Inter-Autonomous-System Routing: Border Gateway Protocol

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Hierarchical routing

BGP
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Network Model
So far we have studied routing over a “flat” network model.
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Also, our objective has been to find the least-cost paths between sources and destinations.
More Realistic Topologies
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An Internet Map

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Higher-Level Objectives

- **Scalability**
  - hundreds of millions of hosts in today’s Internet
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  - an organization might not want to expose its internal network structure
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An *intra-autonomous system routing protocol* runs within an autonomous system (e.g., OSPF)

- this protocol determines internal routes
  - internal router ↔ internal router
  - internal router ↔ gateway router
  - gateway router ↔ gateway router
Hierarchical Structure

AS1

AS2

AS3

AS4
Hierarchical Structure
An *inter-autonomous system routing protocol* determines routing at the autonomous-system level.
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At AS3:
AS1 \rightarrow
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AS1 → AS1; AS2 → AS2; AS4 → AS1.
All routers within an AS compute their *intra-AS* routing information

- using an *intra-domain* routing protocol
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- Both *inter-AS* and *intra-AS* routing information is used to compile the forwarding tables
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- **inter-AS** information is used to figure out that $x$ is reachable through gateway $G_x$.
- **intra-AS** information is used to figure out how to reach $G_x$ within the AS.
- what if $x$ is reachable through multiple gateway routers $G_x, G'_x, \ldots$?
  - use **intra-AS** routing information to determine the costs of the (least-cost) paths to $G_x, G'_x, \ldots$
  - “hot-potato” routing: send it through the closest gateway.
Benefits of Hierarchical Routing

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- External subnet addresses are likely to “aggregate” in groups that admit compact representations
  - this process is called *supernetting*
Inter-AS Routing in the Internet
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  - based on *policies*
- BGP is a *path-vector* protocol
BGP session: a semi-permanent connection between two routers
BGP Architecture and Terminology

- **BGP session**: a semi-permanent connection between two routers

- **BGP peers**: two routers engaged in a BGP session
  - BGP sessions are established over TCP
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- **BGP external session (eBGP)**: a session across two autonomous systems

- **BGP internal session (iBGP)**: a session within an autonomous system
  - note that internal sessions carry *inter*-AS information
  - *intra*-AS routing uses a separate protocol (e.g., OSPF)
Gateway Routers and eBGP

AS1

AS2

AS3

AS4
- **BGP advertisement**: a router advertises routes to networks, much like an entry in a distance-vector
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E.g.,

\[
\begin{align*}
128.138.242.0/24 \\
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\end{align*}
\] → 128.138.242.0/23
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191.224.128.0/22 & \quad 191.224.136.0/21 \\
191.224.132.0/22 &
\end{align*}
\]

\[\rightarrow 128.138.242.0/23 \quad \rightarrow \]

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  - **NEXT-HOP:** specifies the interface (IP address) to use to forward packets towards the advertised destination
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BGP import policy: used to decide whether to accept or reject the route advertisement

- e.g., a router may not want to send its traffic through one of the AS listed in AS-PATH
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   - configured at the router
   - or learned from another router within the same AS
   - essentially a configuration parameter for the AS
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4. ...