Privacy-Preserving Interdomain Routing at Internet Scale

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DFG Deutsche Forschungsgemeinschaft

CROSSING

Disclaimer

Privacy-Preserving

Interdomain Routing

at Internet Scale

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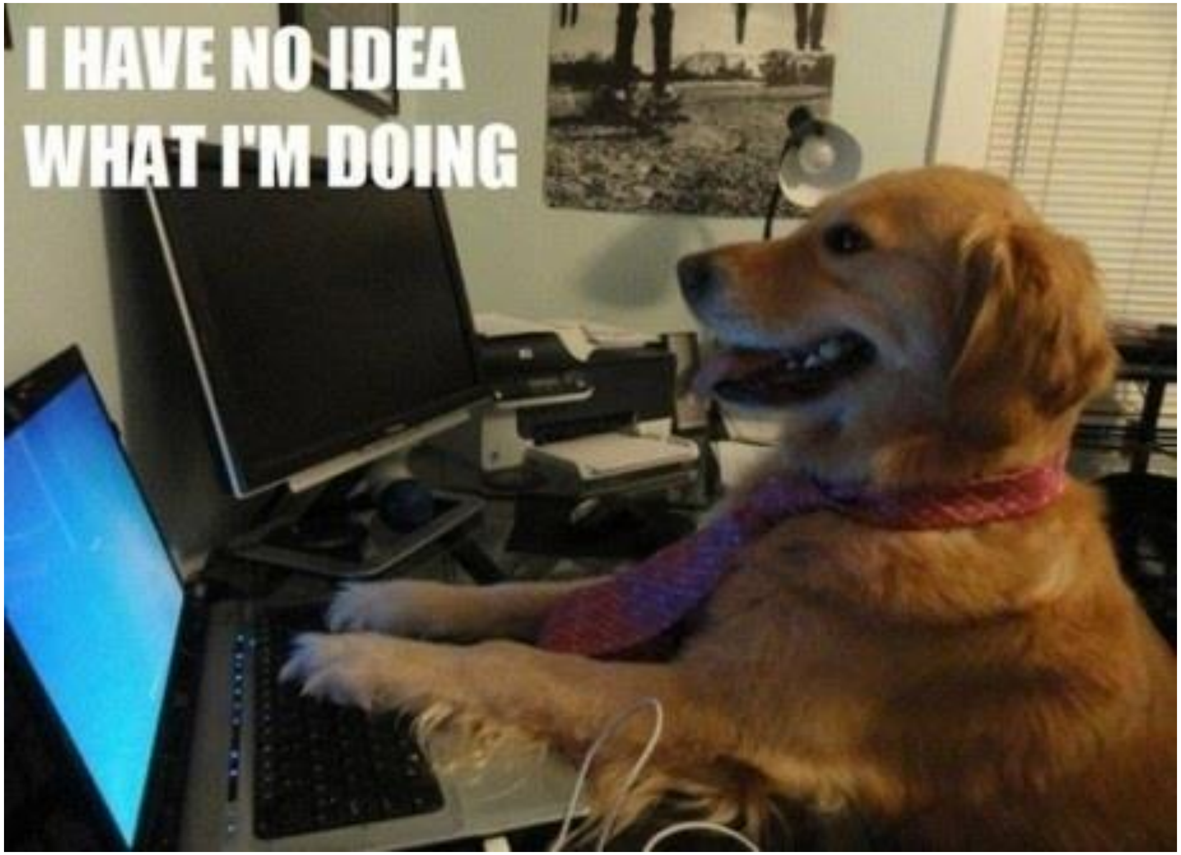
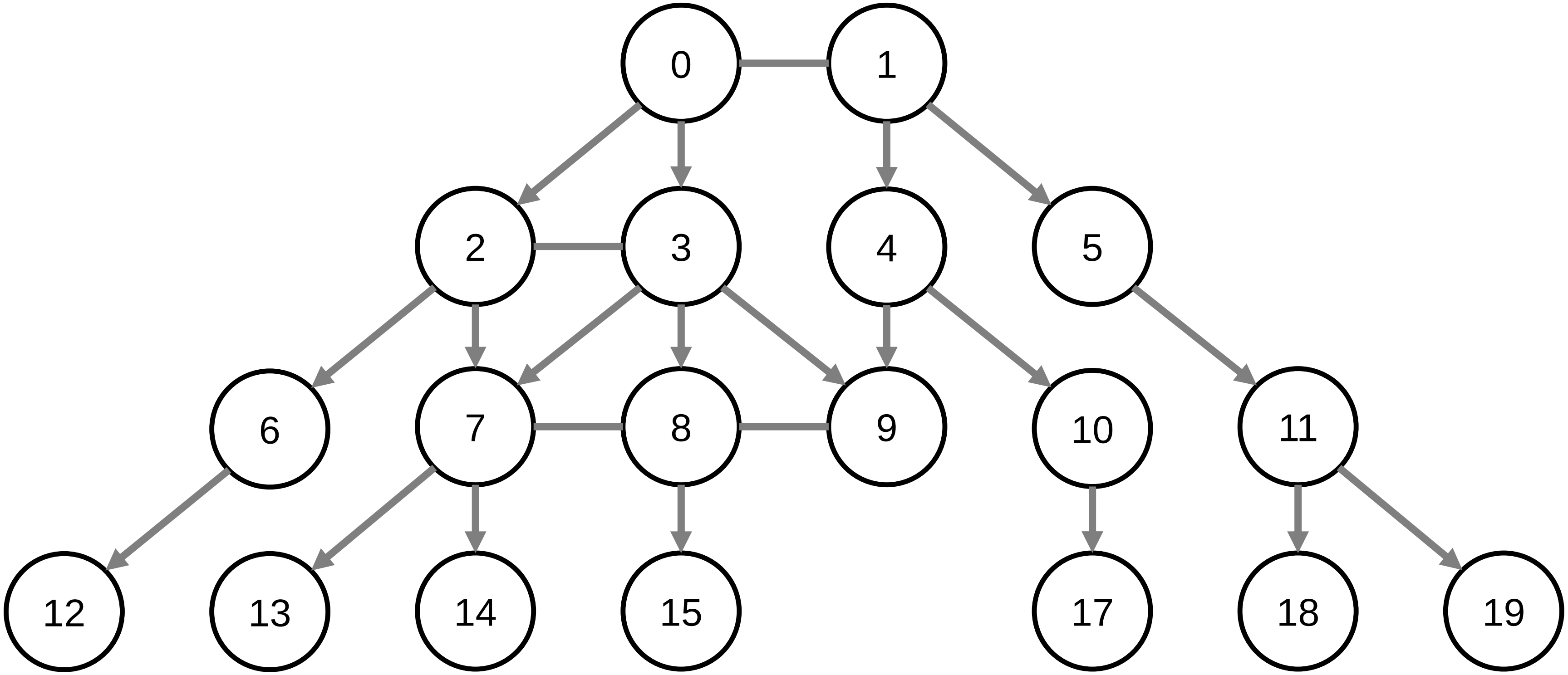


What is BGP? (Approximation)

Compute all the routes to AS16.



