Experiences Deploying Multi-Vantage-Point Domain Validation at Let's Encrypt

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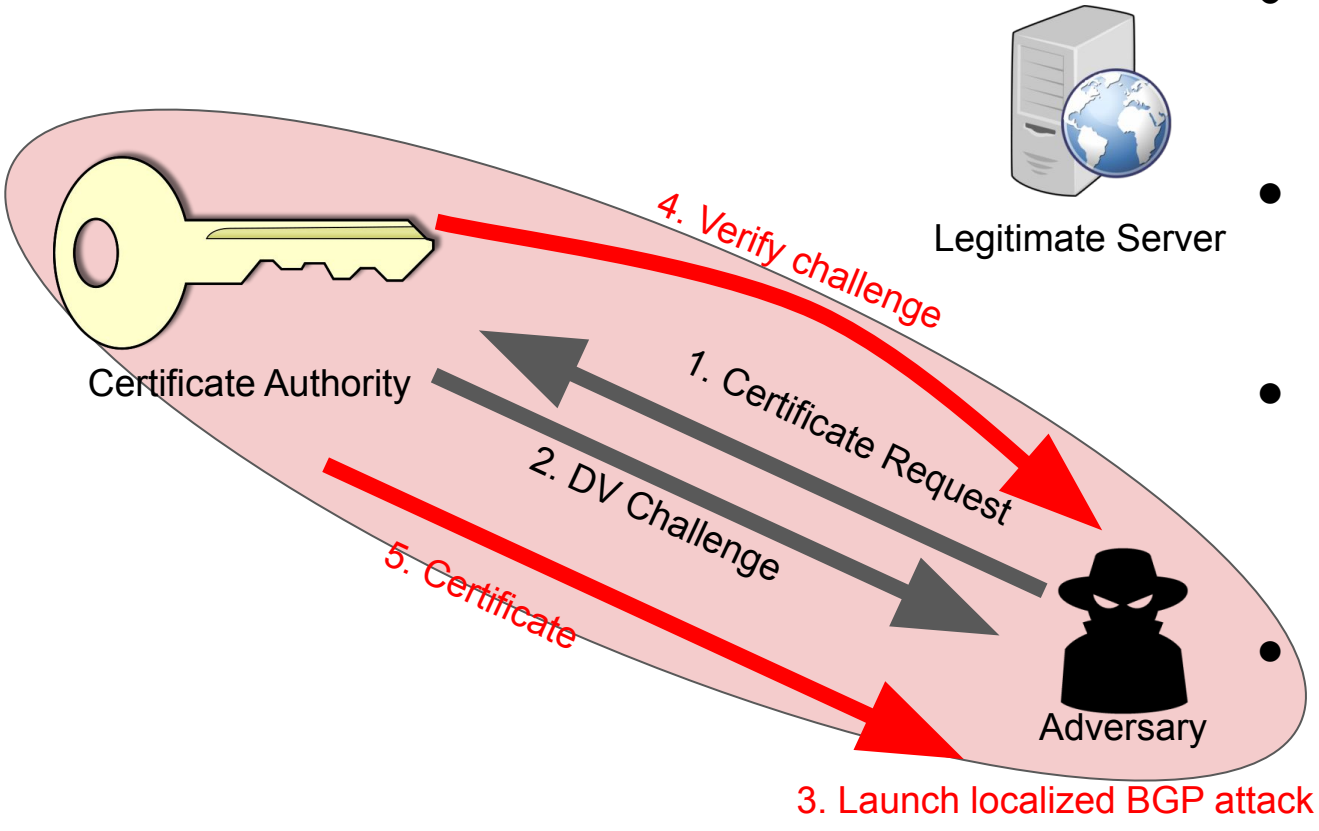
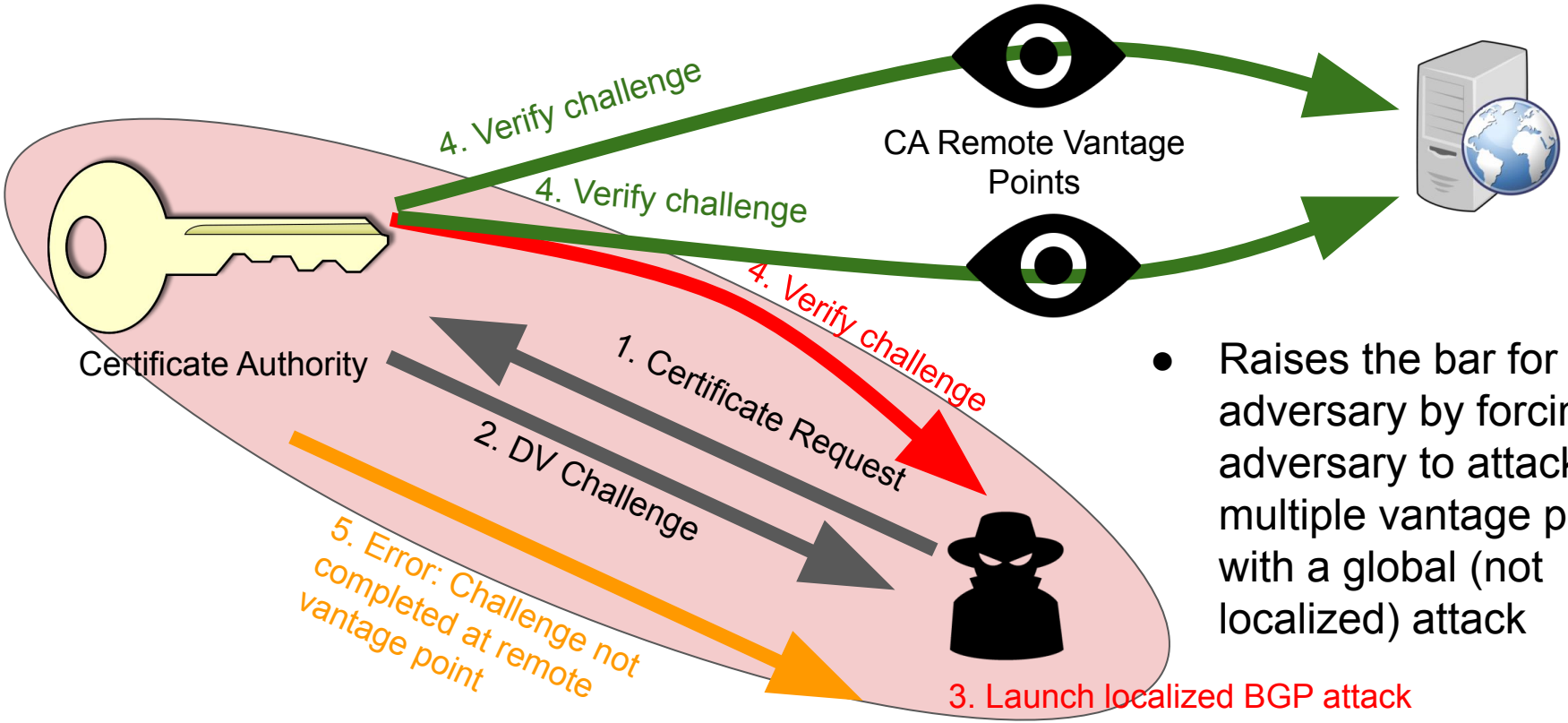
Let's Encrypt

