Processing Spatial Joins at Global-Scale
Research Update for IIS-0430848 “Securely Managing the Lifetime of Versions in Digital Archives”

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Making observational data available for analysis over the Internet is increasingly important in the disciplines such as Astronomy and Biology. The SkyQuery federation of Astronomy databases provides one such service, bringing together multi-terabyte, Astronomy archives that catalog and map spectral characteristics of celestial objects.

In Skyquery, data volume and geography deter scalability. The workload in SkyQuery is network-bound. It is not uncommon for join queries to yield intermediate results that are hundreds of megabytes or more in size. Also, the physical distribution and connectivity of sites in SkyQuery vary tremendously with roughly 30 sites distributed across North America, Western Europe, and East Asia. In this heterogeneous environment, transferring data between sites that cross continental boundaries is highly undesirable because paths that cross long physical distances exhibit higher propagation delay, congestion, and loss rates.

To alleviate this network crisis, we are developing query processing techniques that are sensitive to the global geography of sites. They exploit network locality and avoid narrow, long-haul paths by making these paths more costly during optimization.

To accomplish this, we must change the goals of query optimization. Existing algorithms either reduce the volume of network traffic produced or minimize the time to complete join queries across heterogeneous networks, but do not ensure efficient allocation of network resources. Specifically, algorithms that focus on reducing the volume of traffic under-utilize the network because paths with excess capacity may be overlooked. Algorithms that minimize completion time over-utilize the network by consuming all available resources to achieve a locally optimal plan.

Our system differs in that we introduce metrics that focus on the balanced utilization of all network paths. In doing so, we avoid repeatedly crossing narrow intercontinental links multiple times. Figure gives a sample query schedule over SkyQuery’s International sites that routes intermediate query results through each continent once. Our goal in query scheduling is to maximize query throughput in the federation. Achieving this goal often delays the completion time of an individual query. However, Astronomy workloads are not latency sensitive. Just accessing the data at each site often takes tens of seconds. The capacity of a network path measures the impact of geography on throughput. It describes the number of (intermediate) query results that can be sent across a path over a given time frame. Balanced usage of capacity on all paths maximizes the total query throughput, increasing the number of queries processed more than five-fold.