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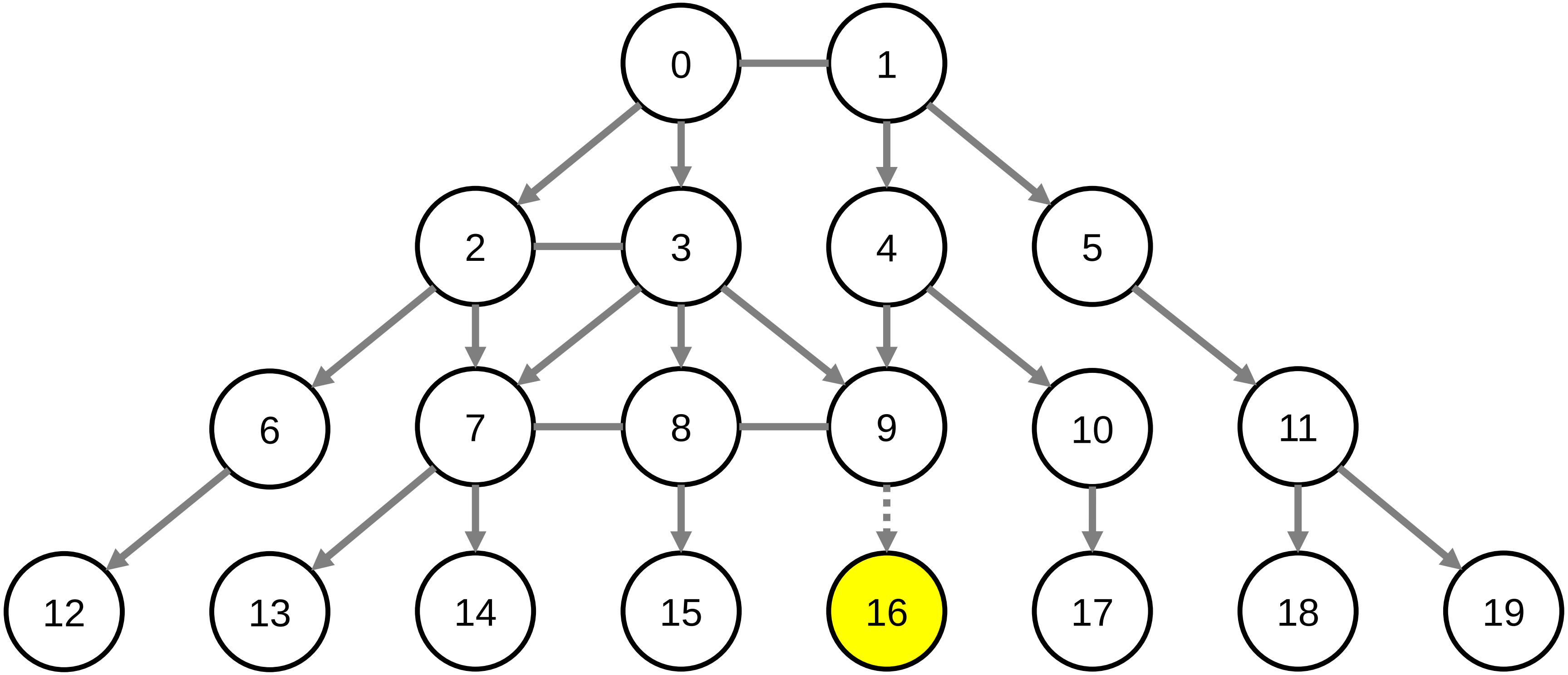
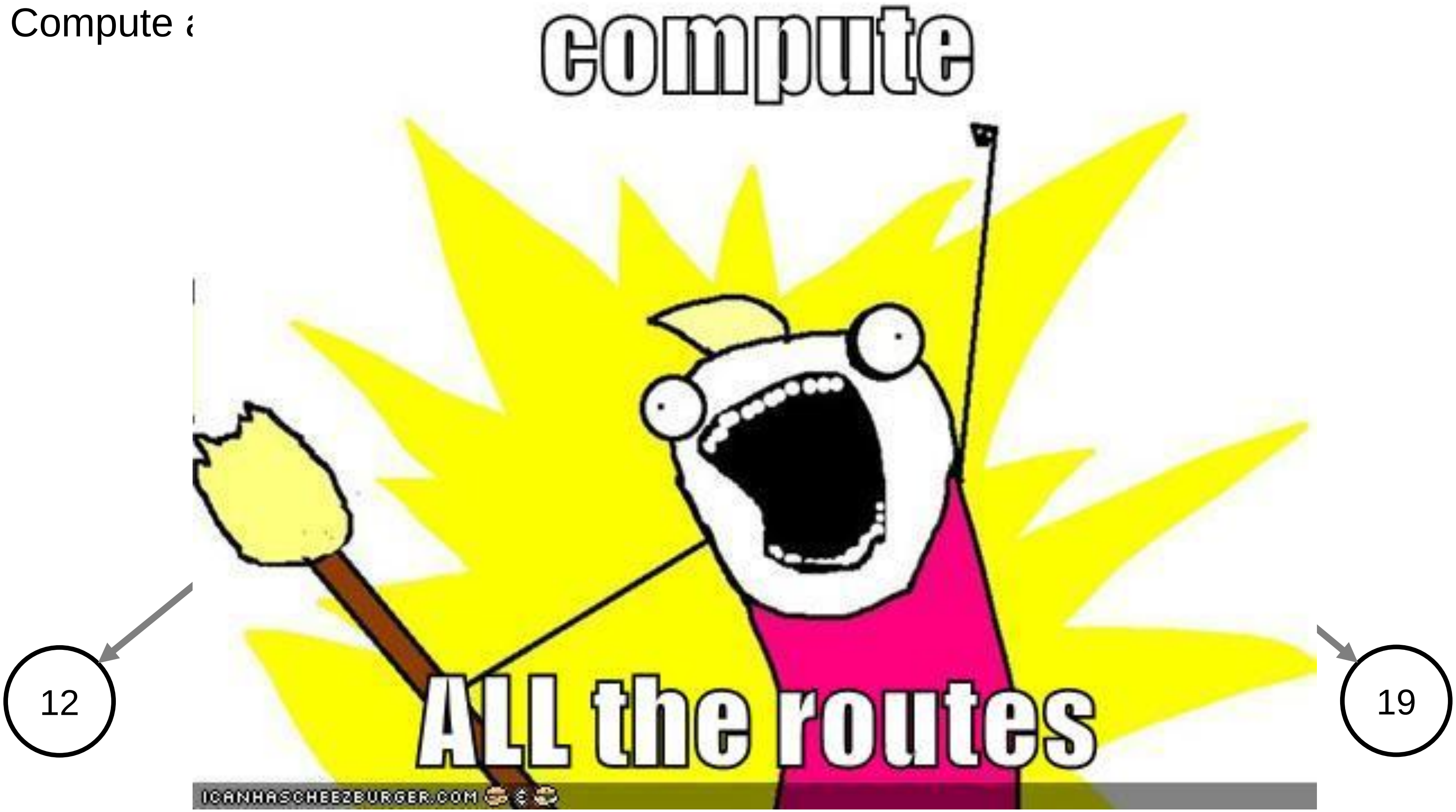
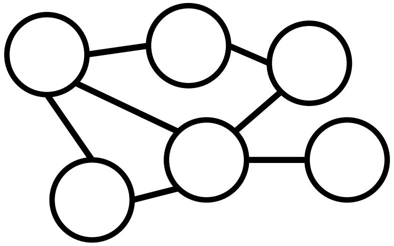


