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A Review of Intradomain Packet Routing Optimization in IP Networks

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Abstract

This paper presents recent work on Intradomain routing optimization using legacy protocols, and identifies important areas where further research is needed. The shortest and optimal routing is discussed in context of intradomain routing protocols. An alternative to having the distributed routing protocols adept to the prevailing traffic, the network operator or automated network management tools can modify the configuration of static parameters that derive the operation of routing protocols using traffic engineering concepts. The Objective of routing optimization is to balance the traffic load in the network with the goal to improve quality of service (QoS) and optimal utilization of available resources. The paper also provides the literature on traffic engineering and other algorithms that contributing to the optimization of Intradomain routing.

Key words: Intra-domain routing protocols, Quality of service, Routing Optimization, Traffic Engineering.

I. Introduction

The first IP networks were used for military or research applications. Mostly static routes were used and routing protocols were based on distance vector algorithms, such as Routing Information Protocol (RIP). The IP networks of today carry mostly commercial traffic. Multimedia applications used today are very delay-sensitive and hence, routing protocols must provide stability, and security, and converge quickly.

With Internet connectivity and web-usage becoming nearly ubiquitous, many day-to-day activities have migrated to the Internet.

User expectation of Internet use has also evolved from "best-effort" connectivity to a high performance medium meeting the bandwidth demands for all types of applications. Media and entertainment are also likely to generate a variety of applications which ride over IP networks. During the last decade the Internet community has witnessed the proliferation of multimedia services such as voice over IP (VoIP), videoconference, live Internet TV/radio and video on demand (VoD). A common feature for these services is the requirement for network paths that satisfy constraints on specific QoS parameters e.g., available bandwidth, maximum delay and delay jitter. The goal is to ensure that enough resources are available so that the end-user is satisfied with the quality of the received service. Entertainment and real-time applications like voice-over-IP, medical telemetry, network gaming and streaming video are quickly becoming prevalent applications over packet-based communication networks. Not only do these applications demand a very diverse set of network performance requirements, networks themselves are also experiencing rapid growth in the number of users and traffic per user. Enterprise data networks are evolving into IP-only data networks. In this IP environment, Open Shortest Path First (OSPF) and Enhanced Interior Gateway Routing Protocol (EIGRP) are two popular interior gateway routing protocols (IGRPs) used by large enterprises. OSPF version 2 is IETF Standard, a link-state protocol is more efficient, more scalable, interoperable, and typically provides superior convergence. For these reasons, enterprises currently have OSPF running in their networks.

Recently, a new approach to the routing optimization has been identified, which has proven to be of significant relevance to companies that have adopted it. This approach is based on the optimization of link weights with different functions that may affect shortest path selection, traffic distribution and finally network routing cost into a single optimization model. The basic idea behind these models is to simultaneously optimize decision variables of different functions that have traditionally been optimized sequentially, in the sense that the optimized output of one stage becomes the input to the other. However, a unified body of literature that deals comprehensively with these types of routing optimization does not exist yet.

II *Routing optimization issues :*

Routing is the core function of a network. It ensures that information accepted for transfer at a source node is delivered to the correct set of destination nodes, at reasonable levels of performance. Early 1960s take place the first routing algorithms that find the shortest path between two points: Bellman-Ford algorithm and Dijkstra algorithm. The Shortest Path is found with static metrics. Bellman-Ford is based on the number of hops between source and destination (RIP uses this algorithm). Dijkstra is based on the cost of a link (OSPF and IS-IS uses this algorithm), EIGRP is based on DUAL algorithm and rely on bandwidth and delay by defaults of the links. If there's a bottleneck in the shortest path, the algorithm does not change the path to another one.

A. Shortest Path and Optimal Routing :

Shortest Path Routing evolution can be splitted in two branches: Disjoint Shortest Path Routing and Multipath Routing. Disjoint

Path Routing provides a pair of minimum total length independent paths to increase the reliability in communications. Some proposals try to find "k" independent paths but they turn into an NP-Complete algorithm.

