

Novel Applications for a SDN-enabled Internet Exchange Point



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Based on joint work with

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BGP is notoriously unflexible and difficult to manage

Operating BGP has at least three limitations

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customized routing decisions

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- policies are applied to direct neighbors
- indirectly influence forwarding paths

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affect end-to-end paths

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- assume destination IP based routing
- policies are applied to direct neighbors
- indirectly influence forwarding paths

what people really want

customized routing decisions

affect end-to-end paths

directing traffic on specific paths

SDN can enable fine-grained, flexible and direct expression of interdomain policies

SDN devices forward based on any packet-header fields
at line rate, enabling flexible forwarding

SDN controller can be controlled by remote parties
on a bilateral basis, without any global standards

SDN controller exerts direct control on the data plane
using a standardized API such as OpenFlow

Internet Exchange Points are perfect places
to deploy new interdomain features

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Internet Exchange Points (IXPs) ...

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AMS-IX:

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600 participants

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- carry a large amount of traffic

AMS-IX:

600 participants

> 2250 Gb/s (peak)

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Internet Exchange Points (IXPs)

- connect a large number of participants
- carry a large amount of traffic
- are a hotbed of innovation

AMS-IX:

600 participants

> 2250 Gb/s (peak)

BGP Route Server

Mobile peering

Open peering

...

Internet Exchange Points are perfect places to deploy new interdomain features

Internet Exchange Points (IXPs)

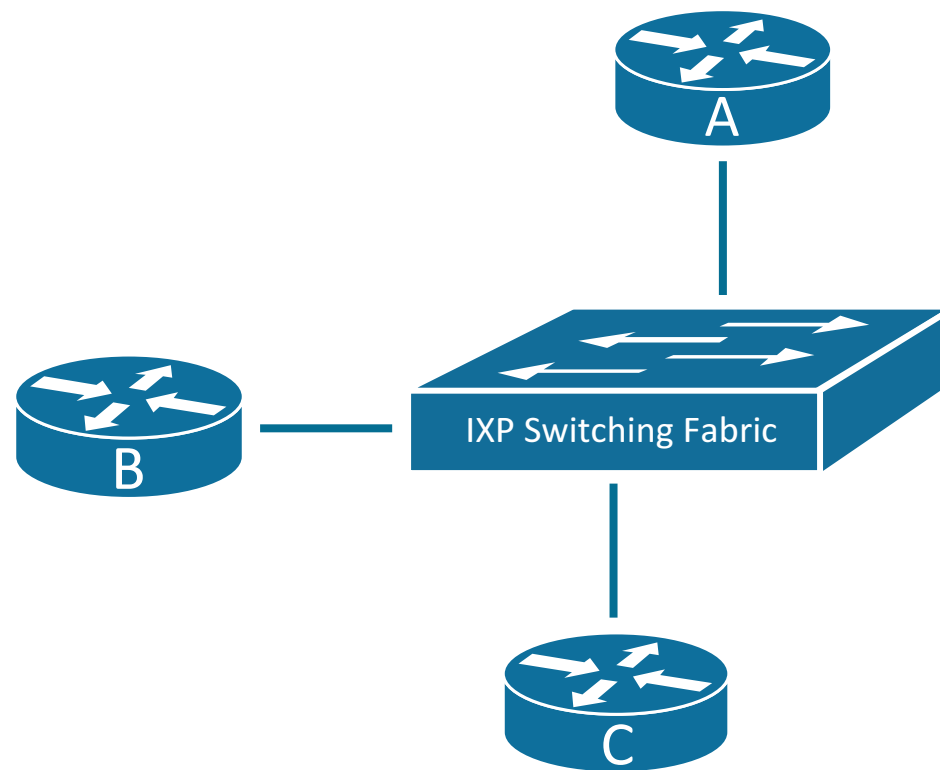
- connect a large number of participants
- carry a large amount of traffic
- are a hotbed of innovation

Even a single deployment can have a large impact!

An IXP is a large L2 domain where participants routers peer using BGP

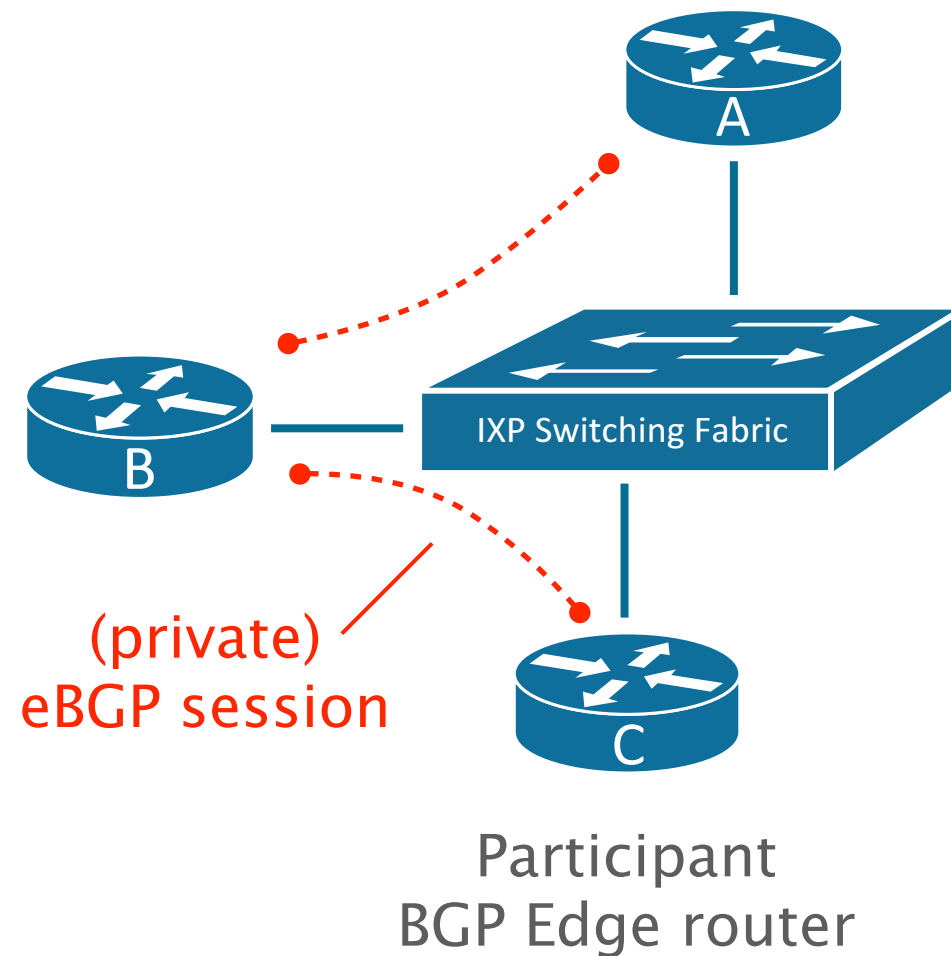


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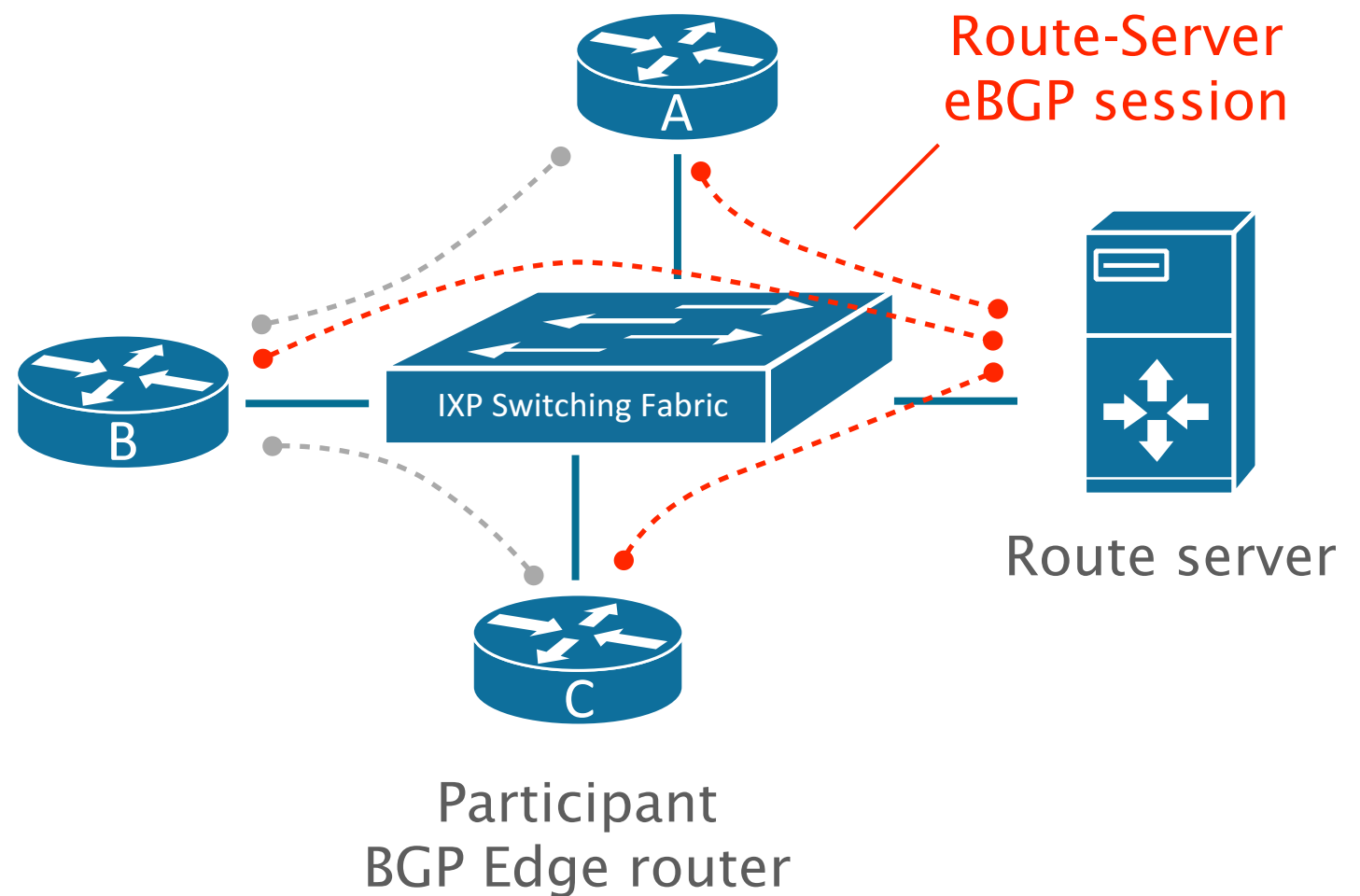


