Inherently Safe Backup Routing with BGP

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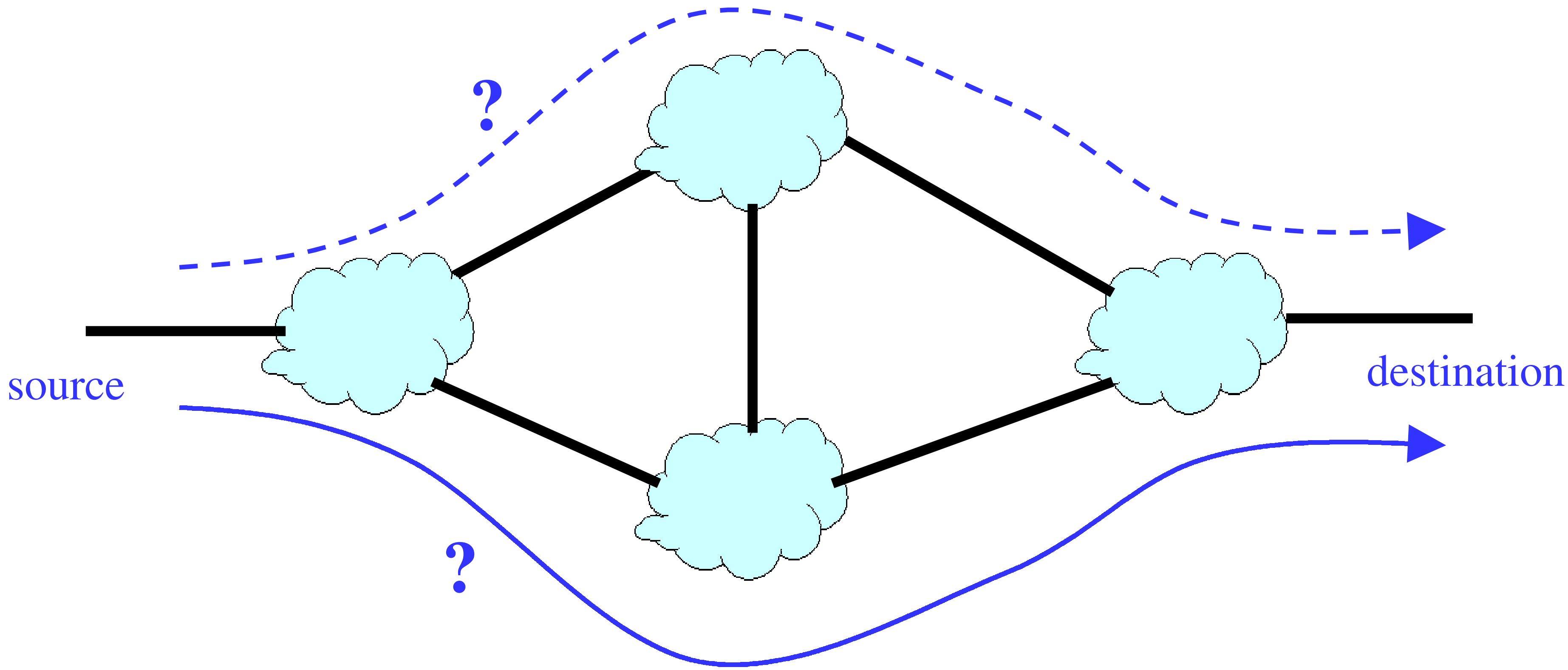
The Problem

- Properties of BGP routing in the Internet
  - Connected graph does *not* imply hosts can communicate
  - Conflicting BGP policies can cause routing divergence