What is BGP? (Approximation)

Compute a



Privacy-Preserving Inter-Domain Routing



Main problems of BGP: Convergence & Privacy

Original idea from [GSP$^+$12] – Centralizing + SMPC!

Problem: only for toy example, impractical runtime.

This work:

Real-world application of secure computation

56k autonomous systems with 239k connections!

We have two solutions that protect:

the **relations** between nodes: customer / provider or peering

the **export policy** and **preferences** of nodes

Generic Secure Two-Party Computation

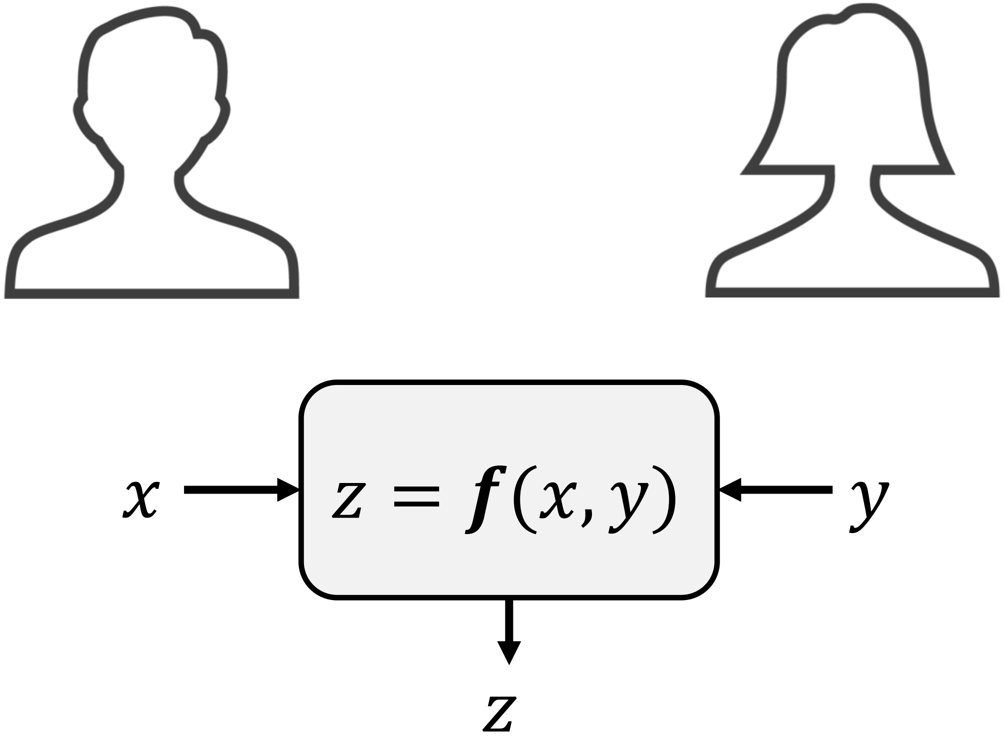
First Ideas date back to 1980s

Generic applications

This work:

Two parties

Security against semi-honest (passive) adversaries



$$x \rightarrow \boxed{z = \boldsymbol{f}(x, y)} \leftarrow y$$

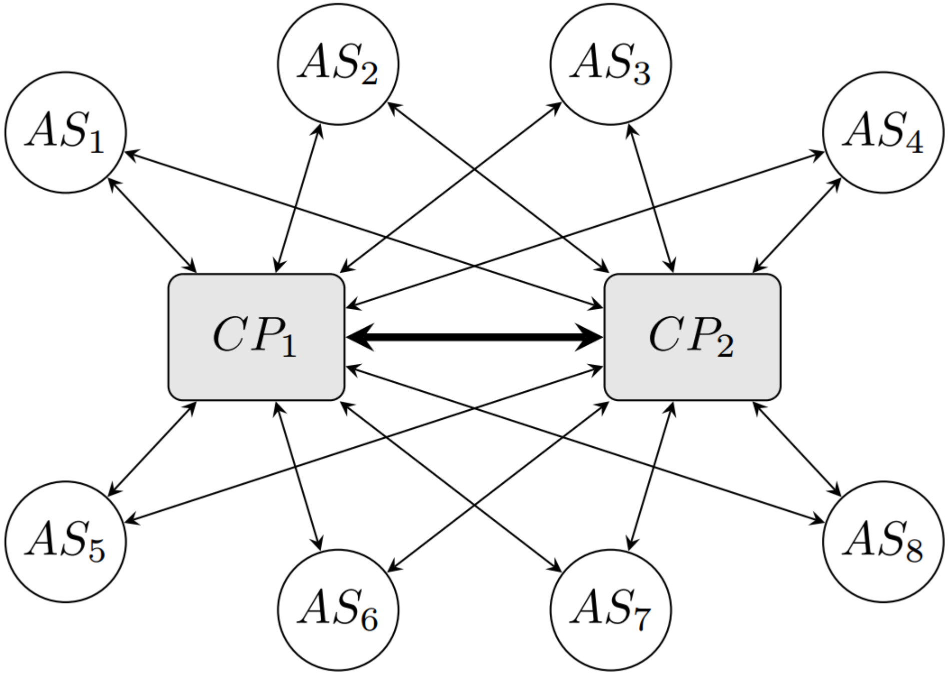
$$\downarrow$$

$$z$$

Privacy-Preserving Inter-Domain Routing

Centralized approach: Privacy-Issues solved by SMPC

- 2 computational parties (*CP*s), running our protocol
- Each node (*AS*) secret-shares his private inputs with the *CP*s



