Peer to Peer Resource Discovery Mechanisms in Grid Computing: A Critical Review

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Abstract- **In computing systems such as the Grid, computing systems provide a lot of resources across multiple administrative domains to in order to handle a huge task. The major challenge faced by the system is to find the right resources on the network. In this paper, we review the resource discovery peer to peer approach that has been used in distributed computing systems. This paper also provides a discussion that shows the differences between the mechanisms considered for scalability, dynamism, reliability and real consultations as well as directions for future research .**

Index Terms— Peer to Peer, Super Peer, Overlay, Mechanism, Resource Discovery.

I. INTRODUCTION

The using term of "Grid" was introduced in 1990 for solving extensive and intensive problems in physical and mechanical information [1]. NASA IPG [2], World Wide Grid Health and Selenium Grid [3] are few examples for networking systems. The computing system of Grid has shown rapid development over networks indicating that computing systems which have high power are available for simple applications; Data Grid [4], which provides a framework for the synthesis of new information from data repositories such as digital libraries and distributed data stores in a wide area network; Information about the network is to integrate information across heterogeneous data sources; Grid services, offering services that cannot be provided by a single computer; wireless network that allows users to share mobile and wireless computing resources, services and information support network that provides the infrastructure for multimedia applications in real time as well as cloud computing. Network architecture has a structure similar to the structure of the internet protocol. The Grid architecture network comprises four layers; collective, fabric, application and connectivity layer [5].

In Grids, resources, including Internet tools, space for storage, computers and cluster of computers, data and programs are widely distributed and heterogeneous as compared to cluster and traditional systems. One of the essential challenges in Grid is discovering of the resource based on the requested task, discovers appropriate resources. Factors that make the resource discovery problem difficult to solve are heterogeneity of resources, distributed ownership, dynamicity and resource evolution, reliability, resource failure and the huge number of resources. For designing a good resource discovery method these factors are necessary [6]. Peer to peer mechanism is usually considered as a technology in which data is shared across a large number of peers and is more successful than centralized approaches [7]. This system is connected to the internet and is a self organizing system with high storage of resources and information. The basic advantage over other approaches is that each peer has equal opportunity to provide services with equal capabilities and roles [8]–[11].

A popular type of P2P systems is P2P computing, it is a distributed computing paradigm that uses large numbers of autonomous hosts as a platform for executing applications. Another important type of P2P computing systems is P2P Grid, which efficiently manages the Grid resources and services in large scale distributed environments and combines web service, Grid and Peer to Peer networks. Further Peer to Peer network is divided into structured, unstructured, hybrid and super to peer networks [12]–[14].

In this article, we provide a comprehensive review for peer to peer approaches. Section one presents unstructured peer to peer mechanisms, whereas structured peer to peer mechanisms are presented in section two. Section three reviews peer to peer hybrid mechanisms. A summary of peer to peer mechanisms is presented in section four. Finally, we conclude the paper in section five.

II. UNSTRUCTURED PEER TO PEER MECHANISMS

The Peer to peer mechanism is usually considered as a technology in which data is shared across a large number of peers and is more successful than centralized approaches [15]–[17]. This system is connected to the internet and it is a self organizing system with high storage of resources and information. The basic advantage over other approaches is that each peer has equal opportunity to provide services with equal capabilities and roles. Distributed data stores in a wide area network; Information about the network is to integrate information across heterogeneous data sources; Grid services, offering services that cannot be provided by a single computer; wireless network that allows users to share parts: request processing, overlay construction, membership protocol and preprocessing. Each member in a Virtual Organization publishes information on at least one local server. Each node may give data about one source or several sources. The requested information is provided to a node known by

the users; it responds with a corresponding resource explanation if this node has the requested query; otherwise it forwards the same information is requested to another node. The information is forwarded by the Intermediate nodes till the time matching resources are found or its TTL expires [20].

The authors in [21] proposed the others a P2P system in which individual resource is defined by a set of linked attributes, used for the discovery of resources in a dynamic Grid where peers hold a set of resources at local level. Depending on bit vector RI (Routing Index) explains a routing strategy, in which queries can be routed through the nodes where they are chances to find their matches, the bit vector indices are applied on two peer topologies. In the first topology peers are simply connected via a tree shaped network based on a single tree. In second topology the inter group links are random in which the network is same as bunch of trees which includes a large number of nodes.