Conflicting Solutions

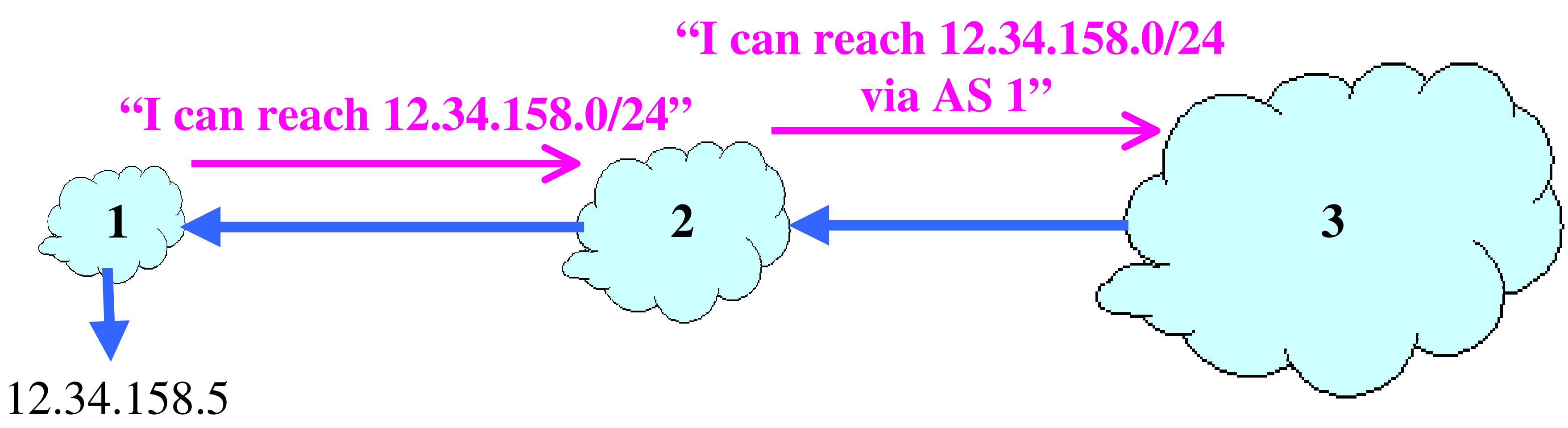
- Avoiding route divergence
  - BGP policies based on commercial relationships
  - Customer-provider and peer-peer relationships
  - Prevents route divergence (SIGMETRICS'00)
- Improving reachability
  - Introducing additional paths for use under failure
  - Homing to multiple service providers (common practice)
  - Backup peering relationships (discussed in RFC 1998)
- Tension
  - Backup paths necessary to improve reachability
  - Backup paths may introduce route divergence

Outline

- Background
  - Border Gateway Protocol (BGP)
  - BGP route divergence example
  - Commercial relationships between ASes
- Backup routing
  - Multi-homed backup and peer-peer backup
  - Assigning an avoidance level to routes
  - Local guidelines for ranking routes
- Conclusion

Interdomain Routing (Between ASes)

- ASes exchange info about who they can reach
- Local policies for path selection (*which to use?*)
- Local policies for route propagation (*who to tell?*)
- Policies configured by the AS's network operator

