# Comparison of various Features of Dynamic Routing Algorithms

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***Abstract:*** *This research paper discusses about the dynamic routing algorithms. The dynamic routing algorithms are mainly classified in two types i.e. Distance Vector routing algorithm (e.g. RIP, IGRP, EIGRP) and Link state routing algorithm (OSPF). The Latest research is giving stress on the adaptability feature and many other features like Scalability, Metric Calculation , Convergence time, Load balancing, Support of VLSM (Variable length subnet masking) and Operational overheads of dynamic routing algorithms. So in this paper the comparison of dynamic routing algorithms will be made in terms of the features and simulation comparison of single path and multi-path link state routing algorithms using ns-2 (network simulator 2) will also be considered.*

## 1. INTRODUCTION

Networking Layer[1][2] plays an important role in decision making in routing the data. Routing mainly concerned with path determination and data transportation. For path determination there are certain routing algorithms and protocols which are used. It is very important to decide the path, which is based on the algorithms and protocols used. Better the algorithm and protocol, better the path is selected and more conveniently data is transported.

**Routing algorithm-**The method in which the routing tables are created and updated is called the routing algorithm. An algorithm is any well-defined computational procedure that takes some value, or set of values, as input and produces some value or set of values as output.

**Routing Protocol -** The software implementation of routing algorithm is called the routing Protocol. Routing protocol exist and operate only in routing devices, whereas network protocols such as IP (Internet Protocol), NetWare or DEC net, which are routable through routers are called routed protocols. Routing Protocols [5] are used by intermediate systems to build tables used in determining paths for data transportation. Examples of Routing Protocols are RIP, IGRP, EIGRP, OSPF, and BGP. The efficiency of routing algorithm [3][5]depends on many features like scalability, convergence time, adaptability to changes, load balancing and VLSM support. Better the features supported by an algorithm, better the algorithm will be. Section 2 gives the background. Section 3 discusses about the comparison features. Section 4 gives the simulation comparison using ns-2(Network Simulator 2), section 5 gives the conclusion followed by the references used in this paper.

## 2. BACKGROUND

Routing algorithms [5] can be further divided into the following types. Static versus dynamic 2. Single Path versus Multi path 3. Flat versus hierarchical 4.Host Intelligent versus Router-Intelligent 5. Intra-domain versus. Inter-domain 6. Link-State versus Distance-vector. Nowadays the research work is in progress on many of above routing algorithms. But more research emphasis is on Link-State routing algorithm and Distance-vector Routing algorithms. Different algorithms are required in different situations depending upon the requirement of the particular condition, because single routing algorithm or protocol is not sufficient in every situation at all times. Single routing protocol may be sufficient for small network, but many different routing protocols are used in large networks. The Internet, e.g., is divided into collection of autonomous systems (ASs), each of which is normally administrated by a single entity. Research work is in progress on two dynamic routing algorithms i.e. Link-State & distance vector routing algorithms. But Link-State routing algorithm is having better research prospectus being open system Interconnection routing algorithm (e.g.OSPF). Research is in Progress on hybrid routing algorithms [13] which includes the features of both algorithm i.e. Link State and Distance vector. Here we emphasise on two types of routing algorithms specially Link-State versus Distance-vector routing algorithms. In decentralized routing algorithms [6] each router has information about the routers it is directly connected to. It doesn't know about every router in the network. These algorithms are known as DV (distance Vector) routing algorithms. In global routing algorithms, every router has complete information about all other routers on the network and the traffic status of the network. These algorithms are known as LS (Link-State) routing algorithms. Examples of Distance vector routing Protocols are RIP, IGRP, EIGRP Examples of Link-State routing Protocols are OSPF and IS-IS.

