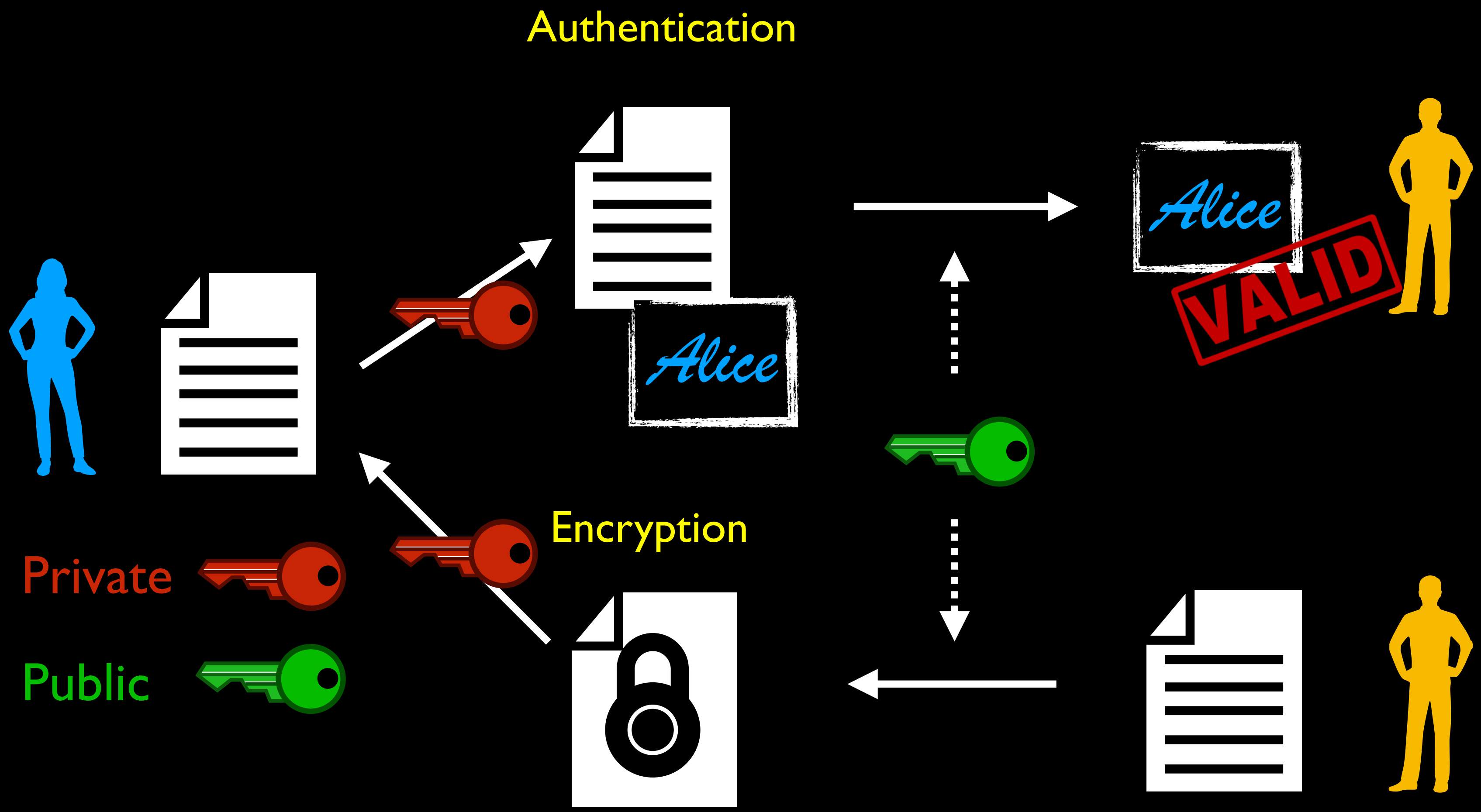
CSCI-351

Data communication and Networks

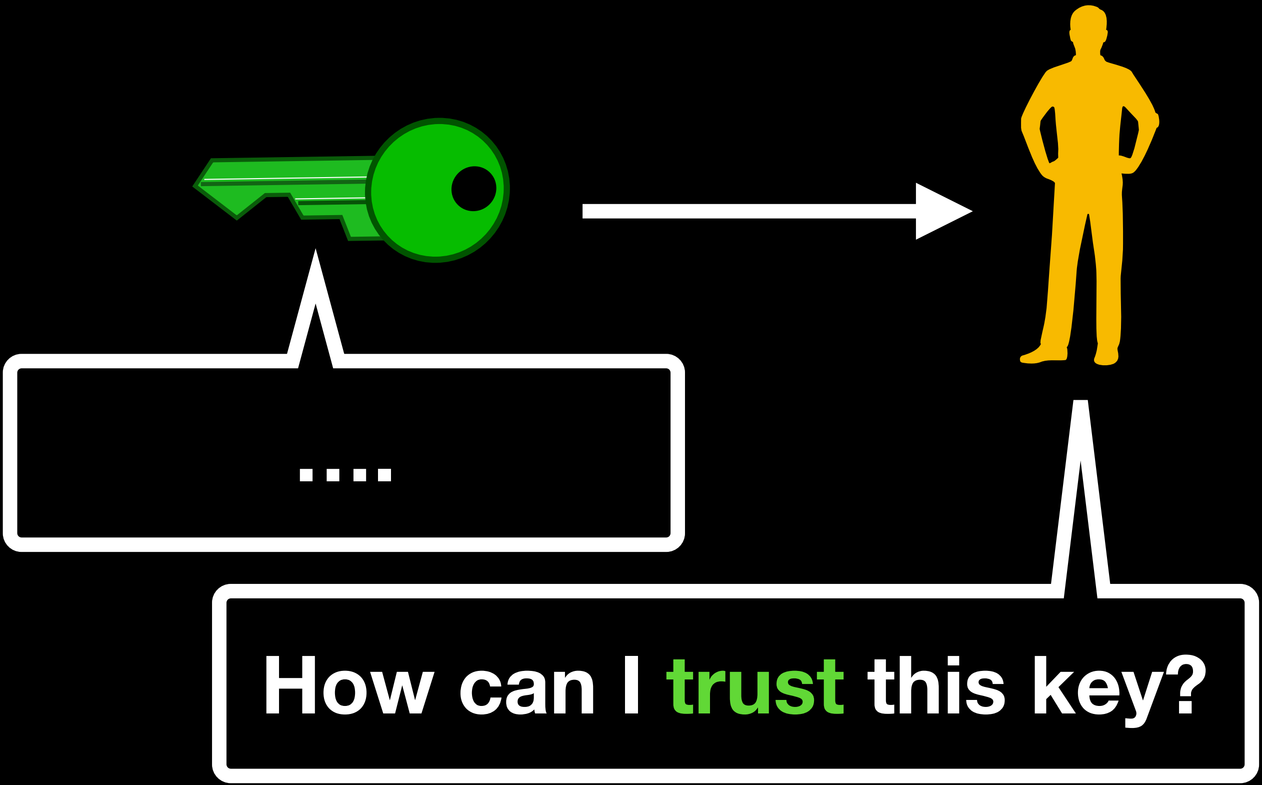
Lecture 16: PKI + DNSSEC

Warning: This may be hard to understand. Do not lose yourself during the class and keep asking questions

Public Key Cryptography



Public Key Infrastructure



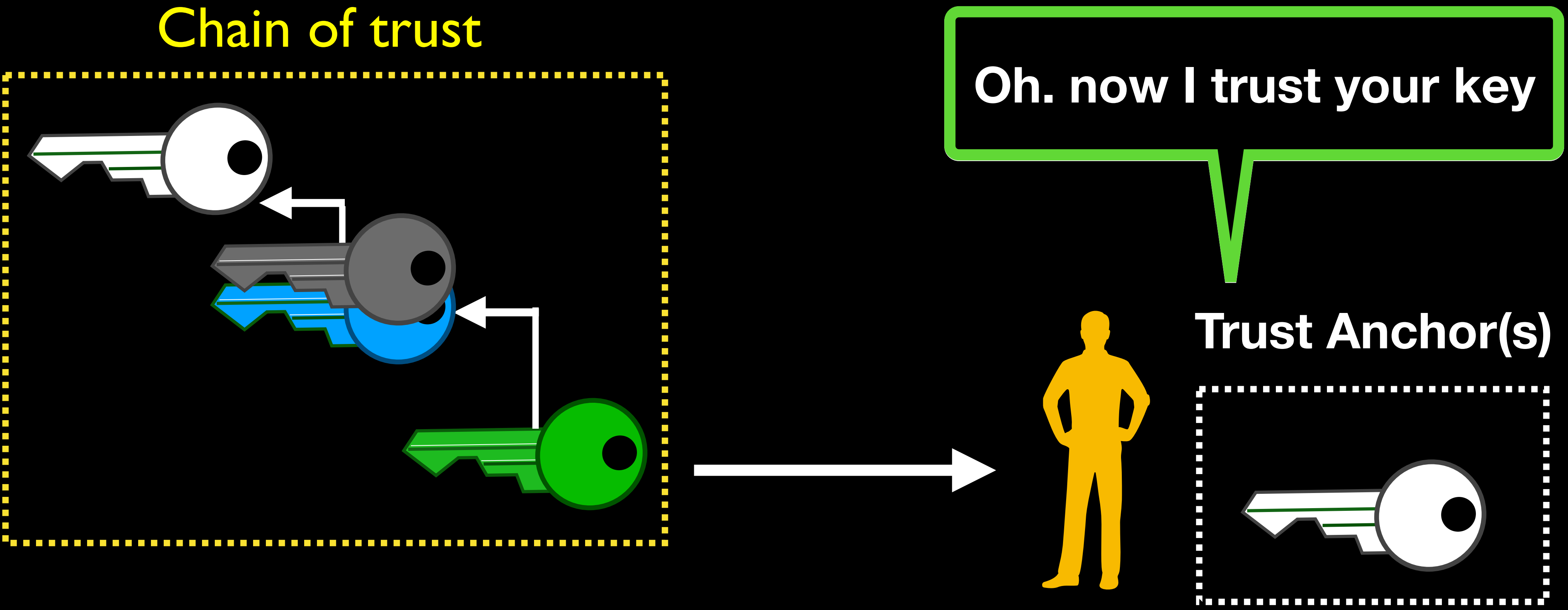
....