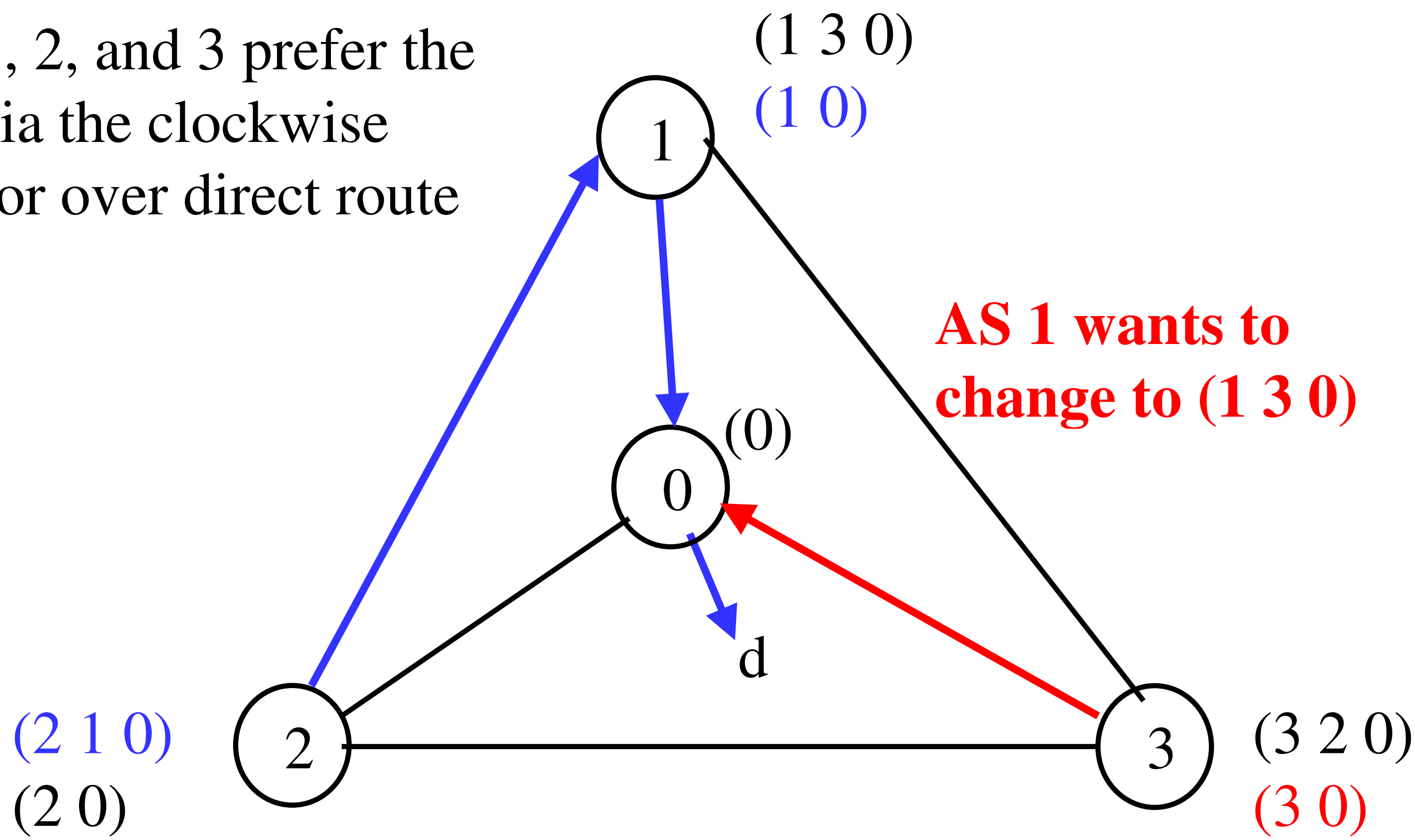


Border Gateway Protocol

- Exchanging route advertisements
  - Pair of routers speak BGP over a TCP connection
  - Advertise best route for a prefix to neighboring ASes
  - Withdraw a route when it is no longer available
- Processing route advertisements
  - Import policies (manipulate incoming advertisements)
  - Decision process (select best route to given prefix)
  - Export policies (manipulate outgoing advertisement)
- No guarantee of convergence or reachability

Route Divergence: Bad Gadget (SIGCOMM'99)

ASes 1, 2, and 3 prefer the route via the clockwise neighbor over direct route

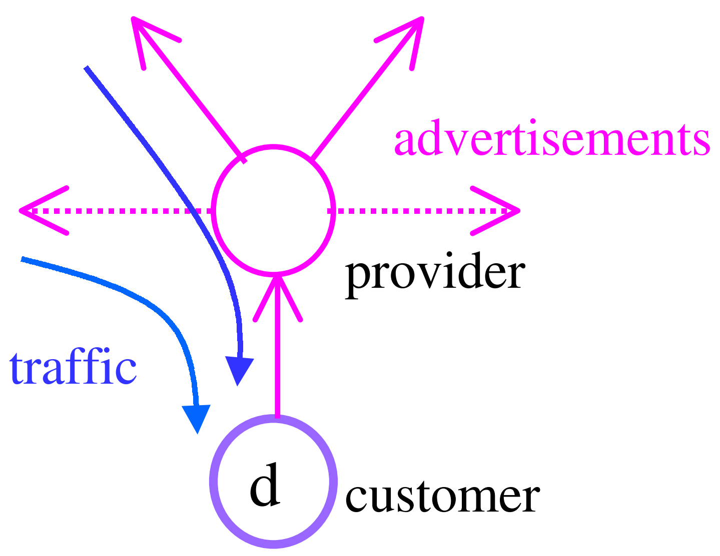


Do route divergence problems actually happen in practice?

