Peer to Peer Systems- A Review

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Abstract:
In this paper we see that Peer to Peer networking is a much efficient alternative to Client-Server networking. Unlike a Client-Server network which has a server node we give each node equal right to share and receive data. . In peer to peer networking, when information content is requested, the traffic and demand profile for that particular information content is monitored and then information content is redistributed to decrease the load on the nodes. The environment for peer to peer computing is highly dynamic i.e. nodes will be continuously adding and leaving the system. HTTP, XML, Gnutella, SOAP e.t.c are some of its enabling technologies. A widely known application of P2P is Bit Torrent file sharing system and another one discussed is online multiplayer gaming which involves peer to peer live video streaming.

Keywords- Peer to Peer, Client/Server networking, XML, Gnutella, HTTP, SOA, BitTorrent, peer to peer live video streaming.

INTRODUCTION

Internet has rapidly grown all over these years due to the worldwide networking it offers. Several nodes are communicating with each other over Web. But in large scale networking like World Wide Web, some problems such as load balancing and fault tolerance used to occur while sharing of resources among the nodes in the network. Such problems motivated the researchers to come up with a solution for the division of processing load and the network bandwidth among every node participating in network. Thus, Peer to Peer Networking was introduced as a solution for this problem. In this paper, we provide a review on Peer to Peer Networking as we define "*Peer to Peer Networking*", "*Benefits of Peer to Peer Networking*", "*What are its enabling technologies*" and present "*An implementation of Peer to Peer Networking*".

2. WHAT IS PEER TO PEER NETWORKING

Peer to Peer Networking is about communication and sharing in the peer community. Peers communicate and share the resources among each other. Peer to Peer networking follows the principle that the world should be connected and widely distributed but it is undesirable that everything should be managed by a centralized infrastructure. Peer to Peer networking is an alternative to Client-Server networking in which there is a special role for the centralized/server node. In Client-Server networking, server node is responsible for storing and sharing information among the clients whereas in Peer to Peer networking all nodes in the network are considered equal and can share information with other nodes in the network. Peer to Peer networking is often confused with Client-Server technology as most of the people do not know the clear difference between both of these terms. The difference can be made clear as given by "Riidiger Schollmeier" [1]

> ***"The most distinctive difference between Client/Server networking and Peer to Peer networking is the concept of an entity acting as a Servent, which is used in Peer-to-Peer networks. Servent is an artificial word which is derived from the first syllable of the term server ("Serv-") and the second syllable of the term client (-*-ent''). Thus, this term Servent shall represent the capability of the nodes of a Peer to Peer network of acting at the same time as server as well as a client. This is completely different to Client/Server networks, within which the participating nodes can either act as a Server or act as a client but cannot embrace both capabilities"***

With the difference made clear between Client-Server and Peer to Peer Systems, it is now essential to define Peer to Peer Networking. This can be understood by the following definition mentioned in [2]

> ***"A network architecture may be called a Peer-to-Peer network, if the participants share a part of their own hardware resources (processing power, storage capacity, network link capacity, printers,..) These shared resources are necessary to provide the Service and content offered by the network (e.g. file sharing or shared workspaces for collaboration): They are accessible by other peers directly, without passing intermediary entities. The participants of such a network are thus resource (Service and content)***

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providers as well as resource (Service and content) (requestors (Servent-concept)."

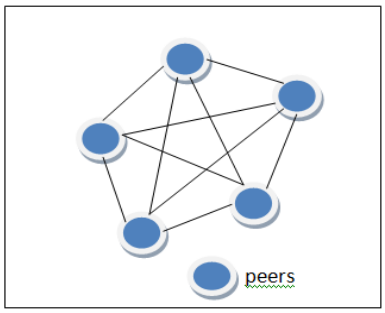

Figure I: Peer to Peer Network

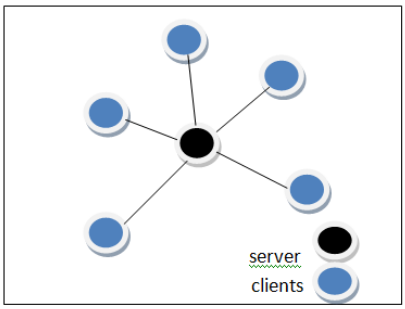

Figure II: Client Server Network

Taxonomy of Computer Systems based on perspective of Peer to Peer is given in Figure III [4]. Computer Systems can be classified into two categories namely centralized systems and distributed systems. Centralized systems are those systems that present to us one unit solutions, it could be single processor, multiprocessor or high end machines like supercomputers or mainframe computers whereas Distributed systems are those systems in which the concept of networking is used by computers to communicate with each other. The components located at the networked computers perform communication by message passing. The components of distributed systems can be further organized into client server and peer to peer model.