How can I **trust** this key?

PKI

Public Key Infrastructure (PKI) supports the (1) distribution and (2) identification of public key

Hierarchical
Public Key Infrastructure



Chain of trust

Oh. now I trust your key

Trust Anchor(s)

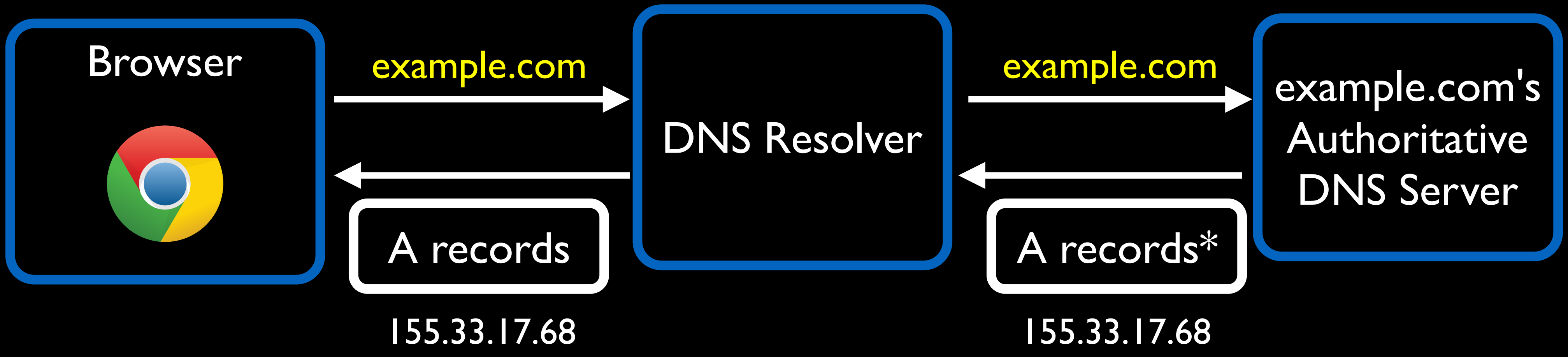
Hierarchical PKI

Many secure protocols in the Internet rely on hierarchical PKI

Something to plug

- I'll be teaching a new (Graduate-Level) Seminar Course in the Spring 2019
  - GCCIS-CSCI-759 Topics In System
  - Title: Public Key Infrastructure and Network Security

Domain Name System (DNS)