The bit vector indices are applied on two peer topologies. In the first topology peers are simply connected via a tree shaped network based on a single tree. The internal design of the network is similar to the tree and the connections within the group are random. The mechanism is also important as it supports the queries with multi attribute ranges. By using a separate DHT for each attribute type, multi-attribute queries have been resolved by using several mechanisms [22].

There is another proposed solution which is based on the network of trees. This solution is easier as it introduces a hierarchical P2P network, which not only preserved simplicity, but is also easy to manage. Although this approach does not recall 100 % because the queries are not capable to retrieve all matching resources, but still RI information can be maintained easily.

The authors in [23] have proposed an unstructured P2P mechanism which is known as LARD (Learning Automata based Resource Discovery). This was introduced to solve the issues of previous methods as it was a decentralized resource discovery algorithm for large scale unstructured P2P Grids. This was introduced to find the shortest path that contains the minimum hops and help the user to connect to the peer that provides the requested resource. This method uses a communication link selected by automaton randomly on which each peer chooses to route the resource provider. Algorithm rewards the selected route if at each stage it selects the route which is shorter than the average of the routes selected before. On the other hand, if the route is not smaller than it is penalized. Thus, as it proceeds, the algorithm proceeds on the route whose expected length is minimized. Thus, algorithms support the P2P Grids in which the peers randomly join leaves and rejoin the whole process. This algorithm provides help for the queries with multi attribute range and also reduces the flooding effect on the performance of the network. It is evident from the results that the proposed algorithm shows better performance in terms of the average hit ratio, average hop count and control message-head in different scale Grids. But one thing is that the number of hops that are used to deliver the service to the requester cannot be confirmed [24]. Figure 1 presents the unstructured peer to peer concept.

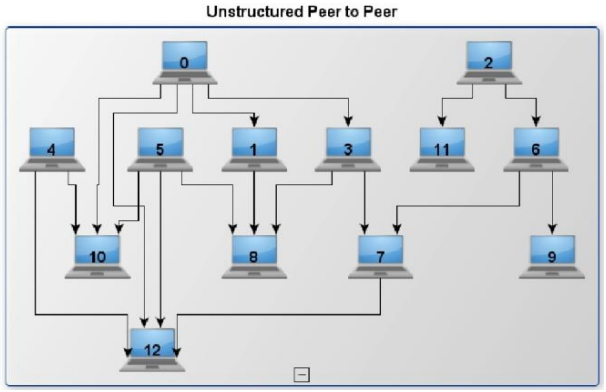

Fig 1. Unstructured peer to peer.

III. STRUCTURED PEER TO PEER MECHANISMS

In this section, we will also discuss the basic properties of a structured P2P mechanism [25]. In structured P2P systems the resource indices are organized and inflexible structure is employed to interconnect the peers. DHT is used to prepare these systems and includes a distributed indexing service based on hashing [26]. The same hash function is used in mapping the resources and peers to a key space. The core of queries in P2P systems is mainly due to the reason that they do not support direct key word searches. Four mechanisms that describe structured P2P systems are explained below [27]–[29].

Chord is the first structured P2P system, introduced in 2001 with frequent node arrivals and departures, is a scalable protocol [30]–[33]. The same hash function is used to map both peers and resources to a bit key space. According to their keys these peers are ordered in one dimensional circle. The lookup process follows the binary search in such a way that the index of all resources whose keys fall in the range of peer, each peer stores it if it is between the predecessor and its own key. The load balance is also achieved as each peer has the responsibility of equal number of keys thus increasing probability.

The authors in [34] introduced another P2P system named as CAN (The Content Addressable Network). Unlike Chord, the defined structured could be secured with very little effort. In this method the neighbor node located near the resource node receives the message. The basic operation includes deletion, lookup and insertion. Despite of the key space or the size of the network, the system tries to minimize the number of each peer's neighbors. CAN does not support range queries even if it is self organizing, fault tolerant and highly scalable. If the data is lost, it does not provide any mechanism for availability of lost data. The CAN based DHT system was expanded by [35] into an indexing infrastructure using Space Filling Curve,

which supports efficient handling of dynamic data and allows querying of ranges. By extending Chord with locality preserving hashing, [36] proposed MAAN, a mechanism which handles multi attribute range queries. MAAN uses locality preserving hashing functions. MAAN maps the valuable information to Chord for attributes with numerical values. MAAN achieves good load balancing among node as it distributes resources to all nodes uniformly. If the attribute are already known and attribute scheme of resources are fixed than MAAN can hold multi attribute range queries well.

