CS 494/594 Homework 4 (Winter 2022)
Instructor: Dr. Nirupama Bulusu
Due Date: **3/1/2022**

Submitted By: - Parth Parashar
For 594 students only: Review the following paper.

- Brandon Schlinker, Hyojeong Kim, Timothy Cui, Ethan Katz-Bassett, Harsha V. Madhyastha, Italo Cunha, James Quinn, Saif Hasan, Petr Lapukhov, and Hongyi Zeng. 2017. Engineering Egress with Edge Fabric. ACM SIGCOMM 2017.

https://research.facebook.com/publications/engineering-egress-with-edge-fabric/

Paper Review
Of
Engineering Egress with Edge Fabric
Steering Oceans of Content to the World

By: - Parth Parashar

In the current world where there are a lot of content providers, here the large content providers build points of presence around the world, which is interconnected with tens or hundreds of networks, which will let providers to better serve users. Internet traffic has very different characteristics than it was 10 years ago. This traffic is increasing because of small number of large content providers, cloud providers and content delivery networks, as an example The Ten Autonomous System (ASes) has alone been contributed 70% of the traffic.

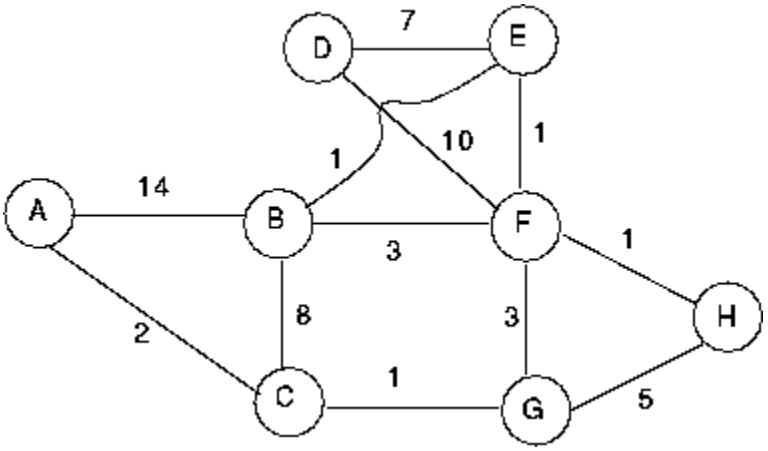
To deliver this high-volume, demanding traffic and improve user-perceived performance and availability, these providers have reshaped the Internet's topology. They serve their users from numerous Points of Presence (PoPs) spread across the globe, where they interconnect with multiple other ASes. A PoP generally has multiple paths available to reach a user network, increasing the likelihood that it has a "short" path. This rich interconnectivity gives providers control over larger portions of the paths and in aggregate provides necessary capacity. Overriding BGP's path selection with performance-aware selection is challenging for multiple reasons. First, BGP does not incorporate performance information. Second, the relative performance of paths to a destination can vary over time. Third, a provider may need to measure multiple non-equivalent paths in near real-time to track relative performance. Fourth, because BGP uses a single path per destination.

Points of presence place a major role to reduce user latency. A PoP serves users from racks of servers. The use of multiple PoP reduces the latencies in two ways like, they cache content to serve users directly, when a user needs to communicate with a data center, the user's TCP connection terminates at the PoP which maintains separate connections with data centers, yielding the benefits of split TCP and TLS

termination. The challenges of BGP is that peering capacity is limited, but BGP is not capacity aware and BGP performance can hurt performance.

The main design decisions of Edge Fabric are; operate on a peer-PoP basis, centralize control with SDN, Incorporate real-time traffic and performance measurements into decisions, use BGP for both routing and control, and leverage existing vendor software and hardware. Edge Fabric needs to know all routing information like; all available routes per prefix, preferred paths per prefix and also traffic information like; current traffic rate per prefix, interface information and projecting interface utilization.
In the end I would like to conclude that the current internet traffic is being dominated by a small number of big content providers and also how they interact with other ASes which help us largely to shape interdomain routing around the world. This paper provides the first public details of the design, implementation, and operational experience of Edge Fabric, a system that steers vast amounts of content to the world. It has been designed it to be simple and scalable, taking advantage of centralized control, existing support in vendor software and hardware, and server-based measurements. I would like to say that, BGP will be the Internet's interdomain routing standard for the foreseeable future and the limitations of BGP can be better understood and every Internet user's experience can be improved.