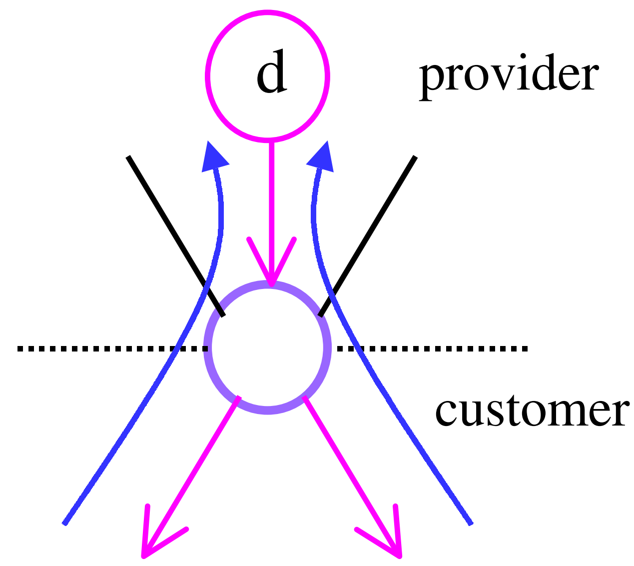
Customer-Provider Relationship

- Customer pays provider for access to the Internet
- AS exports customer's routes to *all* neighbors
- AS exports provider's routes *only* to its customers

Traffic **to** the customer



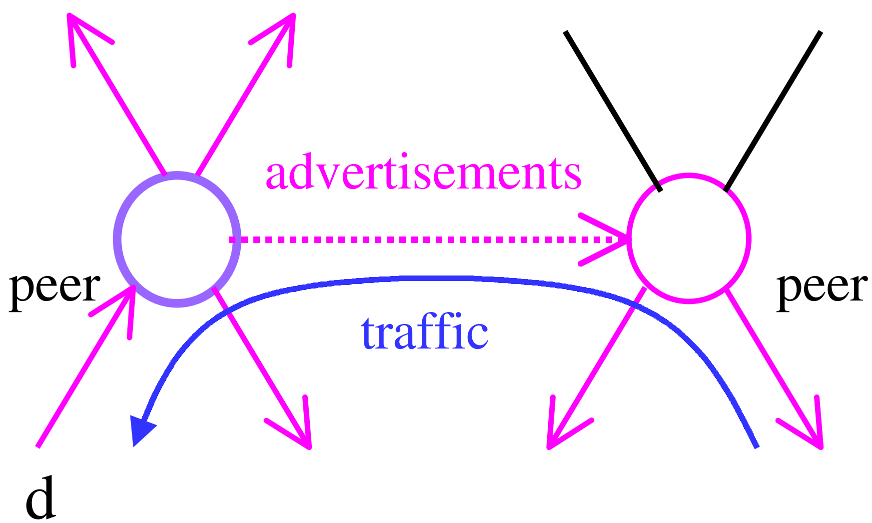
Traffic **from** the customer



Peer-Peer Relationship

- Peers exchange traffic between their customers
- Free of charge (assumption of even traffic load)
- AS exports a peer's routes *only* to its customers

