Advanced Computer Networking (ACN)

Exercise 3 – Solution

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Chair of Network Architectures and Services
School of Computation, Information, and Technology
Technical University of Munich

Outline

Announcements

For questions and problems:

- Always use this mail address: `acn@net.in.tum.de`

Deadline first version:

- The deadline for the first version of Tutorial 3 has passed 15 minutes ago
- Commit and push your solution, if you haven't already

Next week:

- Tuesday:
  - Lecture, project & tutorials offer enough content for 5 ECTS
  - For organizatorial reasons there will be no lecture on Tuesday
- Thursday: Dies academicus - No lecture
- Second deadline is on **Thursday 07.12 14:00**!

Announcements
Guest Lecture on Tuesday, Dec 19

- Presenter: Dr. Cornelius Diekmann
  - 2017 PhD: "Formal Verification of Network Security Management"
  - since 2017: Working for Google as Site Reliability Engineer (SRE)
- Topic: The Art of SLOs
  - Service Level Objectives (SLO) are used to define reliability goals for services
  - Experience how to define and achieve realistic SLOs for services
- Lecture will be streamed
- Lecture will NOT be recorded

Problem 1: Autonomous Systems

1 a)

Program a function which takes a unidirectional NetworkX graph and removes all nodes of the given or smaller degree recursively.

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Input: graph G, degree d
Output: graph without nodes of degree $\leq d$
while true **do**
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    if nothing changed **then**
        return G
    end
end

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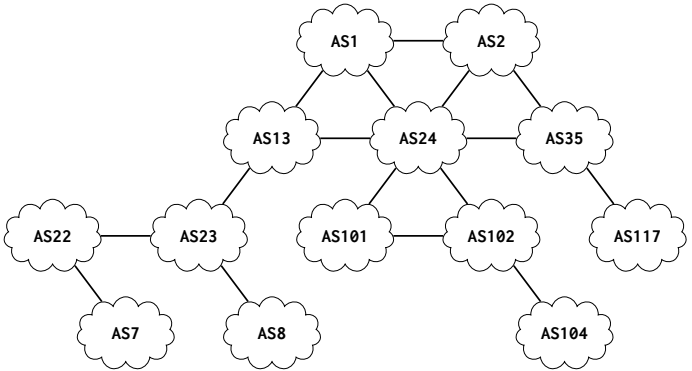
Example: remove nodes of degree 1



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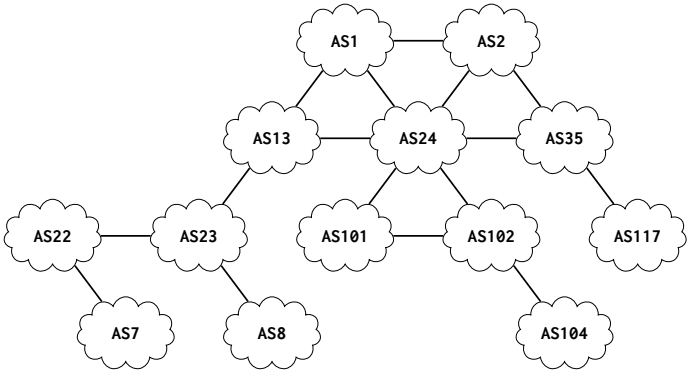
1. Remove AS7, AS8, AS104, AS117



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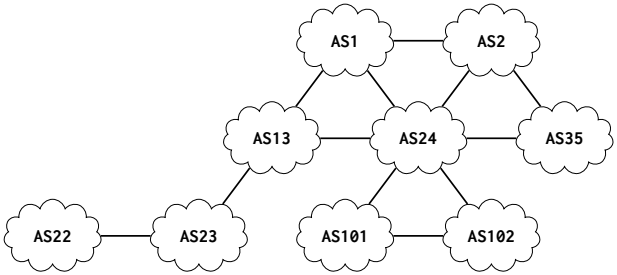
1. Remove AS7, AS8, AS104, AS117
2. Remove AS22



