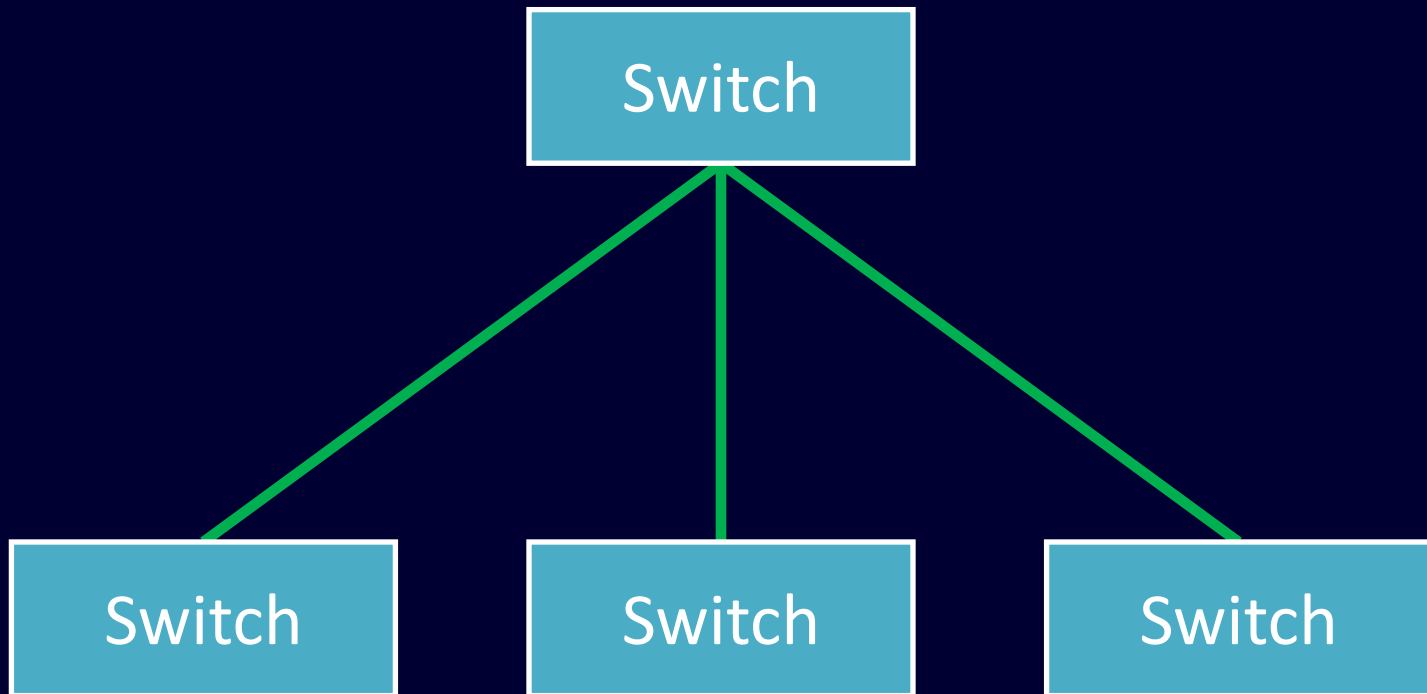


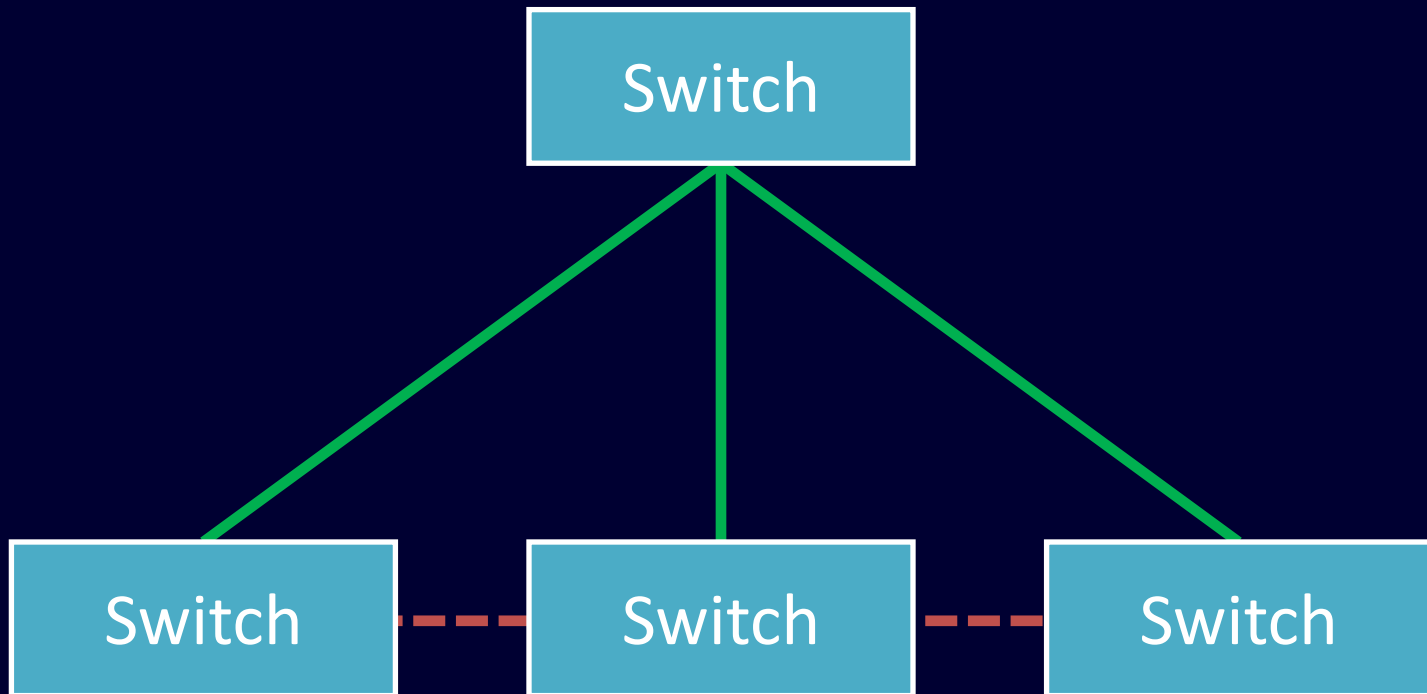
Simplifying Teleprotection Communications With New Packet Transport Technology

**D. DOLEZILEK, C. GORDON, D. ANDERSON,
S. MCCREERY, and W. EDWARDS**
Schweitzer Engineering Laboratories, Inc.

Network Configuration (No Redundancy)

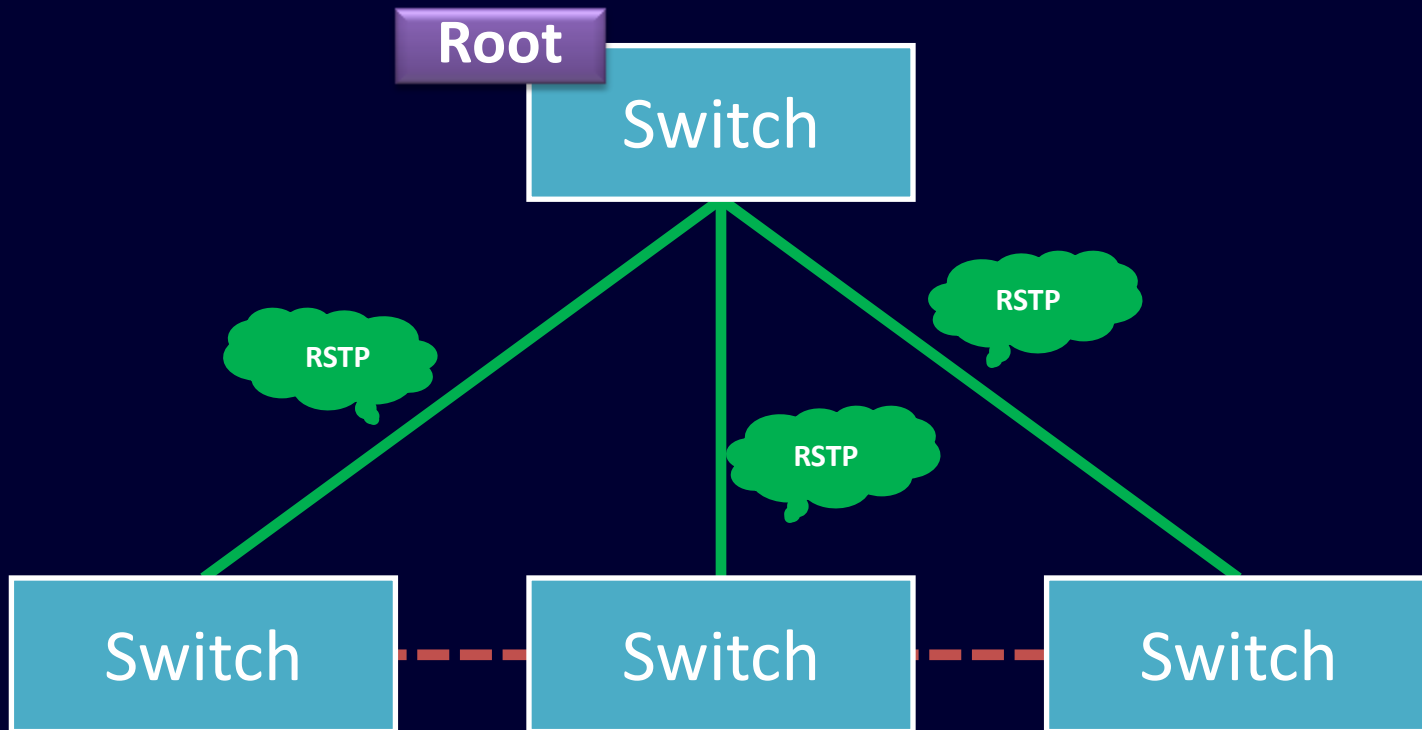


Network Configuration (with Hot Standby Links)



Network Configuration

(STA Management via Constant Communication)

