The State and Challenges of the DNSSEC Deployment

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Monitoring Shows What's Working and What needs Work

- DNS operations must already deal with wide-spread misconfigurations and errors
- DNSSEC adds a significant amount of complexity to plain-old DNS
- In this talk we show evidence that the DNSSEC deployment is gaining ground

  - and -

  evidence that DNSSEC's complexity is becoming visible in crypto management and the delegation hierarchy

Outline

- DNSSEC primer
- Growth of DNSSEC
- Crypto Management
- Crypto is a Challenge Faced by DNSSEC
- Conclusion

DNSSEC Primer

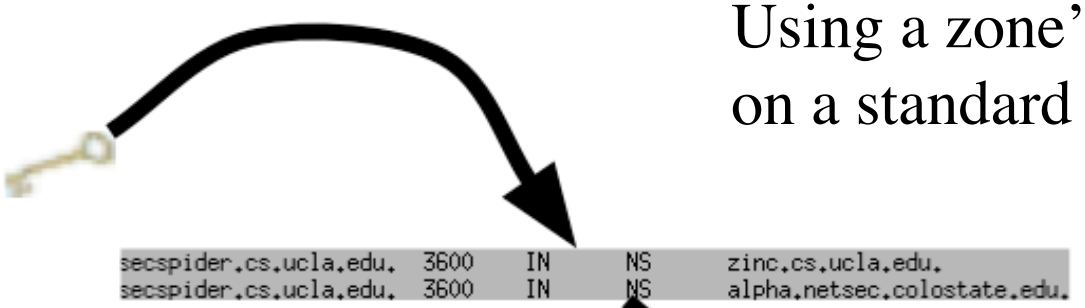
- DNSSEC provides *origin authenticity, data integrity,* and *secure denial of existence* by using public-key cryptography
- Origin authenticity:
  - Resolvers can verify that data has originated from authoritative sources.
- Data integrity
  - Can also verify that responses are not modified in-flight
- Secure denial of existence
  - When there is no data for a query, authoritative servers can provide a response that proves no data exists

How DNSSEC Works

- Each DNSSEC zone creates one or more pairs of public/private key(s)
  - Public portion put in DNSSEC record type DNSKEY
- Zones sign all RRsets with private key(s) and resolvers use DNSKEY(s) to verify RRsets
  - Each RRset has a signature attached to it: RRSIG
- So, if a resolver has a zone's DNSKEY(s) it can verify that RRsets are intact by verifying their RRSIGs

Signing Example

Using a zone's key
on a standard RRset (the NS)



```
secspider.cs.ucla.edu.  3600    IN      NS      zinc.cs.ucla.edu.
secspider.cs.ucla.edu.  3600    IN      NS      alpha.netsec.colostate.edu.
```

Signature (RRSIG) will only verify with the DNSKEY if *no* data was modified

```
secspider.cs.ucla.edu.  3600 IN NS alpha.netsec.colostate.edu.
secspider.cs.ucla.edu.  3600 IN NS zinc.cs.ucla.edu.
secspider.cs.ucla.edu.  3600 IN RRSIG NS 5 4 3600 20080324024800 (
                                20080322024800 44736 secspider.cs.ucla.edu.
                                E4msde1nzVlfGvwDo2X6jLU5d9Xrk37lrYRCZN6yq5ad
                                mABa3B3KgKl13u2VBXDujJZucHSwPQMBy+JOmotZOggf
                                SgQWUYm86v8G7ABHHcI+YFD3z3eqSoAoBAE5ysafop1u
                                g7tw1J4xd/IADIVeu1HnVIKRSycILXzvCwcaDWwAd610
                                9oJUBSMgWZjGzYeJO9Rz0oUUqIqtn9PgVOzdTm+WnRC3
                                LEz50fdoP743QvPhe7RrF9w1KA3MOptTiQA++W8GgO85
                                NhbJ7MD99nEYaEv3+GuDCTkCy5ZOWoI/2Bcjq1NGBDLo
                                71lo6udu72i1tpyRfTEEQUirpInlZ9+IMw== )
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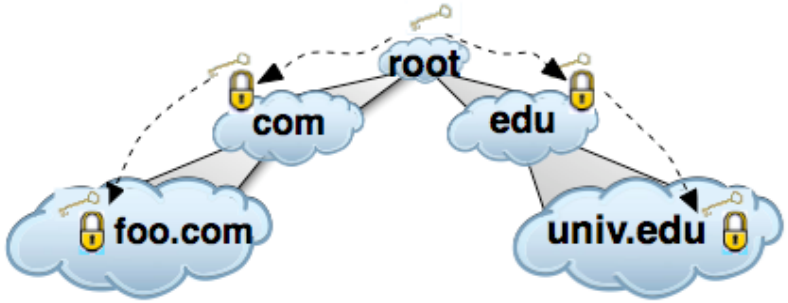
Getting the Keys

- Until a resolver gets the DNSKEY(s) for a zone, data can be spoofed
- How can a resolver know that the DNSKEY(s) *themselves* are not being spoofed?



