Interdomain Routing

Establish routes between autonomous systems (ASes).

Currently done with the Border Gateway Protocol (BGP).
Why is Interdomain Routing Hard?

- Route choices are based on local policies.
- Autonomy: Policies are uncoordinated.
- Expressiveness: Policies are complex.
BGP Route Processing (1)

• The computation of a single node repeats the following:

  Receive routes from neighbors → Update Routing Table → Choose “Best” Route → Send updates to neighbors

• Paths go through neighbors’ choices, which enforces consistency.

• Decisions are made locally, which preserves autonomy.

• Uncoordinated policies can induce protocol oscillations. (Much recent work addresses BGP convergence.)

• Recently, private information, optimization, and incentive-compatibility have also been studied.
BGP Route Processing (2)

Open-ended programming: constrained only by vendor configuration language
Example: Convergence

1

2

Prefer routes through 2

Prefer direct route to d

d
Example: Convergence

Prefer direct route to d

Prefer routes through 2
Example: Convergence

Prefer routes through 2

Prefer direct route to d
Example: Oscillation

BGP might oscillate forever between

1d, 2d and 12d, 21d
Example: Oscillation

BGP might oscillate forever between

1d, 2d
and
12d, 21d
Example: Oscillation

BGP might oscillate forever between $1d, 2d$ and $12d, 21d$.
Example: Oscillation

BGP might oscillate forever between 1d, 2d and 12d, 21d

Prefer routes through 1

Prefer routes through 2
Example: Convergence

1

2

d

Prefer routes through 2

Prefer routes through 1
Example: Convergence

Prefer routes through 2

Prefer routes through 1

1

2

d
Example: Convergence

1 - Prefer routes through 2

2 - Prefer routes through 1

d
Dispute Wheels

Nodes $u_i$, hub routes $R_i$, and spoke routes $Q_i$. Each $u_i$ prefers $R_i Q_{i+1}$ to $Q_i$.

“No dispute wheel”

$\rightarrow$

robust convergence
Gao-Rexford Framework (1)

Neighboring pairs of ASes have one of:

- a *customer-provider* relationship  
  (One node is purchasing connectivity from the other node.)

- a *peering* relationship  
  (Nodes have offered to carry each other’s transit traffic, often to shortcut a longer route.)
Gao-Rexford Framework (2)

- **Global constraint**: no customer-provider cycles
- **Local preference** and **scoping constraints**, which are consistent with Internet economics:
  
  **Preference Constraints**
  - If $k_1$ and $k_2$ are both customers, peers, or providers of $i$, then either $ik_1R_1$ or $ik_2R_2$ can be more valued at $i$.
  - If one is a customer, prefer the route through it. If not, prefer the peer route.

  **Scoping Constraints**
  - Export customer routes to all neighbors and export all routes to customers.
  - Export peer and provider routes to all customers only.

- **Gao-Rexford conditions** => BGP always converges [GR01]