Enabling Layer-2 Path Tracing in SDN through Context Encoding






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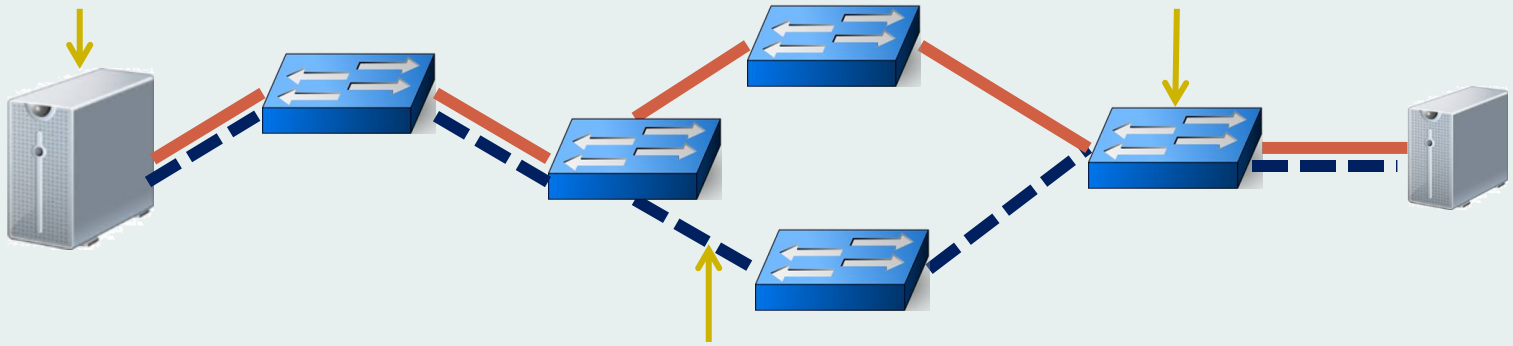
Path Tracing in SDN

1. Correctness:
Passively monitor
the real packets

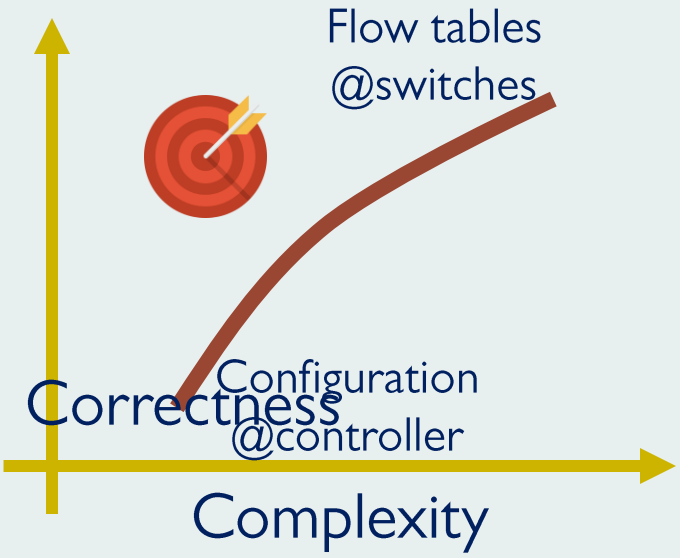
2. Scalability:
Minimal operational,
configuration cost