Participant
BGP Edge router

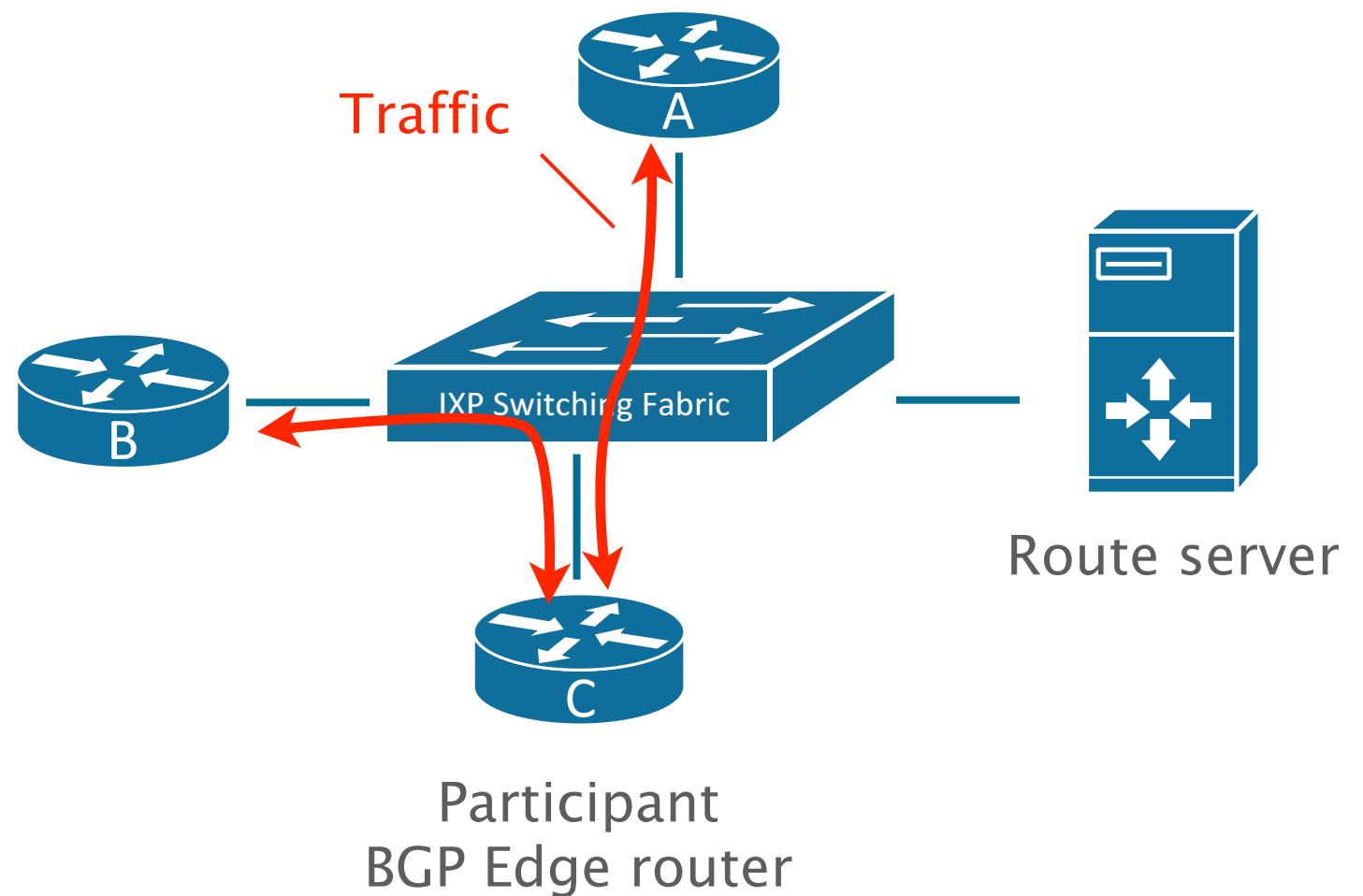
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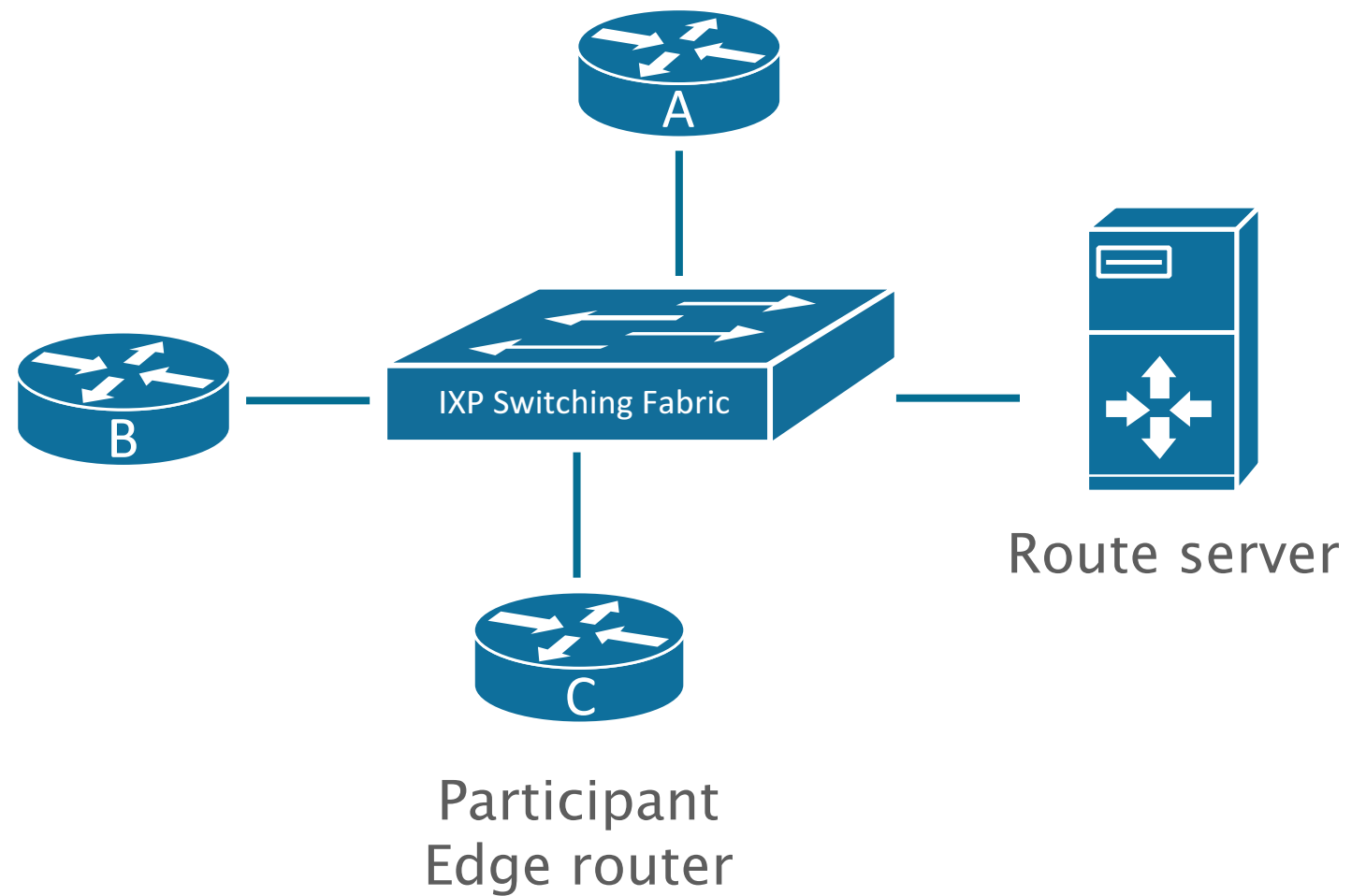
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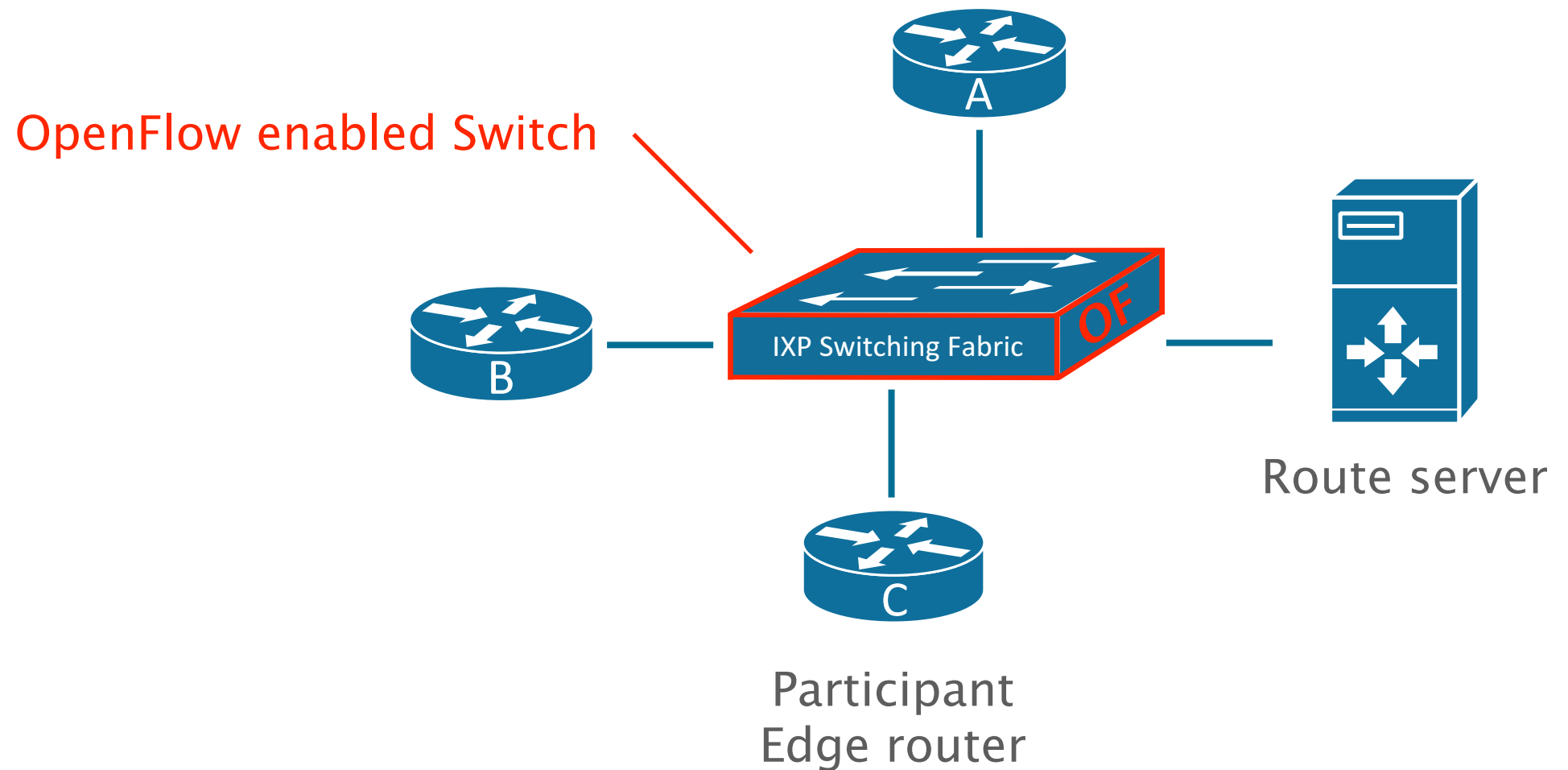
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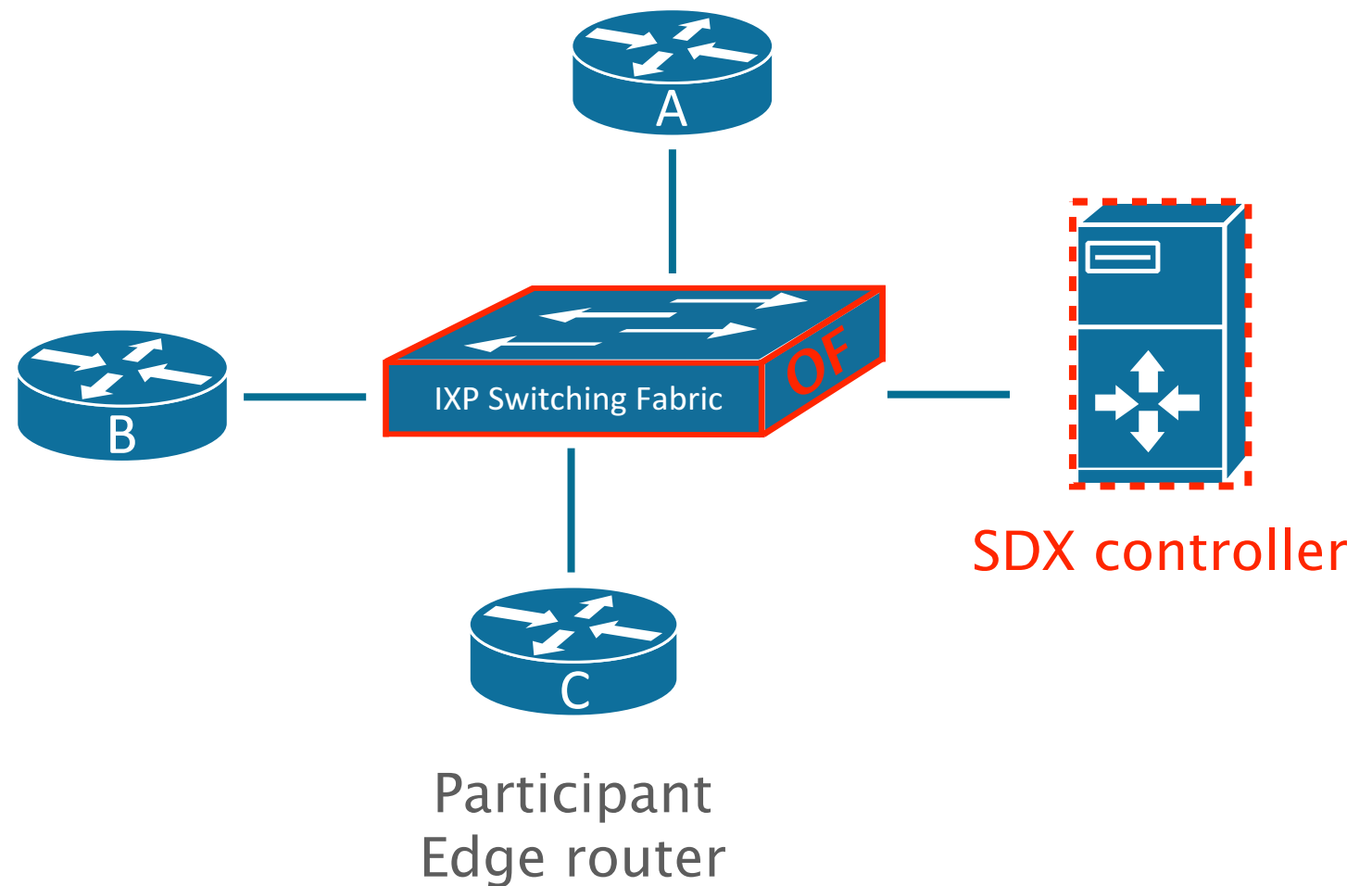
With respect to IXPs, SDN-enabled IXPs (SDX) ...



