Traffic Engineering for Pan-African Research and Education Network: Software Defined Internet eXchange Points

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Introduction

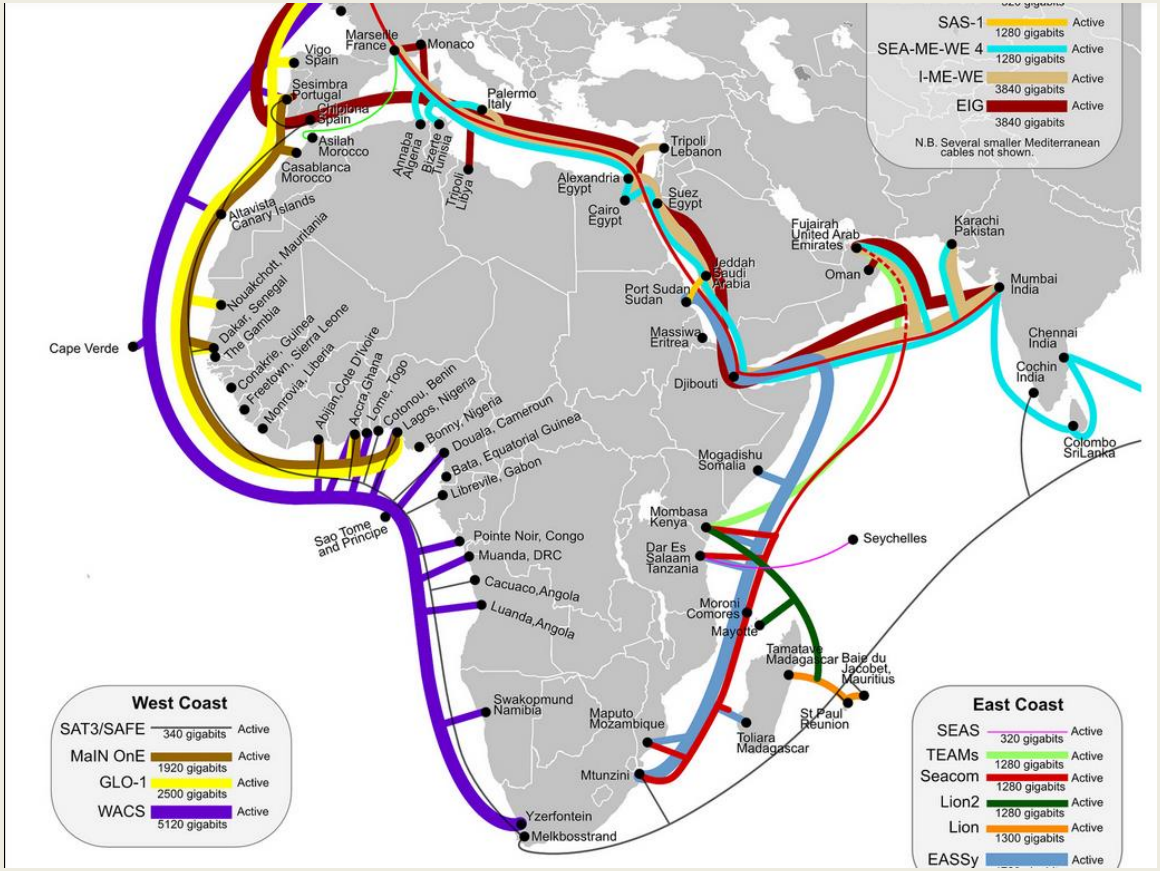
- Pan-African National Research and Education Networks (NRENs)
  - Traffic Engineering Problem
  - Example: Intra-Africa Traffic Flow
- Software Defined Internet Exchange (SDX)
  - Internet Exchange Points and Peering
  - SDX Objectives
  - SDX Structure and Operation

Pan-African Research and Education Networks

- Exclusive data networks for universities and research institutions
- Unique QoS requirements for Research and Education applications
  - Virtual Research Communities, e-infrastructure sharing
- Examples:
  - GEANTE, Internet2, TENET(SANReN)
  - In Africa:
    - UbuntuNet Alliance (East and Southern Africa)
    - WACREN (West and Central Africa)
    - ASREN (Arab States)

