

Formal Semantics and Automated Verification for the Border Gateway Protocol



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Woos**



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D. Ernst**

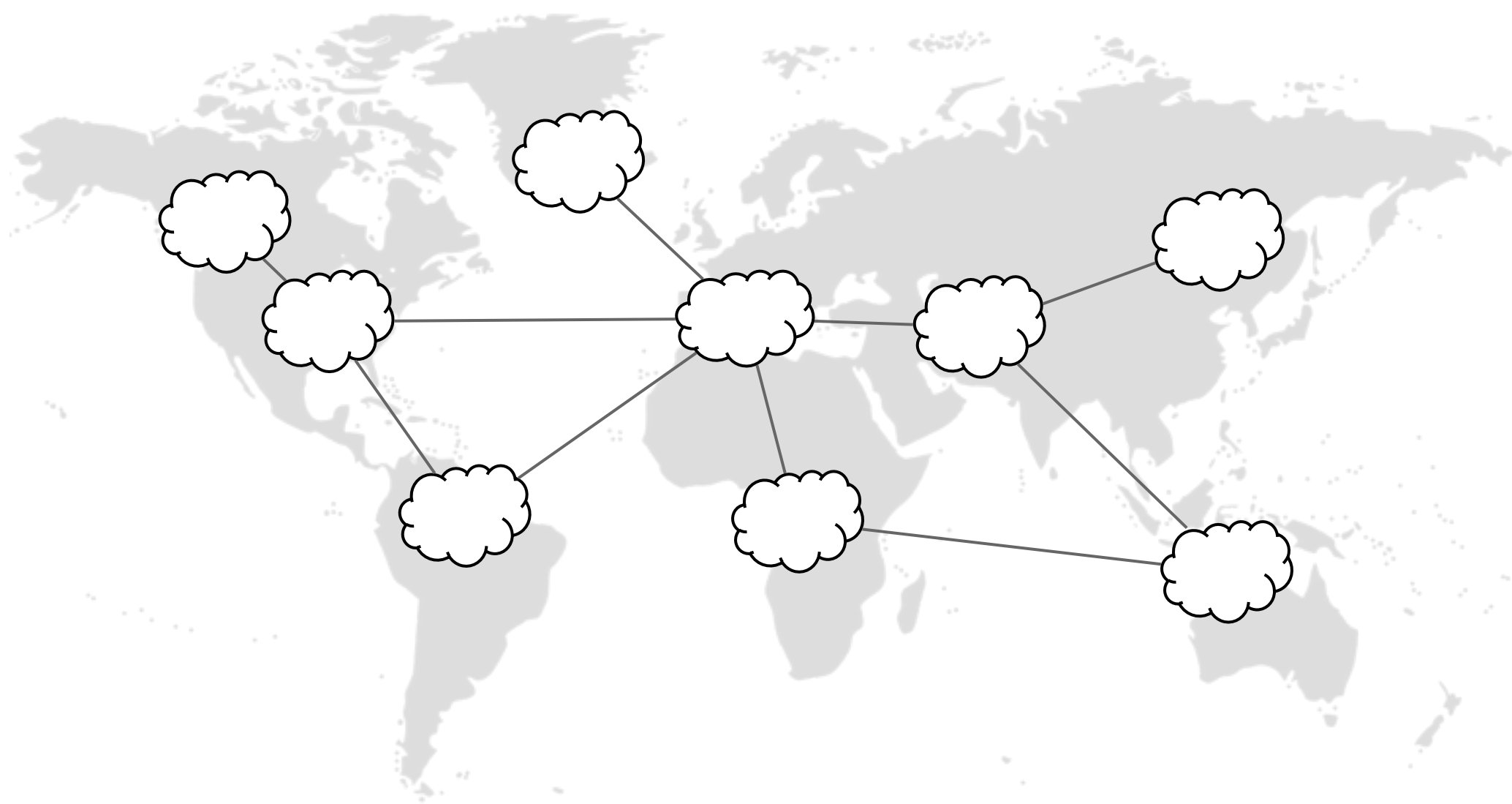


**Arvind
Krishnamurthy**

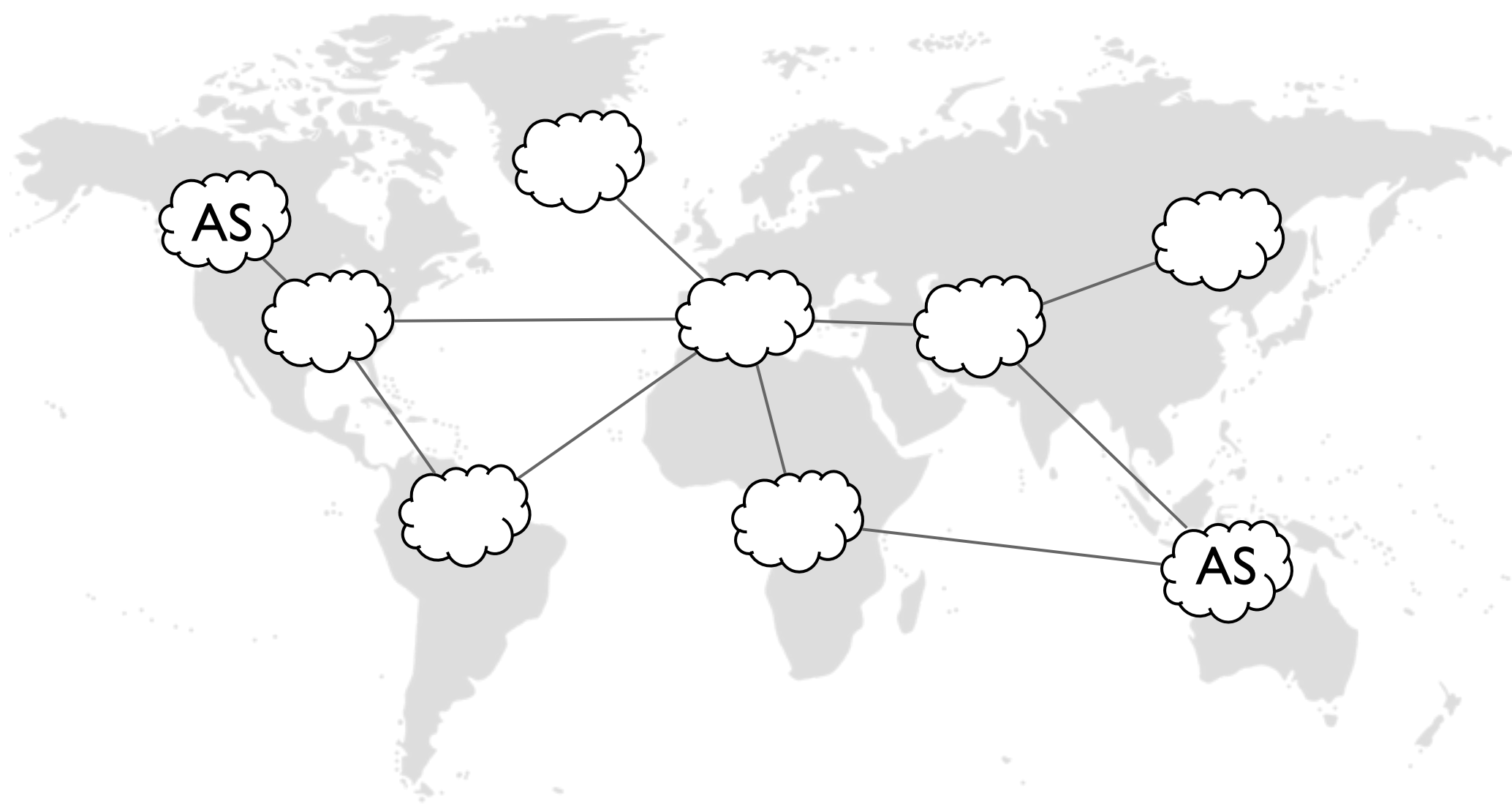


**Zachary
Tatlock**

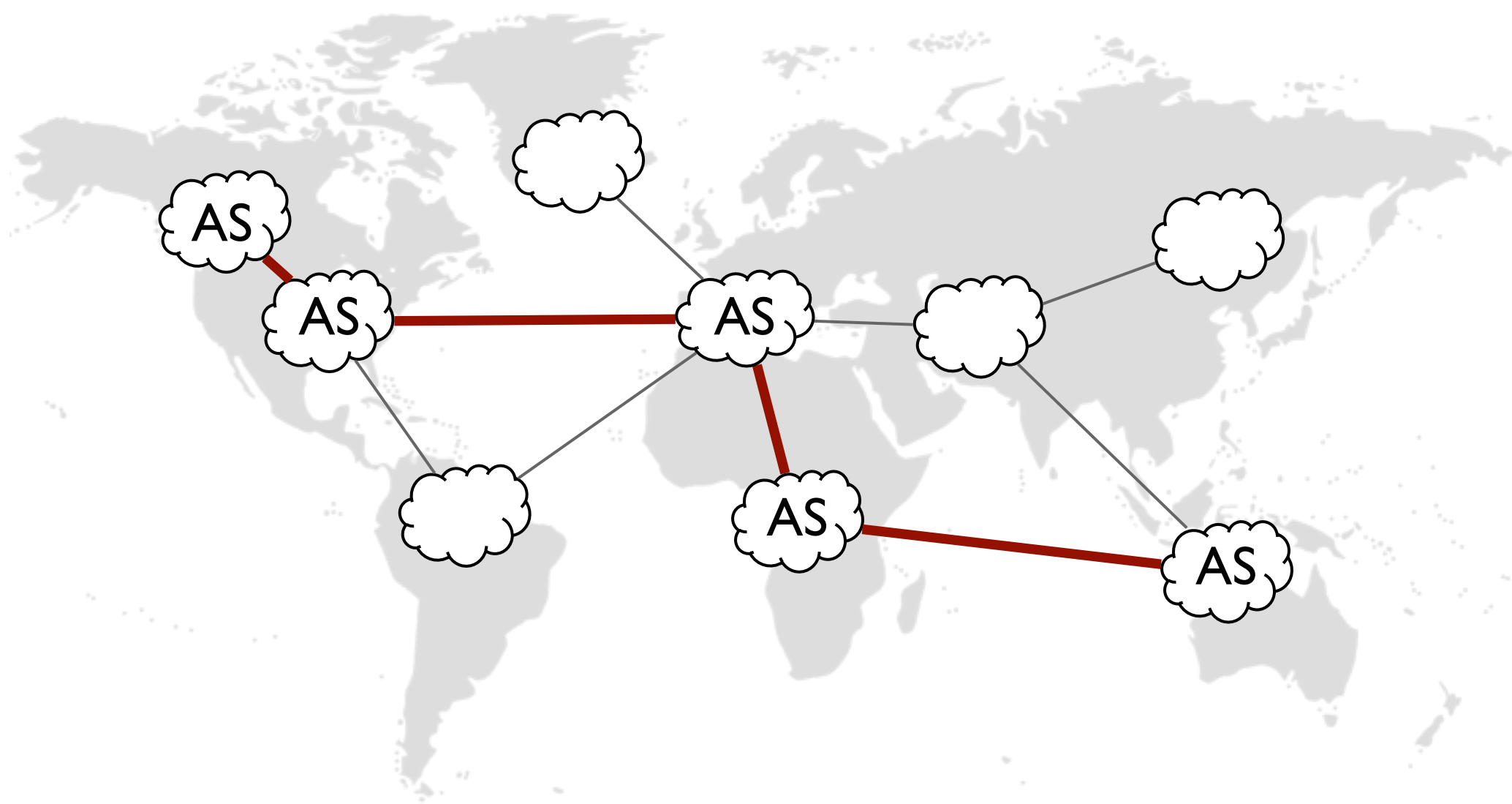
The Border Gateway Protocol



The Border Gateway Protocol

