Software Defined Networking

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

Software Defined Networking

- Changing how we manage networks
  - Data centers, backbones, enterprises, …
- But, so far, mostly *inside* these networks
  - Network virtualization, traffic engineering, …
- In this lecture:
  - Fundamentally change *interdomain* traffic delivery
  - Starting with SDN at *boundaries* between domains

BGP is Not Flexible Enough

- Routing only on **destination IP address blocks**
- Can only influence **immediate neighbors**
  (No ability to affect path selection remotely)
- **Indirect** control over packet forwarding
  (Indirect mechanisms to influence path selection)
- Enables only basic packet **forwarding**
  (Difficult to introduce new in-network services)

Valuable Wide-Area Services

- Application-specific peering
  - Route video traffic one way, and non-video another
- Blocking denial-of-service traffic
  - Dropping unwanted traffic further upstream
- Server load balancing
  - Directing client requests to different data centers
- Steering through network functions
  - Transcoders, scrubbers, caches, crypto, …
- Inbound traffic engineering
  - Splitting incoming traffic over multiple peering links

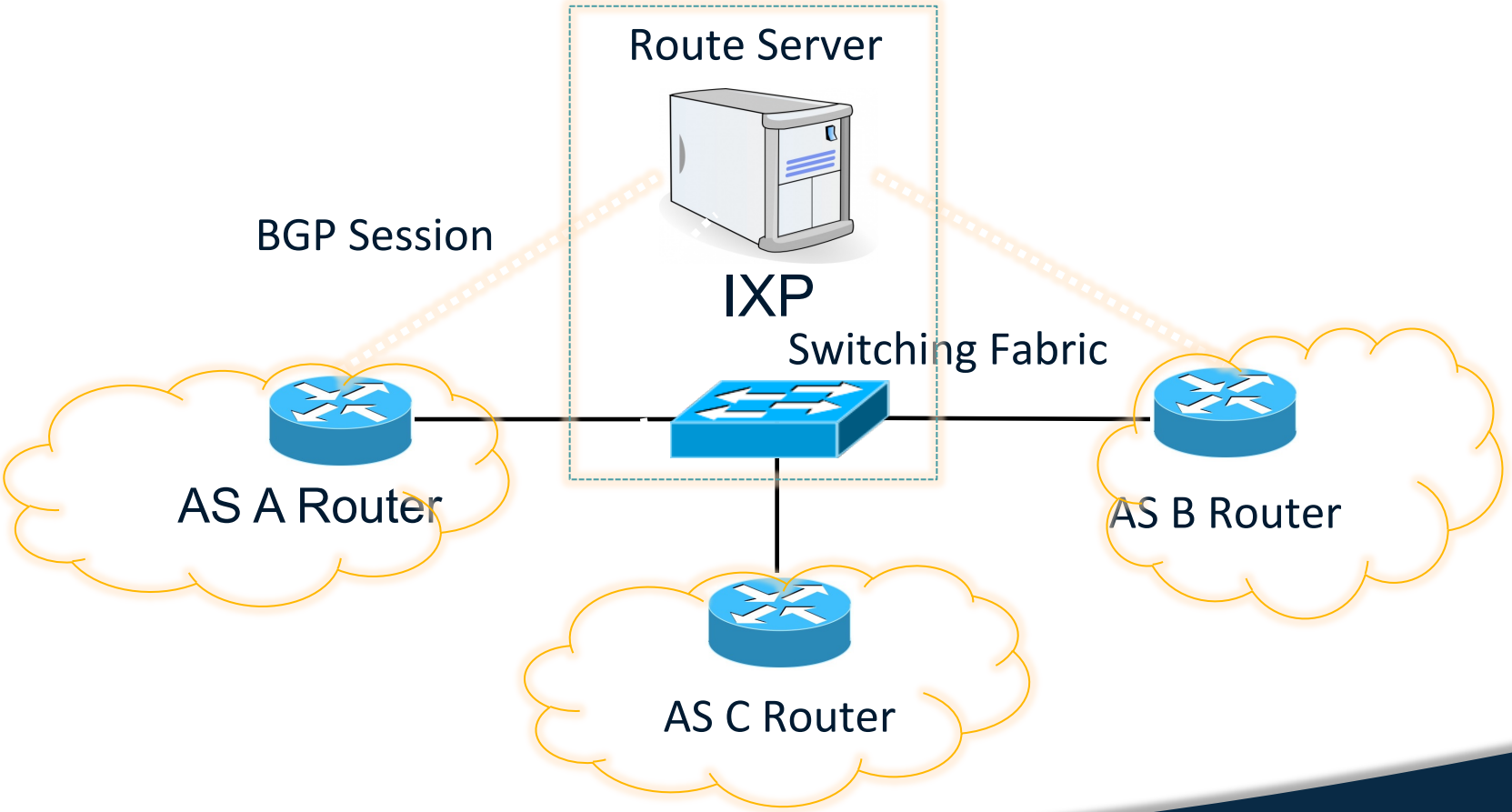
Software-Defined Networking

- Match packets on **multiple header fields**
  (not just destination IP address)
- Control **entire networks** with a single program
  (not just immediate neighbors)
- **Direct control** over packet handling
  (not indirect control via routing protocol arcana)
- Perform many different **actions** on packets
  (beyond basic packet forwarding)