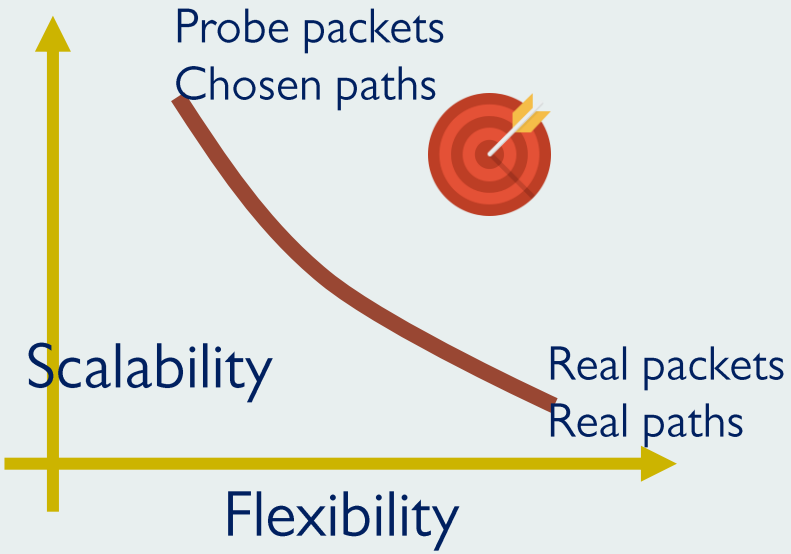
1. Correctness:
Trackdown the real
path in the data plane

Challenges from Accuracy and Scalability

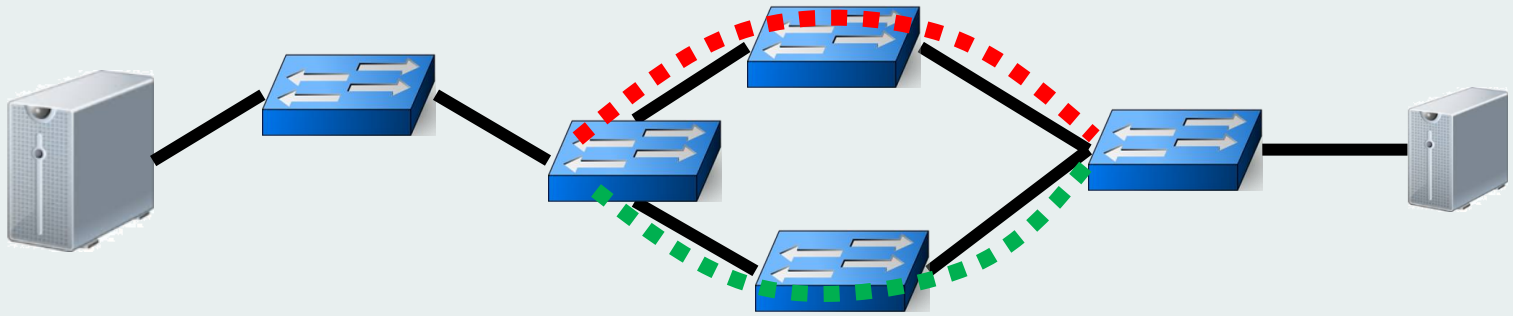
Correctness vs. Complexity



Scalability vs. Flexibility



Reducing Tracing Space

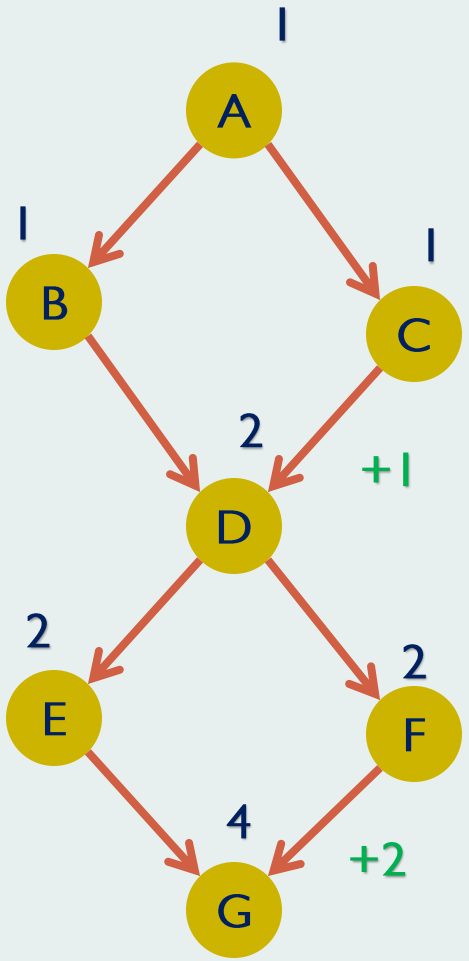


- # of paths is small
  - Monitoring pathlets
- Tagging packets to differentiate paths
  - Precise calling context encoding (PCCE) is utilized
    - Using K bits to differentiate $>2^K$ paths

