The Missing Piece: On Namespace Management in NDN and how DNSSEC Might Help

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The dichotomy of Internet naming

- Internet naming: namespace → content
- w.r.t. how to bind names to content:
  ``… the network had better not care…''[1]
- Indeed, the mechanisms of NDN are well served by their focus on technical issues
- But, we argue that there is still a *demonstrated* (separate) need for namespace management

This isn't DNS, but as the Internet's 30+ year old de facto its phonebook, what can we learn from DNS' *success*?

[1] ``A Conversation with Van Jacobson,'' acmqueue Volume 7, Issue 1, February 23, 2009

Isn’t that what NDN DNS (NDNS) [Afanasyev, 2013] does?

Wait…

. . . or even CCN Key Resolution Service (CCN-KRS) [Mahadevan, 2014]?

i.e. has this already been addressed?

Yes

- Regarding many technical aspects
  - Self-certifying names
  - Trusted Third Parties (TTPs)
  - Etc.

No

- Regarding policy and non-technical aspects
  - Trademarks
  - Legal disputes
  - The operational and *industry* ecosystem that exists in the Internet today

There will be growing pains…

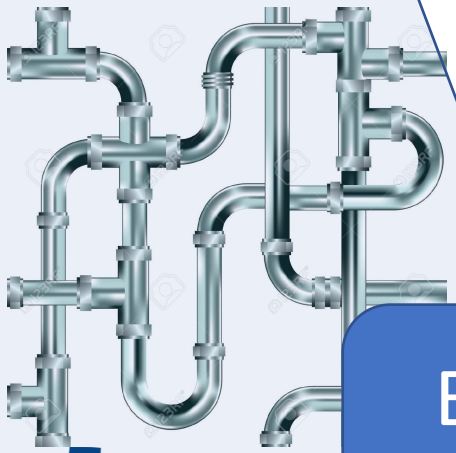
Technical aspects

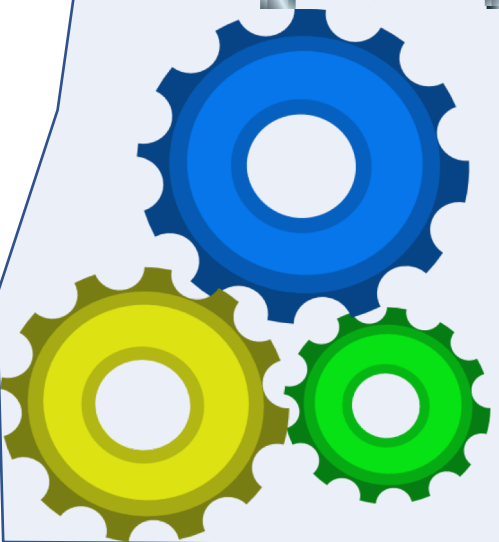
- Mapping names to content is critical
- Securing that mapping is a first-order design point
- Scaling all of the mechanisms is critical to producing deployable solutions
- …
- If industry needed for broad adoption, consider…
  - Has historically brought non-technical considerations

Non-technical

- Names developed commercial value (trademarks, intellectual property, etc.)
- Industry has long since coupled DNS domain names to this
- Technical security gets impacted (i.e. name collisions)

How entries are entered and read from phonebook (IETF for DNS)





How to decide what names *should* be entered in the phonebook (ICANN for DNS)