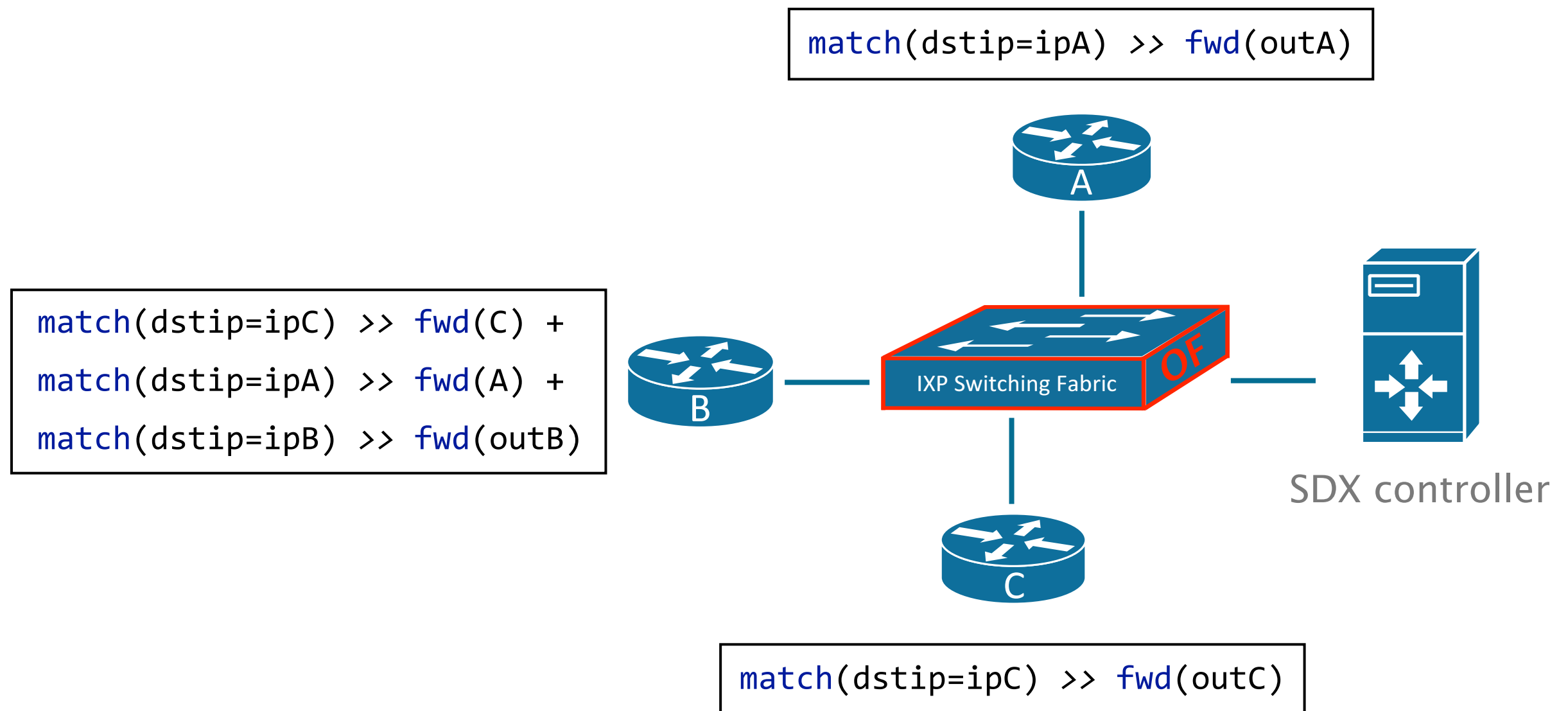
With respect to IXPs, SDN-enabled IXPs (SDX)
data plane relies on SDN-capable devices



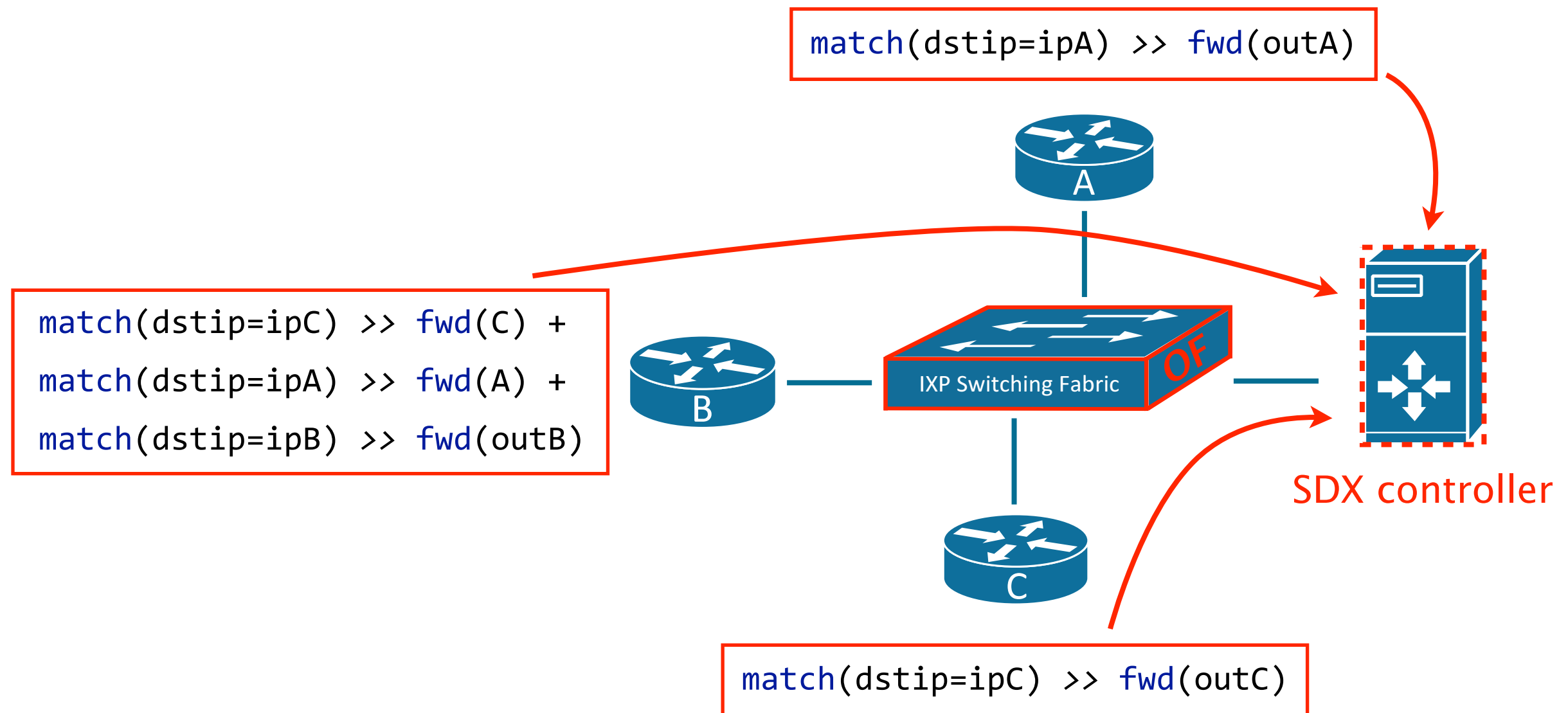
With respect to IXPs, SDN-enabled IXPs (SDX) *control plane* relies on a SDX controller