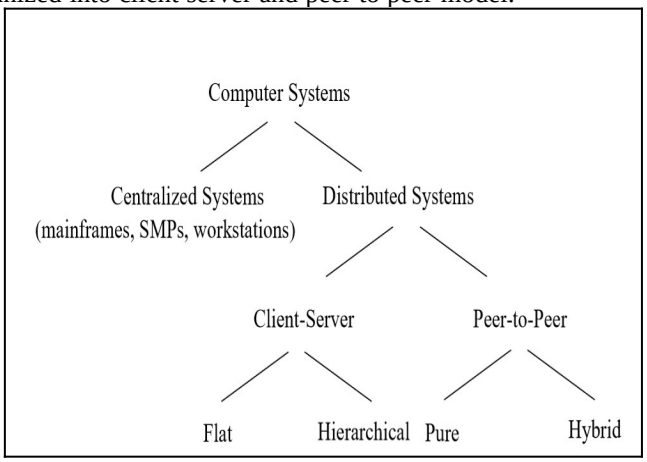

Figure III: Taxonomy of Computer Systems [4]

Peer to Peer Networks can further be classified into two categories based on peer networks with and without central entities. (Figure IV)
They are:-

1. Hybrid Peer to Peer Networks
2. Pure Peer to Peer Networks

Hybrid Peer to Peer Network	Pure Peer to Peer Network
• A Peer to Peer Network • Central entities are allowed in the network • Central entity is necessary to provide parts of the offered network services • Examples: Napster, Aimster, Softwax, iMesh	• A Peer to Peer Network • No central entity is allowed in the network • Any entity chosen to be removed from the network will not result in any loss of the network service • Examples: Gnutella,Freenet

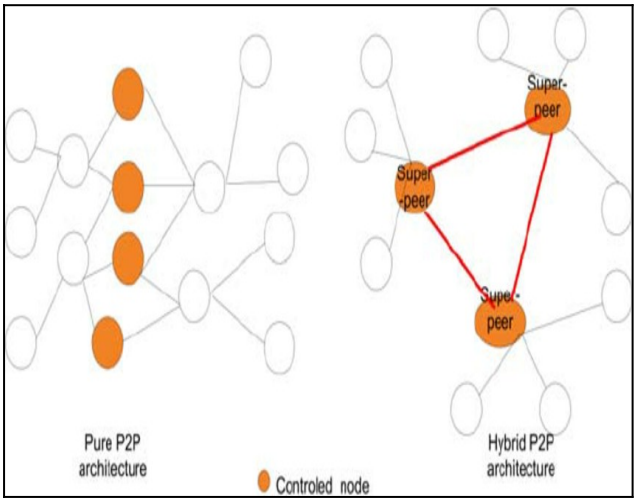

Figure IV: Pure peer to peer VS Hybrid Peer to Peer [5]

3. Benefits of Peer to Peer Networking

Peer to Peer networking offers several advantages such as:- [3][4]