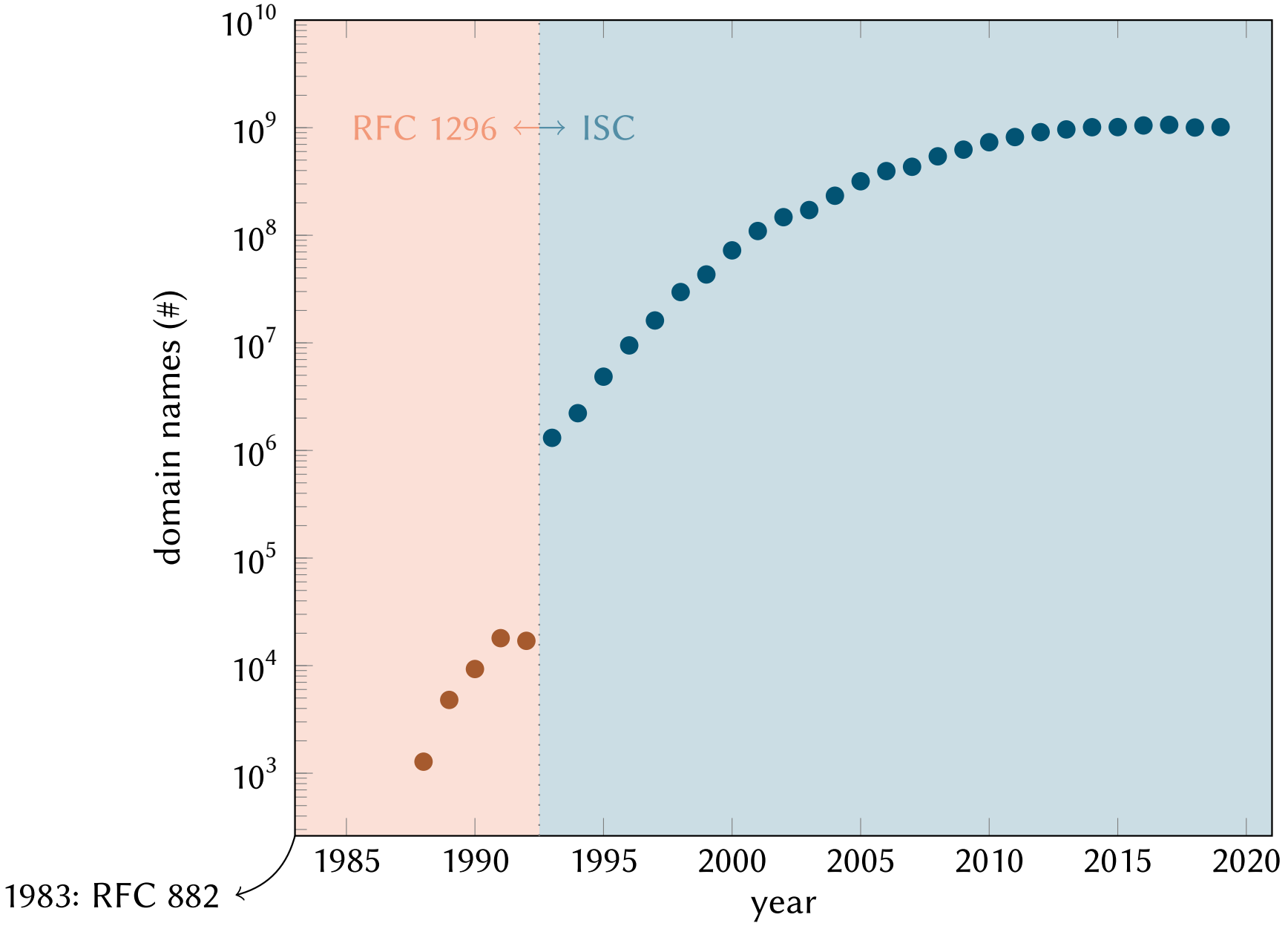
But, why did we wind up needing this (for DNS)???

Often contentious

Did DNS really need a non-technical mechanism? Really?

- Well, first it seemed not: technical protocols came from IETF
- Then *names* became business-critical, and it seemed to need something
- After enough *demonstrated* need, the DNS community evolved the Internet Corporation for Assigned Names and Numbers (ICANN)
- Is it perfect? No. But, perhaps,
  ``Those who cannot remember the past [may be] condemned to repeat it.''[1]

[1] George Santayana, ``The Life of Reason: The Phases of Human Progress'' Vol. 1, 1905