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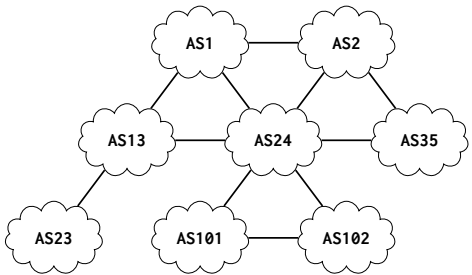

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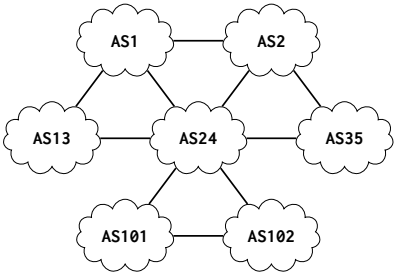
4. Done



1 b)

Write your own function `perform_kcore` which performs the kcore algorithm on a given unidirectional graph.

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Write your own function `perform_kcore` which performs the kcore algorithm on a given unidirectional graph.

Input: graph G
Output: core of G
last $\leftarrow$ G;
core $\leftarrow$ 1;
while true **do**
    remove nodes in G of degree core;
    if G is empty **then**
        return last, core
    end
    last $\leftarrow$ G;
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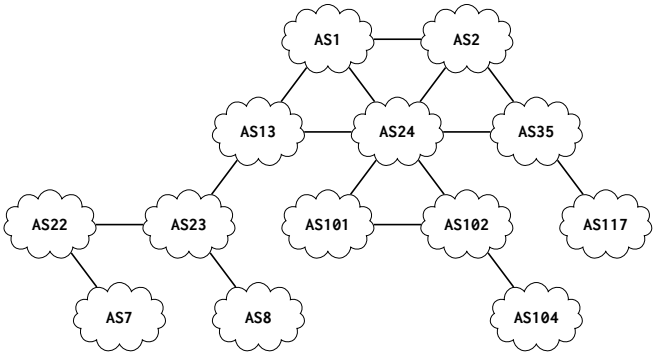
end



Example:

- Remove nodes of degree 1

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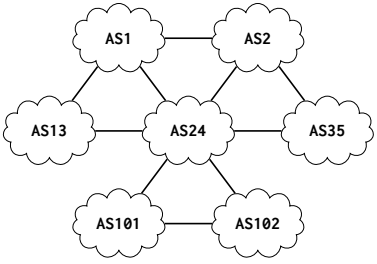

Example:

- Remove nodes of degree 1
- Remove nodes of degree 2

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- Remove nodes of degree 1
- Remove nodes of degree 2
- Graph is empty

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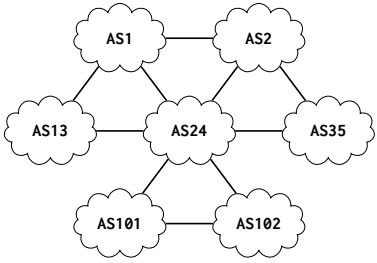

Example:

- Remove nodes of degree 1
- Remove nodes of degree 2
- Graph is empty
- Core is 2

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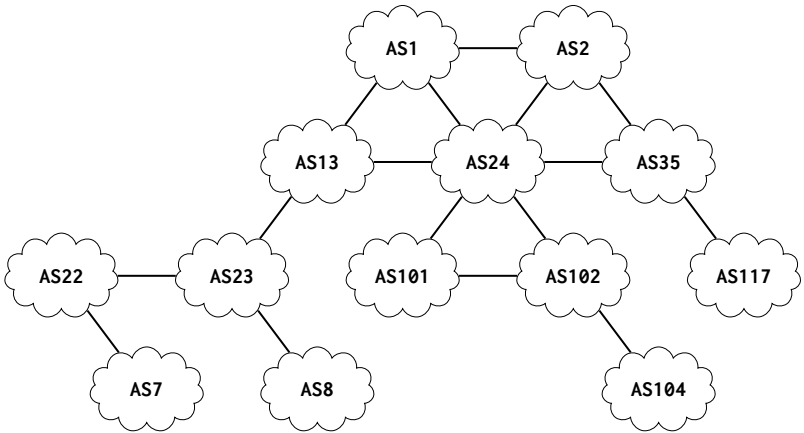
1 c)

Increase the degree of the nodes in the core of the network for the given topology.
You may add exactly one connection between two arbitrary ASes.