Routing Attacks on Certificate Authorities



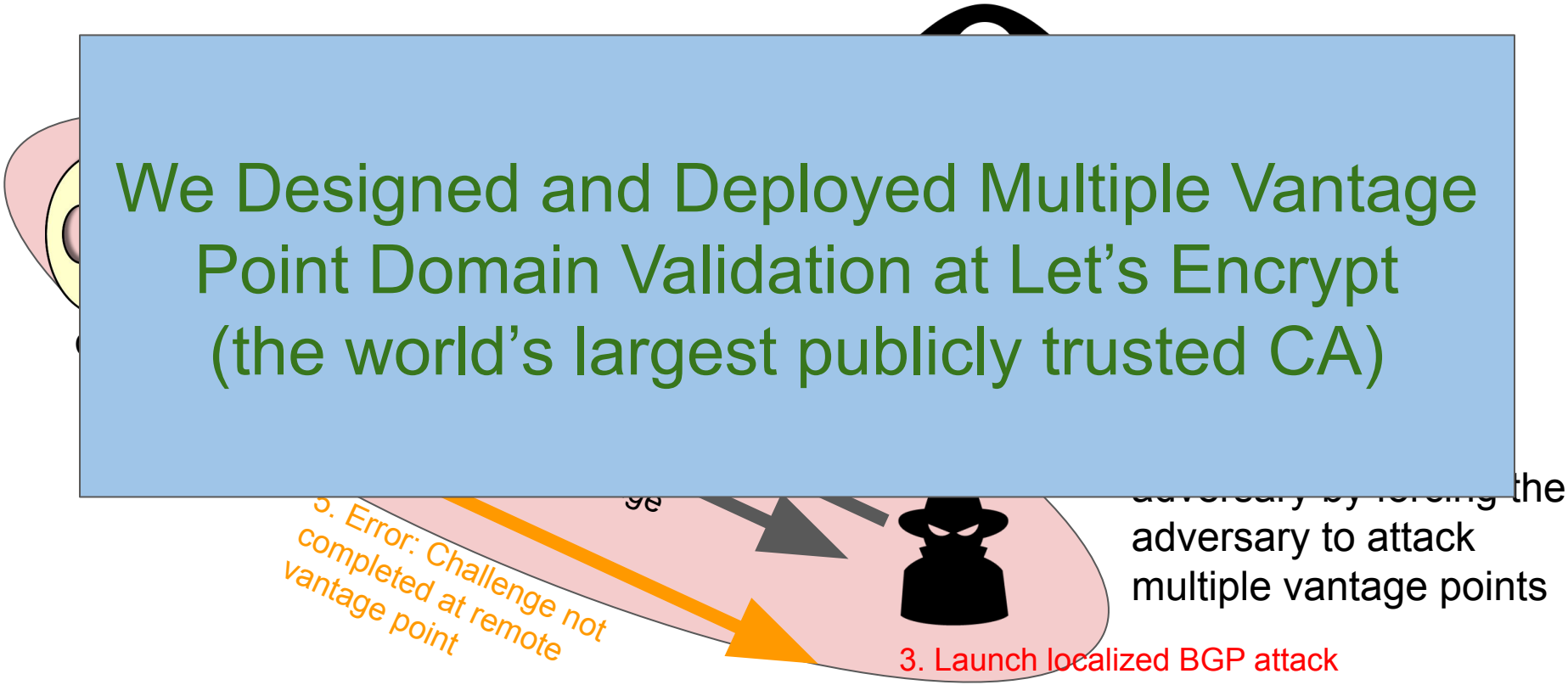
- Trust on the Internet relies on valid digital **certificates**
- **Domain validation** is used to verify identity during certificate issuance
- Adversaries can manipulate Internet routing to direct validation challenge to wrong party
- Adversaries can obtain malicious certificates and man in the middle TLS connections