10^{10}
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domain names (#)
RFC 1296 ⟷ ISC
1985
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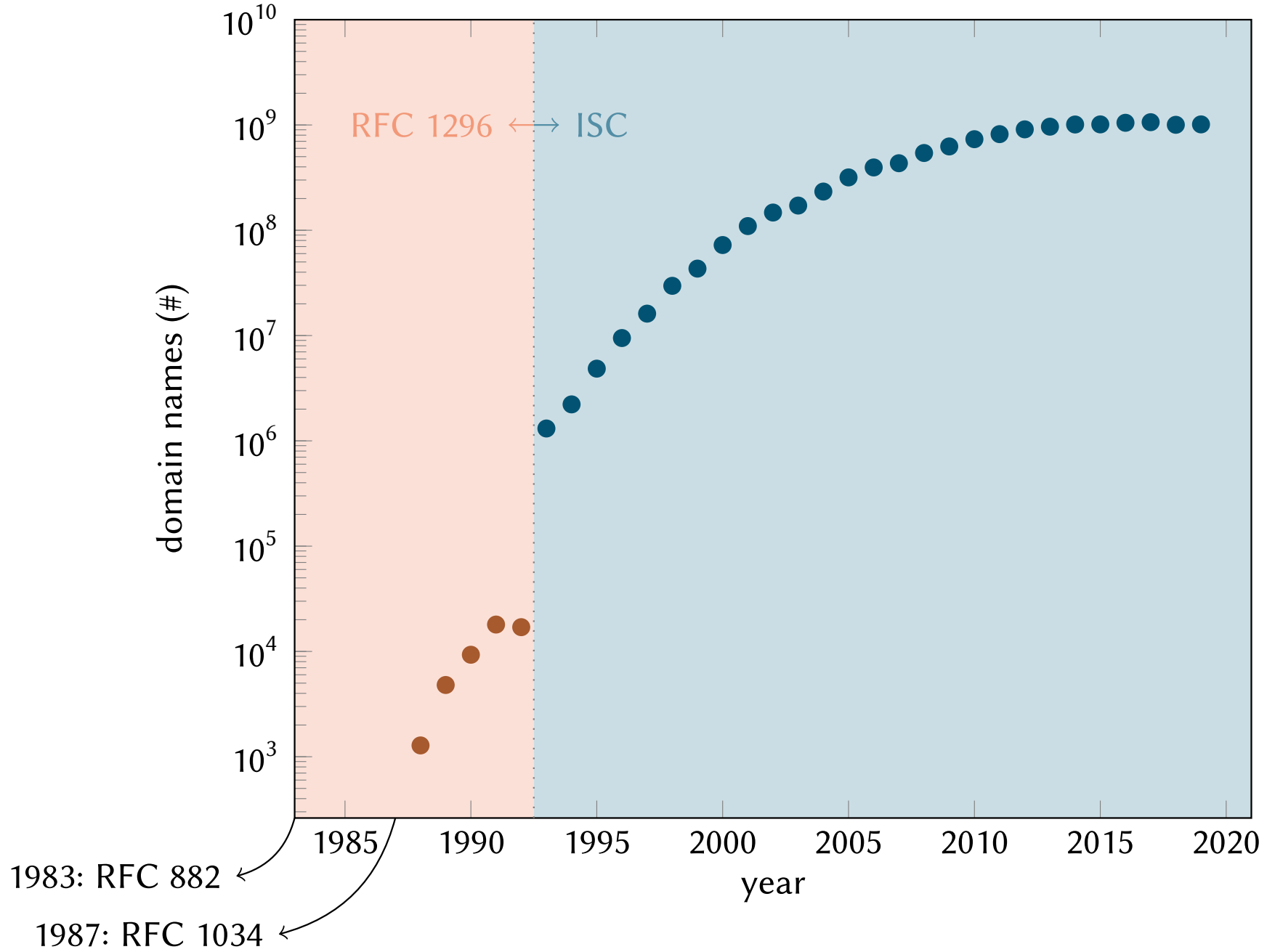
year
1983: RFC 882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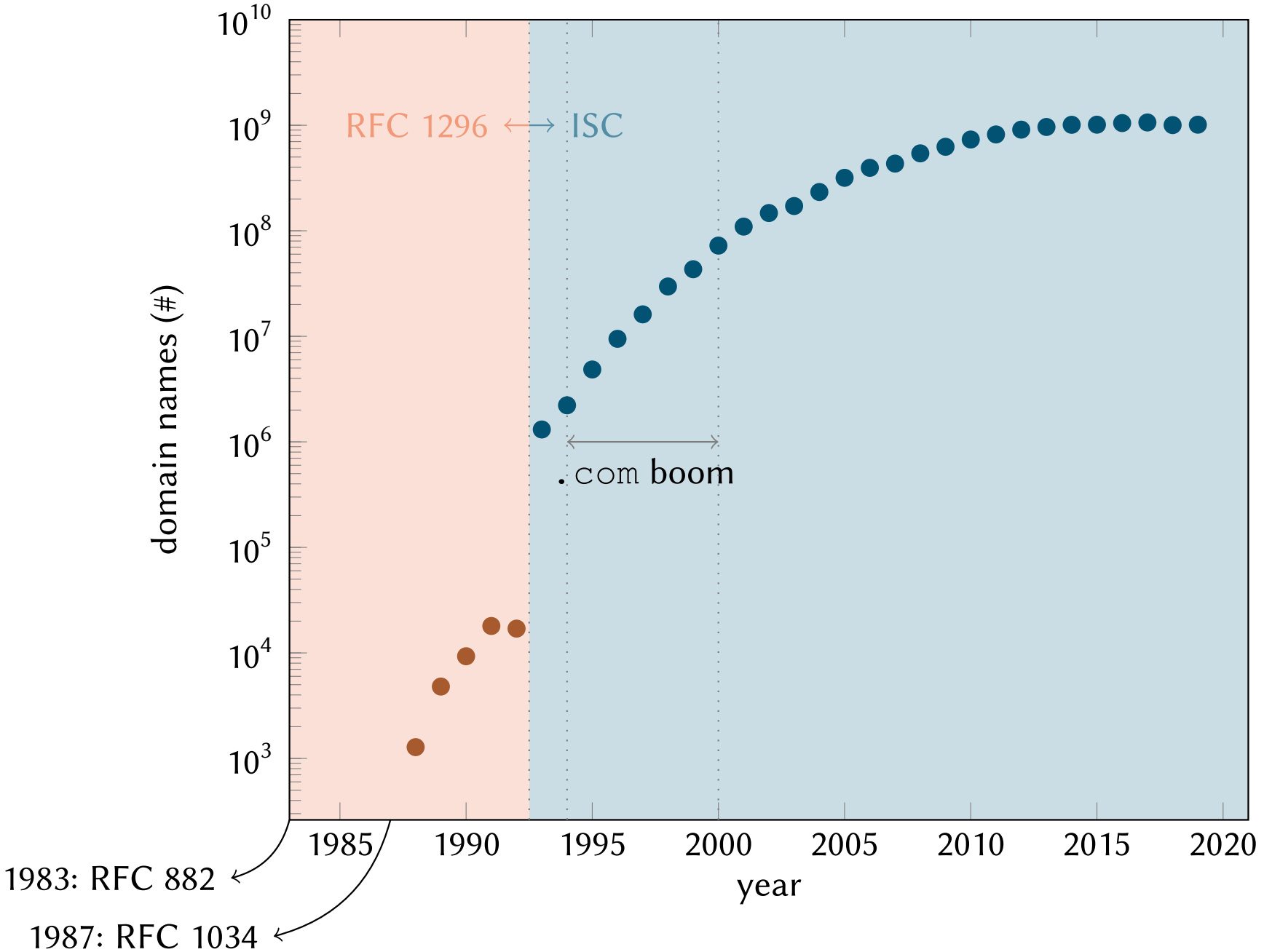