- DNSSEC zones securely delegate from parents to children
- Zones that have no secure parents are called trust anchors
- When a zone is a trust anchor the zones that it delegates to form an *island of security*

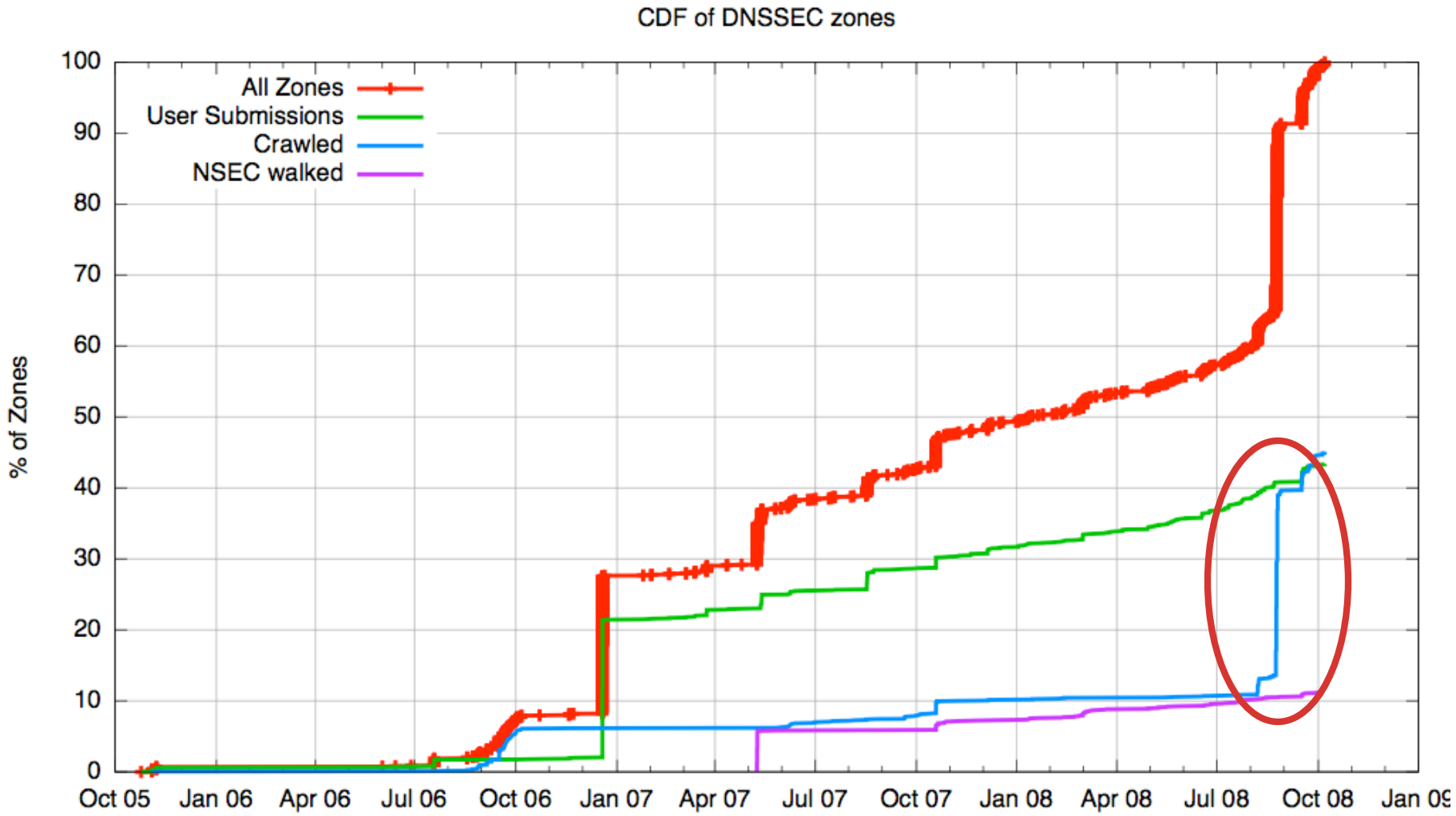
Measurements from SecSpider

- SecSpider is the first DNSSEC monitoring project
  - Began late in 2005
  - Zones taken from user submissions, various crawling engines, and NSEC walking
- Monitoring over time from distributed locations has allowed us to:
  - Observe the deployment's growth
  - Study distributed inconsistencies
  - Study policies and general behavior of early adopters

Production Set

- Zones are classified as production iff they:
  - Are under arpa
    - Reverse mappings - 160.96.179.131.in-addr.arpa
  - Or, are a TLD
    - com, edu, se, de, bg
  - Or, maintain a reachable web server at a www domain
  - Or have a mail server listed under an MX
  - We currently track 1,627 production DNSSEC zones

Growth of DNSSEC

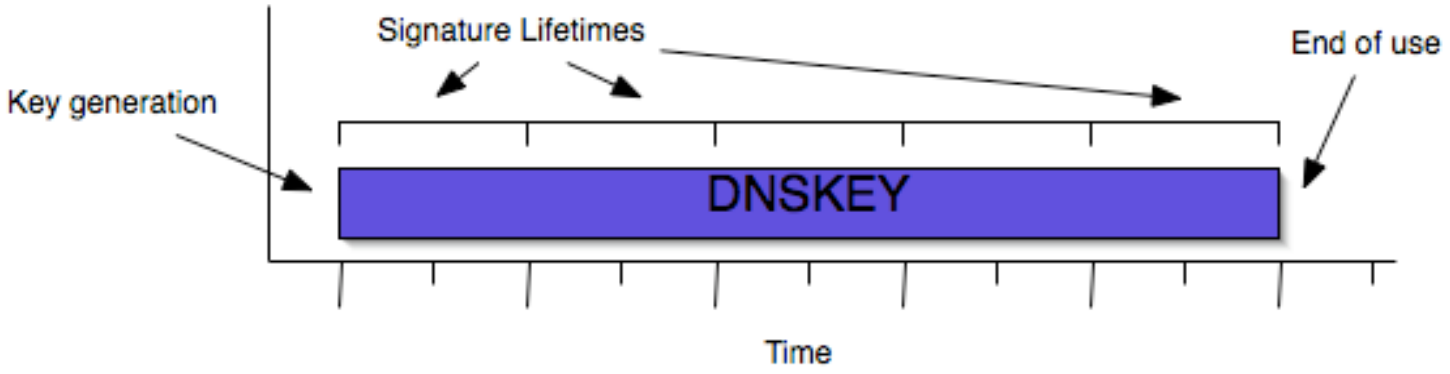


Crypto Management

- Having keys and creating signatures can be more involved that it first seems
- Paul Mockapetris, SIGCOMM'88:
  “Distributing authority for a database does not distribute a corresponding amount of expertise.”
- We, therefore, posit that:
  “Deploying cryptography for a database does not deploy a corresponding amount of expertise.”