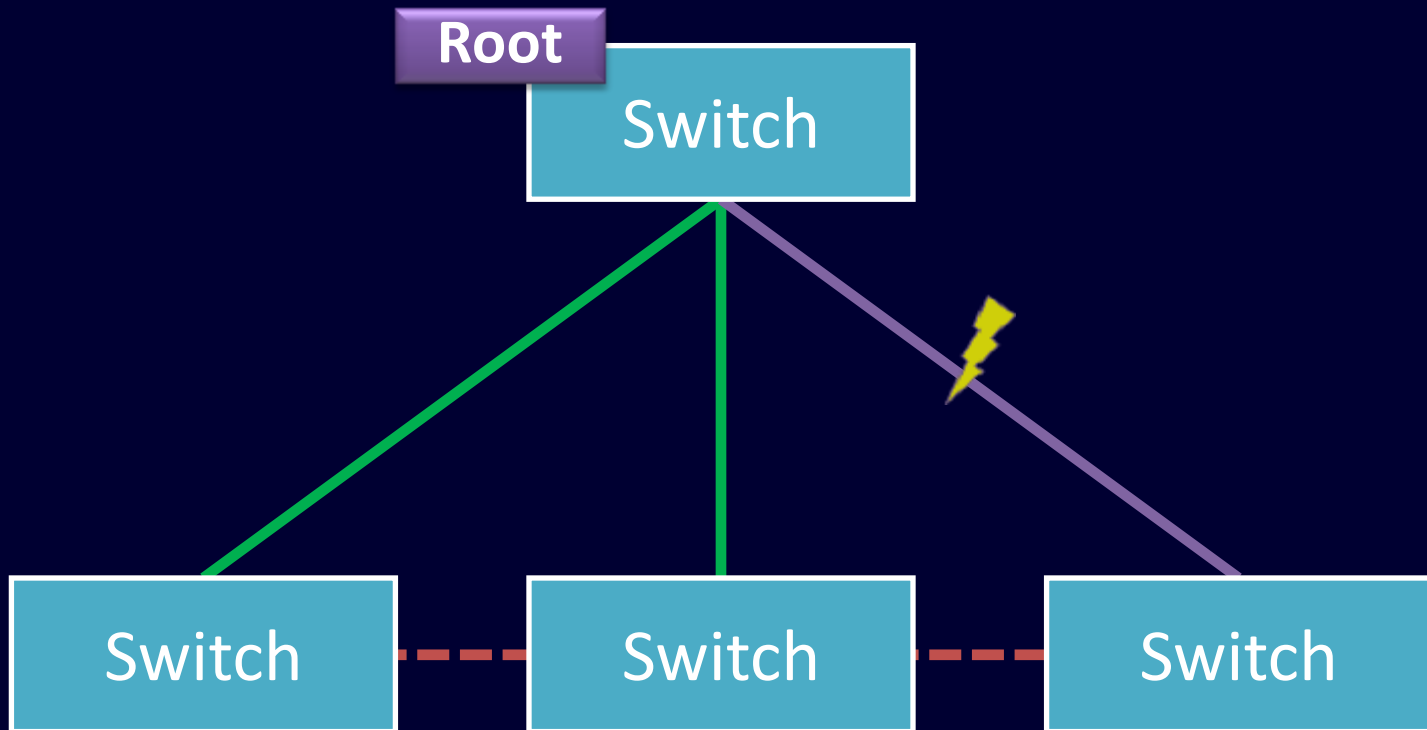


RSTP - rapid spanning tree protocol

STA - spanning tree algorithm

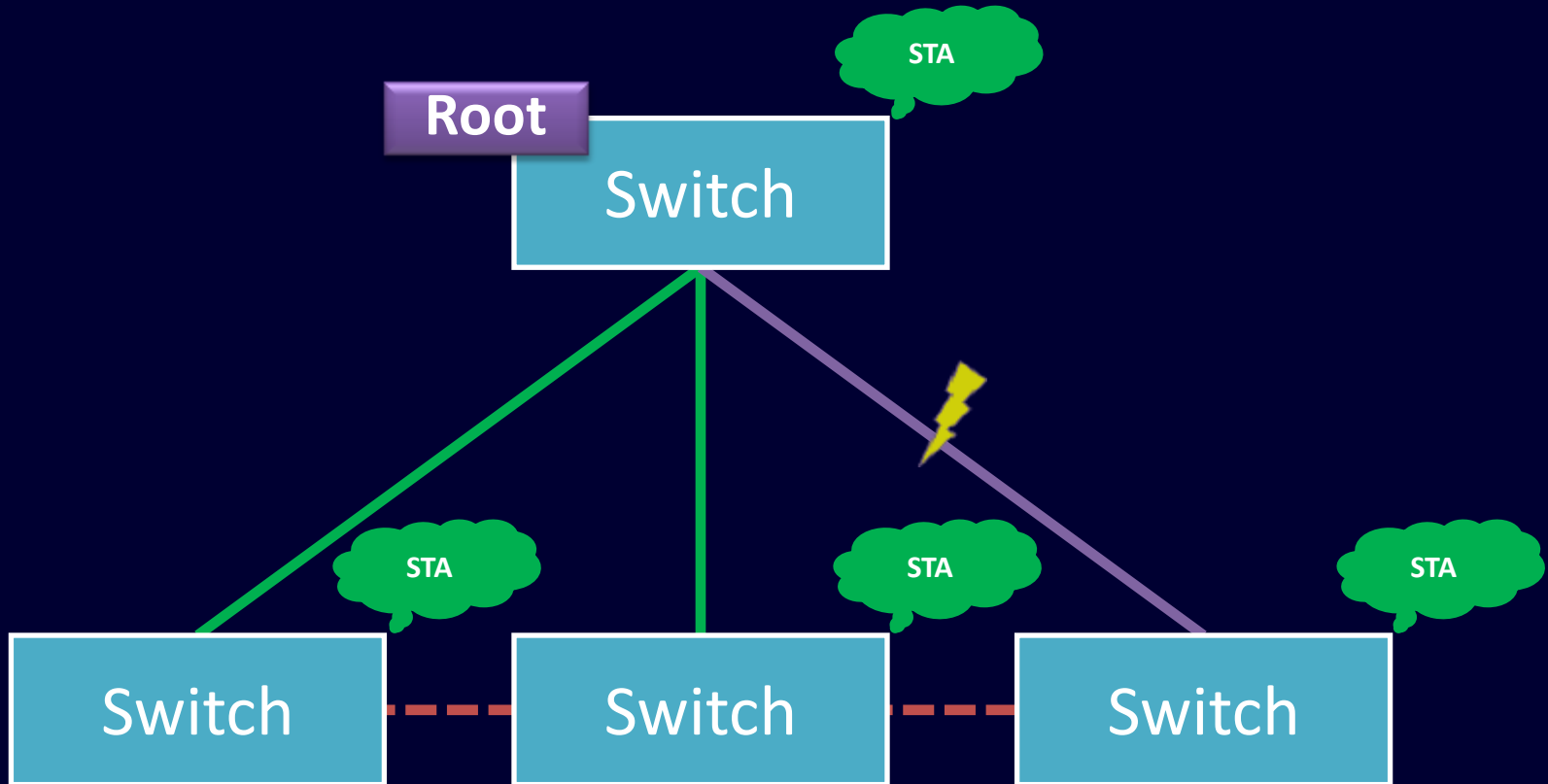
Root device manages decisions

Network Fault

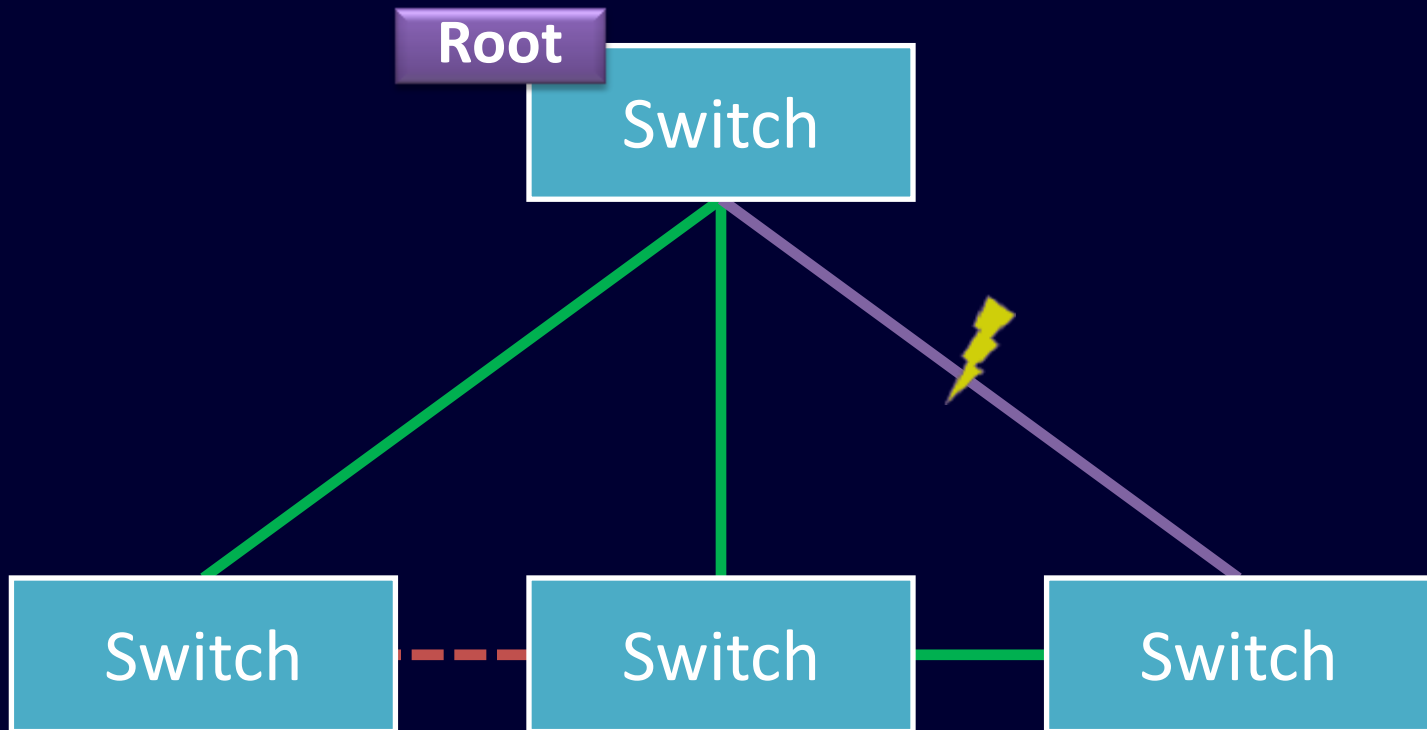


Packets may be dropped during fault

STA Isolates Network Fault

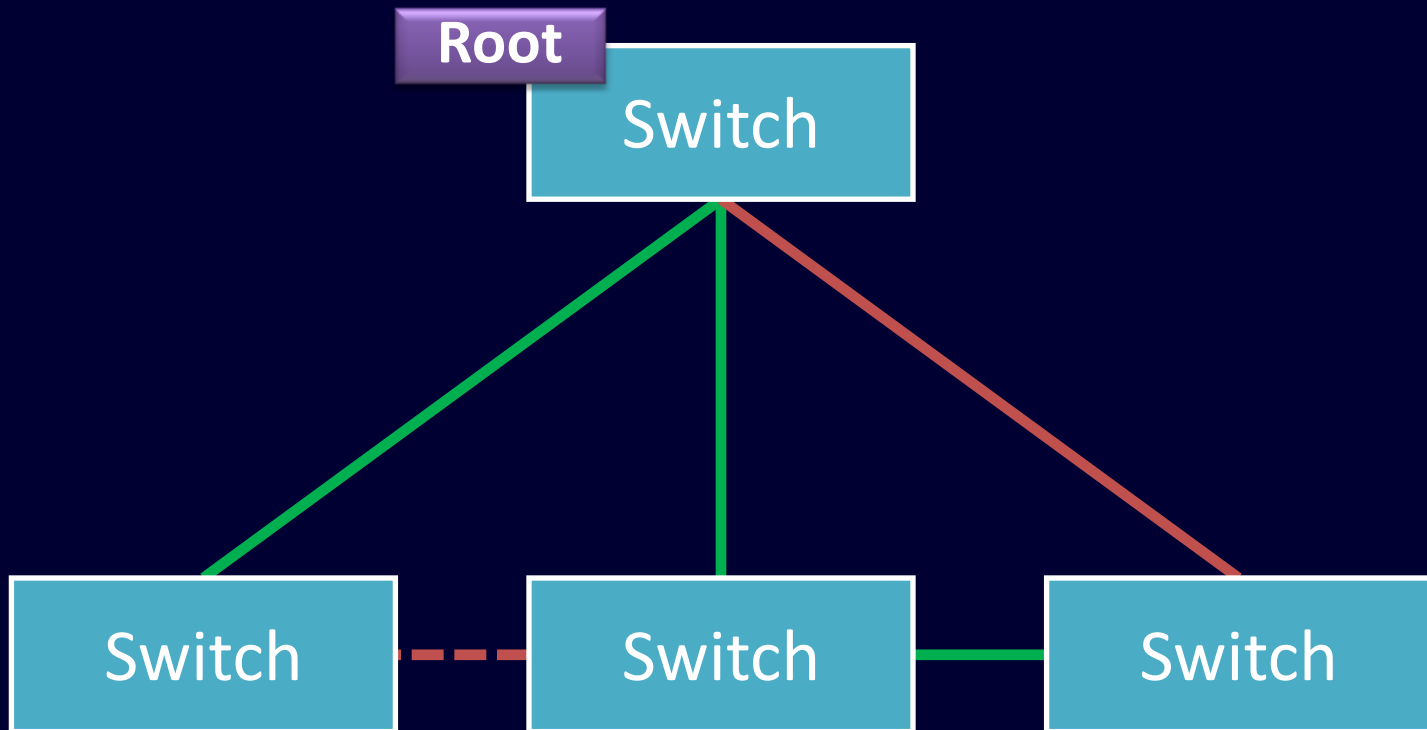


STA Performs Automatic Network Reconfiguration



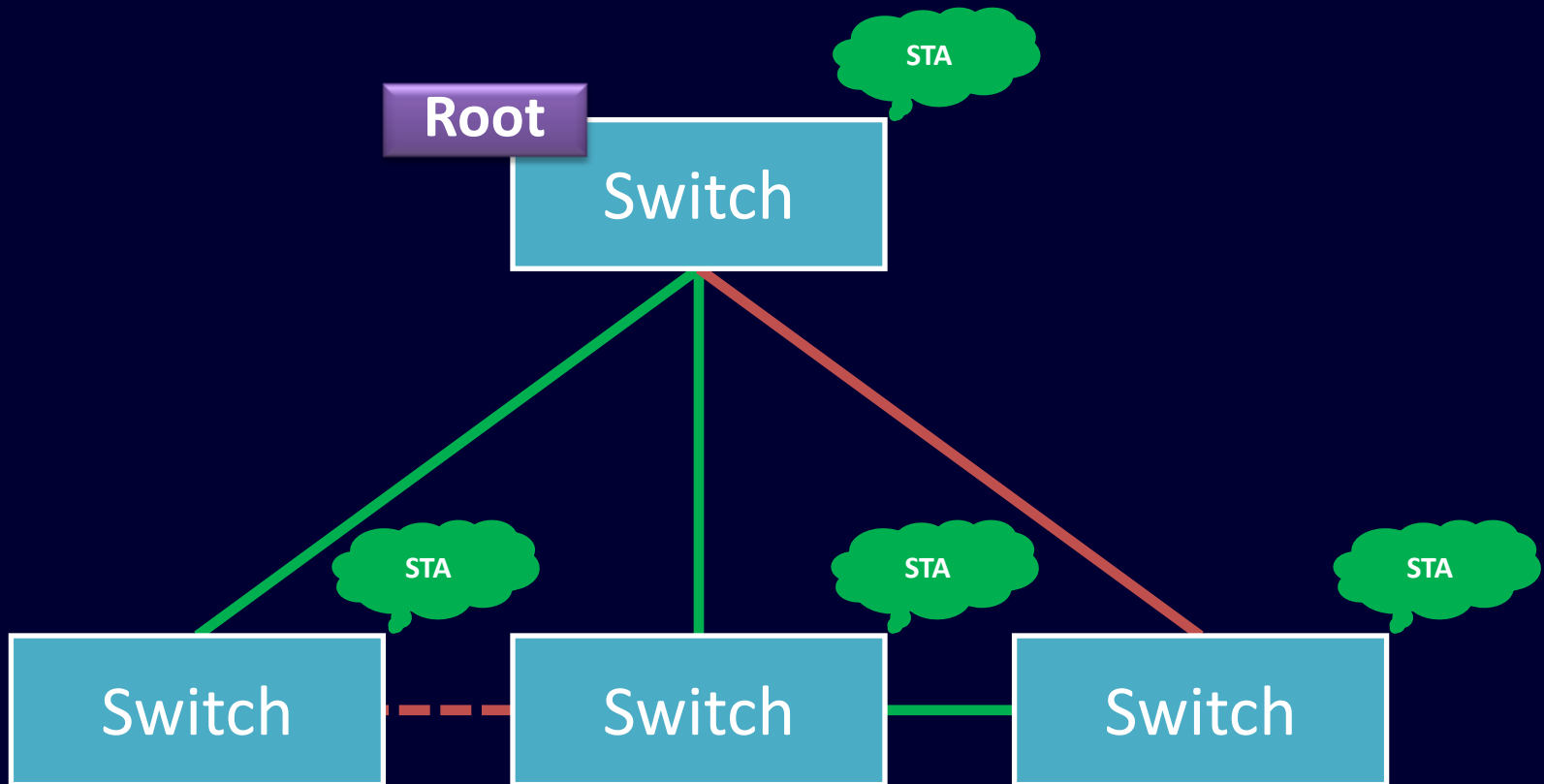
Packets may be dropped during reconfiguration