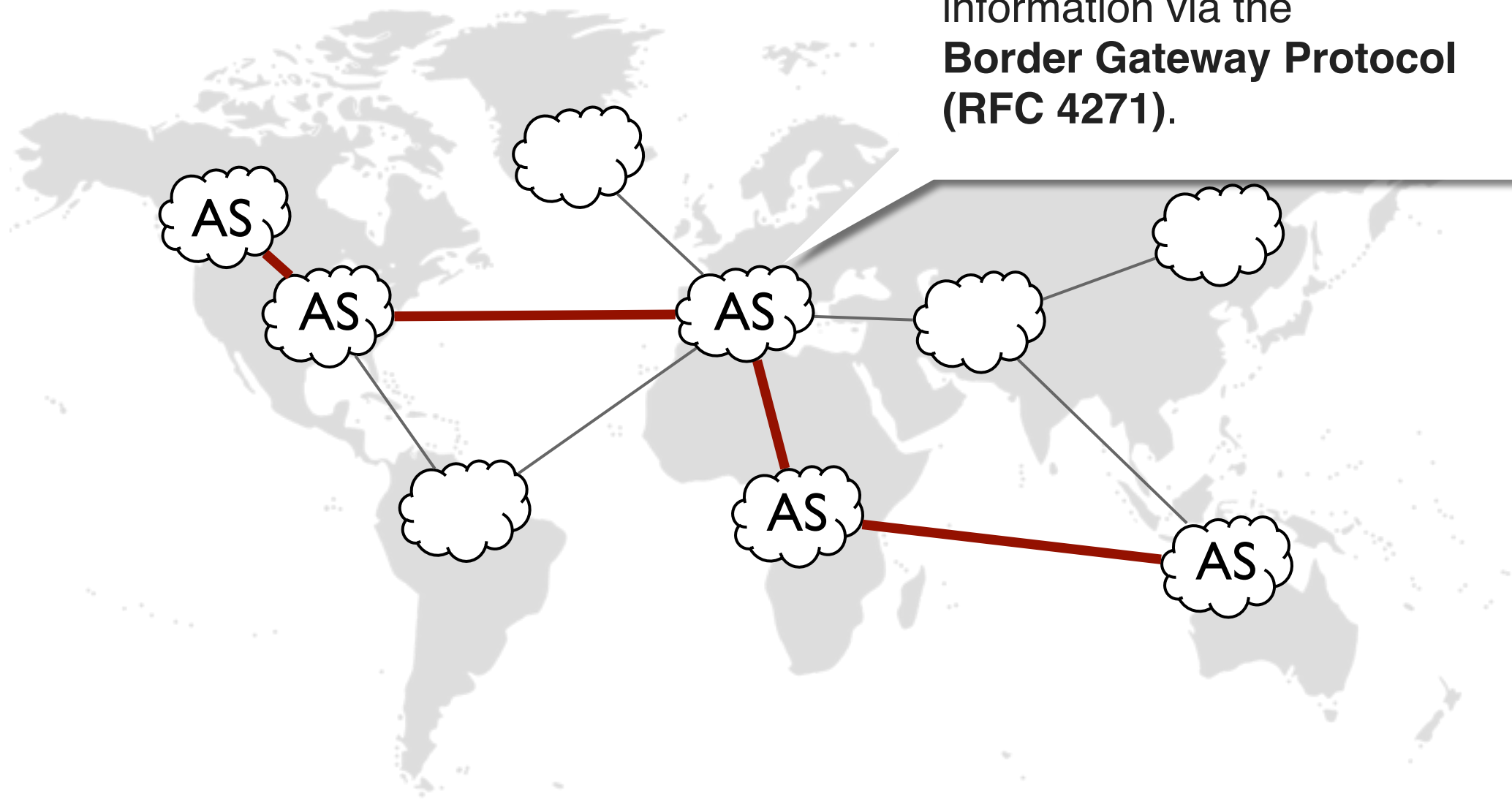


The Border Gateway Protocol



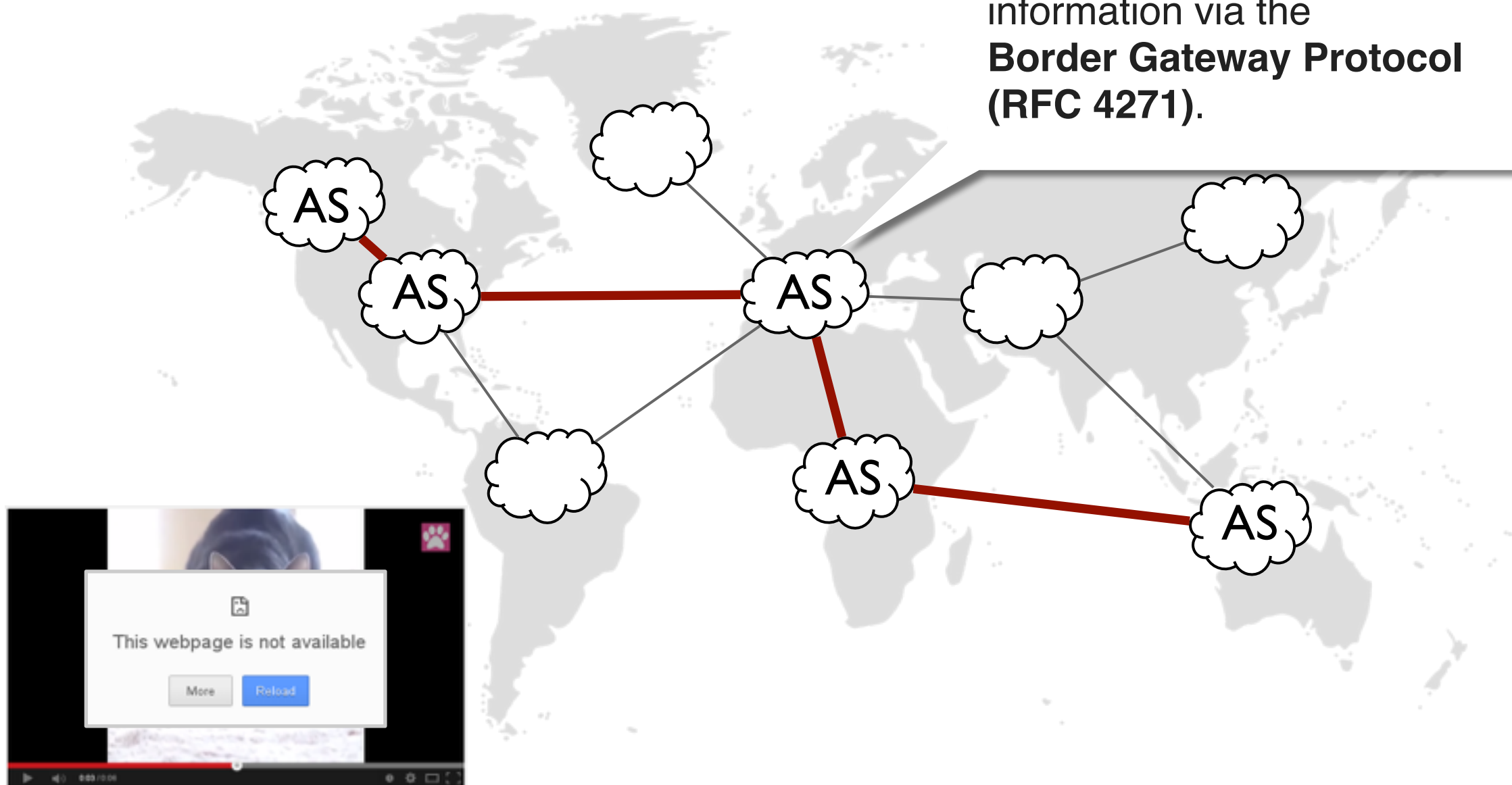
The Border Gateway Protocol

Autonomous systems
communicate routing
information via the
Border Gateway Protocol
(RFC 4271).