## 3. COMPARISON FEATURES

### 3.1 Scalability[3][4]

In telecommunications and software engineering, scalability is a desirable property of a system, a network, or a process, which indicates its ability to either handle growing amounts of work in a graceful manner [9]. It can refer to the capability of a system to increase total throughput under an increased load when resources are added. Scalability can be measured in various dimensions such as load scalability. An algorithm, design or networking protocol is said to scale if it is suitably efficient and practical when applied to large situations. If the design fails when quantity increases then it does not scale. There are two methods of scalability. (1) Scale vertically (scale up) (2) Scale horizontally (scale out). A routing protocol [13] is considered scalable with respect to network size, if the size of the necessary routing table on each node grows as 0(log N), where N is the number of nodes in the network. The hierarchical routing nature of algorithm helps in increasing the scalability. In both Link State and distance vector routing algorithms [6] every router has to save some information about other routers. When the network size grows, the no. of routers in the network increases. Consequently, the size of routing tables increases as well and routers can't handle network traffic as efficiently. Therefore the hierarchical routing is recommended to overcome this problem. In hierarchical routing, routers are classified in groups known as regions. Each router has only the information about the routers in its own region and has no information about routers in other regions. So routers just store one record in their table for every other region

| Distance vector routing Algorithm | Link State Routing Algorithm |
|---|---|
| Less Scalable | Better Scalable |
| Uses Flat Routing | Uses Hierarchcal Routing |
| Examples RIP, IGRP, EIGRP | Example OSPF, IS-IS |

### 3.2 Metric Calculation [3] [4]

What are different types of metric, metric used affects the performance of the network. Algorithms performance depends on the type of metric used. No of hops, no of links, delays, bandwidth, etc may be type of metric used in the routing algorithm.

The term metric is used for measurement of path. It may be cost between two nodes or routers. Some researchers may name it as cost of path, some may name it as length of path between two nodes, some may indicate it as hop count. Distance vector routing algorithm calculates the metric in its own way while the link-state routing algorithm adopts its own way for metric calculation. The different types of distance vector routing algorithms are RIP, IGRP, EIGRP. Link state routing algorithm is OSPF. RIP's metric is hop count. A metric of 16 is considered as infinite in RIP. IGRP uses a complex calculation to produce a single composite metric. IGRP uses bandwidth, delay, reliability and load for metric calculation. Bandwidth in IGRP specifies the lowest rated bandwidth used in the entire path and is manually defined. Delay is the amount of time it takes a single packet to reach the destination, assuming an un-congested network. It is also manually defined. Reliability is defined by the no. of packets that arrive on the link undamaged .

Metric=bandwidth + (bandwidth /(256-load)+delay.

If reliability is set to max, then load is min. and vice-versa. So many researchers suggest that the reliability may not be included in the metric calculation formula. The distance vector routing algorithm uses a more complex metric as compared to link-state routing algorithm. The link-state routing algorithm uses a more useful metric. In link-state routing algorithm different ASs may use different metrics and have different restrictions. Although the link-state protocol does allow a router to build up a picture of the entire topology, the metrics used may vary from one AS to another making it impossible to perform a consistent routing algorithm. Quality of metrics help in better routing decisions and include link speed, capacity, tendency to become congested and overall quality of operation. Distance Vector routing algorithm makes the higher bandwidth better in the metric as Bandwidth rating is $10^7$ divided by the actual bandwidth in kbps of the slowest link. The process of dividing 10000000 by the bandwidth makes faster links better in terms of metric. This final bandwidth number is represented as Be in the formula. In link state routing algorithm particularly in OSPF the bandwidth command is used primarily to configure the cost for the interfaces OSPF uses 100000000 divided by the bandwidth in bps to determine the cost for an interface. Modifying the bandwidth therefore is the primary method of modifying the cost of OSPF interface.

### 3.3 Convergence Time [4][7]

The distance vector routing was used in the ARPANET until 1979, when it was replaced by the link state routing. The two problems caused its demise first, since the delay metric was queue length, it did not take the line bandwidth into account when choosing routes. Initially all the lines were 56Kbps, so the line bandwidth was not an issue, but after some lines had been upgraded to 256 Kbps and others to 1.544 Mpbs, not taking bandwidth into account was a major problem. Second problem count to infinity also existed due to which the algorithm often took long to converge. For these two reasons distance vector routing algorithm was replaced by new algorithm called link state routing algorithm. In link state routing algorithm each router must do the following:

1. Discover its neighbors and learn their network addresses.
2. Measure the delay or cost to each of its neighbors.
3. Construct a packet telling all it has just learned.
4. Send this packet to all other routers.
5. Compute the shortest path to every other router.

