RPKI Deployment: Status, Challenges and the Learning-Validator

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Joint project with

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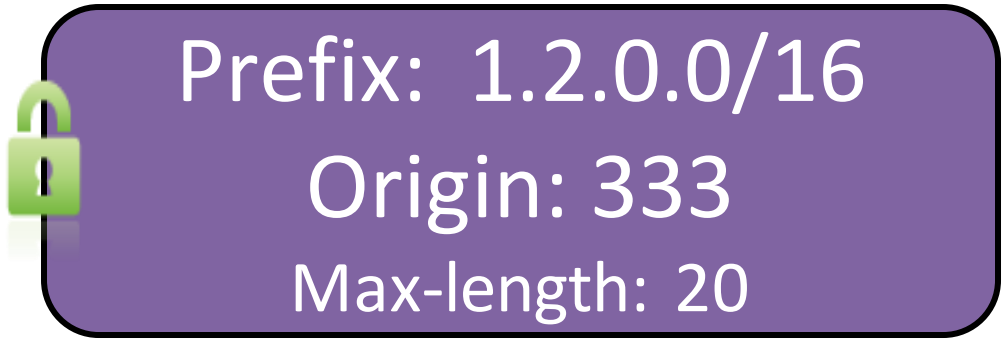
RPKI Deployment: Agenda

- RPKI in a foil
- ROA adoption: trends
- Wrong ROA: causes and damages
- ROV adoption status, challenges
- Impact of partial ROV adoption
- Improving deployment
  - ROAlert.org
  - The Smart Validator
  - Demo
- Conclusions

RPKI: Resource Public Key Infrastructure

- IETF standard [RFC 6480];
  main goal: prevent (sub)prefix hijacks (false origin domain)
- **Idea: issue (signed) Route Origin Authorization (ROA)**:

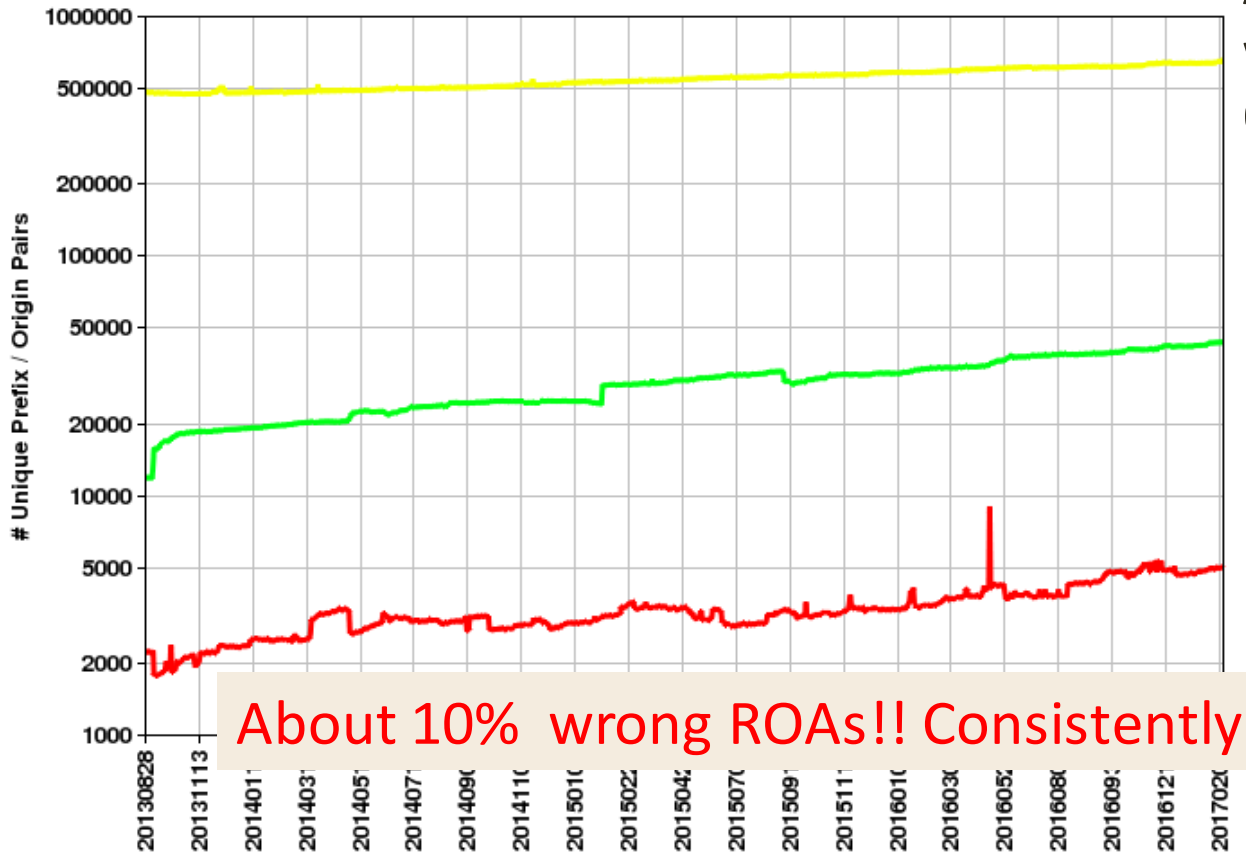


- **For simplicity, we ignore signing details**
- **Domains should do Route Origin Validation (ROV):**
  - **D**rop BGP announcements where origin conflicts with ROA
  - I.e.: Origin is not 333 or more specific than /20

ROA Adoption History

Drop BGP announcements ➔ lose (good?) traffic…

So, how many domains do Route Origin Validation?



Announced without ROA: 647,192 (93%)

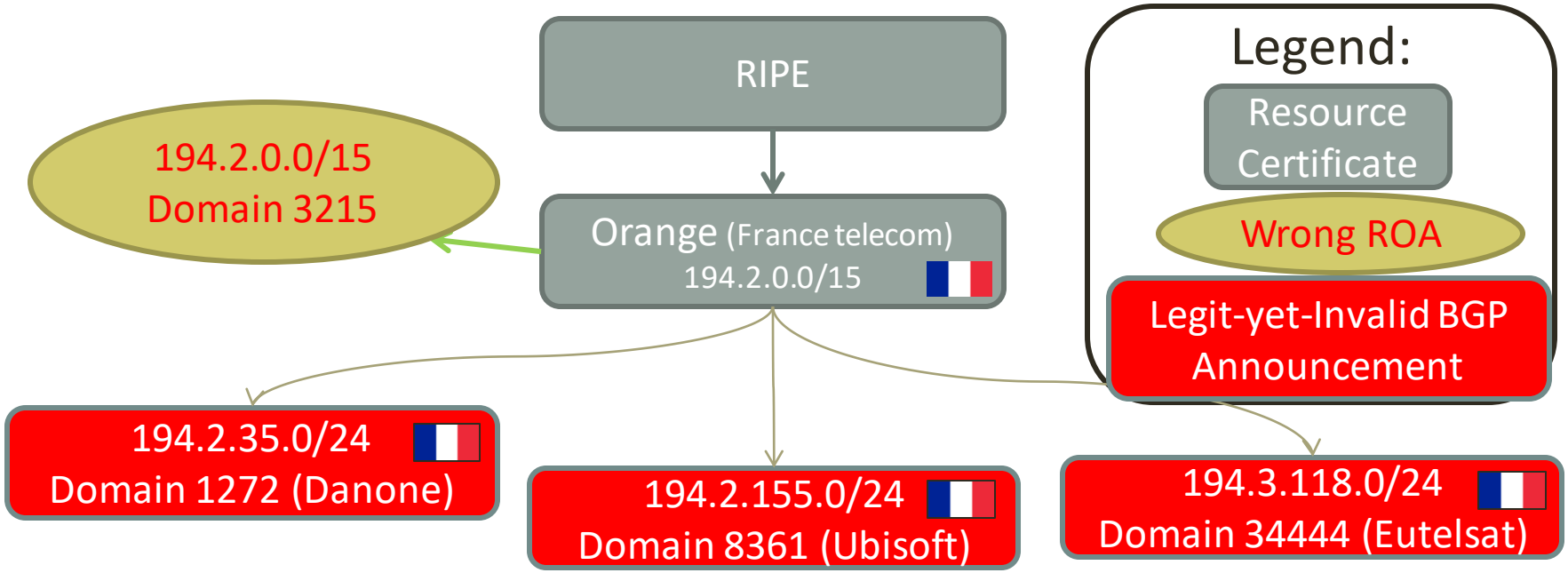
Valid ROAs: 43,796 (6.3%)

Wrong ROAs: 5,015 (0.7%)

About 10% wrong ROAs!! Consistently!!