Intra-Africa Terrestrial Fibre Optic Cable

Afterfiber.net



Africa Under-sea Fiber Cable

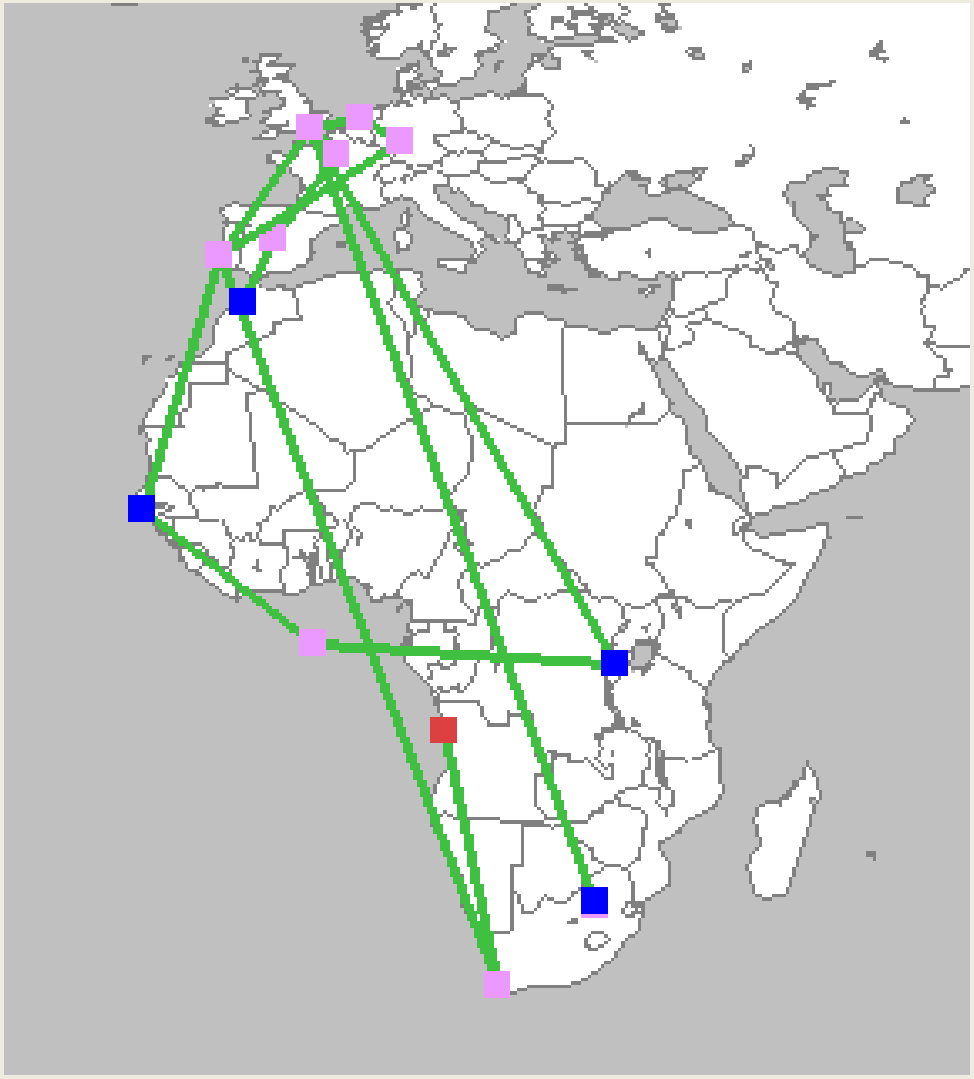
Manypossibilities.net

Intra-Africa Traffic Flow – Preliminary survey

- Traceroute and Ping measurement:
  - Probes sent to 95 IP addresses (African universities in 38 countries)
  - Probe from 5 vantage points in Africa
    - (CAIDA's Scamper tool and Archipelago measurement infrastructure)
  - Obtained Round-Trip Time (RTT) and IP paths
- Geo-location database to obtain location (Cities) of IP hops