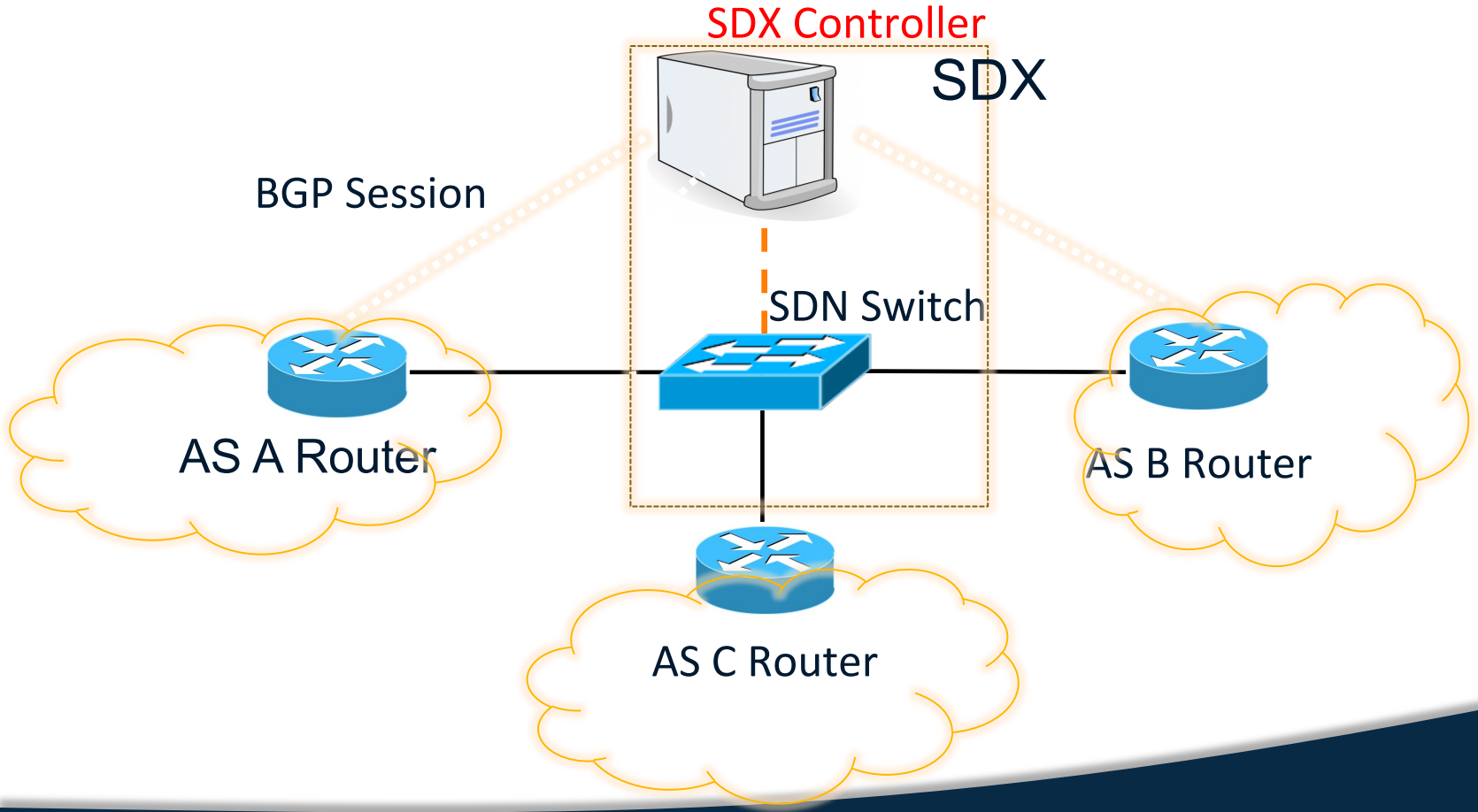
Deploy SDN at Internet Exchanges

- **Leverage:** SDN deployment even at single IXP can benefit tens to hundreds of providers
  - *Without providers deploying new equipment!*
- **Innovation hotbed:** Incentives to innovate, as IXPs on front line of peering disputes
- **Growing in numbers:**
  - 350-400 IXPs
  - ~100 new IXPs established in past few years

