Georgia Institute of Technology

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Software Defined Networking

In this course, you will learn about software defined networking and how it is changing the way communications networks are managed, maintained, and secured.

School of Computer Science

Module 7.2: SDN In the Wild

- Three Lessons
  - Data Centers
  - **Wide-Area Backbone Networks**
    - **SDX: A Software-Defined Internet Exchange**
    - B4: Google's Wide-Area Backbone Network
  - Home Networks
- Programming Assignment
- Quiz

Limitations of BGP

- Routing only on destination IP prefix
  - No customization of routes by application, sender
- Influence only over neighbors
  - No ability to affect end-to-end paths
- Indirect expression of policy
  - Indirect mechanisms to influence path selection (e.g., local preference, AS path prepending)

Idea: Evolution at Internet Exchanges

- New technology at a single IXP can yield benefits for tens to hundreds of ISPs.
- IXPs are currently experiencing a rebirth (*e.g.*, Open IX) and wanting to differentiate.
- New applications create need for richer peering.

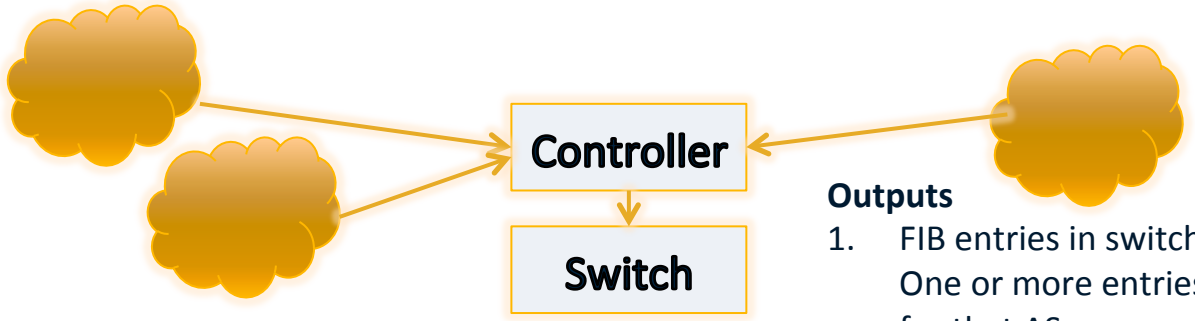
SDN: Challenges and Opportunities

- **Opportunities:** Freedom from constraints
  - Matching of different packet header fields
  - Control messages from remote networks
  - Direct control over data plane
- **Challenges:** No existing SDN control framework for interdomain routing
  - **Scaling:** Hundreds to thousands of ISPs at an IXP

What Today's IXPs Cannot Support

- **Application-specific peering:** Peering for specific applications like video
- **Redirection to middleboxes:** Redirection of specific traffic subsets to middleboxes
- **Traffic offloading:** Avoiding sending traffic through intermediate peers at IXPs
- **Preventing free-riding:** Dropping inbound traffic that is not associated with any peering relationship
- **Wide-area load balancing:** Rewriting destination IP address for load balancing (vs. DNS)

SDX: A Single-IXP Deployment



Inputs

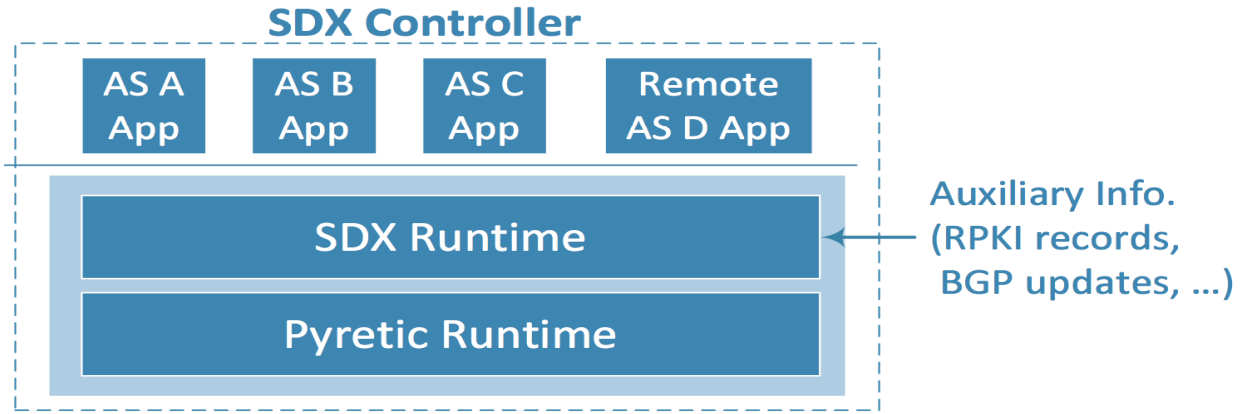
1. Routes (via BGP) per IP prefix (including attributes like price, etc.)
2. Selection function

Outputs

1. FIB entries in switch:
   One or more entries per AS that satisfy the selection for that AS
2. Packet rewriting (e.g., of destination IP address)

- **Step 1:** Controller at exchange receives
  - BGP routes from all ASes at the exchange
  - Auxiliary information
- **Step 2:** Participant at exchange runs a function that executes at the controller to select route, rewrite packets.