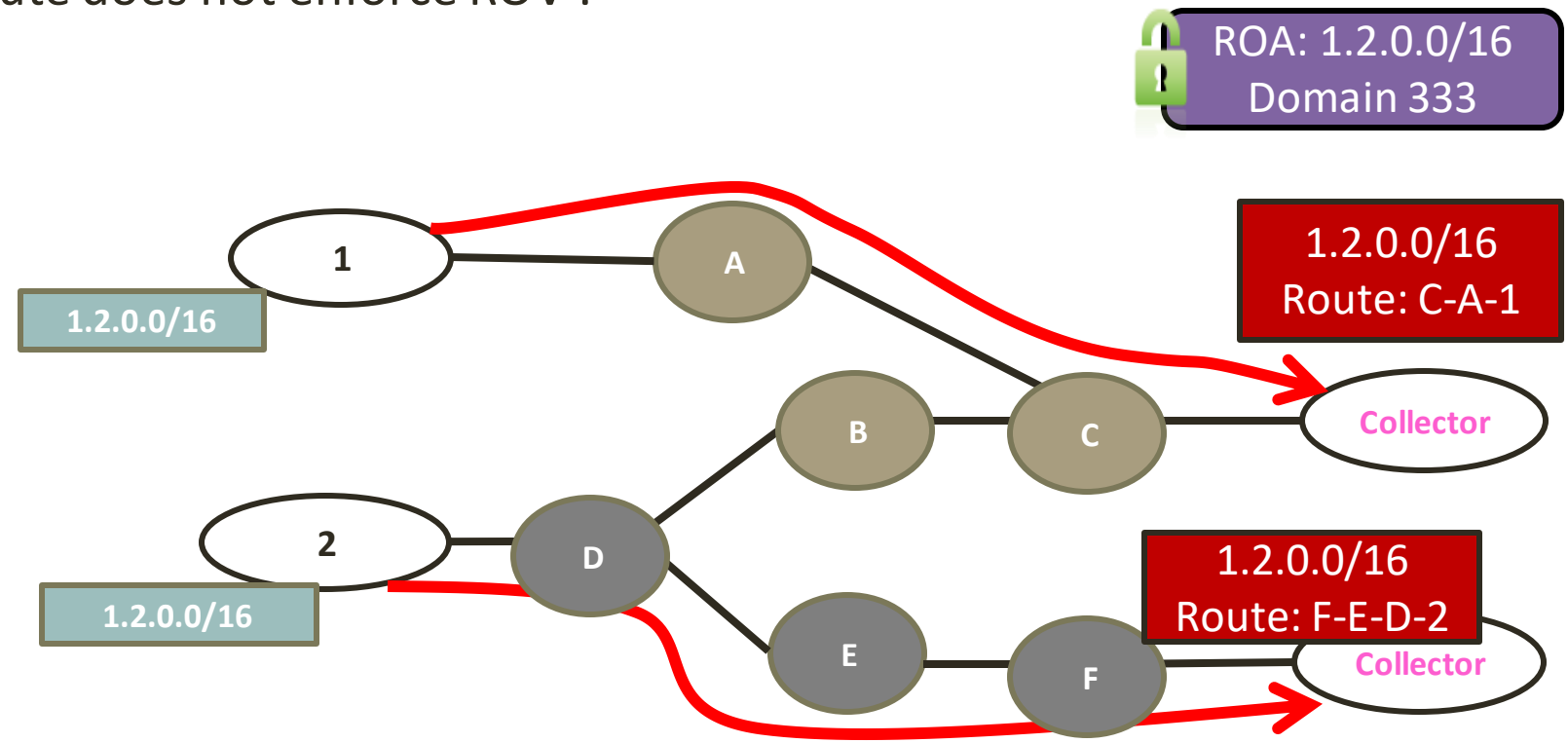
Wrong ROAs??

- Requires **both** authorizations (ROAs) and validation (ROV)
- Risk: ROV with **Wrong ROA**➔ drop legit-yet-invalid announcements
  - Does wrong-ROAs happen? – Typical, real-life example:



Measuring Adoption of Route Origin Validation

- Challenge: no direct way to measure the adoption of ROV
  ➔ no published measurements
- **Idea: use Route-View-project's BGP-collectors – and wrong ROAs!**
- Observation: if collector receives invalid announcement ➔ Entire route does not enforce ROV !



