Service Specific Routing: A Novel Approach

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Abstract

Today's routing involves the 'message in a bottle' approach. In this approach we heavily rely on routing tables to push packets towards the right destination. This leaves little to no control for anyone to precisely direct traffic through an Autonomous System, let alone a neighboring Autonomous system. Thus we would like to control network and security characteristics at endpoints across an interdomain environment. In this paper we show how we used segment routing and BGP working at the data and control planes respectively to create a novel service specific routing framework for intra- and inter-domain network topologies.

Index Terms - segment routing, BGP, service specific routing, IPv6, SDN

1 Introduction

Today's internet plays a vital role in providing a multitude of services for the user. With all traffic being treated the same, the internet demands a more reliable method of routing. Today's routing involves the 'message in a bottle' approach. In this approach we heavily rely on routing tables to push packets towards the right destination. No matter what type of service the traffic may be, all traffic is treated the same. In this primitive approach there is no sense of urgency or priority. Hence a more granular approach over today's routing is needed more than ever.

In past attempts within an Autonomous System (AS) we have seen Multiprotocol Label Switching (MPLS) [3]. In MPLS traffic is directed from one node to the next by the use of short path labels rather than long network addresses. We have also seen Software Defined Networking (SDN) [5] approaches to service specific routing where an individual packet header's attributes are matched and an action is imposed on the packet. Segment Routing (SR) [12] along side IPv6 is the newest in routing paradigms. In SR using IPv6, an ordered list of segments is encoded in a routing extension header. The header contains a list of segments that guide the packet through the AS.

Similarly on the Interdomain level we have seen Software Defined Internet Exchange Points (SDXs) [1, 2]. SDXs bring the ideas behind SDN to interdomain routing. Located between ASes, SDXs aid in service specific routing by allowing the network to execute a far wider range of decisions concerning end-to-end traffic delivery. There also exists service specific routing across domains through the use of SDN [13]. The idea is to form a logically centralized controller running routing processes over multiple ASes. The controller would be aware of (parts of) the policies, and topologies of the ASes. We have also seen approaches at the interdomain level that involve using route servers [10]. Router servers located at the heart of an internet exchange point (IXP) are key enablers for offering new and complex peering options to IXP members.

In this paper we will define a new approach to service specific routing. In our approach we use Border Gateway Protocol (BGP) and segment routing to create a novel service specific interdomain and intradomain routing framework. BGP is the primary form of interdomain communication amongst ASes. As such it's extremely difficult to create a new interdomain protocol because every single AS would need

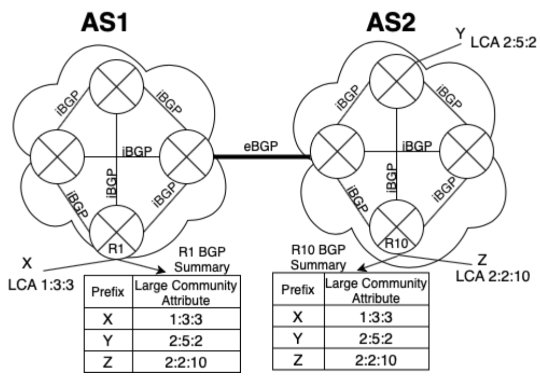

Figure 1: BGP Advertisement with Large Community Attribute

to change in order to enable full internet connectivity. Therefore, we have chosen to remain in the realm of BGP. The combination of BGP working at the control plan and SR working at the data plan enables a fine grained control of the treatment of service specific traffic.

The contributions of this work are the following. First, we propose a new approach to service specific routing involving BGP's large community attribute to inform ASes on how to handle the traffic of an advertised prefix. The ASes will use SR to guide the traffic in a matter they see fit regarding the type of traffic that is being guided. Secondly, we develop a proof of concept demonstration using the POWDER testbed.

2 Background

In our work we use BGP and Segment Routing to create a novel service specific Inter- and intra-domain routing framework. The combination of BGP working at the control plane and Segment Routing working at the data plane gives the ability to have more control on the treatment of service specific traffic across ASes.

BGP [9] is the defacto exterior gateway protocol designed to exchange routing and reachability information between ASes. Internal BGP (iBGP), and external BGP (eBGP) are two forms of BGP. Given away by there respective names they either operate within (internal) the AS, or between (external) ASes. ASes will peer with neighboring ASes to exchange routing information and policy. Thus an eBGP connection between ASes at the TCP level is establish to exchange advertised prefixes. From there iBGP connections within the AS at the TCP level are established with surrounding routers to propagate the prefixes acquired from the neighboring AS. As you can see this works with all connected ASes, therefore an AS can know of an AS two or three neighbors away without a direct connection to it.