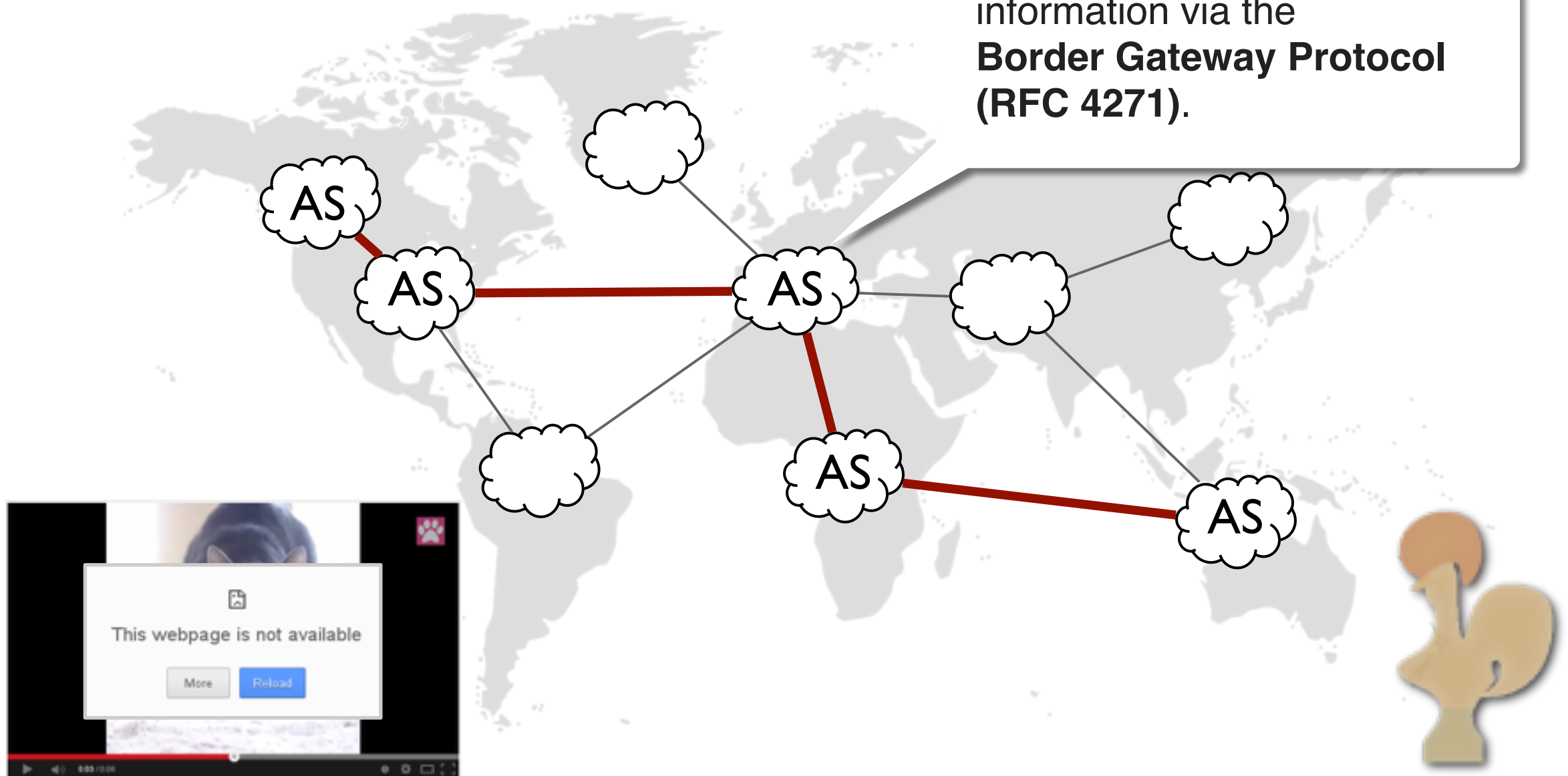
The Border Gateway Protocol

Autonomous systems communicate routing information via the Border Gateway Protocol (RFC 4271).



The Border Gateway Protocol

Autonomous systems communicate routing information via the **Border Gateway Protocol (RFC 4271)**.



Evaluation

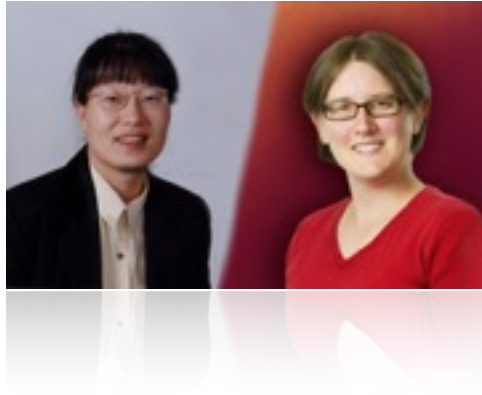


BGP Semantics

Evaluation



BGP Semantics



1. Gao & Rexford Proof

Evaluation



BGP Semantics



1. Gao & Rexford Proof

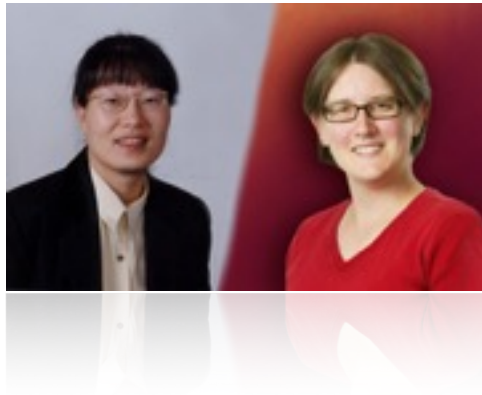
Bagpipe

2. Configuration Verification

Evaluation



BGP Semantics



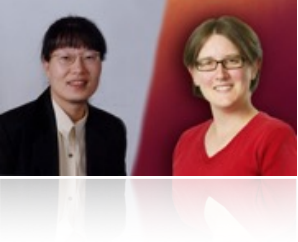
1. Gao & Rexford Proof

Bagpipe

2. Configuration Verification

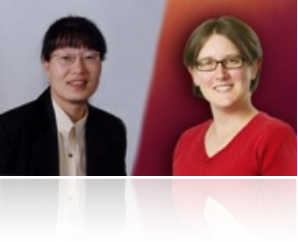


3. Differential Testing



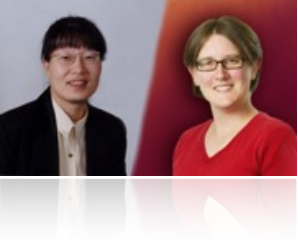
1. Gao & Rexford Proof

Guidelines → BGP Converges!