Multiple vantage point domain validation

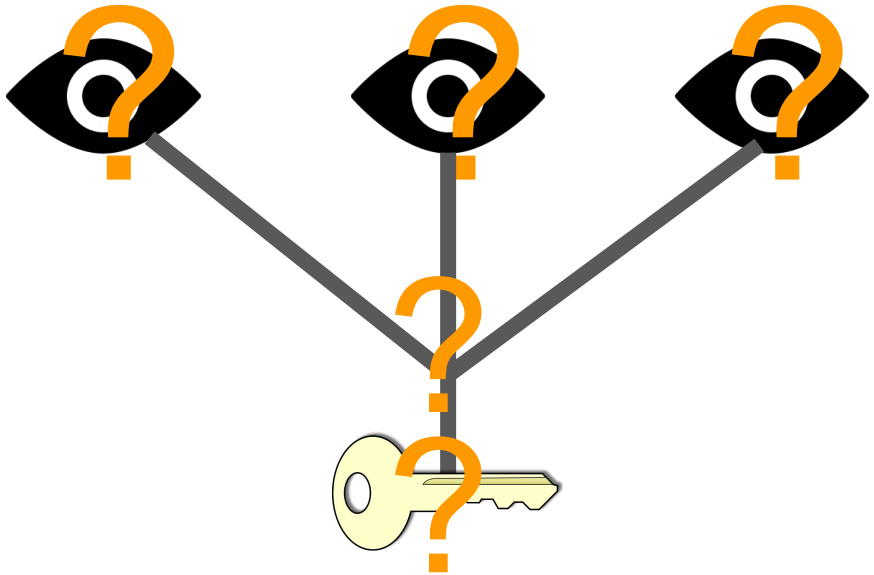


- Raises the bar for an adversary by forcing the adversary to attack multiple vantage points with a global (not localized) attack

Multiple vantage point domain validation



Design Questions



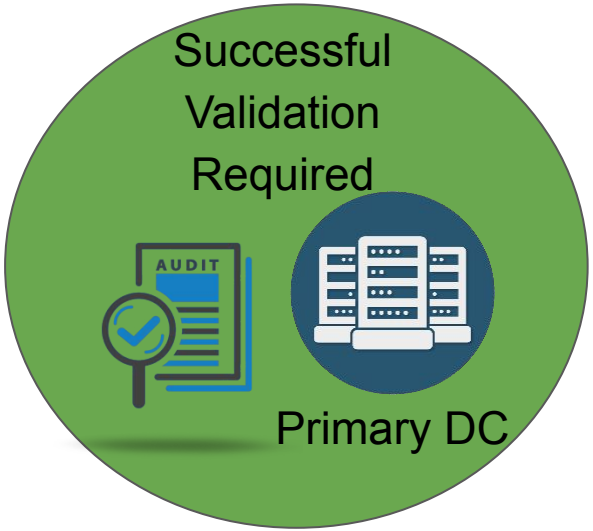
- Where should vantage points be located?
- How should results from vantage points be considered?
- How should the multiple vantage points be integrated into the Let's Encrypt code base?

