadcast jitter, there is MAC or link layer that can make broadcasting suffers from hidden terminal issue on a severe way.

3. EVALUATION

This is a section where we have evaluated CodeTorrent by means of simulations by the application of Qualnet [13]. In following the process of simulations, we have implied IEEE 802.11b PHY/MAC along with data rate of 2Mbps added by Real-Track (RT) mode of mobility model [11]. RT allows to model vehicle mobility within an urban kind of environment that has a relevantly realistic aspect than any other simpler as well as wider implication mobility models like Random Waypoint (RWP) through the process of restricting areas that have nodes which are subject to appear (as in roads). Road map input towards RT model as noted in Figure 1, turns up to be a street map comprising 2,400m× 2,400m Westwood area under the vicinity of UCLA campus.

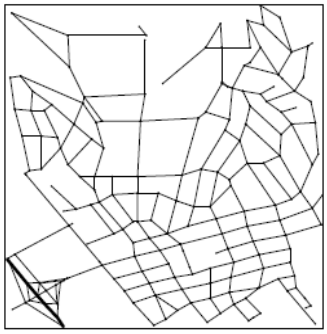

Figure 1: Westwood area in the vicinity of UCLA

Nodes' fraction (represented by popularity) within network gets interested in the process of downloading similar 1MB file. A special kind of node noted called AP that comprises of complete file in the initial state of simulation. Three kinds of static APs remain randomly positioned over roadside places in the area. 1 MB file gets divided in 4 KB pieces. Therefore, total count of pieces is estimated as 250. A piece gets transferred through the application of four 1 KB packets. In case of CodeTorrent, there is a peer that needs to attain 250 linearly independent kinds of coded pieces towards the mode of decoding file.

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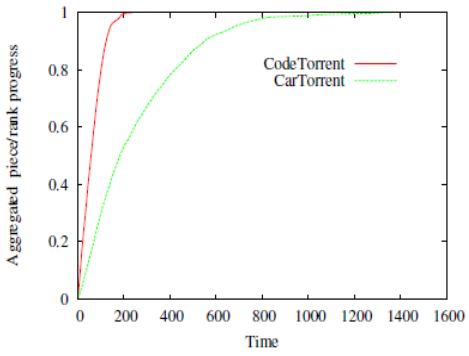

Figure 2: Aggregated downloading progress (200 nodes moving with the maximum speed of 20 m/s. The popularity index is set to 40% meaning that the number of interested nodes is 80 nodes.)

In case of CarTorrent, we implied UDP towards the data packet transfers. Since the underlying routing protocol gets considered, we imply AODV. We have limited the scope related to gossip packets towards 3 hops as has been proposed within original design [10]. We have limited the value of TTL value related to RREQ within AODV towards 3 hops. Each of the nodes is subject to initiate piece for the purpose of downloading either aspects periodically (as every 0.5 second) or over the reception of newer gossip packet. Successful mode of downloading a determined piece is subject to initiate downloading. Availability of the piece that is for gossiping, gets carried out for each of the selected 5 seconds. We have

3.1 Comparison related to Download Delay

Firstly, we have noted the contrast in the process of downloading delay meant for CodeTorrent in reference to CarTorrent within determined setting in order to show benefit of implied probabilistic gossiping: the uninterested as well as the interested nodes there is the forwarded mode of gossiping packets added by probability 0.1 as well as 0.8 respectively.

In the same way, CodeTorrent implies UDP in respect of transfer packets towards the neighbors. CodeTorrent never imply any sort of underlying routing protocol, as the same relies over single hop unicast added by overhearing. The 2^8 field gets implied for coding. Therefore, encoding size related to the coding vector that has been noted as 250B, 6% overhead over the payload.

