

# Performance Evaluation of Load -Balanced Routing via Bounded Randomization<sup>1</sup>

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## Abstract

Future computer networks are expected to carry bursty traffic. Shortest -path routing protocols such as OSPF and RIP have the disadvantage of causing bottlenecks due to their inherent single -path routing. That is, the uniformly selected shortest path between a source and a destination may become highly congested even when many other paths have low utilization. We propose a family of routing schemes that distribute data traffic over the whole network via bounded randomization; in this way, they remove bottlenecks and consequently improve network performance. For each data message to be sent from a source  $s$  to a destination  $d$ , each of the proposed routing protocols randomly chooses an intermediate node  $e$  from a selected set of network nodes, and routes the data message along a shortest path from  $s$  to  $e$ . Then, it routes the data message via a shortest path from  $e$  to  $d$ . Intuitively, we would expect that this increases the effective bandwidth between each source -destination pair. Our simulation results indicate that the family of proposed load -balanced routing protocols distribute traffic evenly over the whole network and, in consequence, increase network performance with respect to throughput, message loss, message delay and link utilization. Moreover, implementing our scheme requires only a simple extension to any shortest -path routing protocol.

## 1. Introduction

In a wide -area store -and-forward computer network, such as the Internet, routing protocols are essential. They are mechanisms for finding an efficient path between any pair of source and destination nodes in the network and for routing data messages along this path. The path must be chosen so that network throughput is maximized and message delay and message loss are reduced as much as possible.

There are mainly two types of routing protocols: *source routing* and *shortest -path routing (destination routing)*. In source routing, as our node determines the path that a data message must take [11]. In shortest-path routing, each node uses its routing table to store a preferred neighbor to each destination. Thus, the routing table specifies only one hop along the path from the current node to the destination. In a stable state of the protocols, the path consisting of consecutive preferred neighbors for a given destination is assumed to be a shortest path to the destination.

Shortest-path routing protocols are classified into two types of routing protocols: *distance-vector routing* [17], for example, used in the RIP Internet protocol [13], and *link -state routing* [14], for example, used in the OSPF Internet protocol [15].

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In the distance-vector routing protocol, each node maintains a routing table and a distance vector, which contain, respectively, a preferred neighbor for the shortest path to each destination in the network and the distance of the path to the destination. Each node has incomplete knowledge of the network topology and knows only its neighboring nodes. From these neighbors, the node chooses the closest neighbor to each destination. Each node periodically sends its distance vector to each of its neighbors in the event of any distance change to any destinations. The node determines which neighbor is the closest to each destination by comparing the distance vectors of its neighbors ([13],[17]).

Link-state routing protocols require each participating node to maintain complete network topology information. Each node actively tests the status of the links between itself and its neighbors. Then, it periodically broadcasts the local link status information to all other nodes. Since each node receives the local link status information from all other nodes, it is able to build a graph of the whole network topology and to compute the shortest path from itself to every other node ([14],[15]).

Shortest-path routing protocols suffer performance degradation because all data messages are routed via the same shortest path to the destination as long as the routing tables remain unchanged. The problem with these routing protocols is that there are no mechanisms for altering the routing other than updating the routing tables. The shortest path may be highly congested, even when many other paths to the destination have low link utilization. This congestion may trigger the loss of valuable data messages due to buffer overflow at some node. Using a single path to the destination limits the maximum throughput possible between the source and the destination to be at most the minimum capacity of any link along the shortest path from the source to the destination.

Maximizing network throughput is an important goal in the design of routing protocols. If the network uses shortest-path routing protocols to carry bursty traffic, then many of these data messages might be dropped due to the limited buffer space of each node when these shortest paths are congested. In this paper, we want to minimize the message loss due to the buffer overflow at each node. We also want to maximize the network throughput. Our approach increases the effective bandwidth between the source and the destination so that more data messages can be delivered. A result in network flow theory, known as the max-flow min-cut theorem [8], shows that distributing the traffic load over all available paths between a source and a destination in the network, instead of using only one path of minimum cost, may increase the effective bandwidth up to the capacity of the minimum cut separating the set of nodes.















