Traffic to/from the peer and its customers

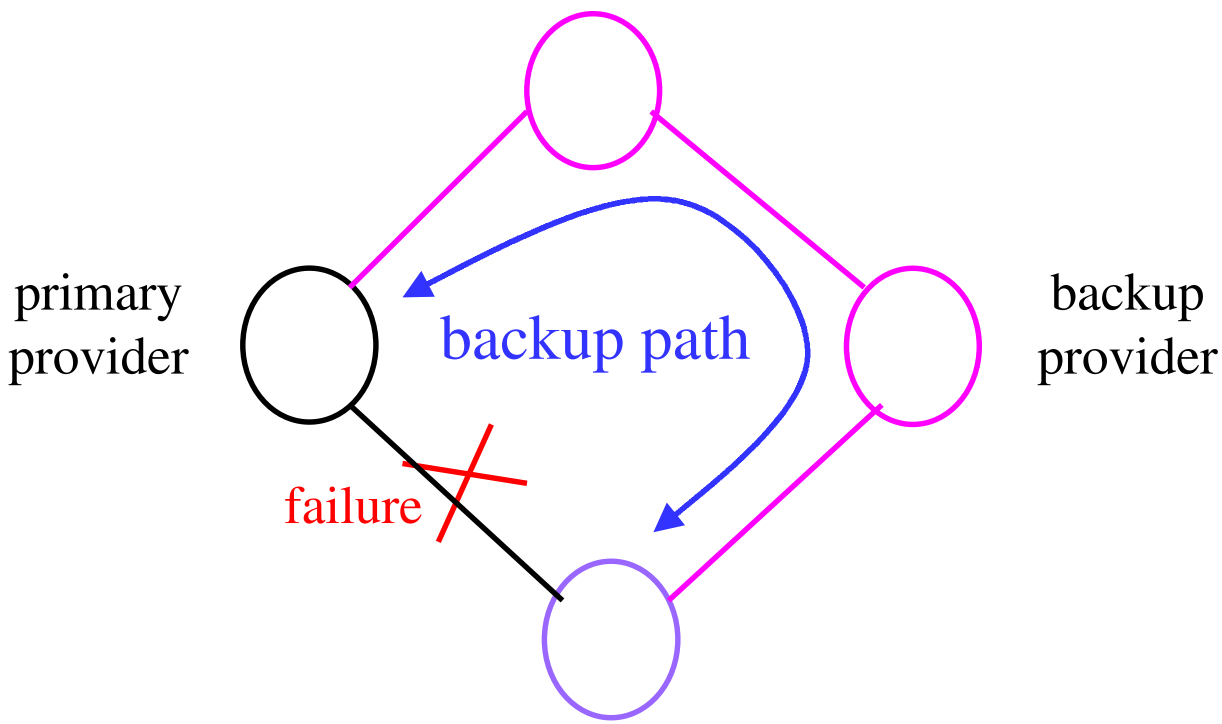


Avoiding Route Divergence (SIGMETRICS'00)

- Export policies based on commercial relationships
  - Peer routes are not exported to other peers/providers
  - Provider routes are not exported to other peers/providers
- Import policies based on commercial relationship
  - Prefer customer routes over peer/provider routes
- Hierarchical customer-provider relationships
  - If *u* is a customer of *v* and *v* is a customer of *w*
  - … then, *w* is not a customer of *u*
- Then, route divergence is provably not a problem