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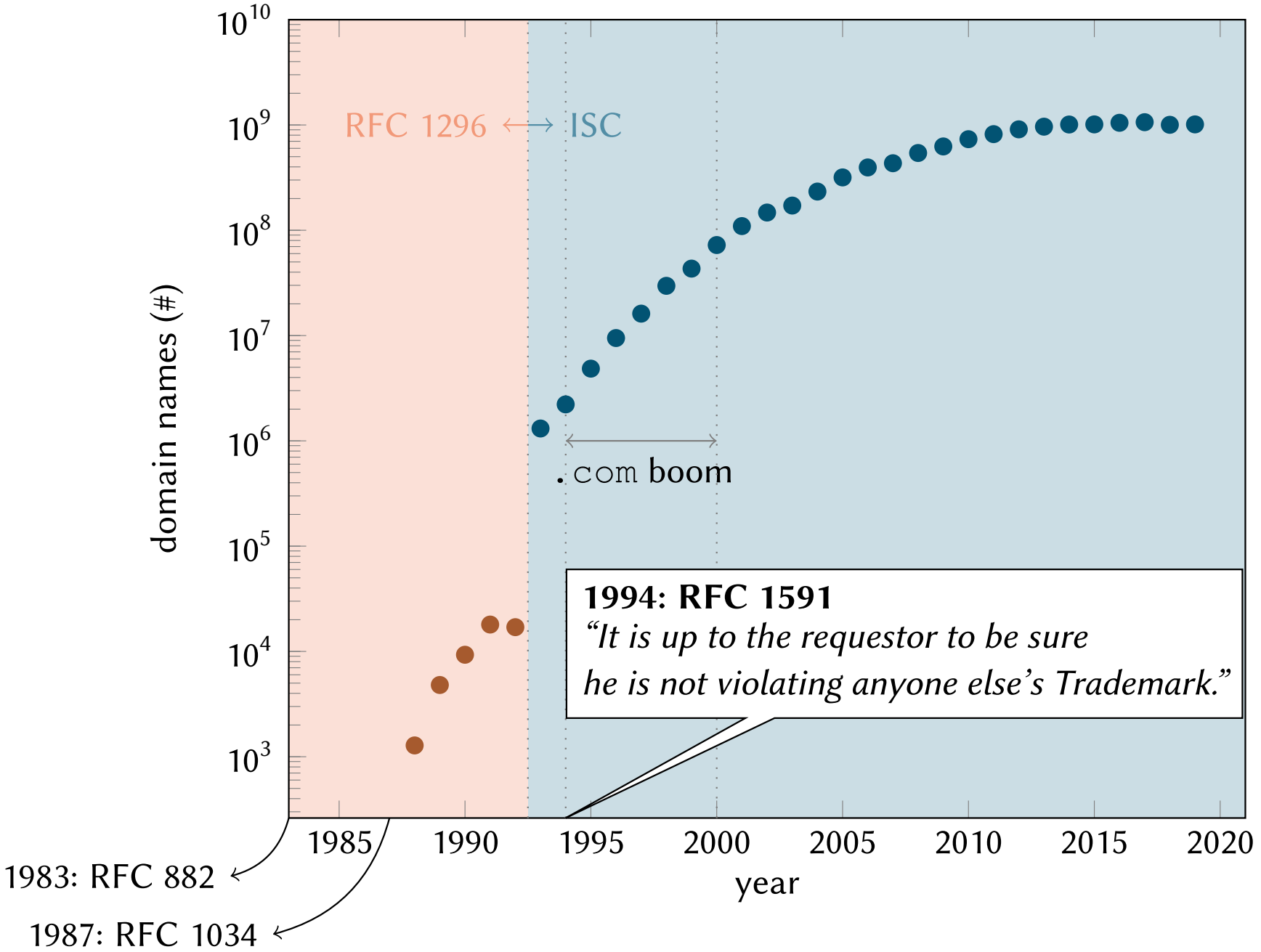
year
1983: RFC 882
1987: RFC 1034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domain names (#)
RFC 1296 ⟷ ISC
.com boom
1994: RFC 1591
