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Performance evaluation of peering-agreements among autonomous systems subject to peer-to-peer traffic

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ABSTRACT

The interconnection of thousands of Autonomous Systems (ASs) makes up the Internet. Each AS shares trade agreements with its neighbors that regulate the costs associated with traffic exchanged on the physical links. These agreements are local, i.e., are settled only between directly connected ASs, but have a global impact by influencing the paths allowed for the routing of network packets and the costs associated with these routes. Indeed, the costs and earnings of interconnected ASs is a function of many factors, such as size of the ASs, existing agreements, routing policy, traffic pattern and AS-level topology. In this paper we present an approach that takes these factors into account to assess peering and transit agreements. Here we focus on traffic generated from P2P activities, but the approach is general enough to be applied to different traffic classes. The P2P model we present is based on the use of the generating function, it allows to perform an analytical study of the traffic associated to file-sharing. The proposed P2P model is able to consider a large number of peers sharing several resources, spread along different ASs connected through a series of links. We validate the results of our P2P model against one of the most widely used P2P simulators, i.e. PeerSim. Using both the AS-level and P2P models we evaluate how the inter-AS P2P traffic influences the AS network cost and earning.

1. Introduction

Studying the relationships between "Autonomous Systems" (ASs) has become an important research issue. Indeed, Internet traffic is generated from applications that are agnostic of the underlying AS topology. This leads to poor usage of network's resources, resulting in an economic damage for ASs. The latter must be studied under realistic traffic assumptions, considering common applications, such as peer-to-peer, Internet 2.0 and social networks.

In particular, peer-to-peer (P2P) applications generate huge data flows that nowadays is a major fraction of the Internet traffic [1]. P2P systems can be used in different contexts, such as file sharing (Gnutella [2], KaZaa [3], eDonkey [4], BitTorrent [5]), telephony applications (Skype [6]), and content delivery infrastructures (see [7]). File-sharing is one of the most popular where contents such as multimedia and software are spread over the network. The size of resources ranges from several kilobytes up to some gigabytes. In order to understand the dynamics of such applications, it is interesting to study how shared resources move across the network. Despite the large number of parameters involved, P2P file sharing applications

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might have different impact on the overall network performance depending on their setting. For instance, a P2P client could be encouraged to seek required contents in peers belonging to the same AS in order to reduce the traffic in the network.

This work exploits the results presented in [8] to study the impact of the commercial relationship among different autonomous systems on the costs of supporting P2P traffic. In particular, in this paper we study the diffusion of a resource in a non-homogeneous environment. Peers are considered being spread among the ASs, each one having its own parameters in terms of resource availability and demand. We propose a probabilistic model that describes the diffusion of a resource taking into account (non-homogeneous) resource popularity and peers behavior. The model is extended to also consider multi-resource scenario where each peer can hold more resource types.

The main goal of this paper is to provide the system administrator the tools to minimize its cost related to the traffic produced by the users of its network. In particular, we want to show how this can be achieved by either trying to settle different peering agreements with other ASs, or by applying intelligent routing schemes that can provide a cheaper use of its resources. Our contribution is twofold: first we present a methodology to account for cost and rewards in complex AS topologies under a given traffic pattern, then we propose an analytical procedure to describe such a pattern in the case of P2P file sharing networks.

The reminder of the paper is organized as follows. After a brief discussion on some related work (Section 2), we describe how we modeled topology and relationships between ASs (Section 3). The resources diffusion in a P2P overlay network is considered in Sections 4–6. We validate the proposed model by simulation in Section 7. Finally, we apply the proposed technique in a complex scenario (Section 8).

2. Background and related work

In this section, we briefly describe the Internet's AS-level, explaining peering and transit agreements between ASs and inter-AS routing protocols. We describe previous attempts in literature to model or optimize AS relationships and routing. We introduce the P2P paradigm and review some of the existing resource diffusion models.

2.1. The Internet AS-level

The term Autonomous System informally identifies a set of routers under the same technical administration, that share common metrics to route packets within the AS, while use an inter-AS protocol for forward network messages to other. An AS appears to its neighbors having a single coherent internal routing plan, announcing routes that are reachable through it.

A more rigorous definition is given in RFC 1930 [9] that defines an AS as a group of IP prefixes that share a unique and clearly defined routing policy. Here "prefix" is referred to a CIDR block, a group of one or more classful networks (A, B or C networks).

In Internet each AS is uniquely identified by an Autonomous System Number (ASN), a 32 bit integer as specified in RFC 4893 [10]. ASN are assigned by the Internet Assigned Numbers Authority (IANA) to Regional Internet Registry (RIRS). RIRSs are responsible for specific geographic areas and in turn assign ASNs to organizations that make request.

The protocol used nowadays to exchange routing and reachability information is the Border Gateway Protocol (BGP) [11–14]. The current version is BGP-4. BGP-4 is defined as an exterior gateway protocol used for intra-AS routing, in contrast to the interior gateway protocols, like Routing Information Protocol (RIP) [15] or Intermediate System To Intermediate System (IS–IS) [16], used within the same AS. Each AS runs some BGP-4 gateways that discover routes exchanging reachability information with other gateway. Each one announces the destinations (i.e. other ASs), that are reachable through it.

BGP is a *Path Vector Protocol*, so gateways exchange full AS-paths, according to their routing policies. These determine what are the best paths to reach a specific destination. A common parameter is the length of AS-path [17], preferring shorter over longer ones, but the AS administration can specify more complex policies.

2.2. Traffic agreements: peering and transit

According to the BGP Topological Model (cf. RFC 1655 [17], Section 2), a direct connection between two AS is both a physical connection (i.e., a shared network formed at least from one border gateway for each AS) and a BGP session running on the border routers (gateways). A connection is demanding in terms of economical resources (hardware, maintenance, technical administration), so commercial agreements are settled between directly connected ASs. An AS could be connected to more ASs and have a specific agreement with each one. In this case the AS is called *multihomed*. Otherwise, a *stub* is an AS that is connected to only one AS.

Among the existing established methods to exchange Internet traffic between directly connected networks, the most used are **peering** and **transit**. In peering two networks do not charge any fees to each other, while a transit agreement occurs when an AS pays to another some fees to reach other parts of Internet. In this case the traffic travels across the seller AS and is forwarded to the next hop to destination.

Peering and transit agreements can influence the way messages are routed on the AS topology because BGP policies used from a network are based on economical and commercial considerations [12]. Indeed, is convenient for an AS to announce