Faulted Segment Stays Inactive

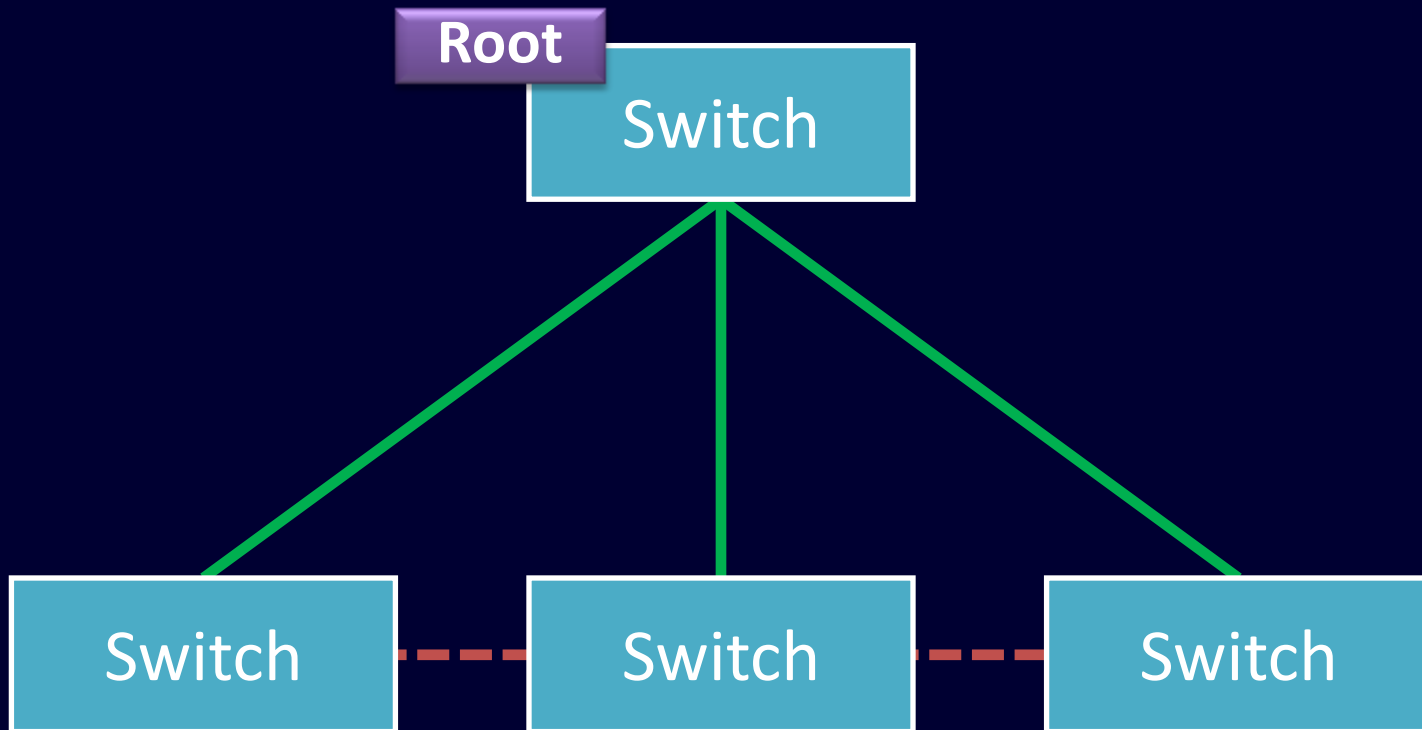


Faulted segment remains inactive

Once Fault Clears, Primary Link is Re-enabled



Network Restored to Original Configuration



Packets may be dropped during restoration

Issue With Traditional Ethernet Switching

- Designed for plug and play
- Conveniently does things “we don’t want”
- Hot standby failover links, no redundancy
- Slow heal times based on generic algorithm
- Can’t model and test various configurations