Browser

example.com

A records

155.33.17.68

DNS Resolver

example.com

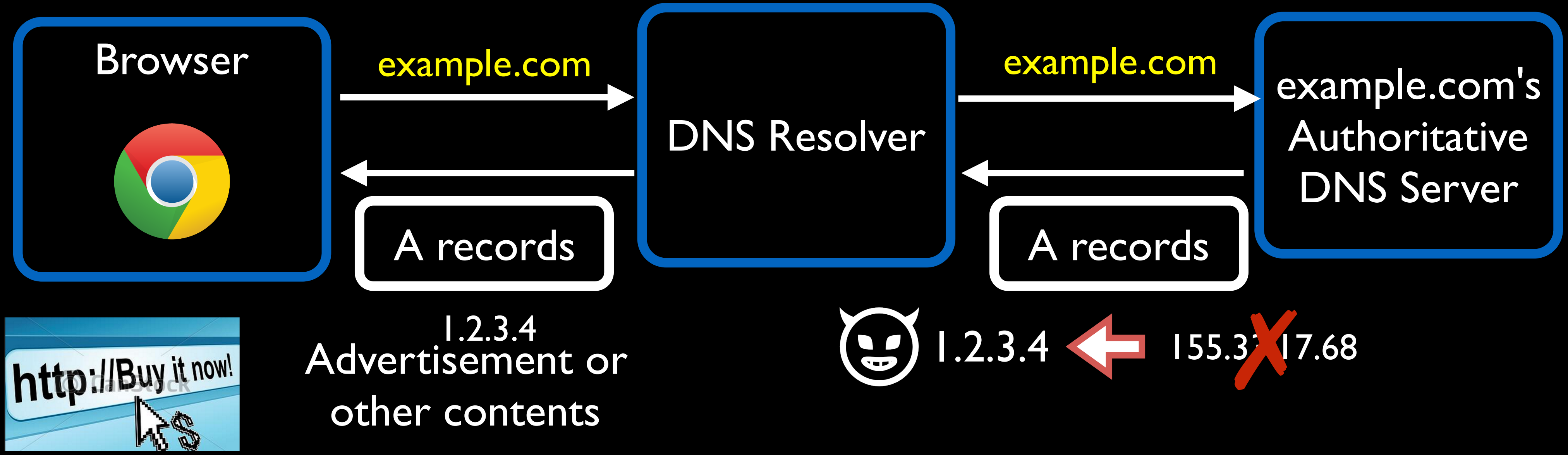
A records*

155.33.17.68

example.com's Authoritative DNS Server

*A record: one of the DNS records that contains IP addresses of a domain name

DNS Spoofing



Browser

example.com

DNS Resolver

example.com

example.com's Authoritative DNS Server

A records

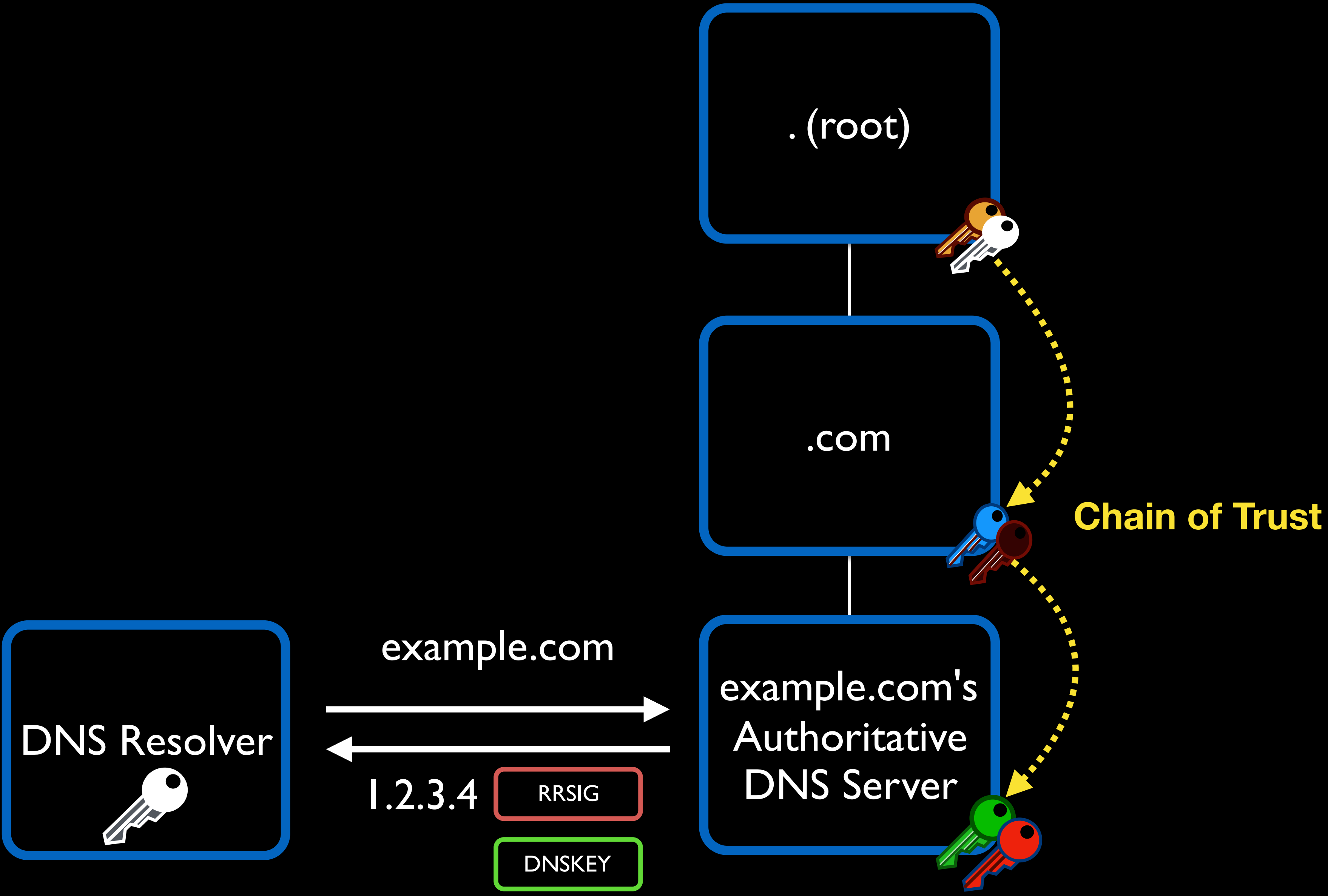
A records

1.2.3.4
Advertisement or
other contents

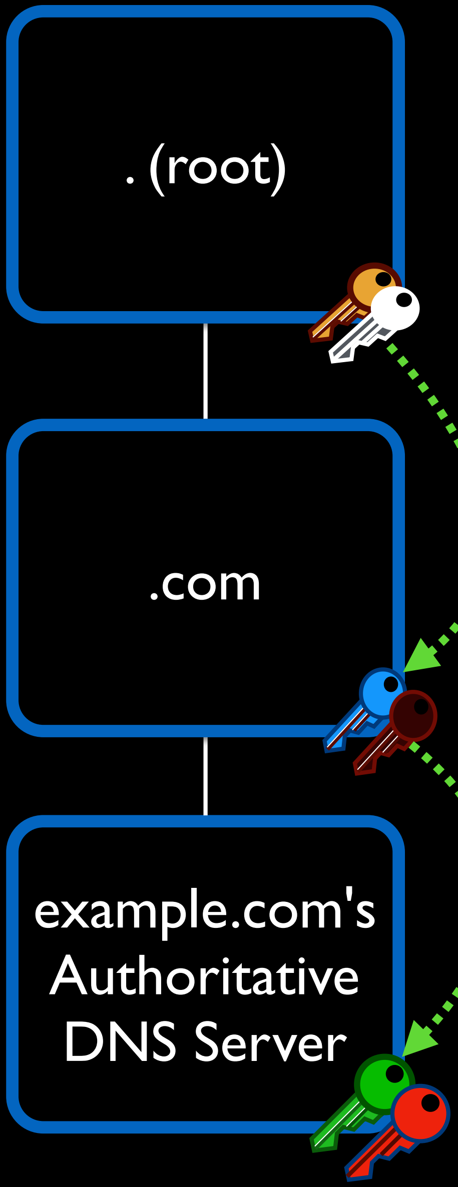
1.2.3.4

155.33.17.68

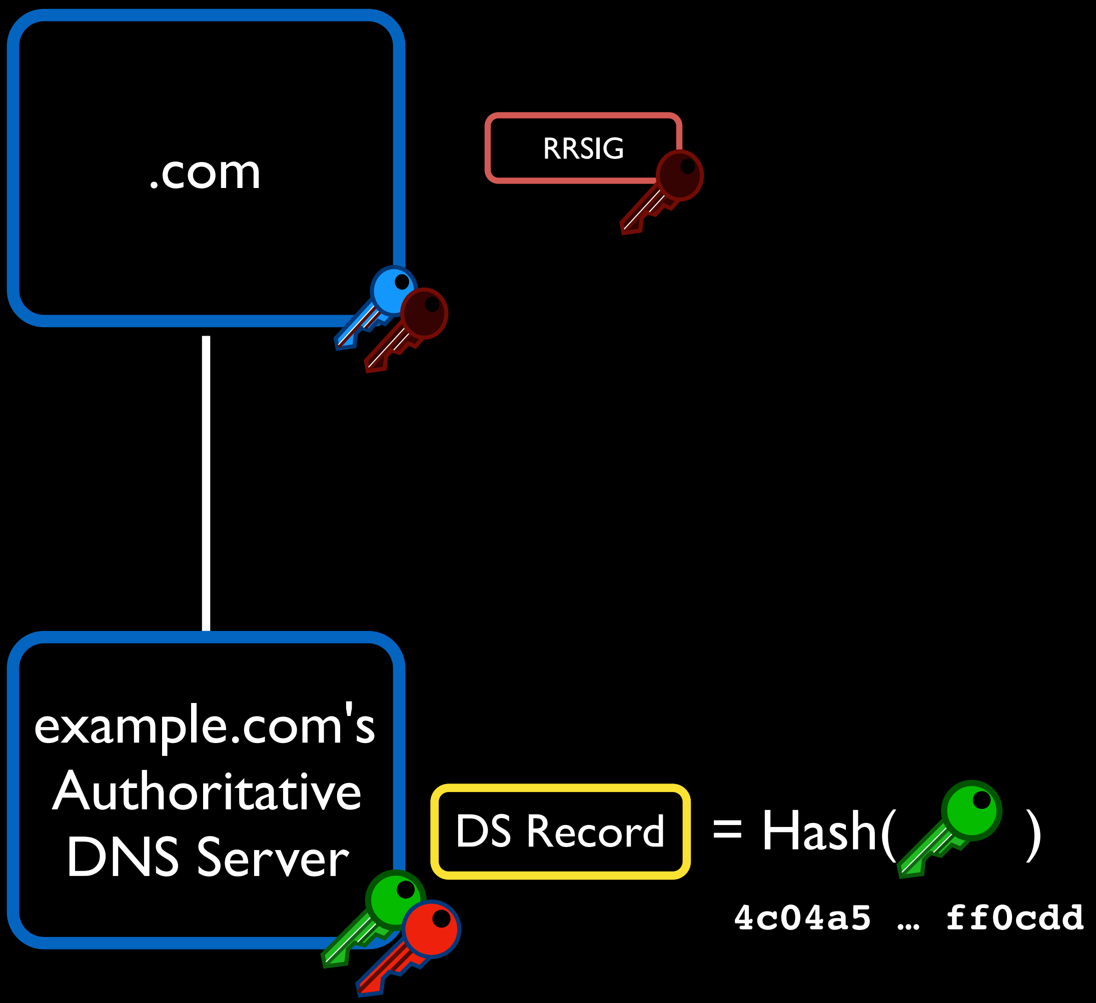
DNSSEC 101


. (root)
.com
Chain of Trust
example.com
DNS Resolver
1.2.3.4
RRSIG
DNSKEY
example.com's Authoritative DNS Server

DNSSEC 101



DNSSEC 101: Hierarchy Builds Trust



.com

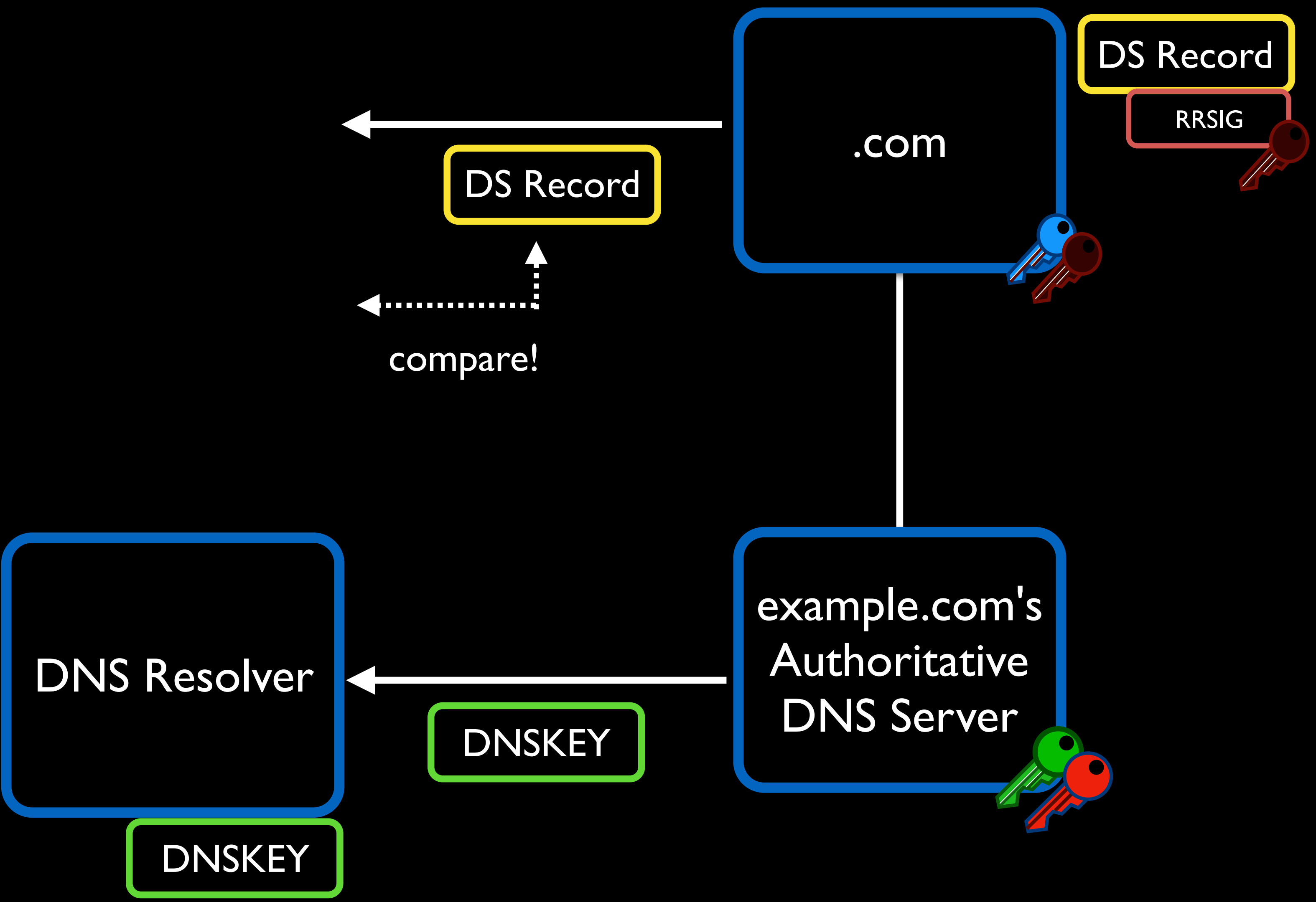
RRSIG

example.com's Authoritative DNS Server

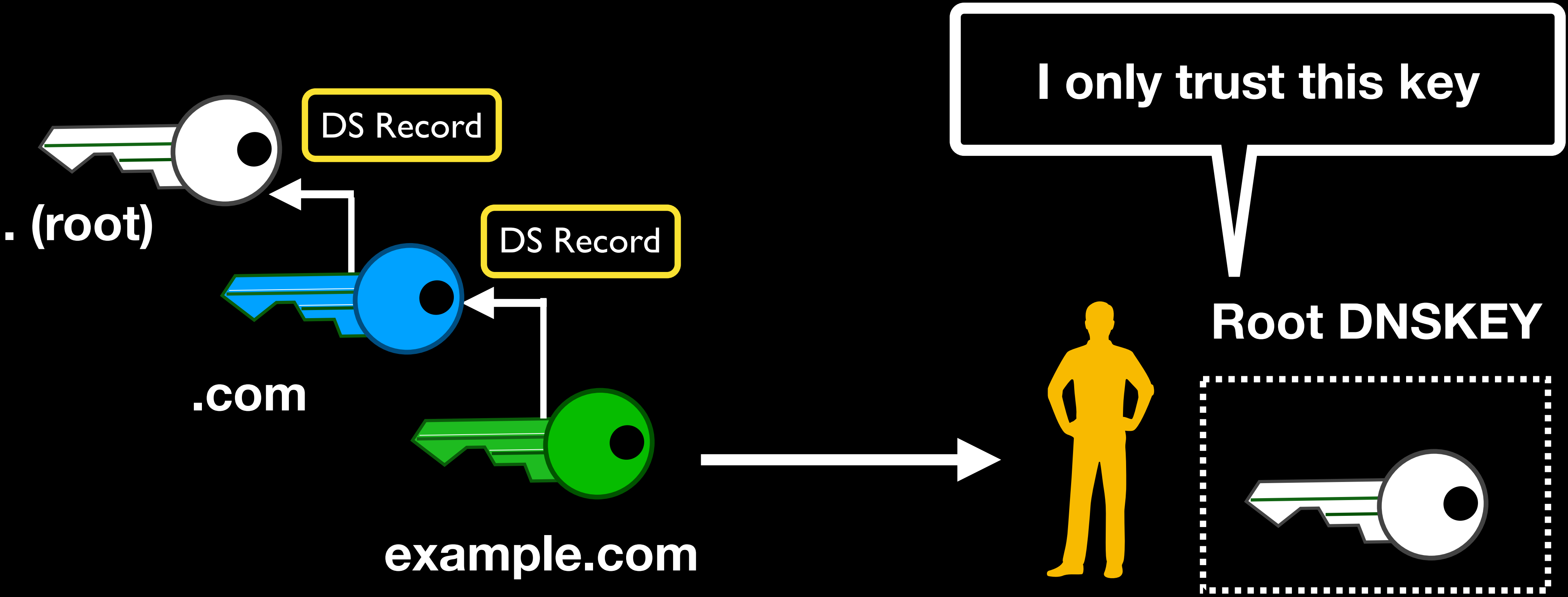
DS Record = Hash( )