1. **(25 points)** Consider the network shown below.



a) **(10 points)** Suppose that each node is running Dijkstra's link state routing algorithm. Starting from an empty tree, determine the order in which the nodes are placed in G's shortest path tree. Break ties using the alphabetical order (eg. B before C).

Answer:

Step	N	D(A), p(A)	D(B), p(B)	D(C), p(C)	D(D), p(D)	D(E), p(E)	D(F), p(F)	D(H), p(H)
0	G	∞	∞	**1, G**	∞	∞	3, G	5, G
1	GC	**3, C**	9, C		∞	∞	3, G	5, G
2	GCA		9, C		∞	∞	**3, G**	5, G
3	GCAF		6, F		13, F	**4, F**		4, F
4	GCAFE		5, E		11, E			**4. F**
5	GCAFEH		**5, E**		11, E			
6	GCAFEHB				**11, E**			
7	GCAFEHBD							

The shortest path from the node G is GCAFEHBD.

b) **(15 points)** Now suppose that each node is running the distributed Distance Vector (DV) routing algorithm. Show how D's distance vector entries get updated from the initial step to step 1, and so on, until final convergence? (You can write your own software to compute the DV).

D's distance vector

	A	B	C	D	E	F	G	H
Initial								
Step 1								

Answer: *D's distance vector*

	A	B	C	D	E	F	G	H

Initial	∞	∞	∞	0	7	10	∞	∞
Step 1	∞	8	∞	0	7	8	13	11
Step 2	22	8	14	0	7	8	11	9
Step 3	16	8	12	0	7	8	11	9
Step 4	14	8	12	0	7	8	11	9

Therefore, D's distance vector is:

D	14	8	12	0	7	8	11	9

2. **(35 points)** Across networking academic research and industry, Software defined networking (SDN) and network function virtualization (NFV) have been transformational. Long-time incumbents such as Intel, Broadcom, Cisco, and IBM have SDN products. Several startups such as Nicira, Contrail have been acquired. SDN solutions have been extensively deployed across enterprises and Google's Wide Area Networks. Finally, SDN is anticipated to transform global-scale carrier networks (such as operated by AT&T, NTT, France Telecom, Deutsche Telekom, and others). To answer this question, you will need to perform some web-based research of your own!
a) **(20 points)** Explain how SDN requirements for carrier networks differ from datacenter networks.

Answer:

Software Defined Networking (SDN), which separates the network control plane from the forwarding plane to enable automated provisioning and policy – based management of network resources.

SDN requirements for carrier networks:

- SDN provides better manageability and flexibility to the network by automating traffic management, shape the network as per "on

demand" customer needs and requirement and also increase the bandwidth

- This SDN would be able to handle growing amount of work due to its dynamic scaling abilities. If any changes made in network architecture it becomes less prone and cost effective as compared to making changes using traditional networking concepts.

SDN requirements for data center networks:

- Since SDN have complete overview of the network, thus they can separate and program functionality at each endpoint individually if required
- SDN has efficient packet forwarding mechanism with the help of specialized software.

SDN is intuitive and easy to deploy and configure

b) **(15 points)** Give one example of a commercial SDN switch that can be deployed in data centers. What functions does it support to manage data center workloads?

Answers:

Example of a commercial SDN switch is cisco ACI.