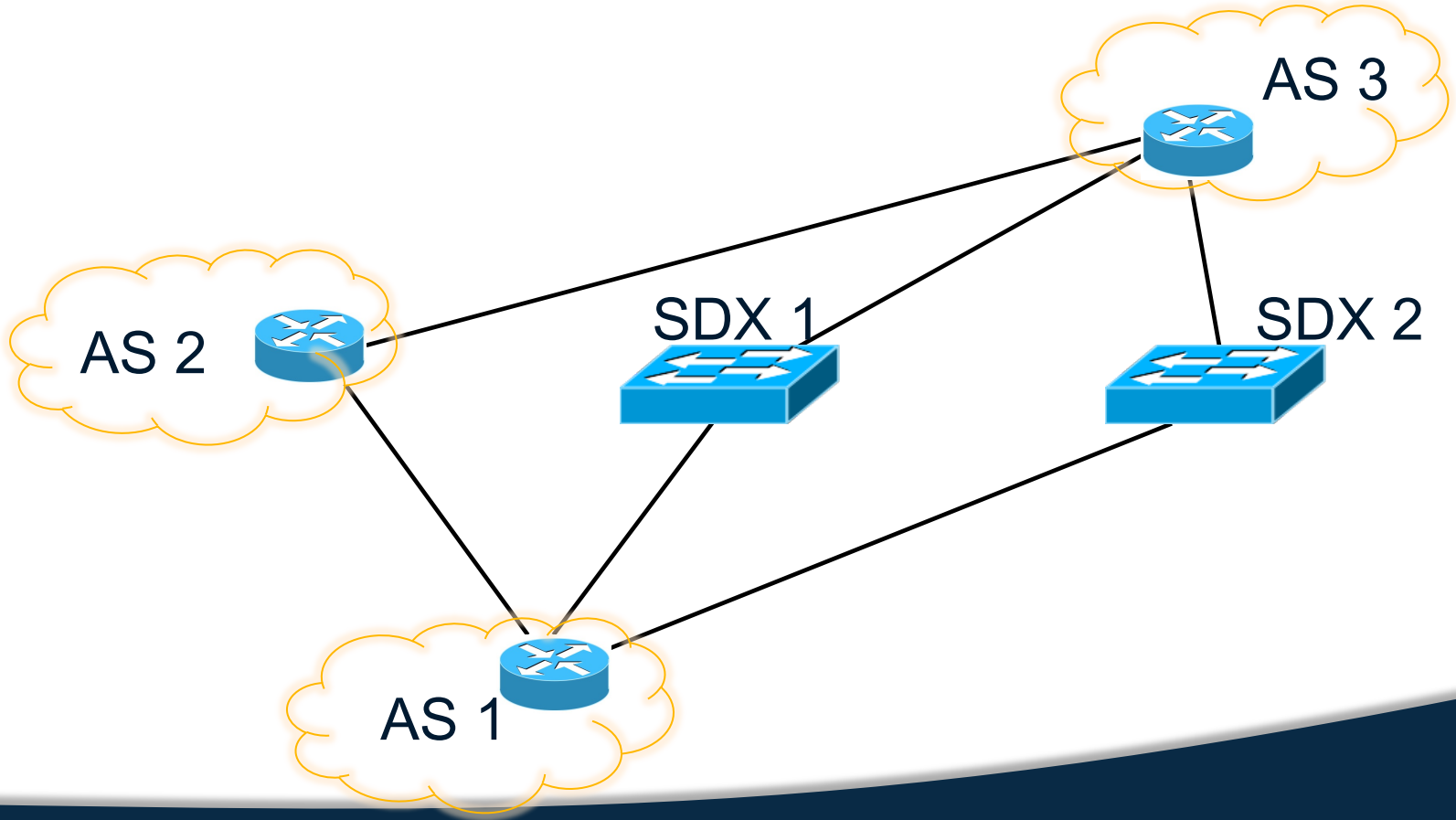
Conventional IXPs



SDX = SDN + IXP

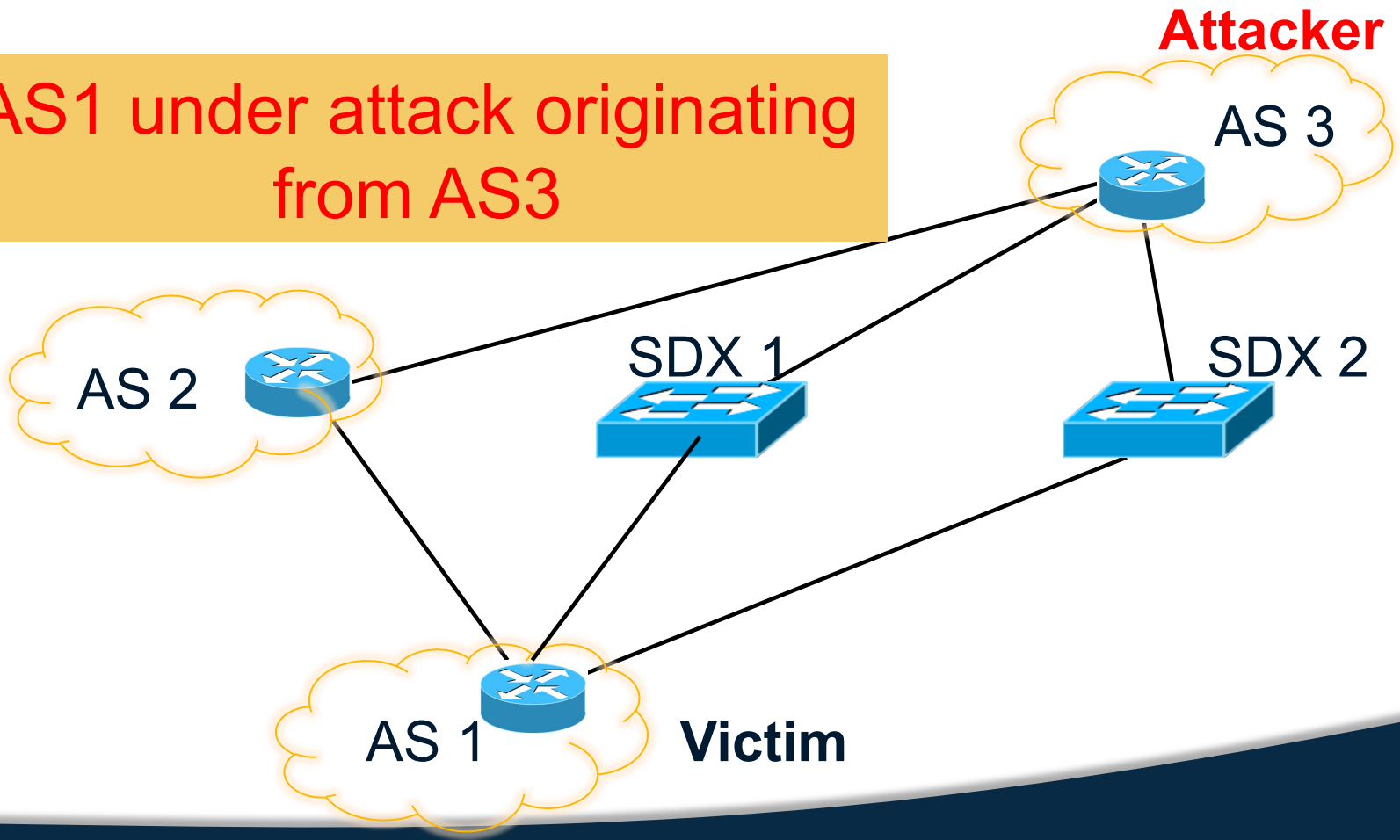

SDX Controller
SDX
BGP Session
SDN Switch
AS A Router
AS B Router
AS C Router