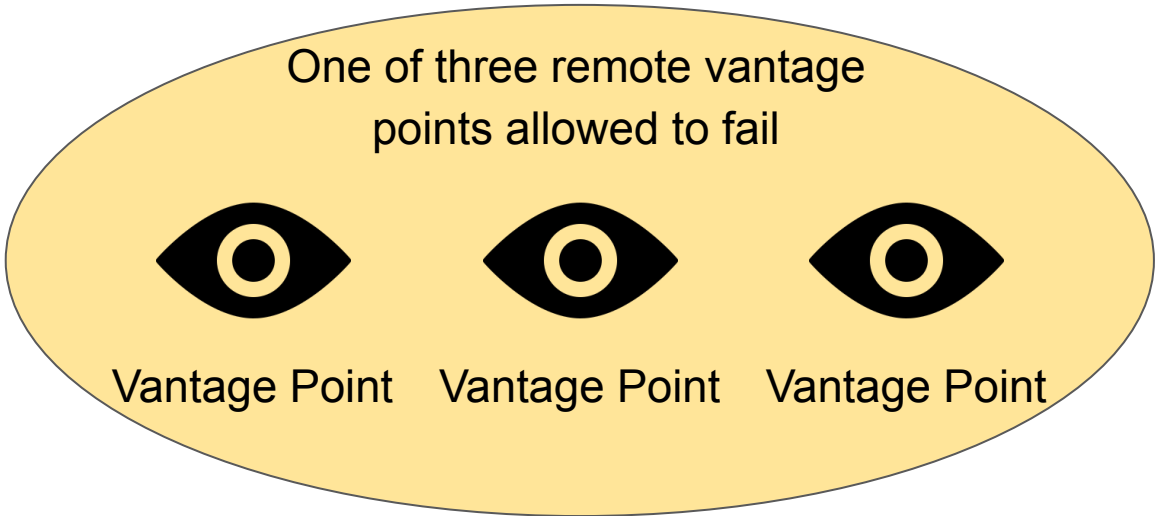
Where should vantage points be located?

- Billing and management are simplified if all vantage points are in same cloud provider
- But does a single cloud provider still provide sufficient security?
  - Yes! If vantage points are spread out geographically they will use local peering connections to route to the victim and will have sufficient diversity
- Vantage points are in the US West Coast, East Coast and Europe

How should results be considered?

- Requiring validation from all vantage points could cause a single outage to take down the CA
- The CA/Browser Forum (that govern CAs) has auditing requirements that are not enforced at remote vantage points



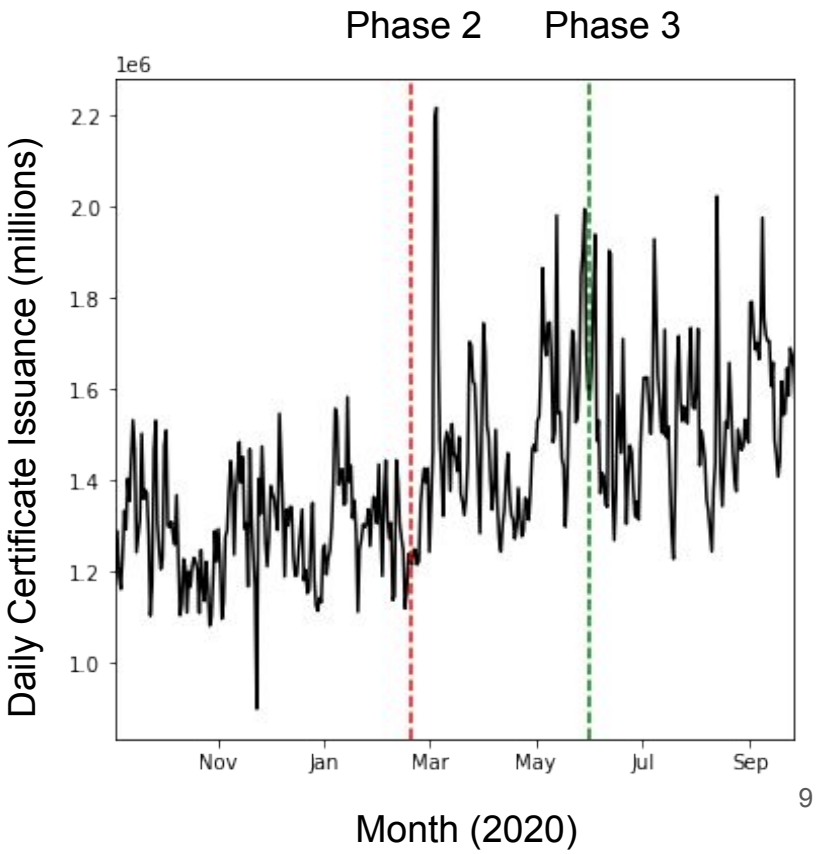


How should the multiple vantage points be integrated into the Let's Encrypt code base?