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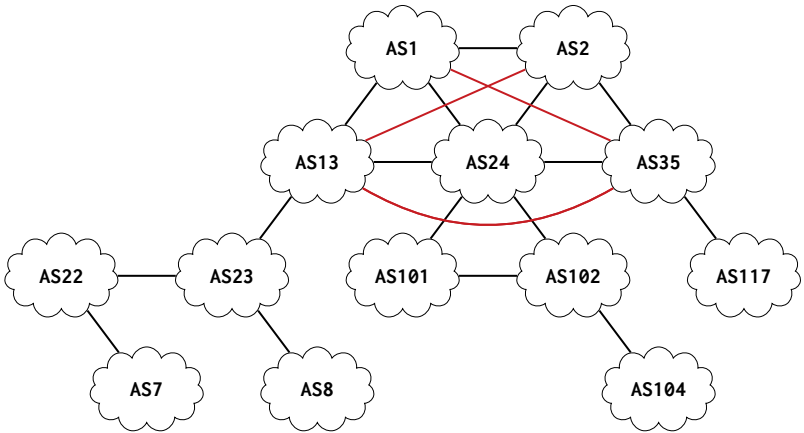

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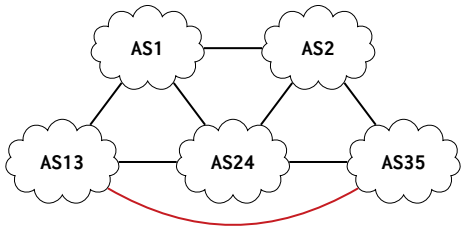

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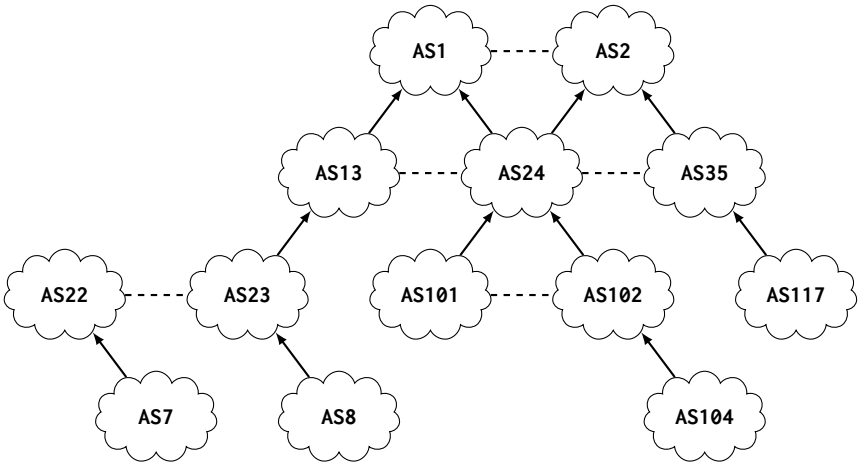
1 d and e)

Define the terms "Tier-1 provider", "stub network", "multi-homed AS", "peering" and "transit".