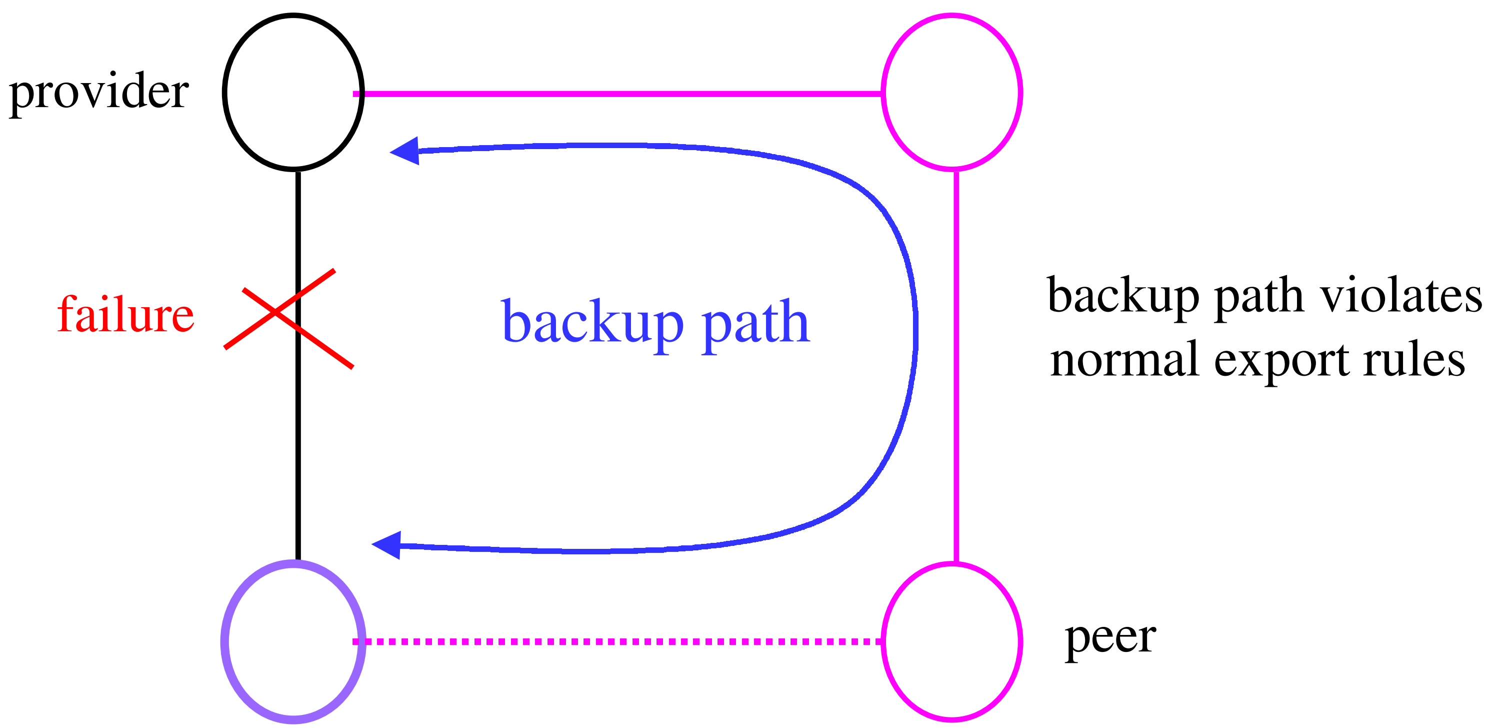
Multi-Homed Backup

- Allow an AS to have a backup provider
- Assign lowest preference for backup route
- Backup route selected when primary fails



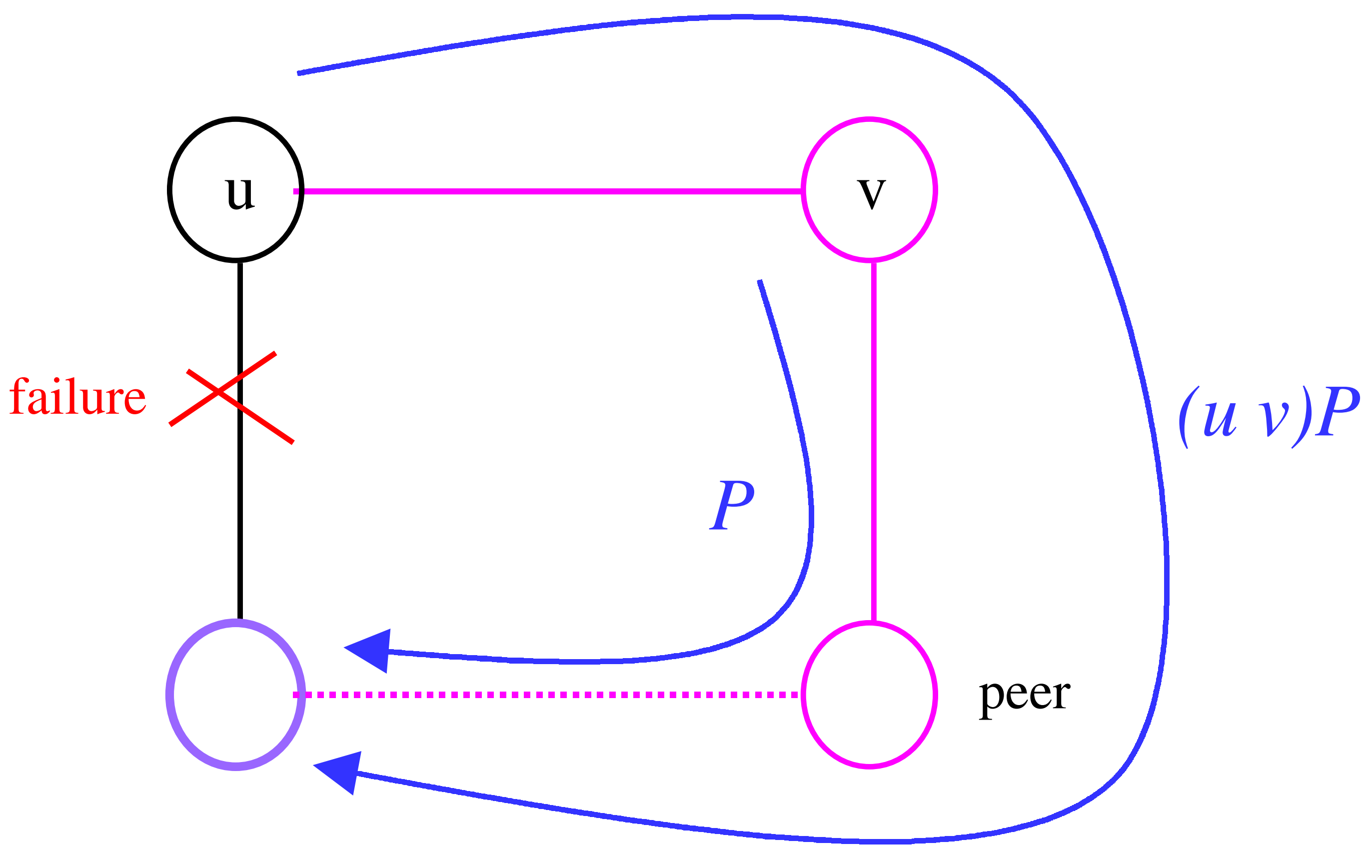
Peer-Peer Backup

- Allow two ASes to provide backup service
- Liberal export policies for backup relationship
- Assign lowest preference to backup routes