We have defined download "*delay*" to get elapsed in case of time for node in order to collect all the determined 250 pieces for the respective CarTorrent or otherwise linearly noted as independent coded pieces in respect of CodeTorrent. Given metric gets evaluated along with different configurations, which are function of notable node density, in response to maximum speed, added by fraction related to the interested nodes.

performance of CodeTorrent of CarTorrent. Progress of aggregated downloading approach (cumulative histogram added by slot size that is of 2 seconds) as has been noted in Figure 2. In reference to a time slot (noted by x-axis), whereby the respective figure shows average

fraction meant for the pieces which are collected through 80 nodes added by averaged fraction that is for linearly independent coded pieces which are collected through 80 nodes for the implication of CarTorrent as well as CodeTorrent respectively. The noted figure has illustrated CodeTorrent in a very important way that expedites entire mode of progress as against CarTorrent.

It has been noted in Figure 3, histogram related to download delays is meant for both protocols

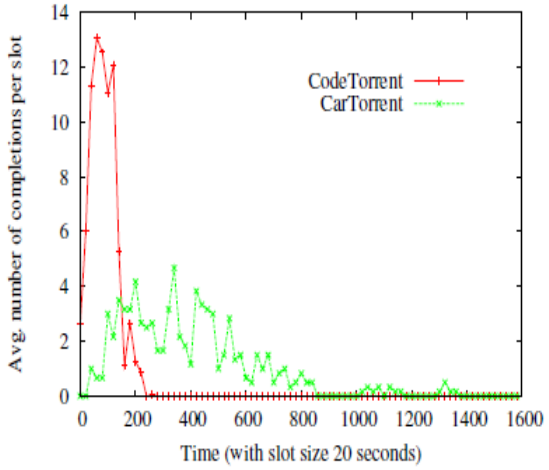

Figure 3: Histogram of download delays

As the count of seeds increases within the network, usefulness meant for the random coded packet is liable to increase and therefore, further is subject to get shortened for downloading time. As a result, it confirms benefits related to network coding, that has been observed within Avalanche within the wired environment [5]. As against this, CarTorrent never show this kind of burst births related to the seeds, yet the seeds are born added by slot size that is for 20 seconds. In reference to CodeTorrent, the collection of nodes assists each other towards the distribution of coded pieces by the application of network coding (as in algebraic mixing). In context of 2nd time slot, i.e., [20,40), we have noted a span of 6 nodes among the seeds (whereby a node turns a seed as it completes the aspects related to downloading of shared contents), that gets followed by burst of an assessed 1 new seeds within next slot.

instead of being gradually because of the competition that is among nodes towards the mode of securing download bandwidth. As for instance, after attainment of a gossip packet from the respective nodes or APs, in case of worst possible scenario, 80 numbers of interested nodes begin to request pieces at the same particular time. Nodes get located away from source that demands to go in respect of mutihop. Consequently, large number of nodes began towards the process of setting up determined connections meant for originator. This is a crowd that is liable to lay effect causing severe contention of channel, therefore leading to performance degradation as in Figure 3. The first aspect of download completion is managed at 3rd slot, [41-50), added by maximum rate of birth of seeds1 that is noted as less than 5. In order to show behavior multihop pulling, within Figure 4, whereby we have shown histogram related to the average hop count that exceed 1 hop along

[1] Number of newly born seeds for a given slot.

with slot size of 20 seconds. Figure clearly declares availability of random piece that increases with the passing of time passes. Noted average hop count decreases gradually. The pulling of multihop was continued till the range of 700 seconds through which there are 93% of total interested nodes turning seeds. In context of 700 second mark, respective nodes are liable to fetch random piece that is notable from their neighbors. It is necessary to note here that CarTorrent implies a closest-rarest first mode of strategy for the selection of respective piece.

