CHAPTER 3

SYSTEM OVERVIEW

3.1 INTRODUCTION

Peer-to-Peer (P2P) technology is attracting a lot of attention since it simplifies the implementation of large ad-hoc distributed repositories of information. Decentralized and unstructured P2P systems are most commonly deployed in today’s internet. Unstructured P2P systems are creating a large portion of network traffic due to their good support for sharing of resources, CPU cycles, and information by peers. In addition to the above, P2P efficiency in computing domain as the extent to which software performs its intended functions with a minimum consumption of computing resources. Due to much traffic, there is delay in transactions. Traffic cost is one of the parameters, network administrators are seriously concerned with. Heavy network traffic limits the scalability of P2P networks. When a query message touches too many unrelated peers in the network, it makes more cost overhead. Reducing query response time with minimum cost overhead in unstructured P2P systems are very important research issue.

Along with the above, P2P security is considered to be more difficult to achieve than traditional security based on the central servers. In P2P networks users continuously access resources provided by other unknown users which, therefore, can be untrustworthy. In all these interactions, the nodes act both as clients (asking for resources) and servers (Providing resources). They can be used to know the degree of confidence that can be put into the nodes with which one has interacted (reputation). This
reputation information can be stored and shared using reputation systems. This way, a reputation system can be used to determine which nodes are trustworthy and which are not. In fact, reputation may be taken into account when making any kind of decision that requires interaction with other nodes. However, when compared to structured P2P systems, unstructured P2P system faces more challenges due the characteristic of dynamic leaving or joining the peers. This lead to the development of new techniques to tackle these challenges. With this in view, this thesis aims at presenting a robust system for reducing query response time by avoiding unnecessary message duplications with minimum cost overhead. This thesis also discusses the issues in securing messages, and presents their solutions in the following Chapters.

This short chapter organized in three sections, which gives a global view of the proposed system for reducing query response time with security. An overview of P2P traffic and query forwarding techniques with cost overhead are presented in the first section. In the second section, an overview of security issues are briefly introduced, which is helpful to understand the related techniques that will be proposed in the subsequent chapters. The third section mainly presents and discusses the performance metrics used for evaluation in this thesis.

3.2 DESIGNING QUERY FORWARDING ALGORITHM AND REDUCTION ON QUERY RESPONSE TIME (RQR) IN P2P SYSTEMS.

The query forwarding and computation of response time in unstructured P2P systems can be divided into the following sub tasks.
- **Identification of Pees (PID):** Once a peer has joined the P2P system, it will periodically ping the network connections and obtain the IP addresses of other peers in the network, which will be used to create new connections for the peer’s rejoining or in case the peer loses some of its connections with its neighbours due to the neighbours departure or failure, or faults in the underlying networks.

- **Source and Destination peer:** The peer which initiates the first query to forward to all other peers is known as source peer. Among the existing peers in the network, the peer which responds the query is known as destination peer.

- **Query Hit:** A query is sent and resent until a certain criteria is satisfied. The number of query hits highly depends on the number of total visited nodes. When the query gets hit by the responder, the process identifies number of links in the system.

- **Response Delay:** When a response is not arrived within the time slot then it is called response delay. It is measured as the time difference between the response received and the time slot.

- **Optimal Path:** The entire existing path between source and destination peer are identified. The path which takes minimum response time to traverse from source to destination peer is labeled as optimal path. This path is used for query processing.
- **Response Time**: Response time of a query is defined as the time period from when the query is issued until when the source peer receives a result from the first responder.

- **Number of duplicate messages**: The RQR maintains a table where it stores the IDs of duplicate messages and the directions (i.e., neighbour peers) from where they arrive. Once a message is identified as a duplicate, it is discarded.

Figure 3.1 shows an example of query message processing in a P2P environment. The proposed RQR design is based on broadcast method, which uses query flooding to propagate queries. Here, every neighbour peer is contacted and forwards the query message to its own neighbours until the query gets hit. In Figure 3.1, peer A initialize a query message msg. Peer A broadcasts msg to B and C. Similarly, B and C propagates msg to D. Since D gets query hit, D is labeled as destination peer.