Precise Calling Context Encoding[1]

1. for s in switches:
    PP[s] = calculatedPossiblePaths(s, A)

2. for s in switches:
for I = <p, s> in getIncomingEdges(s):
    if I is the first:
        continue
    else:
        PN[I] = PP[s]



Sumner, William N., Yunhui Zheng, Dasarath Weeratunge, and Xiangyu Zhang. "Precise Calling Context Encoding." *Software Engineering, IEEE Transactions on* 38, no. 5 (2012): 1160-1177.

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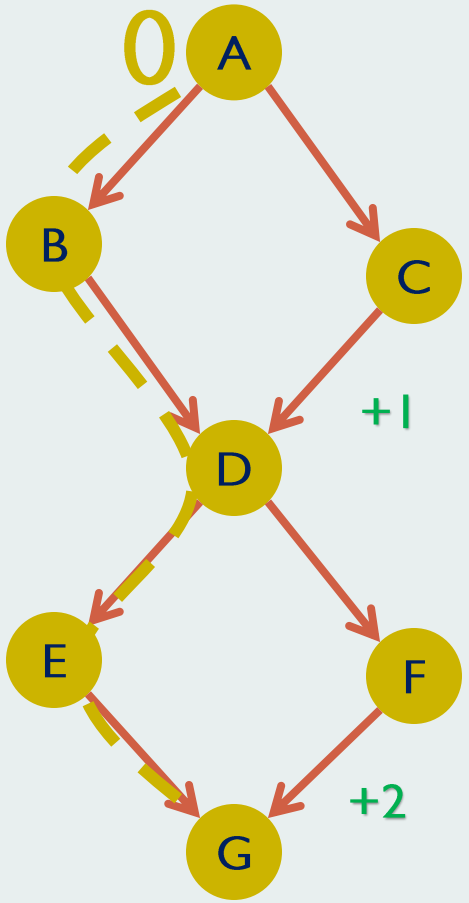
3. for p in DepthFirstSearchPaths(G):
    ID[p] = sum(PN[I] for I in p)



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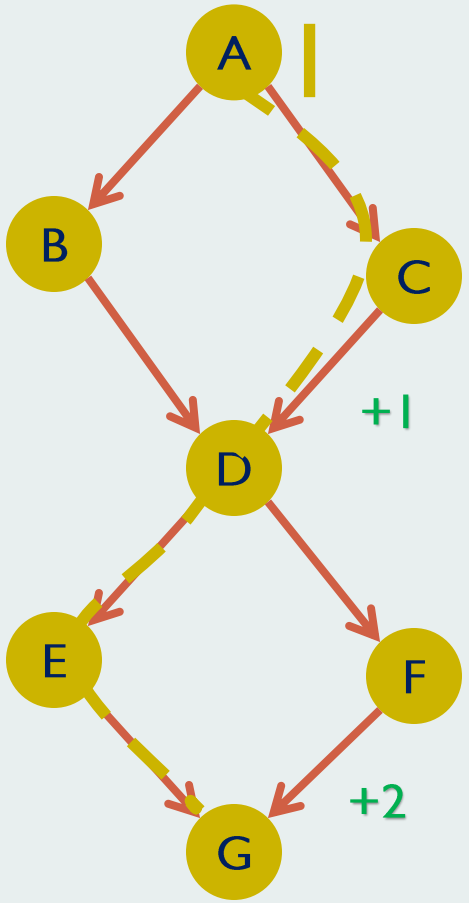