3.2 Impact of mobility

In the process, we started with the investigation of laying impact of the mobility over down- load delay. Average count of download delay started functioning as per node speed added by different node densities that has been illustrated through Figure 5. We are only supposed to present results meant for popularity in relevant to 40% case as results are for other kind of popularity indices showing similar modes of trends. The respective figure illustrates in CarTorrent, since the count of nodes increases; determined performance is subject to remain degraded in a gradual term. In respect of the given popularity index, the context increased the total count of the nodes and the same means that we must increase count of interested nodes; as in the case of N=100 and 200 having 40 as well as 80 interested nodes in a respective manner. Since the interested nodes increases in number, overhead related to the underlying routing protocol added by gossiping turns up problematic. Status of fast mobility get induced more in terms of route errors, particularly as the count of interested nodes turns up to be large.

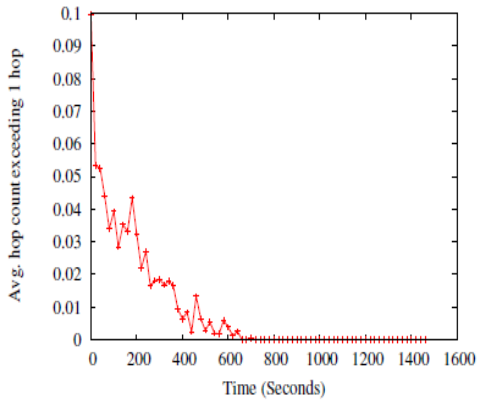

Figure 4: Average hop count histogram for multi-hop pulling in CarTorrent

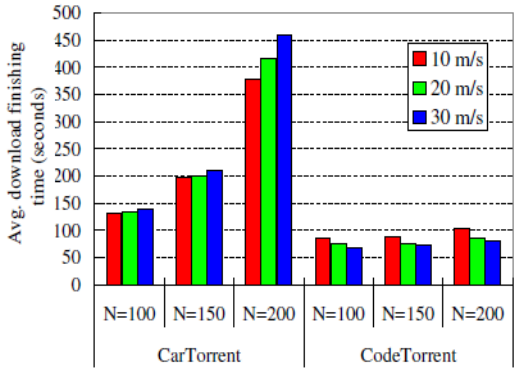

Figure 5: Impact of mobility on average download delay

As for example, as N=200, respective average count of route error messages (or the RERRs) is subject to get increased from 83.1 to 134.6

as the maximum speed is liable to increase from 10 to 30 m/s. these kinds of routes errors are subject to reinitiate route discovery (which is RREQ) added by the instance of worsening network congestion. There is one more significant factor that assists towards congestion related to the periodically noted gossiping approach. Determined simulations related by constrain gossiping packet that can travel to a span of 3 hops, along with gossiping duration fixed by 5 seconds. Network congestion remains inevitably noted for various counts of nodes that were participating the gossiping increase. Moreover, duration for gossiping needs to get adjusted as per mobility to remain accurately selected as per closest node (which is for the closest-rarest foremost selection): which is noted by the higher process of mobility, added by more frequent advertisements. Still, this is subject to exacerbate is meant for the network congestion, which results in terms of performance degradation.

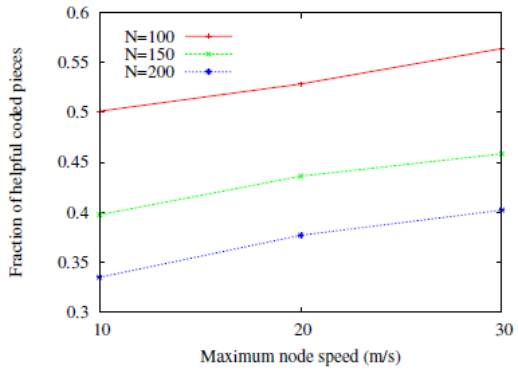

Figure 6: Helpfulness as a function of node speed

In order to support this particular observation, we hereby prefer to present average fraction meant for the helpful coded pieces (which are comprised of linearly independent code vector), which are supposed to get pulled or otherwise overheard from neighbors as noted in Figure 6. Since the average counts of neighbors increases, the approach gets more probable, whereby the node overhears the process of unhelpful coded pieces that again are from determined neighbors. As for instance, in case of static scenario, there is the need of a set of nodes which are located among two groups. These are marked as forwarders,

