**Maximum Likelihood Network Topology Identification from Edge-based Unicast Measurements**

Traditional network topology identification has used methods that require the hosts system clocks to be synchronized to work which is infeasible in larger networks of computers. Often these methods rely on cooperation from the networking equipment, such as the traceroute program used on many systems, to gain metrics needed to identify the network topology and so their metrics can only reveal portions of the network that have those functions enabled. This paper introduces a new way to measure delay in between hosts that does not require clock synchronization or cooperation from networking equipment. Also proposed is a set of criteria used for globally optimal topology identification.

The novel delay-based measurement scheme introduced in this paper is based on special-purpose unicast probe "sandviches", which use the delay differences to analyze the network topology. Two small packets are sent to a receiver, separated by a larger packet destined for someone else. By measuring the difference between the arrival times of the two packets we can find the bandwidth and load of the links between the two hosts. This overcomes some limitations in probe loss and delay based schemes in that: a large number of probes must be sent before a loss-based metric becomes reliable; delay-based metrics require accurate clock synchronization; and delay-based metrics often assume or require GPS access to work properly.

Identifying network topologies has often been done by evaluating the statistical likelihood of every possible topology configuration given the measurements, called the Maximum Likelihood Estimate. This becomes infeasible in larger systems because the number of possible topologies grows exponentially as the number of systems in that network grows. The new framework described in this paper uses a penalized likelihood-based procedure; a special Markov Chain Monte Carlo (MCMC) procedure which concentrates on the regions of the topology space with the highest likelihood of being the true topology. Because the procedure tries to identify the topology globally rather than a small piece at a time, it is much faster, scaling linearly with the number of receivers in the network.