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# Study of IP Network interior gateway routing for optimization

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## ABSTRACT

This paper reviews recent work on routing optimization for interior gateway protocols, and identifies important areas where further research is needed. 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 function that may affect shortest path selection, traffic distribution and finally network routing cost into a single optimization model. The problem of simultaneously considering the characteristics and requirements of different functions to perform an overall optimization has attracted the attention of researchers in recent years and some models have been proposed in this direction.

## 1. INTRODUCTION

Routing optimization provides a means to balance the traffic load in the network with the goal to improve quality of service. The problem of finding efficient routing algorithms has been a fundamental research area in the field of data network. Routing is the act of moving information across an internet from a source to destination and along the way at least one intermediate node typically is encountered.

Each packet on the internet must be passed quickly through each network (AS) that it must traverse to go from source to destination. Most methods currently deployed in the Internet for routing in a network are designed to forward packets along the shortest path. Along with the shortest path offered by routing algorithms used in routing protocols, the quality of Services is also required. Number of metrics like Link bandwidth, delay, link reliability , path length, load on the link etc. are used by Interior routing protocols like RIP, IS-IS, and OSPF as well as by exterior routing protocols such as BGP and EGP. Internet employs the heterogeneous structures due to which routing areas like on-line and off-line, Adaptive, Destination and Source, Hierarchical, Multicast and QoS routing are to be engineered continuously for optimal path for packets from source to destination and to offer quality of services by the network to end-users. In cases where increasing traffic load or temporary traffic variations causes localized link congestion, routing optimization can be carried out to resolve. The idea is to adjust routing polices to current load situations and thus better utilizes available network resources leading to improved performance and quality of service. Internet routing is an important area of TE where lots of gaps are there and must be filled. Continuous optimization is required in this area. 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.

## 1.1 ROUTING PROTOCOLS

RIP (Routing Information Protocol) is a standard for exchange of routing information among gateways and hosts. RIP is designed to work with moderate-size networks using reasonably homogeneous technology. Thus, it is suitable as an Interior Gateway Protocol (IGP) 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 RIP intended to expand the amount of useful information carried in the RIP messages and to add a measure of security. 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. OSPF is the successor of RIP 2 and IS-IS as a solution for large networks standardized by IETF in 1998.OSPF is an interior gateway protocol used for between routers that belong to a single Autonomous System. OSPF uses link-state technology in which routers send each other information about the direct connections and links which they have to other routers. OSPF allows sets of networks to be grouped together. Such a grouping is called an area. The topology of an area is hidden from the rest of the Autonomous System. This information hiding enables a significant reduction in routing traffic. Also, routing within the area is determined only by the area’s own topology, lending the area protection from bad routing data.

## 1.2 TRAFFIC ENGINEERING

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. In some sense, IP networks manage themselves. A host implementing the Transmission Control Protocol (TCP) adjusts its sending rate to the bandwidth available on the path to the destination, and routers react to changes in the network topology by computing new paths. This has made the Internet an extremely robust communication network, even in the face of rapid growth and occasional failures. However, these mechanisms do not ensure that the network runs efficiently. For example, a particular link may be congested despite the presence of under-utilized links in other parts of the network. Or, a voice-over-IP call may travel over a route with high propagation delay when a low-latency path is available. Improving user performance and making more efficient use of network resources requires adapting the routing of traffic to the prevailing demands. This task is referred to as traffic engineering [1]. TE employs the application of technology to the characterization, measurement, modeling and control of network traffic. Traffic oriented measures includes delay, packet loss, load shading, link failure issues and throughput. Optimizing the wrong measures may have disastrous consequences on the emergent properties of the network and thereby on the Quality of service perceived by end users of network services. The application of traffic engineering concepts aids in the measurements and analysis, identifying the properties in terms of enhancing the Quality of service delivered to the end user of network services. Most work on traffic engineering has focused on techniques for controlling the flow of traffic within a single Autonomous System (AS).

### *A. Network performance evolutions*

It is a complicated task practically. Results from performance evolution can be used for identification of existing network problems & guide network optimization. It also helps in predication of potential future network problems. Techniques of achieving performance evolution such as Analysis method, Empirical methods based on measurements & simulation can be used