Key vs. Signature Lifetimes

- There is a distinct difference between the signature lifetimes of DNSKEYs and the actual period of use
  - A key with a short signature lifetime can be re-signed indefinitely!



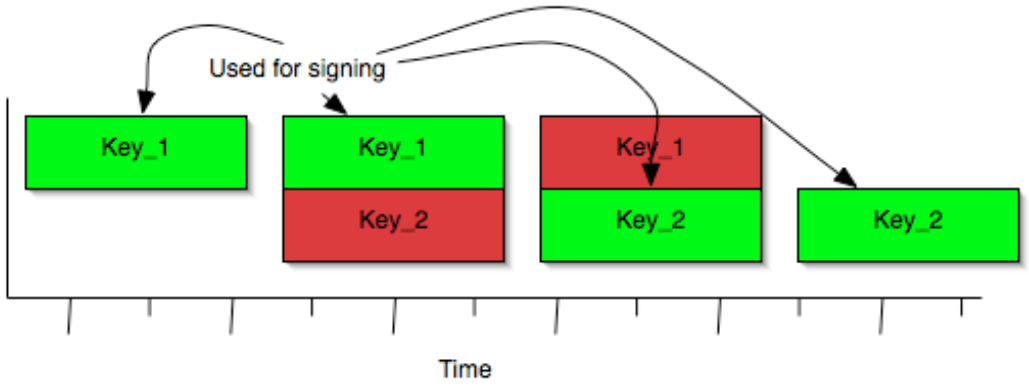
Signature vs Actual Lifetimes

- Signature lifetimes -> Actual average lifetime
  - 0-30 days -> 102.651 days
  - 31-60 days -> 68.9527 days
  - > 60 days -> 395.085
- Pruning keys that have not expired yet
  - 0-30 days -> 83.2043 days
  - 31-60 days -> 209.19 days
  - > 60 days -> 156.762 days

- Key lifetimes are clearly different than signature lifetimes

How Keys *Should* be Changed

