Announcing the Final Examination of Mohammad Ahmad for the degree of Doctor of Philosophy

Time & Location: December 18, 2012 at 2:00 PM in HEC 356
Title: Measuring the evolving Internet ecosystem with exchange points

The Internet ecosystem comprising of thousands of Autonomous Systems (ASes) now include Internet eXchange Points (IXPs) as another critical component in the infrastructure. Peering plays a significant part in driving the economic growth of ASes and is contributing to a variety of structural changes in the Internet. IXPs are a primary component of this peering ecosystem and are playing an increasing role not only in the topology evolution of the Internet but also inter-domain path routing. In this dissertation we study and analyze the overall affects of peering and IXP infrastructure on the Internet. We observe IXP peering is enabling a quicker flattening of the Internet topology and leading to over-utilization of popular inter-AS links. Indiscriminate peering at these locations is leading to higher end-to-end path latencies for ASes peering at an exchange point, an effect magnified at the most popular worldwide IXPs. We first study the effects of recently discovered IXP links on the inter-AS routes using graph based approaches and find that it points towards the changing and flattening landscape in the evolution of the Internet's topology. We then study more IXP effects by using measurements to investigate the networks benefits of peering. We propose and implement a measurement framework which identifies default paths through IXPs and compares them with alternate paths isolating the IXP hop. Our system is running and recording default and alternate path latencies and made publicly available. We model the probability of an alternate path performing better than a default path through an IXP by identifying the underlying factors influencing the end-to-end path latency. Our first-of-its-kind modeling study, which uses a combination of statistical and machine learning approaches, shows that path latencies depend on the popularity of the particular IXP, the size of the provider ASes of the networks peering at common locations and the relative position of the IXP hop along the path. An in-depth comparison of end-to-end path latencies reveal a significant percentage of alternate paths outperforming the default route through an IXP. This characteristic of higher path latencies is magnified in the popular continental exchanges as measured by us in a case study looking at the largest regional IXPs.

We continue by studying another effect of peering which has numerous applications in overlay routing, Triangle Inequality Violations (TIVs). These TIVs in the Internet delay space are created due to peering and we compare their essential characteristics with overlay paths such as detour routes. They are identified and analyzed from existing measurement datasets but on a scale not carried out earlier. Identifying TIVs from large amounts of data efficiently is a challenging exercise and hence we propose and implement a novel parallel measurement architecture using general purpose graphical processor units (GPGPUs). This implementation exhibits the effectiveness of GPUs in analyzing big data sets while the TIVs studied show that the a set of common inter-AS links create these TIVs. This result provides a new insight about the development of TIVs by analyzing a very large data set using GPGPUs.

Overall our work presents numerous insights into the inner workings of the Internet's peering ecosystem. Our measurements show the effects of exchange points on the evolving Internet and exhibits their importance to Internet routing.

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Approved for distribution by Dr. Ratan Guha, Committee Chair, on December 4, 2012.

The public is welcome to attend.