`4c04a5 … ff0cdd`

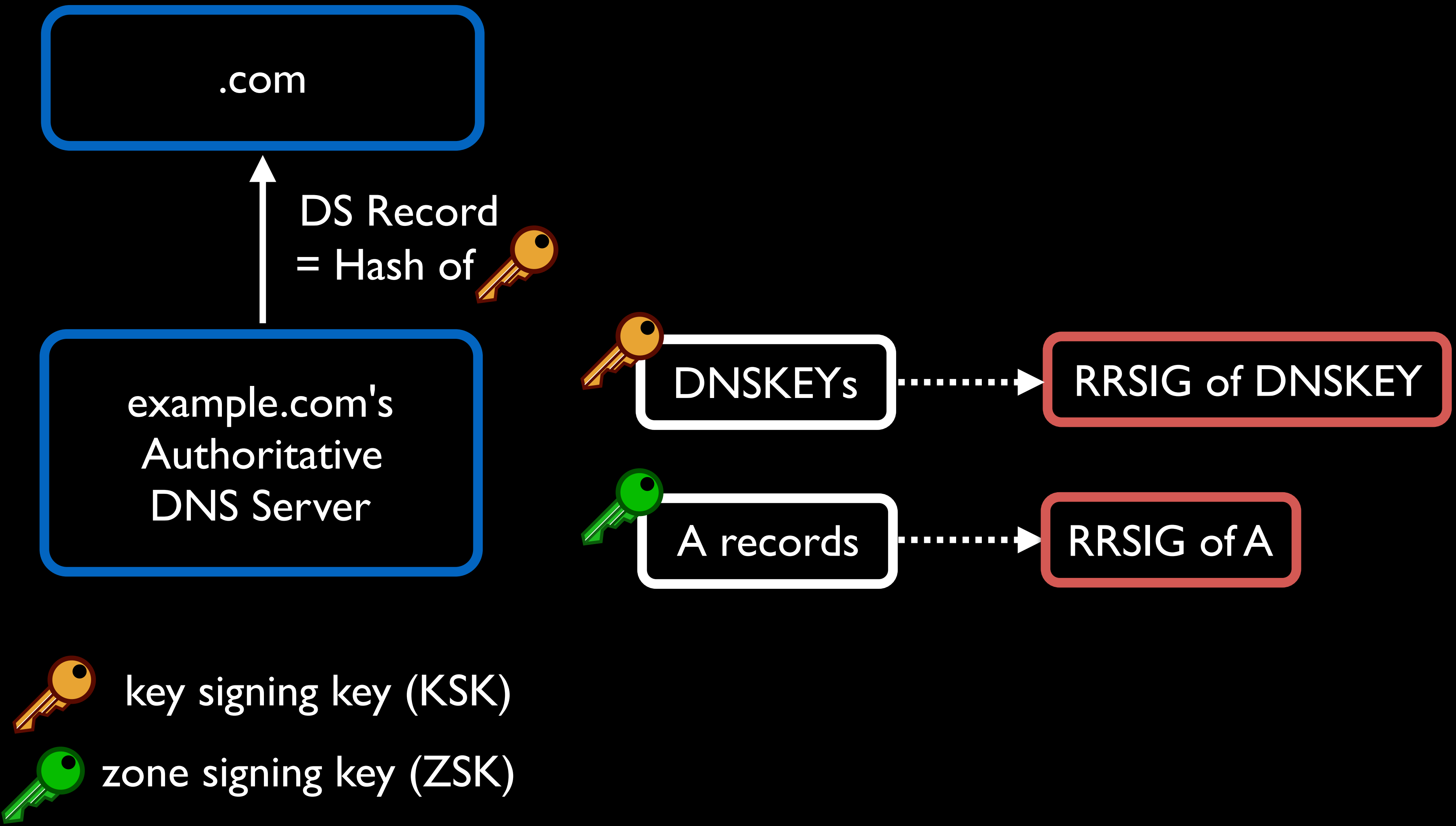
DNSSEC 101: Hierarchy Builds Trust



DNSSEC: Hierarchical PKI



DNSSEC 101
Two DNSKEYs



.com

DS Record
= Hash of

example.com's
Authoritative
DNS Server

DNSKEYs

RRSIG of DNSKEY

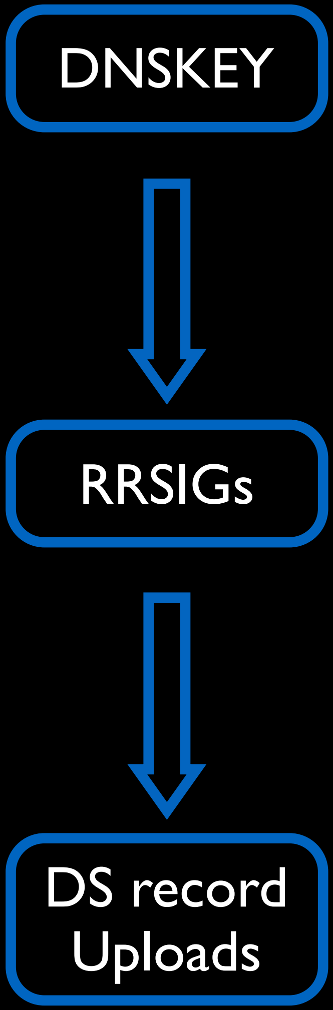
A records

RRSIG of A

key signing key (KSK)

zone signing key (ZSK)

How to Deploy DNSSEC (Correctly)



DNSKEY

RRSIGs

DS record Uploads

(1) Have DNSKEYs

(2) Generate Signatures

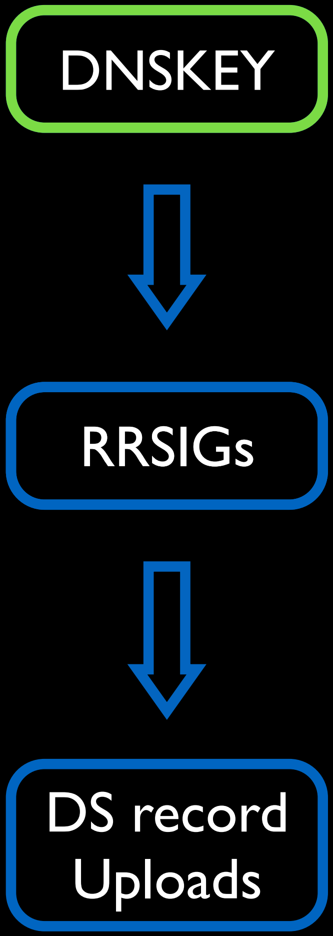
(3) Generate and upload DS record to the parent zone

Scanning All Domains

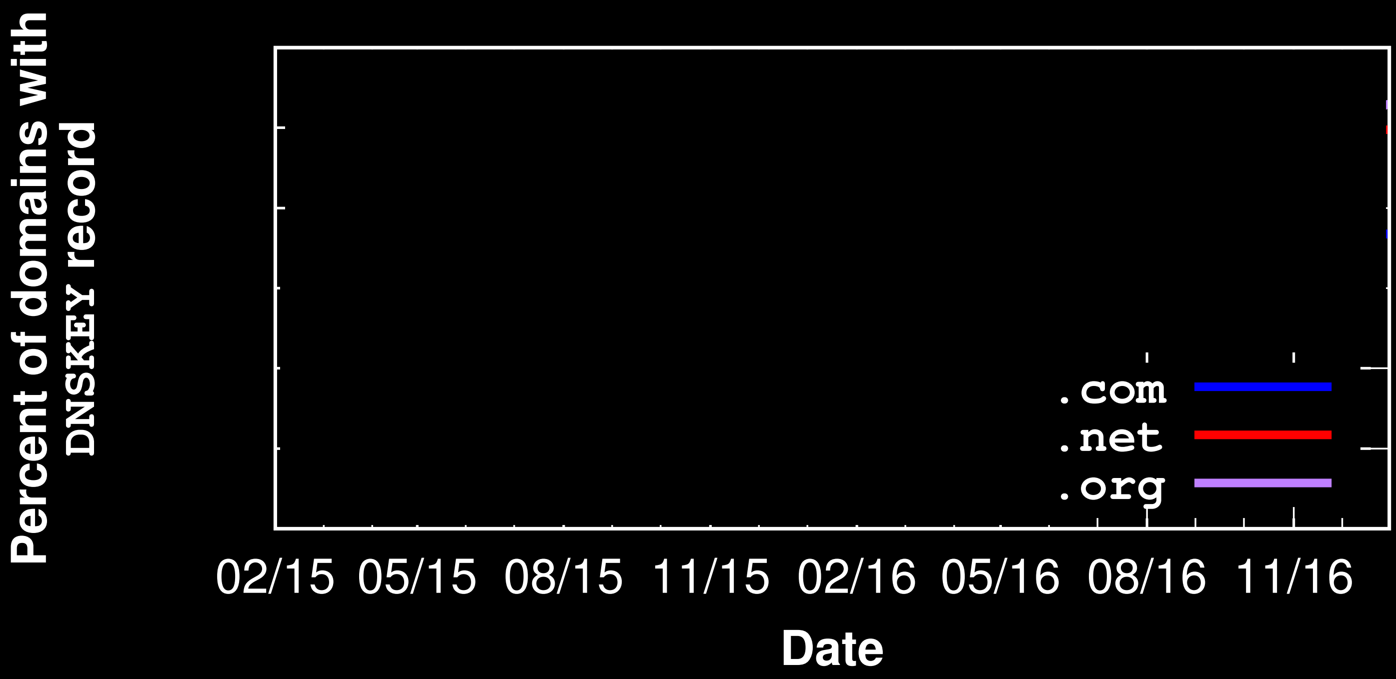
	Daily Scans
TLDs	.com, .org., .net
# of domains	147M domains
Interval	every day
Period	2015/03/01 ~ 2016/12/31

