A Review of Various Approaches to Multipath Routing

Maryada
M.Tech. Student, Department of Computer Science & Applications, Kurukshetra University, Kurukshetra-136119
Email: maryadasaini@gmail.com
Mrs. Shalini Aggarwal
Teacher Fellow, Department of Computer Science & Applications, Kurukshetra University, Kurukshetra-136119
Email: shaliniagg07@gmail.com
Dr. Pardeep Mittal
Assistant Professor, Department of Computer Science & Applications, Kurukshetra University, Kurukshetra-136119
Email: mittalkuk@gmail.com

----------**ABSTRACT**----------
Multipath routing is used to overcome the problems incurred in single path routing such as more power consumption, time consuming, hope count, packet delay, low bandwidth and traffic congestion. Multipath routing distributes the load over other available optimal paths to have balanced results. It is not always the case that multipath is better than single path. Multipath results are good to use where there are limited paths and easily adaptable topologies available. Different algorithms and different protocols are used to find the best path among all available paths algorithms such as Dijkstra algorithm, Bellman Ford algorithm. Various Protocols such as OSPF (open shortest path first), IS-IS (Intermediate System to Intermediate System), ECMP (Equal Cost Multiple path), OMRP (Optimal Multipath Routing Protocol) are used for multipath routing. Different routing tables are made to store the calculated results for minimum path cost and distance from source to destination. On the basis of these tables data is transmitted through multiple paths.

Keywords: ECMP, Multipath Routing, OSPF protocol, Recovery Path Failure, Single Path Routing.

1. Introduction: Routing is the method/ process to find best path to move data traffic from source to destination in a network. Network can be a transportation network, Electronic data network, Management network, and Oil and Gas supply plants. Basically routing is a path between two nodes that are connected through wired or wireless media. It uses different algorithms and protocols with routing tables. There are so many factors that affect the routing table some of them are: Bandwidth, Packet Delay/Data Delay, Hop-Count, Scalability of network/ Topology used, Power consumption, Resilience etc. Some examples of routing problems are: Shortest Path Problem, Arc Routing Problem, Vehicle Routing Problem, Telecommunication Routing Problem, and TSP. On the basis of 'Topology used' routing is divided into 2 categories: Static Routing and Dynamic Routing. As their names suggests Static Routing is fixed and is used for small networks. It uses Public Switched Telephone Network Protocol. Dynamic Routing is used for large networks that changes with time according to user requirements for example in internet networks. It uses OSPF (Open Shortest Path First) and RIP (Routing Information Protocol)

2. Routing

2.1 Shortest Path Routing**:** In shortest path routing there is only one path from source to destination. It's not fault tolerant as traffic can't be diverted on any other way. Packet delay, network congestion, power consumption, packet loss is there due to unavailability of multiple paths. This problem can be solved by using dynamic routers that sense the network and take action according to the situation, where to stop sending messages or slow down the

speed from sender till network become normal. Single path routing is easy to implement as no need to have calculations for best path and no need to maintain routing tables and is suitable for small networks.

2.2 Multipath Routing: As name suggests multiple paths are available to user from source to destination, as network congestion problem is solved and it is fault tolerant, if one of the path fails due to any reason, another path is also available to deliver our data to its destination. It is faster than single path routing as multiple bandwidth paths are available to us. In multipath routing different semantics are used that define how the data is delivered from source to destination as follows: Unicast, Anycast, Multicast, Broadcast, Geocast.

To follow any kind of routing some algorithms and protocols are available that helps us to decide best suitable path according to user needs. Dijkstra algorithm under Link State Routing Algorithms and Bellman Ford Algorithm under Distance Vector Algorithm.

3. Routing algorithms

3.1 Dijkstra algorithm: It was introduced by Edsger W. Dijkstra in 1956 and is published in 1959 i.e. 3 years later [1]. It calculates the shortest path from source to destination in a network. Each path contains some weights that are cost of sending packets and non negative edges. Optimization criteria for an algorithm is based on no. of hops, cost, delay, distance, throughput. The advantage is it is the fastest known single-source shortest path algorithm. And the disadvantage is it performs a blind search which results in wastage of time and resources and can't handle negative weights.

3.2 Bellman Ford algorithm: It was introduced in 1955 by Richard Bellman and Lester Ford but published in 1956. Its new version was introduced in 1957 by Edward F.Moore hence also called as Bellman Ford Moore algorithm. It is also applicable in negative weights graphs where as Dijkstra can't solve them.

Problems with Bellman Ford algorithm is that it can't be scaled well. If any change in topology occurs it takes time to reflect its results. Another major problem with this algorithm is the Count to infinity problem, in which data may never reach to desired destination.