### *B. Intradomain Traffic Engineering*

Traffic engineering depends on having a set of performance objectives that guide the selection of paths, as well as effective mechanisms for the routers to select paths that satisfy these objectives. Most existing IP networks run Interior Gateway Protocols (IGPs) such as OSPF (Open Shortest Path First) or IS-IS (Intermediate System-Intermediate System) that select paths based on static link weights configured by network operators. Routers use these protocols to exchange link weights and construct a complete view of the topology inside the AS. Then, each router computes shortest paths (as the sum of these weights) and creates a table that controls the forwarding of each IP packet to the next hop in its route. Traditionally, IP forwarding depends on the destination address in the IP header of each packet. More recently, routers running Multi-Protocol Label Switching (MPLS) can forward packets based on the label in the MPLS header. In either case, we are concerned with how the path is chosen rather than how the packets are forwarded. On the surface, the basic framework of shortest-path routing does not seem flexible enough to support traffic engineering in an IP network supporting a diverse set of applications. First of all, these IGPs are limited to routing scenarios that can be specified with a single integer weight on each link. However, we argue that link weights suffice to specify near-optimal routing for large, real-world networks. Second of all, in their basic forms, the OSPF and IS-IS protocols do not adapt the link weights in response to changes in traffic or the failures of network elements, and the path-selection process does not directly incorporate any performance objectives (beyond the selection of a "shortest" path). Recent standards activity has proposed traffic-engineering extensions to OSPF and IS-IS to incorporate information about the prevailing traffic into the link-state advertisements and the path selection decisions [2]. However, these extensions require modifications to the routers to collect and disseminate information about network load and compute and establish paths based on the load metrics. Instead, we argue that it is often possible to select static link weights that are resilient to traffic fluctuations and link failures, allowing the use of the traditional incarnations of OSPF and IS-IS.

### *C. Routing Model*

Traffic engineering requires an effective way to predict the flow of traffic through the network based on the routing configuration. Knowing the route(s) between each pair of nodes enables the operators to identify the traffic that imposes load on a congested link and evaluate the influence of possible changes to the IGP parameters. This requires an accurate model of how the routers in an AS compute paths based on the topology and IGP configuration. When all of the links belong to a single OSPF/IS-IS area, path selection simply involves computing the shortest path(s) between each pair of routers (e.g., using Dijkstra's algorithm). Larger networks are typically divided into multiple OSPF/IS-IS areas. For routers in different areas, the path selection depends on the summary information conveyed across area boundaries. In some cases, the network may have multiple shortest paths between the same pair of routers. The OSPF and IS-IS protocol specifications do not dictate how routers handle the presence of multiple shortest paths. In practice, most routers capitalize on the multiple paths to balance load. A router typically splits traffic roughly evenly over each of the outgoing links along a shortest path to the destination. Ultimately, then, the routing model should compute a set of paths for each pair of routers. These paths can be represented in terms of the fraction of the traffic (for this pair of routers) that traverses each of the links. The output of the routing model can be combined with the traffic demands to estimate the volume of traffic on each link, based on the topology and the IGP configuration. The routing model also plays a role in capturing the interaction of the IGP with interdomain routing (i.e., the Border Gateway Protocol (BGP)). A single block of destination IP addresses may be reachable via multiple exit points to neighboring domains. For example, an AS may have multiple links to another service provider at different geographic locations. The BGP decision process selects from these routes based on the IGP cost of the shortest path to each exit point. This enables each router to select the "closest" exit point. The work presents an overview of a routing model that captures the details of multiple OSPF/IS-IS areas, splitting over multiple shortest paths, and the influence of IGP parameters on how the traffic exits the network enroute to a neighboring AS.

## 3. OPTIMIZATION ASPECT

Optimization aspect of TE is a control perspective. Aspect of control within Internet TE can be pro-active or reactive. Pro-active control system takes preventive actions to avoid unfavorable future states. Reactive control system responds correctively and perhaps adaptively to events that have already transpired in the network. Different networks may have different optimization objectives depending upon their business model, operating restrictions and capabilities. Major challenge of Internet TE is the realization of automated control procedures that adapt quickly and economically to significant changes in network state while still maintaining stability and reliability. Optimization objectives of ITE are not a onetime goal but are a continual and interactive process of network performance enhancements. It demands regular development of new technologies and new methodologies for performance improvements, as the traffic grow continuously. So the objectives may change over the time as new requirements and constraints are imposed. TE mechanism must be well defined and sufficiently specific to address, known requirements as well as must be flexible and scalable to accommodate unforeseen future demands.

## 4. ROUTING OPTIMIZATION

Routing optimization provides network operators with a powerful method for traffic engineering. Its general objective is to distribute traffic flows evenly across available network resources in order to avoid network congestion and quality of service degradation. Even in well-dimensioned networks, temporary demand variations and traffic fluctuations can create overload at individual links. In order to avoid potential QoS degradation, it is therefore necessary to monitor the state of a network and to intervene whenever link utilization values approach a certain level. Routing optimization, as a method of traffic engineering, provides a means to alleviate QoS problems caused by skewed traffic loads. It is applicable in networks, which experience localized traffic congestion while still having free bandwidth resources in other areas. By adjusting the routing pattern it might be possible to shift traffic from crowded links to lightly utilized network regions, thus, avoiding overload and keeping up the desired QoS.