Over 750 billion DNS Records

How DNSSEC is deployed

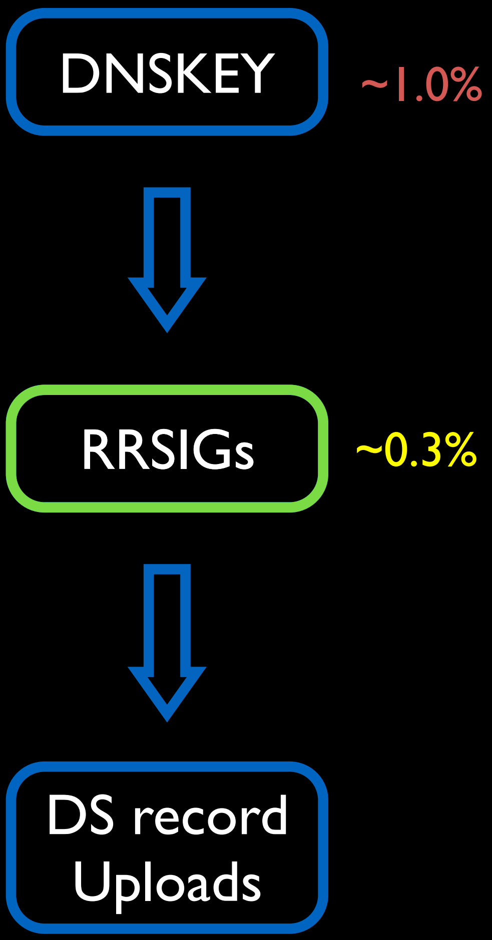


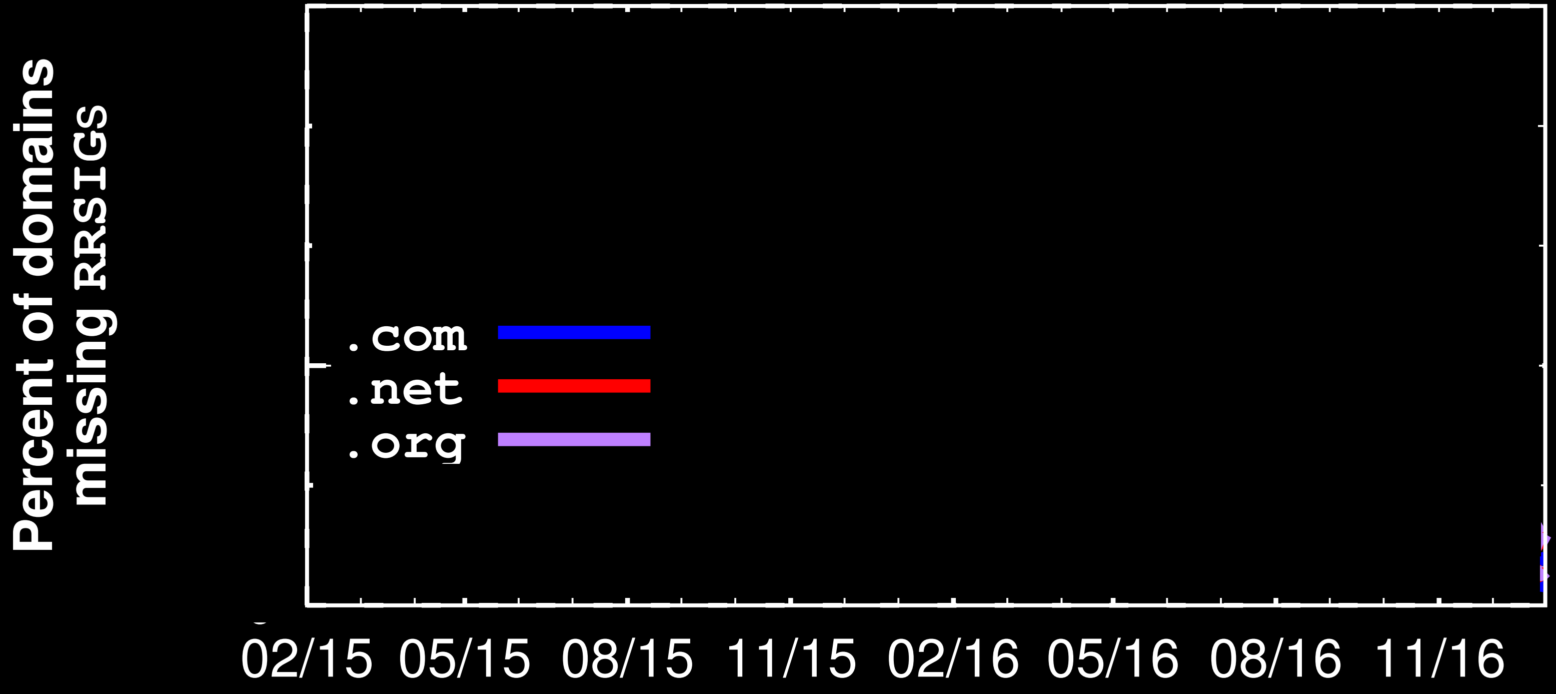
~1.0%



Deployment DNSSEC deployment is rare, but growing

Generating Signatures

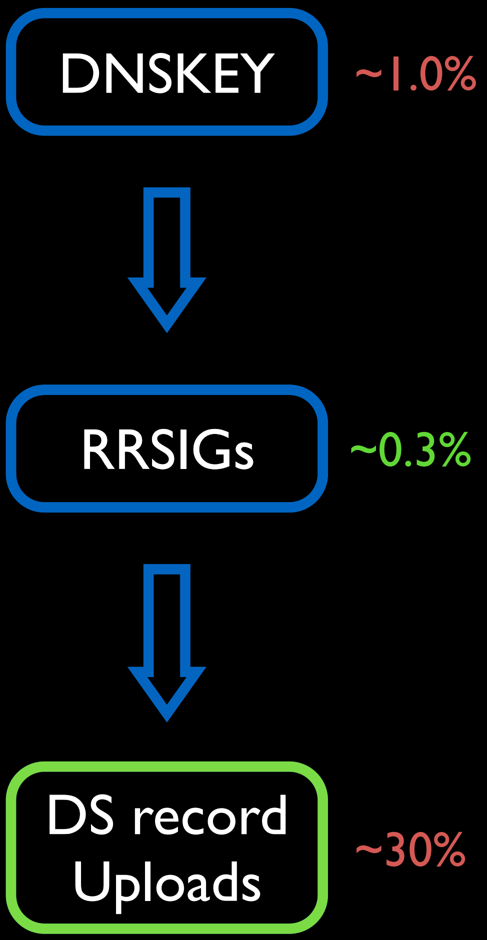




Missing RRSIGs

RRSIGs are rarely missing (0.3%)