Relation-Based Routing

Routing based on **relationship** between nodes:

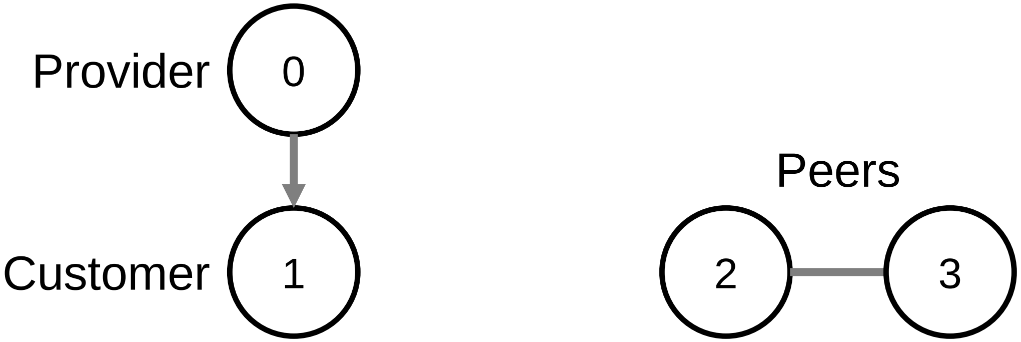
- Customers pay providers to route traffic
- Peers route traffic for free

“*Economically driven*” routing instead of shortest paths

High-level Neighbor Relation Algorithm:

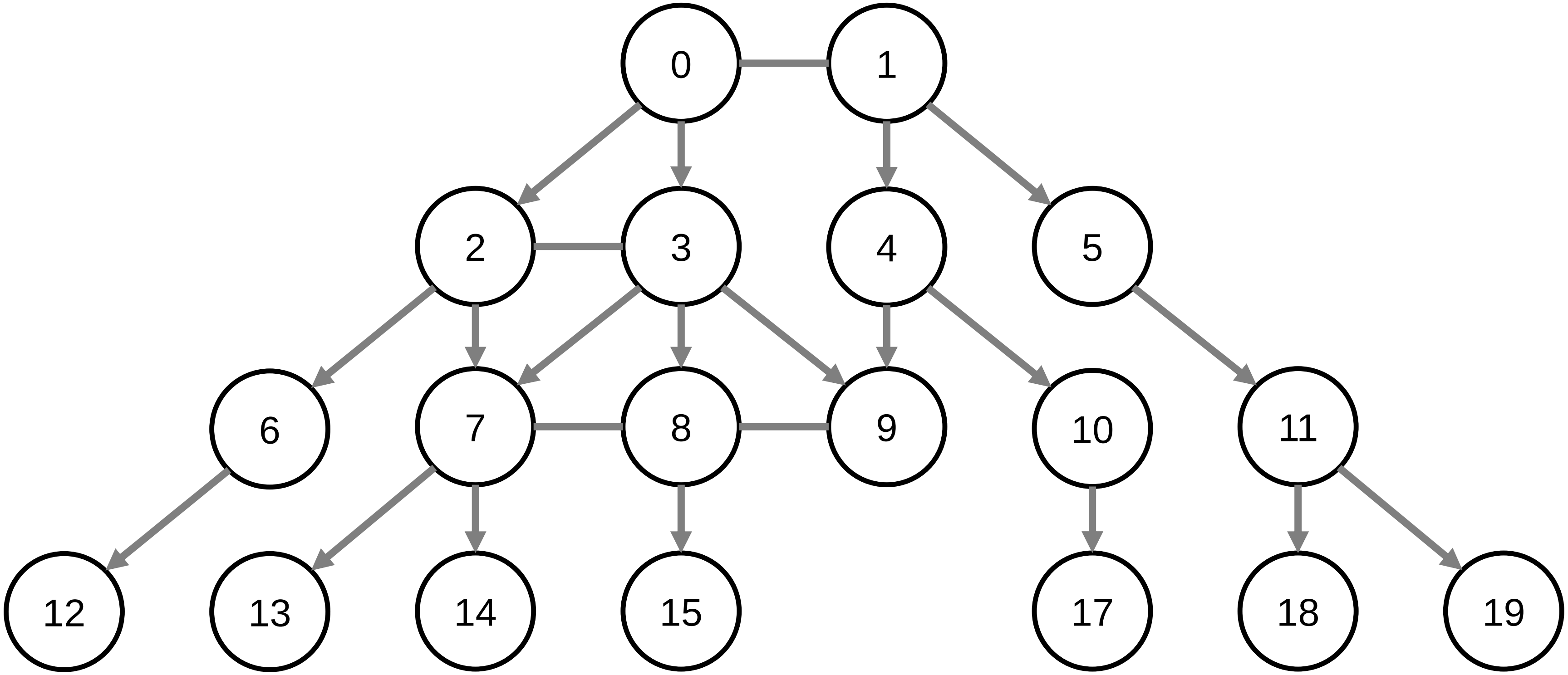
- **Plaintext input: Topology, Target AS** – Private input: **EP - Relations**
- 10 iterations for customer relation hops
- 1 iteration for peer hops
- 10 iterations for provider hops
- **Private output:** for every AS next hop to target AS