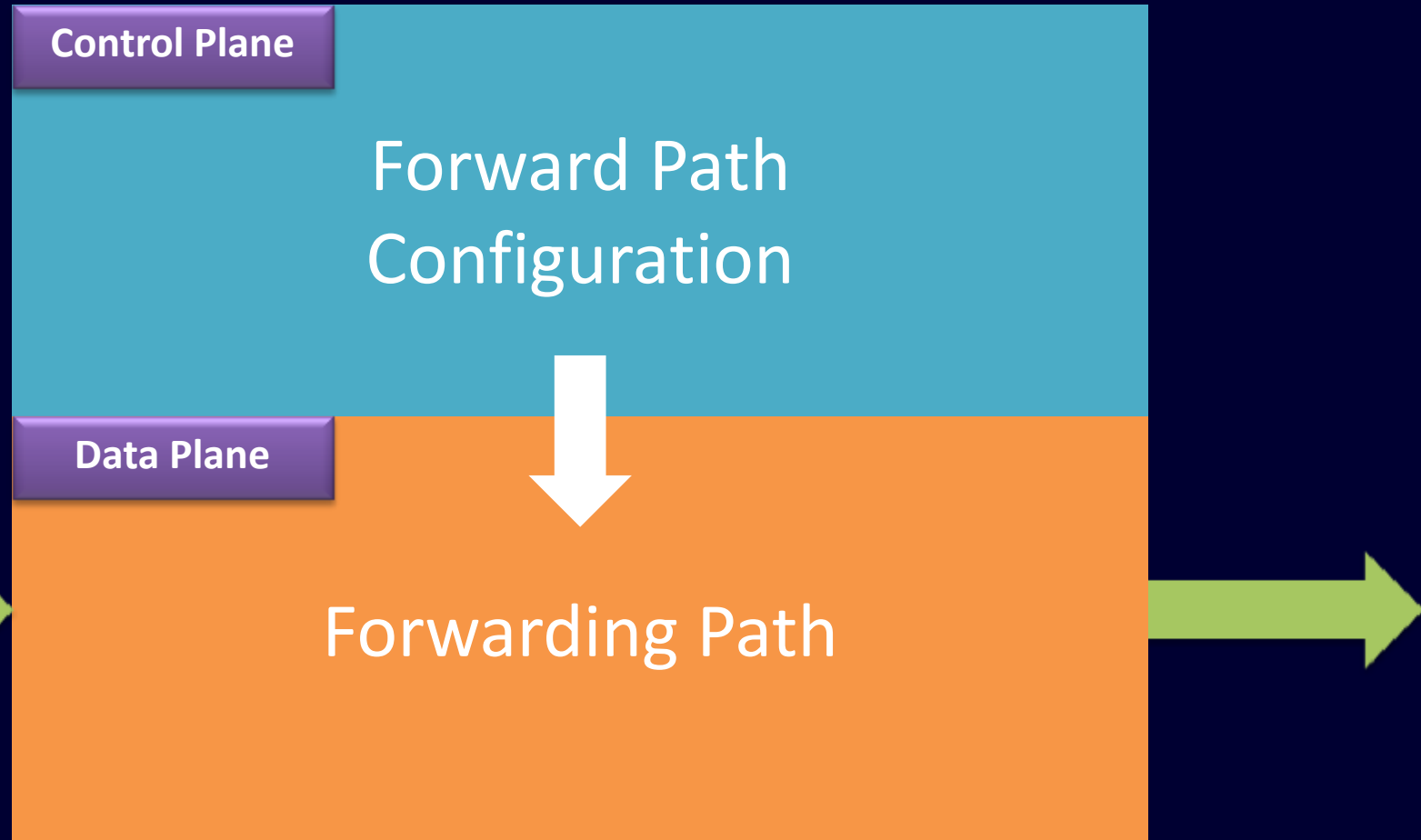
Google, Verizon Alcatel-Lucent, Cisco, Ericsson, Juniper, and Nokia



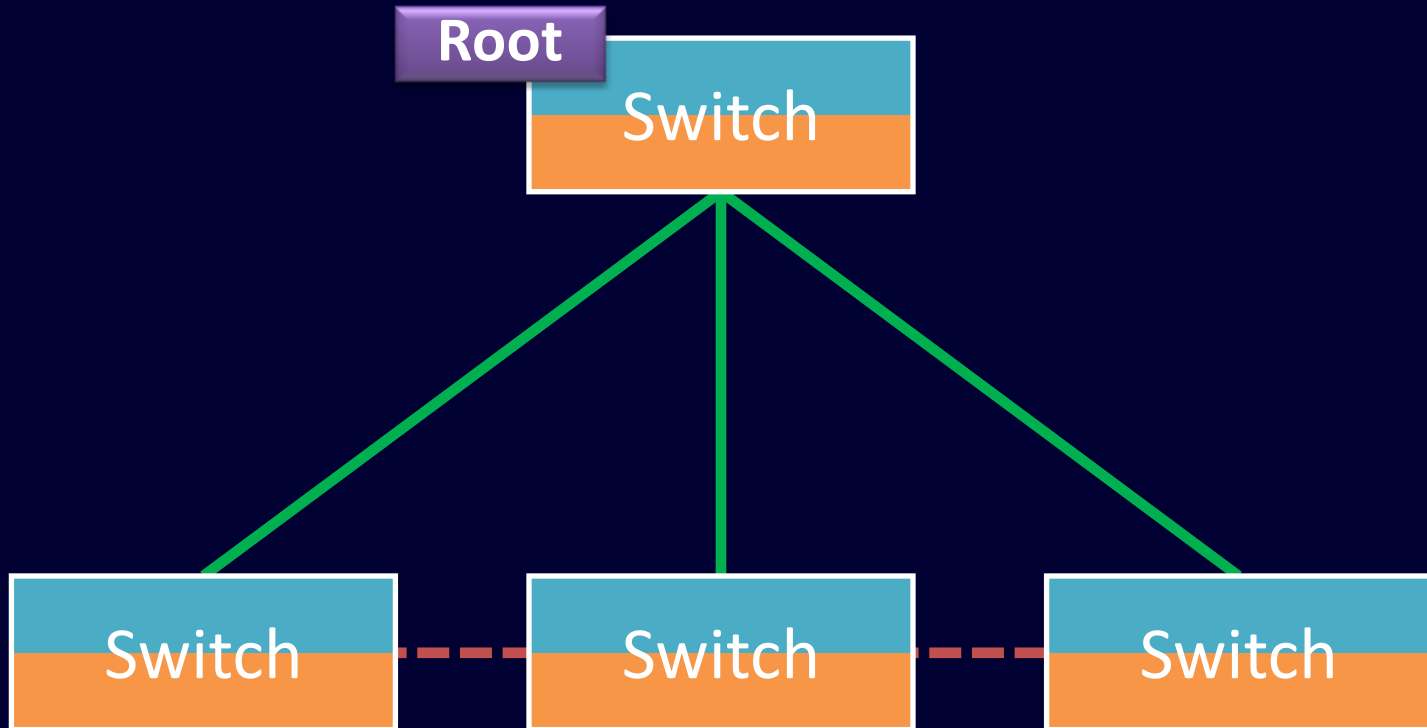
Software Defined Networking

- Permits designers to specify network behavior at each port
- Separates Data and Control Planes with new faster processing
- IT Data Centers (dynamic)
 - ◆ News Article, Video clip
- Industrial Control Networks (static)

Data and Control Planes



Traditional L2 Network



Traditional L2 Data Plane

DEST MAC Address	ACTION
Broadcast	Forward to all ports (except source)
Multicast	Forward to all ports (except source)
MATCH(unicast)	Forward to Matched Port
Default	Forward to all ports (except source)

Ignoring IEEE 802.1Q VLAN tags, Multicast MAC Filtering, etc.