Circuitous Route Problem

- Geographical distance
- High Hop Count
- Cost?
- Round-Trip Time(RTT)/Latency



Intra-Africa traffic vs inter-continental traffic

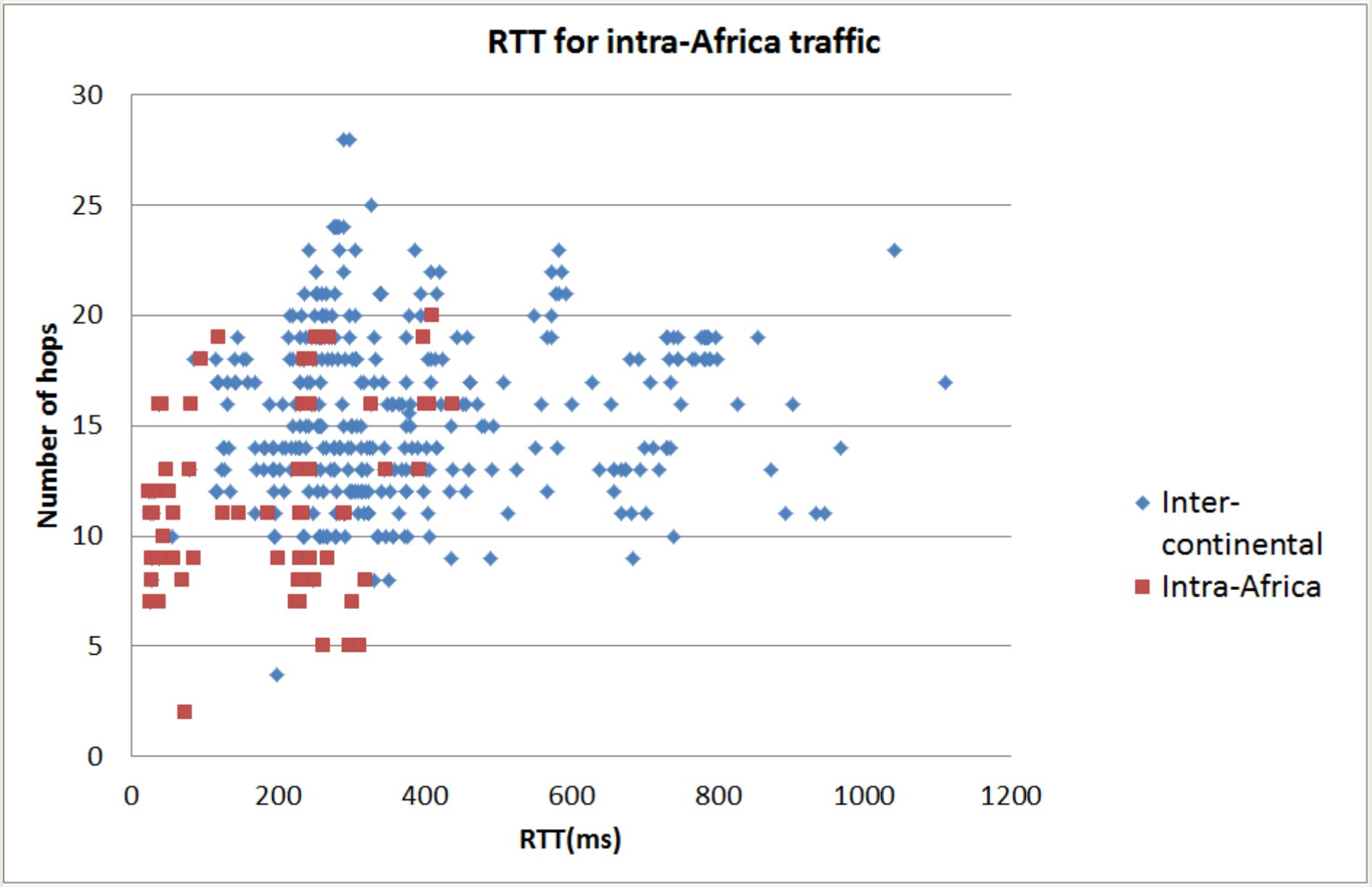
Intra-Africa

- Average RTT: 174ms
- Average Hop count: 11

Inter-continental

- Average RTT: 380ms
- Average Hop count: 15

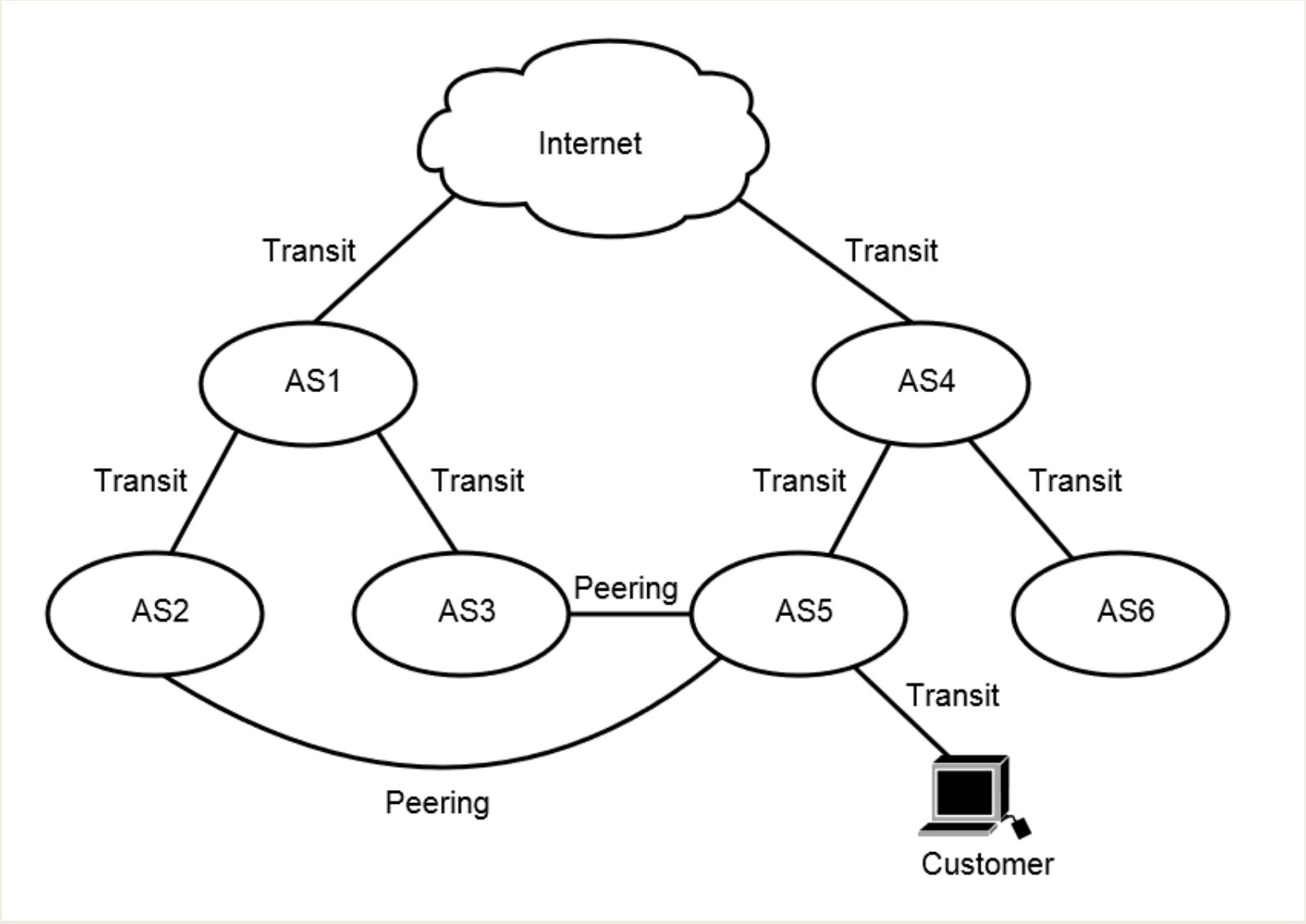
- 80% of traffic traversed inter-continental links
- Trip from Africa's egress point to a remote gateway takes ~107ms (stdev 82)