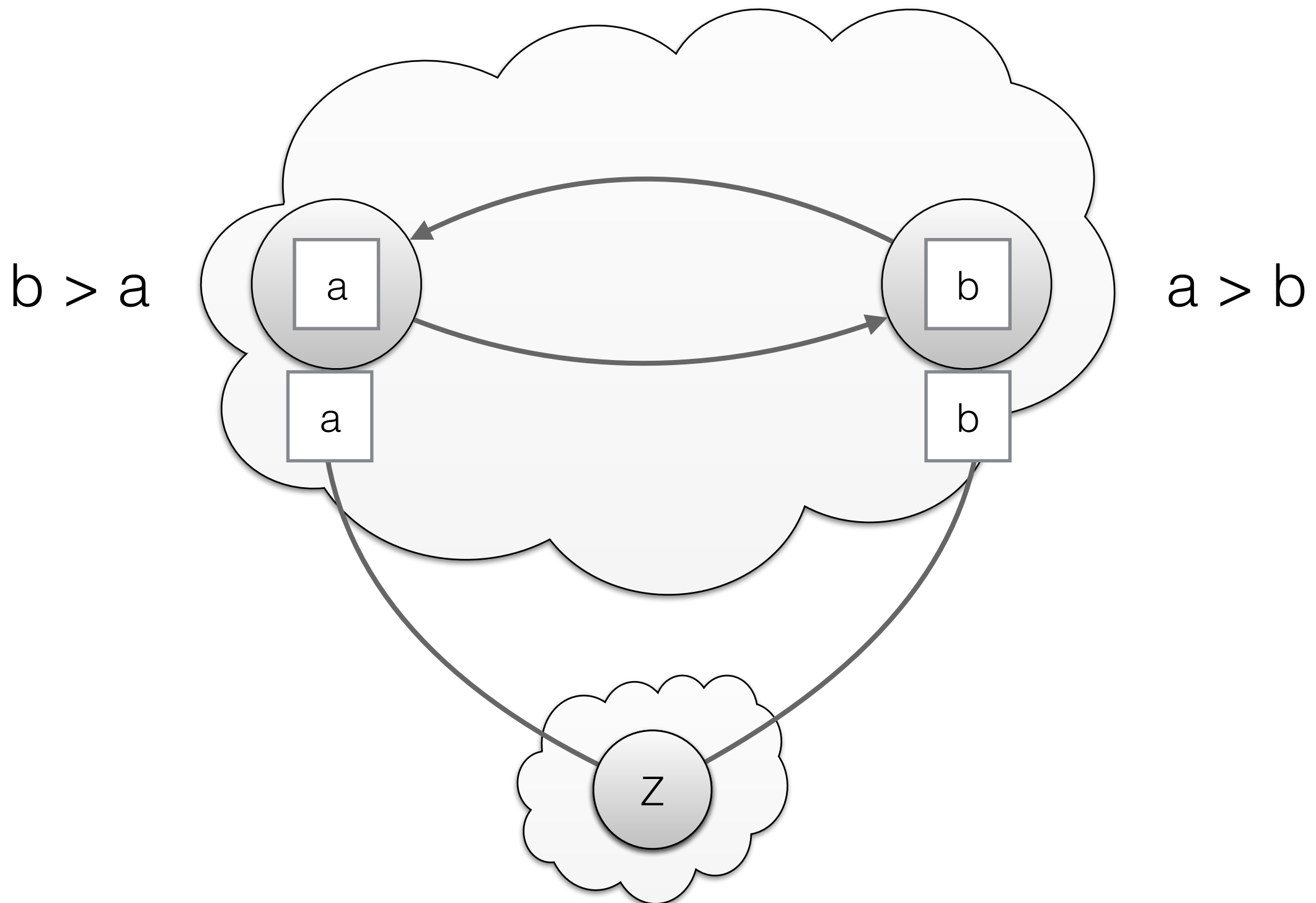
1. Gao & Rexford Proof

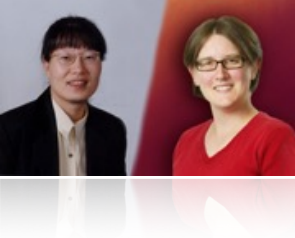
Guidelines \rightarrow BGP Converges! ?



1. Gao & Rexford Proof

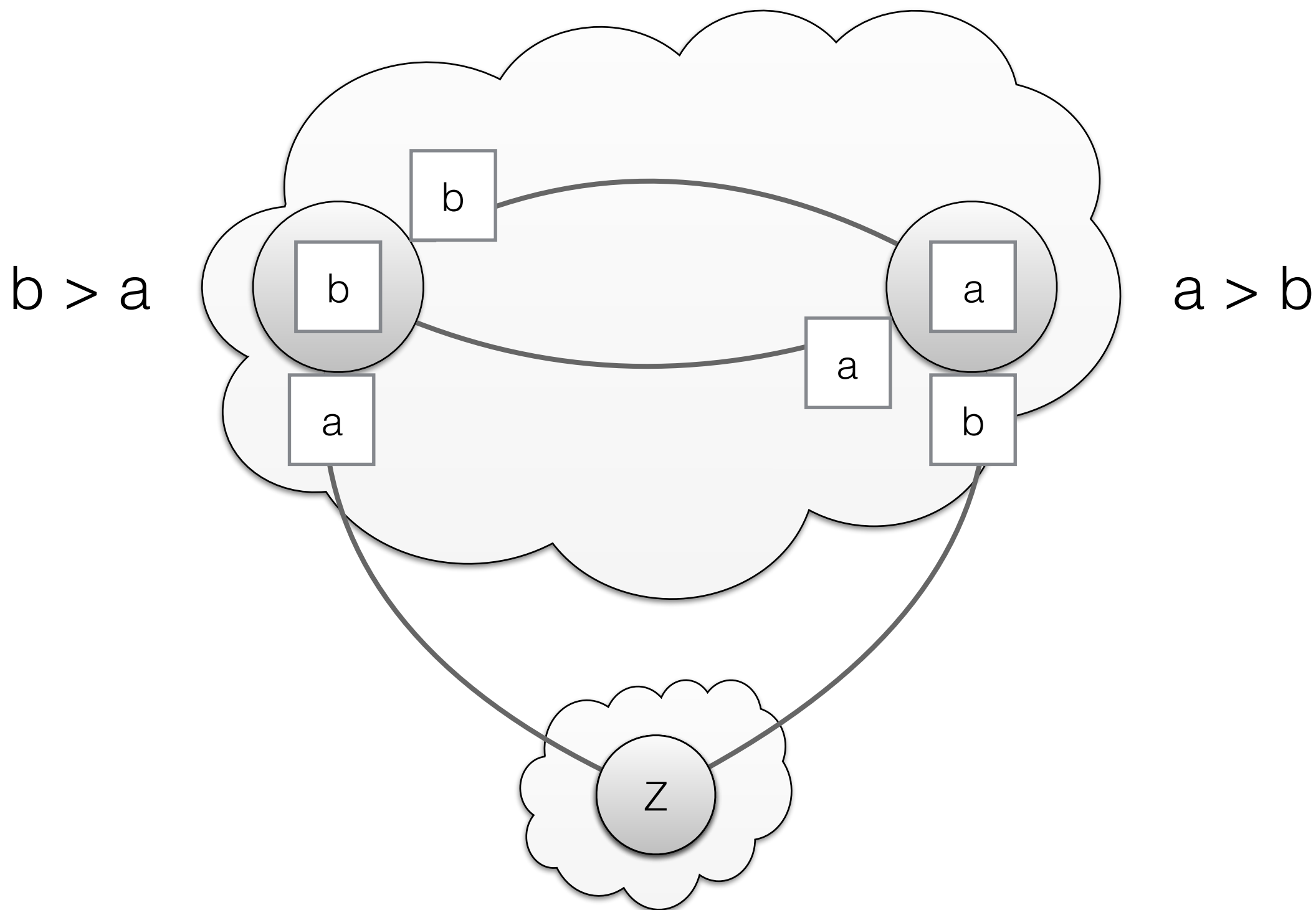
Guidelines \rightarrow BGP Converges! ?