A. Load Balancing
B. Effective Routing
C. Redundancy
D. Reliability (Fault Tolerance)
E. Content Based Addressing

F. Improved Searches
G. Cost Sharing/Reduction
H. Dynamism
I. Anonymity

Load Balancing
Peer to Peer offers a range of policies for information distribution. In such a networking, the load of the network is not entirely on the central node or the server, therefore the load is balanced among all nodes in the network. In peer to peer networking, when information content is requested, the traffic and demand profile for that particular information content is monitored and then information content is redistributed to decrease the load on the nodes. Moreover, content is loaded closer to points of high demand in order to balance the load.
Effective Routing
Any user in the peer to peer network can search the active nodes which contain their desired information; they can then download that information directly from that node and make it available for sharing with other nodes. In this way, any information that is on high demand can be spread across various nodes. The more the network grows, the more content for sharing in network also grows. Thus, if a user is searching for a very rare information item, the user would eventually find it at some node in the network. This quality of peer to peer systems provides us effective routing.
Redundancy
When information is replicated at multiple nodes in a peer to peer network, the result is increased redundancy. The high degree of redundancy ensures higher degree of availability and the higher degree of availability in return means that information could be served to more number of users. Thus, redundancy makes information readily available in a peer to peer network.
Reliability
Peer to Peer network provides reliability. It ensures that the failure of a single node in the network does not result in the failure of the entire network. This quality is also known as Fault Tolerance and it is due to the decentralization in a peer to peer network.
Content Based Addressing
In a peer to peer network, the exact address of the node that contains the desired information content is anonymous for the user. The user requests the information content whereas Peer to peer software finds the nodes containing the content in storage. This leads to grouping of the addresses based on the content that a node has stored. Hence, information is more content specific due to content based addressing.
Improved Searches
Most web search engines store information in huge searchable databases. Such databases are unable to update information when the servers go down. In peer to peer networking, dynamic indexing (information available at any user node is indexed and it remains indexed until user is online) of the content is done. When a user enters into a peer to peer network, its peer to peer indexing begins. A peer to peer network does not depend on search engine robots to update its information, rather the index is always synchronized with the current status of the user.(online) The dynamic indexing of the content and the ability to easily search the desired content differentiates peer to peer network from other applications that allow information sharing.
Cost Sharing
When a centralized architecture is used, the client bears majority of the cost of the system because it is the most important node of the client server architecture. Whereas, if a peer to peer architecture is used, the cost of the system can be divided among the peers.
Dynamism
In peer to peer networking, the environment for peer to peer computing is highly dynamic i.e. nodes will be continuously adding and leaving the system. Thus for an application that requires dynamic environment, peer to peer networking serves as the best approach.
Anonymity
Sometimes, the user does not want the service provider to know his/her involvement in the system. When using a client server network, it is difficult to hide the details of the client from the server. So by using a peer to peer network, anonymity or transparency of the user details can be obtained because in a peer to peer network, activities are performed locally and so the user does not have to provide any information to others.

4. ENABLING TECHNOLOGIES

a) HTTP – Hypertext Transfer Protocol.

b) XML – eXtensible Markup Language, set of rules of writing documents in a way that is readable by both human and machine, includes a lot tags so it stores more meta data than actual data.

c) SOAP – Simple Object Access Protocol, With Simple Object Access Protocol the applications directly communicate with each other over the internet.

d) Gnutella is a file sharing protocol, fresh nodes need know the address of another Gnutella node or use a host list with known IP addresses of other peers, the nodes directly connect with each other. These are file sharing protocol. It works on pure p2p model. It is an application that allows peers to search and download files that other peers have made accessible. A peer broadcasts demand to as many peer as possible and download file/document directly, a peer can receive many responses from peers that have available data. Hops to find data are not constant. A peer thoughtlessly sends request to all other nodes that causes all peers to examine for that document which is not effective.

Each hop increases the time to get results for the query.

e) Freenet, like Gnutella it is also a file sharing protocol. FreeNet is a prime example of how secrecy can be made into a P2P application. It uses a forwarding structure for messages to guarantee that the original requestor of a service cannot be tracked. When a file is found and moved back to the path towards the requesting node, that file is cached to all the peers in the path.

f) Security: uses authentication, Triple DES encryption, and digital signing.

g) Napster, share music files and has been an entity of great importance in the music publishing business. It is hybrid p2p model. When a node needs some data it requests the central index, the central index finds the best available node that fulfills the request, then the communication directly happens between two nodes. The central server can send multiple download locations. Hops to find the data are constant. This makes the network vulnerable due to centralized server.

h) DNS solves the problem of vulnerability which was in Napster due to centralized server. It is hierarchal p2p architecture. It maintains a tree of coordinators and each coordinator manages a group of peers, communication between peers that belong to different coordinators in achieved by higher order coordinators, so if one coordinator fails only its belonging peers are affected.

i) Pastry is routing network which implement a distributed hash table (DHT) similar to Chord. This algorithm have implemented document routing model to ensure that least hops are taken to share a file/document. It keeps track of multiple paths to each peer, when a new peer comes it contacts the gateway peer and routes towards the peer that has the most similar ID to this new peer.