Prevent DDoS Attacks



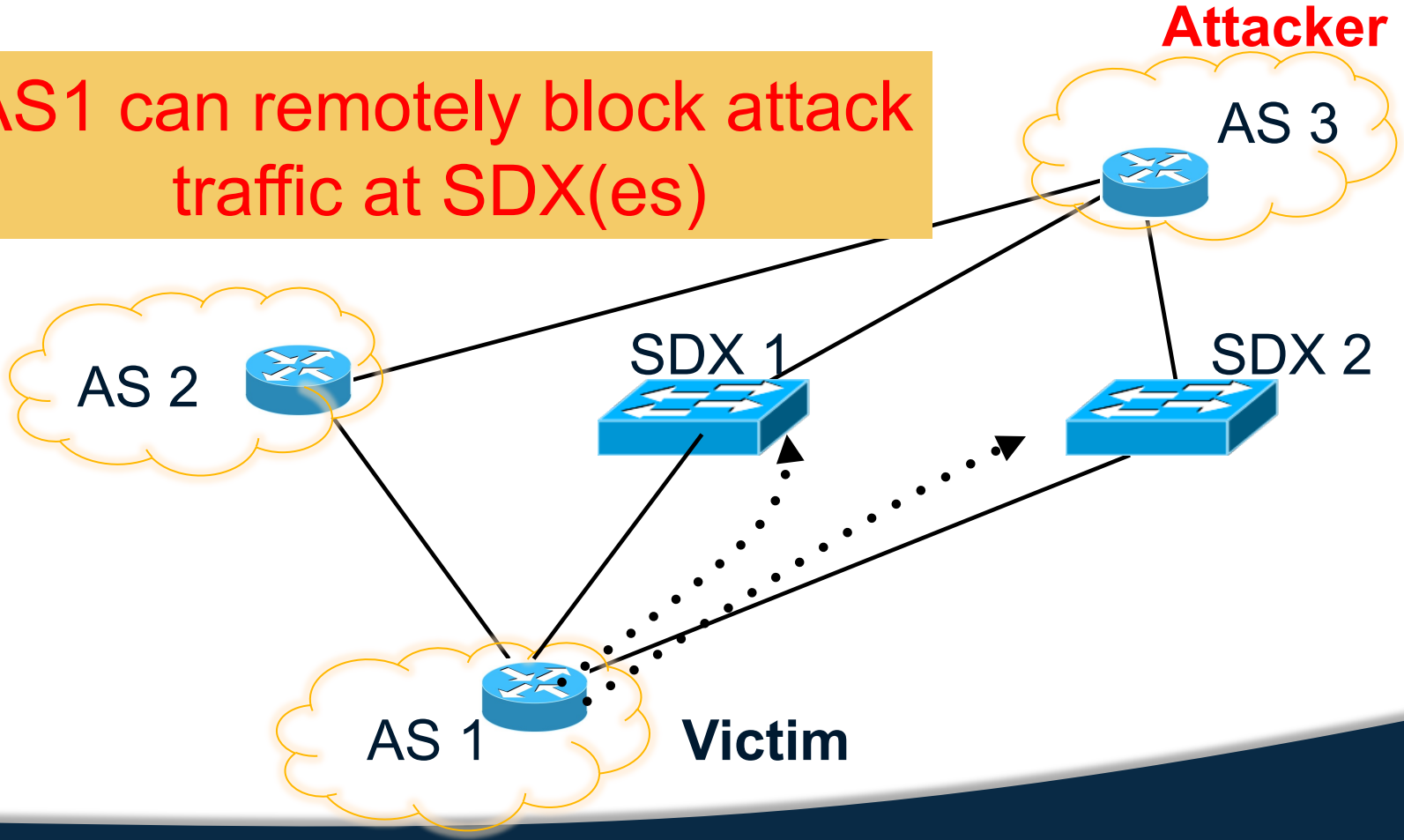
Prevent DDoS Attacks

AS1 under attack originating from AS3



Use Case: Prevent DDoS Attacks

AS1 can remotely block attack traffic at SDX(es)