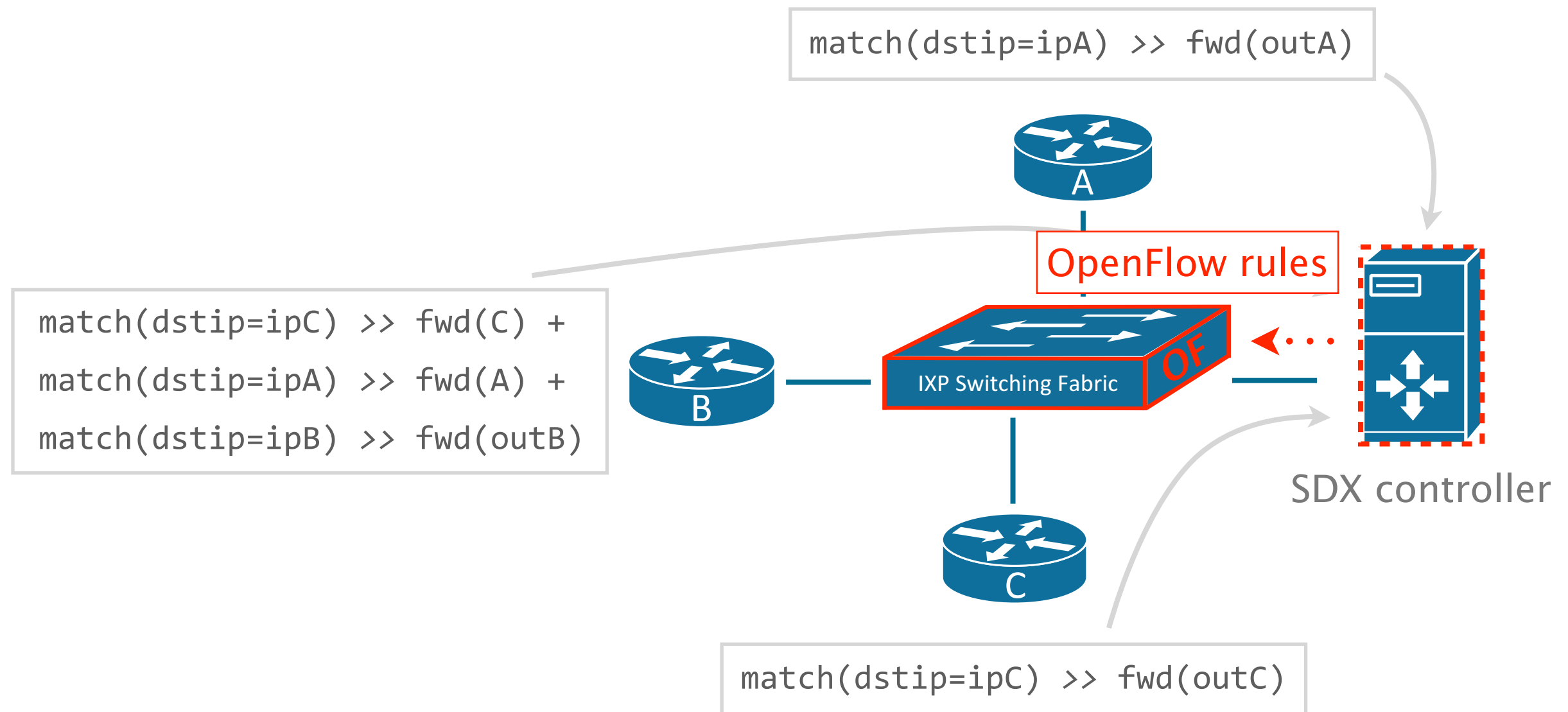
SDX participants write policies using a high-level language on top of a virtual topology



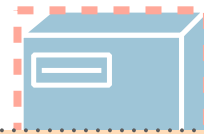
The SDX controller composes policies together ensuring *isolation* and *correctness*



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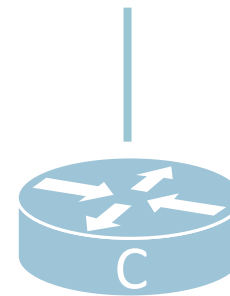


SDX controller



What does SDX enable that was **hard**
or **impossible** to do before?

D



Participant
Edge router



Route server

SDX enables a wide range of novel interdomain applications

security

Prevent/block policy violation

Prevent participants communication

forwarding optimization

Middlebox traffic steering

Traffic offloading

Inbound Traffic Engineering

peering

Application-specific peering

remote-control

Wide-area load balancing

Influence BGP path selection

Upstream blocking of DoS attacks

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Novel Applications for a SDN-enabled Internet Exchange Point



- 1 Inbound Traffic Engineering
- 2 Upstream DoS blocking
- 3 Wide-area load balancing

Novel Applications for a SDN-enabled Internet Exchange Point



1 Inbound Traffic Engineering

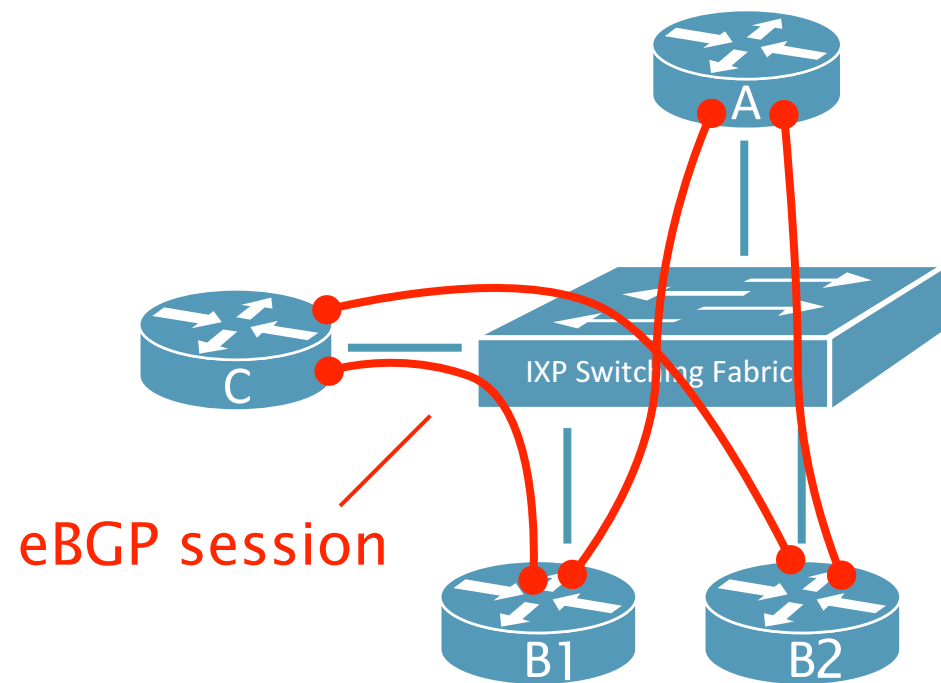
Upstream DoS blocking

Wide-area load balancing

SDX can improve inbound traffic engineering

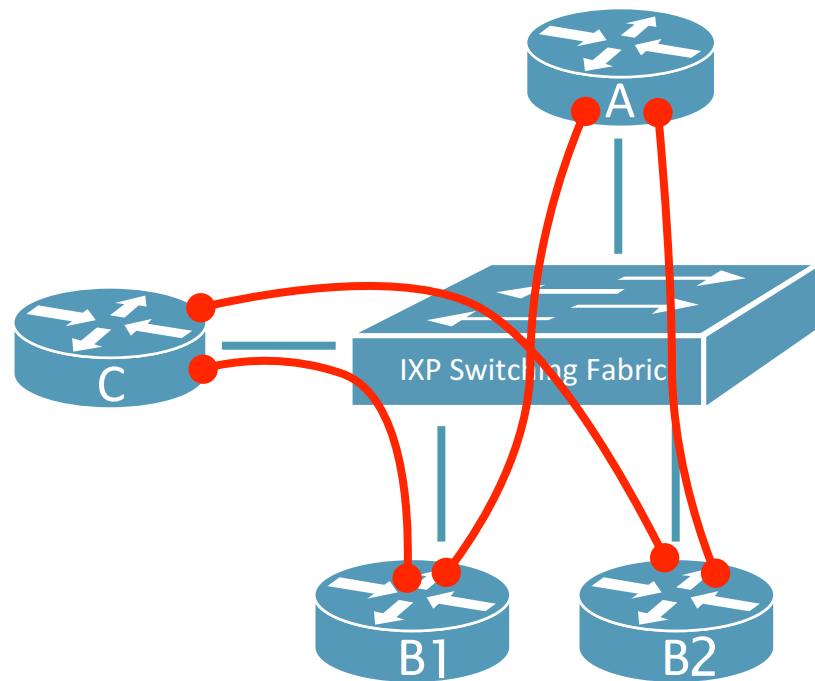
SDX can improve inbound traffic engineering