j) Tapestry is similar to pastry; this algorithm is self-repairing, effective, scalable, location-aware routing to neighboring resources. This algorithm also tries to reduce the numbers of hops taken to route between peers.

k) Chord is an algorithm/protocol for a p2p distributed hash table, peers are assigned ID based on IP of peer through hashing. It have also implemented document routing model, in chord a peer only keeps track of logN other peers, when a joins and leaves of peers occur, this algorithm will only notify logN of the peers of this change, CAN is also similar to chord but here a peer keeps track of only small number of nodes i.e. less than logN. Chord algorithm is a unidirectional space, forming a circular chain of peers but CAN is multidimensional i.e. a peer keeps track of peers in all directions. This leads to maintenance of small number of states and hence increases the scalability.

l) Morpheus is a full-featured P2P file-sharing system introduced by MusicCity, it have a strong search engine that can search for any type of data.

m) Kazaa is a new example of a P2P file sharing scheme that practices SuperNodes as local search hubs, peers communicate with their corresponding local node to exchange information about the files they share.

n) The JXTA protocols allow any device attached to a network to send and receive messages and work together individually of the core network topology. It is a platform that is independent of any language. It is designed to be implemented on any device (appliances, desktops e.tc.). It provides a platform through which peers can take part in community activities across different p2p systems. It have implemented authentication, integrity and discovery like core services

o) .NET My Services is an abandoned collection of XML-based Web services by Microsoft for storing and retrieving information. It is a platform that highly emphasizes on security and privacy. Passport is an online service that provides the authentication of users.

p) DNS – Domain Name System, Translates domain names into IP addresses.

q) Publius: for file sharing, the files are splitted and stored at different servers, so no single server has complete data to attack the encrypted file system. This system uses asymmetric encryption mechanism to protect the shared file and identity of publishing peer.

5. AN IMPLEMENTATION OF PEER TO PEER SYSTEM

Peer to peer has gradually become very popular on internet. One of the most popular applications of P2P is file sharing as it provides scalability which is not present in a traditional client server system. Some commonly known peer to peer file sharing programs are Gnuttella, eDonkey, Kazaa and Bit Torrent.

Bit Torrent

Bit torrent is a new generation in peer to peer file sharing system and it is a great step in field of downloading. It delivers us a very fast platform for downloading a file. It follows protocol like tit for tat, a robust yet simple and effective mechanism, in which a downloader must also be

uploader i.e if a peer wants to receive a file from another peer it has to send a file as well.
In client/Server architecture all the clients communicate via server for all the data they required.

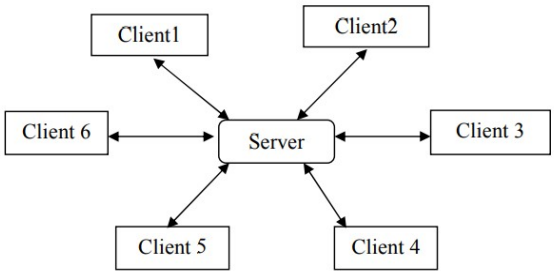

Figure 1. Client/Server Communication

But when the number of clients increases performance of the server decreases just because of load on server. This ultimately causes the failure of the system.

Bit Torrent overcomes this flaw and maximizes data transfer speed by dividing the desired file into chunks. Each peer searches for the pieces of required file and download these pieces. A single peer can download one or more pieces at a time. Bit Torrent protocol allows the entire client to join a cluster to download a file form each other. This protocol has a great importance than the other protocol of communication in peer-to-peer.

In addition to this Bit Torrent provides high uploading bandwidth peers with high downloading bandwidths which prevent free riding which had been a major drawback for previous peer to peer networks.

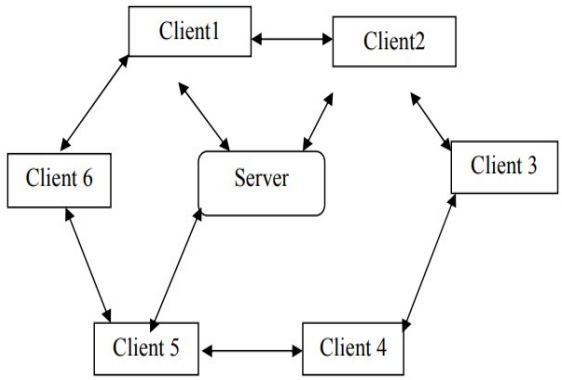

Figure 2. Bit Torrent Protocol Scenario

The important entities involved in Bit Torrent Protocol are:
• Peers or Seeders (Clients).
• Leecher
• Bit Torrent Tracker
• Server
• Torrent File

Peers: Clients which are ready to share files with other Clients in the network.

