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An Analysis of different Routing Algorithm over Large-Scale Dynamic Networks

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***Abstract*- Large-scale, wide area data networks are a part of today's global communication infrastructure. The basic function of such networks is routing, the process that logically connects network nodes by calculating paths between nodes so that data sent by one node traverses the calculated path to its destination. Although many algorithms in graph and operational research literature calculate paths between nodes, the challenge in developing network routing algorithms is in dealing with the scale and distribution of the physical network In this paper we propose an analysis and comparison of the different routing algorithms over todays large scale dynamic networks.**

Keywords: Large Scale Networks, Dynamic Networks ,Data Applications .

I. INTRODUCTION

Network information systems and telecommunication in general rely on a combination of routing strategies and protocols to ensure that information sent by a user is actually received at the desired remote location. In addition, the distributed nature of the problem means that multiple users can make requests simultaneously. This results in delayed response times, information loss or other reductions to the quality of service objectives on which users judge network service.

For example, the Internet consists of a huge amount of local networks interconnected by gateways. Such gateways, generally called routers, usually have physical connections (e.g., Fiber, Satellite, and coaxial cable) or network interface ports (e.g., Ethernet) onto many networks. The determination of the appropriate gateway and port for a particular data packet is called routing. By exchanging information among the other routers, a router usually maintains a list of Internet addresses and their corresponding location in the network. Such a list is called routing table. Routers near the center of a network generally have very large routing tables; those near the edges have small tables. Although the routing table may be configured by hand, it is usually configured to automatically use "Routing Protocols". The routing protocol allows routers to periodically exchange their knowledge of the network. After a period of time, the router becomes aware of all the possible ways to reach any end system in the network. It therefore updates its own routing table, building a picture of how to reach other parts of the network. Protocols are used to implement handshaking activities such as error checking and receiver acknowledgements. In this work, we are interested in the routing problem on computer networks. In doing so, we do not consider protocol issues.

The problem of Routing usually refers to the process used to build the routing table on each router, and determine how a packet travels from its source to destination. From a single packet's point of view, the objective is to arrive at its destination in the shortest possible time, while from the whole network's point of view, the objective is to deliver maximum number of packets in minimum average trip time, use minimum network resources, such as memory, network link, router CPU, etc., and prevent traffic congestion from happening. What's more, we should not neglect some important facts of the problem, such as the local information constraint . Thus, routing is an optimization problem yet with many constraints.

II. ROUTING CONCEPT OVERVIEW

In general, routing algorithms view a network as a weighted graph, where network links are represented as graph edges and network routers as graph vertices. Network routers are network nodes that execute routing algorithms and ensure that data travel the calculated paths. In the weighted graph, the assignment of edge weights depends on the specific routing algorithm; typically, the assignment reflects the latency and bandwidth of the link After a routing algorithm makes these link cost assignments, it then computes paths between nodes. Thus, the specific routing algorithm that routers execute determines the paths that data will travel in the network.

Routing algorithms in today's Internet base their implementations on the *static metric single shortest path* routing model. Single shortest path means that routing algorithms provide, at any given time, the least-cost path between nodes. Static metric refers to link cost assignments which are based on static properties of a link, such as its bandwidth or latency. As shown later, the main drawback of this model is that static metric shortest paths do not always provide good network performance. Internet routing algorithms ensure that two nodes can communicate with each other.

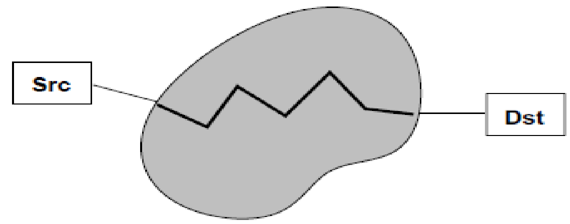

Figure 1. The conceptual Internet routing model.

Routing challenges for large scale dynamic networks

The main challenge in developing network routing algorithms is in dealing with the scale and distribution of the physical network. Because typical wide area networks have nodes on the order of tens of thousands, routing algorithms must be scalable. In addition, routing algorithms must be able to calculate paths in a distributed manner due to the global and distributive nature of physical networks. Moreover, because of the actual physical network, routing algorithms need to cope with events such as physical component failures and recalculate paths whenever such events occur. Finally, routing algorithms need to calculate paths to allow nodes to achieve high network Performance.

III. CLASSICAL ROUTING ALGORITHMS

As we know, a network can be denoted as a graph, which consists of a set of nodes/vertices and a set of links/edges, which connect the nodes in the manner that each link joins two nodes. The following graph (Figure 4) represents the network of the Japanese backbone (NTTNet). NTTNet is the NTT (Nippon Telephone and Telegraph company) fiber-optic corporate backbone. NTTNet is a 55-node, 162-bidirectional link network. Link bandwidth is 6Mbit/sec, while propagation delays range around 1 to 5 msec. It is a narrow long configuration in which the degree of connectivity is low (from 1 to 5), when compared to the US backbone. Hence the Japanese network provides a more demanding configuration for testing routing algorithms, as higher degrees of connectivity lower the possibility of packet loss due to loops, timeouts, i.e., in a narrow long shaped network, once a packet is forwarded in a wrong direction, it might never have the chance to be routed to the desired destination.