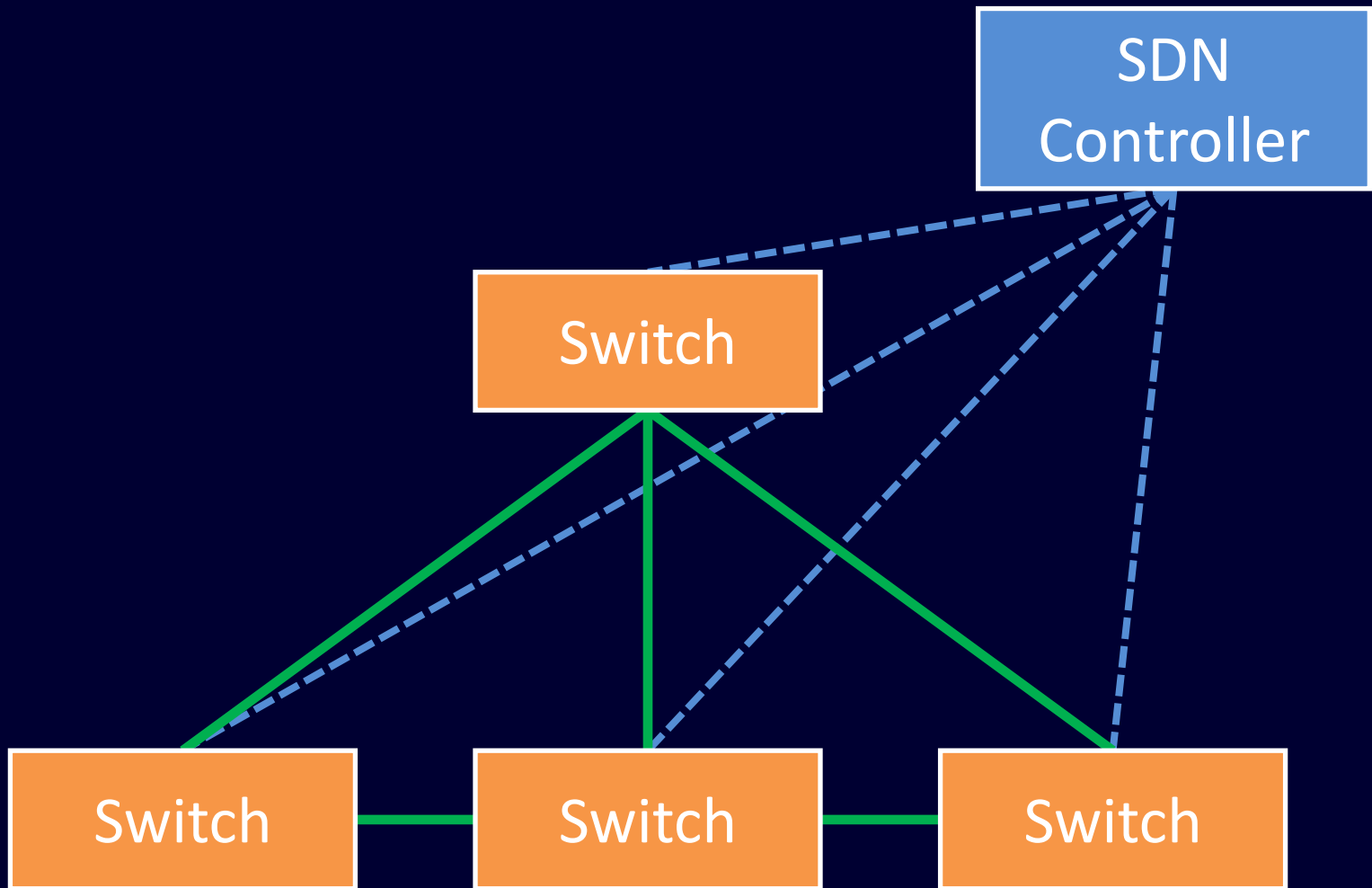
Traditional L2 Control Plane

MAC Learning:

MAC Address	Ethernet Port
00:30:A7:00:00:01	14
00:30:A7:00:5C:73	7
00:30:A7:00:01:7B	2
00:30:A7:00:1A:3C	10

Network Healing:
Spanning Tree Algorithm

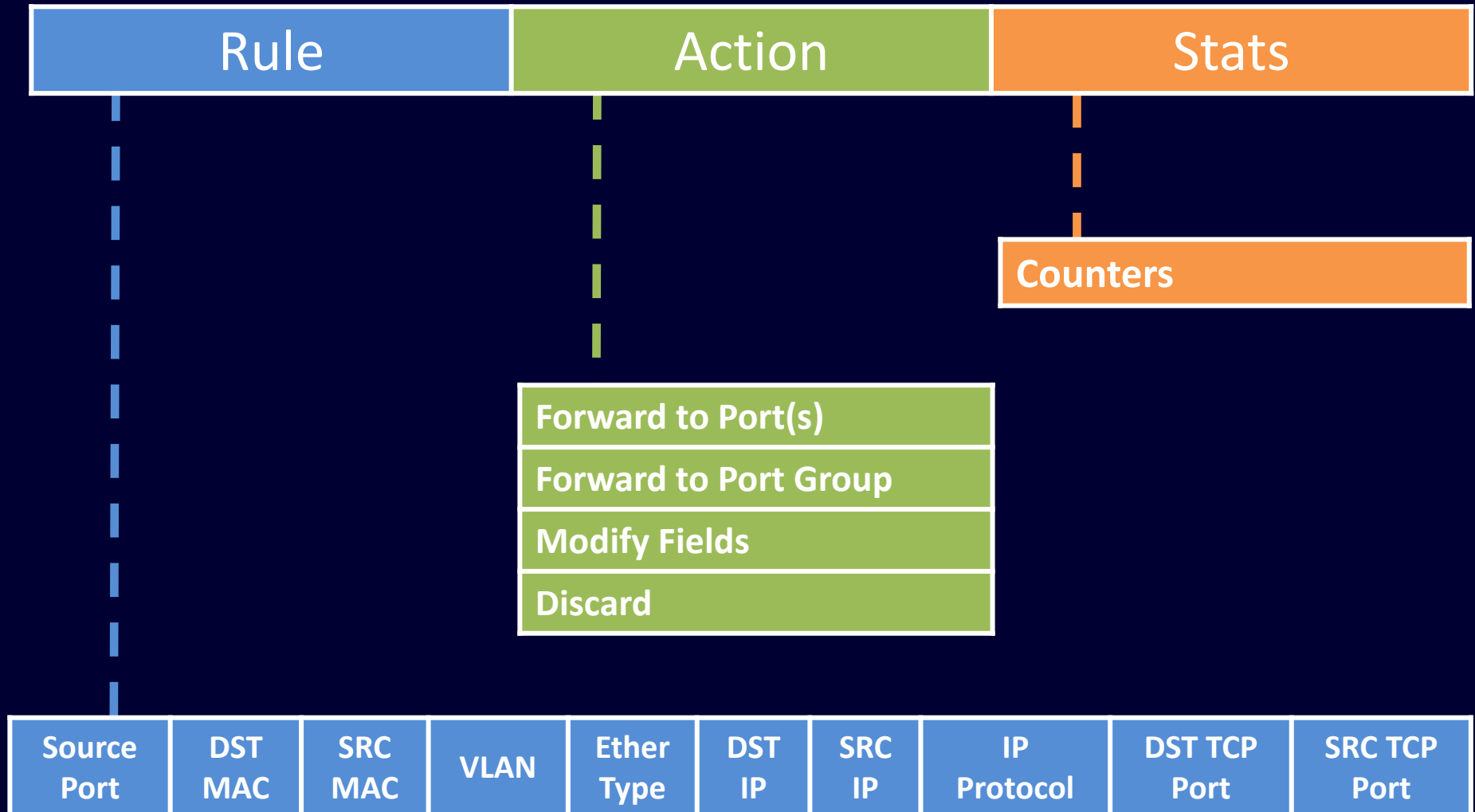
Software Defined Network



SDN Controller

- Responsible for:
 - ◆ Configuration
 - ◆ Monitoring
 - ◆ Management
- Value Add
- Cross Point Switch
 - ◆ Rule / Actions table

SDN Data Plane



GOOSE Message Processing

Source Port	DST MAC	SRC MAC	VLAN	Ether Type	Action
*	01:00:00:00:0B	*	11	GOOSE	Forward Ports: 3, 7

Supports redundant GOOSE paths

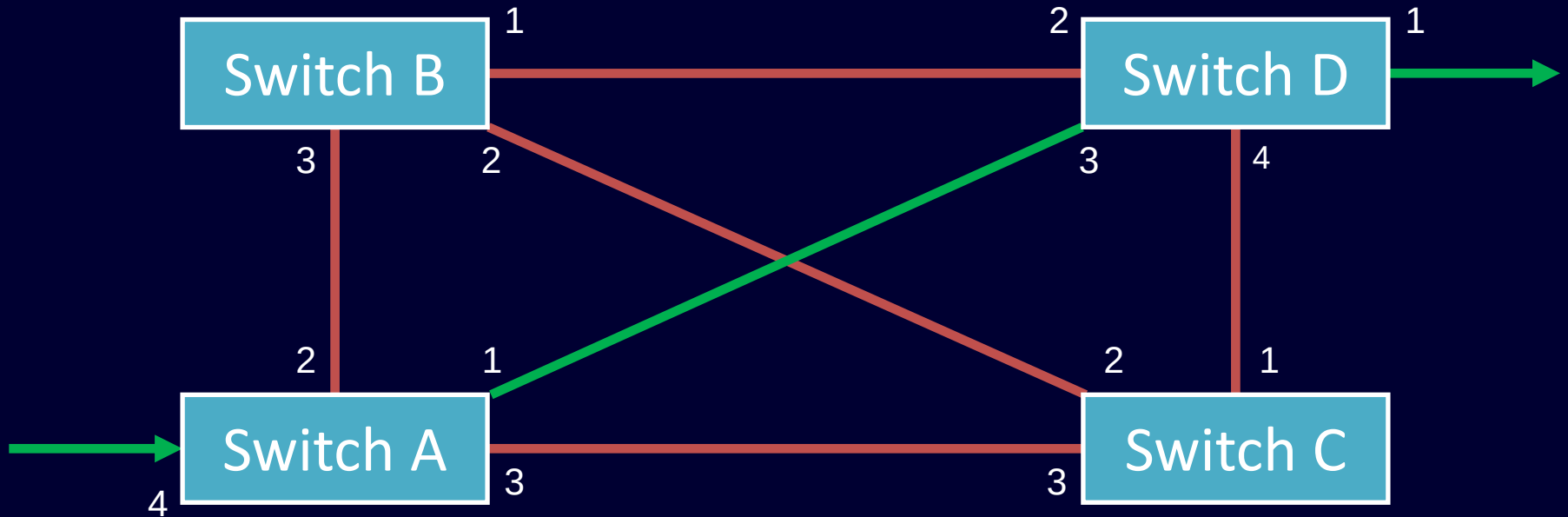
DNP Message Processing

Ether Type	DST IP	IP Protocol	DST TCP Port	Action
IPv4	37.118.14.227	TCP	20000	Forward Port: 3