"It is up to the requestor to be sure
he is not violating anyone else's Trademark."
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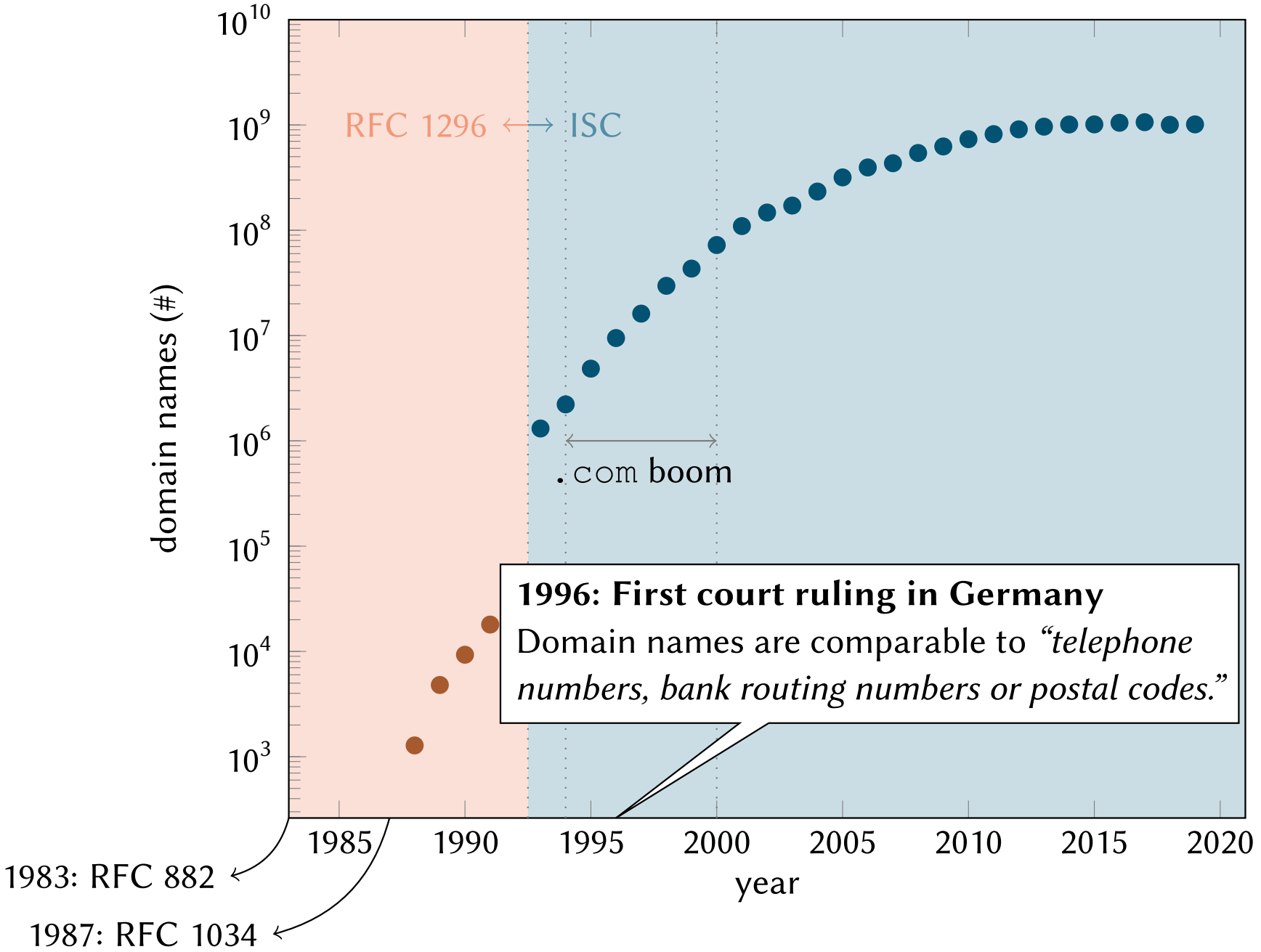
year
1983: RFC 882
1987: RFC 1034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domain names (#)
