## Chapter 2

Chapter - 2 Literature Survey

<table>
<thead>
<tr>
<th>S.NO</th>
<th>Name of the Subtitle</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Factors affecting P2P networks</td>
<td>29</td>
</tr>
<tr>
<td>2.2</td>
<td>Overlay Optimization Methods</td>
<td>34</td>
</tr>
<tr>
<td>2.3</td>
<td>Summary</td>
<td>44</td>
</tr>
</tbody>
</table>
CHAPTER 2

Currently, an enormous investigation is carried in the direction of addressing the problem of topology mismatch in Peer-to-Peer networks. Consequently, fields like artificial Intelligence, graph theory [33], neural networks [34], are in advent intended to identify and minimize topology mismatch problem in P2P networks. Still there are many problems which can't be resolved thoroughly because every part of the effort has a bit of disadvantage while resolving the problem. Peer to Peer networks are able to categorize into numerous kinds depending on specific characteristics such as Pure Peer to Peer and Hybrid Peer to Peer based on the traits of peer management.

2.1 Factors Affecting P2P Networks

The topology mismatch problem in peer-to-peer networks causes a huge amount of unnecessary traffic that reduces the performance, in terms of lengthy communication, query response time, slow convergent speed and shrinking the search scope [30]. The following are the important factors that affect P2P networks.

a. **Traffic Cost** is the amount of unnecessary traffic incurred within the network, which retards the performance and results in lengthy communication.

b. **Search scope** is termed as the number of peers for which the query has been reached within a data discovery process.
Consequently, by means of the equivalent traffic and enhanced searching capacity traffic rate can be reduced.

c. **Average neighbor distance (D)** is utilized in the process of calculating the optimized outcome of a logical topology. Let us consider $S_k$ as the usual barrier among the resource peer $k$ as well as its logical neighbors. The value $S$ is calculated the same as the average of all $S_k$'s, i.e., total number of peers involved within the P2P network. Reducing the average neighbor distance requires an enhanced similarity with the primary physical network.

d. **Query Response time** is described as a response time of a query in terms of time period as of while the query is generated till the resource peer receive the response outcome from the main responder.

e. **Convergent Speed** is the time taken to form complete peer to peer network.

f. **Communication Cost** is the cost incurred to communicate between one autonomous system to another autonomous system.

Fig: 2.1 (a), P2P overlay network
In Fig 2.1 (a) A, B and D are three participating peers and physical topology nodes A, B, C and D respectively. Robust lines mean physical associations and dashed lines signify overlay associations. For instance let us consider message passing from node A to node B. In Figure 2.1(a) A and B are both peer-to-peer neighbors and physical neighbors subsequently unique correspondence is included. Thus in Figure 2.1 (b) since A and B are not peer-to-peer neighbors, A needs to send message to D before sending to B, this includes 5 communications. Obviously such a mapping makes much unnecessary association and extends the query response time. This phenomenon is called topology mismatch issue. Adaptive Connection Establishment (ACE), an algorithm which build’s an overlay multicast tree between each resource node as well as the peers surrounded by certain distance from the resource peer and further optimizing the neighbor associations which are not on the tree to keep hold of the search scope.

Design of ACE [36] includes three phases such as Neighbor Cost table construction, Exchanging Selective Flooding (SF) and Overlay Optimization. Analysis in [36] illustrate that only 2 to 5 percent of
Gnutella associations associate peers within a single independent system (IS), however additionally 40 percent of Gnutella peers are positioned within the top 10 IS's, which means that the majority of the Gnutella generated traffic cross the IS borders in an attempt to enhance topology mismatch expenses. The same message can negotiate the similar physical link many times, which leads to huge amount of unnecessary traffic.