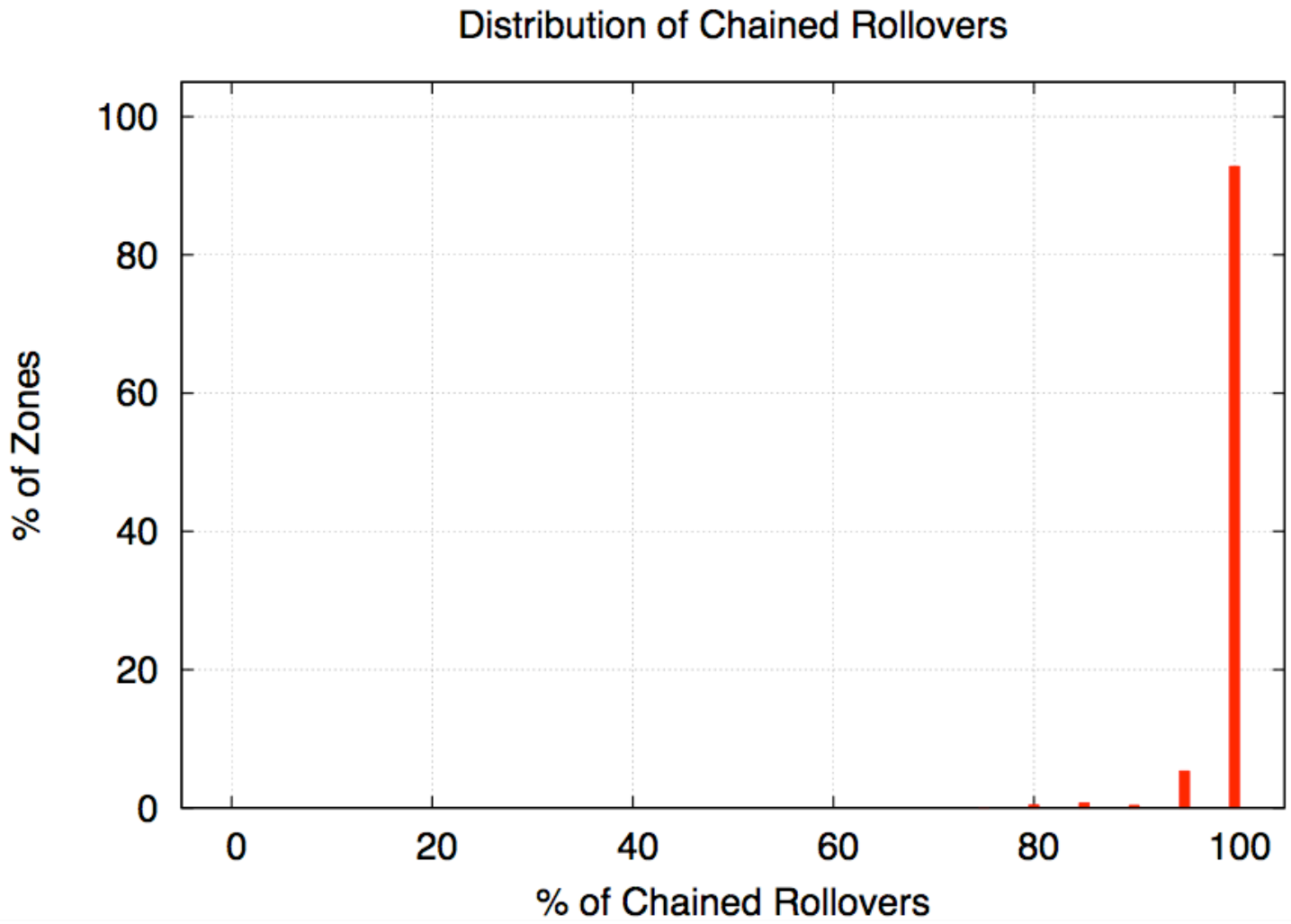
- When Key changes are needed, old keys need to overlap with new keys
- We call these *chained rollovers*
- Sign with Key_1 -> add Key_2 -> Sign with Key_2 -> Stop serving Key_1



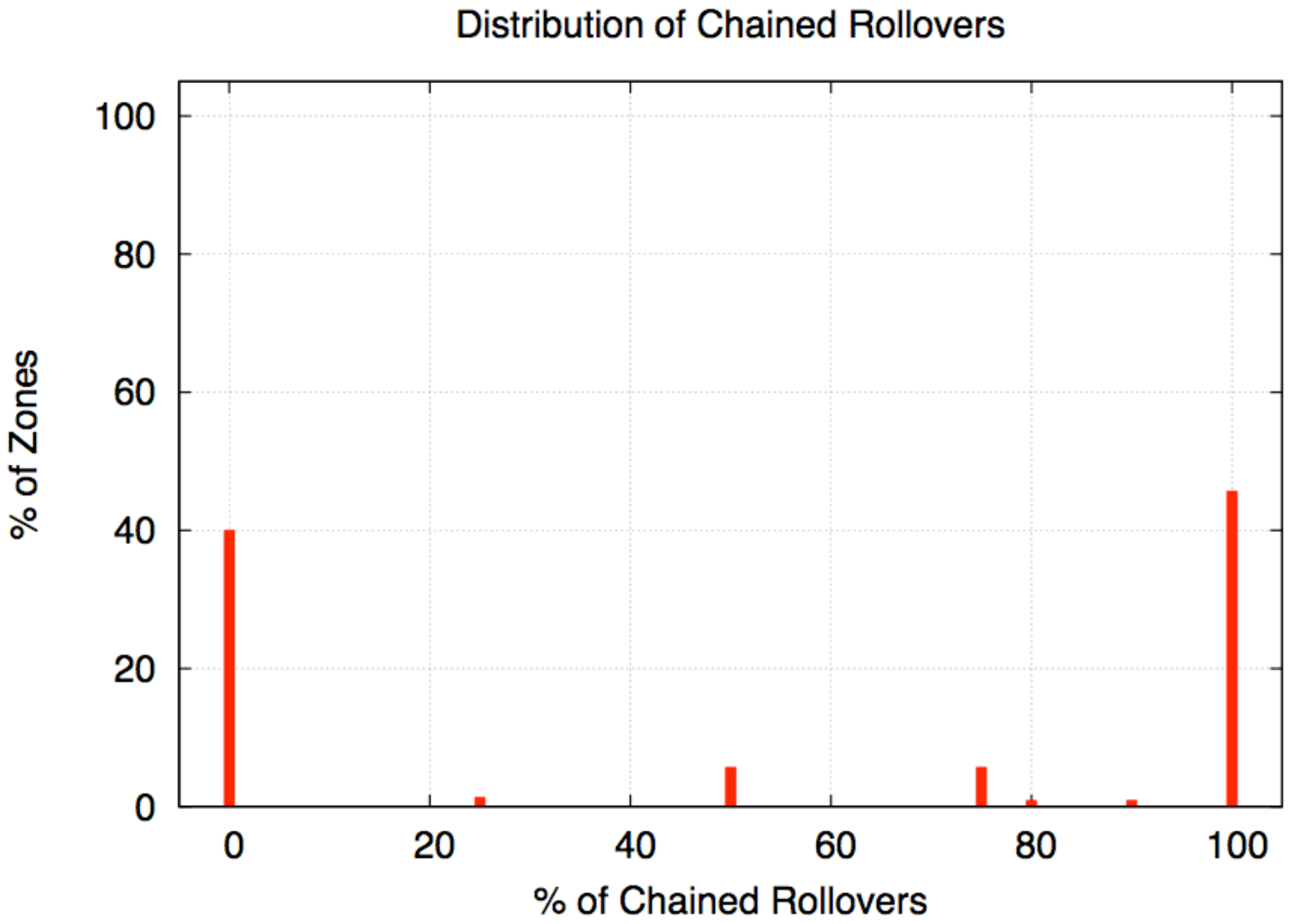
Otherwise…

- Abrupt key changes may leave signatures from old keys in caches
- Resolvers may not be able to verify data with an old signature and a new key
- That is why key changes must be chained
  - Until all signatures from a key have expired, a zone must serve that key, or resolvers may encounter data that seems false

Distribution of Chained Rollovers

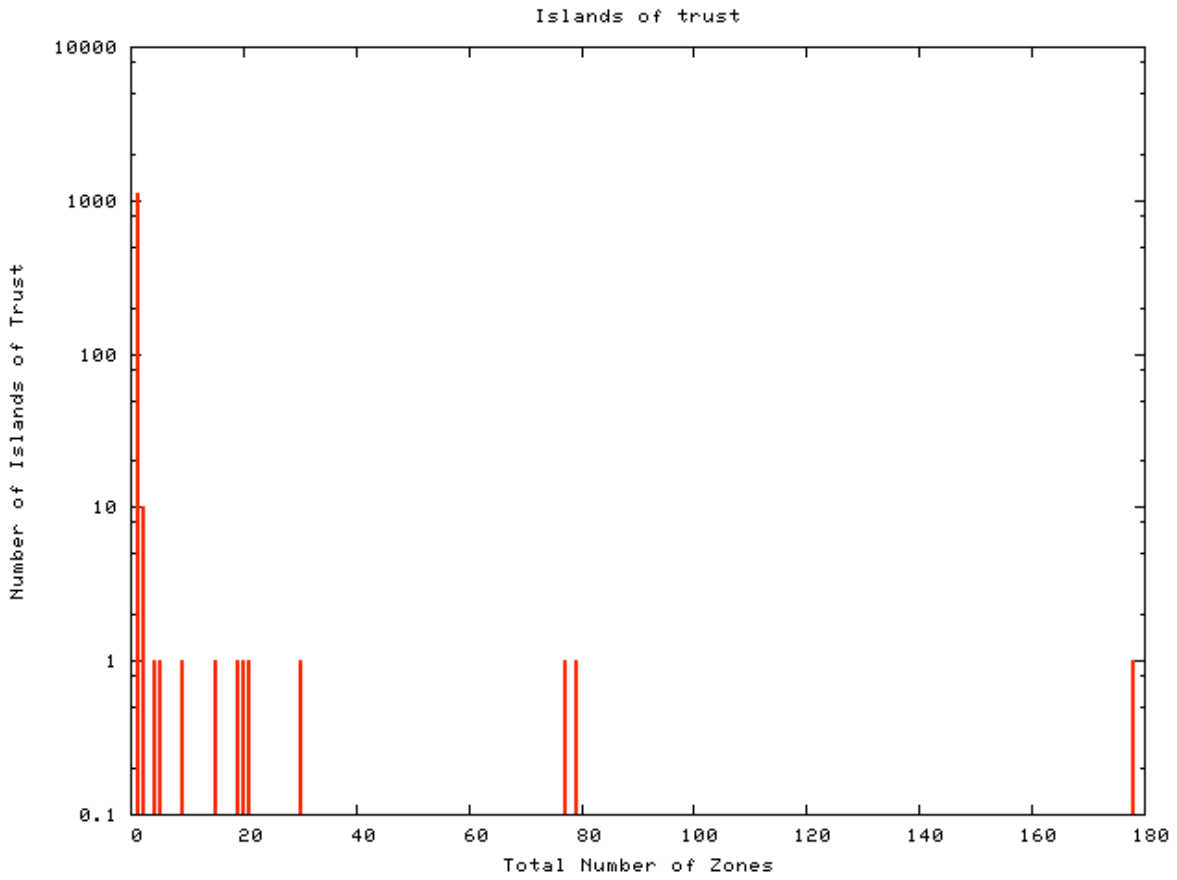


Rollovers - New Keys Only