The authors in [37] proposed an ACO (Ant Colony Optimization), algorithm used for the discovery of resource in large scale peer to peer Grid systems. In this mechanism a query message is represented by each ant. To locate the resources, the ants walk randomly from nest to nest. They will take the same path to return to their original nest, if the ants find the required resources. In terms of their memory they update the routing information on the path. According to the routing information the other ants, which are looking for the same resources, will travel in the system. Thus to travel in the system this method helps most of the ants to choose the shortest path. While reducing the network resource utilization, by sending the packets along the routes that are more often traveled by the ants, this technique avoids a flat flooding by employing multiple ants which can work in parallel the searching efficiency can also be improved. The hit ratio in this mechanism is high with the maximum distance of network.

When it is required the ants can carry a large amount of information in their memory. The mechanism supports multi attribute range query because multiple user requirements stored in memory. Since the Grid users should be able to locate resources with multiple requirements this feature is very important for a Grid system. Figure 2 presents the abstraction view of structured peers.

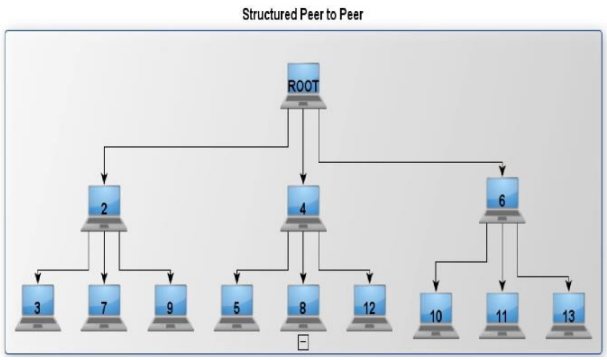

Fig 2. Structured peer to peer.

IV. SUPER TO PEER MECHANISMS

This section discusses the super to peer mechanism of resource discovery in this section. This approach is a convergence of P2P models and Grid environments is a super to peer mechanism. In this mechanism a super peer, serves as a Virtual Organization (VO) in the grid, connects with other super peers to form a higher level network. All peers are super peers in this high level network. To connect many clients' peers to super peers acts as a server and perform tasks such as routing and surfing. In order to achieve a balance between the inherent efficiency of centralized search, load balancing, the autonomy and fault tolerant, these mechanisms are originally proposed after distributed searches.

Gnutella [10], [25] suffers from drawback caused by flooding and it does not scale well in very large networks. In 2002 Gnutella2 was released which tries to solve the drawbacks of Gnutella. There are two types of nodes in Gnutella2: the first type is super peers/hubs and the second type is normal peers/leaves. Single leaf makes one or two connections to hubs. Compared to original Gnutella this approach considerably makes the system much more scalable and reduces the traffic in the network. Gnutella2 required additional network maintenance as it is more complex than Gnutella. This increases the susceptibility of other malicious attacks on the cluster heads.

In 2001 a P2P system was introduced with the name KaZaA [38], it adopted the super peer model in its design. To share resources without any servers, KaZaA is used. In order to connect to a peer to peer network, KaZaA is one program that can be used on a specific machine. There are two types of nodes in KaZaA, leaf nodes and super nodes. When overlay network joins a super node the leaf node sends a report of its resource indexes to the super node. In order to locate the resource search process in the overlay network initiates as soon as a node looks up a resource. Because of its hierarchical architecture KaZaa is more scalable than Gnutella. But as the queries are routed regardless of their content KaZaa cannot support complex queries.

The researchers in [39] proposed a P2P based Grid information service the model of super to peer.

This mechanism provides fault tolerance features, load balancing and autonomy for resource discovery. Single point of failures in each cluster is faced by this mechanism because a super peer node acts as a centralized server for a number of regular peers. This mechanism use of TTL in flooding of operations causes false positive errors.

Based on hypercube computational grid [16] anticipated scalable framework for resource discovery in Peer 2 Peer. The mechanism is constructed through twin layers called Circle Hypercube Service Node (CHyperSN) and Hypercube Service Node (HyperSN). Hypercube Service Node (HyperSN) is connected using ring topology and similarly Circle Hypercube Service Node (CHyperSN) is a set of the ring topology/ set of HyperSN. SN is an ordinary node which has a high CPU speed, high bandwidth connection and high availability. In the proposed mechanism, the index discovery service node is the best node in term of reliability of ordinary nodes, which was chosen in order to balance the load in the CHyperSN overlay. Even in the environment with a highly skewed

resource distribution this mechanism provides the well balanced load among SNs in the whole organization. For the HyperRN overlay construction this mechanism also provides a preserving locality protocol based on a distance metric. According to the policies defined by the target organization, routing between various administrative organizations is permitted because this framework preserves administrative control and autonomy. Due to the scattered resource sharing systems with diverse resources and different sharing policies the proposed method is suitable for large scale. Figure3 shows the abstraction view of super to peer mechanisms.