Multipath routing finds "k" best paths for a destination. The information is load-balanced among these paths and average network delay is reduced. The load-balancing could be made in different ways: Round Robin Load -Balancing where each packet takes a path to the destination and Per Flow Load Balancing: Each TCP flow takes a source destination path.

Optimal routing optimizes the average global delay of a network instead of finding the shortest path to a destination. It is an efficient way of designing a network but not adequate for real networks due to slow convergence and dependence on global parameters, sometimes difficult to know priori.

However there are two different ways to find the best route to a destination: The shortest-path route – It considers static metrics and in recent years QoS Requests such as BW, delay, jitter, reliability; all of them in a dynamic way and The optimal route -The path or paths that minimize the global delay of the network.

B. Routing Information Protocol (RIP):

RIP is a standard for exchange of routing information among gateways and hosts. It is a distance-vector protocol. RIP is most useful as an "interior gateway protocol". The network is organized as a collection of "autonomous systems". Each autonomous system has its own routing technology, which may well be different for different autonomous systems. The routing protocol used within an autonomous system is referred to as an interior gateway protocol, or "IGP". RIP is designed to work with moderate-size networks using reasonably homogeneous technology. Thus, it is suitable as an Interior Gateway Protocol for many campuses and for regional networks using serial lines whose speeds do not vary widely. It is not intended for use in more complex environments. RIP2 derives from RIP, which is an extension of the Routing Information Protocol (RIP) intended to expand the amount of useful information carried in the RIP messages and to add a measure of security. At regular intervals each router sends an update message describing its routing database to all the other routers that it is directly connected to. Some routers will send this message as often as every 30 seconds, so that the network will always have up-to-date information to quickly adapt to changes as computers and routers come on and off the network. RIP2 is an UDP-based protocol.

C. Open Shortest Path First (OSPF) :

OSPF is a dynamic link-state routing protocol that uses a link-state database (LSDB) to build and calculate the shortest path to all known destinations. It is through the use of Dijkstra's SPF algorithm that the information contained within the LSDB is calculated into routes. Open Shortest Path First (OSPF) was standardized by the IETF in 1998 as a solution for large networks[12]. It belongs to the class of link state protocols. Instead of exchanging distance metrics between neighbor routers, all OSPF routers distribute link state information associated with their interfaces to all other routers in the network. This way, every router builds up and maintains its own topology database, which contains elements representing subnets (stub networks), OSPF routers, transit networks (*i.e.*, subnets that connect several routers), aggregated networks (*i.e.*, areas), and destination networks outside the AS. Based on the global view of the network topology, every router is able to perform shortest path computations independently and determine the relevant outgoing interfaces. OSPF differs from EIGRP in that it can be used in hierarchical arrangements, thereby supporting scalability to very large IP networks. It also offers the advantages of capabilities such as On Demand Routing (ODR), acknowledged communications, authentication, and quick convergence due to use of the Dykstra algorithm, Variable Length Subnet Mask (VLSM), route summarization for internal and external routes, and MPLS-TE.

D. Intermediate System to Intermediate System (IS-IS) :

Intermediate System-to-Intermediate System (IS-IS) is a link-state protocol where IS (routers) exchange routing information based on a single metric to determine network topology. In an IS-IS network, there are End Systems, Intermediate Systems, Areas and Domains. End systems are user devices. Intermediate systems are routers. Routers are organized into local groups called "areas", and several areas are grouped together into a "domain". IS-IS is designed primarily providing intra-domain routing or routing within an area. IS-IS, working in conjunction with CLNP, ES-IS, and IDRP, provides complete routing over the entire network. IS-IS routing makes use of two-level hierarchical routing. Level 1 - routers know the topology in their area, including all routers and hosts, but they do not know the identity of routers or destinations outside of their area. Level 1 routers forward all traffic for destinations outside of their area to a level 2 router within their area which knows the level 2 topology. Level 2 routers do not need to know the topology within any level 1 area, except to the extent that a level 2 router may also be a level 1 router within a single area. IS-IS has been adapted to carry IP network information, which is called Integrated IS-IS. Integrated IS-IS has the most important characteristic necessary in a modern routing protocol: It supports VLSM and converges rapidly. It is also scalable to support very large networks. There are two types of IS-IS address: Network Service Access Point (NSAP) - NSAP addresses identify network layer services, one for each service running. Network Entity Title (NET) - NET addresses identify network layer entities or processes instead of services. Devices may have more than one of each of the two types of addresses. However NET's should be unique and the System ID portion of the NSAP must be unique for each system.