SDX-based DDoS protection vs. Conventional Defenses/Blackholing

- **Remote influence**

  Physical connectivity to SDX not required

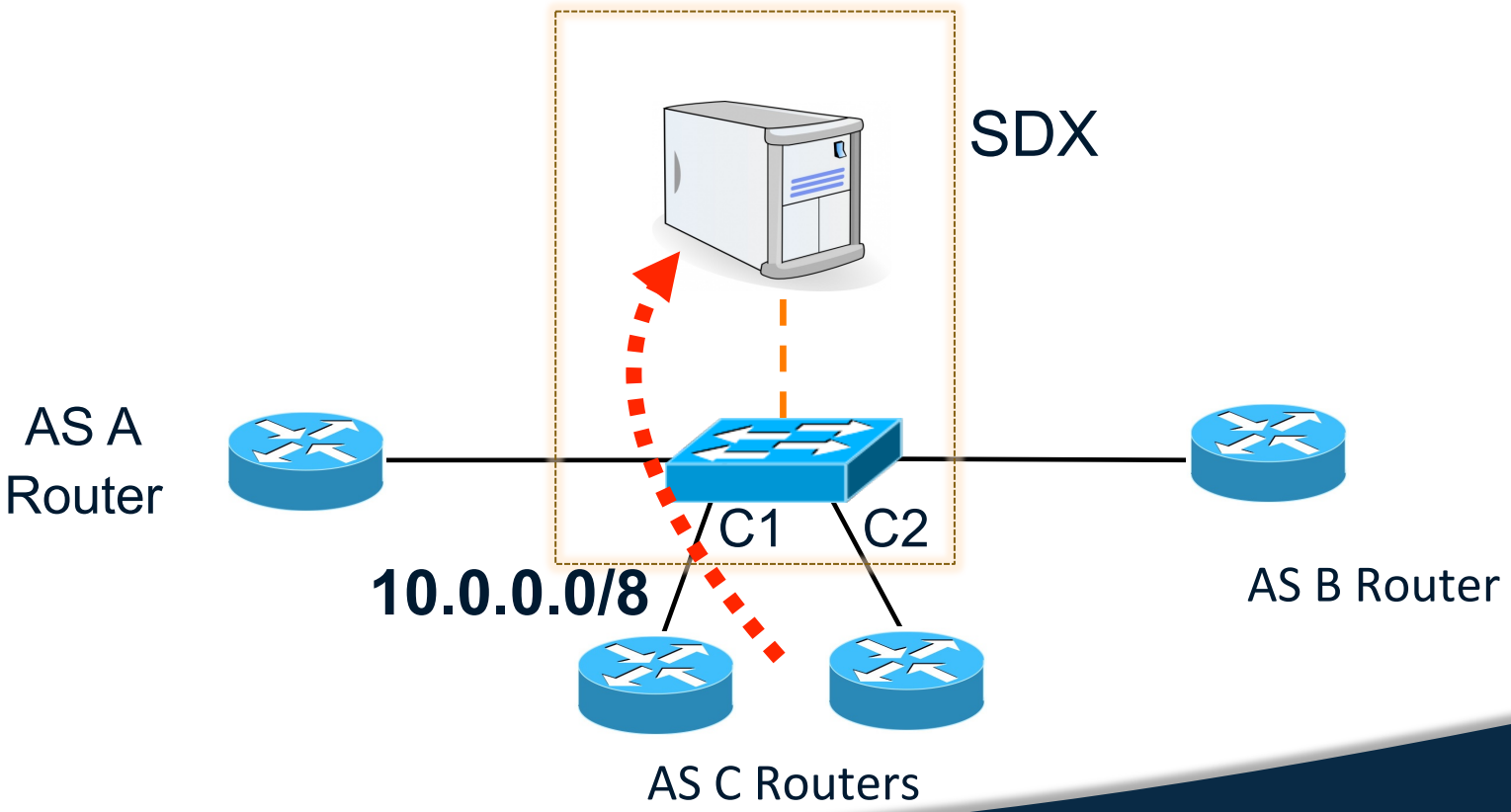
- **More specific**

  Drop rules based on multiple header fields, source address, destination address, port number …

