Supporting Dynamic Secure Interdomain Routing

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Agenda

- SCION Background
- Spot Market – Motivation
- Protocol for Spot Market
- Transaction Times
- Monitoring and Dispute Resolution
- Summary and Future Work

SCION - A Secure Internet Architecture

- End-to-end architecture
  - Designed to fix shortcomings of existing system (IP + BGP)
  - Flexible trust structure – ASes self-organize into isolation domains (ISDs)
  - Path transparency and flexibility (within policy constraints)
  - Use of parallel paths to destination
  - Cryptographically secure routing + forwarding
- Designed to be deployable in today's (relatively static) interdomain relationships

SCION in a Nutshell – Path-based Architecture

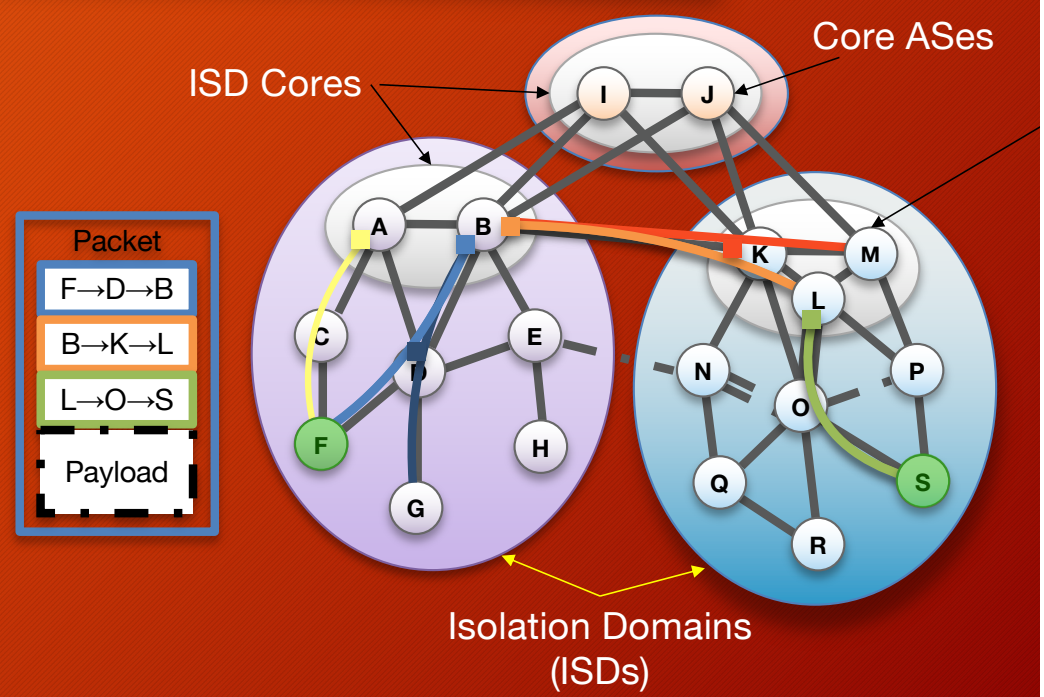
Control Plane - Routing

- Constructs and Disseminates Path Segments

Data Plane - Packet forwarding

- Combine Path Segments to form Path
- Packets carry Paths
- Routers forward packets based on Path