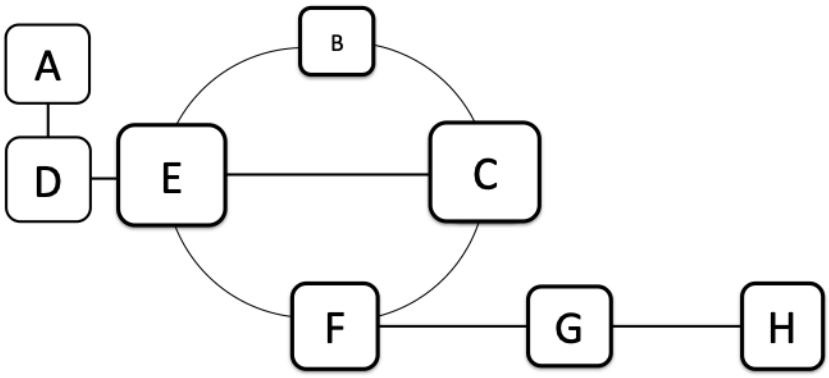
The functions it supports are:

- Centralized policy defined automation management
- Real-time visibility and application health score
- Open and end to end comprehensive security
- Application agility
- Connectivity for physical and virtual workloads with complete visibility on virtual machine traffic
- Ease of deployment

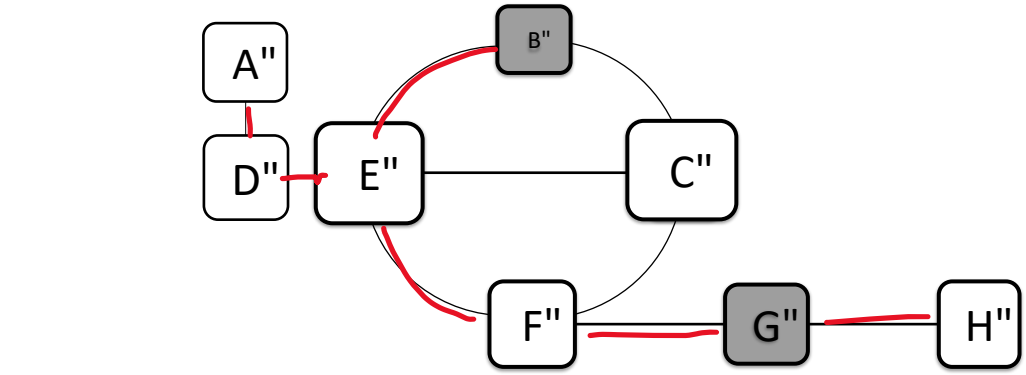
- Intuitive and easy configuration process.

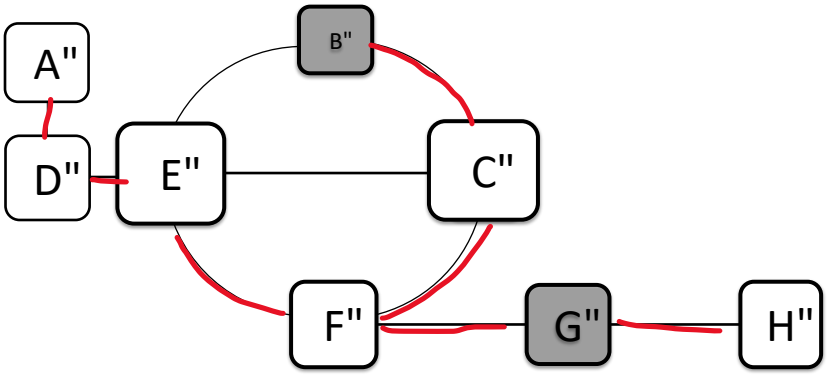
3. (20 points) Multicast Routing

Consider the topology shown below, and suppose that each link has unit cost. Suppose node H is chosen as the center (i.e., rendezvous point) in a center-based routing tree. Assume that each attached router uses its least-cost path to node H to send join messages to H. We also assume that nodes are joining in an alphabetic order (i.e., first A joins, then B etc.) Draw the resulting spanning tree in the figure. Is it unique? Justify your answer.