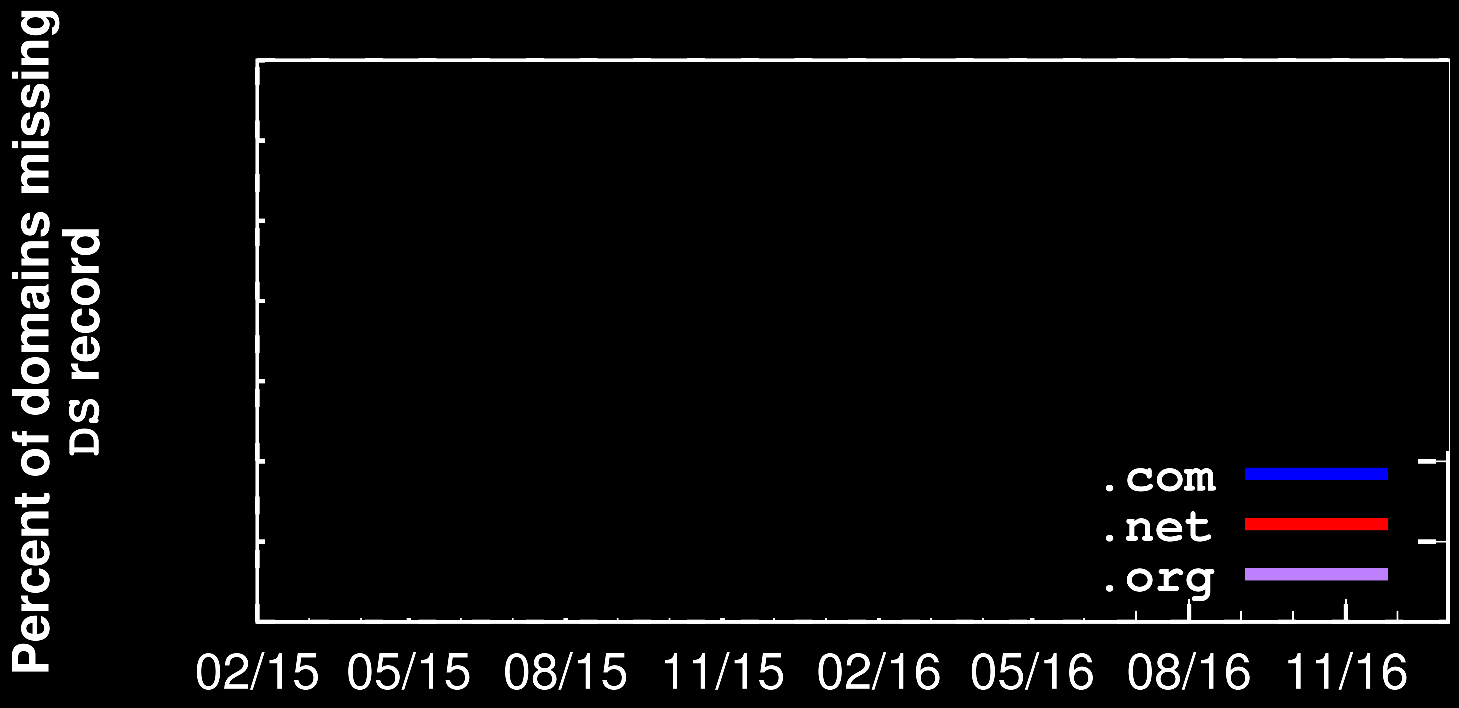
Building a Chain of Trust



DNSKEY ~1.0%

RRSIGs ~0.3%

DS record Uploads ~30%

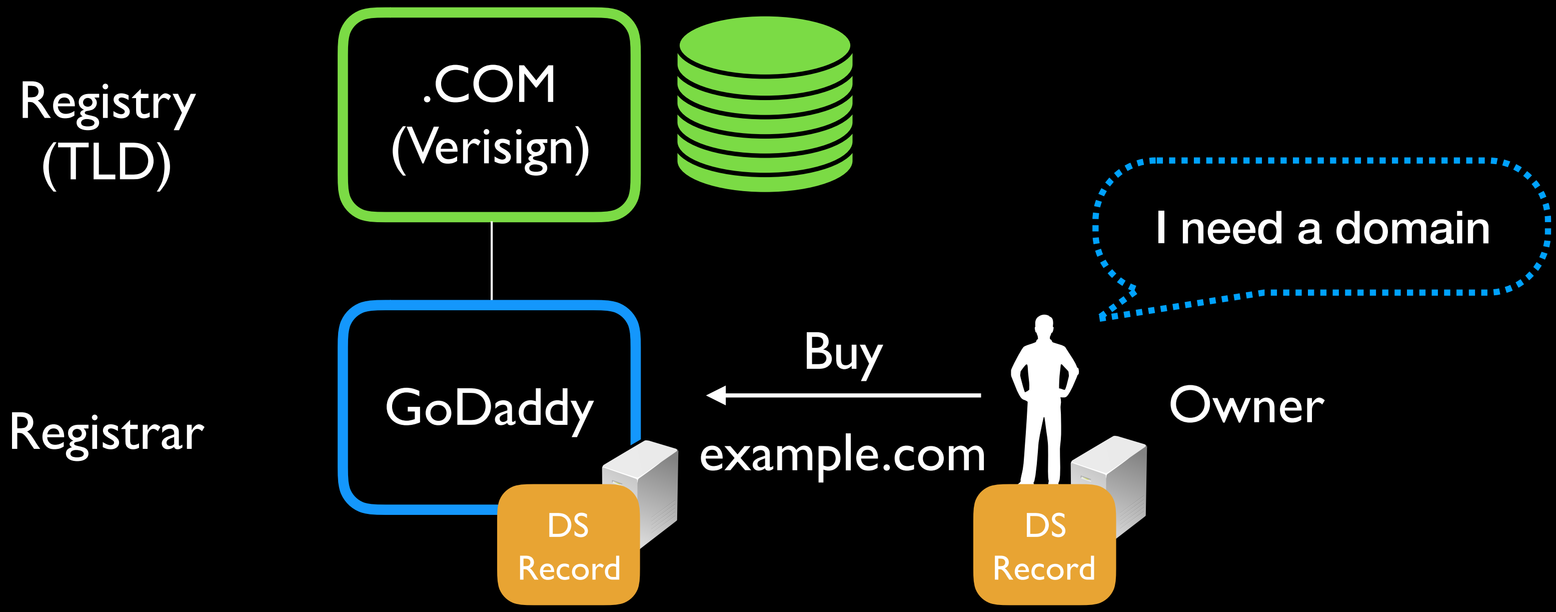


DS Records

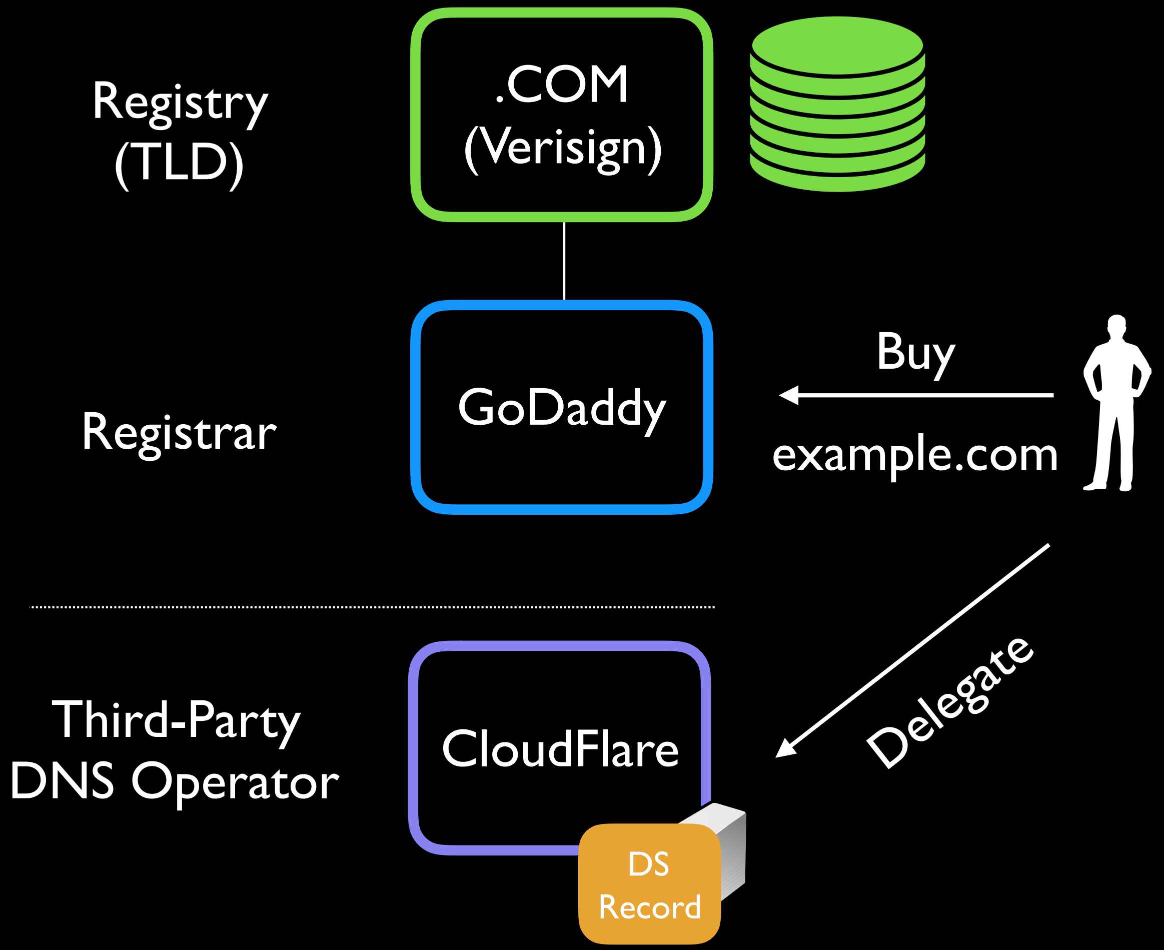
Nearly 30% of domains DO NOT upload DS records!

Why does DNSSEC deployment remain so small?
Why are 30% of domains w/o DS records?