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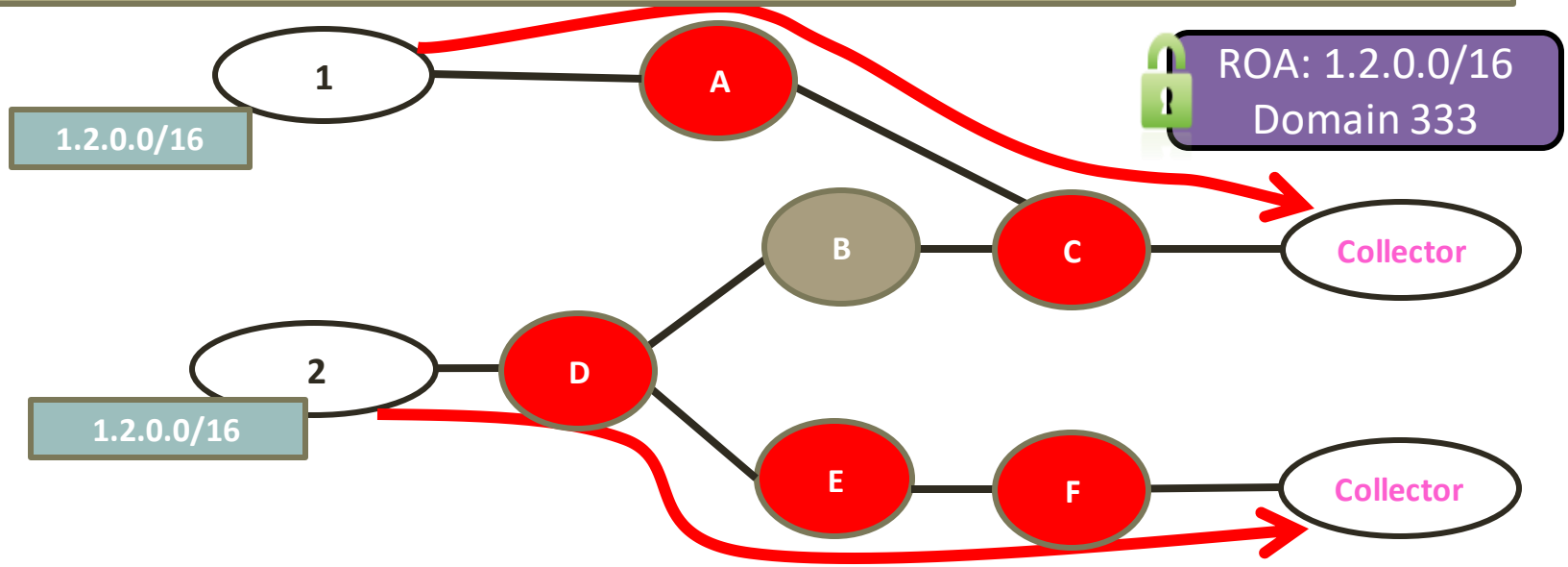
  Entire route does not enforce ROV !

At least 80 of 100 largest domains do not enforce ROV !
Can we meaure more precisely?