Simple routers, stateless operation

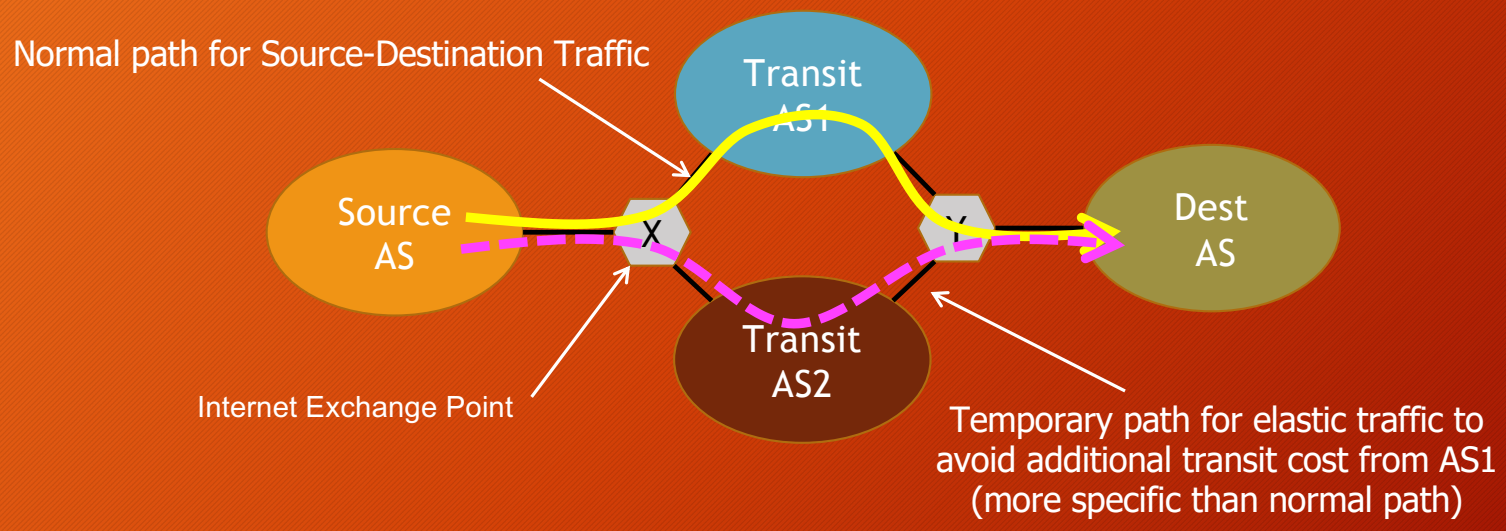


Spot Market for Interdomain Connectivity

- Transit providers relay traffic between access ISPs.
- Transit traffic load varies, more or less predictably.
  ⇒ Transit providers have unused capacity at times.
- Xu and Li, 2015: Transit providers could realize additional profit by selling short-term access to their spare capacity*.
  - Buyer motivation: cheaper transit for shiftable traffic
- Xu and Li did not consider implementation.

*Xu, H. and Li, B., "Spot Transit: Cheaper Internet Transit for Elastic Traffic", *IEEE Transactions on Service Computing*, vol. 8, issue 5, Sept-Oct 2015, pp. 768–781.

Spot Market for Interdomain Connectivity



Spot Market for Internet Connectivity

- Challenges:
  - Trust relationships among AS's today are complex, opaque
  - Transaction costs for peering are high
  - Verifiability, dispute resolution
  - Unit of service?

Protocol Importance

"If an interface between modules is well-defined and easy to understand, then exploiting this interface as a basis for competitive interaction among firms may have a transaction cost low enough to be viable."

David D. Clark, *Designing An Internet*

- IXP (or other intermediary) functions:
  - Collect and propagate transit connectivity offers
  - Collect access provider acceptance of offers
  - Instantiate forwarding state dynamically as offers are consummated

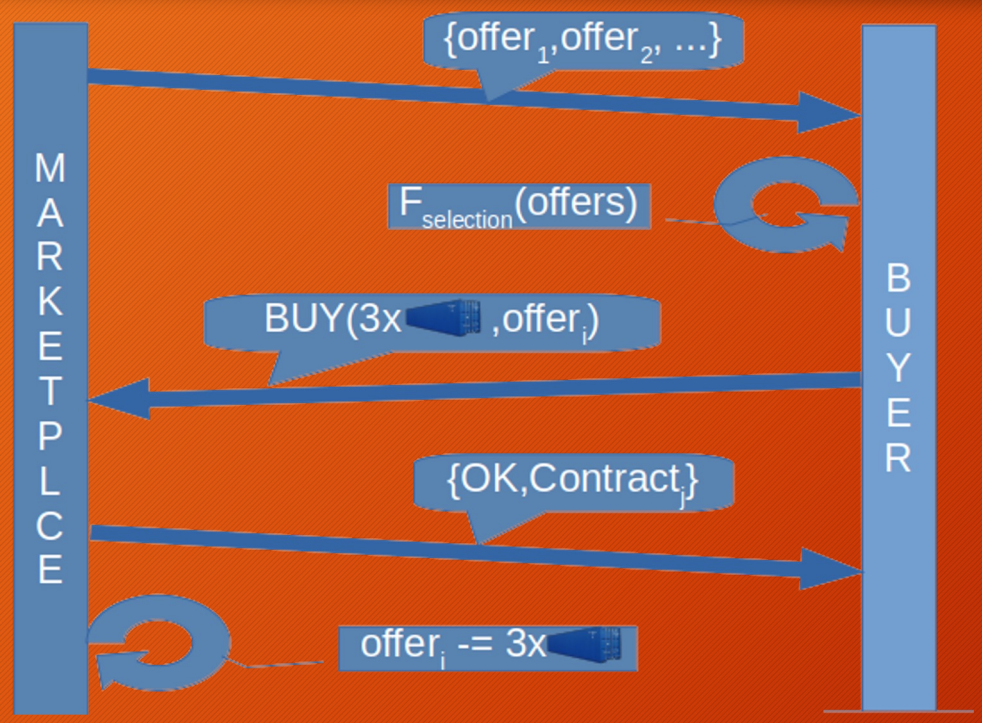
Our Contribution

- Prototyped a "spot market" capability for SCION
  - Leveraging SCION's trust structure
- Identify IXP as potential neutral platform for "marketplace"
  - Matches offers to sell/buy
- Steps toward a standard unit of service for transit
- Toward a general mechanism for "clearing"
  - Usable for other advanced per-flow services
  - Enabling more general "money flow" in the Internet

Implementating the Protocol

- Implemented:
  - Means of propagating offers to neighbors
  - Standard interfaces and low transaction costs
  - Monitoring infrastructure for determining satisfaction
- Also Needed by Sellers:
  - Means of determining available capacity
  - Algorithm for setting price
  - Means of distinguishing revenue-generating traffic from other traffic
    - E.g., SDN rules
- Also Needed by Buyers:
  - Means of measuring elastic demand
  - Means of determining whether/which offer to accept