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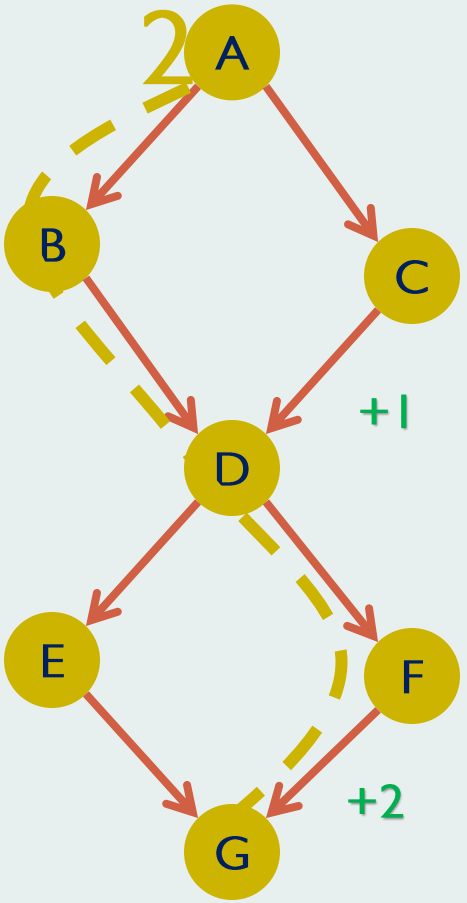

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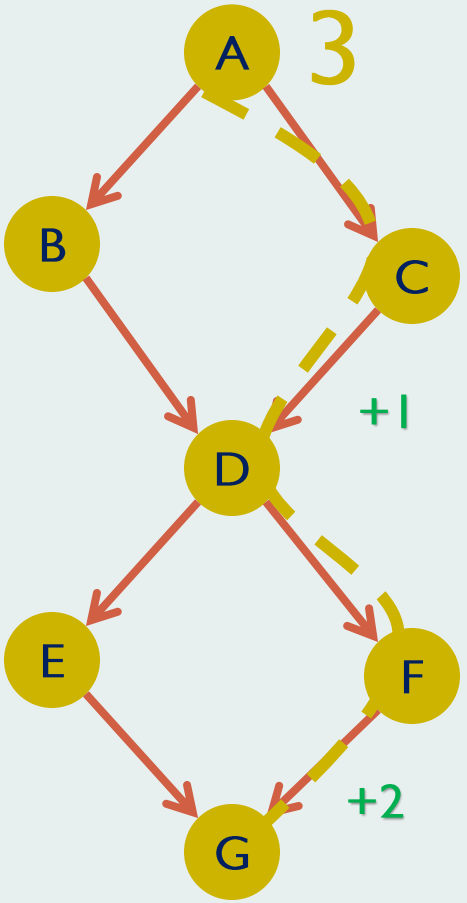

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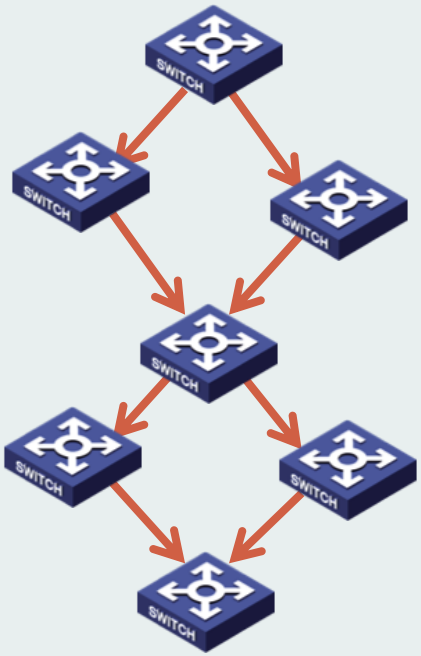
Codebook of Path IDs



