The Revised ARPANET Routing Metric

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The ARPANET routing metric was revised in July 1987. These revisions only affected the individual link costs (or metrics). The original routing algorithm, Shortest Path First (SPF), remained unchanged. Before that, delay-SPF (D-SPF) was used. In D-SPF routes is computed using SPF and the link metric is measured delay. The new approach, Hop-Normalized SPF (HN-SPF), uses a more complicated metric.

The D-SPF link cost is computed this way: for every packet a node receives and forwards, it measures queuing and processing delay to which adds transmission and propagation delay. It averages this total delay in ten-second period and compares the average to the last reported value for the link. If the difference passes a significance criterion, a routing update is generated. This approach works well under light and moderate network traffic loading. But under heavy loading, the following factors contribute to the ineffective performance of D-SPF: 1) The range of permissible delay is too wide. 2) There is no limit on the variation of reported delays in successive updates for a particular link. 3) All nodes adjust their routes in response to a link metric update simultaneously. These factors combine and cause oscillatory behavior in routings.

In HN-SPF, value reported in the routing update is no longer delay, but rather a function of delay. The value of delay is first transformed in to an estimate of the link utilization. The result is then averaged with previous utilization estimate using a recursive filter. Next, the average utilization goes through a linear transformation to normalize the metric. The change in reported cost from one update to the next is limited both in how little and much the cost can change. Finally, a normalization process enforces absolute limits on the value of the metric.

The HN-SPF imposes upper and lower bounds on the metric that depends on link type. The metric is constant until the utilization gets above a threshold. The HN-SPF has three mechanisms that control the change between successively reported updates for a particular link: Averaging, Maximum Change and Minimum Change.

HN-SPF will be most effective when network traffic consist of several small node-to-node flows. To accomplish load-sharing when traffic is dominated by several large flows would require a multi-path routing algorithm.