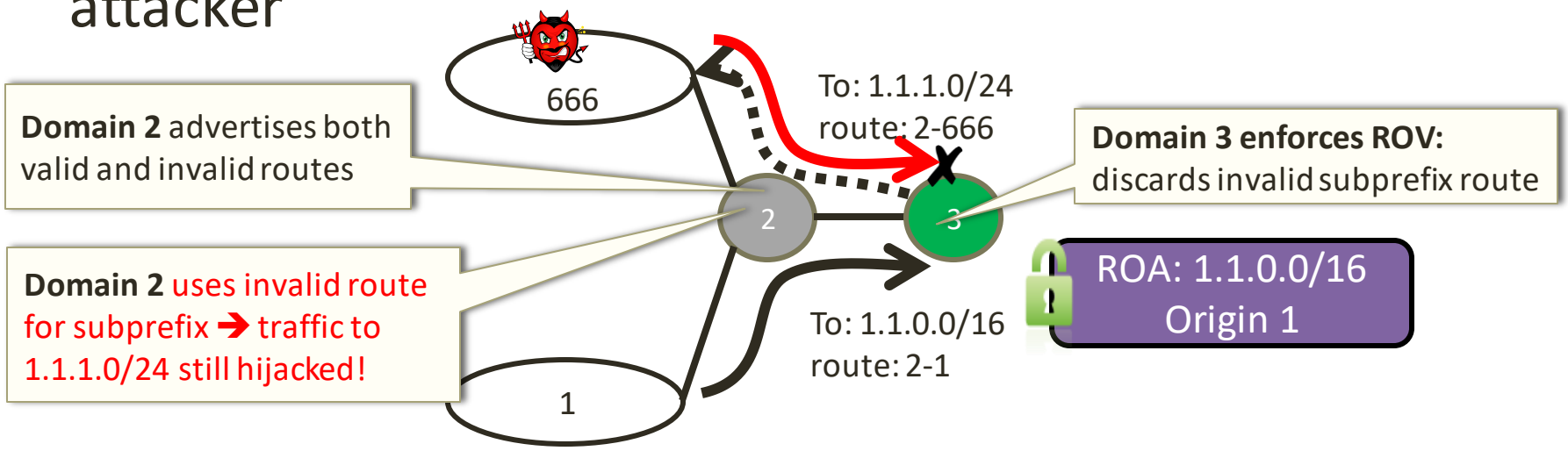


Better ROV Measurements…

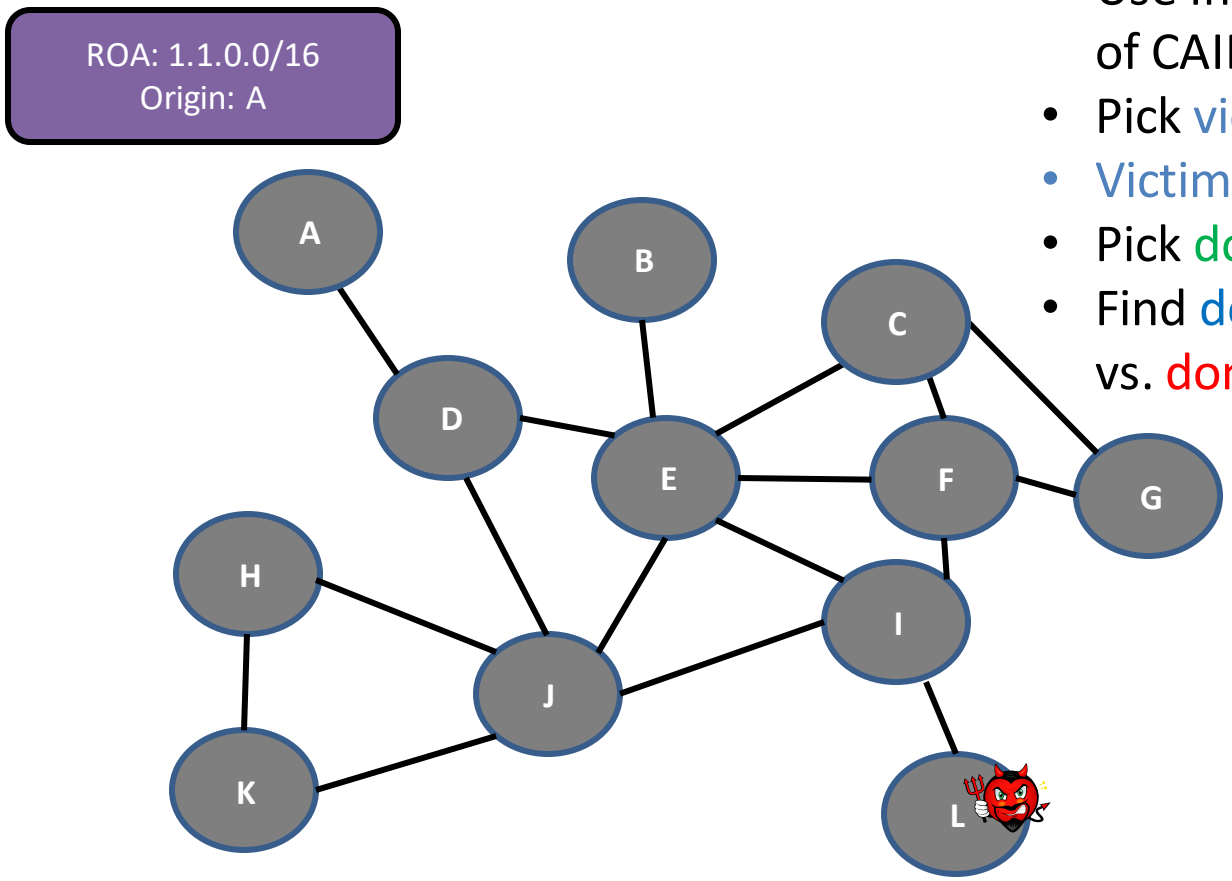
- Dependency on existing wrong ROAs may be misleading
- More reliable: **publish** correct/wrong ROAs (same origin)
- Three different controlled experiments, multiple times:
  - Use RouteView Collectors (as before)
  - Use Trace-route to RIPE atlas probes
  - Use `echo' from servers (ICMP ping or TCP SYN/ACK)
- Experiments still ongoing
- Initial results: **only handful of domains enforce ROV**
  - **None** of the 100 largest domains (cf. <20)
- Similar results apparently from measurements by Randy Bush and others (didn't yet see details)
- What's the impact of partial-deployment of ROV?