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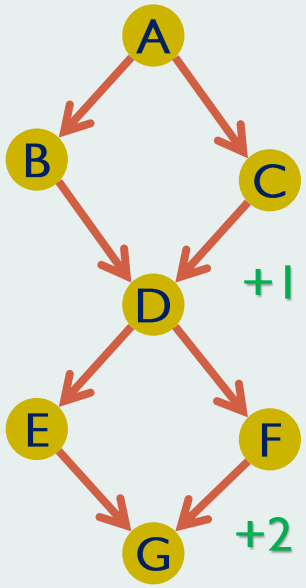
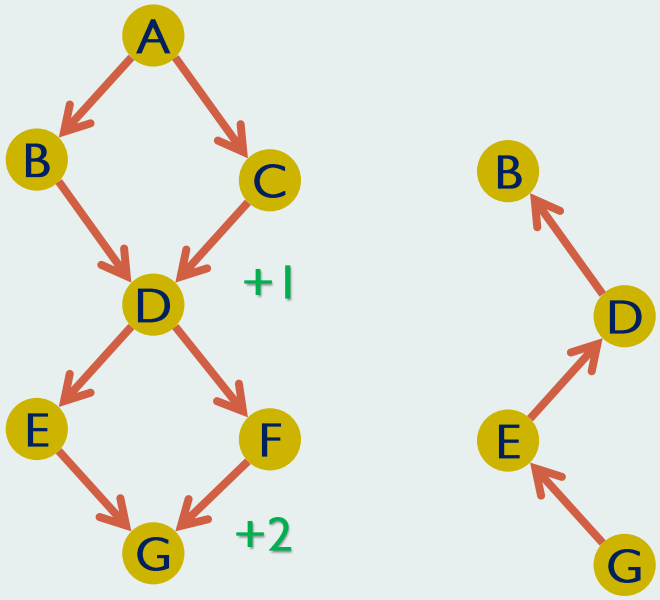