Given an IXP Physical Topology



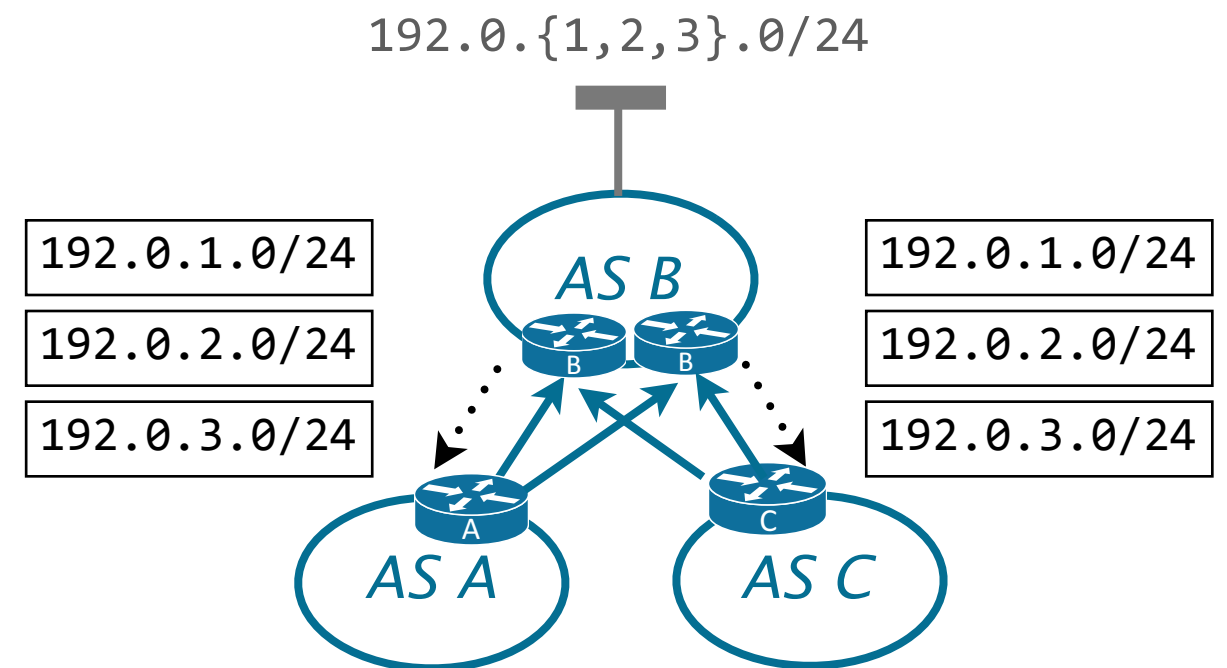
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Given an IXP Physical Topology



and

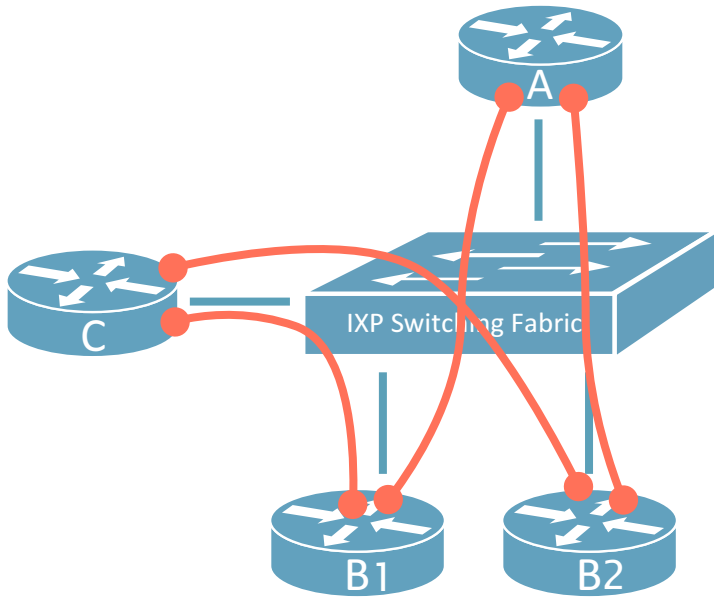
a BGP topology



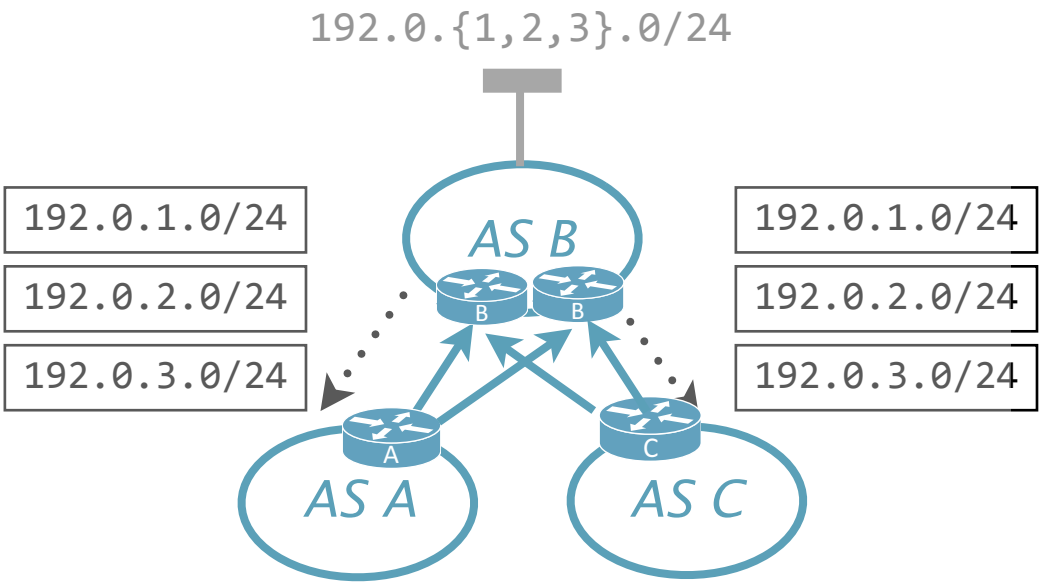
SDX can improve inbound traffic engineering

Implements B's inbound policy

to	from	receive on
192.0.1.0/24	A	B1
192.0.2.0/24	B	B2
192.0.2.0/24	ATT_IP	B2
192.0.2.0/24	*	B1
192.0.3.0/24	*	B2



IXP Topology

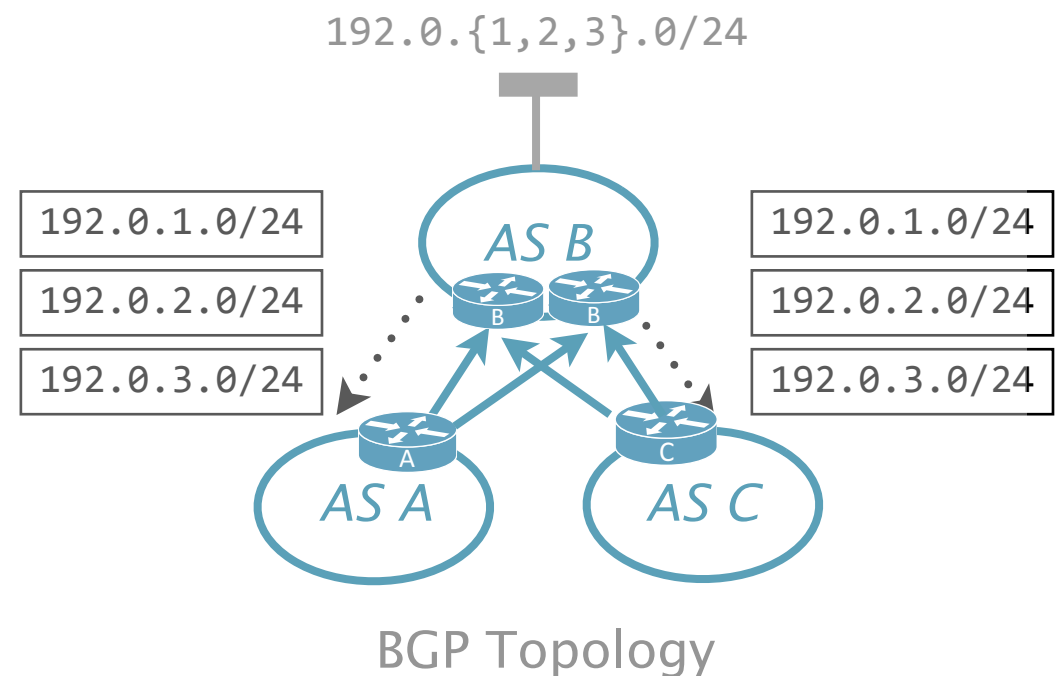
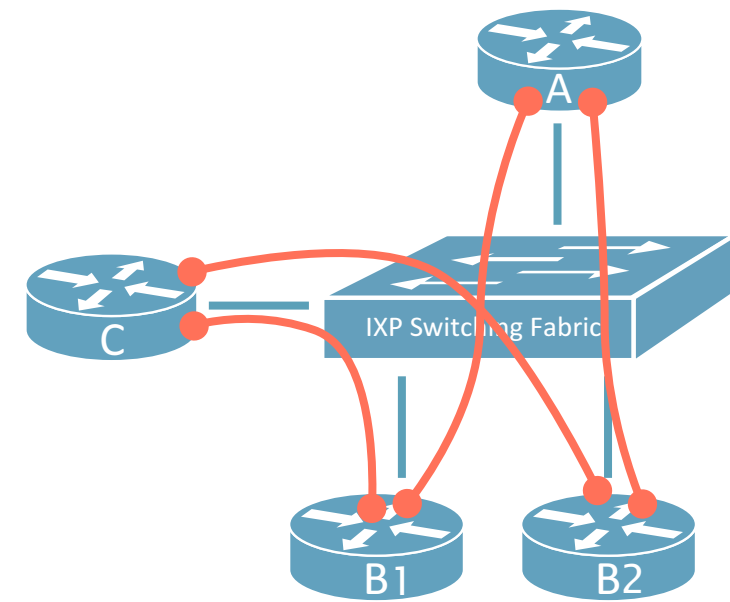


BGP Topology

How do you do that with BGP?

Implements B's inbound policy

to	from	receive on
192.0.1.0/24	A	B1
192.0.2.0/24	B	B2
192.0.2.0/24	ATT_IP	B2
192.0.2.0/24	*	B1
192.0.3.0/24	*	B2



It is at least hard... BGP provides
few knobs to influence remote decisions

Implementing such a policy is configuration-intensive
using AS-Path prepend, MED, community tagging, etc.

and **even impossible** for some requirements...

BGP policies **cannot** influence remote parties
decisions based on source addresses

to	from	receive on
192.0.2.0/24	ATT_IP	B2

In any case, the outcome is **unpredictable**

Implementing such a policy is configuration-intensive
using AS-Path prepend, MED, community tagging, etc.