E. Enhanced Interior Gateway routing protocol (EIGRP) :

EIGRP is a Cisco-proprietary distance vector Interior Gateway Routing Protocol (IGRP) that allows routers to exchange vector updates that represent link distances. These updates are non-periodic, partial and bounded, as generally represented in link state-like functions. The EIGRP updates are based on a diffusing computational algorithm that provides advantages of network resource utilization, loop topology avoidance, link bandwidth conservation, and multiple network-layer protocol support (IP, IP exchange (IPX), and AppleTalk (AT)) over previous generation distance vector routing protocols such as RIP. These characteristics allow EIGRP to be used effectively for small-to-medium-scale IP networks. EIGRP uses the Diffusing Update Algorithm (DUAL).

However, the proprietary status of EIGRP presents an inherent limitation to its universal use. In addition, several other notable deficiencies, such as its inability to be used in a hierarchical arrangement, which precludes its use in large IP networks and its lack of support for Multi-Protocol Layer Switching-Traffic Engineering (MPLS-TE) also, restrict its overall networking utility.

F. Traffic Engineering (TE) .

Traffic engineering involves adapting the routing of traffic to the network conditions, with the joint goals of good user performance and efficient use of network resources. It deals with the issue of evolution, enhancement of performance of traffic and resources and optimization of operational networks. Major objectives of TE involve measurement, characterization, modeling and control of network traffic by application of various technologies & scientific principles. TE addresses various issues like economical resource utilization, network reliability, load balancing and throughput. Resource level performance measurements include node reliability, link reliability and sufficient buffer space at intermediate nodes. Traffic level performance measurements include delay, packet loss and throughput.

A network allows transfer of data from one node to another in network. So the most critical function carried out by network is to transfer data from source to destination by finding optimal path. TE allows the control and optimization of routing function to distribute the traffic effectively in the network. The end user interacts with network through some application or directly, so during the development of TE mechanism & polices, the end user visualization of network performance must be taken in account. An ISP allows network access to end users, so it is the responsibility of ISP to enhance the emergent properties of the network while taking economic considerations into account. During network optimization special care must be taken for choosing the network performance measures. Optimization of wrong measures may have disastrous consequences and thereby on QoS perceived by end users. The application of TE concepts aids in finding the bottlenecks in network, such as routing control, link bandwidth utilization, buffer space management and other computational resources.

One aspect of TE is performance evaluation, which can be carried out by making suitable models and applications of critical technologies, like analytical or simulation methods. TE is a continuous and iterative process by enhancing the utilization of network resources to improve the QoS. The optimization objective may change over the time as per the need of services from the Internet. So the new technologies must be evolved continuously to support the process.

The major challenges of routing optimization is the real implementation of automated control capabilities that adapt quickly any state change in the network involving all performance measures for effective utilization of available network resources.

The first IP-based TE solution was proposed by Fortz[28-30]. The basic idea of their approach is to set the link weights of interior gateway protocols (IGPs) according to the given network topology and traffic demand so as to control intradomain traffic and meet TE objectives. Unlike MPLS based TE, which enables dedicated explicit routing for individual flows, such "fine-grained" path selection cannot be achieved in IP-based TE, as the changes of IGP link weight may affect the routing patterns of the entire set of traffic flows.