![Figure 3.1 Example of query processing in P2P System](image-url)
The proposed RQR design tag query messages with unique identifier, and each peer maintains a list of recently received messages. When a new message arrives, the peer checks whether it has already been received through another path. Note that D receives the same message two times. If this is the case, it simply discards the incoming query message. The metric to measure the network delay between peer is known as traffic cost. Every link has forward and backward response time measures. For example, the response time between peer A to B is denoted as A\(\rightarrow\) B, and B to A is denoted as B\(\rightarrow\) A, and the weight of the response time is recorded in adjacency matrix table. The proposed optimal path algorithm (OPA) is used to find set of all possible paths exists from source node to destination. Among them, the path which has minimum response time is considered as optimal path.

As the thesis focuses on the reduction of query response time, the processes associated with RQR are avoiding unnecessary traffic by eliminating message duplications during query processing. It is assumed that source and destination peer changes based on the peers who are connected in the overlay network.

3.3 SECURITY ISSUES IN P2P SYSTEMS

P2P systems generally require a remarkable amount of trust from their participants. A node must trust that other nodes implement the same protocols and will respect the goals of the system.

- **Reputation Model:** A system that collects, distributes, and aggregates feedback about receivers past behavior. All the interactions in which the nodes act both as clients (asking for resources) and servers (Providing resources) can be used to know the degree of confidence that can be put into the nodes with which one has interacted (reputation).
• **Trustworthy Peer**: Every peer maintains its past transactions. By keeping track of transactions from source to destination peer, and based on the transactions, label it as satisfied transactions (ST) or unsatisfied transactions (UST). From the set of total transactions find the trustworthy peer.

• **Transaction Success Rate (TSR)**: Trustworthy peers always produce satisfactory transactions. The number of satisfactory transaction in a regular interval is measured as TSR.

As the other part of the thesis focuses on the securing information in RQR design, the processes associated with optimal reputation model (ORM) are identifying trustworthy peers to evaluate the transaction success rate.

### 3.4 METHODOLOGIES

Two different methodologies of query forwarding techniques are proposed. A solution to the message duplications which causes more traffic in P2P system is also presented. The experimental results for different sets of data arrived from the overlay network will be presented to demonstrate the high-quality performance of the approaches.

#### 3.4.1 Reduction on Query Response time (RQR) Method

The observation from literature that a separate algorithm needs to be designed for query forwarding sparked the idea to develop a unified scheme to identify the path and visits the peer which are necessary, so as to make the system suitable for unstructured P2P environment. The various factors that motivated this research are:

• The need for a path through which the query is sent and received so as to reduce the time of traverse.
• The need for avoiding unnecessary message duplications, so as to reduce the traffic.

• The need for traversing through links which are necessary, so as to compute the traffic cost overhead.

Two different query forwarding methods are presented to tackle the issues in the literature with two different philosophies, which are made ready for the optimal path.

3.4.1.1 Minimum Spanning Tree (MST)

In order to develop a common path from source to destination, P2P systems form a rich connected graph on which shortest path spanning tree is constructed. When a graph G is connected, a depth-first search starts to visit all the vertices in G. In this case the edges of G are partitioned into two sets (tree edges) N (for nontree edges), where T is the set of edges used or traversed consisting the search and N the set of remaining edges. The set T may be determined by the statement $T=TU\{(v,w)\}$ in the if clauses of DFS. Any tree consisting solely of edges in G including all vertices in G is called a spanning tree.

The representation for graph G (V, E) can be of adjancy matrix of two dimensional $n*n$ array. Here E represents the physical link with weight as the time taken to traverse from one node another. An undirected structure with response time recorded as minimum can be considered as path through which the message can be sent and received. Generally, as long as cycles exist in search paths, there will be message duplications in overlay connections. If a peer receives a query message with the same message ID as the one that it has received before, then the peer will discard the message. This method is more accurate when the searching is based on the random walk, where the peers are
selected randomly. Since the approach to forward the queries is based on random walks, the average query hit ratio differs based on the overlay topology.