ACE is distributed and scalable in such a way that it does not require complete awareness of the entire logical network when each node is optimizing the group of its coherent neighbors. With the intention of reducing redundant traffic caused by flooding and to improve the search performance, two methods have characteristically been anticipated to recover on or after the flooding-based search scheme within unstructured P2P systems. As a replacement to flooding a query to each and every neighbor, the first approach directs the query to peers that are probable to have the requested items depending on a few heuristics retained statistic information [37], [38], [39]. In the subsequent method, a peer keeps directory of other peers for sharing information or it caches query responses for hop by hop transmission of queries.
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<thead>
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<th><strong>Unstructured</strong></th>
<th><strong>Structured</strong></th>
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<tr>
<td><strong>Network structure</strong></td>
<td>No network organization, peers are connected arbitrarily.</td>
<td>Proper network organization, peers maintain a DHT table to specify the successor and predecessor.</td>
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<tr>
<td><strong>Addressing</strong></td>
<td>PeerID is assigned when the peer enters the network; the connections to the neighbors are recorded in the routing table of each node.</td>
<td>Nodes are assigned NodeId from a large identifier space.</td>
</tr>
<tr>
<td><strong>Content placement</strong></td>
<td>Content in the network is present at random and there is no means to identify the position of the content.</td>
<td>Objects are assigned a key from the same identifier space used for addressing.</td>
</tr>
<tr>
<td><strong>Relation between content and Peer</strong></td>
<td>No correlation between the peer and the content present in the network.</td>
<td>Each peer is responsible for a specific part of the content in the network.</td>
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<tr>
<td><strong>Search</strong></td>
<td>Objects of interest have to be searched by either generating and flooding a query randomly</td>
<td>Objects are found easily as the position of the content in structured networks.</td>
</tr>
<tr>
<td><strong>Maintenance overhead</strong></td>
<td>Maintenance is high is due to exchange of ping and pong messages to know the existence of the other peer.</td>
<td>Maintenance is relatively low in terms of their alive messages. But overhead is involved to maintain the DHT table entries.</td>
</tr>
<tr>
<td><strong>Centralization</strong></td>
<td>There is no central entity but several bootstrap nodes are needed for proper functioning of the network</td>
<td>The object and node identifier space is maintained by the DHT, which is the central entity in the network.</td>
</tr>
<tr>
<td><strong>Scalability</strong></td>
<td>These are highly advantageous when it comes to scalability as new nodes can be added quite easily without much overhead</td>
<td>New nodes mean more resources but it will increase the overhead on DHT maintenance.</td>
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### Stability and Churn

| Stability and Churn | Even in the absence of one node other nodes can still respond the system. Unstructured ones are highly stable to churn and they rearrange their routing tables accordingly | Since there is a single point of failure the network may crash in the absence of DHT server. Otherwise the network is highly stable to churn. |

### Symmetry

| Symmetry | In some implementations all the nodes are treated equally and in some hybrid implementations some nodes have high responsibility compared to others. | Except the DHT server all the other nodes are treated equally. |

### Search success

| Search success | The search may or may not result in a success. For low peering items the success is very low compared to structured networks. | The search will always result in a success. Even for low peering items the success is good. |

### Applications

| Applications | Gnutella | Chord, Pastry, CAN |

### 2.2 Overlay Optimization Methods

Conventional topology optimization methods identify and connect with physically closer nodes as overlay neighbors, which results in shrivel of the search scope [41]. Several efforts have been made to deal with the mismatch problem without reducing the search scope, but they either require time synchronization among the involved peers or they should have a low convergent speed.

Yunhao Liu, in [40] presented a scalable bipartite overlay (SBO), an approach for overlay topology optimization by identifying and replacing the mismatched connections. SBO makes use of a proficient approach for distributing and optimization the tasks in peers with various colors.
and white). Design of SBO includes four different phases such as Bootstrapping a novel peer, Neighbor distance probing and reporting white peers, FC (Forward Computing) by red peers and direct neighbor replacement by white peers. Simulation studies of SBO when compared with other existing techniques shows that it reduces the traffic cost by 85% and about 60% of reduction in the query response time which outperforms state of art approaches addressing the topology mismatch problem. SBO can be used to complement other search techniques, such as forwarding-based search mechanisms or cache-based schemes.

The limitations of SBO include the maintenance overhead for storing the color information of all the nodes and also the query response time of SBO is quiet high.

2.2.1 Location aware topology matching (LTM) method

An algorithm is designed by Lionel M. Ni. in [3] for designing an well-organized logical network to remove low productive connections and to choose physically closer nodes as their logical neighbors by still retaining the search scope without decreasing the response time for queries. LTM is scalable and distributed as it doesn't require any comprehensive awareness of the entire overlay network where every node optimizes the association of its logical neighbors.

Design of location-aware topology matching (LTM) approach includes source peer probing, TTL2-detector flooding and Low productive connection cutting. Every peer issues a detector within a very small
region, so as the peers which receive the detector will be able to hold information about virtual delay. Depending on the delay information, the recipient can detect and cut most of the inefficient and unnecessary logical links to add much nearer nodes as their direct neighbors [48]. The simulation studies portray that the whole traffic cost along with the response time of the queries can be appreciably reduced by LTM which avoids shrinking of the search scope.