G. Recommendation for Routing Models:

A desirable routing system is one that takes traffic characteristics and network constraints into account during path selection while maintaining stability. The significant aspect of Internet traffic engineering is routing control. Routing involves many of the key performance measures associated with networks, such as traffic distribution, resource utilization, delay, and throughput. Without effective routing control, it is very difficult to provide good service quality in a wide area network.

Traditional shortest path first (SPF) interior gateway protocols are based on shortest path algorithms and have limited control capabilities for traffic engineering[10]. These limitations include: the well known issues with pure SPF protocols, which do not take network constraints and traffic characteristics into account during route selection. For example,[1] since IGPs always use the shortest paths (based on administratively assigned link metrics) to forward traffic, load sharing cannot be accomplished among paths of different costs. Constraint-based routing is desirable to evolve the routing architecture of IP networks, especially public IP backbones with complex topologies. Constraint-based routing computes routes to fulfill requirements subject to constraints. Constraints may include bandwidth, hop count, delay, and administrative policy instruments such as resource class attributes. This makes it possible to select routes that satisfy a given set of requirements subject to network and administrative policy constraints. Routes computed through constraint-based routing are not necessarily the shortest paths. Constraint-based routing works best with path oriented technologies that support explicit routing, such as MPLS. Constraint-based routing can also be used as a way to redistribute traffic onto the infrastructure. For example, if the bandwidth requirements for path selection and reservable bandwidth attributes of network links are appropriately defined and configured, then congestion problems caused by uneven traffic distribution may be avoided or reduced. In this way, the performance and efficiency of the network can be improved.

A number of enhancements are needed to conventional link state IGPs, such as OSPF and IS-IS and distance vector EIGRP to allow them to distribute additional state information required for constraint-based routing. The extensions to OSPF were described in[26]. Essentially, these enhancements require the propagation of additional information in link state and distance vector advertisements. Specifically, in addition to normal link-state information, an enhanced IGP is required to propagate topology state information needed for constraint-based routing. An enhanced link-state IGP may flood information more frequently than a normal IGP. This is because even without changes in topology, changes in reservable bandwidth or link affinity can trigger the enhanced IGP to initiate flooding. A tradeoff is typically required between the timeliness of the information flooded and the flooding frequency to avoid excessive consumption of link bandwidth and computational resources, and more importantly, to avoid instability. Research on IGP behaviors is still poor so will help operators better understand intra-domain routing instability.

In a TE system,[1] it is also desirable for the routing subsystem to make the load splitting ratio among multiple paths (with equal cost or different cost) configurable. This capability gives network administrators more flexibility in the control of traffic distribution across the network. It can be very useful for avoiding/relieving congestion in certain situations. Examples can be found in[27]. The routing system should also have the capability to control the routes of subsets of traffic without affecting the routes of other traffic if sufficient resources exist for this purpose. This capability allows a more refined control over the distribution of traffic across the network. For example, the ability to move traffic from a source to a destination away from its original path to another path (without affecting other traffic paths) allows traffic to be moved from resource-poor network segments to resource-rich segments. Path oriented technologies such as MPLS inherently support this capability as discussed in[10]. Additionally, the routing subsystem should be able to select different paths for different classes of traffic (or for different traffic behavior aggregates) if the network supports multiple classes of service (different behavior aggregates).

III *Routing optimization considering destination based protocols :*

The work[1] presents recent work on routing optimization using OSPF, and identifies important areas where further research is needed. Data transmission can be unicast, multicast, anycast or broadcast. This[2] gives an overview of the evolution of routing from ARPANET, to recent algorithms that provide some Quality of Service, focusing on unicast distributed routing algorithms. They started scheme with shortest path routing and optimal routing and conclude it with constrained routing protocols.

The work[3] proposed a reinforcement learning (RL) algorithm for packet routing in computer networks with emphasis on different traffic conditions. It is shown that routing with an RL approach, considering the traffic, can result in shorter delivery time and less congestion. A simple, but rational simulation of a computer network has also been tested and the suggested algorithm has been compared with other conventional ones. At the end, it is concluded that the suggested algorithm can perform packet routing efficiently with advantage of considering the dynamics in a real network.