BGP Example – Notation



BGP Example

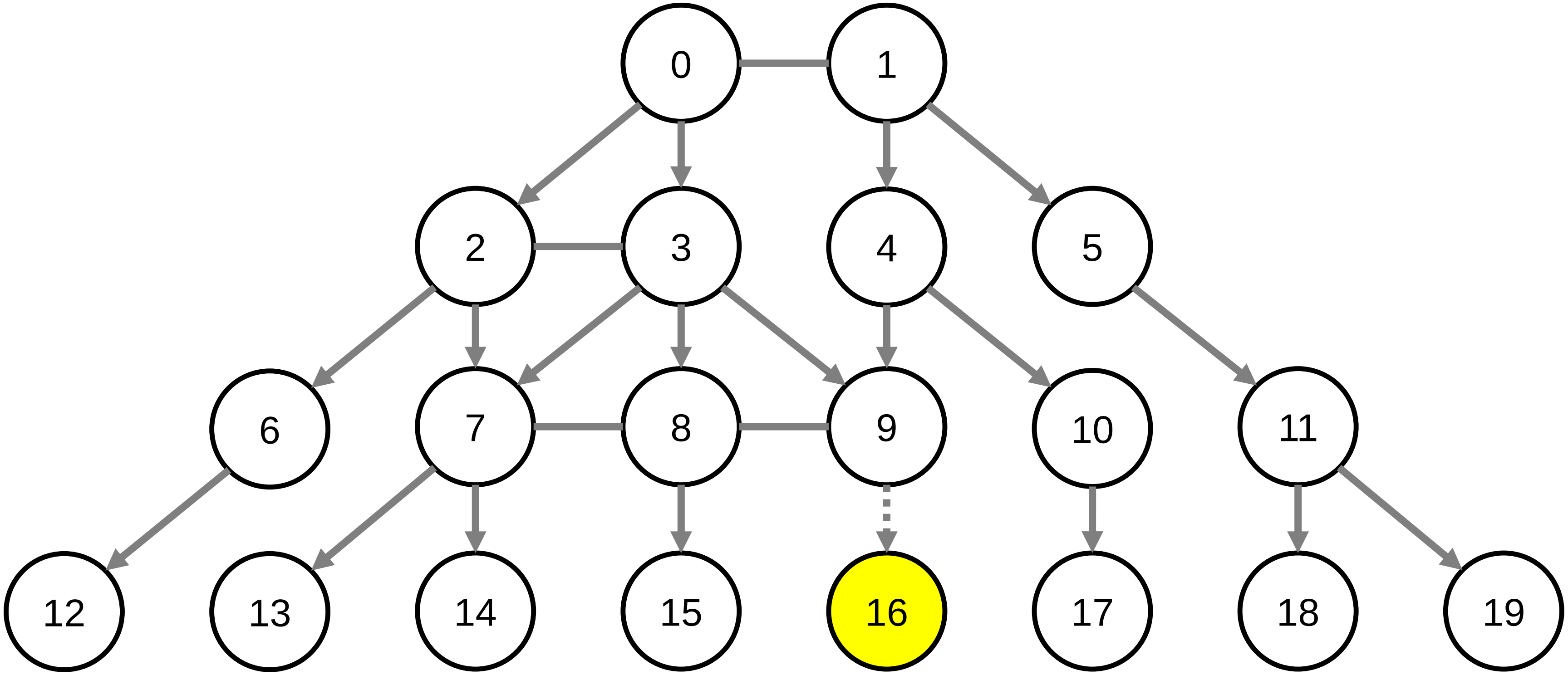
Public network topology



BGP Example

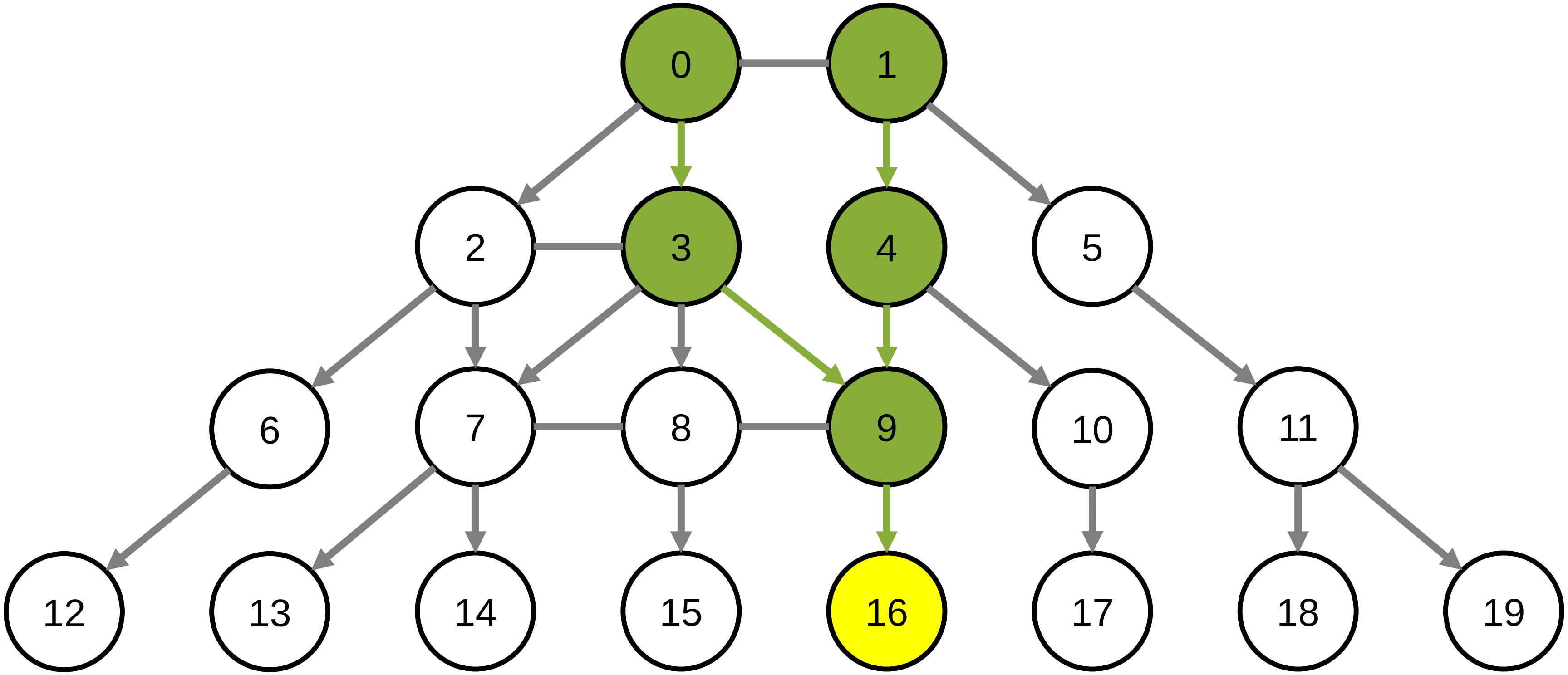
Public network topology

Node 16 is added



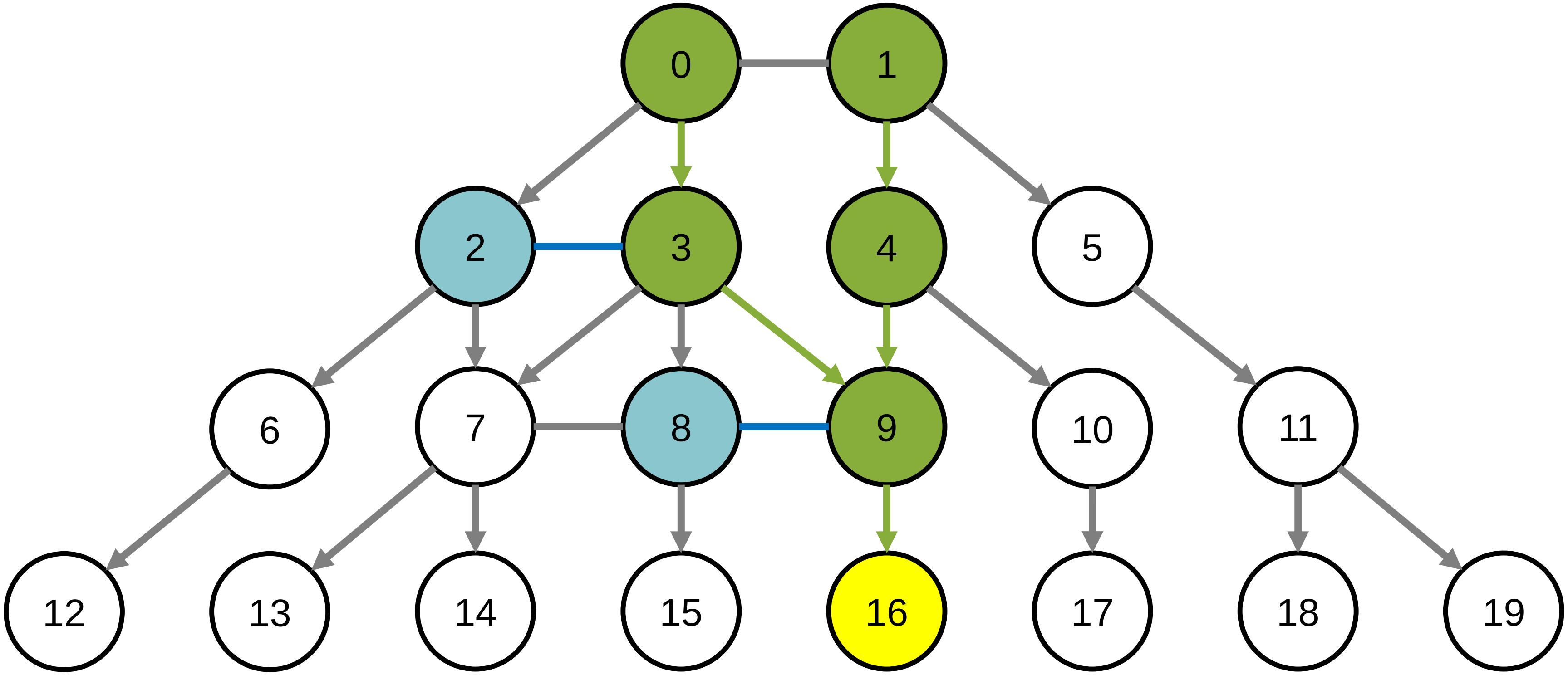
BGP Example