Lionel M. Ni. Illustrates LTM, in multiple environments such as dynamic and static. Static Peer-to-Peer environments shows noteworthy performance which is an added advantage of LTM as it is constant within a variety of network sizes and average number of neighbors. In dynamic environments, the best possible LTM frequency within a new pragmatic peer-to-peer environment is portrayed. The simulation studies of LTM when compared with existing approaches show that around 75% reduction on traffic cost and up to 65% reduction on query response time.

The limitation of LTM is that it requires Network Time Protocol (NTP) for synchronization of events in the peers. It also introduces additional overhead to probe the distances between the nodes.

2.2.2 Metropolis-Hastings scheme

Hung-Chang Hsiao, in [44] presented a analytical model driven topology matching algorithm based on the Metropolis-Hastings scheme to
minimize the traffic cost and communication delay between the peers. The key feature of this topology matching algorithm is that it allows communication delay in routing a scoped broadcast message from node s to node t, to approximate the delay between node s and node t within the physical network. In this approach any peer in the system can be connected with the maximum possible number of geographically closest peers. In addition, when compared with the far-away peers, the peers within the proximity of the physical network connect to one another in higher probability.

The simulation studies shows the topology matching algorithm outperforms when compared with the state-of-the-art solutions designed for attacking the topology mismatch problem and also it portrays remarkable results in terms of broadcast delay as it minimizes the broadcast delay and maximize the broadcast scope.

2.2.3 Topology Construction Algorithm

In [45] Wang Bin proposed a topology construction algorithm which is based on fuzzy clustering for partially decentralized overlay network. The presented algorithm make use of centralized landmarks for reference to examine RTT (round-trip time) values between landmarks and the joining node. Because of the autonomous status of overlay protocols, it is applied in partly decentralized overlay. Algorithms intended to build a consistent topology were proposed to encourage topology similarity degree, for centralized, decentralized and partially
decentralized overlay respectively. The main purpose of considering similarity in topology is to decrease latency stretch of overlay, which is defined as ratio of average latency between nodes within overlay to that in the underlay. It is essential to obtain the latency information between the nodes in underlay.

Wang Bin studies are carried on by examining mismatch in topologies among overlay as well as underlay and by considering uncertain relation of network distance between the nodes, specifically fuzzy relation, clustering scrutiny of fuzzy mathematics is used in the direction of forecasting network distance among nodes based on nodes landmark propinquity vector gained by landmark and RTT techniques. Adding together the algorithm is implemented both on homogeneous networks as well as heterogeneous networks.

### 2.2.4 Adaptive Overlay Topology Optimization

Yunhoa Liu presented Adaptive Overlay Topology Optimization (AOTO) [62] scheme, an algorithm to design an overlay multicast tree between every source node and its immediate coherent neighbors in the direction to improve the mismatch problem by selecting nearer nodes as logical neighbors, at the same time it provides a superior query coverage range. AOTO is scalable and absolutely distributed specifically it doesn't require awareness of the entire overlay network when each node optimizes the connection with its logical neighbors as. For instance
AOTO in Gnutella-like peer-to-peer network, the ART (Average Response Time) of every query is reduced by 40%.

Design of AOTO includes two phases namely, Selective flooding and active topology. Selective flooding builds an overlay multicast tree between each peer and its logical neighbors to route messages on the tree and to reduce flooding traffic without shrinking the search scope. Active topology optimizes overlay and reduce topology mismatch problem by replacing non flooding neighbors with closer nodes as direct neighbors. In addition to the transparency, the AOTO algorithm is only relative to the average number of logical neighbors. This approach also introduces large overhead in forming graph for networks in large scope and does not consider dynamically joining and leaving of the peers. Further, this approach is easy to implement and adaptable to the dynamic nature of peer-to-peer systems.

2.2.5 Common Junction Methodology (CJM)

Shashi Bushan [47] proposed a Common Junction Methodology (CJM) that reduces the logical network traffic at physical level. CJM identify common junction among the accessible paths and traffic is routed only all the way through the common junction and not through the conservative identified paths. Simulation results show that CJM determine the mismatch problem and notably diminish unnecessary P2P traffic. CJM can be implemented on structured as well as unstructured peer-to-peer networks and also minimizes the query response time for
the network. CJM doesn’t modify overlay topology and functions without disturbing the search range of the network. But the problem with CJM is that it requires the modification of underlay physical topology protocols which is not feasible for the current internet topology.

M. Ripeanu in [48] illustrates that the flooding-based routing algorithm that generate 330 TB/month in a Gnutella network with only 50,000 nodes, considering the fact that internet consists of nodes more in number. Decentralized information distribution and the discovery techniques will be the enhanced options for the exploitation of peer-to-peer networks.