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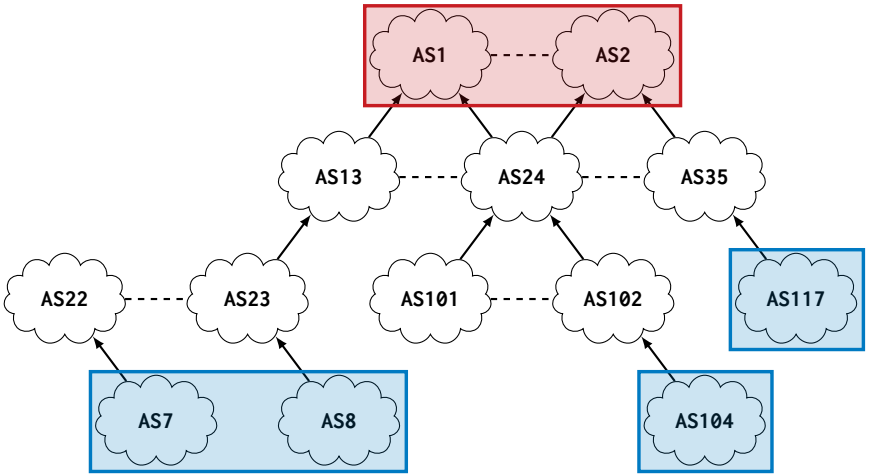
Relevant RFCs: e.g. 7454, 1772, 4384



1 f)

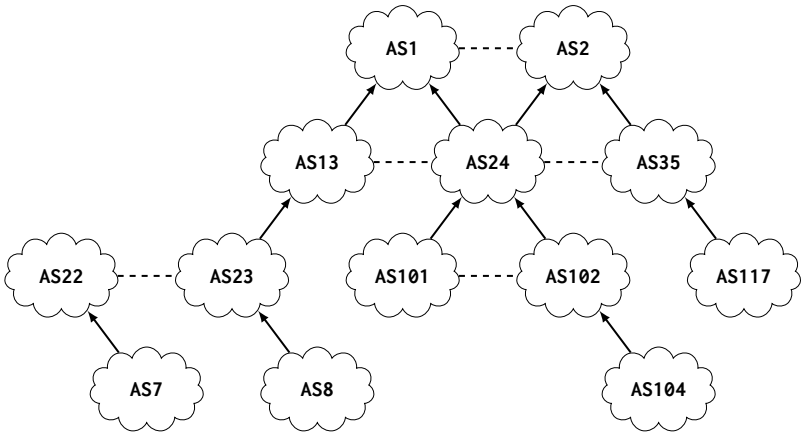
How can a transit agreement be trivially represented in the routing table of the client?

- As client, you expect your provider to offer connectivity to the Internet
- If you do not have a better/cheaper route you want to use the provider

→ You can use a default route

1 g)

Reason how the traffic to AS8 will be routed on AS level for sources in AS7, AS101, AS104 and AS117 considering common peering and transit agreements?



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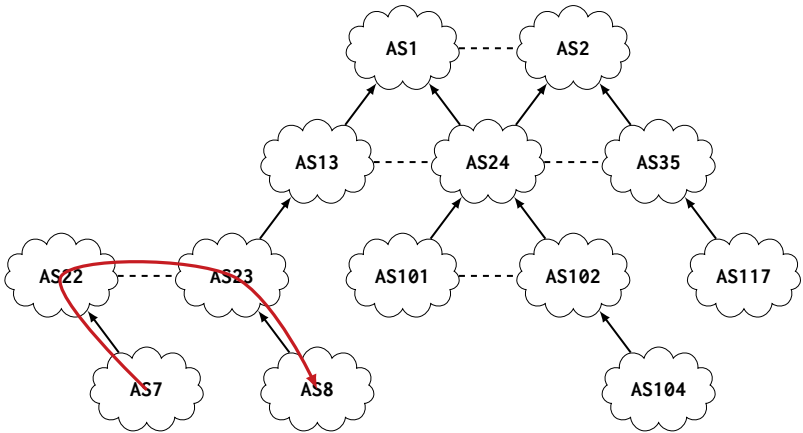