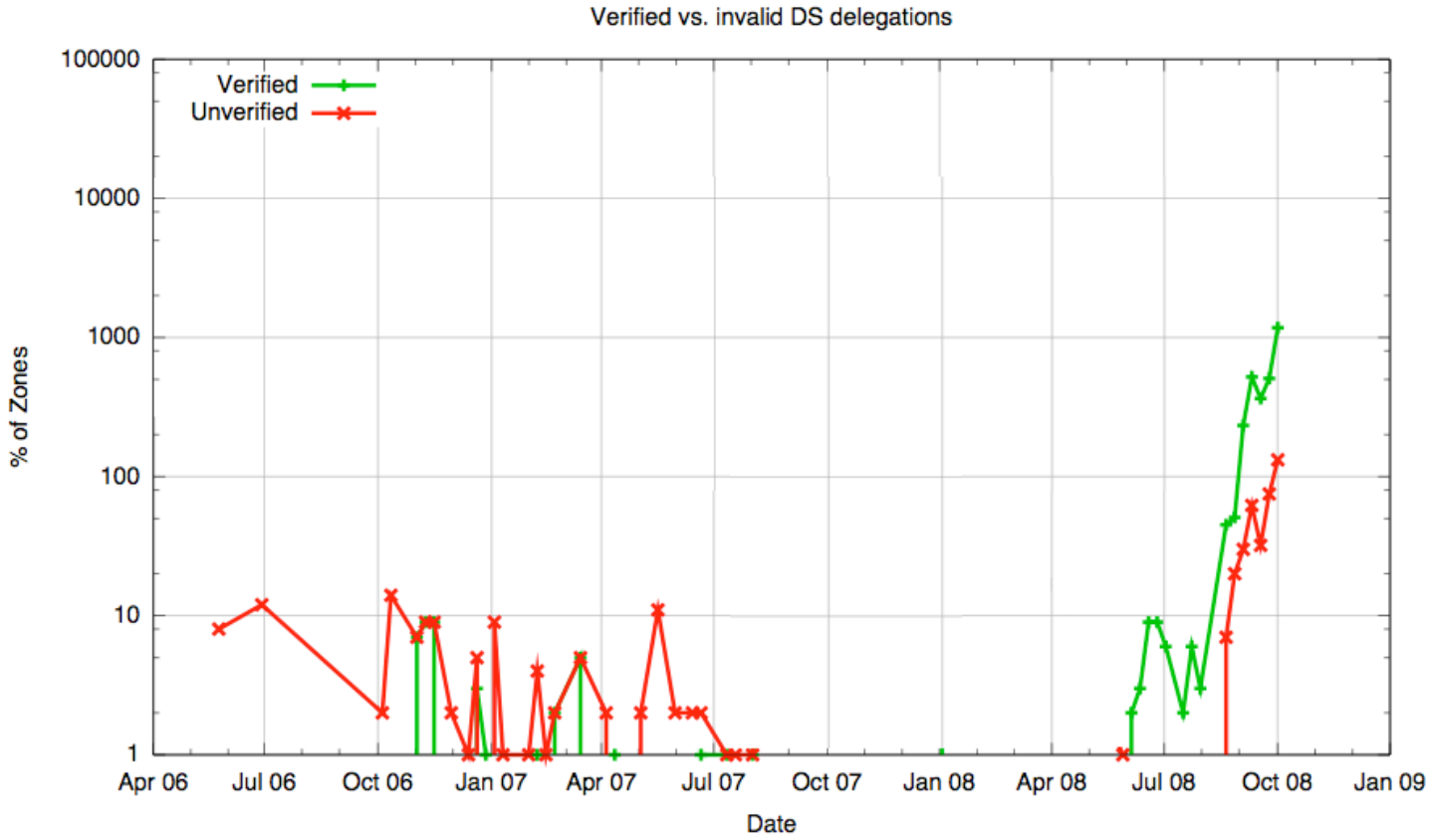


Learning Keys - the Delegation Hierarchy

- 1,134 trust anchors *today*
  - Out of 1,627 zones
  - 1,113 islands size 1 (98.15%)
- Coordination with a parent zone is an involved process



Verifiable Secure Delegations

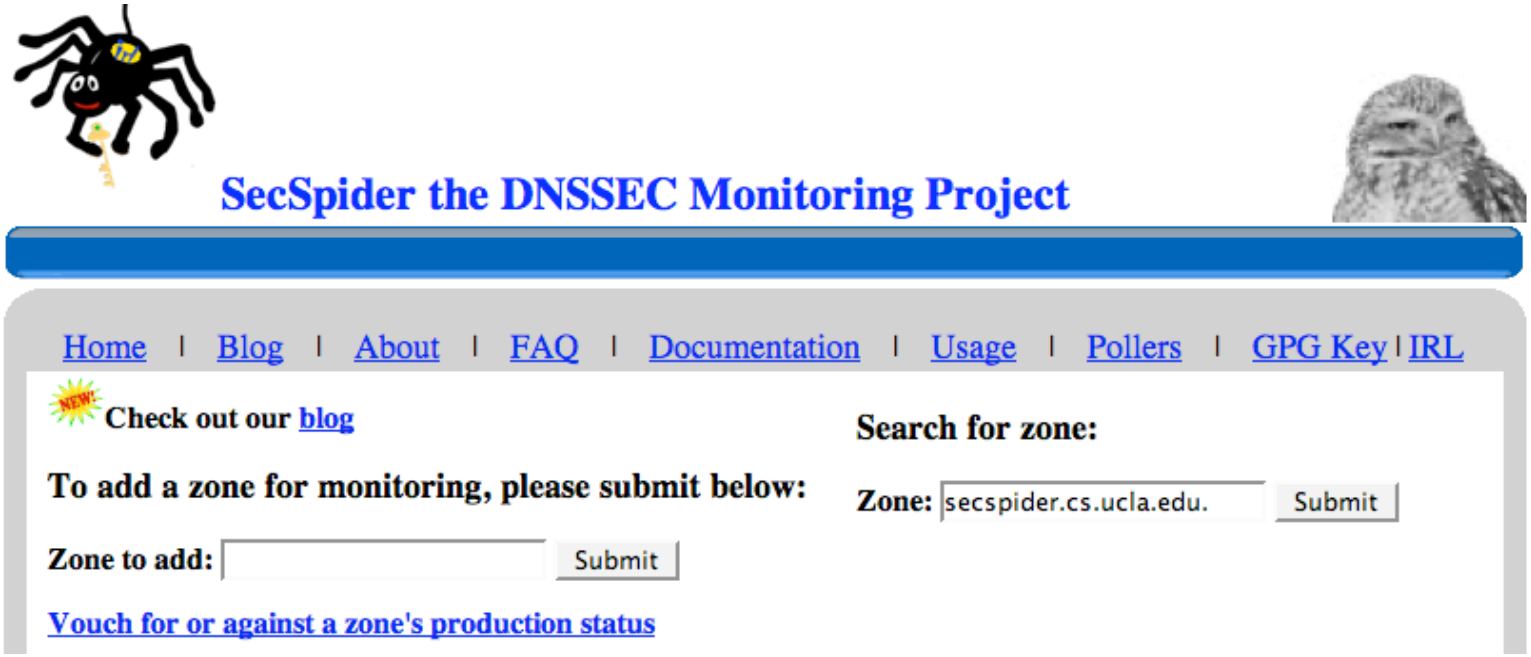


- Monitoring blip in the middle, but w/ the uptake in DNSSEC we are seeing more misconfigurations

Conclusions

- DNSSEC is taking off
  - Though it still has a ways to go
- Though the uptake is encouraging, we must be mindful of configuration complexity / errors
- We need tools that can see misoncfigurations and help operators (like SecSpider)