The simulation studies and results of CJM portrays remarkable outcome in reducing the traffic cost and minimizing the response time of the network. CJM provides a solution to the topology mismatch problem in the direction of reducing the search scope and it had the capability to work on any overlay topology, centralized or decentralized topology.

K. Aberer in [24] has discussed graph based performance techniques that address the topology mismatch problem to provide efficient solutions for the proposals discussed above. To understand design trade-offs in unstructured peer-to-peer networks, random graph based performance evaluation techniques are required. A bipartite random graph is designed based on the connections between the peers and super peers (in Gnutella terminology they are called as leaves and ultra-peers). The queries are forwarded to the super peers and then to
the normal peers that are connected to super peers in a random graph [62]. Either level of peers is taken into consideration to address the problem of topology mismatch between overlay network and physical network throughout the internet and peers, super peers are segregated into their respective groups.

Gnutella application topology with input model parameters are considered at both levels and experiments are conducted on those parameters. The simulation results show that the modeling technique evaluates the effect of locality awareness on nodes in the network. Most of the peer sampling algorithms experience many topology related problems as they need to design random graphs and node tables which are hard to evaluate efficiently and correctly. To allocate link transition probabilities of a peer-to-peer network, two distributed algorithms are proposed in [12] to estimate largest eigen values of the network.

In [36] some peer-to-peer file sharing systems optimization is done by considering the bandwidth of each node in the network and a threshold value is considered for the downloading capacity of each peer based on its bandwidth and each peer chooses its service peer based on its download speed and file size. Topology mismatch and the low efficiency of the nodes are reduced in the above discussed manner and it can be applied for current peer-to-peer system.
The peer-to-peer protocol, Gnutella also experiences the topology mismatch problem between underlying physical network and overlay network that leads to inefficient usage of physical network. In order to improve the scalability and performance of the Gnutella protocol significant changes are made to bring out the techniques that measure and analyze the robust performance of Gnutella peer-to-peer network. Quasi constant distribution component and power law component [31] are combined to form multi-modal distribution to analyze Gnutella connectivity of a node. This process enhances the reliability such that simulation results without this technique shows inefficient performance. Two approaches that are mainly focused to evade the topology mismatch problem and to design the peer-to-peer network are discussed below [62].

To construct an efficient peer-to-peer network the node should be aware of its locality similar to the distribution of HTTP requests in the network. Introducing query caching scheme in dynamic peer-to-peer network that relies on the user interest improves the performance of the overall network.

Another way to improve the dynamic peer-to-peer network is to replace the flooding mechanism to forward queries by group communication mechanisms and smart routing techniques. One of the ways to protect dynamic and adaptive nature of Gnutella protocol and to reduce the resource consumption is to use broadcasting techniques combined with query forwarding mechanisms. The huge amount of data
from the virtual space on which Gnutella operates is collected and used in simulation studies. The solution discussed in [34] is feasible and guarantees the efficiency, robustness of peer-to-peer network that reduces the topology mismatch problem by constructing the overlay using super-nodes and Information Exchange scheme named SOBIE that differs from other peer-to-peer overlays such as structured, unstructured, meshed and tree-like peer-to-peer overlay. SOPHIE is designed in such a way that it reduces the topology mismatch by considering the super peers, the delay between the nodes and the time of information exchange between two peers.

The information regarding peers is exchanged among the nodes in the network when required. The mechanism addressed in [31] to find and stop free riders, where a free rider is a peer that uses the services of the other peers without contributing its own services which leads to the same problem as occurred by topology mismatch problem in peer-to-peer networks. By considering the factors such as total number of query messages, the query success rate, the average query hops, convergent speed and system connectivity, the simulation studies on SOBIE [56] has achieved robustness and high efficiency in peer-to-peer networks.

In [64] as the peer-to-peer systems are not aware of the underlying network it has mainly two drawbacks. Firstly, the average latency between any two neighbors in peer-to-peer overlay is amplified as each peer doesn’t actively communicate with the peers closer to IP layer
having smaller latency. The second disadvantage is that, the IP path for every peer-to-peer overlay connection will have huge number of routers which specify that even a single, 1-hop, the message within the peer-to-peer overlay must travel through a lot of routers as well as autonomous systems before it reaches its destination. One of the major reasons behind the observed peer-to-peer traffic in the Internet [65] is inefficient routing. As of now, most peer-to-peer systems are mainly concerned with file-sharing.

2.3 Summary

This chapter mainly focused on a survey of the problem “topology mismatch” in P2P unstructured networks. This chapter mainly gives the overall existing techniques that are stated in the problem.