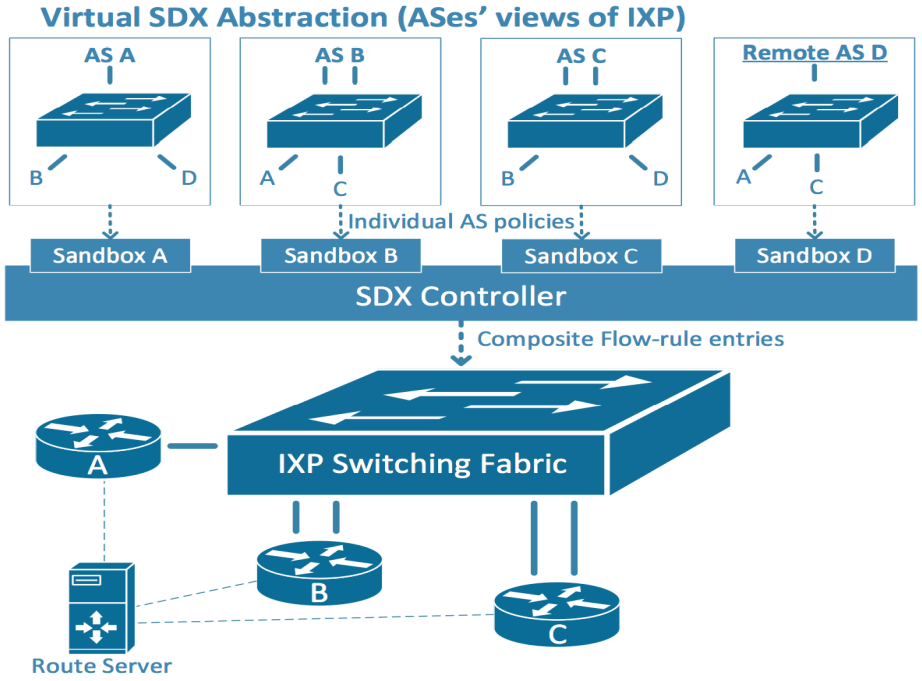
SDX Architecture



- **Each AS sees only its own virtual IXP topology (isolation)**
- Applications run on top of SDX runtime
- Runtime makes decisions based on both participants' applciations and policies and auxiliary information (e.g., route server information)
- Runtime resolves conflicts using parallel and sequential composition (Pyretic)

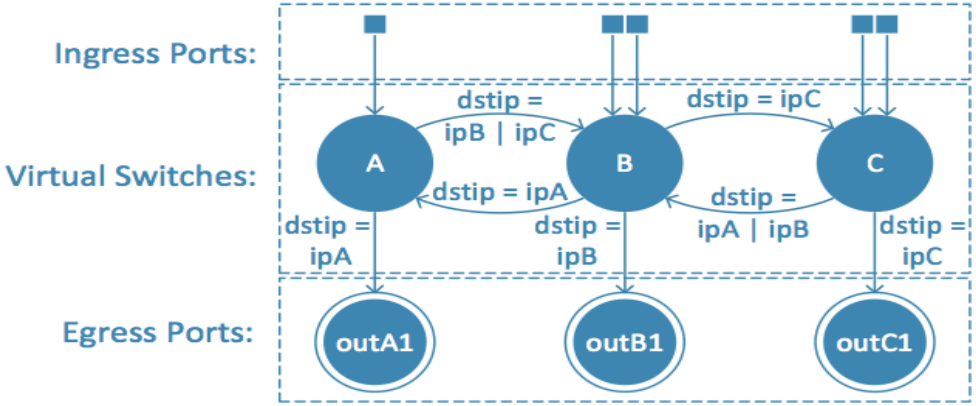
Virtual SDX Abstraction

- ISPs that do not have business relationships with one another cannot see each other.
  - (*e.g.*, AS A and C have no direct connection)
- Enforced using symbolic execution at SDX



Implementing the Virtual SDX Abstraction

- **Symbolic execution:** Tag packets on input, use state machine to determine output port.



- **Sequential composition of ISP policies:** SDX runtime composes policies in order based on result from symbolic execution.

Summary

- Interdomain routing continues to be plagued by problems with security and manageability.
- An **SDN-based exchange (SDX)** is promising for both fixing these problems and presenting new opportunities
- Many research challenges remain, both for building the exchange and for using it