In the routing optimization approach based on native IP routing where packets are forwarded in a next-hop destination-based manner along paths that were determined by the routing protocol [3]. When computing the paths, routers take into account specific metric values associated with every link. While these link metrics usually have a physically relevant meaning such as, propagation delay, cost or bandwidth. By modifying the link metric values, the path pattern of traffic flows through the network can be manipulated. Since routers exchange link information and recalculate routes automatically, this form of traffic engineering requires only little administrative effort [3]. After changing link weights, routers adjust the paths autonomously while no special action has to be taken by the administrator. However, this simplicity also has its drawback. Due to possible temporary inconsistencies during rerouting processes, packets might be dropped or delayed, causing service quality to degrade. Therefore, this optimization method is mainly applicable for medium and long-term adjustments. By default, most conventional routing protocols base their path computation only on one additive link metric, which typically results in shortest-path routing. However, some protocols allow more than one type of metric being taken into account when calculating the forwarding paths. An additional concave link metric introduces more routing flexibility and, thus, offers greater optimization potential. The Enhanced Interior Gateway Routing Protocol (EIGRP) is a protocol proposed by Cisco [4]. With EIGRP, every interface (i.e., link) has four different metric types associated with it: delay, bandwidth, reliability, and cost, which all can be considered for path computation. The first two parameters are assigned statically, while the third and the fourth are determined by the routers during network operation. When a router computes the path towards a destination, it considers a combination of these metric parameters.

## 5. OSPF VERSUS MPLS ROUTING PROTOCOLS

Unfortunately, most intra-domain internet routing protocols today do not support a free distribution of flow between source and destination as defined above in general routing problem. The most common protocol today is Open Shortest Path First (OSPF). In this protocol, the network operator assigns a weight to each link, and shortest paths from each router to each destination are computed using these weights as lengths of the links. In each router, the next link on all shortest paths to all possible destinations is stored in a table, and a demand going in the router is sent to its destination by splitting the flow between the links that are on the shortest paths to the destination. The exact mechanics of the splitting can be somewhat complicated, depending on the implementation. The quality of OSPF routing depends highly on the choice of weights. Nevertheless, these are often just set as inversely proportional to the capacities of the links, without taking any knowledge of the demand into account. It is widely believed that the OSPF protocol is not flexible enough to give good load balancing. This is one of the reasons for introducing the more flexible Multi-protocol Label Switching (MPLS) technologies [5]. With MPLS one can in principle decide the path for each individual packet. Hence, we can simulate a solution to the general routing problem by distributing the packets on the paths between a source-destination pair. The MPLS technology has some disadvantages. First of all, MPLS is not yet widely deployed, let alone tested. Second OSPF routing is simpler in the sense that the routing is completely determined by one weight for each arc.

## 6. CONSTRAINT BASED ROUTING

Traditional shortest path first (SPF) interior gateway protocols are based on shortest path algorithms and have limited control capabilities for traffic engineering. These limitations include: 1. the well known issues with pure SPF protocols, which do not take network constraints and traffic characteristics into account during route selection. For example, 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 [6]. 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 (even for best effort traffic). 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, to allow them to distribute additional state information required for constraint-based routing. These extensions to OSPF were described inessentially; these enhancements require the propagation of additional information in link state 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. In a TE system, 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 congestion in certain situations. Examples can be found in [7].

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.

## 7. CONCLUSION

It is not an easy task to classify the existing work on routing optimization. While optimal solutions are very hard to obtain, heuristic procedures could be developed to obtain approximate solutions for this complex problem. Analytical formulation of problems that consider more than two functions and exact or approximate solution procedures are still needed. The review of the work done on routing optimization makes evident that the consideration of two or more functions and their interrelations into a single model makes the optimization problem much harder to solve than the previous disjoint optimization problems.

## 8. REFERENCES

[1] D. Awduche, A. Chiu, A. Elwalid, I. Widjaja, and X. Xiao, “Overview and principles of Internet traffic engineering,” IETF, RFC 3272, May 2002.

[2] D. Katz, D. Yeung, and K. Kompella, “Traffic engineering extensions to OSPF.” Work in progress,Internet Draft draft-katz-yeung-ospf-traffic-06.txt, Expires April 2002.

[3] Anton Riedl, Member, IEEE, and Dominic A. Schupke, Member, IEEE” Routing Optimization in IP Networks Utilizing Additive and Concave Link Metrics” IEEE/ACM TRANSACTIONS ON NETWORKING, VOL. 15, NO. 5, OCTOBER 2007

[4] A. Zinin, Cisco IP Routing. Boston, MA: Addison-Wesley, 2002.

[5] E. C. Rosen, A. Viswanathan, and R. Callon, “Multiprotocol label switching architecture,” Network Working Group, Internet Draft (work in progress), http://search.ietf.org/internet-drafts/draftietf- mpls-arch-05.txt, 1999.

[6] Nor Musliza Mustafa, Mohamed Othman “A Review of Routing Optimization Using OSPF”, Proceedings of the 2007 IEEE International Conference on Telecommunications and Malaysia International Conference on Communications, 14-17 May 2007, Penang, Malaysia

[7] X. Xiao, A. Hannan, B. Bailey, L. Ni, "Traffic Engineering with MPLS in the Internet", IEEE Network magazine, Mar. 2000.