4.Protocols

Protocols are the set of rules that define the way how routers will communicate with each other. They are divided into different broad categories:

- Interior gateway protocol type1, Link State Routing Protocol, such as OSPF, IS-IS.
- Interior gateway protocol type2, Distance Vector Routing Protocols, such as Routing Information Protocol, RIPV2, IGRP.
- Exterior gateway protocol for Autonomous system, such as (BGP) Border Gateway Protocol, Path Vector Routing Protocol.
- Routed Protocol that deliver application traffic from 1 network to another such as Internet Protocol and Internetwork Packet Exchange.

4.1 Open Shortest Path First Protocol: It comes under Link State Routing; it is used for single autonomous systems and hence called Interior Gateway Protocol sometimes. OSPF uses Dijkstra to find smallest path between source and destination and create routing

table by getting instant information from its neighboring nodes. It detects faults and new updates easily in the network. It support IPV4 and IPV6 in different area with convention, area 0 or (0.0.0.0) as backbone area. It does not support TCP/IP protocol. It has its own way to detect and correct errors. IP packets only move from one hope to another they can't move more than one hop as they comes under Link State Category, where updates are taken from neighbors only.

OSPF uses different area types that are unknown to outer networks. Areas can be Backbone area, Stub area, Not-So-Stub Area, Totally Stub by Area etc. It uses different router types as Internal Router, Area Border Router, Backbone Router, and Autonomous System Boundary Routers. OSPF is extended to 'Traffic Engineering' where it uses non-IP networks as optical networks. 4 types of metrics are used as intra area; inter area, external type1, external type2 for routers used. OSPF guarantee loop free paths and can support up to 850 routers practically, 1000 on high load with little degradation in performance for more network load, skip to IS-IS protocol. OSPF build 3 separate tables as neighbor table, topology table, routing table.

5. Related Work

(S.Nelakuditi and Z.L.Zhang, 2001) described that multipath routing reduces congestion problem by distributing traffic over different bandwidth paths. While distributing the load user should keep in mind two things i.e. no. of available paths where to send the traffic and another is the way how to choose them. Authors proposed a hybrid approach where they have exchanged globally and locally information of links to have complete and better results. They said their proposed work is having good throughput and lesser overhead than that of all other available link state updates. As distribution of load over multiple available paths minimizes the congestion problem and increases the availability of bandwidth. In shortest path overloading problem is there, where other available paths were under loaded. Multipath minimizes the no of paths, so that you do not have too much overhead to maintain them, if no of paths increases complexity to distribute the load and maintain the routing table also increases. Authors introduced Wide Disjoint Paths where traffic is proportioned on a few available widest disjoint paths. They proposed a hybrid approach where local and global information is shared to have better results while selecting and forwarding the traffic over the network sometimes causes the bottleneck problem. At the end authors concluded that the proportional routing paradigm is used where traffic is proportioned among good paths not on all available paths. They proposed a hybrid approach for sharing local and global information over the network. They introduced Wide Disjoint Paths, EBP (Equalizing Blocking Probability) [9] its objective is to find proportion of set). They compared WDP with Optimal Proportional Routing Scheme and proved that their proposed scheme is having higher throughput with lesser overhead than other schemes available.

(R.Mahajan et al, 2003) proposed a new approach to approximate ISP link weights using end to end measurements, earlier OSPF and IS-IS were used to have simple and concise model for routing networks but they extended routing level ISP maps, which have connectivity with consistent weights. Authors studied the issues while finding routing models that are used to forward paths within an ISP; they found a constraint-based method which can be used to

approximate ISP link weights which are completely based on end to end measurements. At the end authors concluded that there approach is efficient enough and can handle effectively the noisy data. This information of link weights become the backbone for six ISP networks and inferred weights can characterized this routing better than random metrics calculated on node latency and hope count as these inferred weights characterized routing between 84% to 99%for six ISP's, while random metrics did this only for 47% to 84% of them. There approach enhances the ISP topology with link weights and make them useful in simulation. These link weights can also step towards the direction of Intra-Domain routing and Traffic Engineering.

(Y.Ganjali, A.Keshavarzian, 2004) [2] introduced a new model for evaluating the load balance under multipath routing, when the path chosen were the first k shortest paths. Using the new model the author showed that unless they used very large no of paths, the load distribution was almost the same as single path routing that was in contrary to the previous existing results that assumed that multipath routing distributed the load uniformly, they also showed that unless they used huge no of paths, multipath routing does not improves the load balancing.

(P.Merindol et al, 2008) [7] described that Dynamic Routing Protocol are used for load distribution over the network. They described their incoming Interface Multipath Routing Technique [8], DT (p) and then technique for load balancing, DT (p)-TE based on link monitoring. They have compared there technique with other available techniques by simulation method using different topologies. DT (p)-TE used other available alternate paths to reduce packet loss. Future scope / improvement in their work can be done by adjusting time scale parameter of the load balancer and co-ordination between the routers to avoid inappropriate load shifting.

