BGPSecurity in Partial Deployment
Is the Juice Worth the Squeeze?

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Border Gateway Protocol

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The de-facto inter-domain routing protocol

Functionality:

- Connect Autonomous Systems (ASes), e.g. ISPs
- Exchange IP block reachability information

BGP Security Issues

There are two main security issues in BGP:

- IP prefix hijacking
- AS path forgery

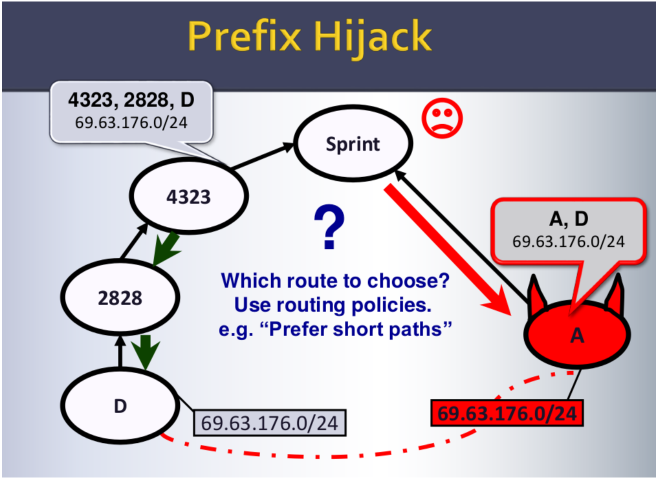
IP prefix hijacking

The attacker claims to be the origin AS of certain prefixes.

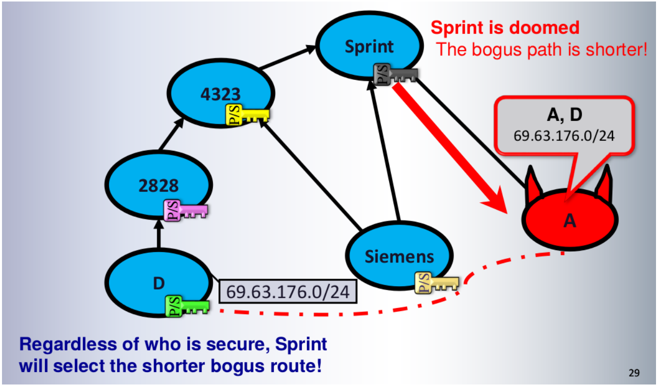
AS path forgery

The attacker claims to have a non-existing path toward the prefixes.

Prefix Hijacking Example



Path Forgery Example



BGP Security Solutions

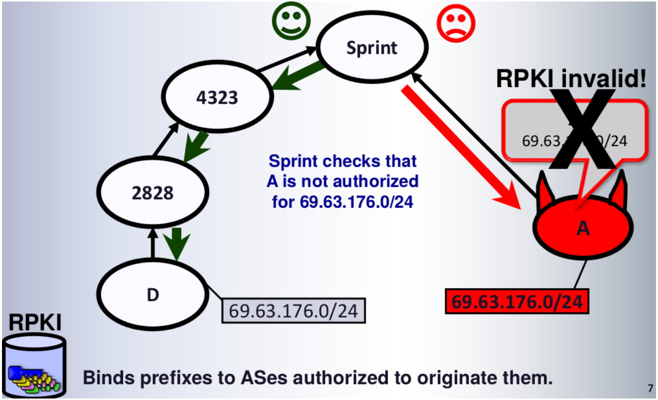
RPKI (resource public key infrastructure) cryptographically secure the prefix ownership information.

- it stores all the secure objects in several centralized repositories
- a router can verify a prefix announcement by compare the origin information with RPKI database
- the results can be valid, invalid, or unknown

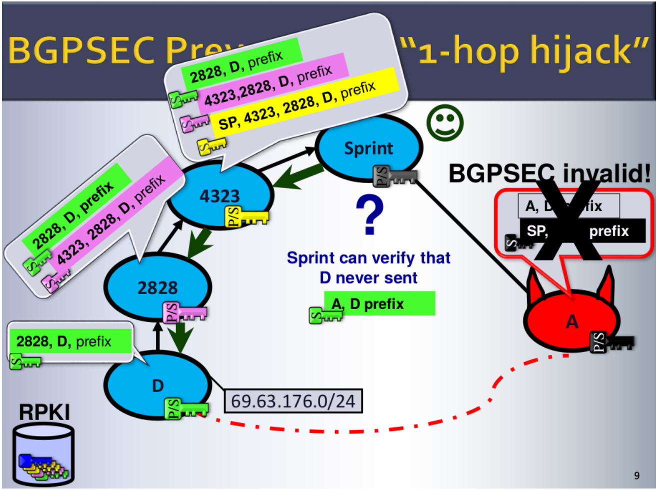
BGPSEC tries to secure AS paths updates by requiring all ASes sign their updates.

- On each propagation, an AS will sign the path with its own private key
- a verifier can look at the signatures of all the ASes in the path and verify against their public key

RPKI Example



BGPSEC Example



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BGP Decision Making

Each autonomous system (AS) operates on its own policy, and a BGPSEC secured route may not represent its best interests.

The million dollar question:

Are the ASes going to prefer a more secure route over a legacy route?