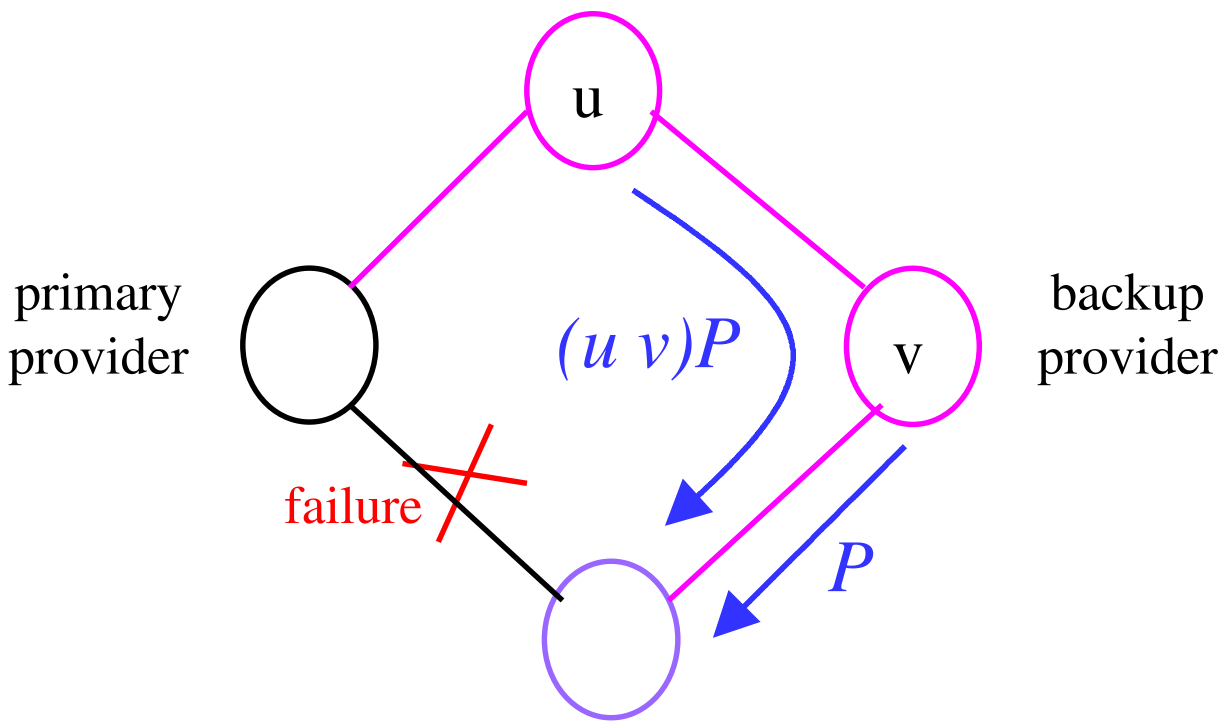
Backup Paths Have Global Significance

- Once a backup path, always a backup path
- If P at AS v is a backup path, so is $(u\ v)P$ at AS u