In[4] problem of traffic engineering (TE) is discussed to assess the relevance of using Gene Expression Programming (GEP) as a new fine tuning algorithm in destination-based TE. They presented a new TE scheme where link weights are computed using GEP and used as fine-tuning parameters in destination-based path selection. They apply the newly proposed TE scheme to compute the routing paths for the traffic offered to a 23- and 30-node test networks under different traffic conditions and differentiated services situations. They evaluated the performance achieved by the

GEP algorithm and compared to a memetic and the Open Shortest Path First (OSPF) algorithms in a simulated routing environment using the NS packet level simulator. Preliminary results reveal the relative efficiency of GEP compared to the memetic algorithm and OSPF routing.

An intra-domain[5] routing algorithm based on multi-commodity flow optimisation is presented which enable load sensitive forwarding over multiple paths. It is neither constrained by weight-tuning of legacy routing protocols, such as OSPF, nor requires a totally new forwarding mechanism, such as MPLS. These characteristics are accomplished by aggregating the traffic flows destined for the same egress into one commodity in the optimisation and using a hash based forwarding mechanism. The aggregation also results in a reduction of computational complexity which makes the algorithm feasible for on-line load balancing. Another contribution is the optimisation objective function which allows precise tuning of the tradeoff between load balancing and total network efficiency.

The research workers[6] propose a genetic algorithm based approach for providing optimized integrated solutions to the route selection and capacity flow assignment problems On basis of prior theoretical research they indicated that these problems belong to the class of nonlinear combinatorial optimization problems, which are mostly (if not all) NP-hard problems. Although the traditional Lagrange relaxation and sub-gradient optimization methods can be used for tackling these problems, the results generated by these algorithms are locally optimal instead of globally optimal. With their novel formulation and genetic modeling, the proposed algorithm generates much better solutions than two well known efficient methods in their simulation studies.

The[7] addresses QoS routing as a NP-Complete problem. They propose two heuristic algorithms. The first algorithm proposed is an improvement of direct quantization algorithm proposed by Xin[8]. The proposed algorithm makes use of the "distance" information to obtain topology information which could be used to reduce the execution time and memory requirement. The proposed algorithm vastly improves upon the Xin's algorithm in situation where certain nodes are unreachable from source node or there is no direct path from the node under consideration to destination node. They guarantees, that the proposed algorithm returns a path, given that there exists a path which meets the constraints. The second algorithm considers QoS routing from a centralized node.

They[9] describe how to identify configuration mistakes by parsing and analyzing configuration data extracted from the various routers. They first present an overview of IP networking from the viewpoint of an Internet Service Provider (ISP) and describe the kinds of errors that can appear within and across router configuration files. To narrow the scope of the problem, they then focus attention on the configuration commands that relate to traffic engineering--tuning the Intradomain routing protocol to control the flow of traffic through the ISP network. They present a case study of a prototype tool, developed in collaboration with AT&T IP Services, for checking the configuration of the AT&T IP Backbone and providing input to other systems for network visualization and traffic engineering.

In[10], explained the applications of MPLS to traffic engineering in IP networks. The concepts and challenges of TE in the Internet are reviewed. In[11], the problem of designing a network that employs a non-bifurcated shortest path routing protocol is discussed. The network's nodes and the set of potential links are given together with a set of forecasted end-to-end traffic demands. All relevant hardware components installable at links or nodes are considered. The goal is to simultaneously choose the network's topology, to decide which hardware components to install on which links and nodes, and to find appropriate routing weights such that the overall network cost is minimized. They also present a mathematical optimization model for this problem and an algorithmic solution approach based on a Lagrangian relaxation. Computational results achieved with this approach for several real-world network planning problems are reported.