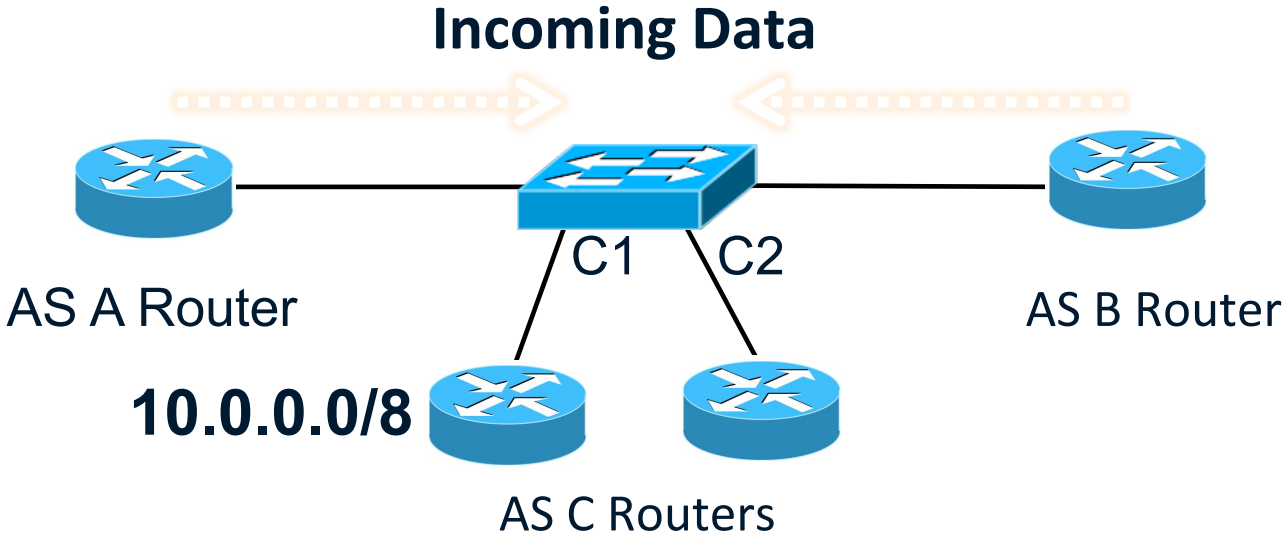
- **Coordinated**

  Drop rules can be coordinated across multiple IXPs

Inbound Traffic Engineering

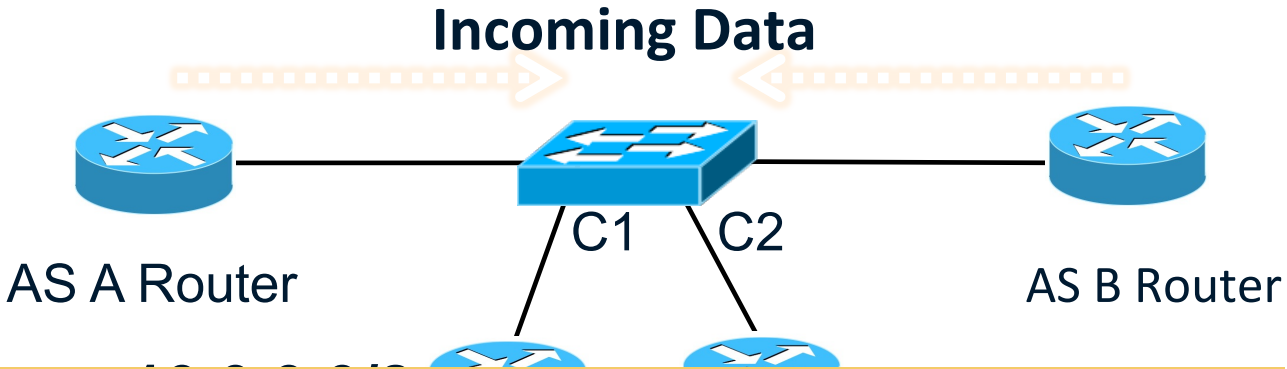


Inbound Traffic Engineering



Incoming Traffic	Out Port	Using BGP	Using SDX
dstport = 80	C1		

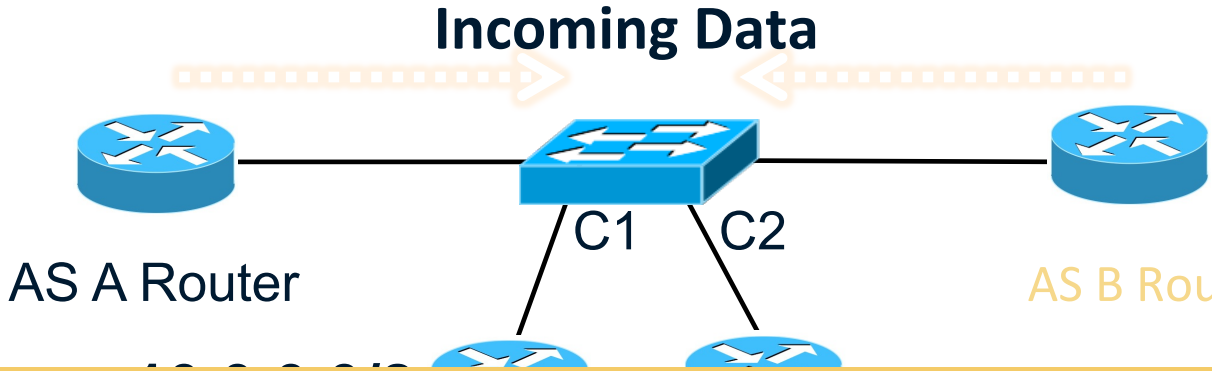
Inbound Traffic Engineering



Fine grained policies not possible with BGP

Incoming Traffic	Out Port	Using BGP	Using SDX
dstport = 80	C1	?	