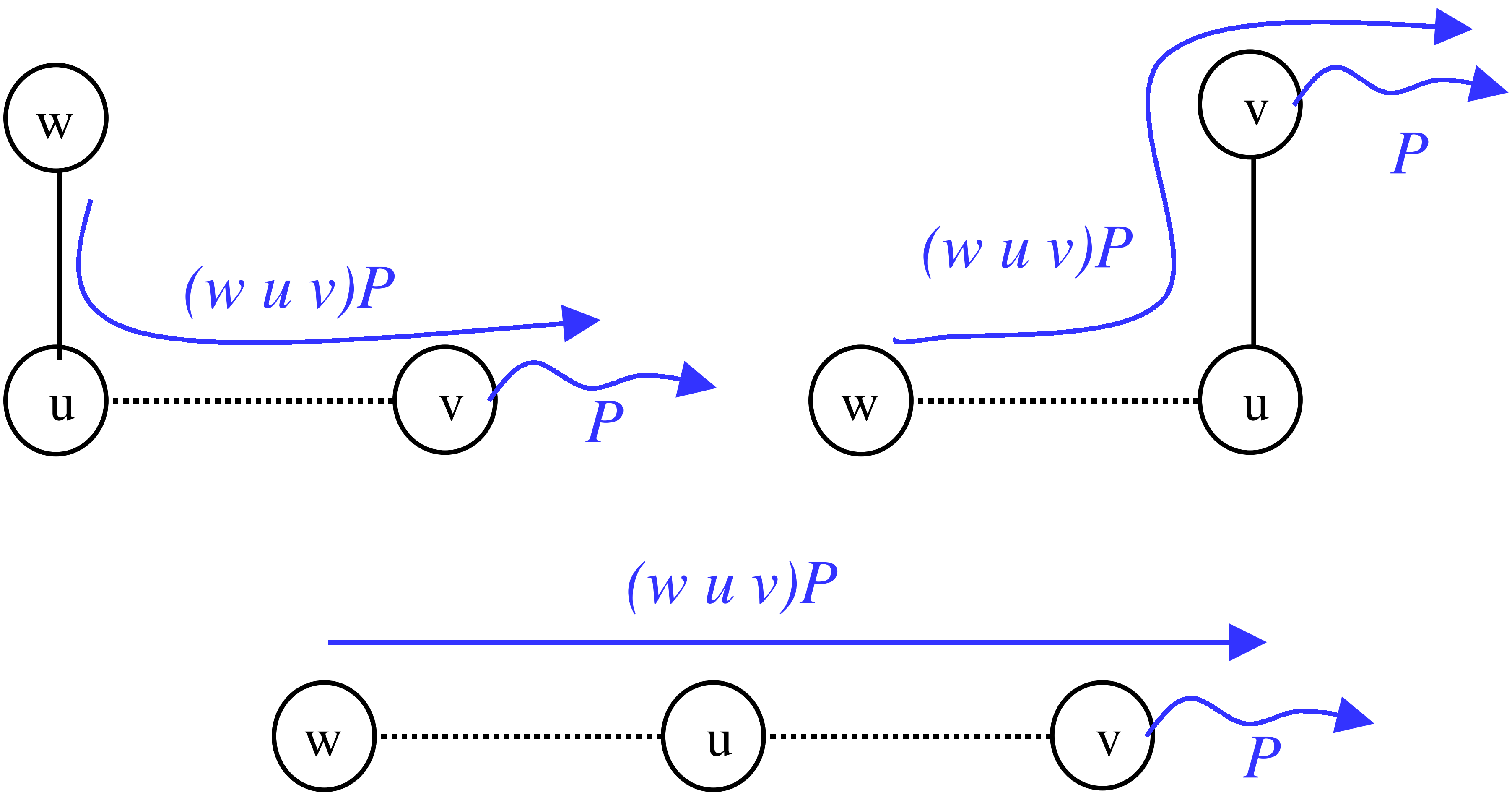


Avoidance Levels

- Each path has *avoidance level* (e.g., integer weight)
- Avoidance level cannot decrease as it is advertised
- Avoidance level $K(P)$ cannot exceed $K((u\ v)P)$



Mandatory Increase in Avoidance Level ("Steps")



K((w u v)P) **must** be greater than *K((u v)P)*

Ranking Between Paths

- Lower ranking for backup paths
  - Prefer primary paths over backup paths
  - Prefer path *P* with a smaller avoidance level *K(P)*
- Higher ranking for customer routes
  - Ranking between paths with same avoidance level
  - Prefer path via customer over path via peer or provider
- Inherent safety
  - Guaranteed to prevent route divergence (proof in paper)
  - Result holds under any failures and policy changes

Conclusions

- Realization in BGP
  - New BGP attribute and change in decision process, or
  - Community attribute to convey avoidance level (and configuration rules for assigning local preference)
- Properties of our solution
  - Backup paths available under link and router failure
  - Guaranteed safety under all failure scenarios
  - Local configuration of BGP policies in each AS
  - Policies consistent with AS commercial relationships