RTT for intra-Africa traffic
Number of hops
RTT(ms)
0
5
10
15
20
25
30
0
200
400
600
800
1000
1200
Inter-continental
Intra-Africa

Research Objectives

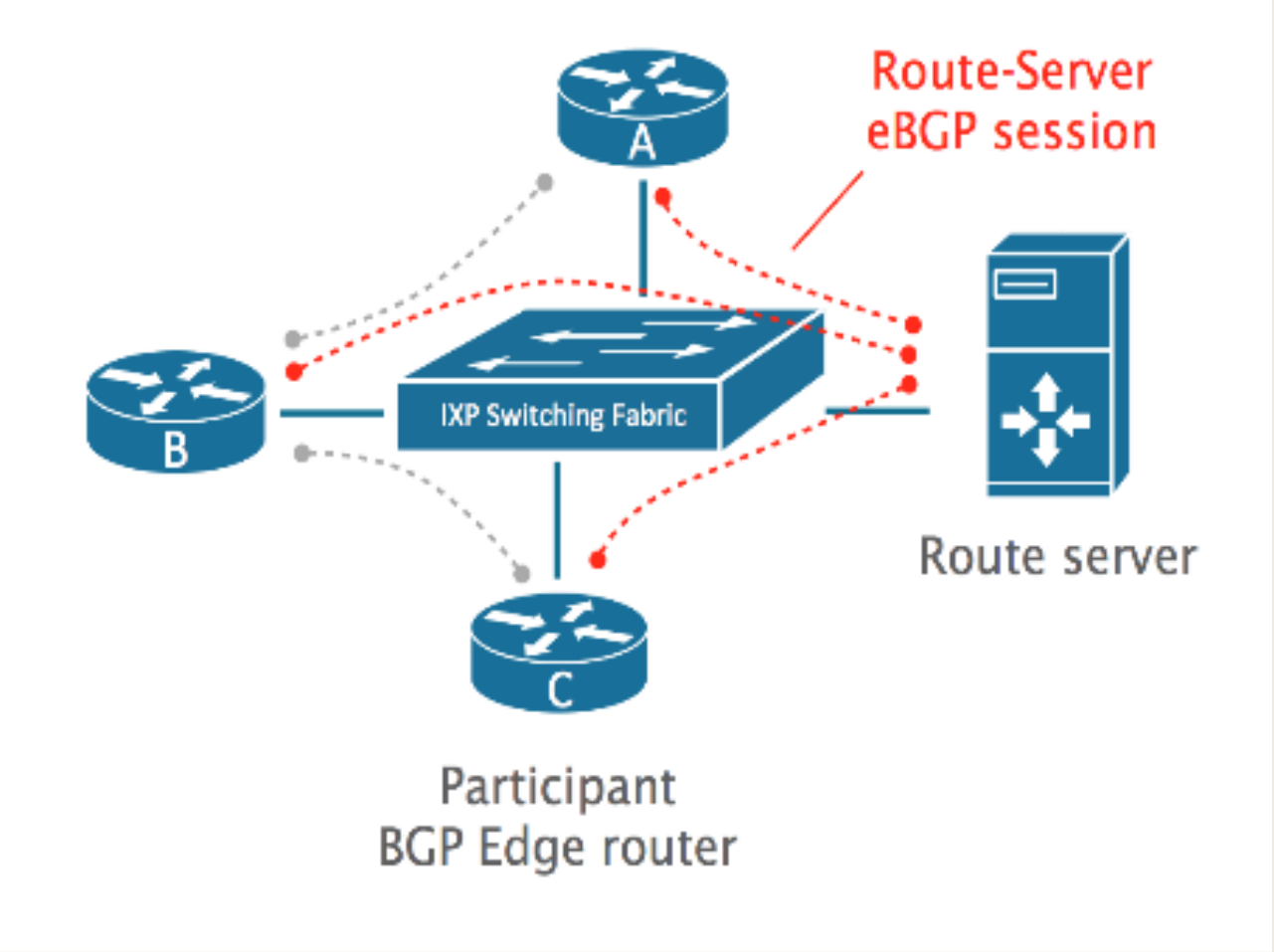
- How to better design the Pan-African Research and Education Network logical topology for optimal traffic exchange
  - to achieve a flexible and dynamic peering environment using novel hierarchical routing architectures such as LISP, as well as software defined networking protocols such as OpenFlow
  - to optimize cross-border peering through topology awareness and measurable network metrics