Absolutely no guarantee that the remote party will comply
one can only “influence” remote decisions

Networks engineers have no choice but to “try and see”
which makes it impossible to adapt to traffic pattern

With a SDX, implementing B's inbound policy is **easy**

SDX policies give B *direct* control on its forwarding paths

to	from	fwd
192.0.1.0/24	A	B1
192.0.2.0/24	B	B2
192.0.2.0/24	ATT_IP	B2
192.0.2.0/24	*	B1
192.0.3.0/24	*	B2



B's SDX Policy

```
match(dstip=192.0.1.0/24, srcmac=A) >> fwd(B1)
match(dstip=192.0.2.0/24, srcmac=B) >> fwd(B2)
match(dstip=192.0.2.0/24, srcip=ATT) >> fwd(B2)
match(dstip=192.0.2.0/24) >> fwd(B1)
match(dstip=192.0.3.0/24) >> fwd(B2)
```

Novel Applications for a SDN-enabled Internet Exchange Point



Inbound Traffic Engineering

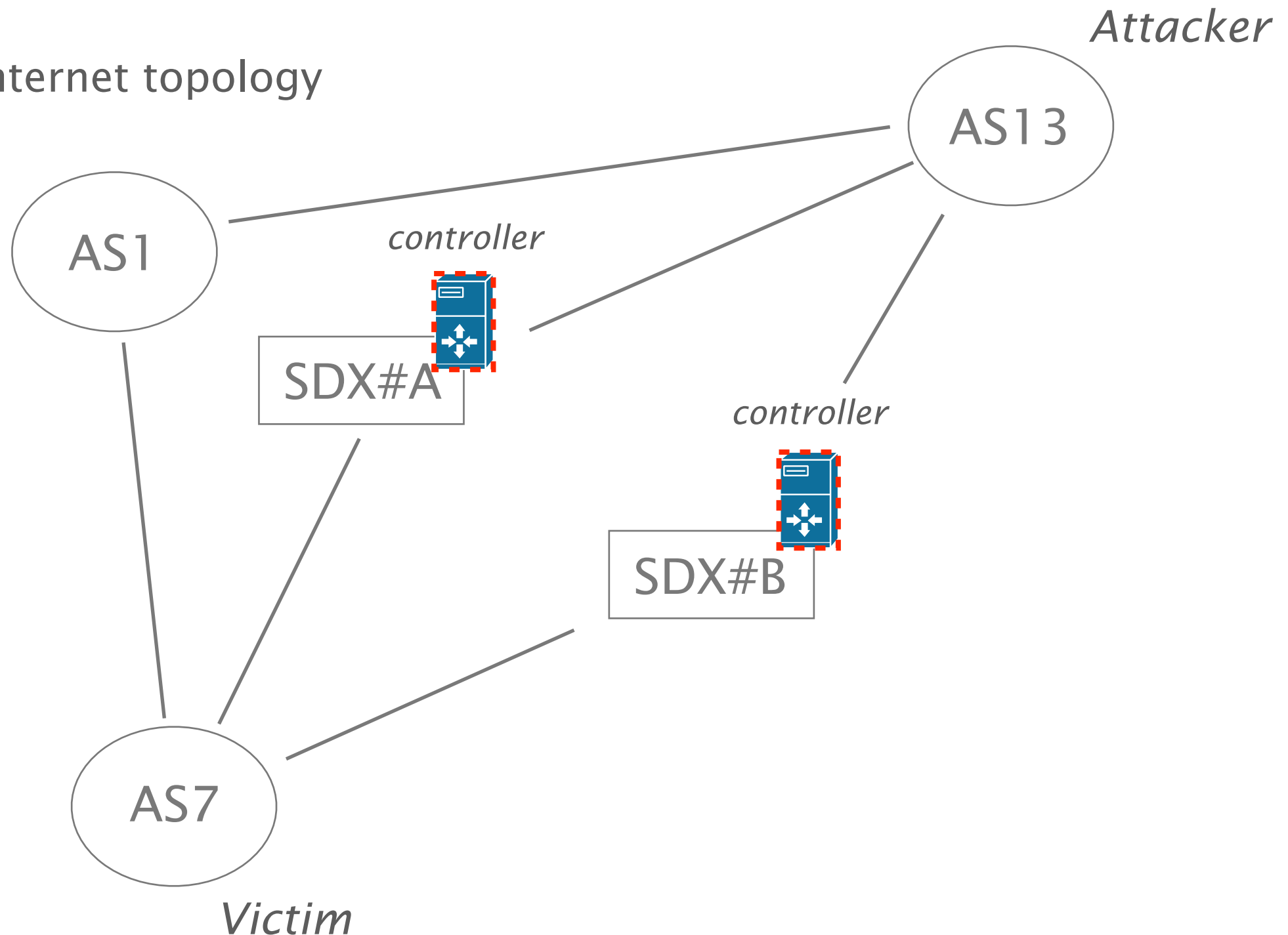
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Upstream DoS blocking