The nodes and links have capacities, such as buffer size and processing time for nodes, bandwidth for links. A non-directed graph G = {N, A} with a node set N and an arc set A provides a formal framework for describing network connectivity. Finding the shortest paths among nodes can be solved in polynomial time (using Dijkstra's algorithm, Bellman-Frod's algorithm), while flow optimization, i.e., maximizing packets delivery (throughput) when links have transmission limitations is known to be a NP-complete problem (Ahuja et. al., 1993). Note, however, this classical definition of the problem assumes a static (worst case) load and complete information. In practice neither are necessarily known and the problem becomes more difficult.

The routing protocols are responsible for exchanging routing information between routers, and helping each router build a routing table for each possible destination sub-network. Packet destinations are therefore expressed in terms of sub-networks (Norris, Pretty, 2000). Figure 4 represents the node connectivity above the sub-network level. It is only at this level that we are interested in routing.

The routing protocols being widely used on the Internet are usually based on one of the following general principles: Static Routing, Distance Vector Routing, Link State Routing, or Path Vector Routing. In small networks, for example, a small network of a small business with leased line connection to the Internet, Static Routing is commonly used to configure the default route. When the topology of a network changes frequently, static routing is no longer suitable for such a dynamic environment; distance vector routing and link state routing have advantage over static routing. Distance vector routing relies on the regular updates of routing information to keep the routing tables on every router up to date. The objective of link state routing is to let every router maintain a map of the network topology.

Routing protocol RIP2 (Routing Information Protocol version 2, RFC2453, STD0056) is widely used in small networks. As the original Interior Gateway Routing Protocol (IGRP), RIP is a kind of Distance Vector Routing algorithm, more specifically, based on the distributed Bellman-Ford algorithm for the Graph Shortest Path problem.

RIP works well in small networks, but becomes increasingly less efficient as network size increases. It also suffers from the count-to-infinity and slow convergence problems. Count-to-infinity is an issue with hop counts, it happens in some subtle network failure situation resulting from mutual deception routing information updates. All distance vector protocols are susceptible to this well-known "count to infinity" problem (Perlman, 1992).

OSPF (Open Shortest Path First, RFC2328, and STD0054) is a more modern protocol from the IGRP family, which is based on the Dijkstra's algorithm. OSPF is much more successful than RIP and is used in many networks, although it requires human configuration. That is, a series of assumptions, based on global information, is required to configure the protocol.

RIP and OSPF belong to IGRP. IGRP protocols are routing protocols for autonomous systems (ASs). These include: RIP, EIGRP, ISIS, OSPF, and SPF. An AS is a group of routers that are within one administrative domain and that run the same routing protocol. The public Internet nowadays is composed of ASs, and EGP (Exterior Gateway Protocol), which are designed for routing among the ASs. BGP (Border Gateway Protocol) is a kind of EGP. BGP uses path vector routing, where a path is an ordered list of AS numbers. Every entry in the routing table contains the destination network, next router, and path to reach the destination.

As discussed above, a range of different routing protocols exist, each with their own strengths and weaknesses. Static routing is simple, but has poor scalability and robustness properties (which is a key advantage of dynamic routing). RIP suffers count-to-infinity and slow convergence problems, and takes up a lot of bandwidth. All these make RIP (or other distance vector protocols) only good for small networks, and not competent for larger networks; OSPF (or other link state protocols) are designed with scalability, but their complexity makes it hard to design and configure the network efficiently. The path vector routing attribute of BGP leads to some attractive features, such as policy routing, loop prevention, and so forth. OSPF and BGP have a common weakness in that the design relies on several core routers. As discussed using the centralized design has many drawbacks for the case of highly distributed networks.

IV. RECENT RESEARCH APPROACHES

Several approaches have been proposed for addressing these objectives including: active networking (Tennenhouse et. al., 1997), social insect metaphors (Di Caro, Dorigo, 1998), (Dorigo et. al., 1996), cognitive packet networks (Gelenbe et. al., 1999), evolutionary approaches (Sinclair, 1993), (Munetomo et. al., 1997), and what might be loosely called other 'adaptive' techniques (Corne et. al., 2000). The evolutionary approaches usually represent a route/path by an ordered list of nodes, and then try to achieve the routing problem by evolving the "paths" or "routing tables". Moreover, Evolutionary and 'adaptive' techniques typically involve using evolutionary or neural techniques to produce a 'routing controller' as opposed to a 'routing table' at each node, where the controller typically requires knowledge of the global connectivity to ensure a valid route. Both the social insect metaphor and the cognitive packet approach provide a methodology for routing, without constraints; by using the packets themselves to investigate and report network topology and performance. Similarly, mobile agents discover edges by traversing them, and update the routing table on the landed hosts (Minar et. al., 1999).

All methods as currently implemented suffer from one drawback or another. For example, cognitive packet networks and active networking algorithms attempt to provide routing programs at the packet level, hence achieving scalable run time efficiency becomes an issue. The Social Insect Metaphor approach is discussed in the following section, and limitations investigated under a strict local information constraint. This will form the basis for combining a multi-agent approach with Genetic Algorithms for avoiding any reference to global information.

Conclusions and Future Work

On comparing the routing algorithms, we should not focus on a separate measurement index, but consider them comprehensively. An ideal algorithm would be able to deliver more data packets (number of arrived packets) irrespective of the network scenario, send the packets to their destinations using shorter trip times (average trip time, finish time, and throughput), while the queue size is minimized. In order to achieve these goals, the routing algorithm must be capable of finding the appropriate routes, recognizing dynamic changes to network traffic and topology, adapt the routers to the new conditions, route the data packets efficiently while distributing the work load among the network. Therefore, we believe that network resources must work as a cooperative team. In addition, it is important to include system/network overheads, such as buffer occupations, CPU usage, or network resources needed to support the algorithm.

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