- Let's Encrypt has a modular code base connected by RPC calls (which are authenticated and secure over the public Internet)
- Much of the code from the original validation authority (VA) can be reused for multiVA
- MultiVA is a extension to the original VA module (leaving other parts of the code unaffected)
  - Only ~200 lines of code needed for core multiVA logic
- Open-source code:
  - https://github.com/letsencrypt/boulder/blob/main/va/va.go

Preventing disruptions with a phased deployment

- Phase 1: Monitoring only: multiVA results are logged but do not influence validation
  - Used to test mutiVA code at scale and log any potential errors and estimate costs (~$100 per month per VA)
- Phase 2: Enforcing with exception list: multiVA is enforced except on certain accounts
- Phase 3: Full deployment



Preventing disruptions with a phased deployment

Since enforcement, over half a billion certificates have been signed with multiVA

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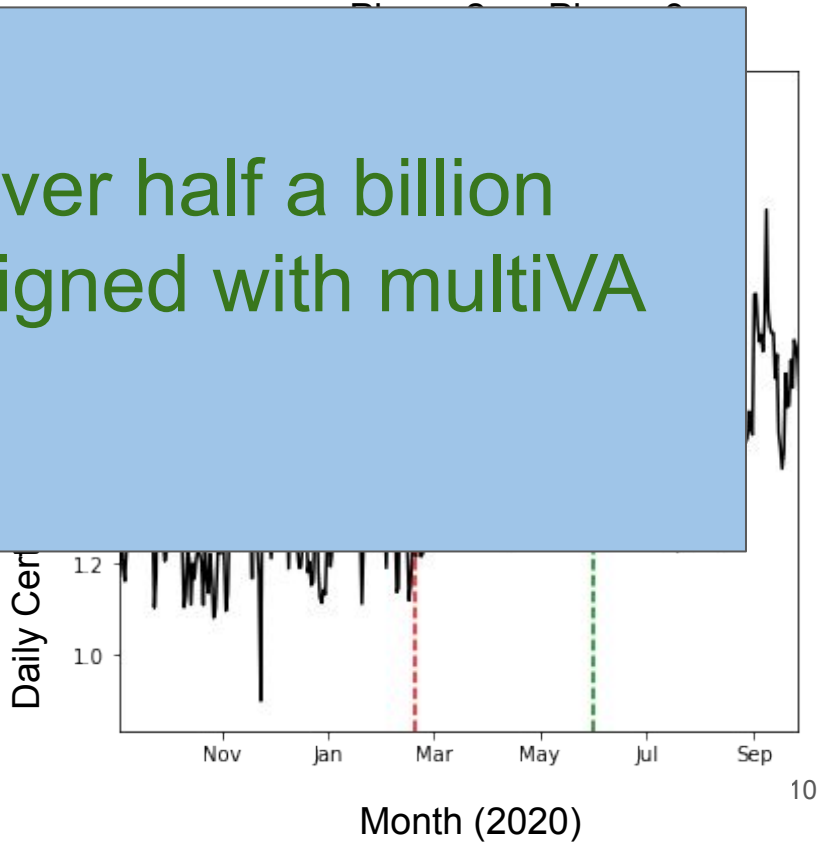
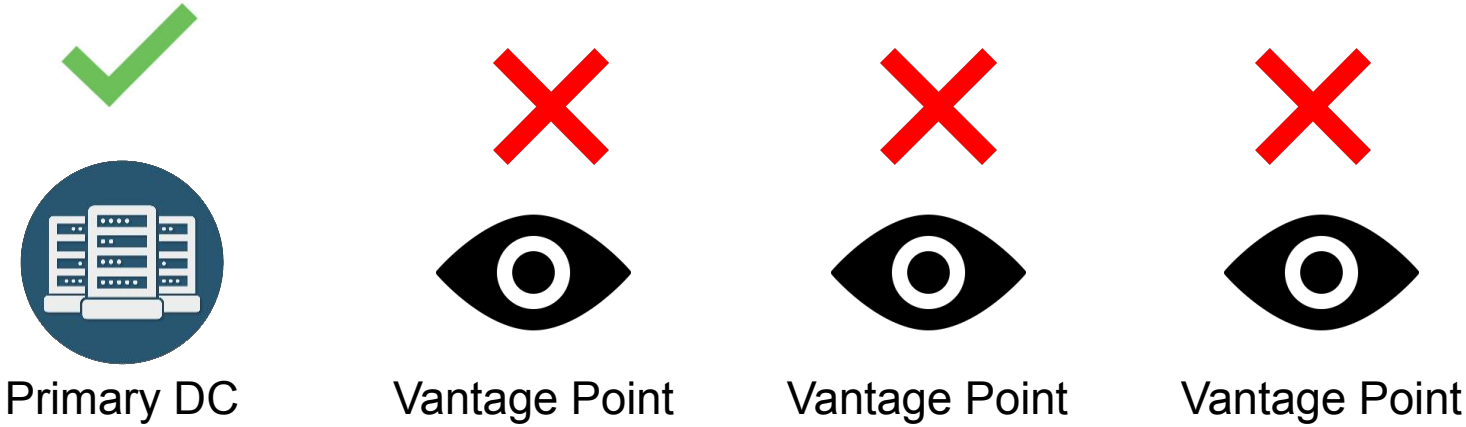
- Phase 3: Full deployment