In effect, the complete topology and all delays are experimentally measured and distributed to every router. Then Dijkstra's algorithm can be run to find the shortest path to every other router. Because of not forming routing loops in the network the link state routing algorithm is widely used in actual networks. The protocol using link state routing algorithm i.e. OSPF is widely used in the Internet. AP2502N router uses OSPF routing protocol. As the routing loops are not formed in link state routing algorithm so this algorithm converges fastly as compared to distance vector routing algorithm.

### 3.4 Time Complexity [7]

The defining characteristics of DVP algorithms is that each router sends information about all participating routers to its local neighbors. When the DVP algorithm begins, each DVP router knows the link cost to its neighbors. In first iteration each router sends information about its neighbors to its neighbors. At the end of the iteration each router gets the current best path costs to all routers within 1 hop from itself in a graph of diameter 2. The diameter of the graph known to a router increases by 1 with every passing iteration. For deriving time complexity of this algorithm on each iteration a router receives O(N) routing tables where N is the number of neighbors. Each routing table contains R entries, where R is the no. of participating routers in the AS. On each iteration, every router in the AS expands the network neighborhood that it knows about by 1. The algorithm stabilizes when each router has expanded its horizon to the diameter of the network D. Hence the time complexity of DVP is O(NRD). In Link State algorithms each router sends information about local neighbors to all participating routers. As the network topology or link costs change, routers exchange information and recomputed the shortest path trees to ensure that their local database is consistent with the current state of the network. To derive the time complexity of the link-state routing algorithm, note that computing the routing table involves running Dijkstra's algorithm on the network topology. If the network contains R routers, the asymptotic behavior of the standard implementation of Dijkstra's algorithm is given by $O(R^2)$. A heap based implementation of Dijkstra's algorithm reduces the computational complexity to O (R log R). This computational cost is lower than the distance vector protocol.

### 3.5 Load balancing [3][4][10]

Both the algorithm i.e. Distance Vector and Link-State handles the traffic in their own way. The distance vector routing algorithms and link state routing algorithm comparison for load balancing is shown below:

| Distance vector routing Algorithm | Link State Routing Algorithm |
|---|---|
| Better for small and medium size networks | Better for large size networks |
| Examples RIP, IGRP, EIGRP | Example OSPF, IS-IS |
| RIP is unable to provide load balancing. IGRP, EIGRP, provides the capability of load balancing | OSPF provides better load balancing among equal cost multi-paths as compared to distance vector routing algorithms. |
| It provides load distribution capability among un-equal cost paths using variable | Provides load distribution capability among equal cost paths, also among un-equal cost paths using bandwidth sensitive algorithms. |
| Pinhole congestion problem occurs | No Pinhole congestion problem occurs |

RIP version 2 performs better load balancing in small inter-networks. But in case of WAN, OSPF is preferable than RIP version 2. IGRP load balances across equal-cost links similar to RIP. However due to IGRP's advanced metric it is unlike to ever get two completely equal metrics for the same destination. Therefore IGRP includes a function called variance to define how different two metrics can be and still be considered equal cost. IGRP load balances across unequal-cost routes for the routers having worst metrics and not for the routers with the best metrics. In OSPF if two or more paths have an equal metric, then SPF (Shortest path first) algorithm adds both routes to the routing table and load balances equally. OSPF-ECMP [11] protocol distributes the load equally between equal cost multi-paths. But in this protocol there is a static allocation of traffic due to which there is a chance of traffic congestion. For dynamic load distribution among equal-cost multi-paths OSPF-OMP [11] routing protocol is well suited which dynamically distributes the traffic among equal-cost multi-paths. By making use of good data structures and reducing the control & signaling overheads in OSPF-OMP, we can make better load balancing in this algorithm.