For the control plane, we use BGP's Large Community Attribute [8] to advertise the service specific routes from the service provider to its adjacent and non-adjacent ASes. BGP already contains multiple attributes that help define the prefix that's being advertised. Large community attribute is already allowed to be advertised with the BGP prefix, thus there is no need to add or change BGP in any away. Our approach revolves around using already defined attributes in a new way. The large community attribute consists of three 4-octet values. The only required step is for a network operator to configure these values. The first octet defines the AS number of the advertising AS, while the remaining two octets define the function and parameters associated with the community. Ideally ASes will receive the prefix advertisements and associate the prefix with a specific service for the traffic destined to this prefix. **Figure 1** is an example illustration of BGP Advertisements.

Internet Protocol version 6 (IPv6) [11] is the most recent version of the internet protocol. IPv6 in the near future is intended to replace IPv4. IPv6 is the preferred method for segment routing. IPv6 contains an extension header that was designed to offer flexibility by augmenting the IPv6 header with a set of instructions. There are six different types of extension headers, but the most important for our purposes is the "routing header." The routing header is used by an IPv6 source to list one or more intermediate nodes to be "visited" on the way to a packet's destination. As you will read about this in the next paragraph this sounds a lot like segment routing. Thus IPv6 is an ideal candidate because of its segment routing header capabilities and because it's the newest version of IP.

Segment Routing [4] involves a packet being

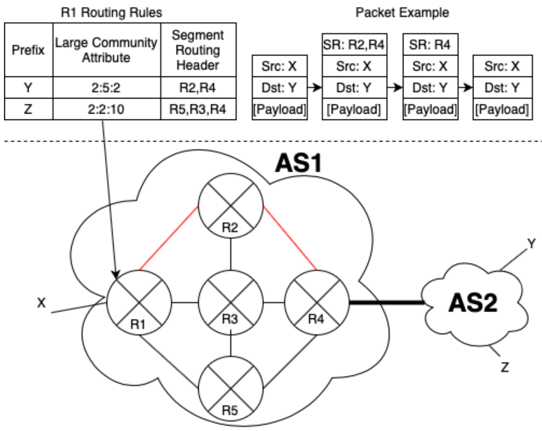

Figure 2: Segment Routed traffic based on BGP large community attribute

steered through a network topology. A segment can represent any instruction, topological or service based. But for our purposes segments represent IPv6 addresses within an AS. When a host is ready to send traffic through a network, the router will attach a routing header to the IPv6 packet. The routing header will contain a list of IPv6 addresses (segments) that guide the packet through the network before it reaches its destination. As stated in the previous paragraph, segment routing can be directly applied to the IPv6 architecture. **Figure 2** is an example illustration of Segment Routing involving BGP large community attribute.

3 Approach

Our approach is designed towards using modified BGP at the control plane and segment Routing at the data plane. **Figure 3** shows an example topology where AS1, AS2, and AS3 are three connected Autonomous systems. H-7 in AS1 has requested a data transfer to H-16 in AS3. For the sake of this example lets assume that H-16's advertisement contains H-16's prefix, and a large BGP community attribute of the form 3:5:2. Thus, thanks to BGP, H-7 is made aware of H-16 and its attributes. BGP's large community attribute tells the ASes that come in contact with the advertisements that H-16's comes from AS3, and that we would like to associate service 5, and of that service we would like type 2. To give a more concrete example lets associate service 5 with data transfers, and type 2 to be large elephant flows. Thus, H-16 would be associate with large data flow transfers. When H-7 sends data to H-16, H-7's packets through the use of SDN will be matched by destination and be prepended a segment routing header. The segment routing header is formed by the service specific control unit. The service specific control unit is made aware of BGP advertisements and associates paths within the AS to depending on the BGP large community attribute that is being advertised. Next all traffic from H-7 to H-16 will be segment routed through AS1 and into AS2. AS2 has also established its own segment routing paths depending on the type of large community attributes advertised by the prefix. Thus a new segment routing header is added at the gateway router to guide the packets to their destination.

We will now go more into detail behind the specifics of our approach.

BGP: This component in our design handles the control plane. The prefixes advertised by an AS reaches all connected ASes through the use of iBGP and eBGP. Furthermore, each advertised prefix contains a large community attribute. The large community attribute ties a prefix with a specific service that will be acted upon by each AS. The BGP large community attribute [8] consists of three 4-octet values. GlobalAdminstrator:Function:Parameter. The first 4-octet value refers to the global administrator. In our approach the global administrator will represent the AS number. The remaining two 4-octet values will represent the service and the type. Services can be any type of internet traffic (e.g. data transfer, video streaming). While the type value is a specific type within the service (e.g for data transfer we could have large data transfers). The services associated with each large community attribute will be an agreed upon policy between all ASes.