Inbound Traffic Engineering



Enables fine-grained traffic engineering policies

Incoming Traffic	Out Port	Using BGP	Using SDX
dstport = 80	C1	?	match(dstport =80)→ fwd(C1)

Building SDX is Challenging

- Programming **abstractions**

  How networks define SDX policies and how are they combined together?

- **Interoperation** with BGP

  How to provide flexibility w/o breaking global routing?

- **Scalability**

  How to handle policies for hundreds of peers, half million address blocks, and matches on multiple header fields?

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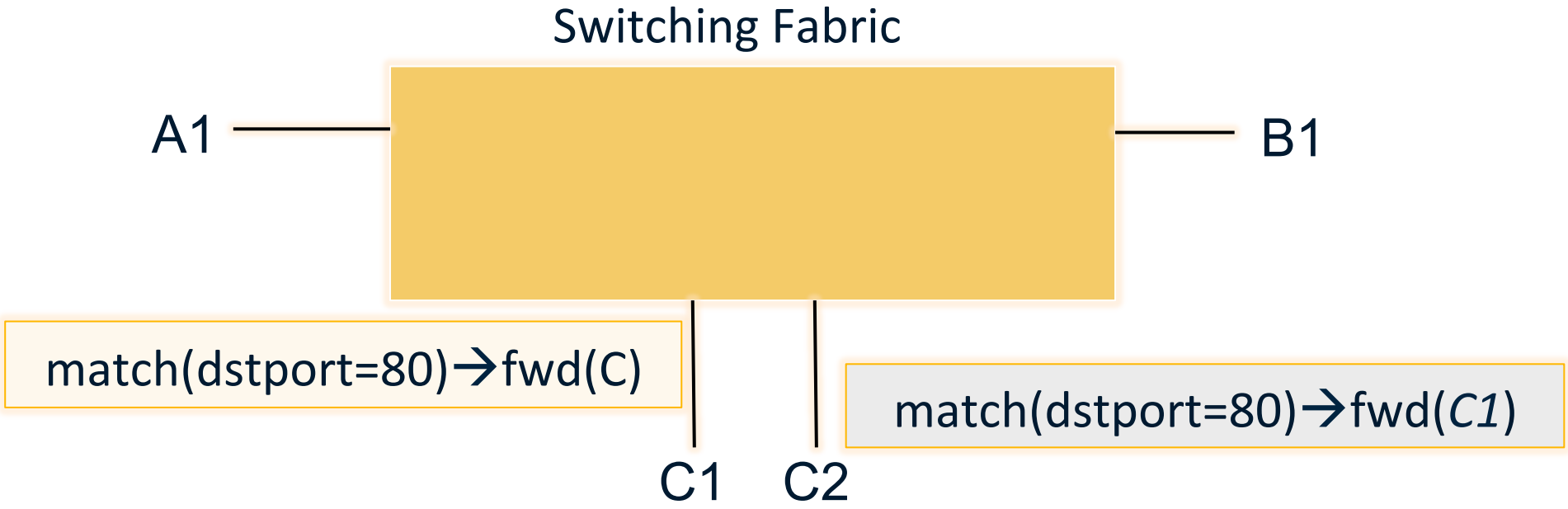
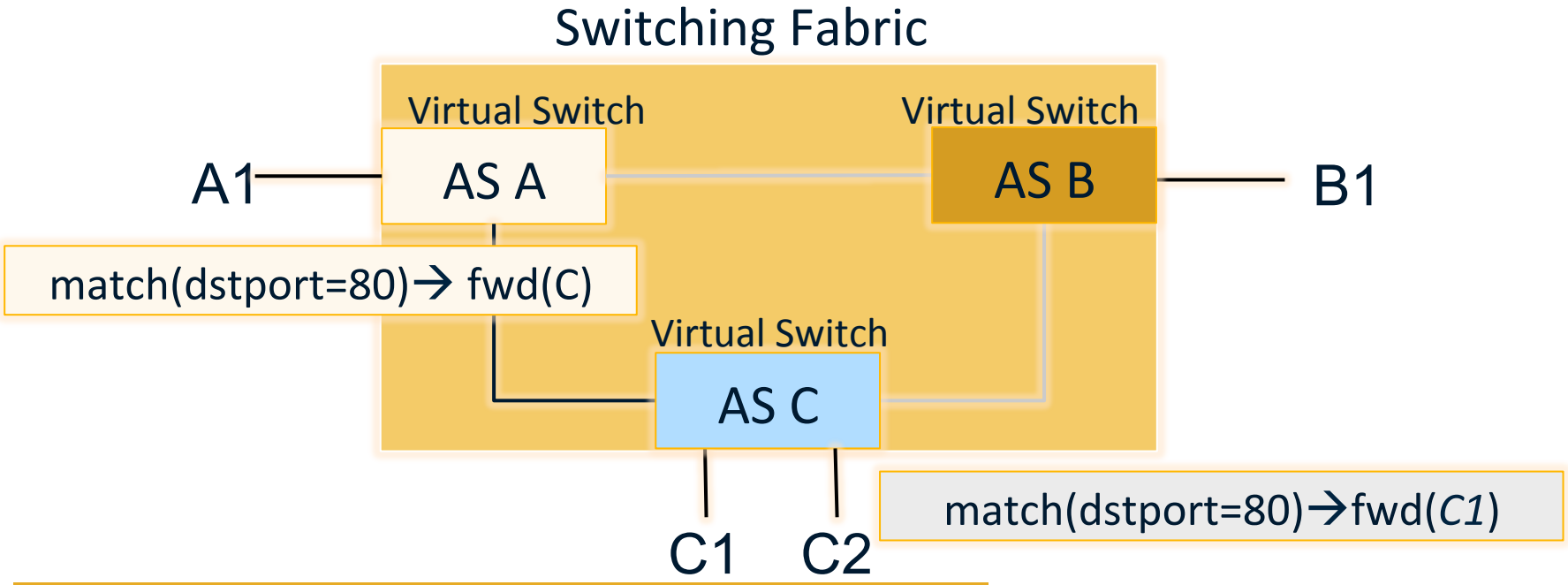
Directly Program the SDX Switch