Peering and IXPs



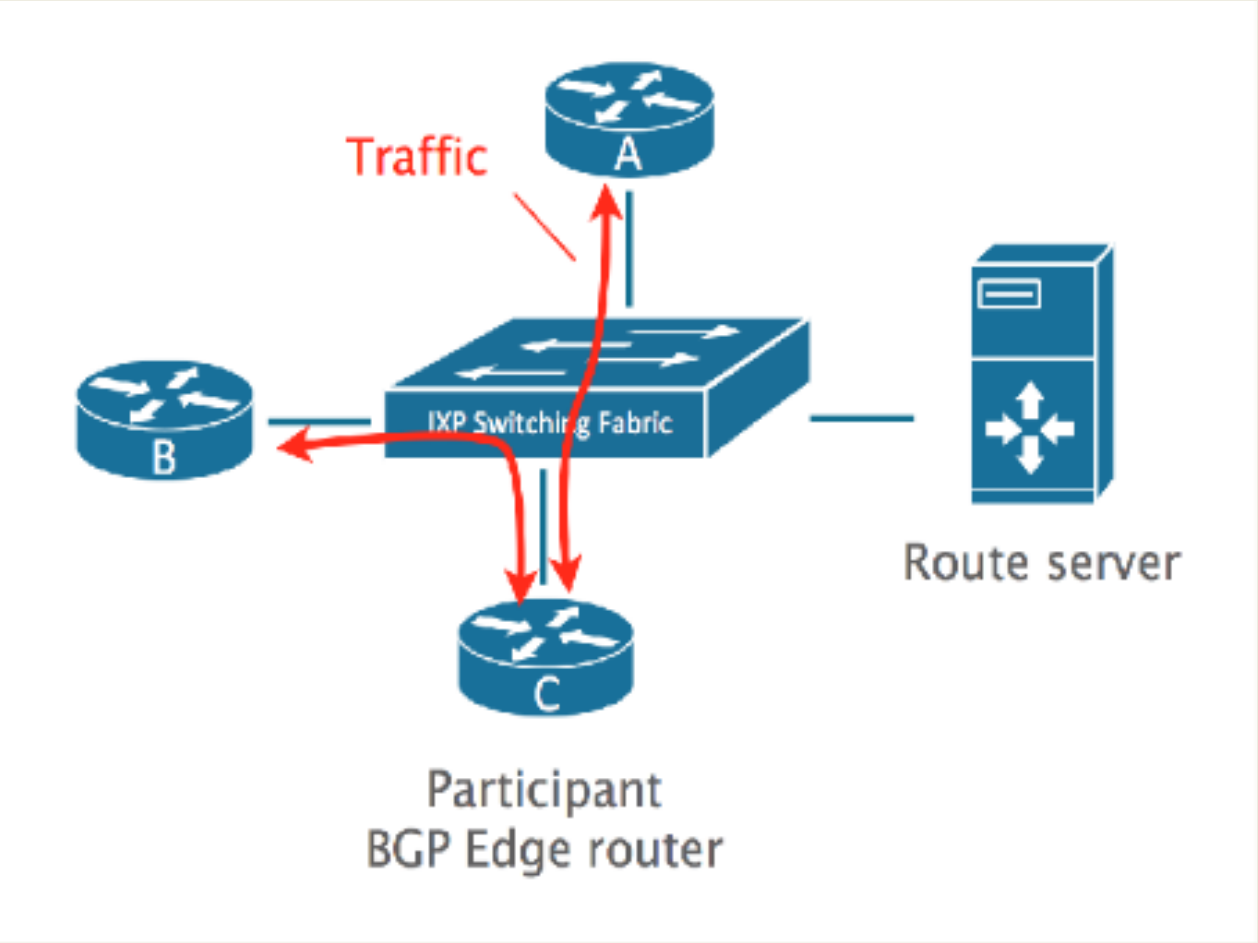
Internet eXchange Points (IXPs)

Layer 2 domain where participants peer using Border Gateway Protocol (BGP)



Internet eXchange Points (IXPs)

Traffic flow (Data Path) is through the layer 2 switch



Problems with BGP Peering

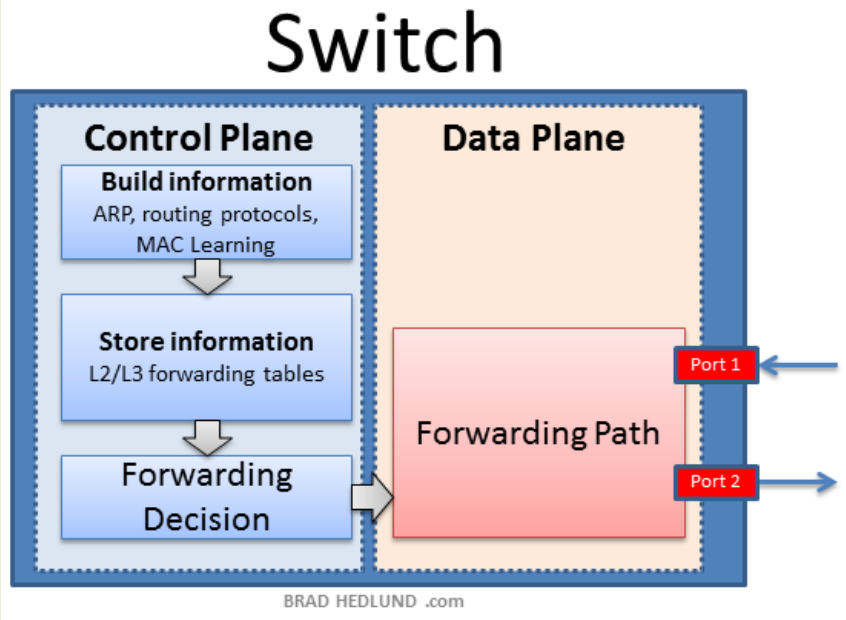
- Inflexible:
  - Coarse-grained policies (AS Level)
  - Based only on destination prefix: application or sender cannot customize end to end path
  - Indirect means of influencing path selection e.g AS path-prepending