### 3.6 VLSM Support [3]

The problem with class-based addresses is that they are typically either too big or too small to be of use in most situations. The distance vector routing algorithm like RIP version 1 is not able to send masks with routing updates but in RIP version 2, subnet masks are transmitted with RIP2 updates. If updates to a router for subnets of a major network are never received, then this network is known as discontinuous network . The comparison is shown in the table below:

| Distance vector routing Algorithm | Link State Routing Algorithm |
|---|---|
| IGRP, RIPI does not support VLSM | OSPF support both VLSM and CIDR like EIGRP |
| RIP version is not able to send mask with routing updates but rip version 2 subnet masks are transmitted with RIP2 updates | OSPF includes the subnet mask in routing updates OSPF supports for discontinues networks. |

### 3.7 Operational overheads [4]

Distance vector routing algorithm sends the routing updates regularly to its neighbors and the router is having the knowledge about its directly connected neighbor routers, not about all routers in the network. But in Link state routing algorithm each router is having complete knowledge about topology of the network and therefore particularly in OSPF does not require that updates be sent at regular intervals. It sends the updates only when a change in topology has occurred. Therefore Link state routing algorithm is having less operational overheads than distance vector routing algorithm.

## 4. SIMULATION RESULTS

The simulation results obtained for comparing the performance of single path and multipath routing algorithm using ns-2 (network simulator 2) are depicted in Fig 2. The packet loss w.r.t offered load (Mbps) comparison of single path and multi-path link state routing algorithms is shown in Fig. 2. The topology considered is shown in Fig 1. The bandwidth and delay of links used in the topology is shown in table 1.0.

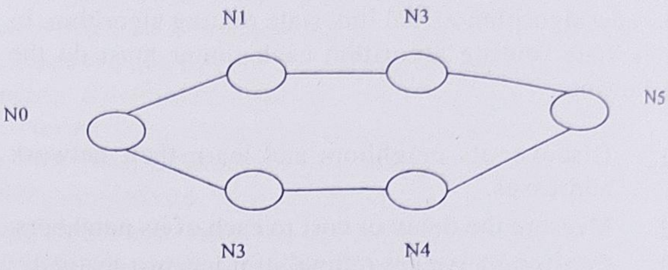


**Fig 1. Topology for case study**

**Table 1.0. Bandwidth and delay of links used in topology**

| Sr.No. | Link | Capacity | Delay |
|---|---|---|---|
| 1. | N0-N1 | 0.5Mbps | 2ms |
| 2. | N0-N2 | 0.5Mbps | 2ms |
| 3. | N1-N3 | 0.5Mbps | 2ms |
| 4. | N3-N5 | 0.5Mbps | 2ms |
| 5. | N2-N4 | 0.5Mbps | 2ms |
| 6. | N4-N5 | 0.5Mbps | 2ms |

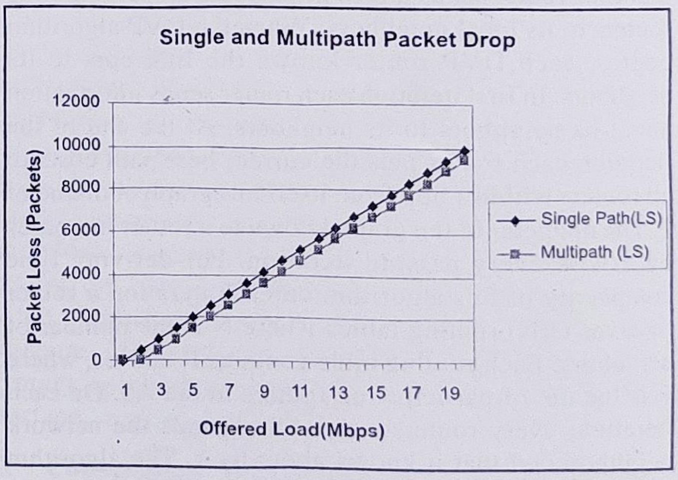


**Fig. 2. Packets drop comparison of single and multi-path link state routing algorithm**

## 5. CONCLUSION

In this research paper it is concluded that after considering the different features of dynamic routing algorithms, Link-state routing algorithms are better as compared to distance vector routing algorithms due to their better scalability, better metric, better convergence time, improved load balancing, better support of VLSM and less operational overheads. Simulation comparison of link state and distance vector also concludes that the link states routing algorithm is better than distance vector routing algorithm [8][9].The simulation results concludes that multi-path link state routing algorithm gives better performance than single path link state routing algorithm in term of packet loss, throughput, reliability of packet delivery and load balancing. But this is not the end of the conclusion because there are further many prospectus particularly in traffic engineering in dynamic adaptive routing algorithms.

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