Benign Failures

Benign Failures:
Certificates that blocked because of multiVA where no attack was present



Understanding Benign Failures

- Causes of benign failures:
  - Domain registration and certificate request often happen around the same time
  - DNS may not have fully propagated causing failures at remote vantage points
- Mitigating benign failures:
  - Use a quorum policy (e.g., allow one vantage point to fail)
  - Customers can try again: ~50% of failed certificates are retried and ultimately signed

Understanding Benign Failures

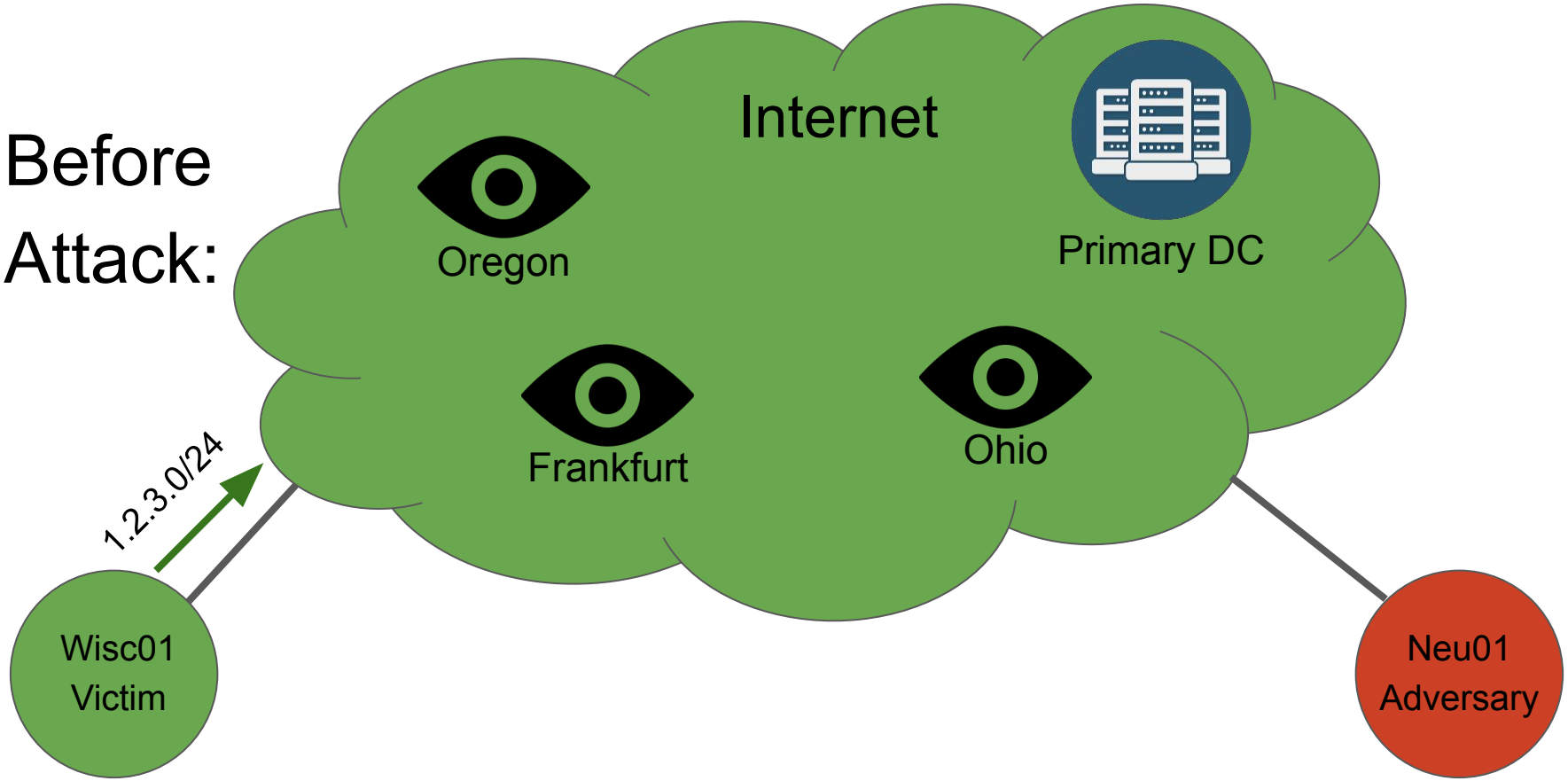
- Benign Failure rate is manageable at Internet scale
-
  - Use a quorum policy (e.g., allow one vantage point to fail)
  - Customers can try again: ~50% of failed certificates are retried and ultimately signed