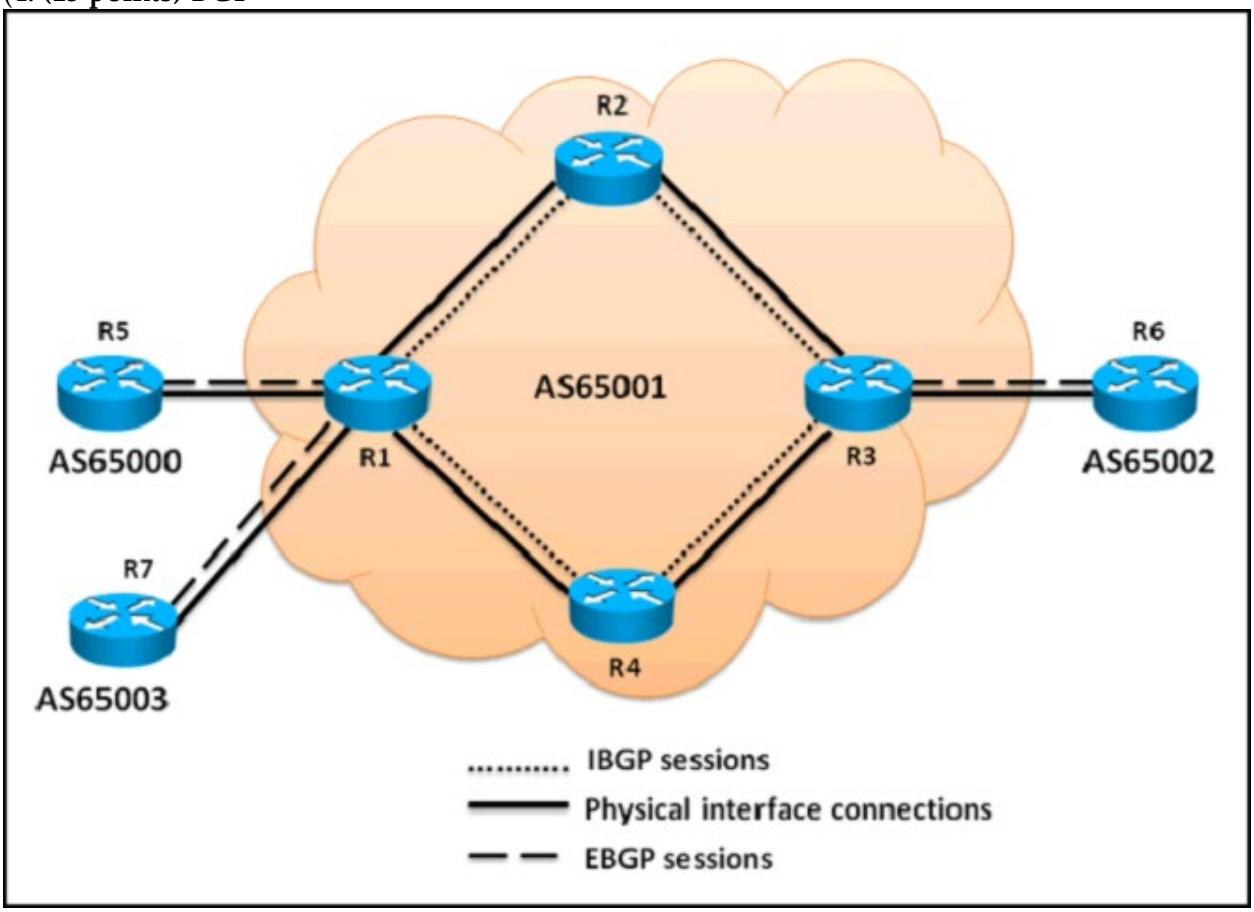
Answer:





- There are 2 paths, either paths can be from B" to H" through E" or from B" to H' through C", since both the paths have same cost, and both are paths would have same minimum cost.
- No, its is not unique. Any nodes which have no attached group present or no attached downstream members can send prune message which can lead to the node being removed from the spanning tree.

(4. **(15 points) BGP**



Consider the topology diagram above (source : Cisco).

Which of the following three statements are correct regarding the BGP routing updates? (Choose three.)

a) The EBGP routing updates received by R1 from R5 will be propagated to the R2, R4, and R7 routers

b) The EBGP routing updates received by R3 from R6 will be propagated to the R2 and R4 routers

c) The EBGP routing updates received by R1 from R5 will be propagated to the R2 and R4 routers

d) The IBGP routing updates received by R3 from R2 will be propagated to the R6 router

e) The IBGP routing updates received by R2 from R1 will be propagated to the R3 router

f) The IBGP routing updates received by R1 from R4 will be propagated to the R5, R7, and R2 routers

Answer: - a,b,d