### 3.4.1.2 Optimal Path Algorithm (OPA)

This approach is designed to improve the robustness of the MST method for handling existence of cycles in network. This system is an efficient method to select query forwarding paths and logical neighbours. In RQR (Reduction on Query Response time) design, $G$ the given Graph with $G (V, E)$ as structure, where $V$ represents the set of all peers and $E$ represents the link between two peers. All peers who are connected in the network are in ready state to probe or compute the queries. When a peer initiates the query message to send to all its logical neighbours who are connected directly, the time is recorded in the database. As soon as the query gets hit the response received from the first peer are also be recorded.

In this process of query forwarding technique, if any peer receives a message with same message ID which exists in the message duplications table then the message can be discarded. The peer that gets first query hit is labeled as destination peer. The optimal path algorithm finds all the possible paths existing from source to destination along with the optimum path through which the query can be forwarded. After computing all the above, the query is forwarded through the optimal path and the time taken to send and receive the queries are recorded as Adjacency matrix. At initially time quantum is assigned along with system time for peers. If any peer is not arrived response within the time quantum given to them, then the queries are resend until a query gets hit and the waiting time is calculated along with the processing time.
This algorithm is introduced to select the optimal path to distinguish the path which is possible to traverse from source to destination in minimum time interval or minimum response time. Along with above performance metrics the path minimizes the number of duplicate messages and thereby reduces the traffic and traffic cost overhead. This algorithm is designed to visit the nodes which are necessary for transactions. The optimality of this algorithm provides an improved system performance in both the way by improving system efficiency and quality of service (QoS).

### 3.4.2 Optimal Reputation Model (ORM)

Different works reported in the literature demand the development of new techniques for the P2P systems to provide security during message transactions. This challenge is met by identifying trustworthy peer in existing scenario by ORM technique.

Here, an approach is proposed in which all the peers in the P2P network are identified by identity certificate. The reputation of a given peer is attached to its identity. The identity certificates are generated using self-certification, and all peers maintain their own certificate authority which issues the identity certificate to the peer (Zhu et al 2009). Peer trust allocates the reputation information to a certain node on the network for storage, by using hash functions (Chun–Hsin, and Chun-Wei Huang 2009). The authors of Peer Trust (Zhu et al 2006) argue that trust models based solely on feedback from other peer in the community which is ineffective and inaccurate. The Authors recommended the “degree satisfaction” of the peer from previous transactions and the number of transactions a peer performs in the system should be accounted for before calculating the reputation of the recommended peer.
On the other hand multilevel reputation system maintains each peer’s reputation level according to its periodic contribution to other peers in the network and can encourage free-riders to share their resources. But the periodic contribution is also an accumulative value; it cannot respond to the dynamic behaviors of peers (Runfang et al 2008). The researchers (Zhou et al 2008) store reputation data in the form of a binary search tree over the network. Any agent looking for the recommendation data of another agent searches the P2P network and computes the reputation from the recommendations received. Along with reputation, the proposed RQR system generally requires a remarkable amount of trust from their participants. A node must trust that other nodes implement the same protocols and will respect the goals of the system.

Definition 1: Define $T_{ij}(n)$ as the trustworthy of peer $j$ in the view of peer $i$ for the $n$-th direct transaction. The value of $T_{ij}(n)$ can be gained according to the satisfaction level of peer $i$ to the $n$-th service from peer $j$.

Definition 2: Define $W_{ij}(n)$ as the adaptive transaction importance in the $n$-th transaction between peer $i$ and peer $j$. The bigger the value of $W_{ij}(n)$ is the more important transaction.