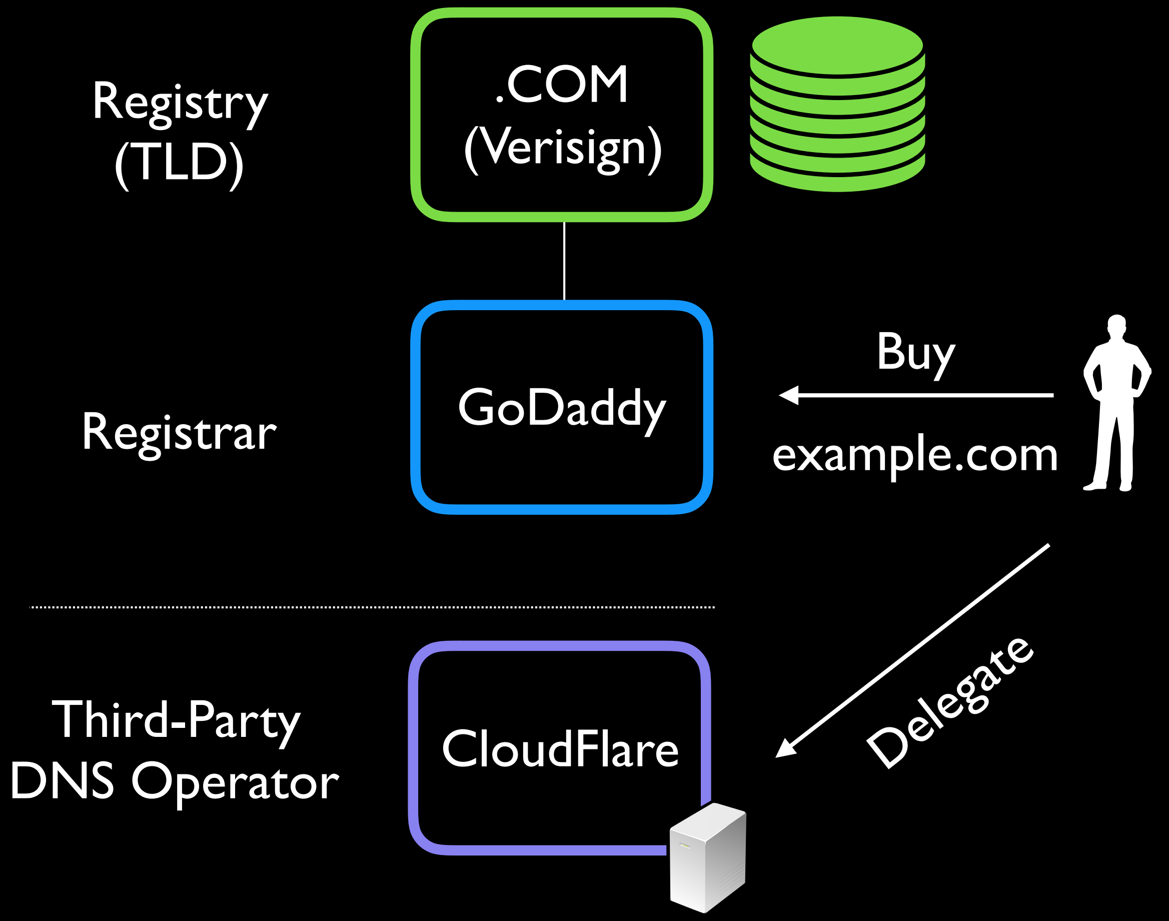
Deploying a DNSSEC on Your Server



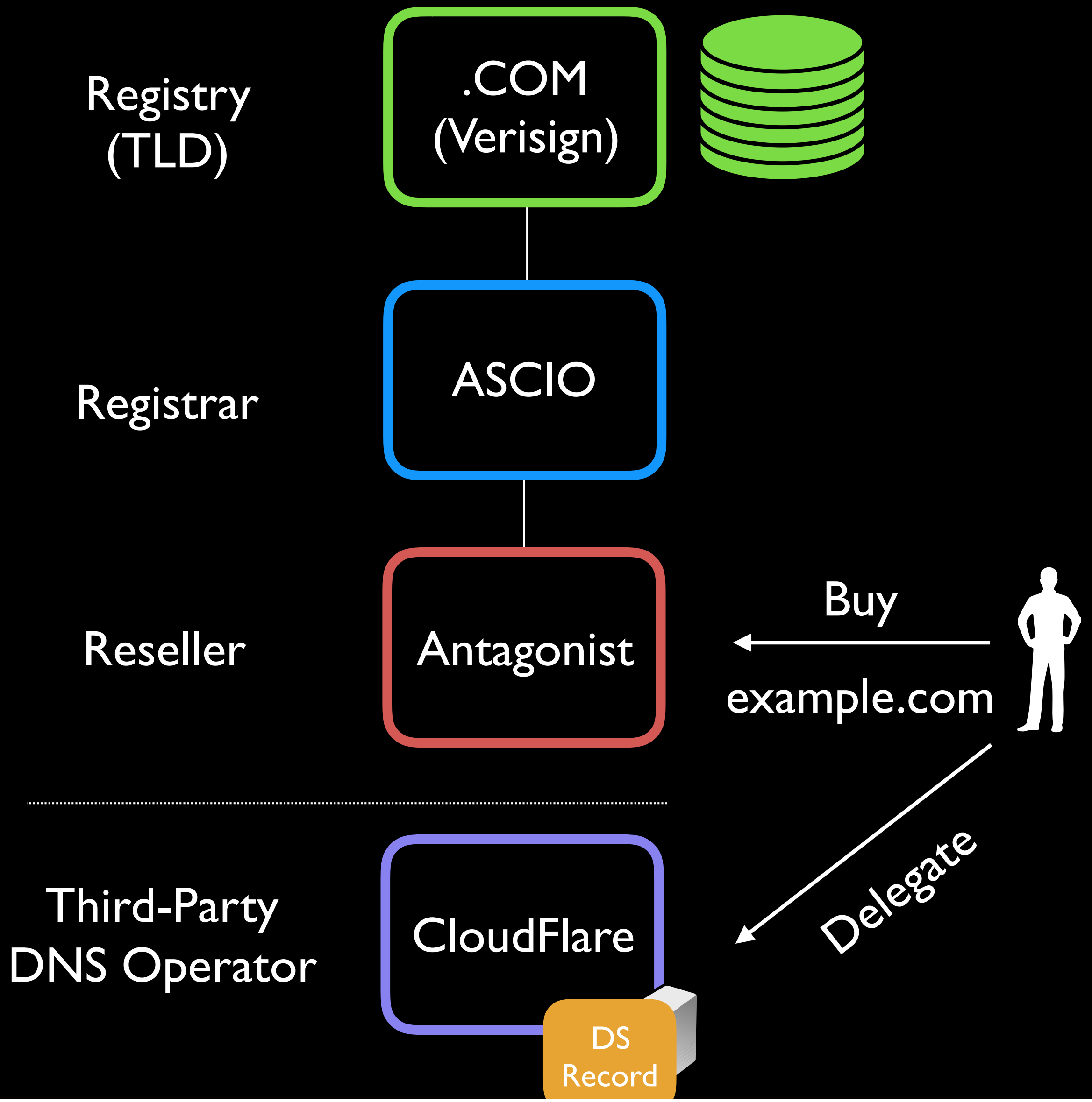
Third Party DNS Operator



Third Party DNS Operator



Reseller



Registry (TLD)

.COM (Verisign)

Registrar

ASCIO

Reseller

Antagonist

Buy

example.com

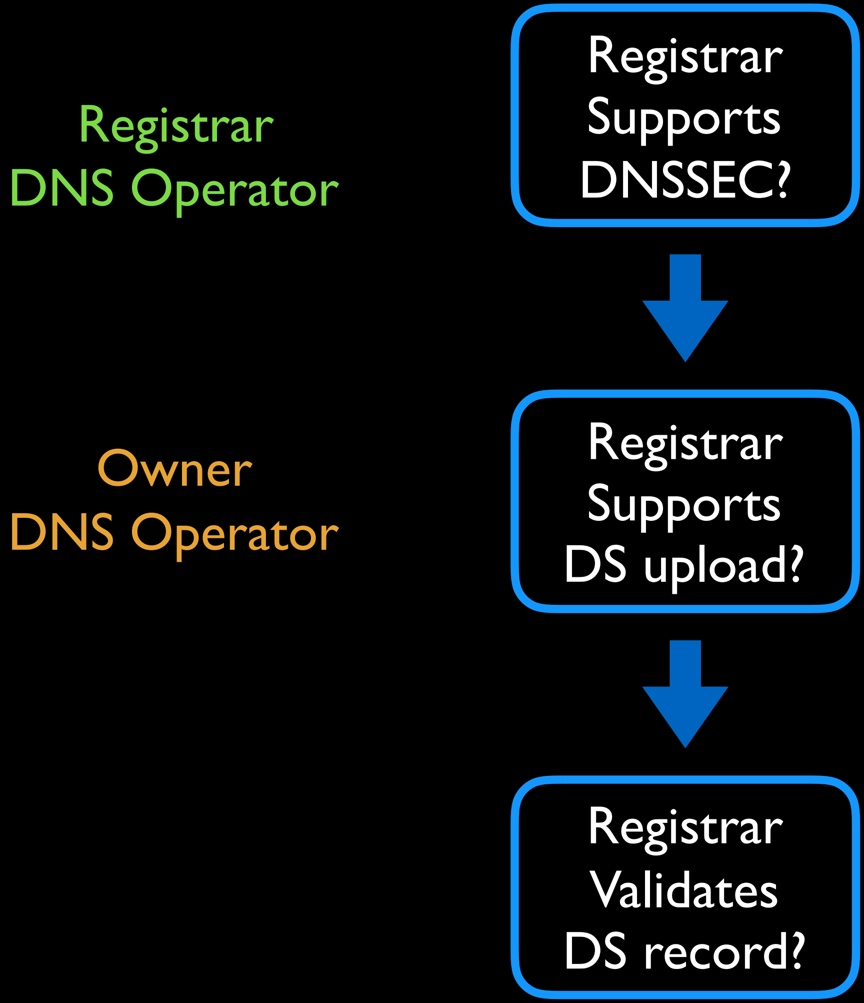
Third-Party DNS Operator

CloudFlare

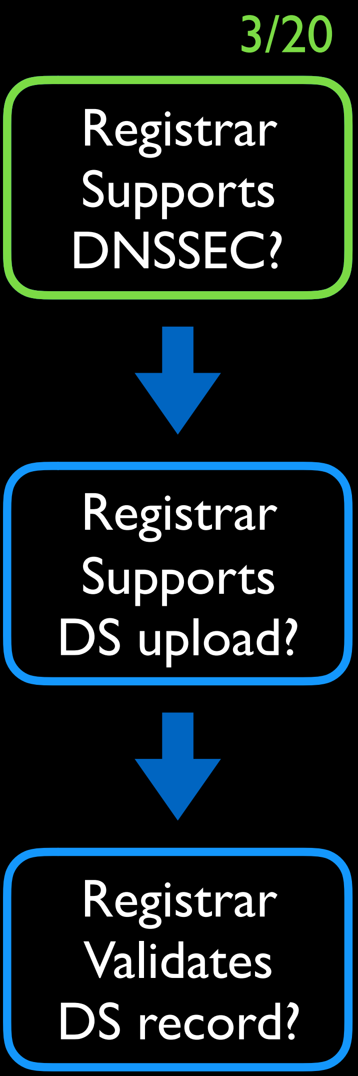
DS Record

Delegate

Checking Registrar's DNSSEC Policy


Registrar
DNS Operator
Registrar Supports DNSSEC?
Owner
DNS Operator
Registrar Supports DS upload?
Registrar Validates DS record?

Popular Registrar’s DNSSEC Policy


3/20
Registrar Supports DNSSEC?
Registrar Supports DS upload?
Registrar Validates DS record?