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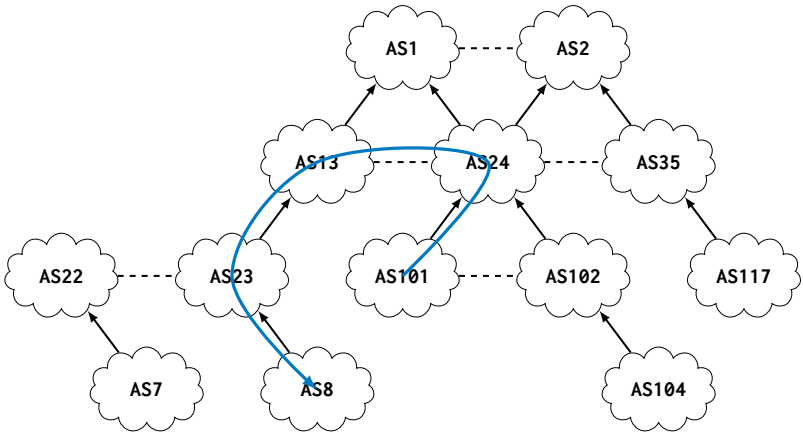

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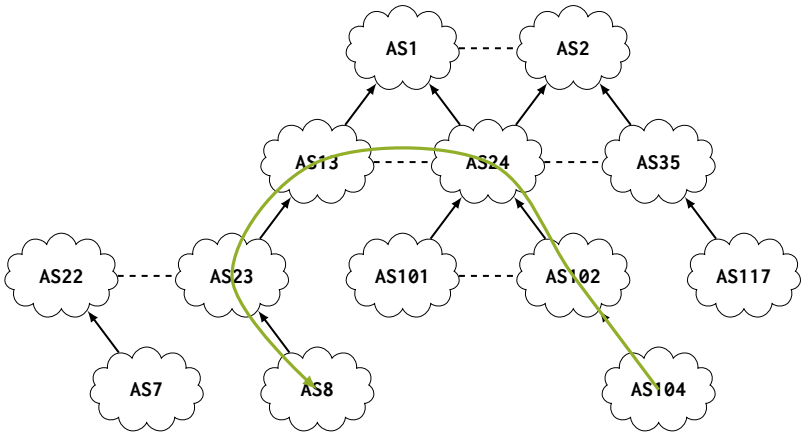

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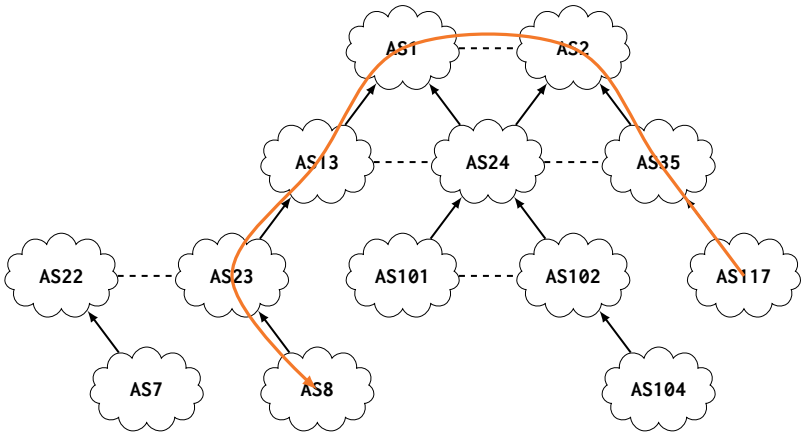
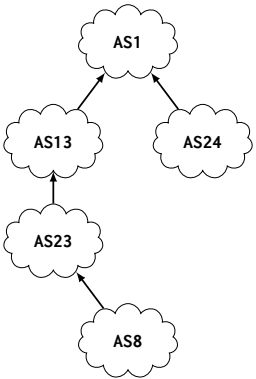


1 h-j)

BGP Hijacking is a major threat. Attacks are categorized into different classes based on their properties.