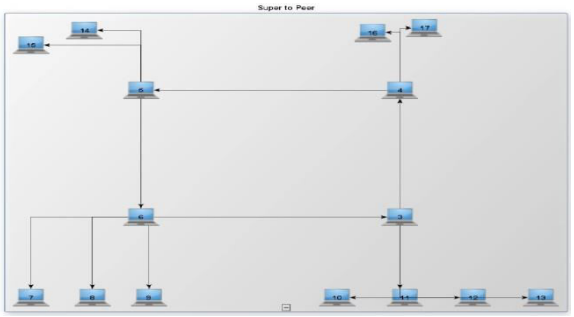

Fig 3. Structured super to peer.

V. HYBRID MECHANISMS

Hybrid mechanisms have been proposed to overcome the drawbacks. While overcoming their inherited drawbacks, these mechanisms benefit from the efficiency of each combining mechanism.

In November, 1999 Jonathan Hess proposed P2P architecture, based on hybrid and associative clustering, which is known as Direct Connect, in which each interest group is being guided by a hub. Hubs are placed on central servers, software that organize the life of each cluster, but do not participate in the resource exchange process. All hubs are registered on the Hub List Server. Hub List Server helps the clients to discover hubs. Similarly as in P2P, a user can directly exchange resources or information with any other user in the same cluster and can freely choose interesting group/cluster.

The hub is required to have a considerable amount of upload bandwidth available because the clients connect to a central source of distribution (the hub) of information. Even on local area networks, Direct Connect requires a user to run a hub. The hub is used for keyword searches, chat and address discovery. While replying to resource discovery queries hubs facilitate to contact between clients and give information about them. In order to increase the probability of finding requested resources in Direct Connect, minimum number of resources are shared by every peers, thus to ensure that a large diversity of data is presented on the network. The hubs have a bottleneck because they are using central servers and are unable to handle all the network traffic of large scale networks. At larger networks Direct Connect scales poorly.

In 2001 Sun Microsystems designed a search system for hybrid P2P architecture which is known as JXTA (Juxtapose) [40]. JXTA is globally decentralized but locally centralized. Using a DHT and a Random Walker, JXTA's search algorithm is a hybrid mechanism. Service Layer, Application Layer, and Core Layer divide the JXTA platform. JXTA performs with six XML based protocols. In a JXTA network, peers are likely to interact through the services they consume or offer. JXTA platform is independent, is more suitable for flexible communication, lightweight and their most important advantage is their interoperability with any other digital device. It is better suited for limited capability devices and has significantly less administration costs. Since modem links slow down the propagation of queries, thus broadcasting a request can reduce the performance.

A hybrid P2P based Grid resource discovery system which supports both push and pull models, static and dynamic information retrieval was designed and implemented by [41]. The dynamic information search is performed in an efficient unstructured way, but for static information the search is performed in a structured way. To locate dynamic information, this mechanism couples the broadcast method of unstructured systems with a structured topology to reduce the effort of providing a global view of the system resources the mechanism combines the completely decentralized P2P paradigm with a limited degree of centrality. Based on the level of service they can provide, the peers are divided into two categories (Super peers and Peers). In this model, each Super peer acts as a server for a number of regular Peers, while at a higher level Super peer connected to each other in a P2P fashion. This method allows for a tradeoff between staleness of providing information and message cost for resource discovery. The participants with high bandwidth acts as super peers and the most of the other participants are normal peers.

In the P2P overlay, Super peers participate normally by taking advantage of the heterogeneity of participating nodes. Peers improve the scalability of the system, as they participate in the system indirectly by connecting to Super peers. Peers give static information to their related Super peer about the resources they manage. Only those peers whose resources match the static criteria receive a query from a Super peer. If the resource information matches the dynamic part of the query the Peers will respond. In this framework, according to a well known DHT based system the Super peers are organized using Chord. Based on static information the Chord structure not only resolves queries quickly, but in the overlay, allows a query to be distributed across all nodes to avoid duplicate messages [33].