Protocol Description



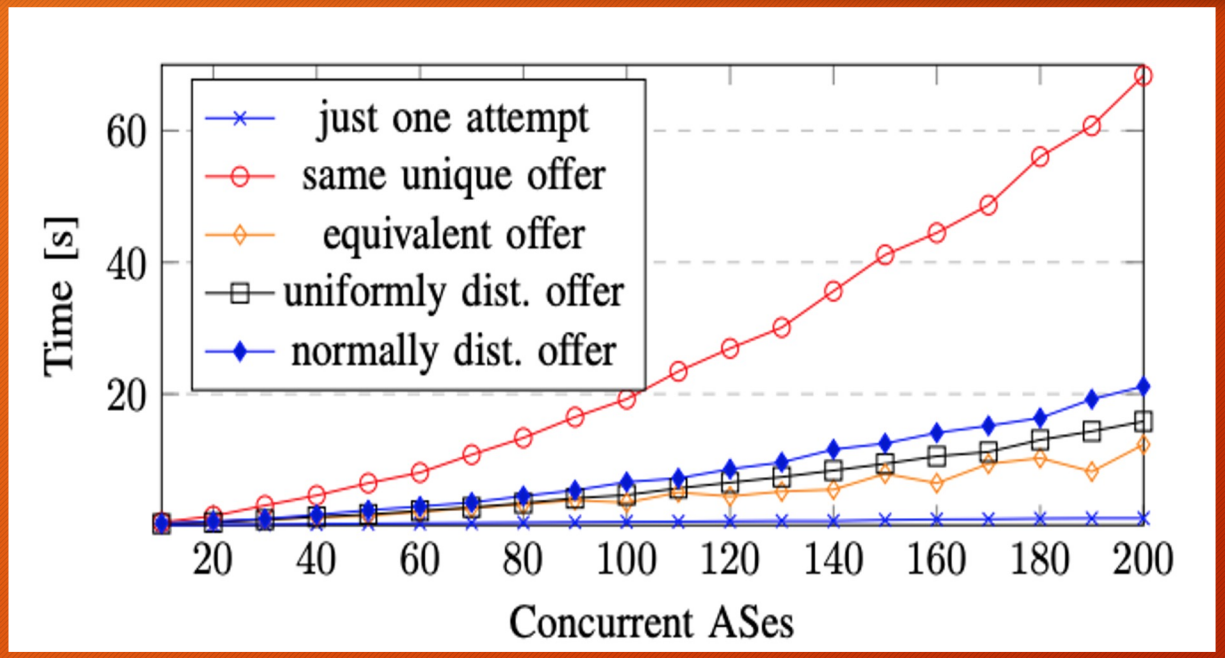
Sellers and buyers interact with the marketplace via RPCs

- Sellers publish their offers in full
- Buyers can buy portions of the offer
- Marketplace supports efficient purchasing even with high contention

As a result:

- Buyers and sellers do not reveal their strategies
- Their decision making is independent

Transaction Times

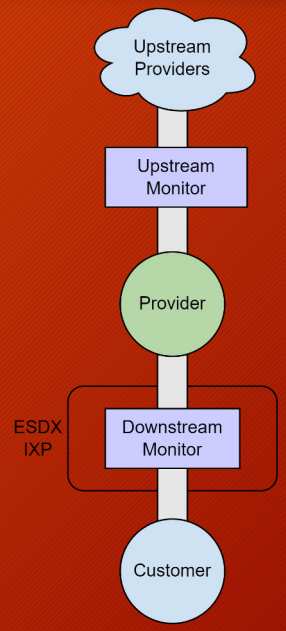


Scenario:

- ASes buy any offer that fits their policy.
- Seller's offers suitable for all buyers.
- Transactions carried out FIFO.
- One sale per offer.

Monitoring and Dispute Resolution

- Verify bandwidth profile by monitoring traffic between customer AS and provider (seller) AS
- Monitors log observed bandwidth per time interval
- Contract fulfilled if:
  - Observed bandwidth is within contract bandwidth profile
  - Bandwidth upstream and downstream of provider matches
- Logs are used as evidence in offline dispute resolution process
- Monitor implemented as eBPF XDP kernel function



Summary

- A spot market for connectivity can improve total welfare
  - Shown by Xu and Li, 2015
- We developed a prototype capability for a <u>single</u> AS to offer transit services to neighbors via a "market".
  - Transaction protocol: offers to sell, orders, confirmation
  - Monitoring component to collect evidence of (mis)behavior of buyers & sellers

Summary

- Standard economic interfaces can lower transaction costs and barriers to entry
  - Analog of the "shipping container" in multi-modal freight transport
- An efficient marketplace, with low transaction costs, could be used for other advanced inter-domain services.

Future Work

- Extension to multiple AS-hops
- Appropriate "container size"
- QoS (Build on COLIBRI)
- Pilot deployment?