

BGP routing policies in ISP networks

Author:

Matthew Caesar (PhD in UC Berkeley, post-doc in Princeton, now a professor in UIUC)

Jennifer Rexford (was a professor in Princeton, winner of Grace Hopper)

BGP Overview

Optional: Link State Routing Algorithm (Dijkstra), Distance-Vector Routing Algorithm (Bellman-Ford)

1. History: hierarchical routing: AS and ISP
2. prior to 1989 (when BGP was born), backbone NSFNET phase II and its regional networks used EGP, the architecture was "core routers – non-core routers"...

GGP/EGP

EGP: not a routing protocol, reachability exchange protocol, distance-vector

- exchange the complete routing table every 3min no matter whether there is a update
- no path info
- difficult to scale or detect routing loops
- constrain the topology to be a spanning tree
- directly on IP

You name the disadvantages...

3. BGP inventor: Kirk Loughee (Cisco), Yakov Rekhter, with help of Len Bosack (Cisco).

BGP: three-napkin protocol, designed in 1989, IETF 12

Positioned as a short-termed design...

BGP Fields

version	2 bytes
length	2 bytes
type	2 bytes
total length	2 bytes
reserved	0
flag	1 bit
update sequence number	4 bytes
originator ID	4 bytes
cluster list	variable
next hop	4 bytes
AS path	variable
community	variable
extended community	variable
MP reach list	variable
MP next hop	variable
MP unreach list	variable
MP next hop reach	variable
MP unreach next hop	variable
MP next hop reach	variable
MP unreach next hop	variable
MP next hop reach	variable
MP unreach next hop	variable

BGP Message Types

1. link type over a span - by use of remote link type (1 byte)
2. version and type code
3. update sequence number (4 bytes)
4. update error - when update is received
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99. update error - when update is received
100. update error - when update is received

State Diagram

```

    graph TD
        IDLE --> OPEN
        OPEN --> OPEN_CONFIRM
        OPEN_CONFIRM --> OPEN_CONFIRM_CONFIRM
        OPEN_CONFIRM_CONFIRM --> ESTABLISHED
        ESTABLISHED --> ESTABLISHED
        ESTABLISHED --> IDLE
        ESTABLISHED --> OPEN
        ESTABLISHED --> OPEN_CONFIRM
        ESTABLISHED --> OPEN_CONFIRM_CONFIRM
        ESTABLISHED --> ESTABLISHED
    
```

longhoo@cs.cmu.edu 9/5-9/20-1991 (11-7) BGP
 jre@cs.cmu.edu (800)487-3886 (2-C) BGP

- BGP overcame the problems of EGP described above. It evolved through the years

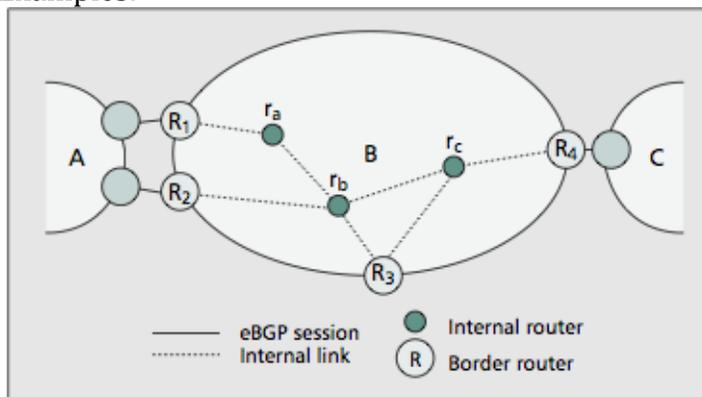
RFC Number	Date	Name	BGP Version
1105	June 1989	A Border Gateway Protocol (BGP)	BGP-1
1163	June 1990	A Border Gateway Protocol (BGP)	BGP-2
1267	October 1991	Border Gateway Protocol 3 (BGP-3)	BGP-3
1654	July 1994	A Border Gateway Protocol 4 (BGP-4)	BGP-4
1771	March 1995	A Border Gateway Protocol 4 (BGP-4)	BGP-4

One big change of BGP4 is its support for **routing policies**.

- By the time of publishing BGP4 RFC, it has already been deployed widely across the Internet!