ID	dst	path
0	G	ABDEG
2	G	ABDFG
1	G	ACDEG
3	G	ACDFG
…		
…		
…		

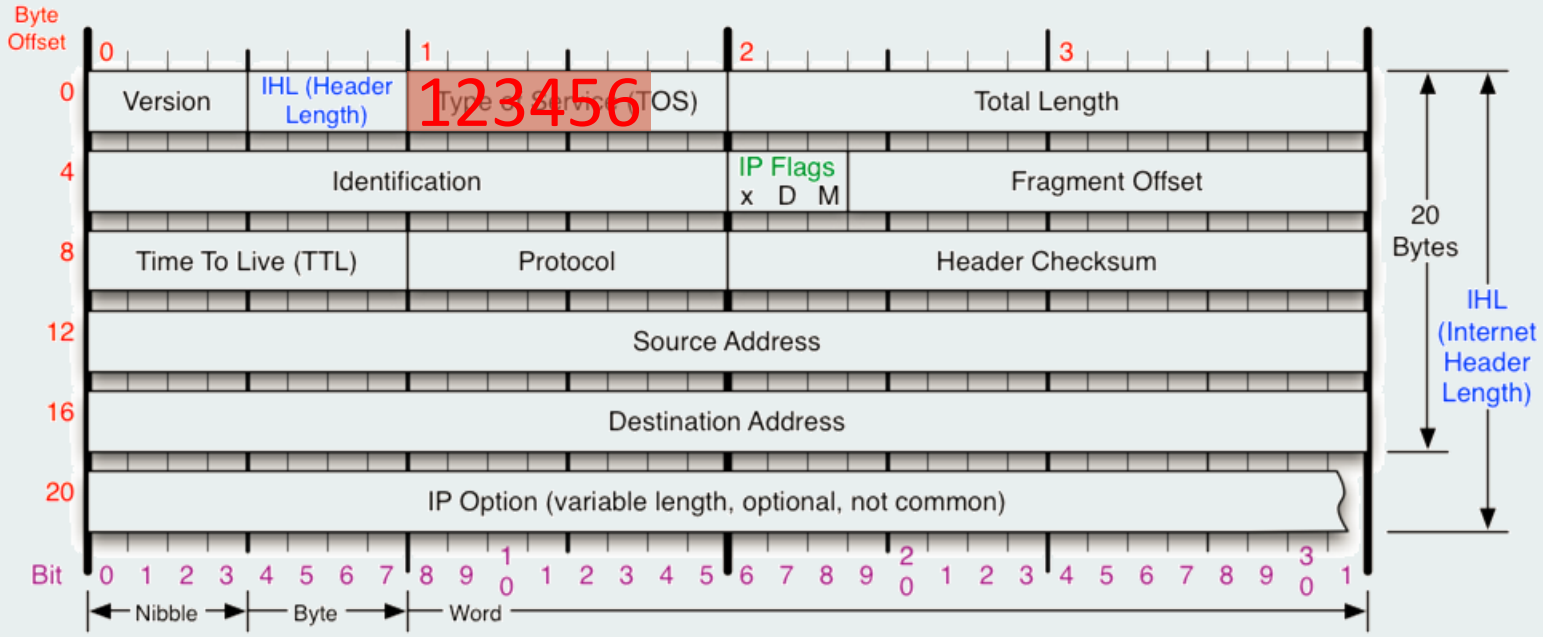
Codebook of Path IDs



ID	dst	path
0	G	ABDEG
2	G	ABDFG
1	G	ACDEG
3	G	ACDFG
0	**B**	**GEDB**
…		
…		

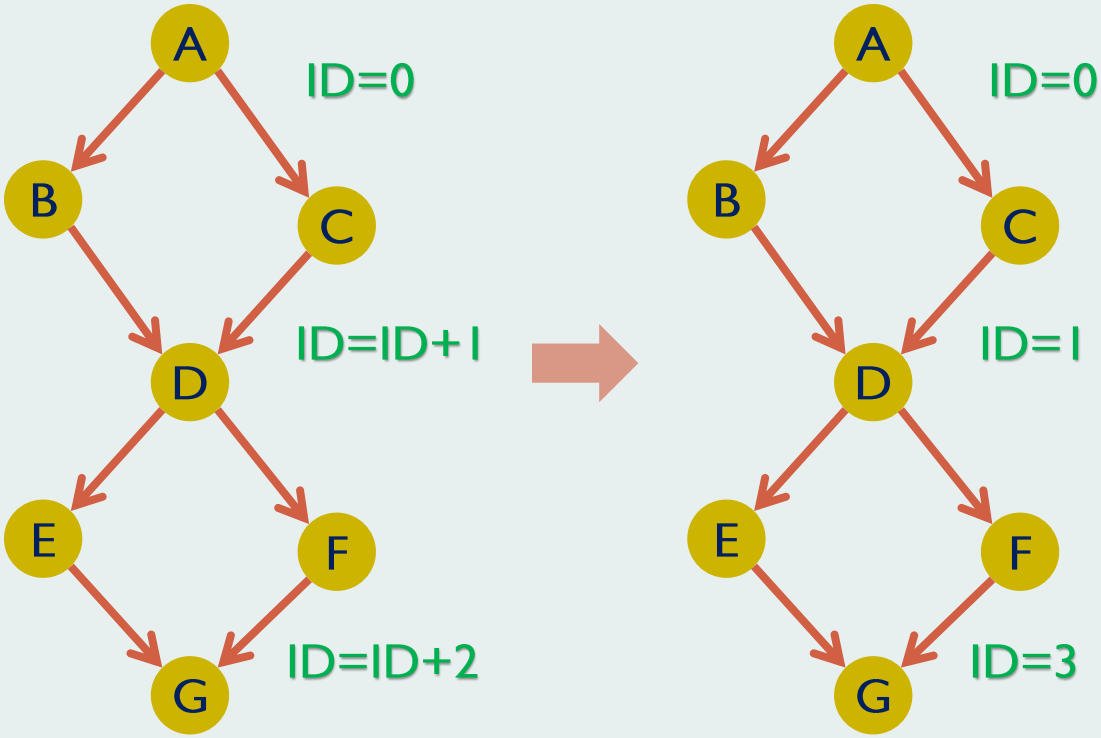
- `ID` + `dst` can uniquely identify a path
  - As long as `ID`s can be imprinted into packets, the paths can be determined