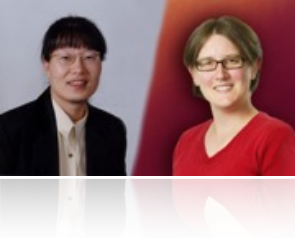




1. Gao & Rexford Proof

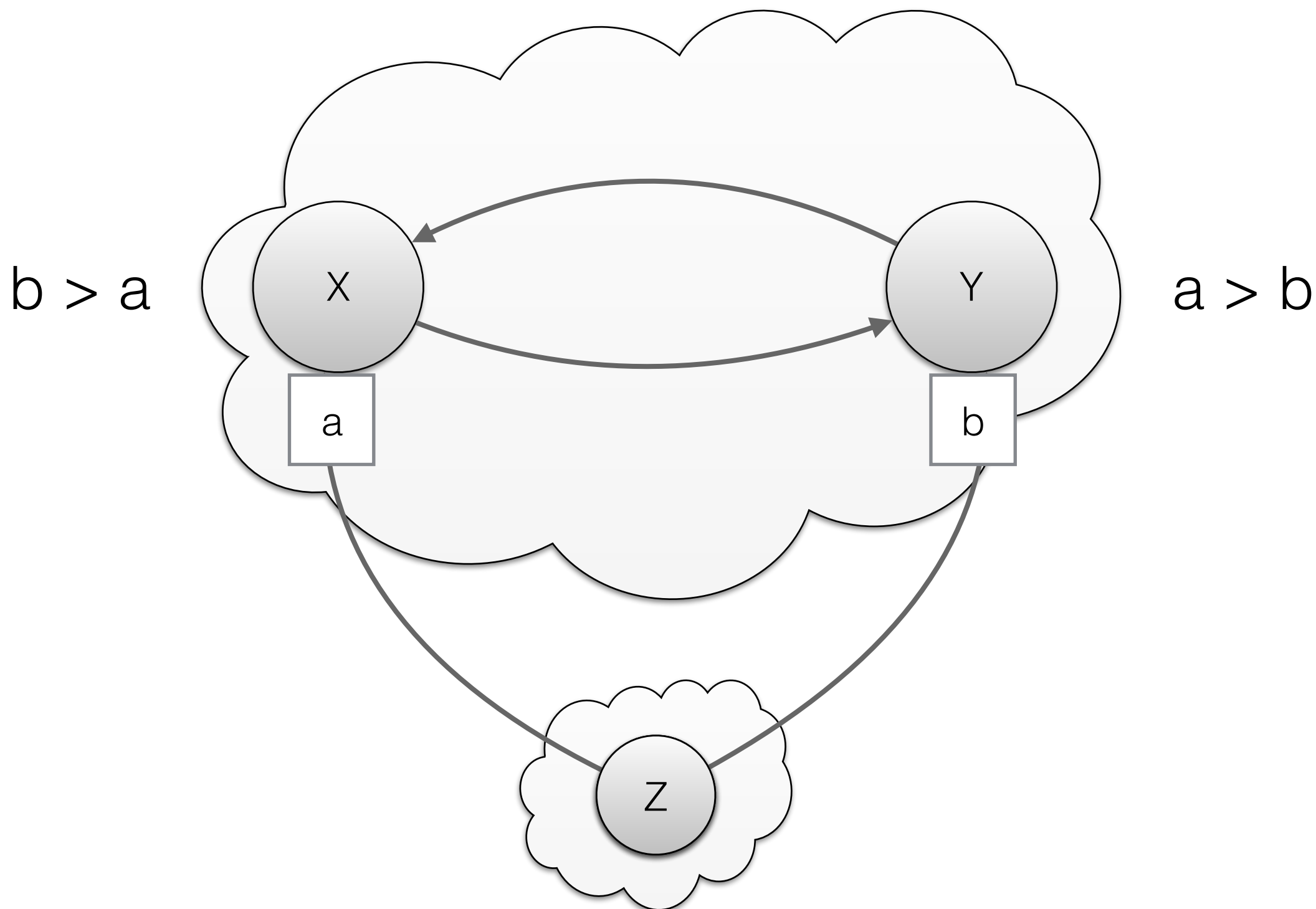
Guidelines \rightarrow BGP Converges! ?

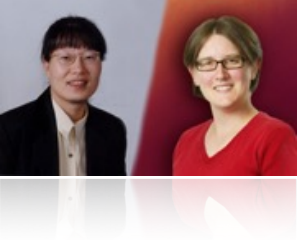




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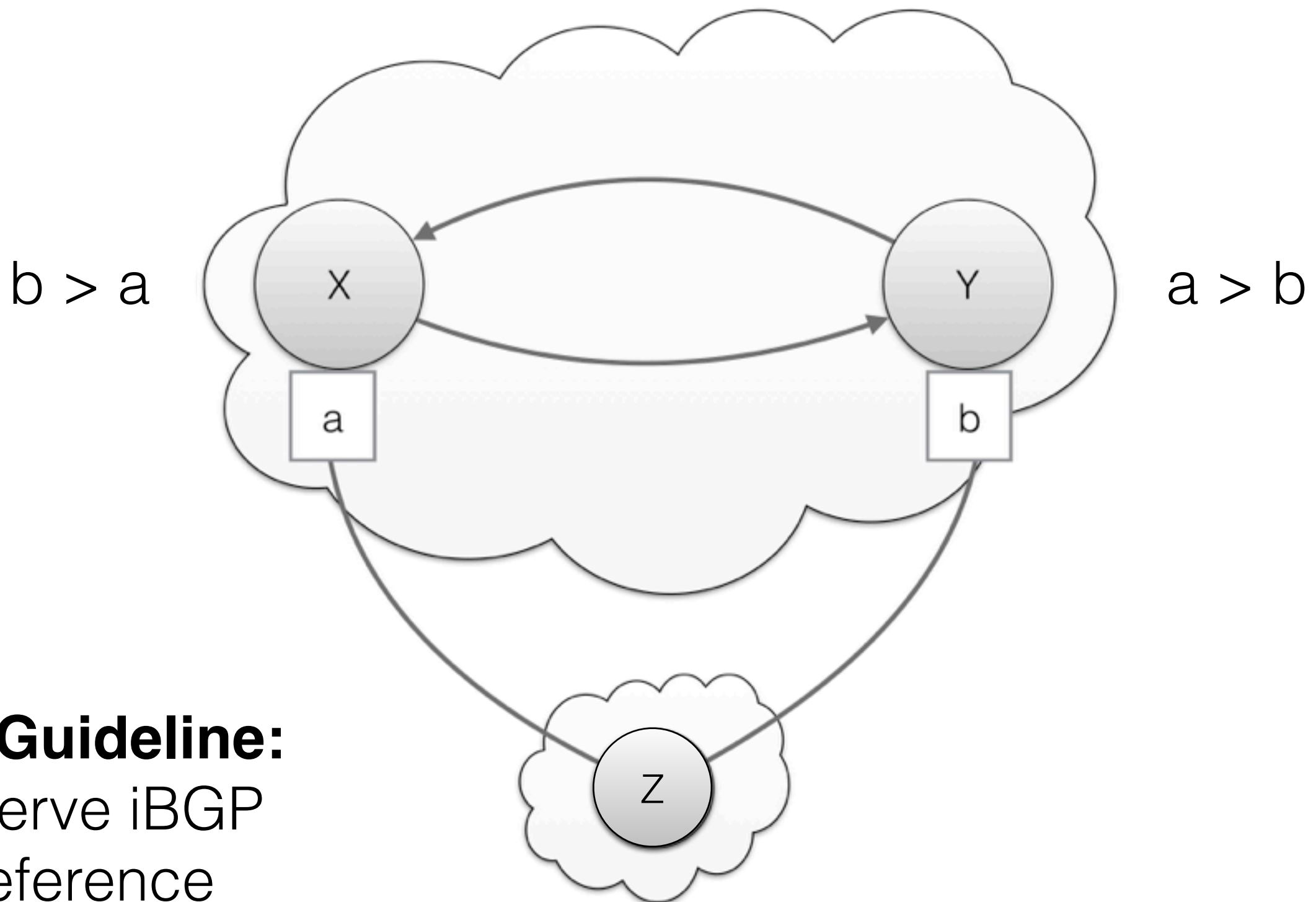
Guidelines \rightarrow BGP Converges! ?