Definition 3: The symbol $T_{ij}$ expresses the total trustworthy of peer $j$ in the view of peer $i$ based on its direct interactions with peer $j$.

$$T_{ij} = \frac{\sum T_{ij}(n) \ast W_{ij}(n) \ast (1-\mu)(M-n)}{\sum W_{ij}(n) \ast (1-\mu)(M-n)}$$

Where, $\mu$ is time delay and it determines the weight given to the most recent past observations. $M$ denotes the total number of direct interactions between $i$ and $j$. 
Definition 4: The transaction successful ratio (TSR) is defined as

\[
\text{TSR} = \frac{\text{Number of satisfied transactions (ST)}}{\text{Total number of transactions (TST)}}
\]

An attempt was made to integrate all the above mentioned factors such as reputation, trust evaluation malicious peer and self assigned identifiers to build a unified framework for providing security during message transactions. The integration of all the above factors yields promising results by reducing the number of malicious transactions in the proposed RQR system design.

3.5 SYSTEM REQUIREMENTS

This thesis is intended to reduce the unnecessary traffic and provides security in unstructured P2P environment effectively. So, query processing techniques for various methodologies in this thesis are implemented using Java software. MySQL are used as database to store all the transactions during the process of forwarding query messages and to identify the trustworthy peers.

Software and Hardware requirements for this thesis are listed below:

**Software requirements:** JAVA, JMS (Java Message Service), My SQL.

**Hardware requirements:**

- Computer with CPU of 3.0 GHz
- 2 Gbytes RAM
- 80GB Hard disk drive
- CD-ROM or DVD-ROM drive
- Keyboard and a Microsoft Mouse or some other compatible pointing device

3.6 DATABASES FOR EXPERIMENTS

This thesis is proposed to handle traffic with different types of query messages, different set of peers and also provides trustworthy peers to make the P2P environment healthier. These data are collected during different scenarios in query forwarding and message transactions.

**Query forwarding:** For this process, data set of query processing has been gathered from the records of the following databases.

- **Response Time:** Table to store the response time of two dimensional n*n array (the data can be stored as \( A \rightarrow B = 5\text{ms.} \)). Name of the table is RTT (Response Time Table).

- **Message Duplications:** This stores the count of the number of duplicate messages arrived in a peer (MDT Message Duplication Table).

- **Query Hit Rate:** The total number of query get hits before the query timed out (i.e. TTL=0) (QHT Query Hit Table).

- **Response Delay:** The time difference between the response and the time slot assigned to it (RDT Response Delay Table).

- **Message transactions:** The number of messages that traverse the overlay connection (MTT Message transaction Table).
- **Structure table (ST):** Which maintains the number of physical link exists and logical neighbours in an overlay network.

  The above data are generated in two scenarios, namely (1) Periodic and (2) Event driven.

  1. **Periodic data generation:** In this each peer conducts neighbour distance probing at a predetermined time interval (TI).

  2. **Event driven data generation:** This produces and sends an updated table to its peer only if there is a change in its logical connections with its neighbours leaving or an peer’s joining as its new neighbour

**Optimal Reputation Model:** For this process, data set of transactions has been gathered from the records of the following databases.

- **History table (HT):** The table has the data of past transactions.

- **Transaction Success Rate (TSR):** The number of satisfactory transactions in a regular interval is measured as TSR.

### 3.7 PERFORMANCE METRICS USED IN RQR DESIGN

The following metrics are used to compare and analyze the performance of the proposed design.
• **Query Hit Rate**: The query hit rate measures the effectiveness of OPA algorithm and is defined as the average percentage of queries that are resolved successfully.

• **Query Response Time**: The time delay between peers when messages are in transit.

• **Traffic cost overhead**: It is a function of network resources used in an information search process and other related expenses.

• **Trustworthy peer**: During query message transactions if number of satisfied transactions is more than unsatisfied transactions in a peer, then it is known as trustworthy peer.

• **Transaction successful ratio (TSR)**: TSR is defined as the ratio of the number of successful transactions over the number of total transactions.

### 3.8 SUMMARY

This chapter has introduced a global view of the proposed system for reducing query response time and to provide secured transactions in an unstructured P2P environment. In the first section, an overview of query forwarding technique is presented. The second section has briefly introduced an overview of the proposed Optimal Reputation Model to overcome the security issues. The third section mainly has discussed the characteristics of the databases used for evaluation, and the performance metrics are used to compare and analyze the performance in this thesis.