Software Defined Internet eXchange (SDX)

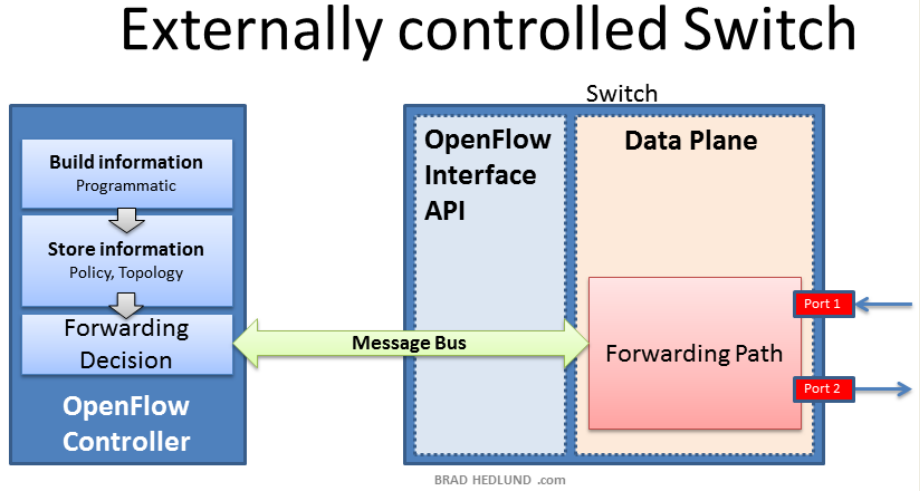
- Software Defined Networking: Switch control plane moved to a software/programmatic controller
- OpenFlow protocol: Standardized API for remote and programmatic control of switch forwarding table