Separate SCADA and Engineering Access

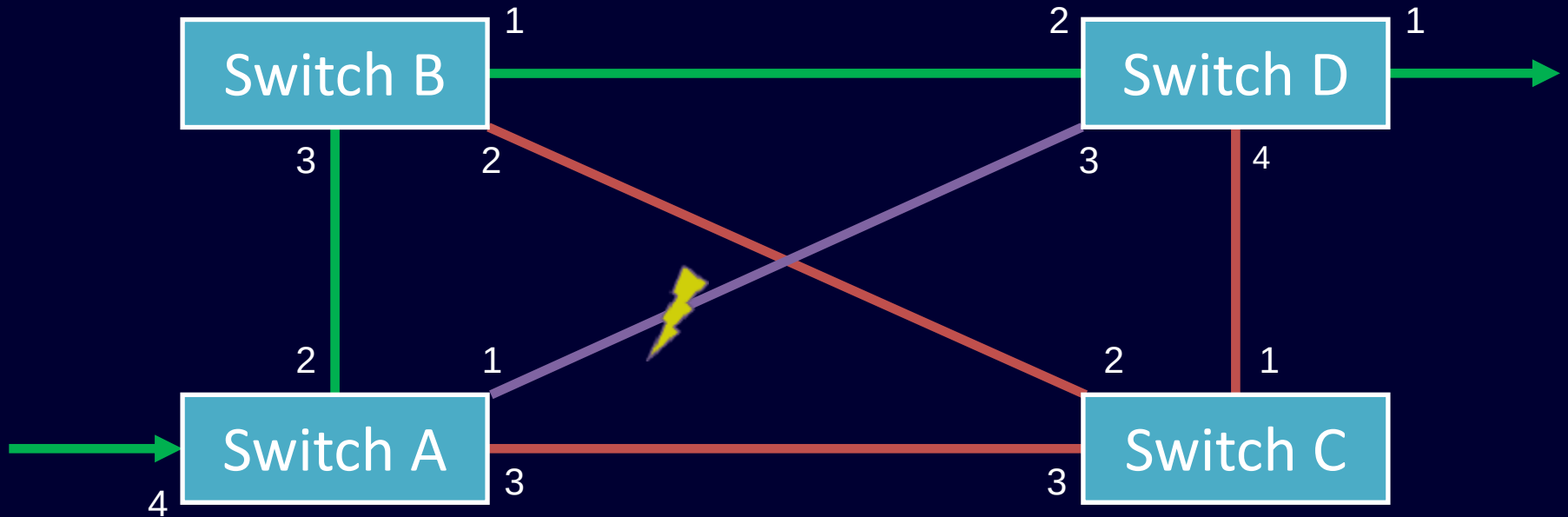
Ether Type	DST IP	IP Protocol	DST TCP Port	Action
IPv4	37.118.14.227	TCP	20000	Forward Port: 3
IPv4	37.118.14.227	TCP	23	Forward Port: 4

SDN Network Configuration



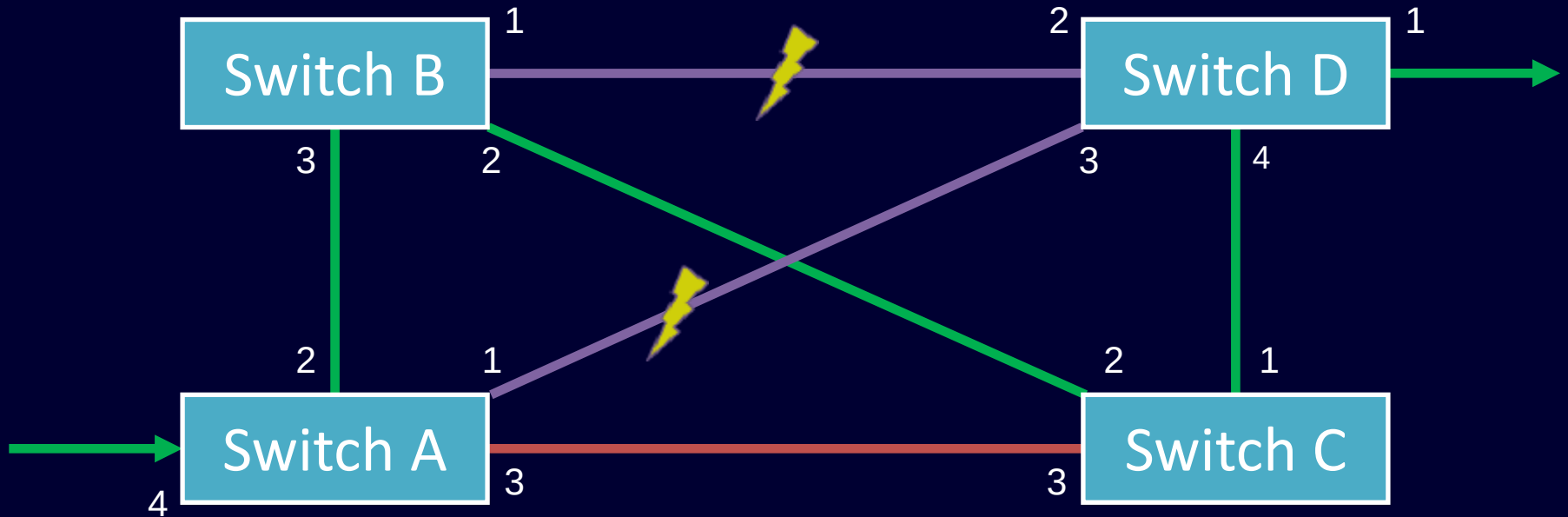
Switch	Port Groups
A	1, 2, 3
B	1, 2, 3
C	1, 2
D	1

SDN Network Configuration (One Fault)



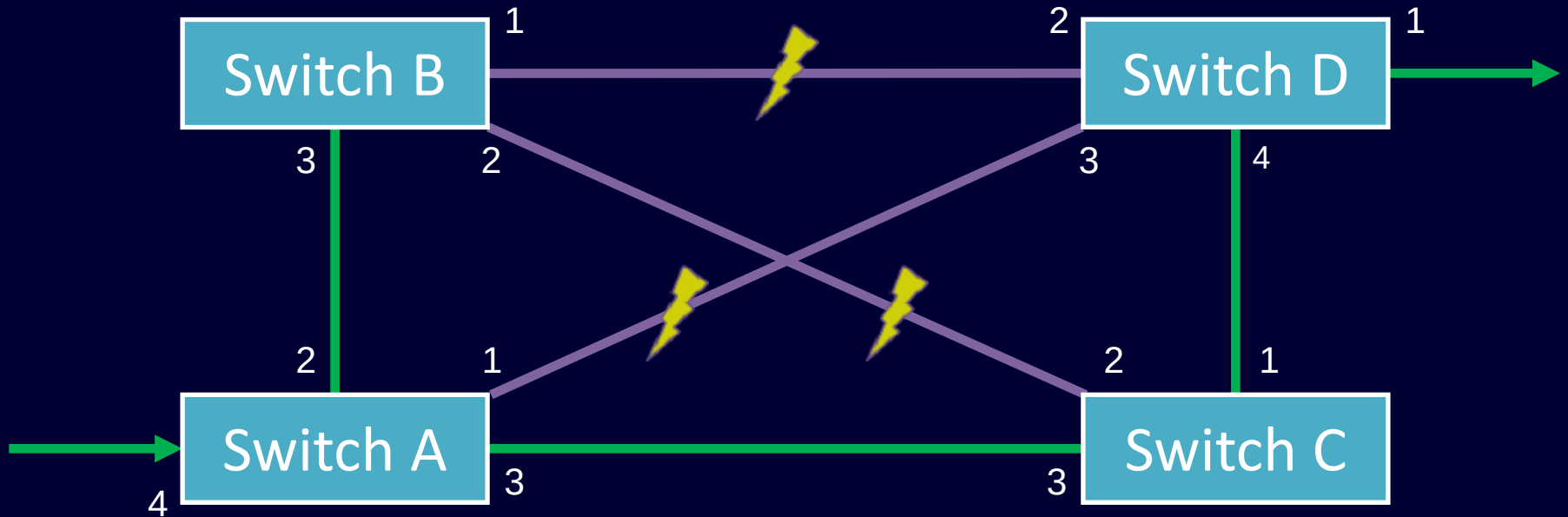
Switch	Port Groups
A	1, 2, 3
B	1, 2, 3
C	1, 2
D	1

SDN Network Configuration (Two Faults)



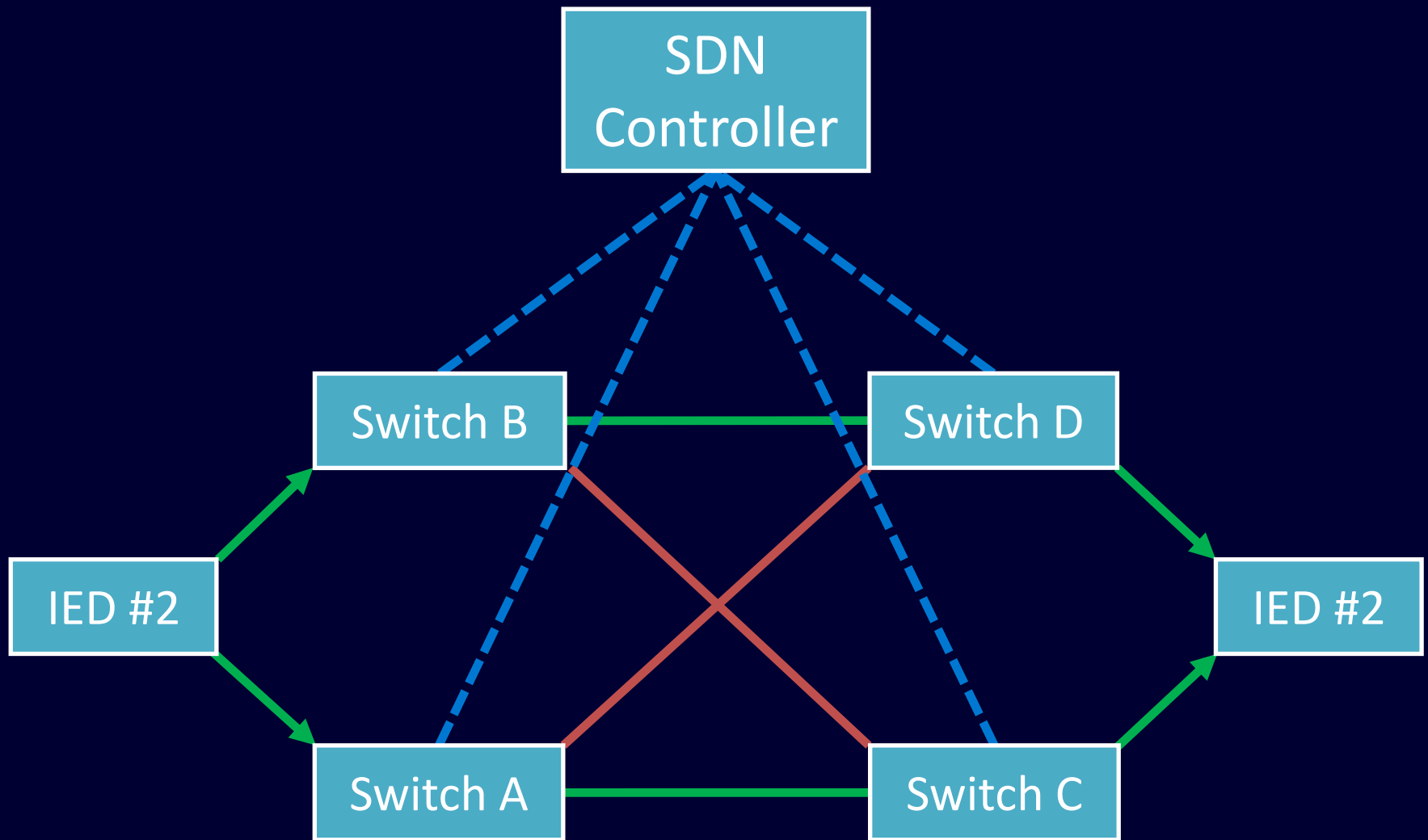
Switch	Port Groups
A	1, 2, 3
B	1, 2, 3
C	1, 2
D	1