Partial Adoption of ROV:
Collateral damage

- Domains not doing ROV might cause ROV-enforcing domains to fall victim to prefix hijacking
- Control-Plane vs. Data-Plane Mismatch: domain discards invalid announcement, yet data flows to attacker



Security in Partial ROV Adoption: Simulation Framework



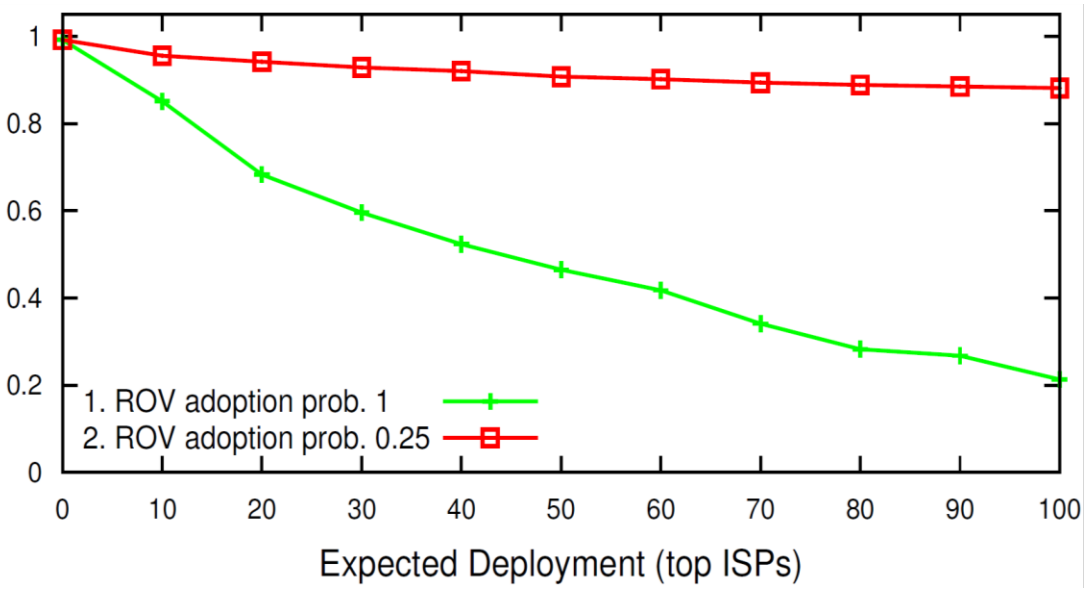
- Use Internet domain topology of CAIDA
- Pick victim & attacker
- Victim's prefix has a ROA
- Pick domains doing ROV
- Find domains sending to victim vs. domains sending to attacker

Empirically-derived topology from CAIDA. Includes inferred peering links [Giotsas et al., SIGCOMM'13]

Security with Partial ROV Adoption

- Subprefix-hijack success rate for adoption by x largest domains
- Compare: 100% vs. 25% adoption by other domains
- Significant benefit - but only if almost all large domains adopt – **and** most other domains adopt too
- We are very far from this!