Leechers: peers in a network who doesn't want to share their files with other peers.
Bit Torrent Tracker: The Trackers are in the Server and holds information that include:

1. The IP addresses of all Peers that are connected with Tracker.
2. Hash number interrelated with each file segment or piece

Torrent File: This file holds information about files that is shared in a network. Hashes are contained by this file for each piece before it shares with the other clients. This file also contains all the information like IP Address about Tracker. This file contains hashes for each segment before sharing it with other Clients. It also contains the information (IP Address) about the Tracker.

The main idea behind the Bit Torrent is to split the data into pieces of approximately 256 Kb size .A peer that want to download the file, must connect to several other peers that have the pieces of that file to their own machines. To assist this process, centralized software is used by the Bit Torrent called Tracker.
Unauthorized clients are not allowed to communicate with the server just because of ensuring security by the Tracker. It also allowed the downloader to download file from server as well as different peers.
A downloader that wants to download file, firstly connects to tracker of file. Then a random list of peers is returned by the Tracker and a connection is established between the downloader and the other peers. The Tracker also finds what type of data pieces each peer resides. At a given time each Up loader allowed to upload only to fixed number. Uploading the file is called unchoking. When the torrent file is creating form original file, then smaller pieces of original files is created. Torrent files contain the SHA-1 hash codes. Verified the data by computing SHA-1 and comparing it to the corresponding SHA-1 code. When file is downloaded and verified then the one downloading peer reports to the other one. Now this piece of data is available for the other peers.

Algorithms

- One-to-one file swapping algorithm

In many peer to peer file sharing protocols. One user himself selects a user from whom it wants to download file. What pieces of the file are to be downloaded from which peers require the way of knowing with the aim of receiving the complete file as fast as possible. Choosing peers to connect to is a two-sided problem. First, we really need a way of discovering best order of downloading pieces. This information is determined by the piece selection algorithm.

- The Piece Selection Algorithm

How Bit Torrent selects what pieces of the file to download have great impacts on the performance of the protocol. It is very important to be smart enough while selecting pieces This process will increases download speed of file, and make sure it that all pieces is somewhere in the network if the seeder leaves.

- Resource Allocation

In Bit Torrent there is no centralized resource allocation is exist. Maximizing download rate is depend upon to all the peer themselves. To decide it that which peers is upload to which other peer, a peer practices of "tit-for-tat" algorithm. This strategy comes from repeated game theory, and is a strategy of cooperation based on reciprocity.
The core is to do onto others as they do onto you [9]:
1. On the first move cooperate.
2. On each succeeding move do what your opponent did the previous move.
3. Be prepared to forgive after carrying out just one act of retaliation.

Multiplayer online games
Another very recent example of peer to peer is multiplayer online games which include peer to peer live video streaming system. In Massively Multiplayer Online Games, commonly known as MMOGs, large numbers of online users are allowed to adopt the same virtual world and can interact with each other. This can be done in various competing and competing scenarios. Gamers within an MMOG become members of online communities who share common objectives as well as adventures. Players are given option to play collaboratively against other groups or simply play as an individual. They also have an option to play against computer controlled enemies.

The old mediums used by MMOGs were centralized i.e they had a Client/Server based system as a result we had large bandwidths and the costs of the servers were high as well. Inorder to make it cost-effective and reduce bandwidth peer to peer live streaming videos were used.

In a Computer Network Game system we use a hyprid peer to peer live streaming videos which is diffused across different levels through a multicast tree as shown in the figure.

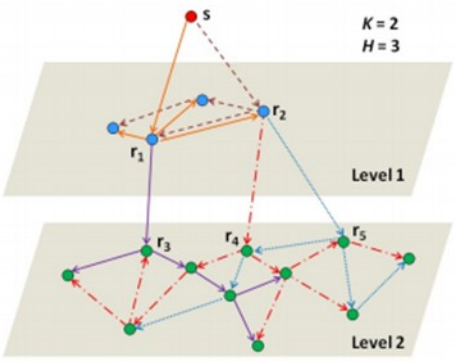

Figure 3 a multicast tree of a CNG system

Construction and management
Since in a multiplayer online game we won't have a game confined to a single layer thus we take care of this problem in this following section and explain the inter-level interaction in a multi-leveled game.