Instead of flooding the entire network for each query, to locate the desired information, this mechanism allows the query distribution to the maximum number of nodes. This further reduced the cost of lookup as it depends upon the number of results required by the user and the matching resources. Queries response time will be slow if the query is not answered in the lower layer.

A hybrid discovery mechanism that combines the advantage of clustered solutions and peer to peer mechanisms was proposed by [42]. After analyzing the main limitations of these systems, he studied the existing service discovery and resource architectures in order to remove the limitations. To avoid flooding, queries are forwarded by peripheral nodes. Multicasting is limited to the discovery zone and uses peer to peer communication. This approach leads to Zone Routing Protocol (ZRP) which is based on the idea of zones. For each Grid node a separate discovery zone is defined which is composed of all the neighbor nodes and whose distance to the node does not exceed a certain number of hops (zone radius). This mechanism is adaptable to changing conditions, exhibits low discovery delay, does not require any management effort, reduces bandwidth consumption and is scalable. But the problem here is that the query request is forwarded to the repeated zones and the same query request could be forwarded by the nose several times. A hybrid mechanism is reliable although it has high overhead. Figure 4 shows the abstraction view of hybrid peer mechanisms.

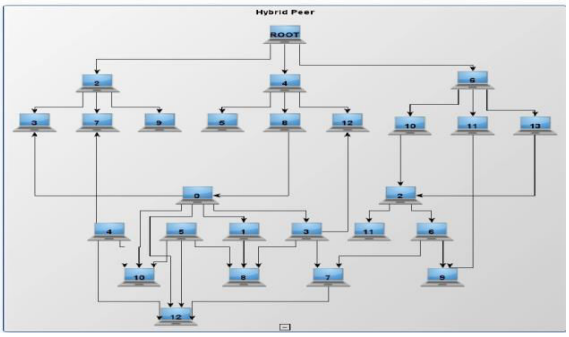

Fig 4. Hybrid peer mechanisms.

VI. PEER TO PEER MECHANISMS COMPARISON

Table 1 presents the strengths and weaknesses for the reviewed mechanisms. In this section we explained four main categories which provide important features about P2P mechanisms. The main advantages of these mechanisms include 1) it is easy to set up these mechanisms. . 2) Unlike server based architecture, all peers share all the resources. 3) In P2P mechanism failure of one peer does not affect the functionality of other peers which shows that central dependency is eliminated, making it more reliable. 4) Since every user is the administrator of his machine and can control their shared resources there is no need for full-time system administration. 5) The maintenance cost of these mechanisms is comparatively very low. On the other hand the disadvantages include 1) administration is difficult because the whole system is decentralized. 2) In these mechanisms, security is low. 3) Since in these mechanisms, each computer should have its own backup system, therefore backup or data recovery is very difficult. 4) Quality of Service (QoS) is not guaranteed.

VII. CONCLUSION

The structured mechanisms in Peer-to-Peer are to support multi-attribute queries, but it faces the issue of the broadcasting network widely. On the other hand the Peer-to-Peer mechanisms which are unstructured face the issue of the broadcasting network widely and false positive errors.

The upcoming researches and work should be based on building a mechanism which covers all the problems faced in the literature.

TABLE I
SUMMARY OF P2P MECHANISMS AND HIGHLIGHTS OF THEIR STRENGTHS AND WEAKNESSES

Mechanism	Technique	Strength	Weakness
Structured	Is based on distributed indexing service	Can support resource diversity and provides scalability, robustness, and Self-organizing; also, support dynamic attribute queries	Suffers from high traffic, low scalability and false-positive errors. It not rapidly changes the information and not fully supports the multi-attribute range queries
Unstructured	Each peer is randomly connected to a fixed number of peers	Is reliable in terms of query correctness, SPF and false-positive errors. It can tolerate node dynamicity, and scalable since complexities are low and load is distributed	Does not fully support the dynamic and multi-attribute range queries and suffers from the network-wide broadcast storm problem
Hybrid	Combines two mechanisms and benefit from the advantageous of them	Provides high reliability	Suffers from high overhead
Super to Peer	Divided into clusters, each clusters having one or more super-peers	Provides autonomy, load-balancing and fault-tolerant. Also support range and multi-attribute queries	Suffers from difficult implementation, false-positive errors, complex clustering procedure, and SPF in each cluster. Dynamic attribute queries not supported

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