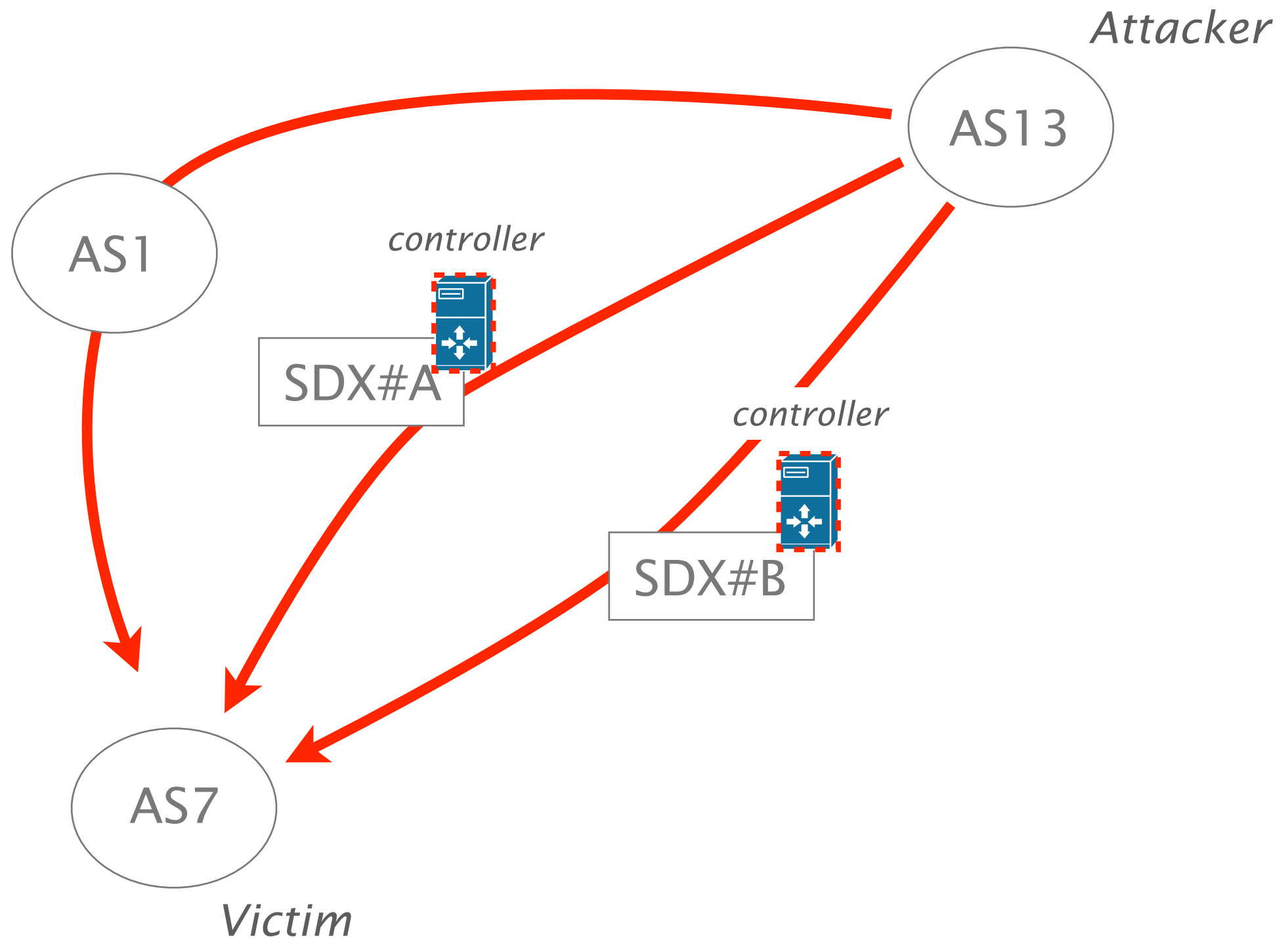
Wide-area load balancing

SDX can help blocking DoS attacks closer to the source

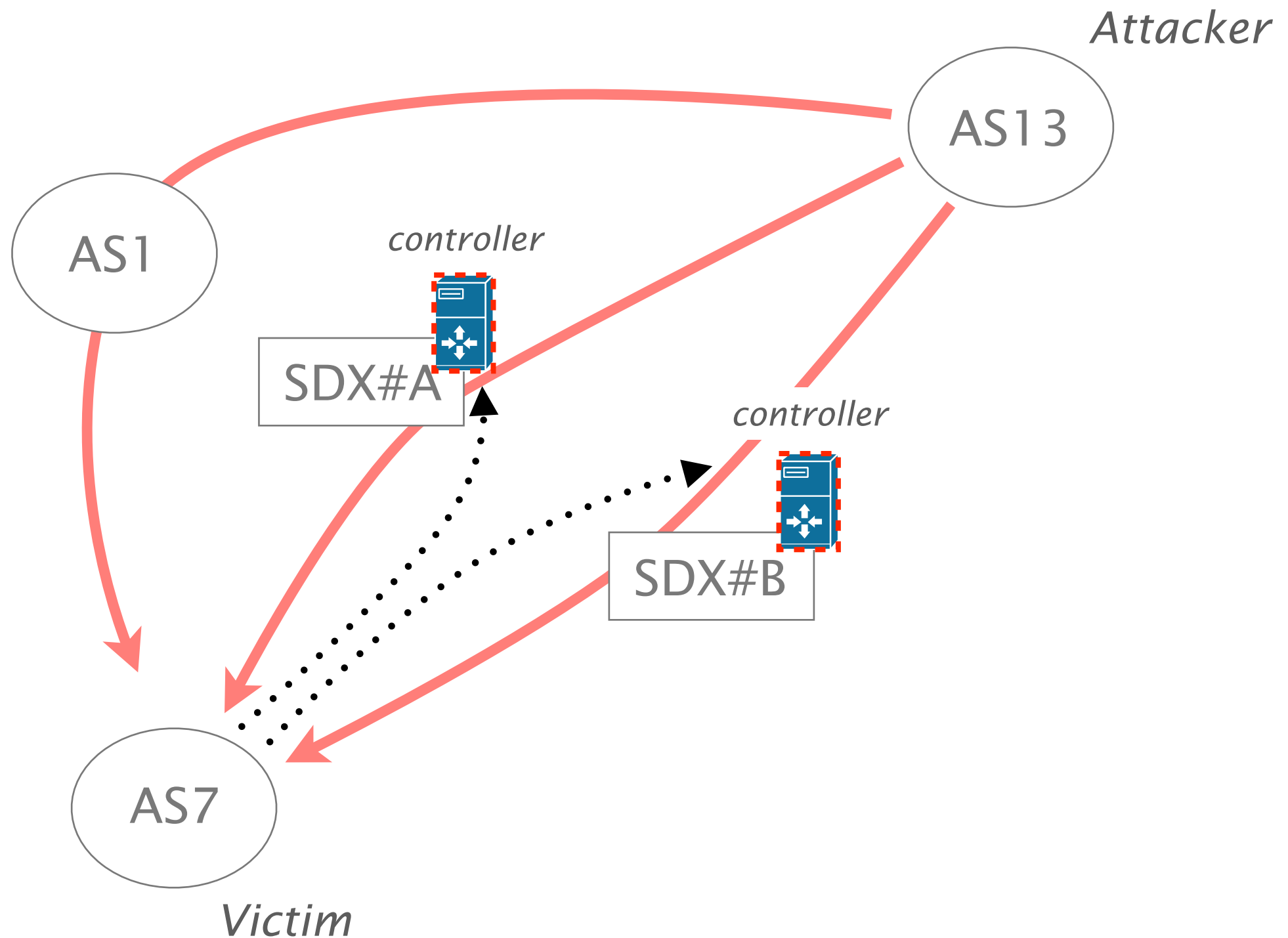
A simple Internet topology



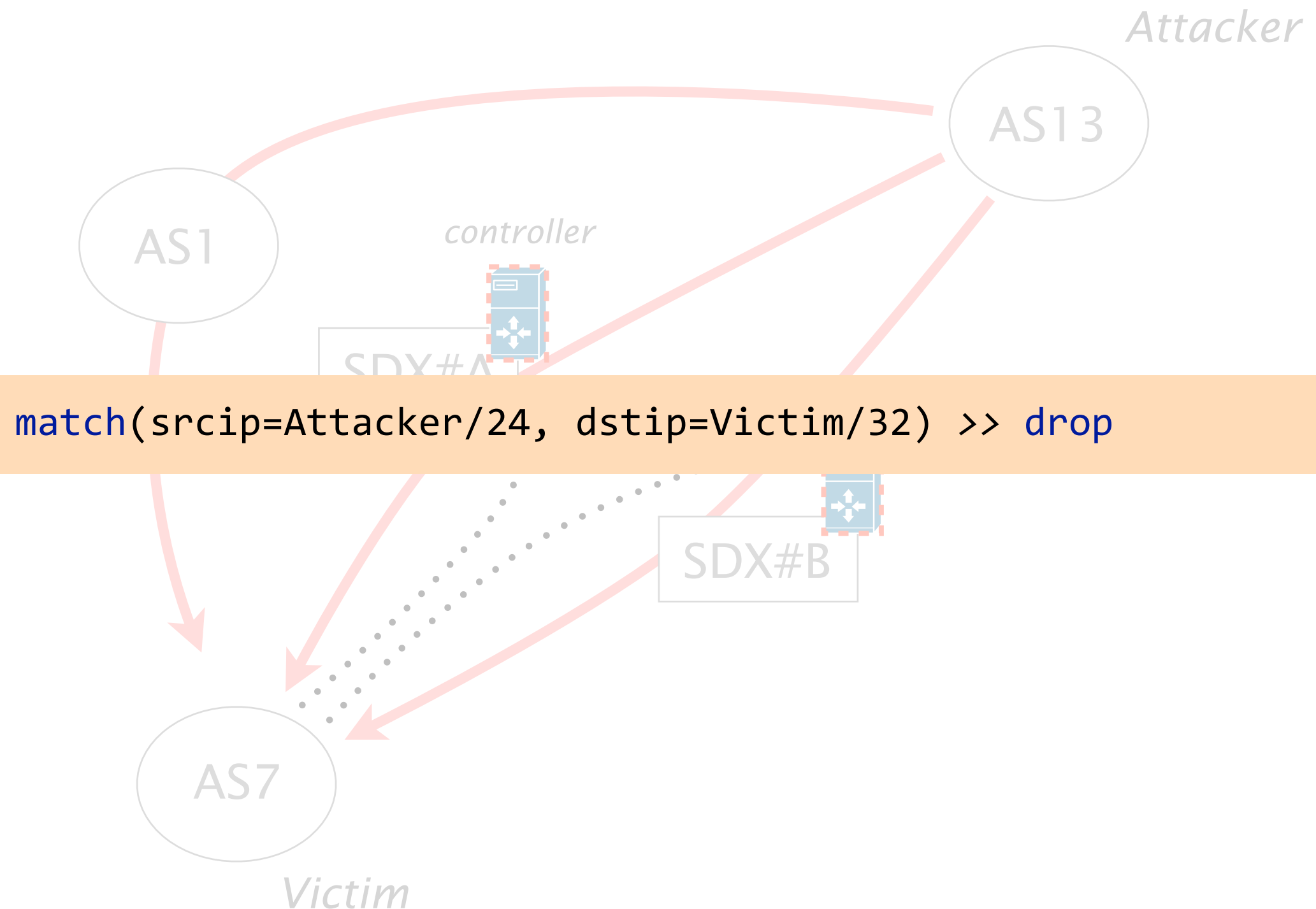
AS7 is under a DoS attack
originated by AS13



AS7 can remotely install drop rule in the SDX platforms



AS7 can remotely install drop rule in the SDX platforms



SDX-based DoS protection is more efficient than traditional blackholing solutions

Remote ASes could drop traffic destined to their network even if there are not physically connect to the IXP!

Traffic drop can be done based on any field
source address, destination address, port number, etc.

Traffic drop can be coordinated across multiple IXPs
thanks to SDX controllers collaboration

Novel Applications for a SDN-enabled Internet Exchange Point



Inbound Traffic Engineering

Upstream DoS blocking

3

Wide-area load balancing

DNS-based wide-area load balancing has several limitations

High TTL values lead to slow recovery when a server fails
due to caching by local DNS servers and browsers

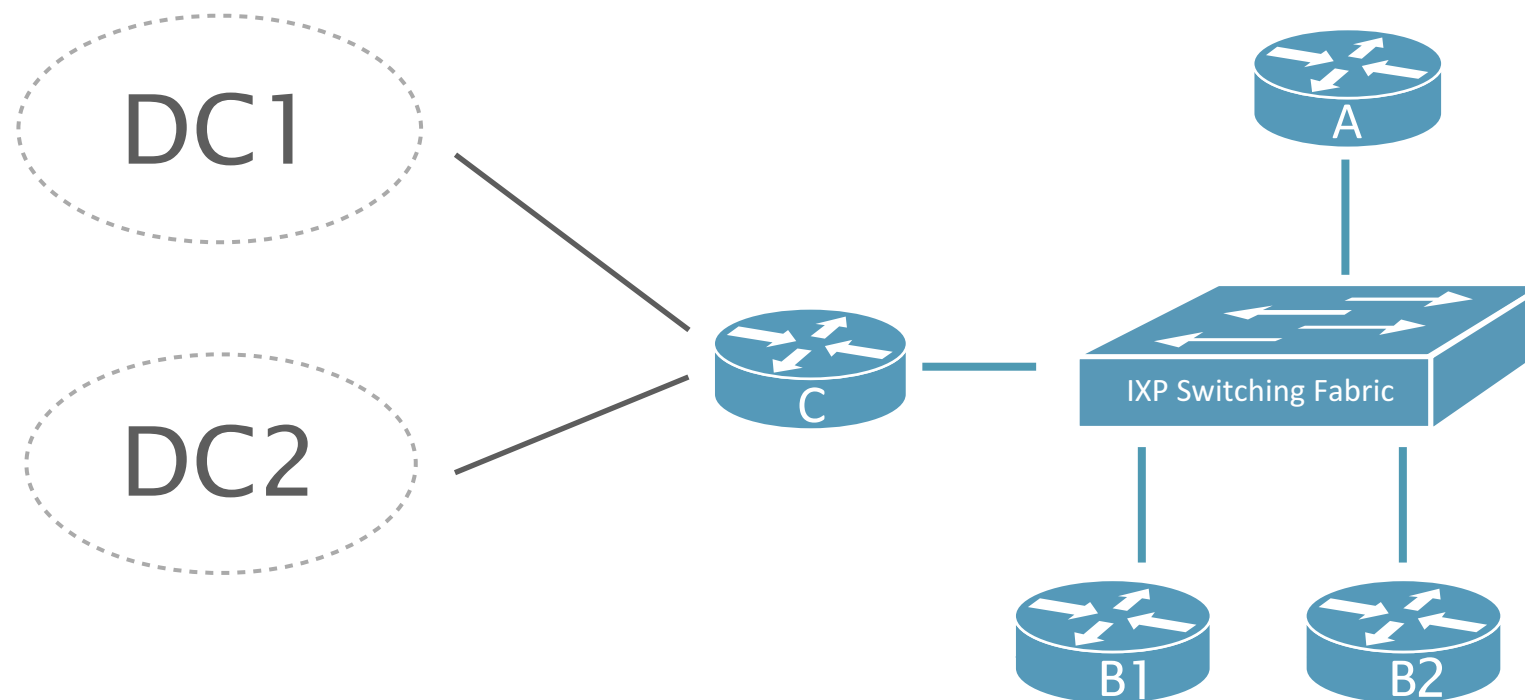
Low TTL values lead to higher delay for DNS resolution
due to cache misses

Load-balancing is not based on the client IP address
but on the IP address of the DNS resolver (e.g., Google DNS)

SDX enable direct and quick control
of traffic redirection

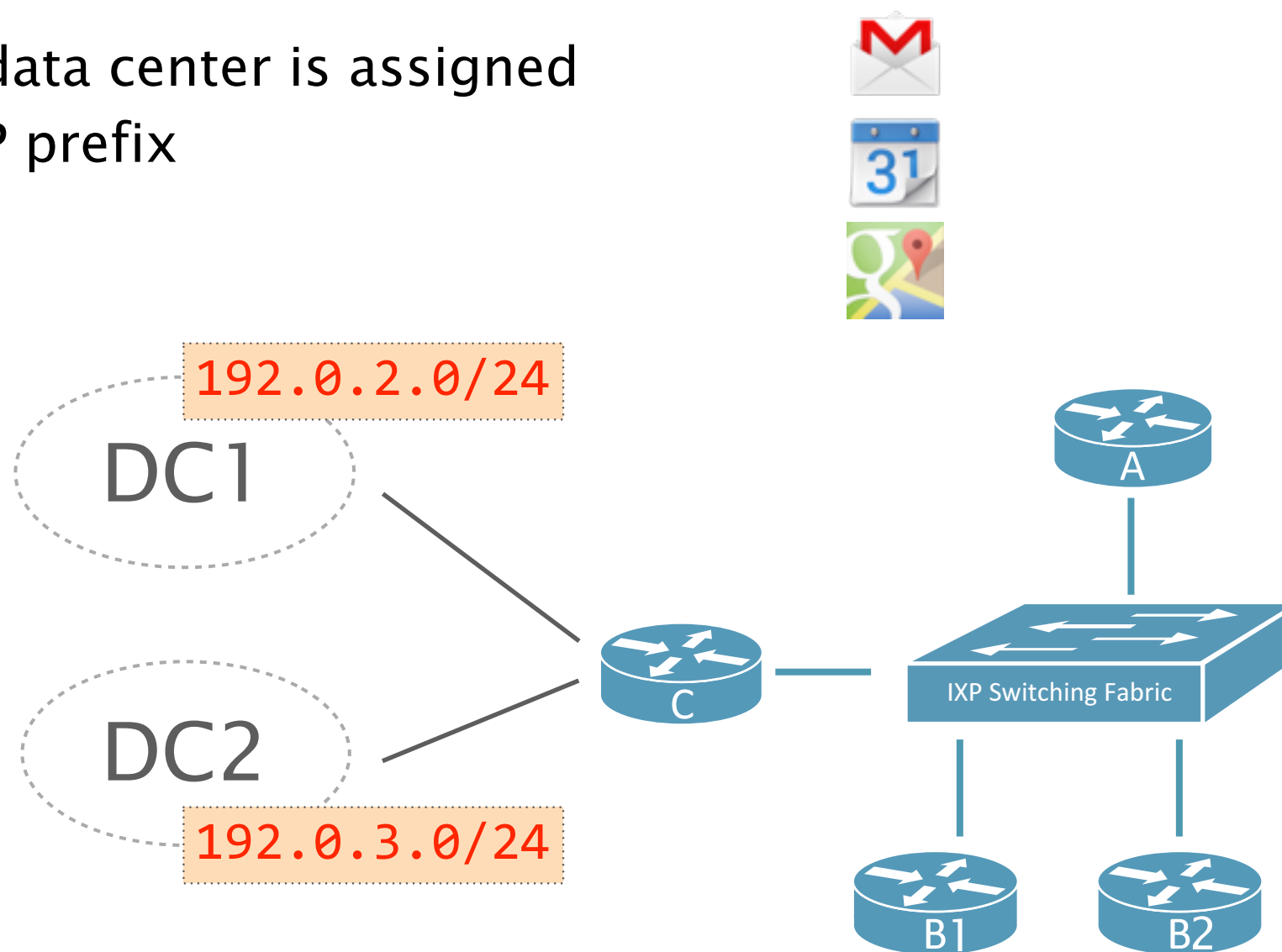
SDX enable direct and quick control of traffic redirection