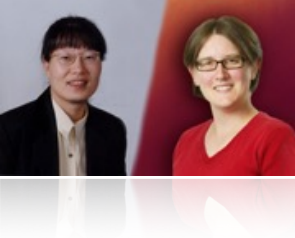




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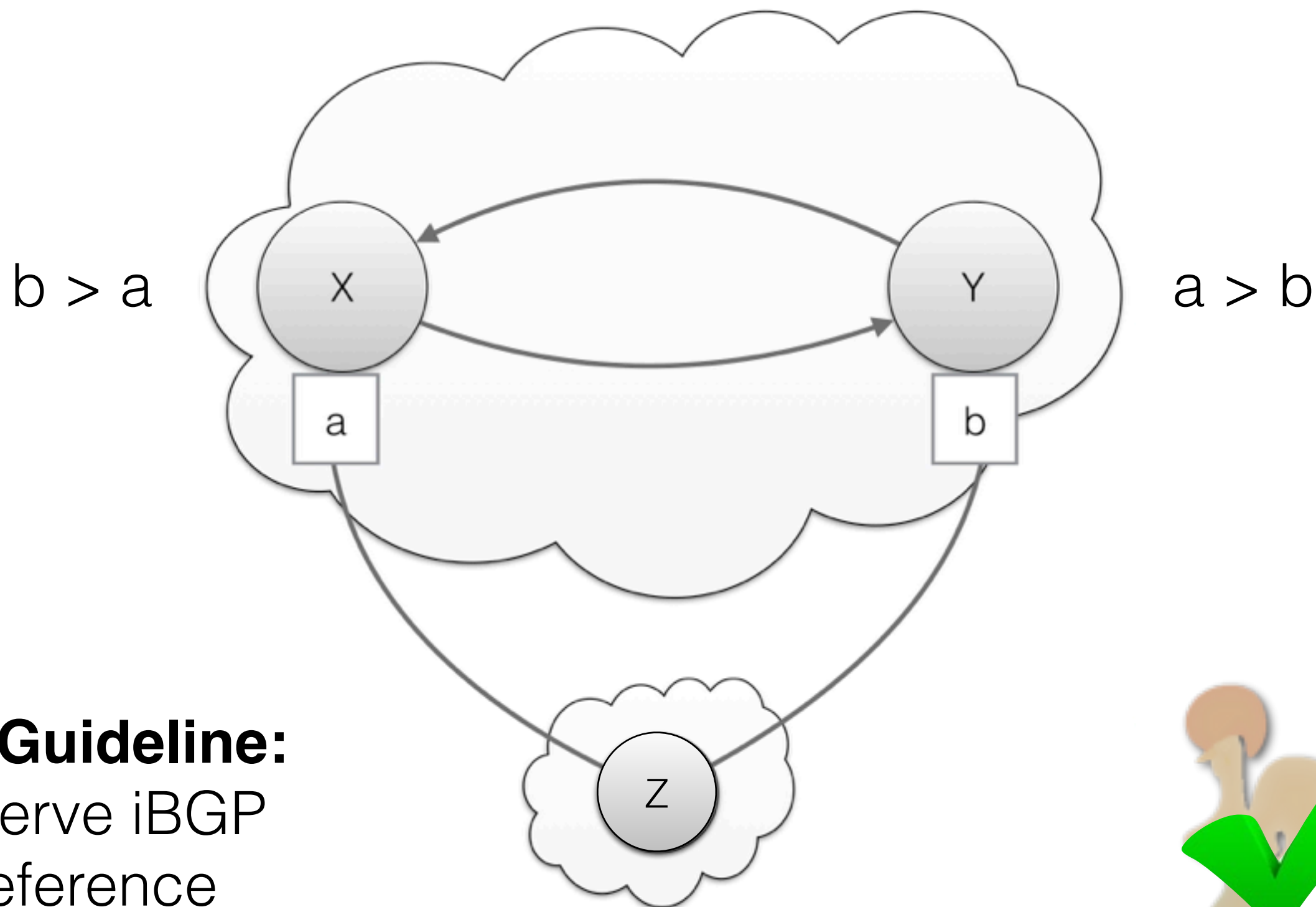
Guidelines → BGP Converges! ?





1. Gao & Rexford Proof

Guidelines → BGP Converges! ?

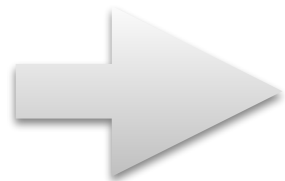


New Guideline:
Preserve iBGP
Preference

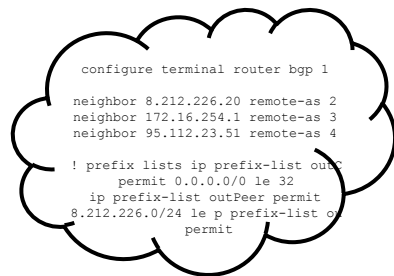
2. Configuration Verification



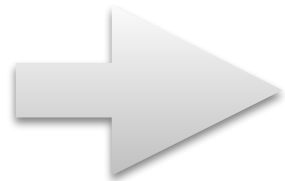
Specification



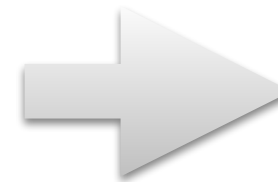
Bagpipe



Configuration

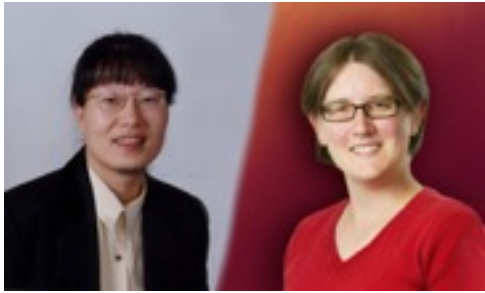


Correctness
Proof



Counter
Example

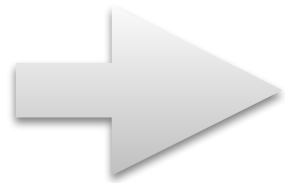
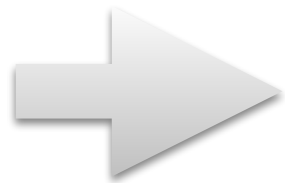
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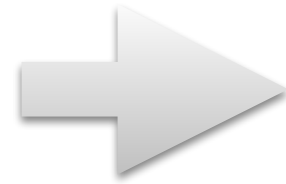
GaoRexford



Internet2 > 100K

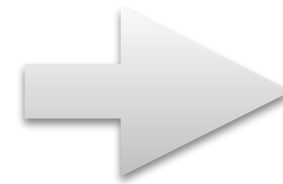
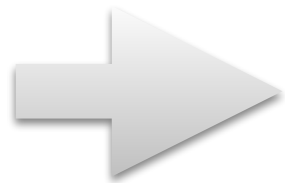


Bagpipe



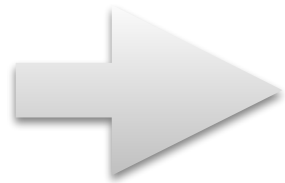
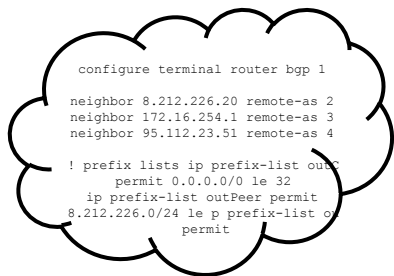
14 problems

