Lecture #9: Routing at scale, and with policy
Katrina’s favorite protocol
1970s: ARPAnet  
1978: flexibility and layering  
early 80s: growth → change  
late 80s: growth → problems  
1993: commercialization

hosts.txt  distance-vector routing  
TCP, UDP  OSPF, EGP, DNS  
(a link-state routing protocol)  
congestion collapse  
policy routing  
CIDR

application  
the things that actually generate traffic

transport  
sharing the network, reliability (or not)  
examples: TCP, UDP

network  
naming, addressing, routing  
examples: IP

link  
communication between two directly-connected nodes  
examples: ethernet, bluetooth, 802.11 (wifi)

last time: neither distance-vector nor link-state routing will scale to the size of the Internet, nor do either let us address policy routing

CAIDA's IPv4 AS Core, February 2017  
(https://www.caida.org/research/topology/as_core_network/2017/)
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notice that I’m not highlighting the network layer; we’ll talk about why

this time: scale and policy!
(so we’re thinking about the Internet specifically today, not just any network)
**scalable routing**: a few different things allow us to route across the Internet
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3. topological addressing: assign addresses in contiguous blocks to make advertisements smaller

- 18.0.0.0, ... , 18.0.0.255
- 18.0.0.0/24
scalable routing: a few different things allow us to route across the Internet

1. hierarchy of routing: route between ASes, and then within an AS

2. path-vector routing: advertisements include the path, to better detect routing loops

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now that we have scale, we want a means to implement policy
common AS relationships
arrows describe the flow of money; traffic may flow in both directions
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customer pays provider for transit
common AS relationships
arrows describe the flow of money; traffic may flow in both directions

**customer** pays **provider** for transit
Katrina LaCurts | lacurts@mit.edu | 6.033 2021

makes money whenever any traffic flows on this link

common AS relationships
arrows describe the flow of money; traffic may flow in both directions

customer pays provider for transit
makes money whenever *any* traffic flows on this link

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customer pays provider for transit

makes money whenever any traffic flows on this link
typically a provider will charge more money to its customers than it pays its own provider, so still makes a profit here

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**customer** pays **provider** for transit

**peers** allow (free*) mutual access to each other’s customers
*as long as the amount of traffic in each direction is roughly equal
customer pays provider for transit

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customer relationship

provider relationship

peers relationship

common AS relationships

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common AS relationships
arrows describe the flow of money; traffic may flow in both directions
If one peer allows its two peers to send traffic through it to their respective customers, it makes no money.

Common AS relationships:
- Arrows describe the flow of money; traffic may flow in both directions.
- **Customer** pays **provider** for transit.
- **Peers** allow (free*) mutual access to each other's customers, as long as the amount of traffic in each direction is roughly equal.
customer pays provider for transit

peers allow (free*) mutual access to each other's customers

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common AS relationships
arrows describe the flow of money; traffic may flow in both directions

*customer pays provider* for transit

*peers allow (free*) mutual access to each other’s customers*

*as long as the amount of traffic in each direction is roughly equal*

*these relationships are reflected in export policies*
*which routes to advertise, and to whom*
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these relationships are reflected in **export policies**
which routes to advertise, and to whom

we’re focusing on the middle blue node right now; ignore the gray nodes
providers tell everyone about themselves and their customers, and tell their customers about everyone!

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providers tell everyone about themselves and their customers, and tell their customers about everyone
a provider wants its customers to send and receive as much traffic through the provider as possible

a provider wants its customers to send and receive as much traffic through the provider as possible

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this slide represents one “round” of advertisements from the blue node; other routes will be discovered in subsequent rounds (see next slide)
providers tell everyone about themselves and their customers, and tell their customers about everyone.

peers tell each other about their customers.

these relationships are reflected in export policies, which routes to advertise, and to whom.

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 providers tell each other about their customers.

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notice that peers do not tell each other about their own providers; they would lose money providing that transit.

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in this example, some of our ASes are **unable** to send traffic to XXXX; they do not know about any routes to it.

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**these relationships are reflected in export policies**
- Which routes to advertise, and to whom.
- **providers** tell everyone about themselves and their customers, and tell their customers about everyone.
- **peers** tell each other about their customers.
In this example, some of our ASes are unable to send traffic to \[\text{XXXXX}\]; they do not know about any routes to it.

In fact, there are quite a few ASes here that are disconnected from one another.

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These relationships are reflected in **export policies** which routes to advertise, and to whom.

**Providers** tell everyone about themselves and their customers, and tell their customers about everyone.

**Peers** tell each other about their customers.
providers tell everyone about themselves and their customers, and tell their customers about everyone

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providers tell everyone about themselves and their customers, and tell their customers about everyone's peers tell each other about their customers
on the Internet, all of the top tier ("tier-1") ISPs peer, to provide global connectivity

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these relationships are also reflected in **import policies**
which routes to use
ASes set their own import policies. Typically, if an AS hears about multiple routes to a destination, it will prefer to use its customers first, then peers, then providers. If that’s not enough, a variety of other attributes are provided.

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These relationships are also reflected in **import policies**, which routes to use.

On the Internet, all of the top tier (“tier-1”) ISPs peer, to provide global connectivity.

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BGP is an **application layer** protocol, even though it deals with routing

- **application** the things that actually generate traffic
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it works on the Internet (which is good), but the size of routing tables, route instability, multihoming, and iBGP all cause scaling issues

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is BGP secure?

it is not!

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**does BGP scale?**

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**is BGP secure?**

it is not!

*Mark Imbriaco*
@markimbriaco

BGP basically relies on the honor system

*holly* @girlziplocked

What’s a dirty secret that everybody in your industry knows about but anyone outside of your line of work would be scandalized to hear?

Show this thread
on the Internet, we have to solve all of the “normal” networking problems (addressing, routing, transport) at massive scale, while supporting a diverse group of applications and competing economic interests.

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