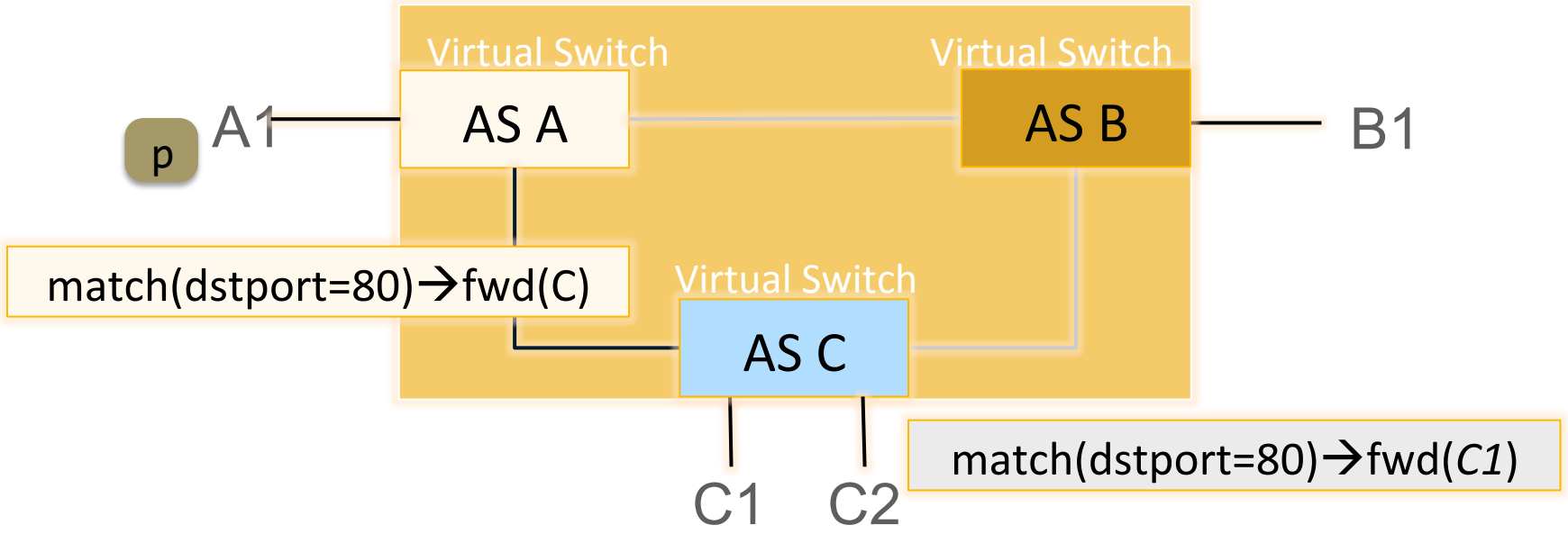
AS A & C directly program the SDX Switch

Virtual Switch Abstraction



Each AS writes policies for its own virtual switch

Combining Participant's Policies



Synthesize: match(inport=A1 & dstport=80) → fwd(C1)

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SDX Platform

- Running code with full BGP integration
  - Github available from http://sdx.cs.princeton.edu
- SDX testbeds:
  - Transit Portal for “in the wild” experiments
  - Mininet for controller experiments
- Ongoing deployment opportunities
  - Princeton, DOD/IC, GENI, SOX, Internet2, ESnet
  - Regional IXPs in US, Europe, and Africa

Conclusion

- The Internet is changing
  - New challenges for content delivery
  - Increasing importance of IXPs
- SDN can let providers innovate
  - New capabilities and abstractions
- Next steps
  - Operational deployments
  - Additional SDX applications
  - Distributed exchange points