Empirical analysis of core-edge separation by decomposing Internet topology graph
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Introduction
The Internet global routing system is facing a potential scaling challenge in routing table size fast growth, especially under the IPv6 wide deployment. More discussion is in RFC4984. Many practical routing solutions have been proposed, of which the typical solutions is core-edge separation (e.g., Cisco’s LIS, INLP, IGP). They often take Map-n-Encap schemes to deliver packet in the transit core, and A global mapping service between blocked prefixes and separation points are maintained. Our paper is to answer “what-if” questions on the effects of the core-edge separation approach.

Abstract
BGP Protocol is the de facto standard protocol used in the Internet inter-domain routing to connect all of the autonomous systems (ASes). Owing to multi-homing and traffic engineering, the BGP routing table size of default free zone (DFZ) is growing rapidly. Inter-domain routing is facing the scaling challenge. Many solutions have been proposed. Among them, the core-edge separation schemes get more attentions than others due to its practical advantages. In this paper, we quantify the impact of the core-edge separation on Internet inter-domain routing. We decompose the topology graph by k-core and customer-provider based decomposition methods, and estimate the impact of deploying separation at different level of topological hierarchy.

Methods
There is no clear separation line between core and edge in the Internet complex AS topology. We decompose the topology tier structure by:
1) basic stub-transit separation
transit networks as the core, and stub networks as the edge.
2) k-core decomposition
For a graph G, after removing all nodes with degree less than k recursively, the remained unique subgraph is defined as a k-core. Each of the nodes in k-core subgraph has a degree greater or equal than k. And, the node that belongs to k-core, but be removed in (k+1)-core are assigned a shell index (or say corarness) of value k. All the nodes of shell index k form the k-shell.
3) customer-provider hierarchy decomposition
The customer-provider (c2p) commercial relationship reflect the hierarchical structure in the Internet AS-level topology graph. We use Gc to denote the graph that is composed of the edges of c2p relationship. Each edge is a directed edge from a customer to a provider. Then, we remove the leaf nodes that have empty in-degree, and assign them level-0. Repeat this process, we will get level-1, level-2, …, until there is no AS node with empty in-degree.

Results
1) Stub and transit AS growth trend (by years)
Figure 1. The growth of AS nodes
Figure 2. The growth of prefixes and mapping size

Discussion and Conclusions
1) Separating all of stub ASes (84%) can block 43% prefixes into transit ASes. The routing table reduction is not significant, and it has a high deployment cost that near to 80% transit ASes need to deploy separation devices (i.e., tunnel routers).
2) Stub-transit separation can benefit much than half of reduction of BGP churns in transit ASes.
3) It seems that there is a middle belt in topological structure which connects lower tier ASes and top tier ASes. Moving core-edge separation points upwards to the middle belt will get further effect that more than 80-90% prefixes can be blocked at the lower tiers. It also can reduce the range of deployment.
4) Moving separation line upwards will lead to increase the size of mapping table.
5) More complicated separation strategies (not simply stub-transit split) are needed to get an optimal effect for core-edge separation solutions.

References
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