In[12], presents a routing optimization problem solved by a nondeterministic algorithm with DNA computing. They[13] propose several heuristic algorithms that, using MPLS capabilities from simple greedy algorithms to more complex meta-heuristics based on tabu-search optimization, provide network operators with a control framework for the routing plane. Simulation results show the benefits of the proposed framework, which guarantees better performance compared to the classic static routing algorithms used in today's networks.

In[14], defined an optimization problem where the objective includes end-user utilities and the network operator cost function. A distributed solution (DATE) is proposed to this problem balances the tension between robustness and optimality in two ways. First, by incorporating the operator's cost function into the objective, DATE protects the network from short traffic bursts. Second, by finding a distributed solution, the algorithm can react to traffic shifts on a smaller timescale. Stability (both convergence in the deterministic fluid model and stochastic stability when session-level arrivals are considered), optimality, and robustness of DATE are proved and illustrated.

They[15], present a novel generalized algorithm designed and developed to obtain optimal path traffic routing for communication network. An algorithm is presented by considering the routing design metrics distance between the hops, number of hops, hop failure and congestion. The selected network for the generalized algorithm is capable of handling a network of any structure with any number of hops. The developed algorithm is tested and presented with a typical example. They present the performance measure of network congestion with Single Server Queuing model using Artificial Neural network. They[16], presents a Genetic algorithm is used to optimise the parameters for a sequence of packets sent over the Internet. Only the parameters that a client machine can change are used and the fitness is based on the delay time returned by the Trace route program. The GA performance is compared to a fixed packet size with no priority used to assess the status of the network.

In[17], discusses the modeling and computational challenges of optimizing the tunable parameters, starting with conventional intradomain routing protocols that compute shortest paths as the sum of configurable link weights. Then, they consider the problem of optimizing the interdomain routing policies that control the flow of traffic from one network to another. Optimization based on local search has proven quite effective in grappling with the complexity of the routing protocols and the diversity of the performance objectives, and tools based on local search are in wide use in today's large IP networks.

In[18], a survey is carried out for flexible multipath routing techniques which are both scalable and incentive compatible. Techniques covered include: multihoming, tagging, tunneling, and extensions to existing Internet routing protocols. They[19] propose a novel dynamic least cost multicast routing protocol using hybrid genetic algorithm for IP networks. Their protocol finds the multicast tree with minimum cost subject to delay, degree, and bandwidth constraints. The proposed protocol has the following features: i. Heuristic local search function has been devised and embedded with normal genetic operation to increase the speed and to get the optimized tree, ii. It is efficient to handle the dynamic situation arises due to either change in the multicast group membership or node / link failure, iii. Two different crossover and mutation probabilities have been used for maintaining the diversity of solution and quick convergence. The simulation results have shown that proposed protocol generates dynamic multicast tree with lower cost. Results have also shown that the proposed algorithm has better convergence rate, better dynamic request success rate and less execution time than other existing algorithms. Effects of degree and delay constraints have also been analyzed for the multicast tree interns of search success rate.

The work[20] Levchenko *et al.* present a new link-state routing algorithm called Approximate Link state (XL) aimed at increasing routing efficiency by suppressing updates from parts of the network. We prove that three simple criteria for update propagation are sufficient to guarantee soundness, completeness and bounded optimality for any such algorithm. They show, via simulation, that XL significantly outperforms standard link-state and distance vector algorithms in some cases reducing overhead by more than an order of magnitude—while having negligible impact on path length. Finally, they argue that existing link-state protocols, such as OSPF, can incorporate XL routing in a backwards compatible and incrementally deployable fashion.