Service Specific Control Unit: This component in our design is used to map control plane BGP advertisements to appropriate segment routing paths. Using link state data the service specific control unit will automatically form segment routing headers that are

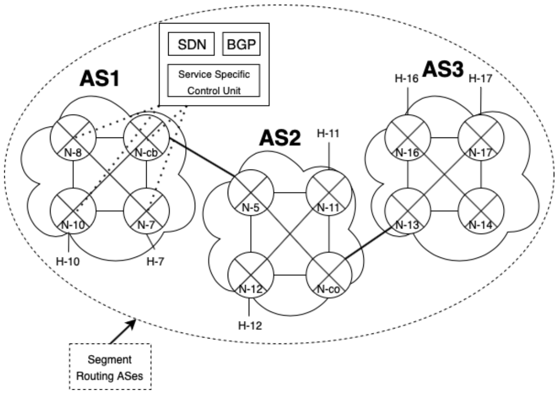

Figure 3: End to End Interdomain Example

used to guide the packet through the AS based on the constraints associate with the advertisements large community attribute.

SDN: This component in our design is primarily used to map a packet to an appropriate segment routing header. SDN will work closely with the service specific control unit to match a packet's destination, and prepend the segment routing header to the packet to guide it through the AS.

4 Implementation

Now we will proceed to discuss the implementation behind our design. We will discuss in detail what our work uses to achieve service specific routing at the intra- and inter-domain topologies.

BGP BGP is used to support prefix advertisement along with the usage of BGP large community attribute. Where the large community attribute is designed to be seen as number:number:number. Where the first number is the global identifier, and the second and third numbers respectively represent the service and subtype of a service.

Free Range Routing We choose Free Range Routing (FRR) to be our routing stack. We will be running IPv6 in our network. The daemons we have chosen to use in FRR are Zebra, BGP, and OSPFv3. Zebra is an ip routing manger that provides us with routing table updates, interface lookups, and redistribution of routes between different routing protocols. Next we used BGP, specifically BGP version 4. Lastly, we used OSPFv3 that supports OSPF routing for an IPv6 network.

Segment Routing For the adoption of segment routing into our network we we used a linux kernel and set various sysctls to enable segment routing. [6]

SDN We created our own application to be able to read BGP prefixes, and acquire their respective large community attribute. From there we had associated segment routing rules that would be pushed into the router depending on the service type the large community attribute defined for the prefix.

5 Evaluation

We have evaluated our service specific approach on a Three-AS network topology, each containing 4 routers and 2 hosts. We evaluate our results as compared to... [TODO]: Add evaluations of various use cases here and possibly compare it to current routing [Didn't get to this because of time constraints]

6 Related Work

Service specific routing (SSR) gives us the ability to guide specific data traffic to and from a destination. SSR within an AS is governed today by SDN, MPLS, SR, and a combination of SDN with Network Function Virtualization (NFV). Meanwhile, SSR at the Inter-domain level is primarily guided by SDXs. In this paper we introduce a new flavor of SSR that utilizes SR, SDN, and BGP's large community attribute.

MPLS networking revolves around using labels to guide traffic within the AS. This is MPLS's primary strength because not only does traffic engineering allow us to choose the shortest path, but it also creates a specified path given constraints. However, customizing Quality of Service (QoS) policies that MPLS uses to guide its traffic based on specified services is a difficult task. Adding an SDN controller [3] to facilitated and check the reliability of QoS policies improves the MPLS method to SSR. Collected information pertaining to the routers and their paths (e.g. bandwidth, broken links), is given to the SDN controller, so that it can create appropriate Label-Switched Paths.

Current routing services do not have the ability to manage network resources and cannot optimally choose dynamic services. However, a combination of SDN and NFV through the use of a matching algorithm facilitate suitable routing services per request. The combination of the two create an Adaptive Routing Service Customization (ARSC) [5]. ARSC provides unique customizable QoS routing algorithms that can be used for the user and the ISP.

There are also researches on SR, specifically SR's ability to use live traffic and topology information to optimize the network of an AS in real time [12]. Through the use of a critical reroute design's route planner, this approach tries to reduce abundant traffic off a link by providing alternate paths using SR. Once the route has been chosen, the path is encoded as a list of Segment IDs (SIDs) dictating the packet where it needs to go to next.

SDX research is a growing field. BGP serves as an IP prefix destination based forwarding network. This limits the internet's ability to service specific traffic. At Internet Exchange Points (IXPs) an SDN controller has been added to direct traffic based on packet header matching. This allows for specific decision based on the type of service, or sender/receiver. IXPs are the current location to focus on, as they connect various ASes, and actuate policy agreements. Given the variety of services today, SDX could install custom rules for groups of flows to specific parts of the flow space [1]. However, SDX's current switch hardware cannot support large forwarding tables, nor efficiently create policy-based routes. iSDX [2] is a version of SDX that can scale and perform for larger IXPs.

7 Conclusion

This work presents a practical approach to network service specific routing using BGP's large community attribute, SDN, and segment routing. Additionally, it describes the design and implementation of the approach we take to provide service specific routing on a three-AS topology. Our approach shows that we can achieve adequate service specific routing in the intra- and inter-domain topologies without having to change much our defacto exterior gateway protocol: BGP. Furthermore, we evaluate our new approach to the current routing system and show just how useful service specific routing can be.

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