Subprefix hijack success rate



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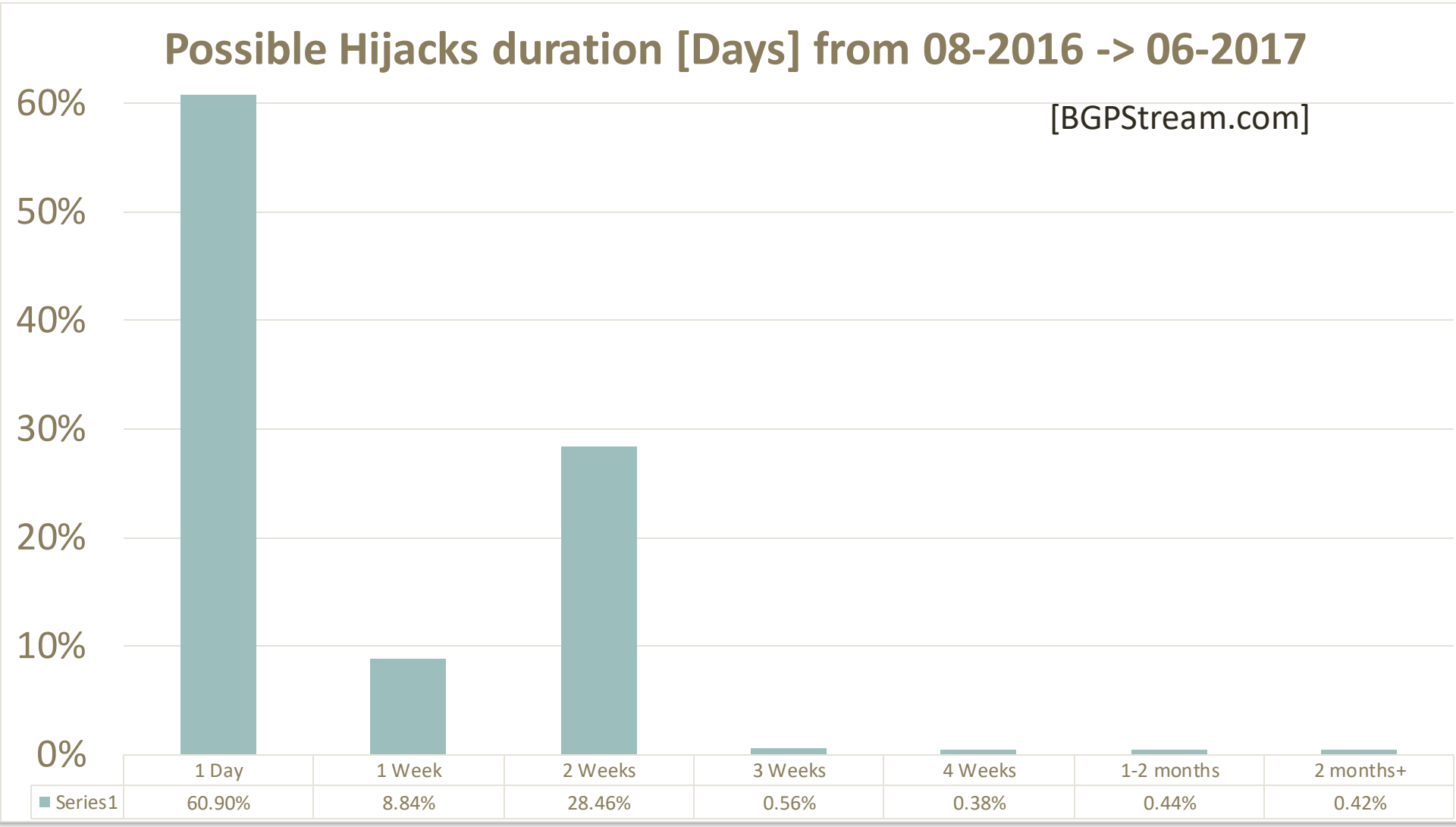
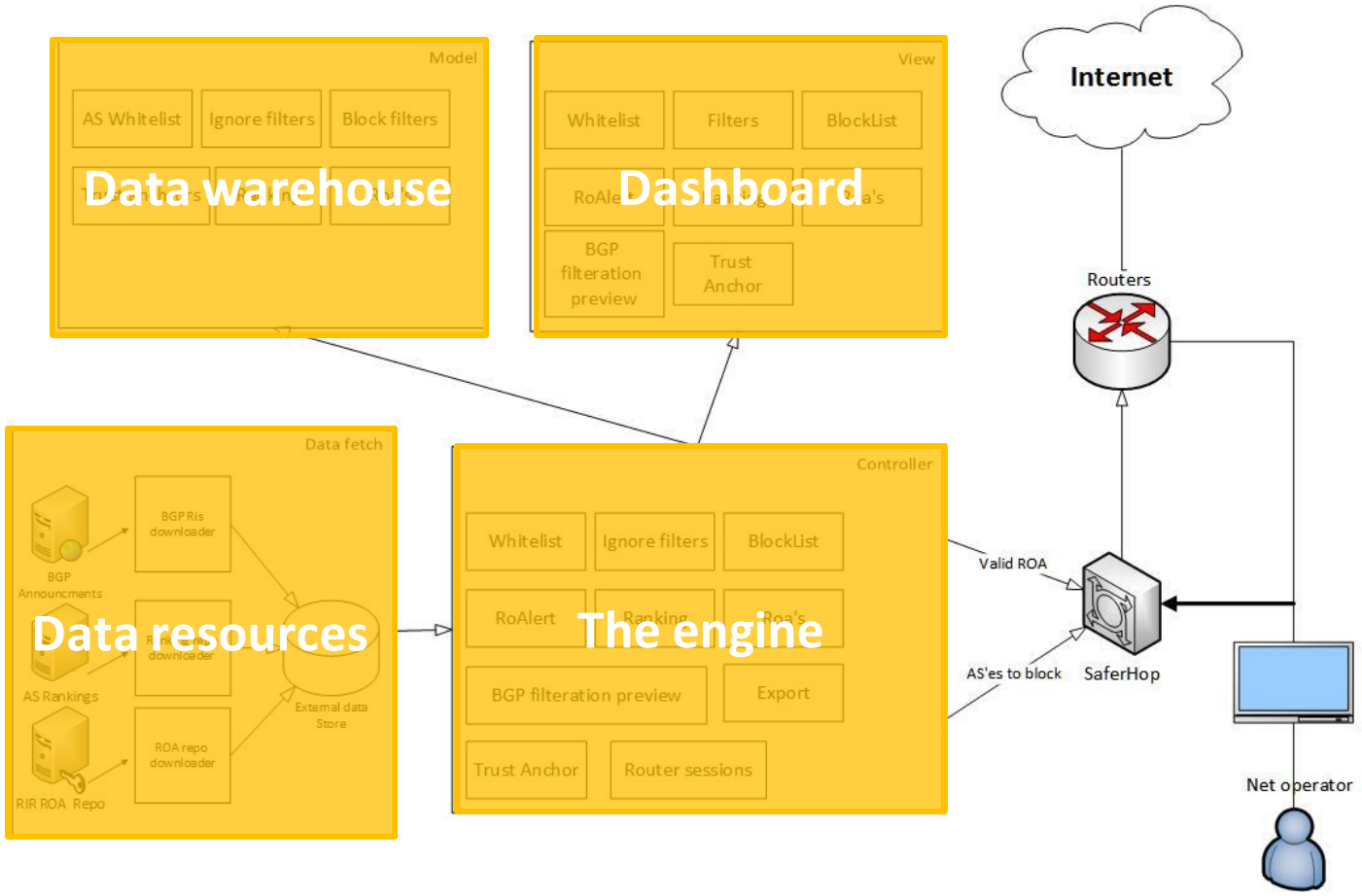
Fixing ROAs and ROV deployment