They[21], present a review of Internet traffic engineering from the perspective of routing optimization. They classify the algorithms into multiple dimensions: unicast/multicast, intra-/interdomain, IP-/MPLS-based and offline/online TE schemes. In[22], argued that instead of optimizing existing protocols, protocols should be designed with optimization in mind from the beginning realizing that optimization problems in network management are induced by assumptions adopted in protocol design. The[23], presents routing optimization based on conventional routing protocols where packets are forwarded hop-by-hop in a destination-based manner. They consider routing protocols, which are able to take into account concave routing metrics in addition to additive ones. The concave link metric introduces an additional degree of freedom for routing optimization, thus, increasing its optimization potential. They present and evaluate a mixed-integer programming model, which works on these metrics. This model unifies the optimization for single-metric and dual-metric routing concepts and also includes the consideration of multipath routing. Furthermore, we propose a heuristic algorithm usable for larger network instances. Numerical results indicate that employment of both the dual-metric concept and multipath routing can achieve considerably better utilization results than default-configured single-metric routing.

They[24], discuss Overlay Routing Protocol (ORP), a framework for unicast overlay routing, which will be used to test various QoS routing protocols and algorithms. They discussed that emergence of new types of popular multimedia services recquires in the long run a quality-of-service (QoS) solution better than the best-effort service provided by IP. Failure to widely deploy either one of the main architectures for IP QoS, integrated services (IntServ) or differentiated services (DiffServ), has fueled research into alternate solutions based on overlay networks on top of IP. The work of[25] present Filter-based forwarding that allows you to control the next-hop selection for customer traffic by defining input packet filters that examine the fields in a packet's header. If a packet satisfies the match conditions of the filter, the packet is forwarded using the routing table instance specified in the filter action statement.

IV *Suggestions for further research :*

The models reviewed in this paper represent a significant advance in the routing optimization based on Traffic Engineering as well as without Traffic Engineering. However, research in this area still shows many gaps that further research must fill. Most research work is based on simulation models instead of considering real networks.

The possible objectives of routing optimization are manifold and there is no unique definition of what is considered an optimum routing solution. Assuming that the network infrastructure is given and that link and possibly node capacities are assigned, three objective categories, which intuitively are similar but which reflect three different perspectives of network operation, are: 1) maximization of achievable traffic throughput 2) optimization of quality of service and 3) optimization of resource utilization. Further research in the routing optimization could take into consideration more complex and real networks for analysis. Optimal solutions are very hard to obtain, better heuristic procedures could be developed to obtain approximate solutions for this complex problem. Research is also needed for the multiple products in the routing technologies that would constitute a significant contribution to the field. A methodology to balance the complexity of this kind of problems with the applicability of the results obtained from them could be vital in the development of solution methodologies that remain tractable and at the same time suitable for practical application. The review of the work done on routing optimization makes evident that the consideration of two or more metrics into a single model makes the optimization problem much harder to solve than the previous disjoint optimization problems.

Researchers should exercise increased creativity in the analysis of the routing optimization models and in the development of heuristic procedures capable of handling the bigger challenge of integrated analyses. More research is needed to identify overall frameworks for which routing optimization are beneficial and compensate the increased complexity of the problem. The routing optimization using OSPF has proven to be of significant benefit to companies that have applied it under adequate conditions. The identification of the relevant instances of the optimized problem and their solutions is a task that still needs to be undertaken.

V Conclusion

This survey paper, addresses various issues in routing optimization for QoS, based on Traffic Engineering. A desirable routing system is one that takes traffic characteristics and network constraints into account during path selection while maintaining stability. From the work carried out in literature it is identified that most widely used protocol in Internet is OSPF. IP routing protocols have tunable parameters that operators or automated management tools can configure using traffic engineering methodologies to drive routers to direct traffic on shortest paths. But parameter configuration is also complex and IP protocols do not support much enough for optimization. The correct setting of all network control parameters is complex and NP-Complete in nature. An overview of some of the basic issues surrounding traffic engineering in intradomain IP networks is also presented. Routing involves many of the key performance measures associated with networks, such as traffic distribution, resource utilization, delay, and throughput. Without effective routing control, it is very difficult to provide good service quality in a wide area network. QoS is an important fact in today networks but most of the QoS routing proposals are NP-Complete and need a heuristic version or some modifications for an approximated solution. Some evolutionary approach based algorithms are also implemented in literature using simulation and concluded that intuitive approaches can better handle such problems compared to analytical approaches.

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