BGP as an Inter-Domain Protocol

- BGP basics: iBGP and eBGP
 - Functionalities:
 - For each AS: obtain reachability information, reachability propagation within AS, make decisions
 - For the Internet: Reachability advertisement
 - Route: prefix and its path attributes (e.g. AS-PATH, NEXT-HOP)
- Examples:



- Difference between inter-AS routing protocol and intra-AS routing protocol
 - Policy
 - Scale
 - Performance

Routing Policies in Internet

- Decision process of BGP

Step	Attribute	Controlled by local or neighbor AS?
1.	Highest LocalPref	Local
2.	Lowest AS path length	Neighbor
3.	Lowest origin type	Neither
4.	Lowest MED	Neighbor
5.	eBGP-learned over iBGP-learned	Neither
6.	Lowest IGP cost to border router	Local
7.	Lowest router ID (to break ties)	Neither

2. 3 steps to process route advertisement:

- import policies
- decision process
- export policies

ISPs tweak the above 3 steps in order to implement the routing policies

Policy Taxonomy

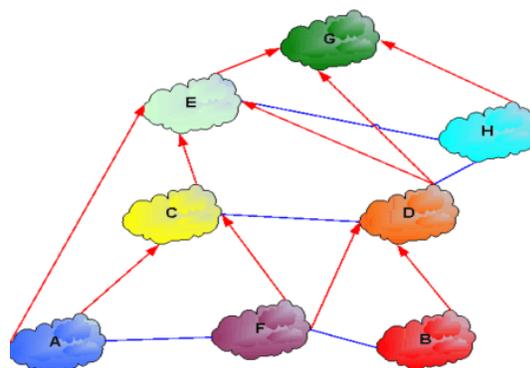
1. Business Relationships

- Customer-provider

Tier-1: AT&T

- They only provide transit traffic (need payment) or peer with other ISPs.
- Disconnection between two peering Tier-1 ISPs will partition the Internet.
- Example: 2005, Cogent and Level3. Pop question: 3 scenarios to determine if you may have access problem
- Sidebar: Being a pure Tier-1 is not an easy job...

Tier-2: Comcast

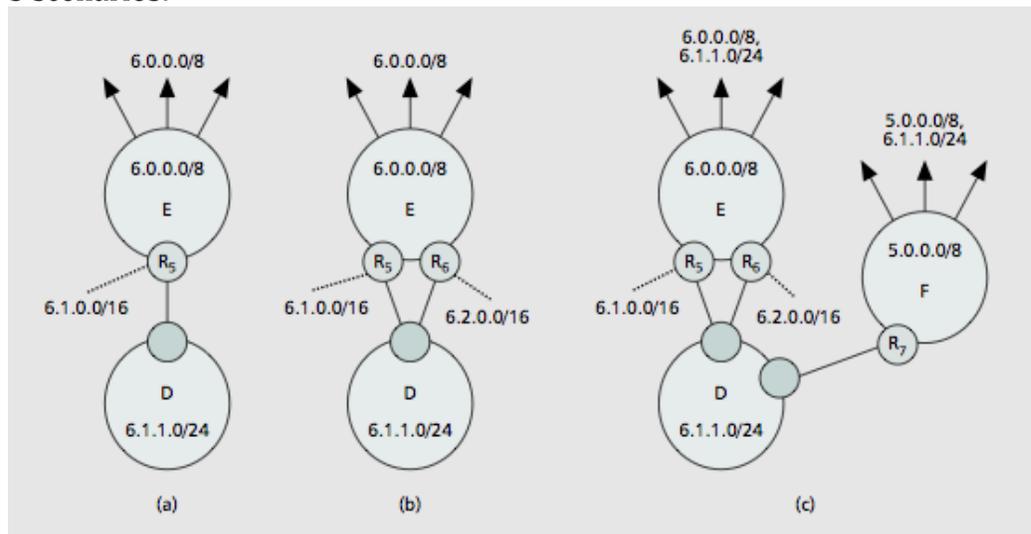


Example: A->B, C->H

Tier-3: resell transit

- Peer-peer

- Backup
 - Paper: change the local-perf to influence decision process
 - Paper: controlling exports, using community attributes
2. Traffic Engineering
- Outbound Traffic Engineering
Change local-perf
Achieve load balancing---goal of Traffic Engineering
 - Inbound Traffic Engineering
Change MED
Inflate the AS-PATH
 - Remote Control: community attributes
3. Scalability
- Limit the routing table size
Protect local ISP from other ISPs
Protect other ISPs: route aggregate
3 scenarios:



- Limit the number of routing changes:
Flap damping: improving routing instability
4. Security
- Discard Invalid routes: import policies
 - Rewrite path attributes to prevent violations of peering agreements
 - Export policies: filter out sensitive information
 - Prevention of DoS attack
Paper: discard offensive routes/updates
IP Hijack Example: Feb 2008, Pakistan telecom hijacked Youtube by creating a black hole, propagated by BGP through the whole Internet, result: Youtube unavailable for 2 hours. (by using longest-prefix match in routing table) This can also be used to eavesdrop....

However, BGP remains as an in-secure protocol: BGP was designed when everyone was trusted...