Software Defined Networking

Ordinary Switch



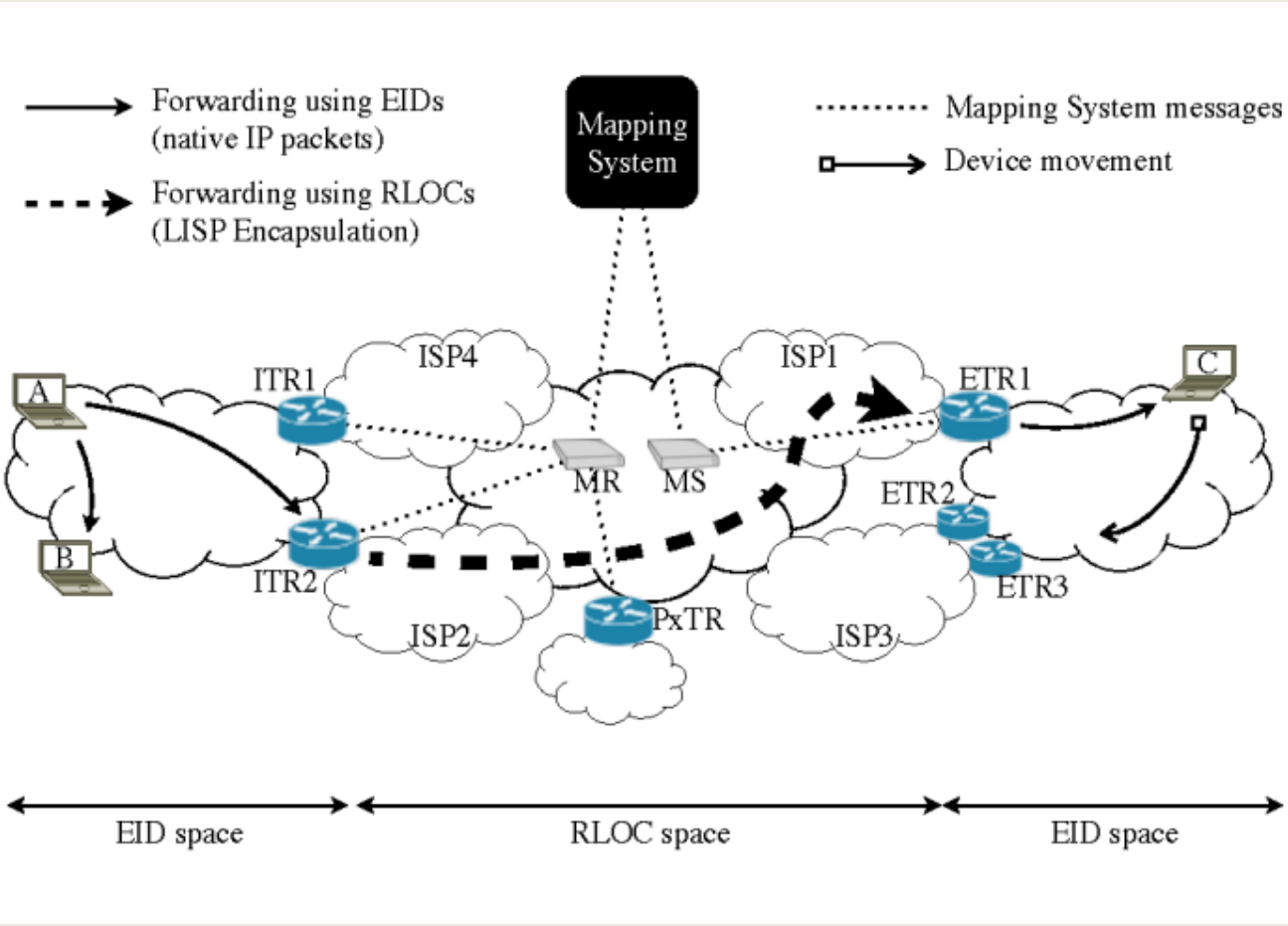
OpenFlow Switch



Locator/Identifier Separation Protocol (LISP)

- Divides the IP address space into Locators and Identifiers
  - Route Locators(RLOCs): Internet Core (global reachability)
  - Endpoint Identifiers(EIDs): Edge networks
  - EID-to-RLOC Mapping System
- IETF standard, Cisco, lisp4.net

Locator/Identifier Separation Protocol



- Multiple RLOCs per EID (enable multi-homing)
- EID/RLOC preferences (enable inbound traffic engineering)

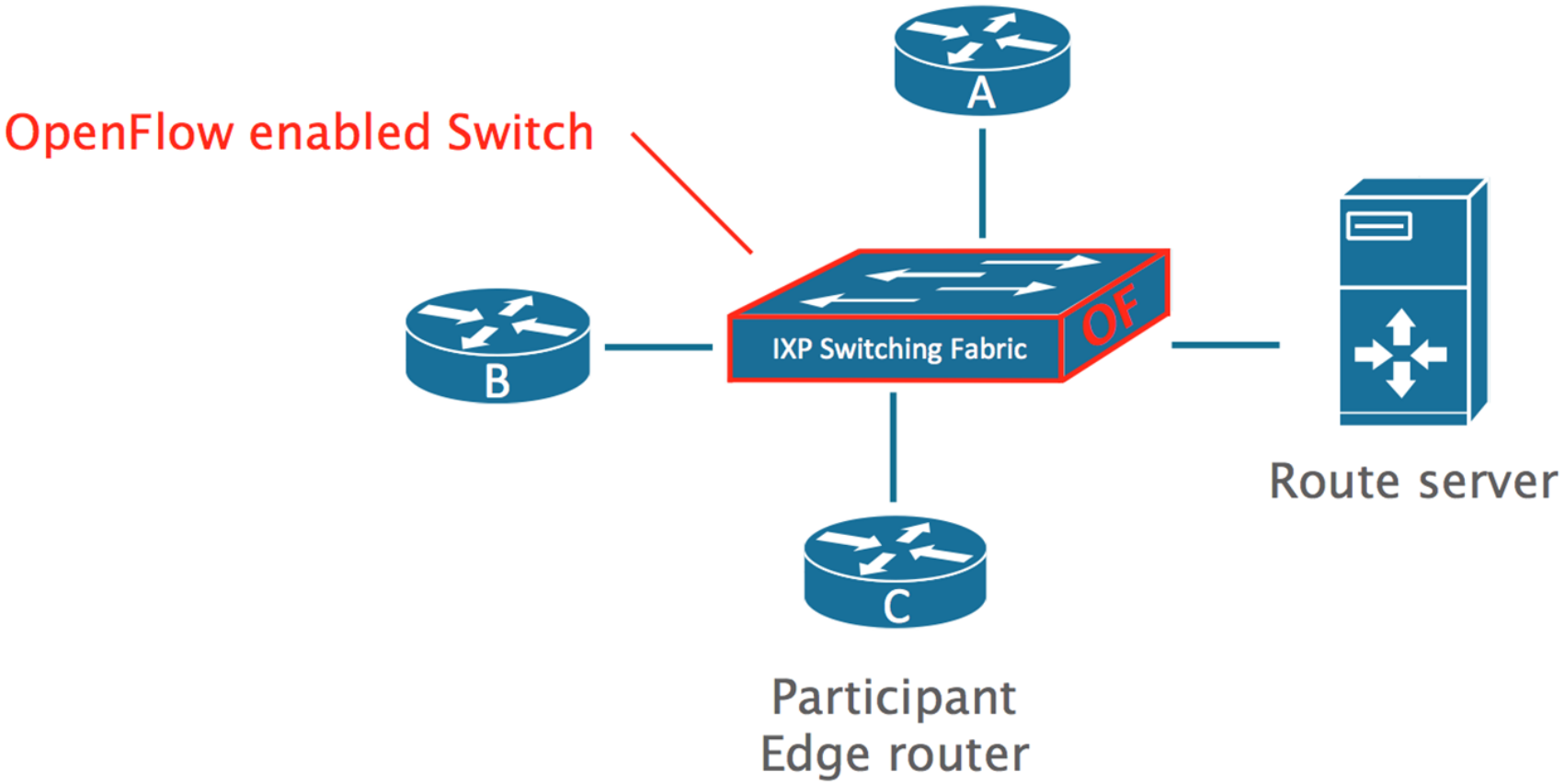
Key Objectives (Wish list)