SDN Network Configuration (Three Faults)

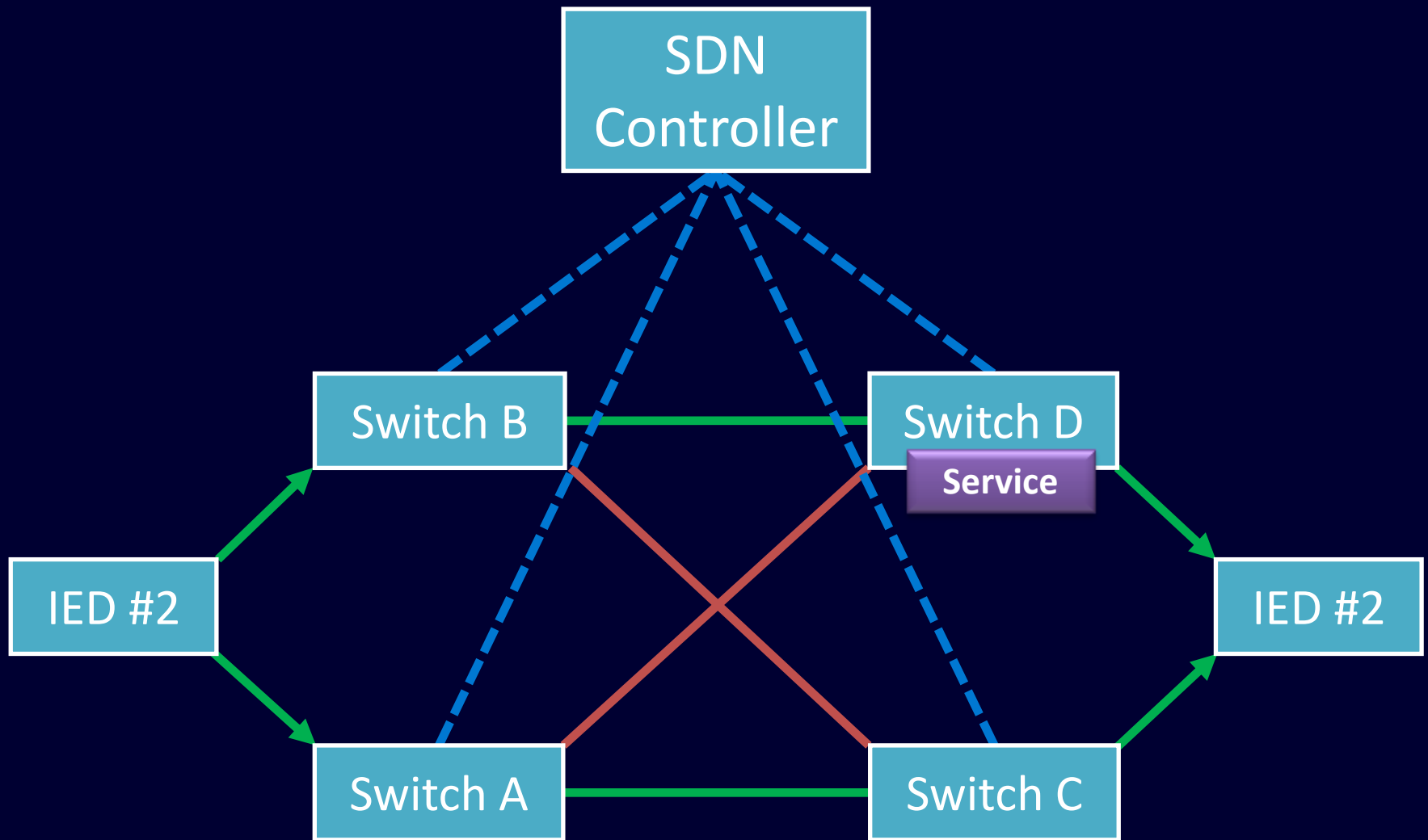


Switch	Port Groups
A	1, 2, 3
B	1, 2, 3
C	1, 2
D	1

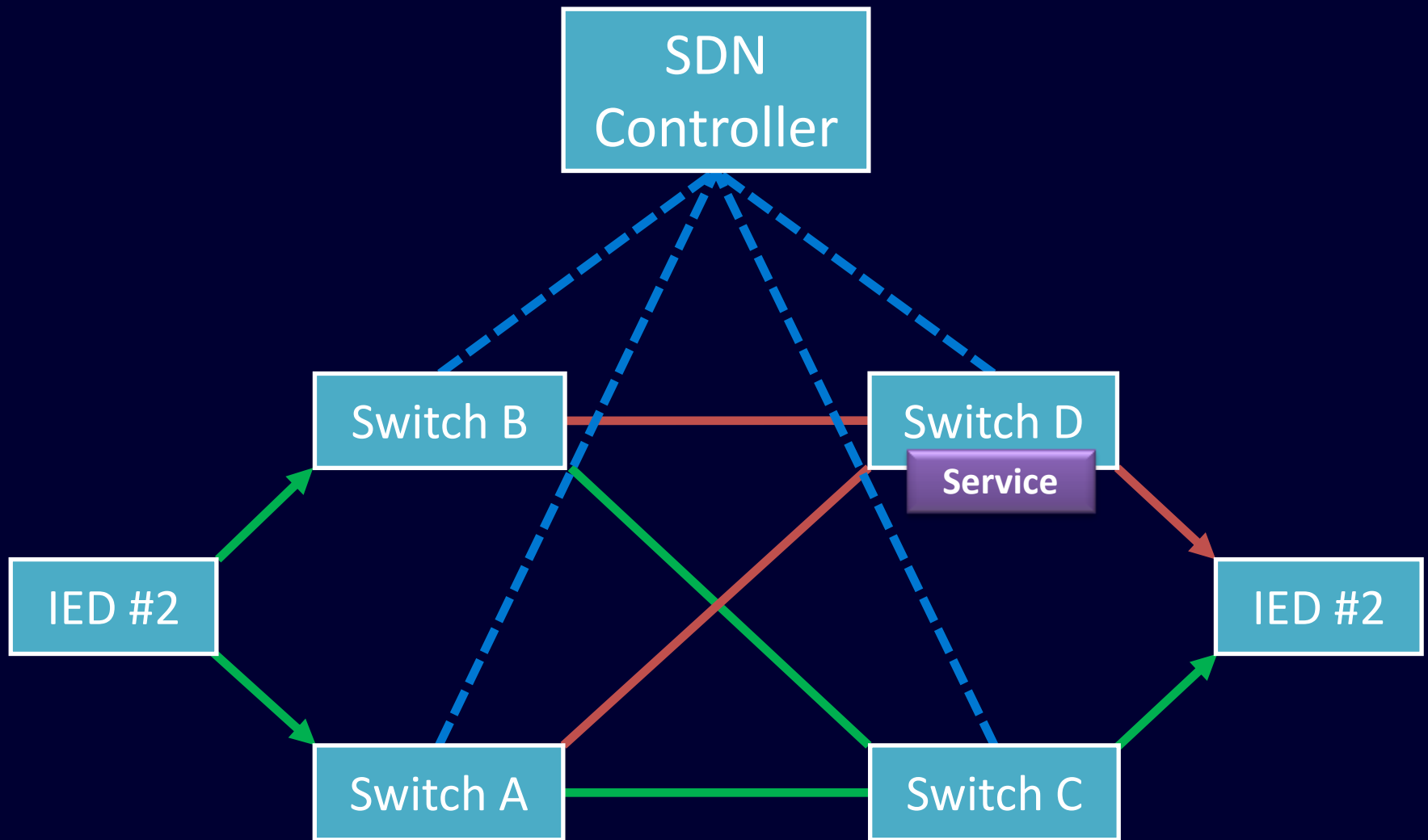
Planned Maintenance



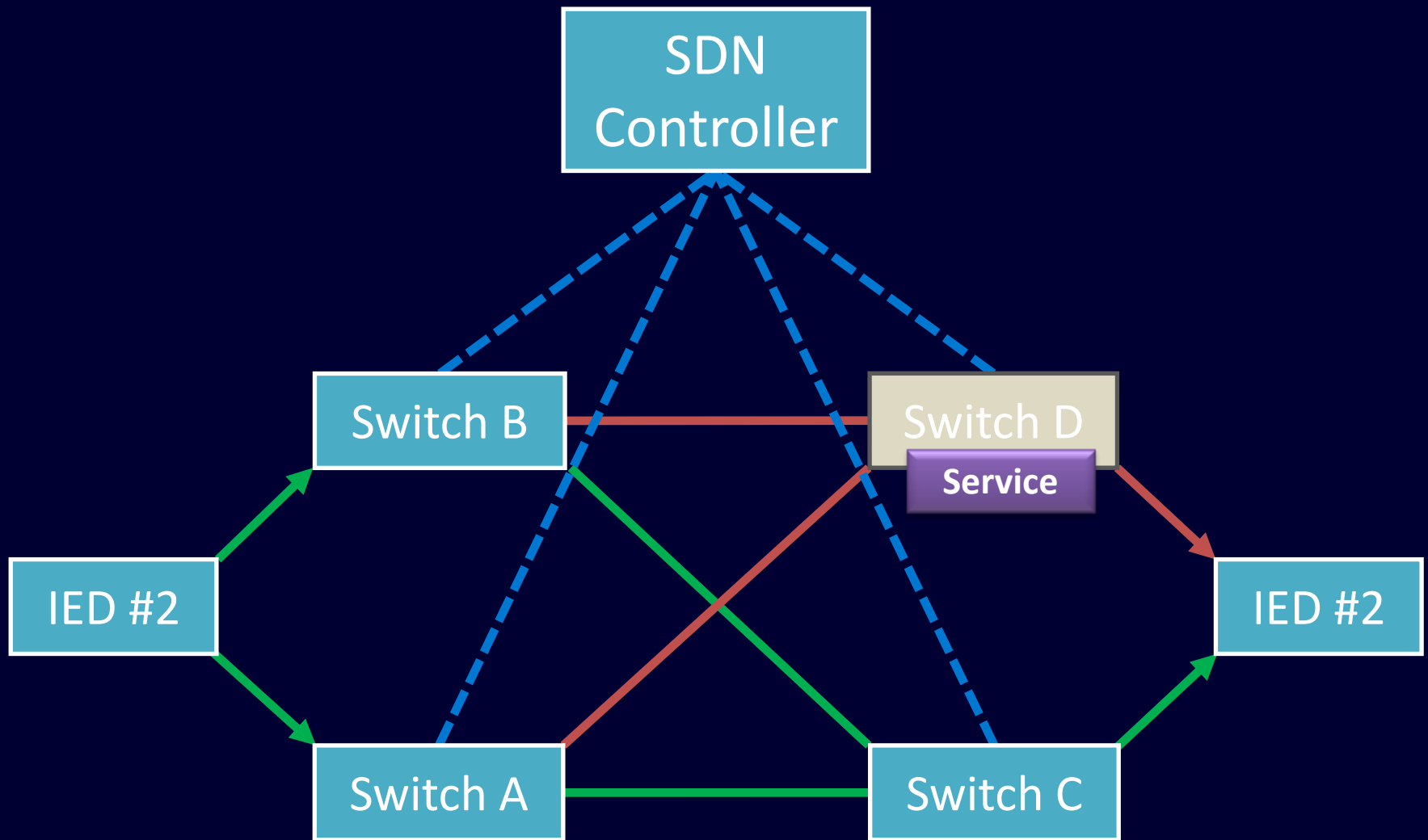
Planned Maintenance



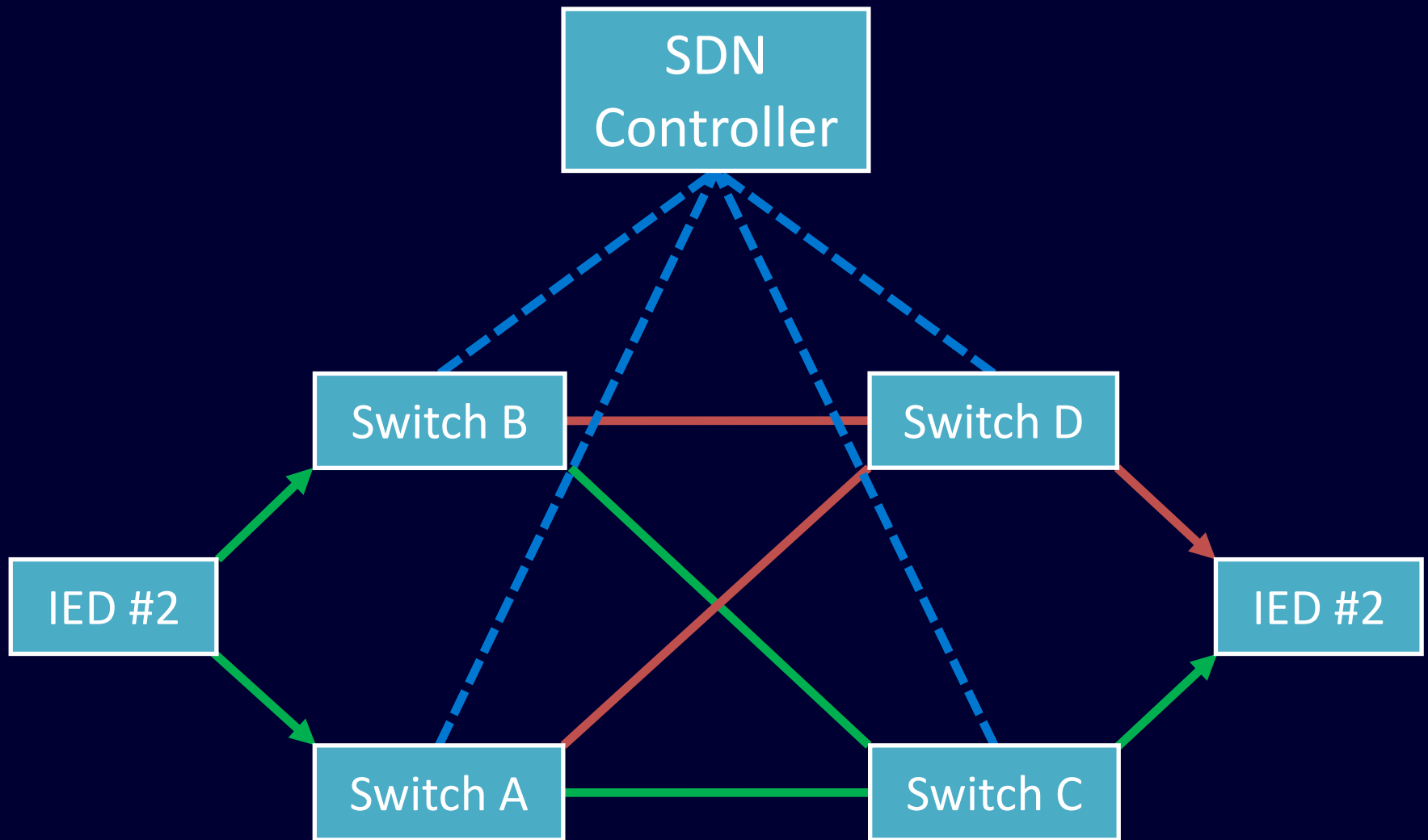
Planned Maintenance