- **ROAlert.org: identifying wrong ROAs**
  - Also email alerts when sysadmin-email located: 40% fixed!
  - ➔ Should be deployed `officially'
- **Smart validator** (experiments with Cisco, LinkedIn, .. You??)
  - **Manual + Learning mode** (identify wrong ROAs)
  - **Two conservative modes**:
    - **Ignore mode**: ignore wrong ROAs, respect correct ROAs
    - **Auto-Extend mode:** add `virtual' ROAs (to correct `wrong')
  - **ROV++**: reduce collateral-damage; gives **incentive** to deploy
  - **Path-end validation: easy, strong extension to RPKI**
    - See SigComm16 paper – or ask me ☺

Learning based on time:



Architecture



Smart Validator Dashboard Examples

Manual+Learning mode

Auto-Extend mode

Beyond BGP: Routing Against DoS

- BGP is limited to single fixed route
  - Easier to congest – e.g., in Denial-of-Service (DoS)
- BGP isn't congestion-sensitive
  - Route does not depend on congestion, delays, loss
  - Slow response to link failure
- **IP** provides only best-effort service
  - No quality guarantees (max delay, max loss rate)
  - Quality-of-Service (QoS) extensions: only **within** domain
- ➔ Secure Accountable Inter-domain Forwarding
  - **On going project – talk to me…**

Conclusions

- Routing security: fun & important research area
- RPKI improves BGP's security… **if** deployed widely
  - ➔ ROAlert and Improved validator (ROV++)
- BGPsec deployment… unlikely ?
  - ➔ Path-End instead? Effective – and deployable!

More questions?
Thanks !