2. Configuration Verification



19 problems

- GaoRexford
- NoMaritan
- BlockToExternal
- 10 Juniper Scenarios

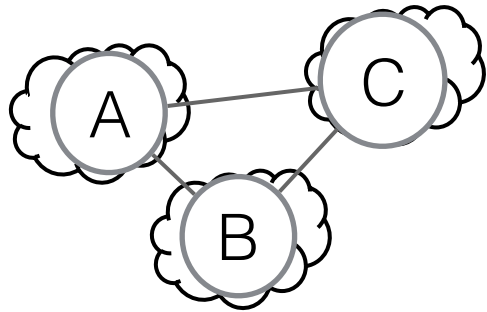


- Internet2 >100K
- BelWü >200K
- Selfnet >50

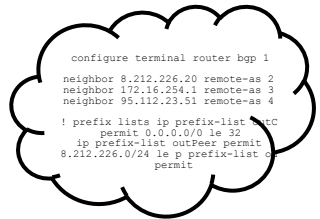


3. Differential Testing

100,000x Random



Topology

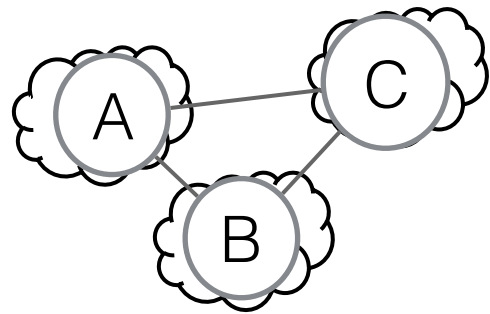


Configuration

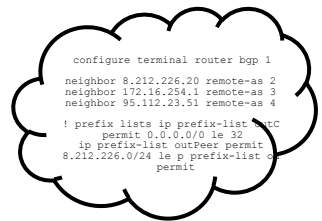


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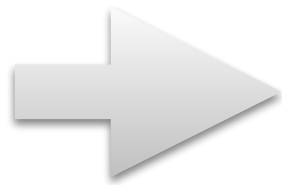
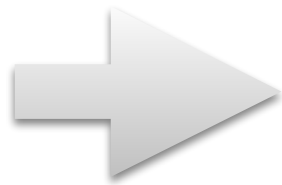
100,000x Random



Topology



Configuration

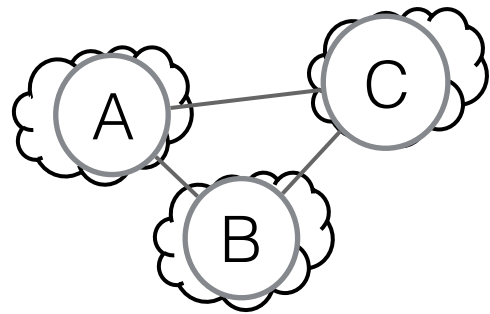


**C-BGP
Simulator**

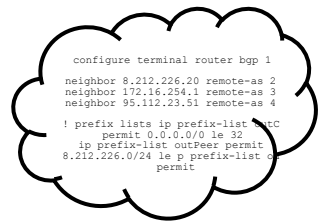


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100,000x Random

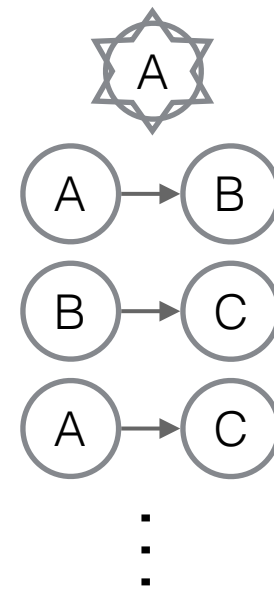


Topology



Configuration

**C-BGP
Simulator**

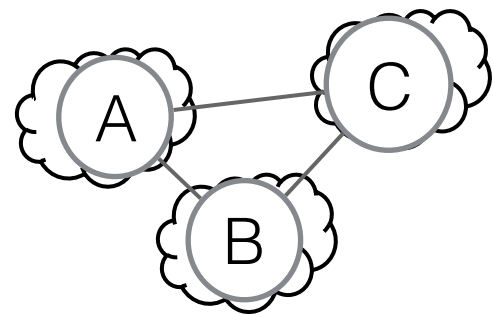


Trace

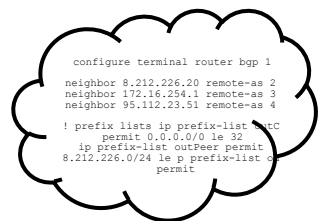


3. Differential Testing

100,000x Random

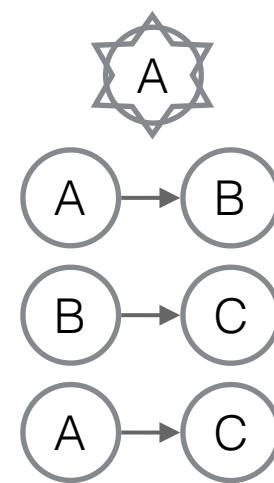


Topology



Configuration

**C-BGP
Simulator**



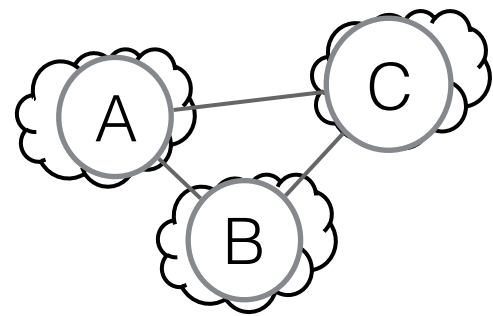
Trace



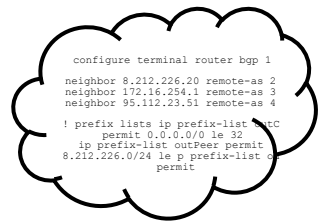


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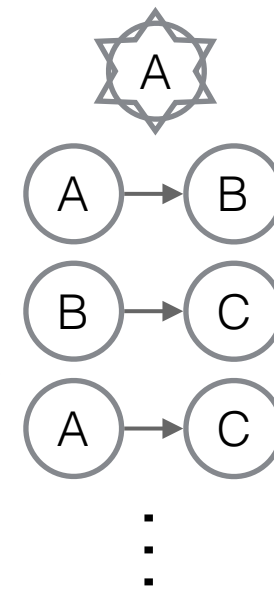


Topology



Configuration

**C-BGP
Simulator**



Trace



- Resends Identical Announcements
- Modifies AdjRIBsIn

Related Work

- Simple Path-Vector Protocol
Griffin, et al. TON'10
- Gao & Rexford's Semantics
Gao, Rexford, SIGMETRICS'00
- Isabelle Semantics
Voellmy, SafeConfig'09

Related Work

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Simplified: iBGP, Tie-Breaking, Withdrawals, ...

Thank You



1. Gao & Rexford Proof



2. Configuration Verification



3. Differential Testing