(Y.O.Lee et al, 2011)[3] studied that audio and video streaming need proper and continuous network service so that if any failure occurs it will recover as soon as possible. They need to maintain additional information like address and computations in routing tables and need extra infrastructure. Recovery path failures, time taken to recover from failure is transient time that causes problem for continuous media applications, proactive recovery schemes are used to have backup continuous support during failures due to additional information backup paths length increases that causes delay of data and unbalanced load. Authors explored that if primary and recovery paths made disjoint, than the additional infrastructure used for recovery can also be used for multipath routing when no failure occurs. Authors used two proactive recovery schemes i.e. MRC [4] Multiple Routing Configuration. And NotVia[5]

Older algorithms used for calculating the disjoint path removes the link to the primary paths thus they have high complexity and were difficult to implement. At the end authors concluded that the proposed D-MRC and D-NotVia provide better results for backup paths, with small path stretch and disjointness. D-NotVia is better than D-MR for the stretch and disjointness thus better in QoS and load balancing, but its overhead is higher than D-MRC.

(S.Upadhyaya and G.Devi, 2011)[6] state that multipath routing is a technique that uses bandwidth in a better way to distribute the traffic over congestion/ heavy load. There are multiple paths available for same destination. There are two methods to handle traffic congestion one is to

distribute the data over multiple available paths another is to move data over the best chosen path and keep other available paths for recovery or backup purpose. They have studied different algorithms for load distribution and congestion and then they have discussed the methods for constructing and selecting path for multiple path routing. Two things should be kept in mind while implementing multipath routing one is calculate multiple paths and another is distributing the traffic load. Authors used K-Shortest path but many other shortest paths were also calculated. They discussed the constrained and unconstrained problems. Constraints are the conditions that should be satisfied during path selection example is loop free and disjoint paths (node disjoint or link disjoint). They have discussed about ECMP i.e. Equal Cost Multiple Paths but it limits itself to shortest path due to which load balancing and congestion control capacity of network also limit. They presented Multi Path Algorithms that can be used with OSPF as new version to find new alternate hops for loop free paths not to destination but to next hop. This information is stored in routers that will be helpful in failure recovery. Authors described the methods that are used for selecting the paths to transfer the traffic are Hashing, Round Robin, Random and Flow cache. At the end they concluded that multipath utilizes the network resources better than single path routing and discussed various approaches for path identification that helps to improve QoS.

6. Conclusion:

This paper presented a review on multipath routing and it has been observed that it performs better than single path routing in most of the situations. It is applicable in many fields to improve the traffic congestion and load balancing. Some of techniques are studies that are useful in reducing traffic, cost, distance, fault tolerant, increased bandwidth, and improved reliability. Different researchers have used different algorithms and protocols such as OSPF and IS-IS protocol, Dijkstra algorithm, Multipath Routing Configuration, NotVia ,D-MRC, Equal Cost Multiple Path techniques (ECMP), DT(p) Dijkstra traverse algorithm, Optimal Proportional Routing Scheme, Wide Disjoint Paths etc. to show their results. By using these algorithms and protocols the problem of congestion can be reduced upto some extent over the network. These may be helpful in increasing bandwidth, decreases overhead for routing tables, improved packet delivery and easy recovery from failure of network. Overall it may be concluded that multipath routing is going to be the future of networking.

References:

Dijkstra, Edward W., Reflections on “A note on two problems in connation with graphs (PDF) Dijkstra 1959, p. 270

Yashar Ganjali, A. K. (2004). Load Balancing in Ad Hoc Networks: Single-path Routing v.s Multi-path Routing. *IEEE*. , 1120-1125.

Yong Oh Lee, A. L. (2011). Constructing disjoint paths for failure recovery and multipath routing. *Science Direct* , 1-12.

A. Kvalbein, F. Hansen, T. Cicic, S. Gjessing, and O. Lysne. ”Fast IP network recovery using multiple routing configurations.” In Proc. of INFOCOM, April 2006.

S. Bryant, M. Shand, and S. Previdi. ”IP fast reroute using notvia addresses.” Internet draft, draft-ietf-rtgwg-ipfrr-notvia-addresses-00.txt, Dec. 2006.

Devi*2, D. S. (2011). Path identification in multipath routing. Journal of Global Research in Computer Science , 1-3.

Pascal Mérindol, J.-J. P. (2008). Improving Load Balancing with Multipath Routing. 1-8.

P. Merindol, J. J. Pansiot, and S. Cateloin, “Path computation for incoming interface multipath routing,” in *ECUMN’07*, 2007, pp. 75–85.

Zhang, S. N.-L. (2001). On Selection of Paths for Multipath Routing. *Springer* , 170-184.