Intra-Level Multicast Trees
We use multicast trees for video diffusion on each level. Each multicast tree has a root and it is used to transmit one packet of encoded symbols from the source peer to different peers. The packet directly received from the source by the tree's root.

- In order to check a peer has received the whole source block it is important it should receive K packets of encode symbols.
- Every peer v has an upload capacity which is denoted by cv. It is the number of packets the node v can transmit.

Overlay construction – Insertion
Here we discuss how a new player or peer is inserted to the overlay when it makes a joint request.

Algorithm 1 Overlay construction algorithm - Insertion

Require: Complete graph $G(V, E)$,
v : *unspanned* peer sending join request,
L : number of levels in the overlay,
L_{max} : maximum number of levels the overlay can have,
K : minimum number of packets to be received
Ensure: Forest F_l in each level l

for $l = 1$ to L **and** v is unspanned **do**
  insert v in forest F_l
end for
if v is unspanned **then**
  if $L < L_{max}$ **and** $C_L^{next} \geq K$ **then**
    insert v in forest F_{L+1}
  else if $c_v > c_u$ where $u \in V$ with minimum capacity **then**
    replace u by v in all trees containing u
    reject u
  else
    reject v
  end if
end if

In the following algorithm we first see that the peer v is a part of any other level or not then we add it into any tree having space to insert a peer. Then we check that whether

v has been added to the last level if yes then we leave it as it is else we move it further down.
Then we see that the vertex at which we are is less than v if yes we reject u else reject v.
Overlay construction-Removal
Here we discuss what happens when a player or peer wishes to leave an overlay

Algorithm 2 Overlay construction algorithm - Removal

Require: Complete graph $G(V, E)$,
v : *spanned* peer in level l' sending removal request,
F_l : height-bounded forest in level l,
T_l^k : tree $\in F_l$,
L : number of levels in the overlay
Ensure: Forest F_l in each level l

remove v from forest $F_{l'}$
for $l = l'$ to L **and** $|F_l| > C_{l-1}^{next}$ **do**
  sort trees in F_l in increasing size order
  for $k = 1$ to $|F_l|$ **and** $|F_l| > C_{l-1}^{next}$ **do**
    $W \leftarrow$ all nodes in T_l^k
    sort nodes in W in increasing height order (i.e., leaf nodes first)
    for $i = 1$ to $|W|$ **and** v_i is a leaf $\in W$ **do**
      find a tree $T_l^m \in F_l$ into which v_i can be inserted
      if v_i is inserted in T_l^m **then**
        remove v_i from T_l^k
      end if
    end for
    if T_l^k does not contain any node **then**
      $F_l \leftarrow F_l \backslash \{T_l^k\}$
    end if
  end for
  if $|F_l| > C_{l-1}^{next}$ **then**
    remove node $u \in V_l$ with minimum capacity from F_l
    end of the algorithm
  end if
end for

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Journal/Conference	Impact Factor/Rank
1. Peer to Peer Networking and Applications	1.18
2. Performance Evaluation – P2P Computing Systems	1.78
3. Computer	1.94
4. IEEE Internet Computing	2.0
5. Computer Networks: The International Journal of Computer and Telecommunications Networking	2.5
6. IEEE Transactions on Knowledge and Data Engineering	2.7
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8. Computer Communications	3.3
9. Computer Communication Review	3.5
10. IEEE Transactions on Mobile Computing	3.8
11. IEEE Transactions on Parallel and Distributed Systems	3.9
12. IEEE Journal on Selected Areas in Communication	7.17
13. IEEE International Conference on Peer to Peer Computing	C
14. ACM International Conference on Information and Knowledge Management	A
15. 4th International Conference on Peer to Peer Computing	A
16. 25th IEEE International Conference on Distributed Computing System	A
17. International Conference on Parallel Processing	A
18. IEEE International Conference on Pervasive Computing and Communications	A*
19. Foundations of Software Engineering	A*

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23. Modeling and Performance Analysis of Bit Torrent like Peer to Peer Networks	**Dongyu Qiu ; R. Srikant**	**Computer Communication Review**	**1583**