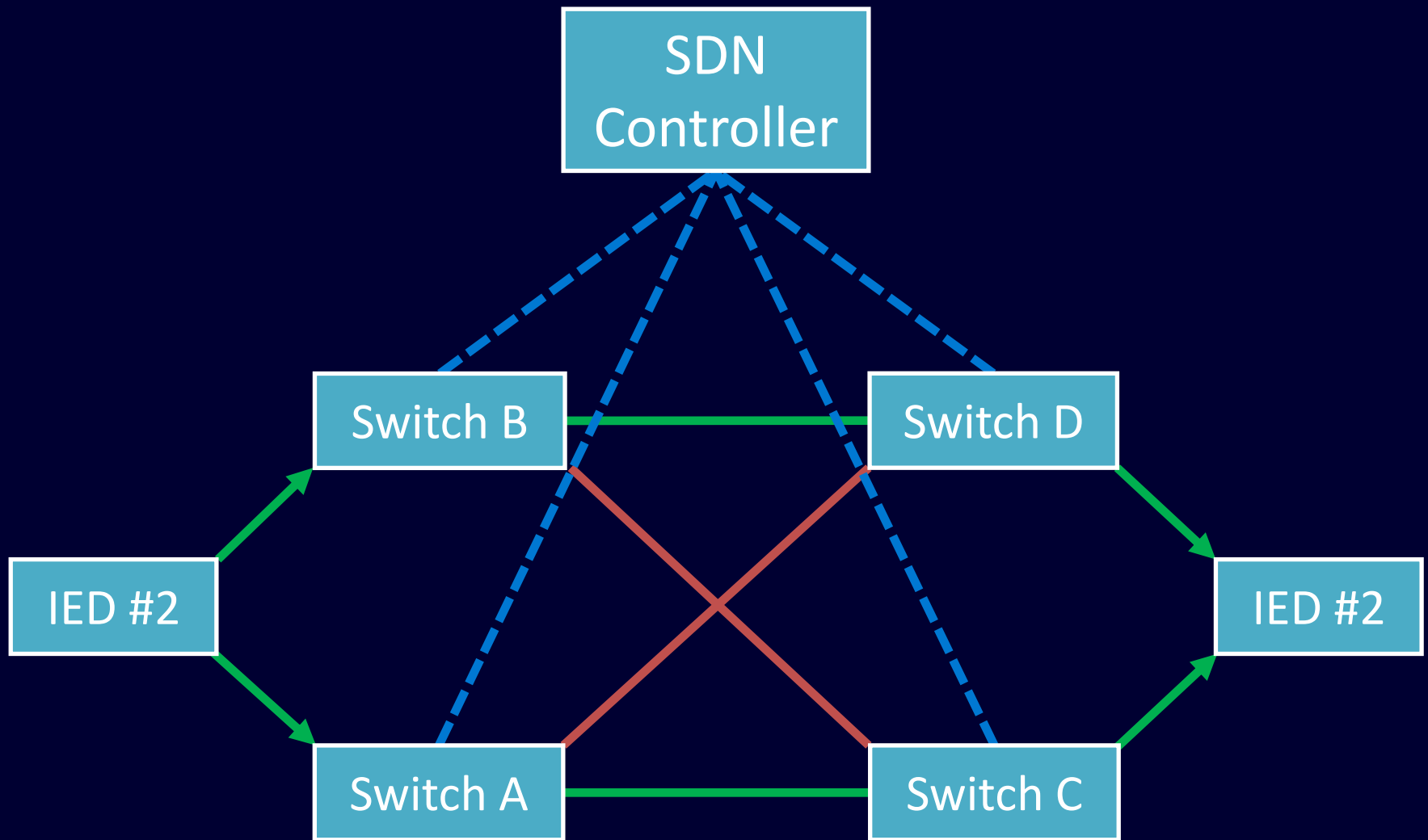
Planned Maintenance



Planned Maintenance



Planned Maintenance



Conclusions

	Traditional	SDN
Network architecture	Plug and Play	Engineered
Network redundancy	Hot Standby	Engineered
Network healing	Dynamic (slow)	Static (fast)
Network verification	Field Test	Model, Stage, Test