- Collaborative and dynamic selection of ‘shorter’ paths
  - Eg using measured topology metrics, preferences
- Application Specific Peering

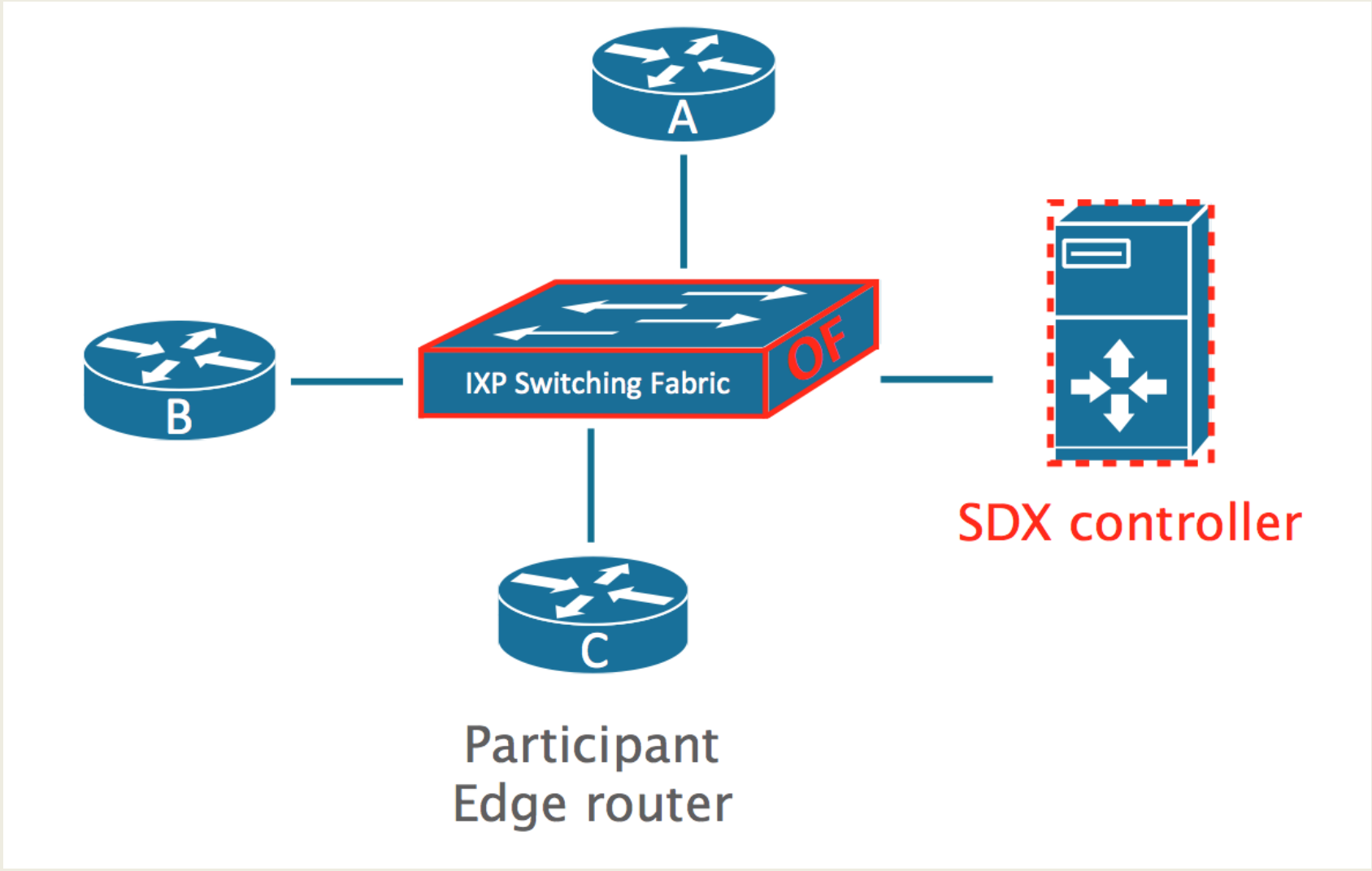
SDX Components

- OpenFlow Switch
- SDN Controller
- LISP Map-Server
- LISP edge routers (Ingress and Egress Transit Routers)

SDX Components



SDX Components



Design Challenges

- Route computation across multiple domains/exchange points
- Independent route selection in a collaborative environment
- Secure Routing:
  - If external input is to influence route selection
  - Enforcement of preferences and policies

Summary

- Circuitous routes impact latency
- Software Defined Internet eXchange points can help create more flexible and dynamic peering environment
  - OpenFlow and LISP offer new opportunities for peering and traffic engineering

Thank You.