Registrar (Authoritative Nameserver)	Registrar DNS Operator
GoDaddy (domaincontrol.com)	🟢
NameCheap (registrar-servers.com)	⚠
OVH (ovh.net)	🟢
HostGator (hostgator.com)	✗
Amazon (aws-dns)	✗
Google (googledomains.com)	✗
123-reg (123-reg.co.uk)	✗
RightSide (name.com)	✗
eNom (name-services.com)	✗
NameBright (namebrightdns.com)	✗
DreamHost (dreamhost.com)	✗
The others (10 registrars)	✗

⚠ *Some nameservers don’t support DNSSEC*

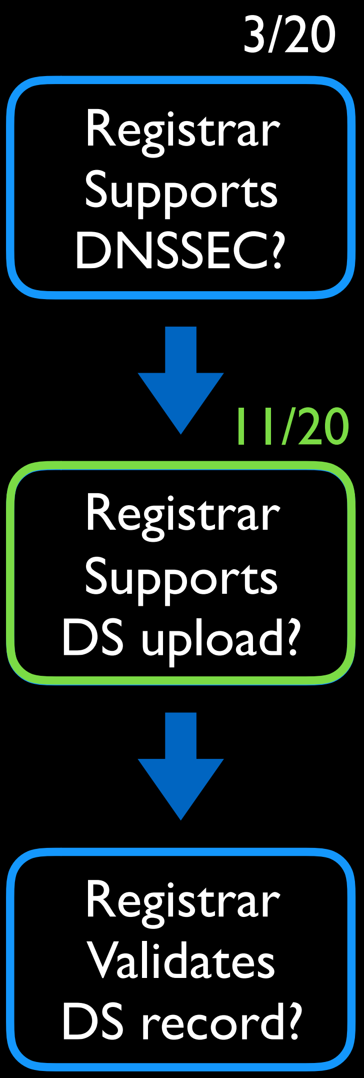
Anecdotal Examples

Experiment	Result
We saw the DNSKEY deployed (but not DS records) so asked why you don’t upload DS records.	[1] They removed a DNSSEC menu [2] “*Most people do not understand DNS, so imagine the white faces when I mention DNSSEC*”
We asked a registrar to upload a DS record by email from the different email address than the one that registered	It was installed successfully
We asked a registrar to upload a DS record to our domain via web live chat	It was installed on *someone else’s* domain due to a mistake by the customer service agent

Details of the Last Example

```
3:45:32 PM tijay hg-dnssec.com 3600 IN DS 2371 13 2
129f34c04ac58ece5218b9894148304a736a63757f58ff0cddd9b8df4989
3:56:05 PM Jeniffer S Awesome! one moment
3:56:09 PM Jeniffer S I have now save the request
information! Manage DNSSEC paananenmusic.com Record added
successfully. It can take 4-8 hours for DNS to propagate
3:57:19 PM tijay paananenmusic.com?
3:57:28 PM tijay my domain is hg-dnssec.com?
3:58:41 PM Jeniffer S I apologize, you are right, silly me,
one moment
```

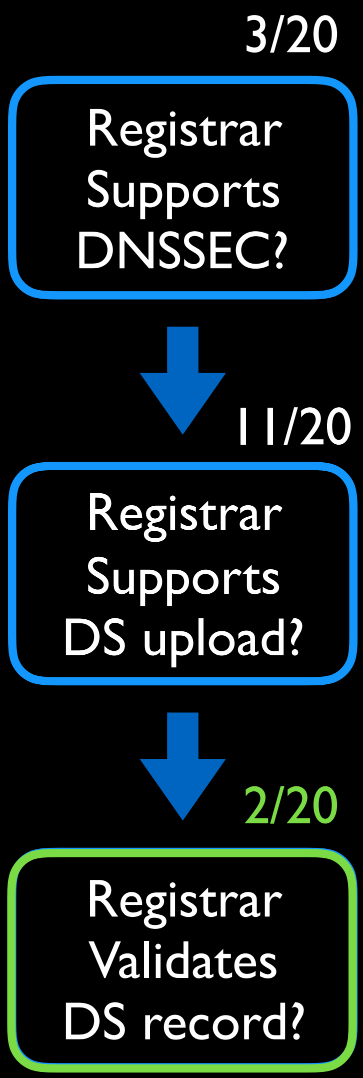
Popular Registrar’s DNSSEC Policy



3/20
Registrar Supports DNSSEC?
11/20
Registrar Supports DS upload?
Registrar Validates DS record?

Registrar (Authoritative Nameserver)	Owner DNS Operator	
	DS Upload	
	Web	Email
GoDaddy (domaincontrol.com)	●	—
NameCheap (registrar-servers.com)	●	—
OVH (ovh.net)	●	—
HostGator (hostgator.com)	●	—
Amazon (aws-dns)	●	—
Google (googledomains.com)	●	—
123-reg (123-reg.co.uk)	●	—
RightSide (name.com)	●	—
eNom (name-services.com)	✗	●
NameBright (namebrightdns.com)	✗	●
DreamHost (dreamhost.com)	✗	●
The others (10 registrars)	✗	✗

Popular Registrar's DNSSEC Policy


3/20
Registrar Supports DNSSEC?
11/20
Registrar Supports DS upload?
2/20
Registrar Validates DS record?

Registrar (Authoritative Nameserver)	Owner DNS Operator DS Upload		DS Validation
	Web	Email	
GoDaddy (domaincontrol.com)	●	—	✗
NameCheap (registrar-servers.com)	●	—	✗
OVH (ovh.net)	●	—	●
HostGator (hostgator.com)	●	—	✗
Amazon (aws-dns)	●	—	✗
Google (googledomains.com)	●	—	✗
123-reg (123-reg.co.uk)	●	—	✗
RightSide (name.com)	●	—	✗
eNom (name-services.com)	✗	●	✗
NameBright (namebrightdns.com)	✗	●	✗
DreamHost (dreamhost.com)	✗	●	●
The others (10 registrars)	✗	✗	✗

Summary: Registrar’s DNSSEC Support

	DNS Operator	# of Registrar	What this means to you
Support DNSSEC?	Registrar	3/20	If you don’t want to run your own name server, most of the time, you CAN’T deploy DNSSEC (17/20)
	Owner	11/20	If you do want run your own nameserver, still you CAN’T deploy DNSSEC for 9/20
Check DS Validation	Owner	2/11	If you happen to upload an incorrect DS record, your domain will be inaccessible

Why are DNSSEC support of registrars so rare?

Cost of Managements

	DNS	DNSSEC
# of Records	DNSSEC introduces much more records (e.g., need signatures for each record)	
Size of Records	Signatures are usually 3~6 times larger than non-DNSSEC records*	
Management	-	Strong Key Unique Key Rollover

Operational Cost

Operational cost of DNSSEC is higher than that of DNS

***DNSSEC and Its Potential for DDoS Attacks (IMC'14)**

Case Study: Registrar’s Policy

	Registrar DNS Operator		Owner DNS Operator	
	Support DNSSEC	Pricing	Support DNSSEC	Pricing
# of registrars	3	Free: 2	11	Free
		Paid: 1		

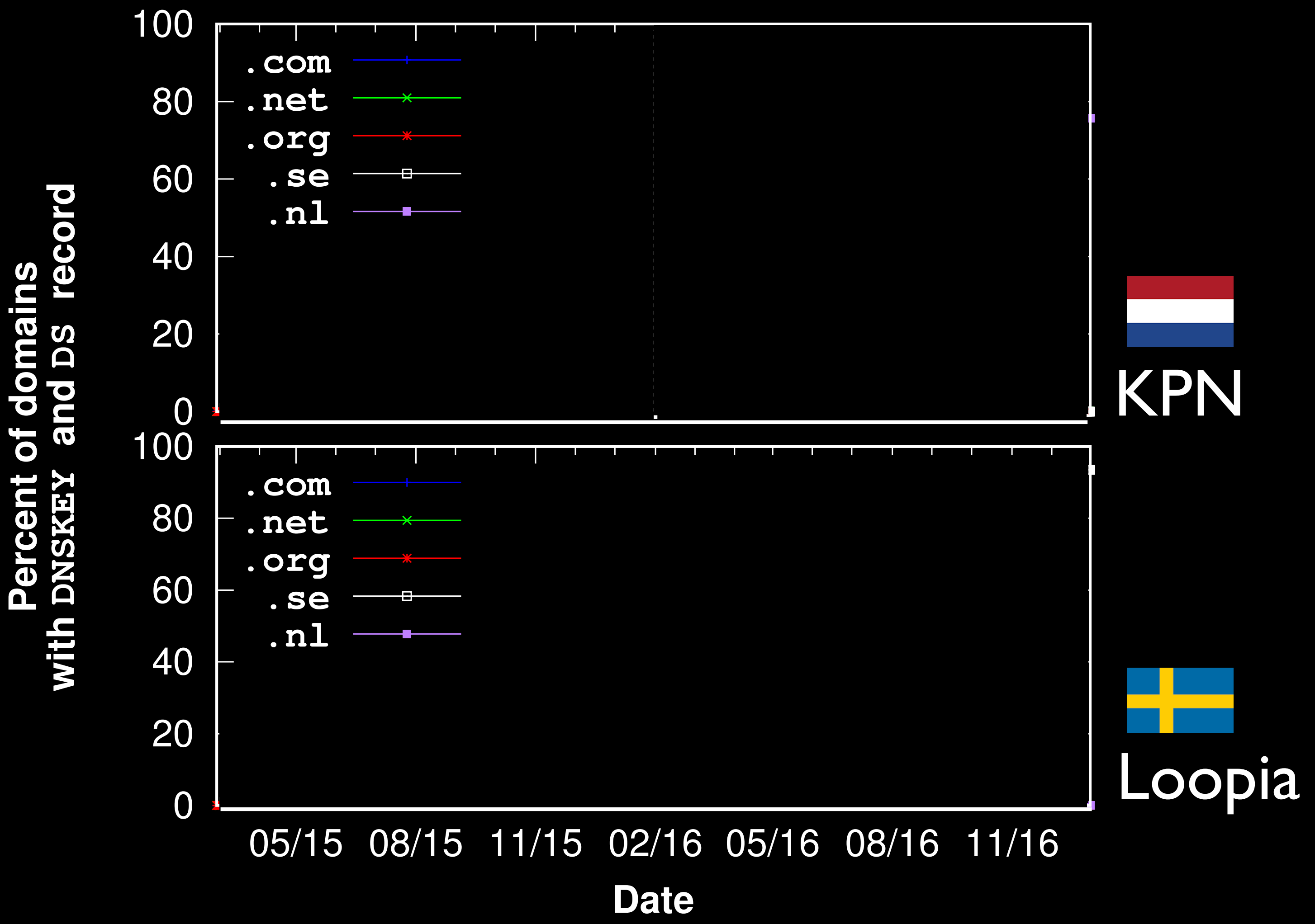
Registrars manage all DNS records

Registrars DO NOT need to manage DNS records at all

Scanning All Domains

TLD	Measurement Period (Daily Scan)	Domains	
		Total	Percent w/ DNSKEY
.com	2015/03/01 ~ 2016/12/31	118,147,199	0.7%
.net	2015/03/01 ~ 2016/12/31	13,773,903	1.0%
.org	2015/03/01 ~ 2016/12/31	9,682,750	1.1%
.nl	2016/02/09 ~ 2016/12/31	5,674,208	51.6%
.se	2016/06/07 ~ 2016/12/31	1,388,372	46.7%

Case Study: Financial Incentives



Financial Incentive

Financial gain is a huge incentive for deploying DNSSEC to certain domains