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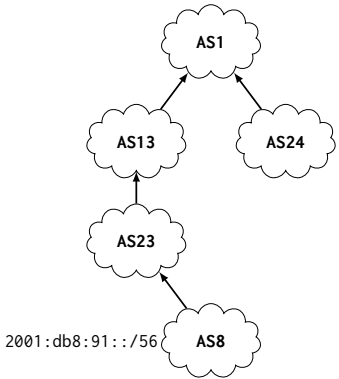

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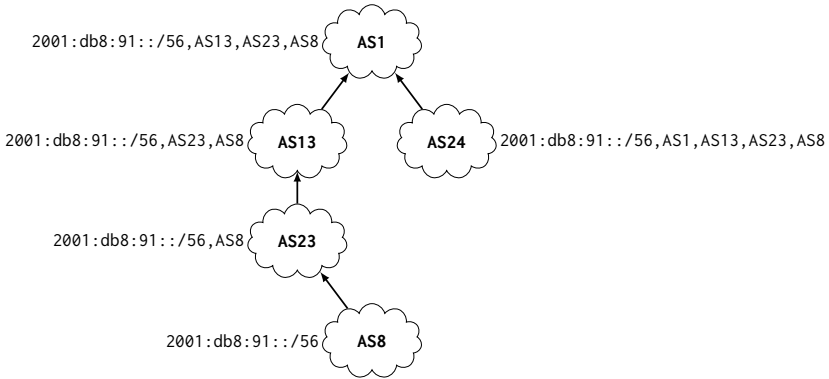

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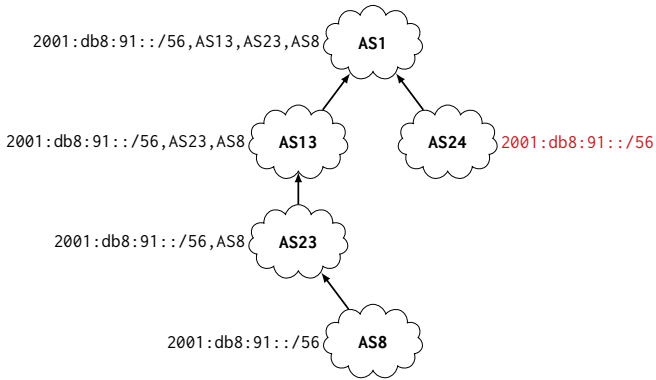

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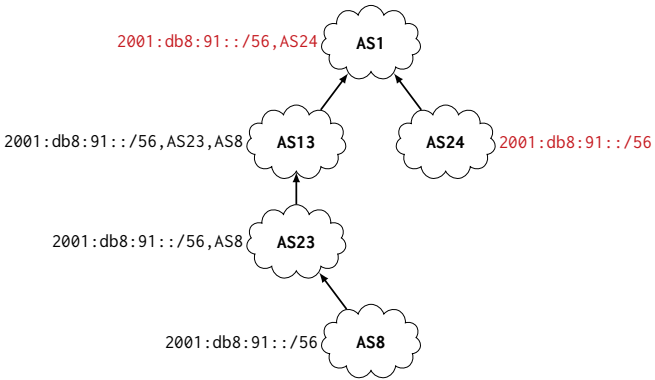

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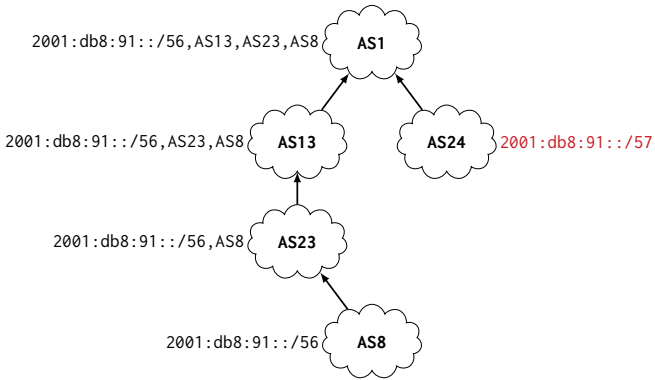