BGP Decision Making

For each BGP update, the following aspects needs to be considered to decide whether to accept the update or discard it:

- **Security:** whether the path is secure, and the origin is authorized
- **Local preference:** whether the nexthop is a customer (making money), or a provider (losing money), or a peer.
- **AS paths:** which path is shorter
- **Tie breakers:** e.g. geographic location, priority, etc.

BGP Decision Making with Security

The authors defined three levels of securities, and surveyed 100 network operators.

- **Security 1st: (10%)** always prefer secure routes over insecure routes.
- **Security 2nd: (20%)** cost is more important than security. (i.e. customer is preferred)
- **Security 3rd: (41%)** cost and path distance is more important than security.

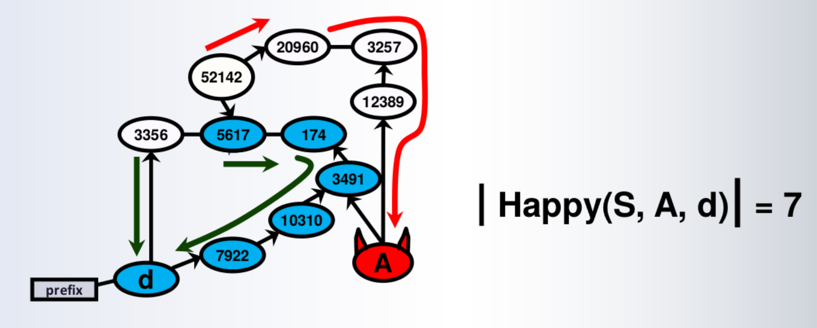
Threat Model

The attacker

- claims to be directly connected to the target AS, shortens the path
- announces the updates using legacy BGP protocol

Happiness

If a AS does not use the attacker's fake path, it is "happy".



Quantifying Security

$$H_{M,D}(S) = \frac{1}{|D|(|M-1|)(|V-2|)} \sum_{m \in M} \sum_{d \in D \setminus \{m\}} H(m, d, S)$$

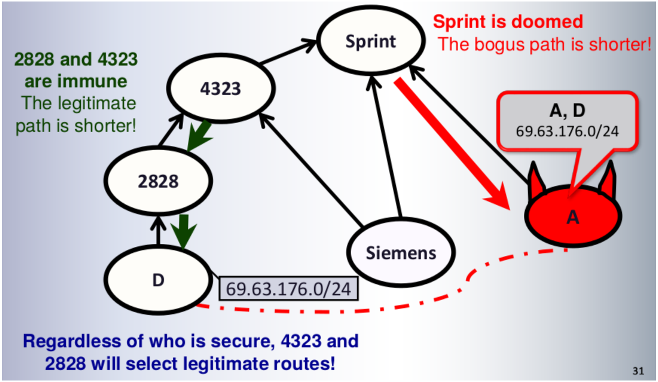
or

$$H_{M,D}(S) = \frac{1}{|V|^3} \sum_{m \in M} \sum_{d \in D \setminus \{m\}} H(m, d, S)$$

- S – BGPSEC enabled ASes
- M – Set of attacker ASes
- D – Set of target ASes
- V – All ASes
- H – **Happiness**: number of ASes that will not select the attacker's path

Observations

Under Security 3^{rd} model, Sprint is doomed, Siemems has a chance, 2828 and 4323 are immune.



Observations

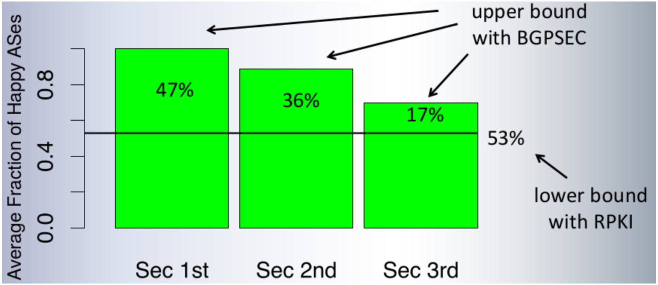
Regardless of the BGPSEC deployment:

- Doomed ASes: always choose bogus routes
- Immune ASes: always choose legitimate routes

Upper bound and lower bound of the overall happiness:

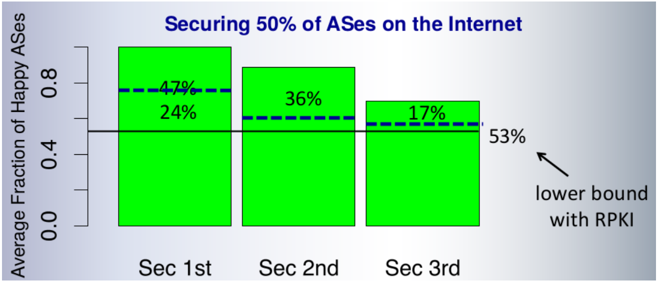
- Upper bound: 1 - fraction of doomed ASes
- Lower bound: fraction of the immune ASes

Security Improvement - Full Deployment



With full deloyment, in the most realistic security 3^{rd} model, we can only achieve 17% more security than simply doing RPKI (lower bound).

Security Improvement - Half Deployment



Security 3^{rd} – 4%
Security 2^{nd} – 8%

Takeaway

Main takeaway

Unless reaching very high deployment percentage, BGPSEC cannot provide much security improvement under the most popular security 3^{rd} model.