Routes through **customers** to 16



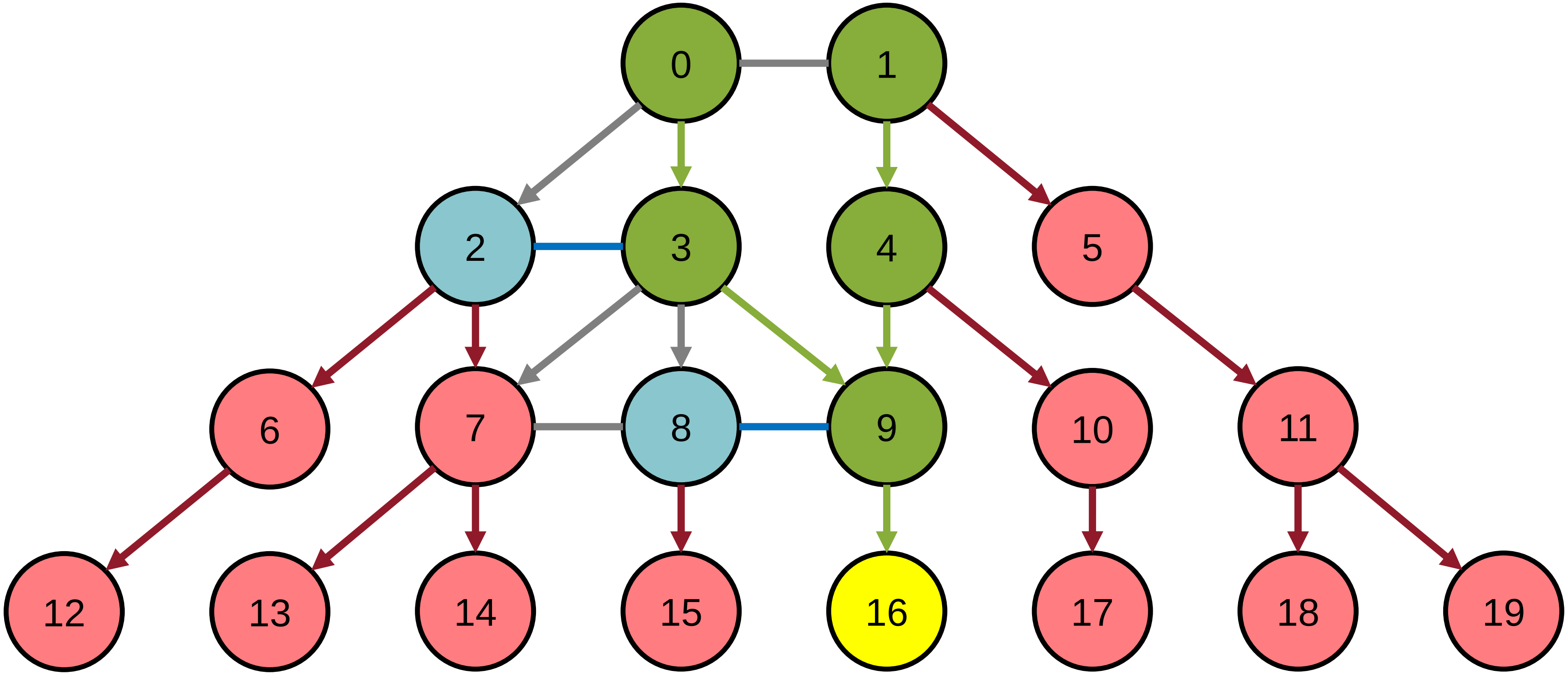
BGP Example

Routes through **peers** to 16



BGP Example

Routes through **providers** to 16



Preference-Based Routing

Routing based on **export policy** and **preference** between nodes:

- ASes decide which routes are *published (exported)*
- ASes have *preferences* for their neighbors

High-level Neighbor Preference Algorithm:

Plaintext input: Topology, Target AS – Private input: **EP - Preferences**

```
21 Iterations:
for all ASes:
  for all of the ASes neighbors:
    find highest preference neighbor with published route to target
```

Private output: for every AS next hop to target AS

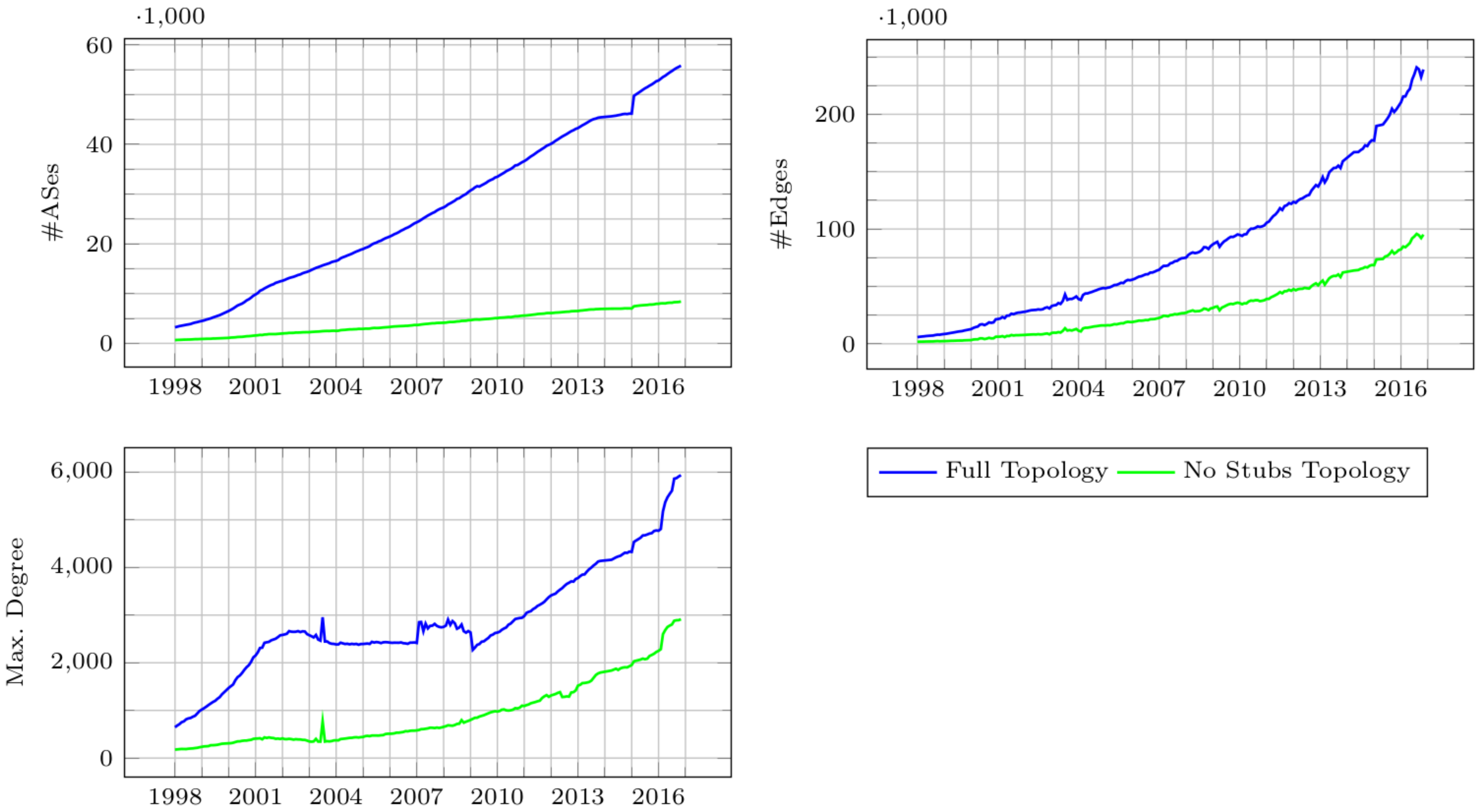
Privacy-Preserving BGP – Circuit

Algorithms built as **Boolean Circuit**:

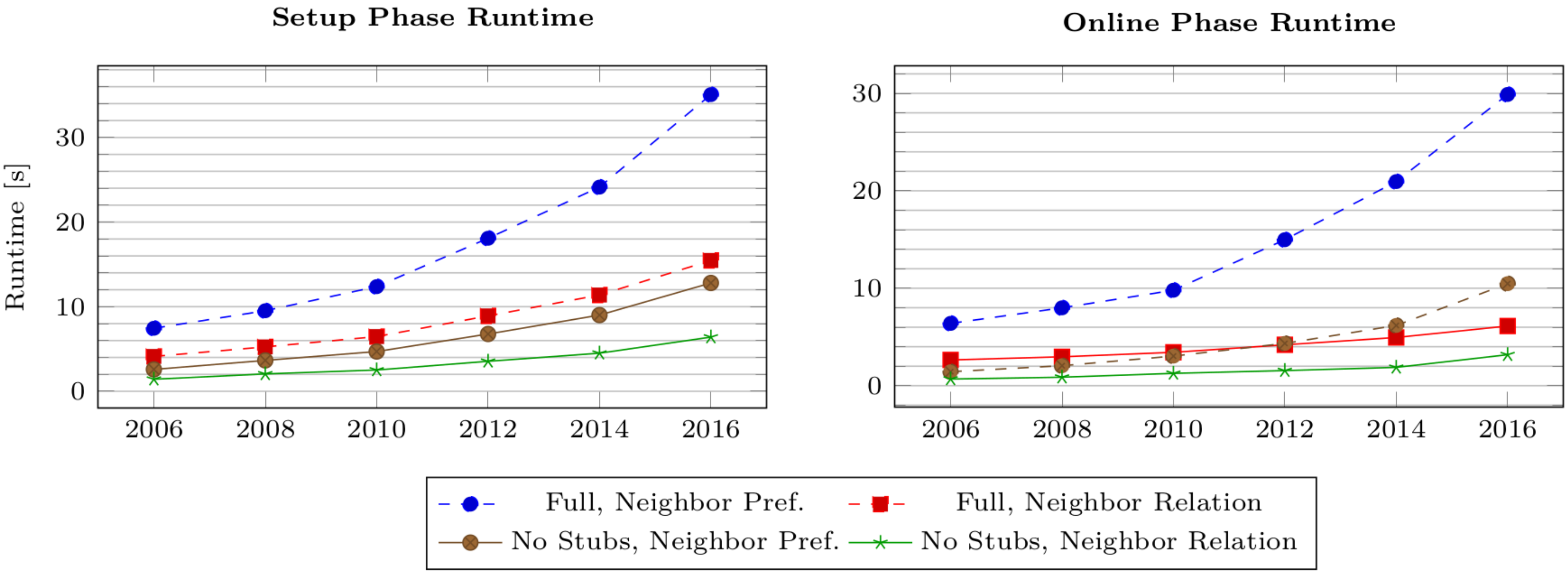
- SIMD operations
  - 1 operation for multiple bits in parallel
  - Process all nodes in parallel on circuit level
- Efficient MUX with vector-ANDs in GMW
  - only 1 OT for n-bit values
- Tree structure for depth-efficient parallel evaluation