Where to Store Encoded Path IDs



Fayazbakhsh, Seyed Kaveh, Vyas Sekar, Minlan Yu, and Jeffrey C. Mogul. "FlowTags: enforcing network-wide policies in the presence of dynamic middlebox actions." *HotSDN* 2013.

Enabling Actions of "ID=ID+X"



Directly assign values instead of increment

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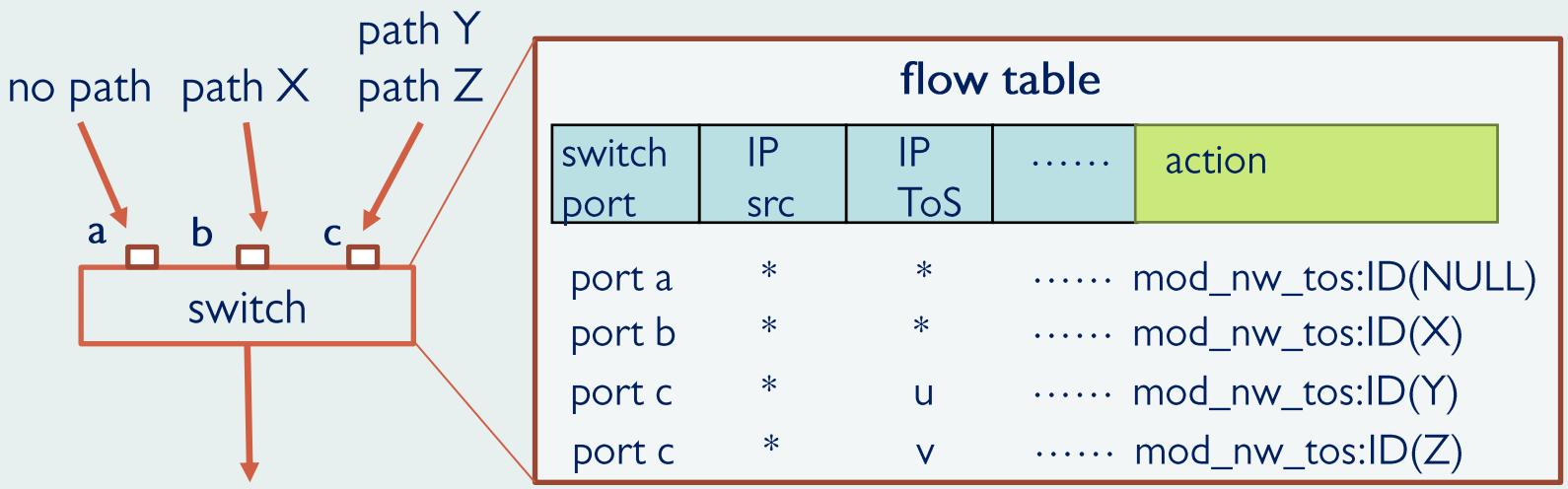
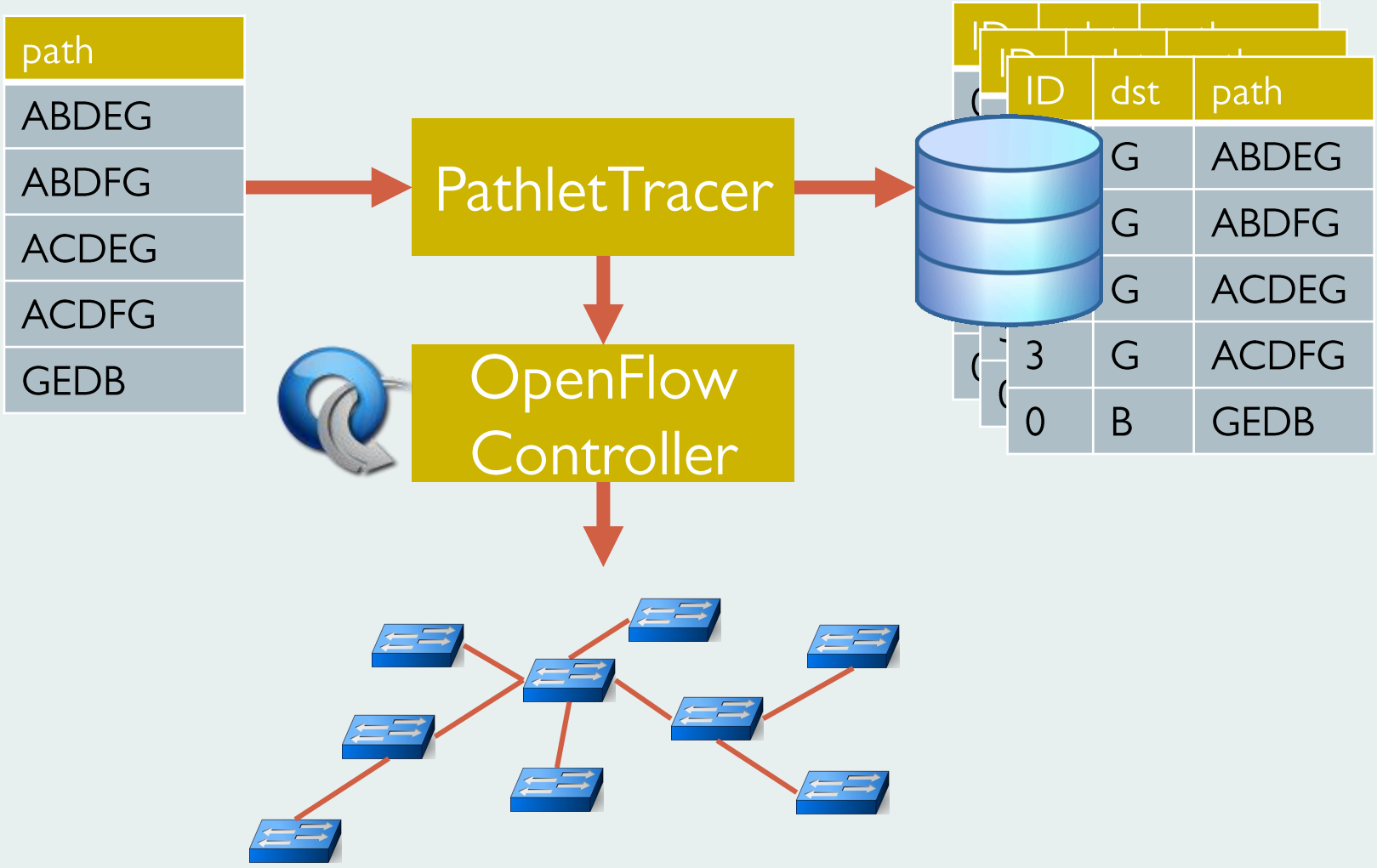


Branch enumerating ingress ports and paths

- Port 'a': port with no path
- Port 'b': port with one path
- Port 'c': port with multiple paths

PathletTracer: Path Tracing System



Conclusions

- A scalable data-plane path tracing application for SDN networks
  - Accuracy: data plane tracing
    - Tagging flows with path identifiers
  - Scalability: calling context encoding
    - Tracing more than 2^K paths by re-using K bits in packet headers

Thank You! Questions?