As against this, average download delay led by CodeTorrent is subject to decrease as the process of mobility increases. As CodeTorrent is followed by single hop data that is relevant in terms of pulling a swell as overhearing, whereby the mobility plays as a significant role like data dissemination latency that can be reduced along with increased kind of mobility. Ease gets noted as an explanation, we are liable to imagine two kinds of nodes that were travelling in the same path, yet without any other kinds of contacts till they reach end of path. After the process of exchanging useful data in the initial stage, and the remaining contact span turn up useless to each other. In this approach we have realized useless span of time that turns up just as a shortened aspect as we increase mobility. As noted in Figure 5, the aspect of “mobility” based mixing over top of relevant algebraic mixing by network coding is subject to add further aspects reducing delay.

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who will receive more prominent and linearly dependent coded pieces as the size of respective target group increases.[2] In case of nodes having mobile, the same can remain alleviated, as well as can remain helpfulness in terms of developing added by increased mobility. One particular caveat is noted as mobility turns up too high, relevant contact period will be too short to exchange any piece, and therefore the same can adversely affect performance. In the current scenario, we are developing mathematical model towards the process of quantifying impact of mobility.

RELATED WORK

Sharing content within MANETs remain roughly categorized in accordance to a protocol that gets noted for the application of mobility-assist or the technique for cross-layer proceeding. Mobility-assist kind of protocol aims in the utilisation of node mobility towards disseminating or retrieving content or otherwise index. 7DS [12] concentrates in sharing content of the web among various nodes and the same was based on higher mode of locality related to information accessibility within geographic area, even being without any kind of Internet connectivity. A node is liable to pull as well as carry content that is of great interest from determined neighbors, therefore diffusing content in the respective network. In terms of Passive Distributed Index (PDI) [9], the context of mobility gets exploited in reference to disseminating as well as maintaining distributed index for the shared content. There is a basic kind of operation meant for CodeTorrent that are relevantly same to former approaches. Still, CodeTorrent gets designed towards the offering of a BitTorrent style in terms of content distribution along with network coding as has been proposed in [5]. Our core emphasis as noted in this paper is on the process of analysing impact led by mobility over performance of respective sharing of content added by network coding.

Techniques of cross-layer are subject to incorporate the process of routing layer in reference to sharing of content as well as indexing. There are innumerable protocols that lay importance over the trend of overcoming discrepancy among logical over-lay as well as physical topology meant for mobile nodes. As for instance, XL-Gnutella [3] maps logical overlay for the neighbors towards physical neighbors. The approach of CarTorrent [10], that is a BitTorrent style is about sharing content protocol within wireless networks, implies proximity-driven selection piece that is termed towards the performance being better than rarest of the selection made over first piece. In the same way, ORION [7] creates an on-demand structure for content-based overlay that is closely in similarity with topology related to the underlying network. As against this, there are approaches as in CodeTorrent that considers changes under dynamic

[2] Assuming that they continue to forward pieces to the next group.

conditions for the topology as well as intermittent connectivity caused towards higher mobility within VANET and different kinds of issues that have disregarded former mobile on a peer-to-peer based researches like addressing, nod or user density, modes of non-cooperativeness, and above all unreliable channel.

5. CONCLUSION

Conclusively, this particular research assisted us in proposing a network coding that is based on the file swarming protocol. We have noted that this research paper offered a notable work within progress as well as preliminary results. We still need to explore all the other kinds of parameters as well as optimization scopes, which are related to the proposed protocol. Instead, we kept determined protocol effective in reference to simplest form that is meant for clearer presentation of the main idea. Our determined approach is not responsible completely for the process of resolving determined issues as in VANET P2P systems, yet is a simple way for the purpose of mitigating the problems.

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