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An analysis of the economic impact of strategic deaggregation

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ABSTRACT

The advertisement of more-specific prefixes provides network operators with a fine-grained method to control the interdomain ingress traffic. Prefix deaggregation is recognized as a steady long-lived phenomenon at the interdomain level, despite its well-known negative effects for the community. In this paper, we look past the original motivation for deploying deaggregation in the first place, and instead we focus on its aftermath. We identify and analyze here one particular side-effect of deaggregation regarding the economic impact of this type of strategy: decreasing the transit traffic bill. We propose a general Internet model to analyze the effect of advertising more-specific prefixes on the incoming transit traffic burstiness. We show that deaggregation combined with selective advertisements has a traffic stabilization side-effect, which translates into a decrease of the transit traffic bill. Next, we develop a methodology for Internet Service Providers (ISPs) to monitor general occurrences of prefix deaggregation within their customer base. Thus, the ISPs can detect selective advertisements of deaggregated prefixes, and thus identify customers which impact the business of their providers. We apply the proposed methodology on a complete set of data including routing, traffic, topological and billing information provided by a major Japanese ISP and we discuss the obtained results.

1. Introduction

The Internet is the interconnection of over 40,000 domains known as Autonomous Systems (ASes), which engage in dynamic relationships that interplay with their technical and economic necessities. The routing between ASes relies on the Border Gateway Protocol (BGP), which is responsible for the exchange of reachability information and the selection of paths according to the routing preferences of each entity active in the Internet. By tweaking BGP configurations, network operators implement their preferences in the form of routing policies, which are designed to accommodate myriad economic and technical goals. Thus, the way in which the traffic flows in the interdomain is influenced both by the path dynamics triggered by the continuous evolution of the Internet topology and by the complexity of the routing policies of each network.

Hence, individual network managers need to permanently adapt to the interdomain changes and, by engineering the Internet traffic, optimize the use of their network. Interdomain traffic engineering requirements are diverse and depend on the connectivity of the AS with others and on the type of business handled by the network [1]. One important task achieved through the use of traffic

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engineering tools is the control and optimization of the routing function in order to allow the ASes to shift the traffic inside and outside their network in the most effective way.

The injection of *more-specific prefixes* through BGP represents a powerful traffic engineering tool which offers a fine-grained method to control the interdomain ingress traffic. This technique implies that ASes selectively announce distinct fragments of their address block to different upstream providers. This type of phenomenon is commonly known as *prefix deaggregation*. For example, by using this strategy, geographically-spread networks can divert different amounts of traffic corresponding to different points of presence (PoP), thus attracting traffic into their network through the PoP closest to the final destination. Furthermore, in order to achieve load balancing purposes, deaggregated prefixes are announced to different providers so that the corresponding traffic flows only through the preferred transit links.

Several adjacent phenomena associated with deaggregation have been identified and studied by the research community. The most important negative side-effect of the widespread adoption of this technique is the artificial inflation of the BGP routing table, which can affect the scalability of the global routing system. This issue has become an important concern of the entire Internet community over the past years [2]. From this perspective, this type of behavior is considered to be harmful [2], as it heavily impacts the global routing table and it acts counter to the goals of the Classless Inter Domain Routing (CIDR) architecture, which encourages address aggregation.

In this paper, we indicate that, in spite of the negative overtone of prefix deaggregation, a series of advantageous by-products result from deploying the strategy. These by-products come up independently of the main motivation for ASes to deploy deaggregation strategies in the first place. For example, one alleged secondary benefit is the increased security of the network announcing more specifics in the interdomain. Some even claim that prefix deaggregation can inadvertently protect the AS against prefix-hijacking attacks [3]. Recognizing as a reality the sustained popularity of prefix deaggregation in the Internet [4], we look past the initial motivations behind deploying this type of strategy, and instead focus on its *aftermath*. More specifically, we investigate here the potential economic impact of deaggregation, independently of the main reasons driving the network operators to fragment their allocated address space.

We study the impact address-space fragmentation has on the transit traffic bill of the networks originating the more-specific prefixes, first from a theoretical point of view and then through the analysis of real-world data from an operational ISP. We find that, as a result of the unique interaction between the path dynamics in the current Internet, the asymmetrical popularity of traffic sources and the popular billing method which relies on the 95th percentile of traffic [5,6], the ASes which engineer their incoming traffic using deaggregation might enjoy one collateral benefit which, to the best of our knowledge, has not been previously studied: *the decrease of their transit traffic bill*.[1]

For the purpose of this paper, we define *strategic*[2] *deaggregation* as the action of splitting the address block and selectively injecting each more-specific prefix to different disjoint subsets of providers. Customers which exhibit this behavior may be able to game the 95th percentile billing rule and possibly have a negative impact on the business of their ISPs. We show that with strategic deaggregation, network operators can reduce the route diversity towards each prefix announced and, consequently, also the traffic fluctuations on the corresponding transit link, thus further impacting the monthly traffic bill paid to the transit providers.

First, we propose a model to analyze the effect of different deaggregating strategies on the traffic stability and, ultimately, on the transit cost for the deaggregating ASes. The model accounts for the route dynamics which are responsible for large traffic shifts in the interdomain, like previously observed in [7]. The general Internet model disencumbers our analysis of the complex Internet phenomena, maintaining a continuous focus on the impact of different deaggregating strategies on the transit traffic stability and ultimately on the transit cost incurred on the customer ASes. We integrate in the Internet model three important elements, i.e., the interdomain routing model, the traffic model and the cost model, whose entanglement offers the necessary underlying structure for the analysis of these intricate Internet phenomena. We estimate the model parameters by performing an extensive analysis of publicly available real BGP routing information. We afterwards quantify the actual impact of strategic deaggregation.

Second, we turn out attention to the operational Internet to detect and analyze occurrences of strategic deaggregation. We take the point of view of a transit provider (with customers which might be using strategic deaggregation) and ask a two-staged question:

(1) *How extensive is the use of prefix deaggregation among the customer networks?* We further propose a methodology to identify cases of deaggregated prefixes within the customer base of an operational ISP within a certain time-window. We enable any operator with the necessary dataset to detect the customers which are new deaggregators and monitor their behavior in time.
(2) *Can it be verified that deaggregation combined with selective advertisements decreases the transit bill of some customers?*

[1] We stress that, in this paper, we analyze the existence of an economic **side-effect** of prefix deaggregation. We do not perform here a study of the central motivations driving operators to perform prefix deaggregation in the first place, nor do we defend or encourage the usage of deaggregation in the Internet. We merely acknowledge the popularity of this strategy in the Internet and further investigate the possibility of an inadvertent economic gain for the deaggregating party. Regardless of the main goal to be achieved though deaggregation, we observe that, in certain conditions, the deaggregating AS can indeed enjoy a decrease of its transit traffic bill as a by-product of the deaggregation strategies deployed.

[2] We use here the term *strategic* to accentuate the fact that the decision is based on optimizing behavior, since it might increase the benefits for the network deploying it. This relies on definitions provided in rational choice theory.