Evaluating Security via Real-World Attacks

- Tested with real-world BGP attacks on domains we controlled and certificates requested from Let’s Encrypt
- Ethical Considerations:
  - Performed using the PEERING testbed
  - Had authorization from PEERING to announce IP prefix at all PEERING nodes
  - IP prefixes/domains were only used for this experiment (i.e., no real users or services)

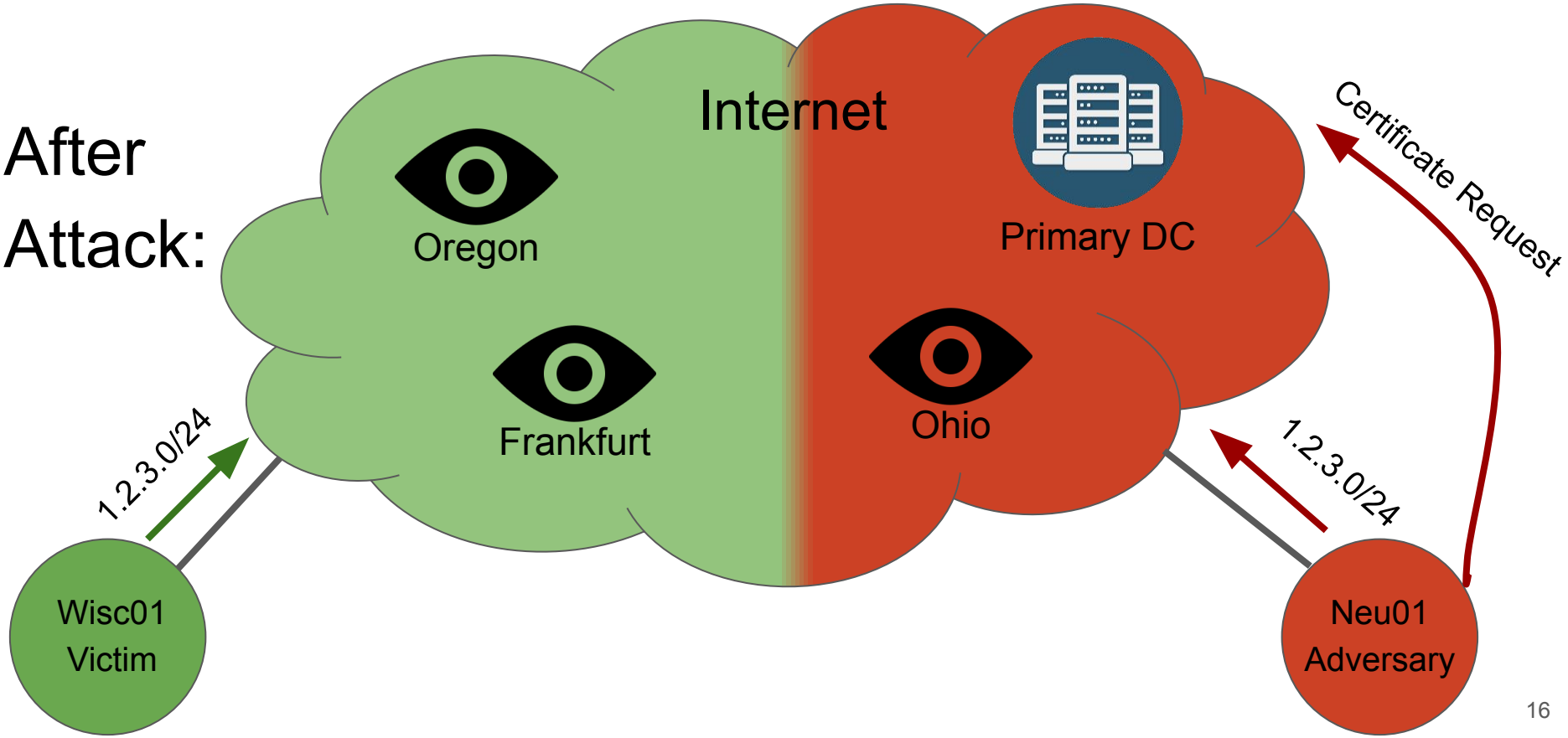
Real world attacks with PEERING testbed

Before Attack:

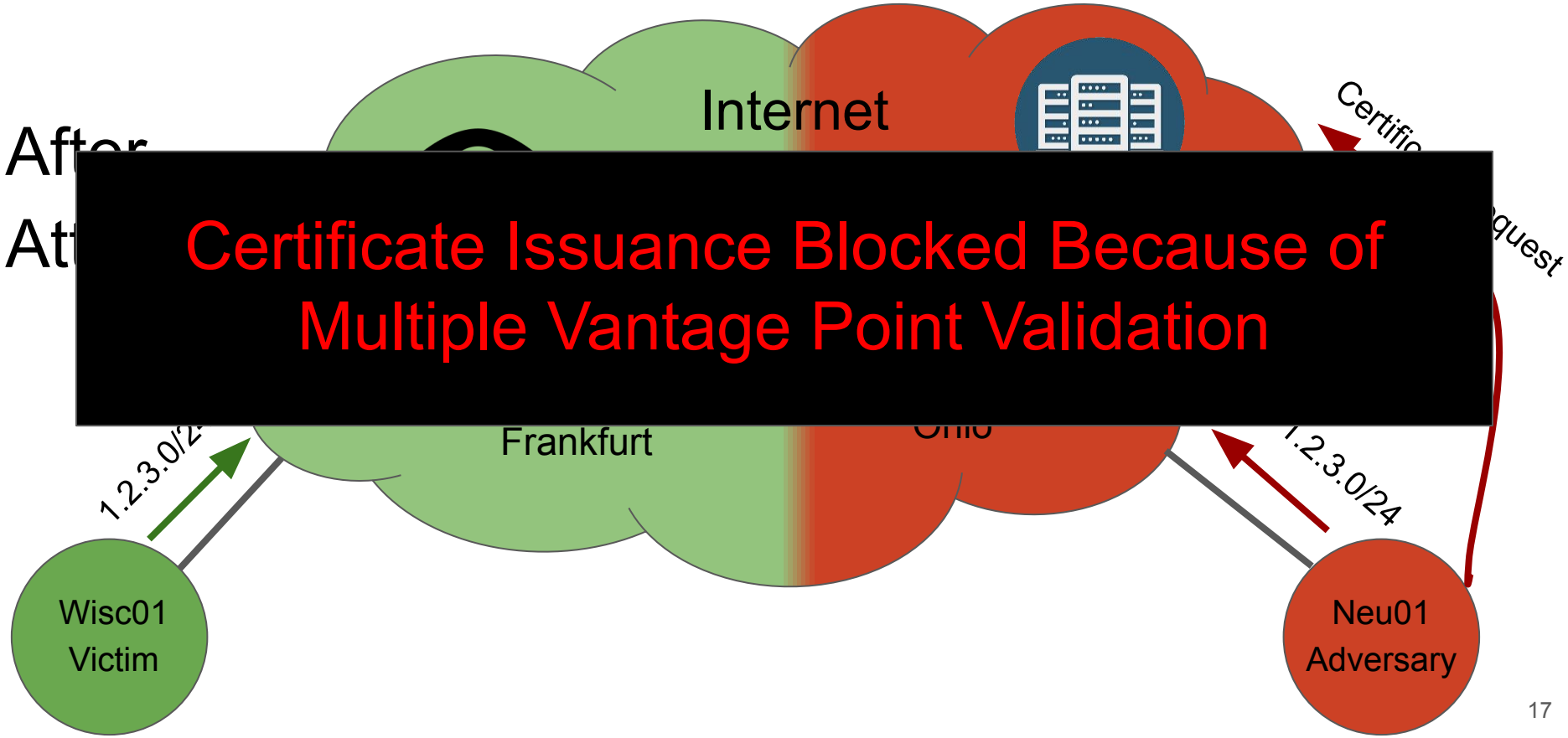


Real world attacks with PEERING testbed

After Attack:



Real world attacks with PEERING testbed



Certificate Issuance Blocked Because of Multiple Vantage Point Validation

Considering more adversaries shows security improvement

- Considered all six other active PEERING nodes as adversaries attacking wisc01
- Without multiVA: five out of six attacks succeeded
- With multiVA: only one out of the six attacks succeeded

Evaluating security via simulations

- Measured “resilience”:

  The fraction of ASes on the Internet that are topologically incapable of launching a BGP attack to get a certificate for a domain.

- MultiVA increased median domain resilience from .62 to .95
- Even greater improvement on 10th percentile domain from .10 to .51
- More vantage points further improve resilience

Conclusion

- MultiVA design is feasible at Internet scale (i.e., deployed at Let's Encrypt with more than half a billion certs issued)
- Next steps: pushing for more CA adoption and ultimately full industry adoption
- Code is open source and available at:
  - https://github.com/letsencrypt/boulder/blob/main/va/va.go

Conclusion

Questions?

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