C is a CDN hosting three types of services:



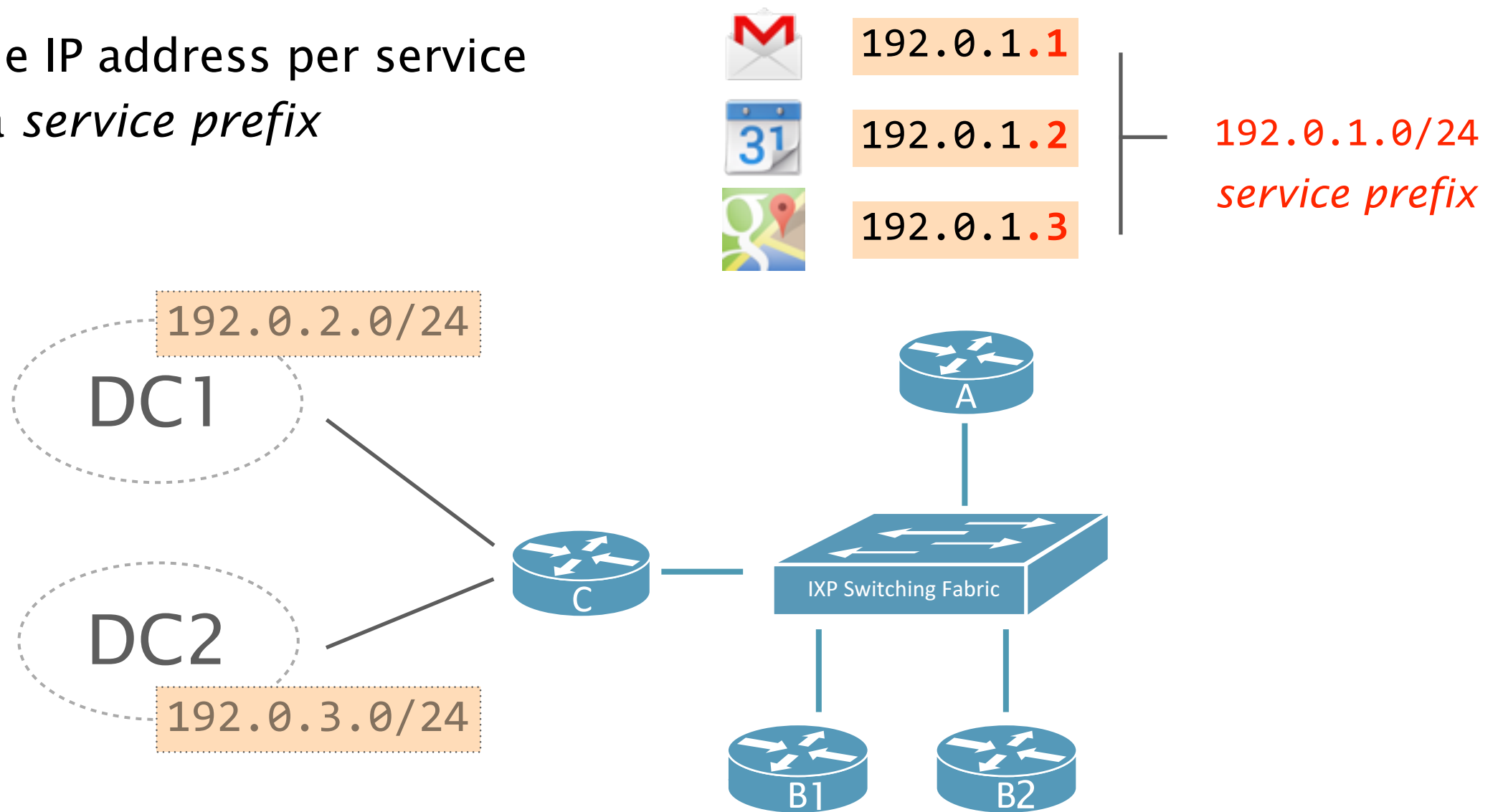
SDX enable direct and quick control of traffic redirection

Each of C's data center is assigned to a single IP prefix



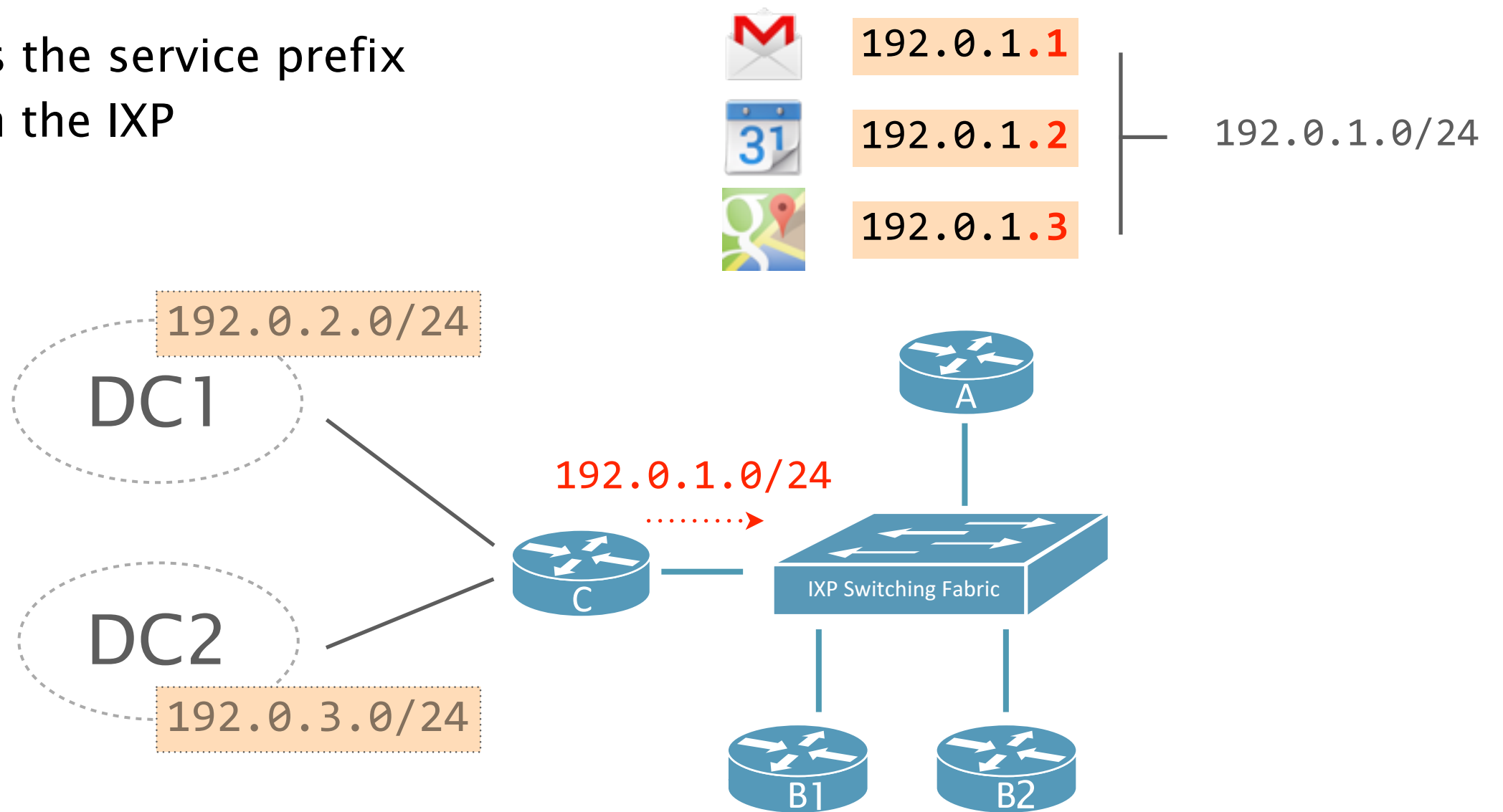
SDX enable direct and quick control of traffic redirection

C assigns one IP address per service taken from a *service prefix*



SDX enable direct and quick control of traffic redirection

C announces the service prefix directly from the IXP



SDX enable direct and quick control of traffic redirection

C installs a policy to direct requests to a given service to the appropriate replica based on the client's IP address

```
match(dstip=192.0.1.1) >>  
  (match(srcip=0.0.0.0/1) >>  
    mod(dstip=192.0.2.161)) +  
  (match(srcip=128.0.0.0/1) >>  
    mod(dstip=192.0.3.139))  
...
```



SDX enable direct and quick control of traffic redirection

SDX load-balancing is

- fast no more problem due to DNS caching
- flexible any load-balancing algorithm can be used
- efficient based on the actual client IP address

Novel Applications for a SDN-enabled Internet Exchange Point



Inbound Traffic Engineering

Upstream DoS blocking

Wide-area load balancing

We have running code as well as a first deployment site

We have implemented a first SDX controller prototype
which supports policies composition

We have partnered with a large regional IXP in Atlanta
which hosts many large content providers such as Akamai

Ping me if you are interested in knowing more

Several challenges remain

We need authentication mechanisms to validate policies

e.g., using RPKI

We need “access-lists” to constrain the policies

e.g., limiting the capabilities available to each participant

We need to make the platform scalable

as SDN devices currently support a relatively small # of rules

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