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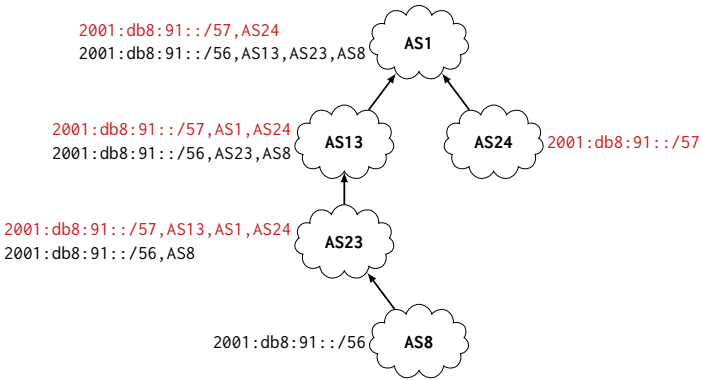

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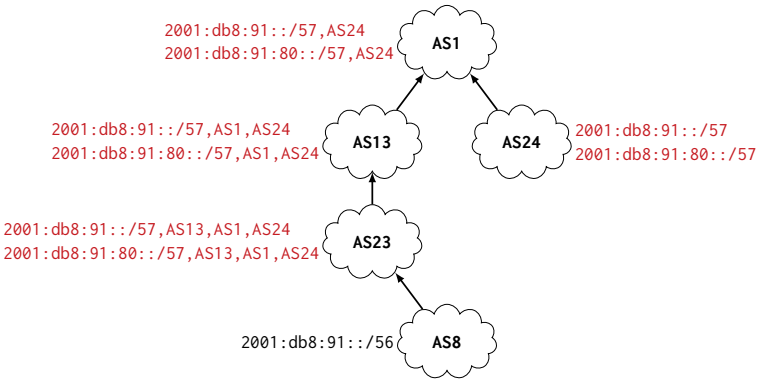

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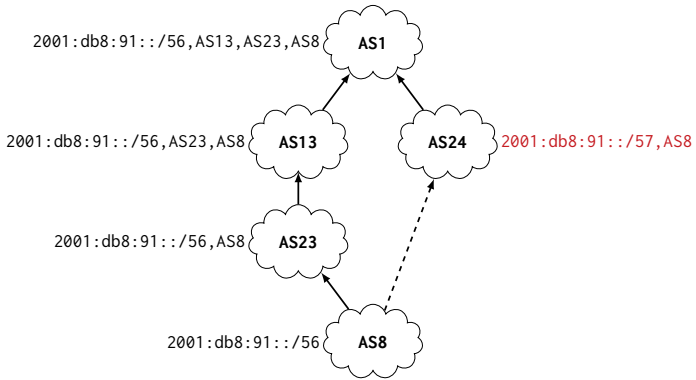

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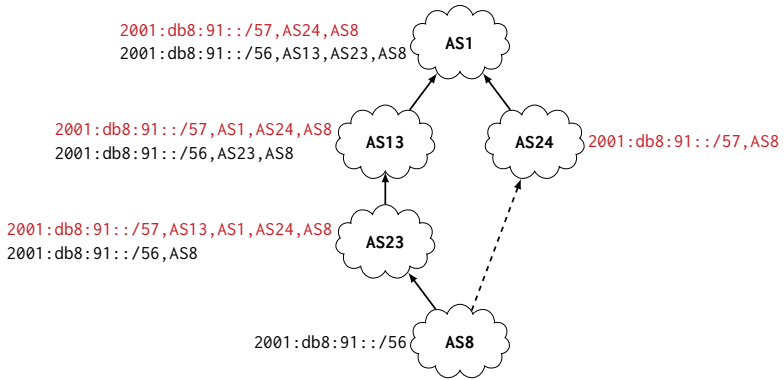

1 k)

- Internet Routing Registries (IRR) filtering
  - Central places with public routing information
  - Used to validate announcements
- Route Origin Validation via RPKI
  - Signatures of prefix announcements from the owning AS at RIR — Route Origin Announcements (ROAs)
  - RIRs are trust anchor and distribute ROAs
  - ROV means validating announcements against available ROAs
  - ROV **can not** protect from path hijacks
- Use information from provisioning process (MANRS)
  - Mutually Agreed Norms for Routing Security (MANRS) — global initiative to improve routing security