Algorithmic optimization: ignore stub nodes (85% of ASes)

CAIDA: BGP Statistics 1998 – 2016



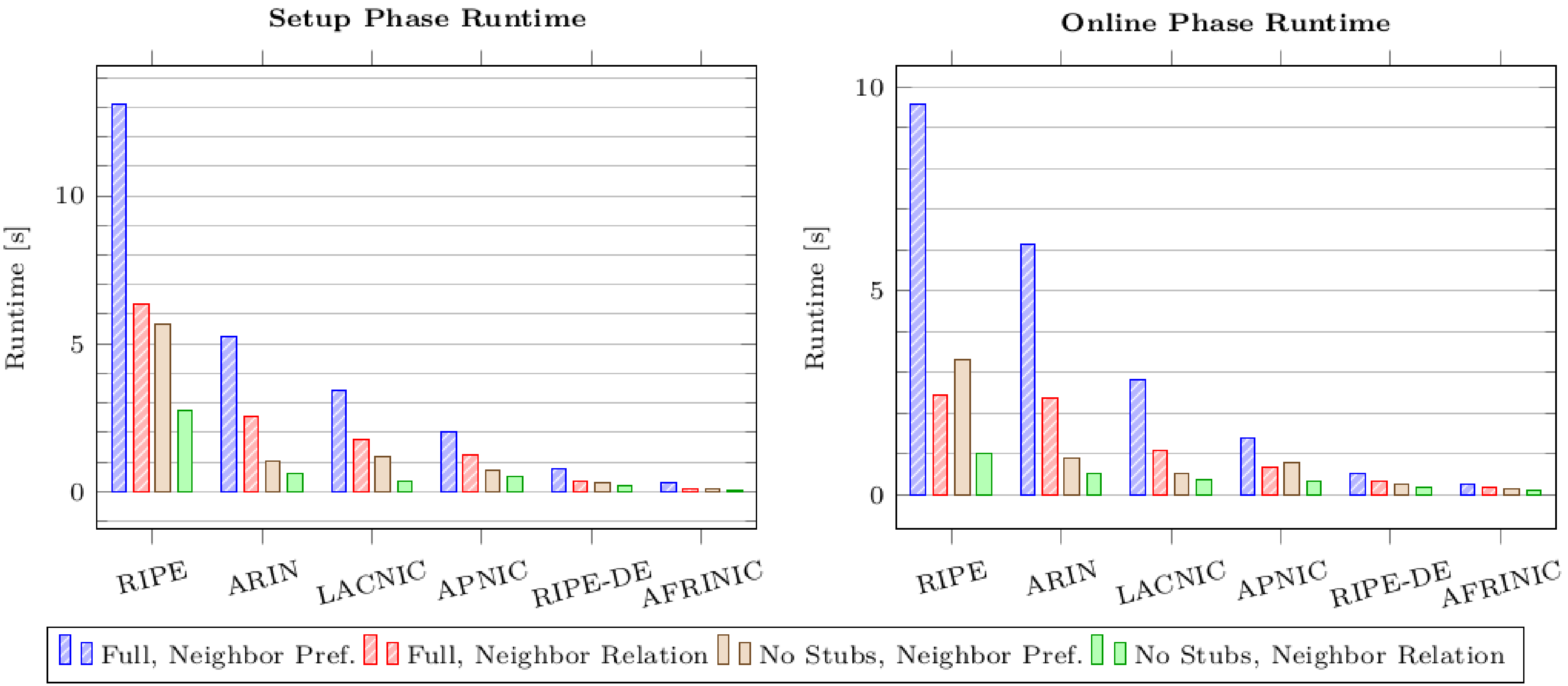
BGP Benchmarks: Full Topology



BGP Benchmarks: Full Topology

ime
Runtime [s]
30
20
10
0
2006
20
2014
2016
THE RUNTIME
IS TOO DAMN HIGH
imgflip.com

BGP Benchmarks: RIR Topology



Future Work and Conclusion

Hiding the topology?

Actual deployment?

Summary:

Real-World SMPC application

Made possible by algorithmic improvements and engineering

Thanks for your attention!

Questions?

References

[GSP+12] D. Gupta, A. Segal, A. Panda, G. Segev, M. Schapira, J. Feigenbaum, J. Rexford, and S. Shenker. A new approach to interdomain routing based on secure multi-party computation. In *ACM Workshop on Hot Topics in Networks (HotNets'12)*, pages 37–42. ACM, 2012

Icons: http://www.iconsmind.com

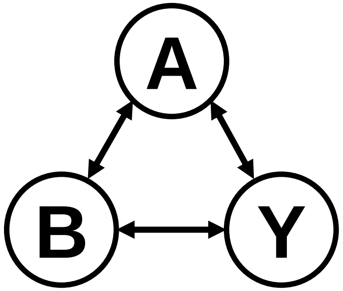
ABY – A Framework for Efficient Mixed-Protocol Secure Two-Party Computation

C++ Framework for mixed-protocol secure two-party computation

Published at Network & Distributed Systems Symposium (NDSS'15)

Multiple Protocols:

- **A**rithmetic Sharing
- **B**oolean Sharing (with the GMW protocol)
- **Y**ao's Garbled Circuits



Protocols split in **Setup** and **Online** phase

http://www.encrypto.de/code/ABY