- We also need tools to help automate as much of the operational complexity as is safe
  - The delegation hierarchy serves as evidence that complexity can lead to slow uptake and errors

Come Visit us



http://secspider.cs.ucla.edu/

Questions?

Backup

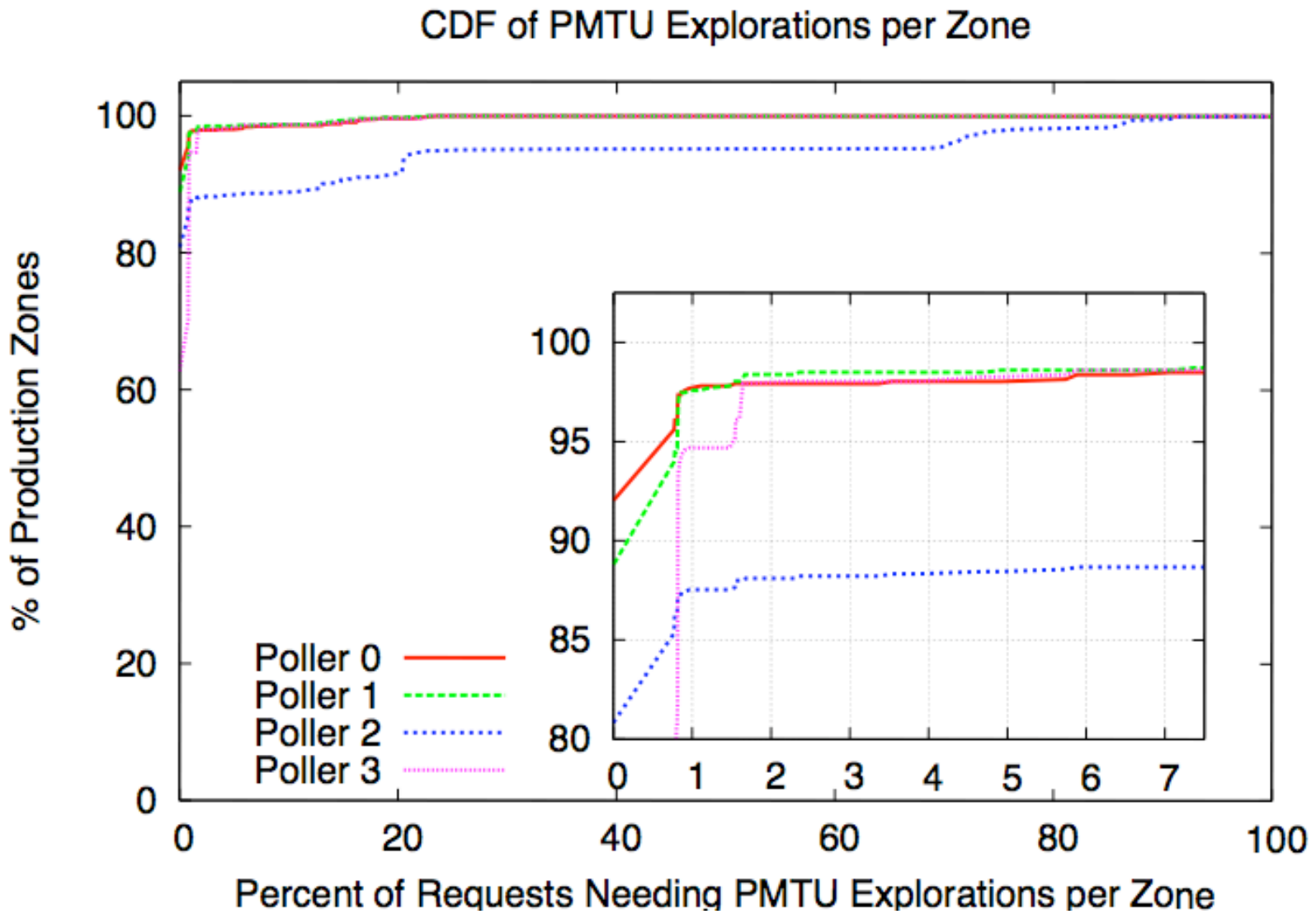
Distributed Polling

- We use distributed pollers to measure consistency (or inconsistencies)
- For example: DNSKEY RRsets spoofing at one poller will not fool others, and discrepencies can be seen

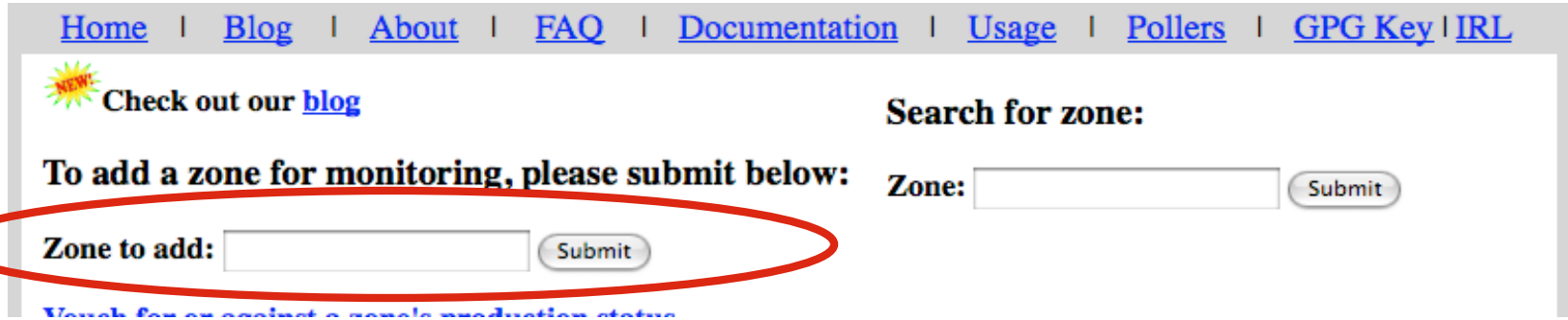
- In addition, network issues can cause some vantage points to be unable (or less able) to access DNSSEC information
  - We call this *availability dispersion*

Submissions by TLD Since August 2008

- 290 ru
- 147 br
- 71 arpa
- 43 com
- 31 de
- 28 se
- 27 org
- 15 net
- 12 pr
- 11 bg
- 10 eu
- 9 fr
- 8 edu
- 8 asia
- 7 uk
- 6 hk
- 4 ch
- 3 info
- 3 gov


CDF of PMTU Explorations per Zone
% of Production Zones
Percent of Requests Needing PMTU Explorations per Zone
Poller 0
Poller 1
Poller 2
Poller 3
0
20
40
60
80
100
85
90
95
1
2
3
4
5
6
7

How to Use SecSpider



- From our front page, submit your zone
- After the next polling cycle, you will see your zone on our web site
- For DNSKEYs (for example) check their consistency

Checkout Our Paper in IMC

- "Quantifying the Operational Status of the DNSSEC Deployment" http://irl.cs.ucla.edu/papers/imc71-osterweil.pdf