RFC 1296
ISC
.com boom
1996: First court ruling in Germany
Domain names are comparable to "telephone numbers, bank routing numbers or postal codes."
1985
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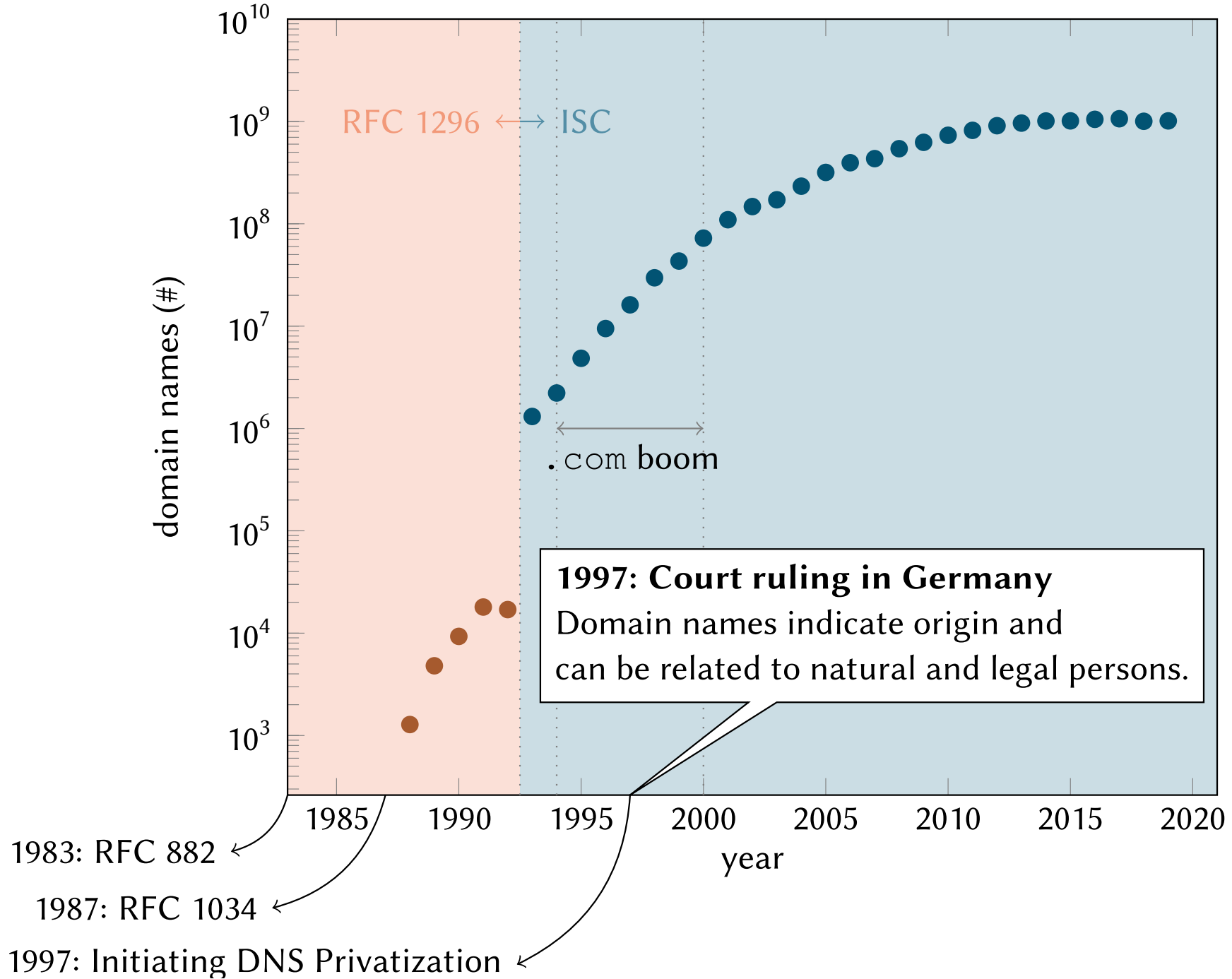
2020
year
1983: RFC 882
1987: RFC 1034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10^{3}
domain names (#)
RFC 1296
ISC
.com boom
1997: Court ruling in Germany
Domain names indicate origin and
can be related to natural and legal persons.
1985
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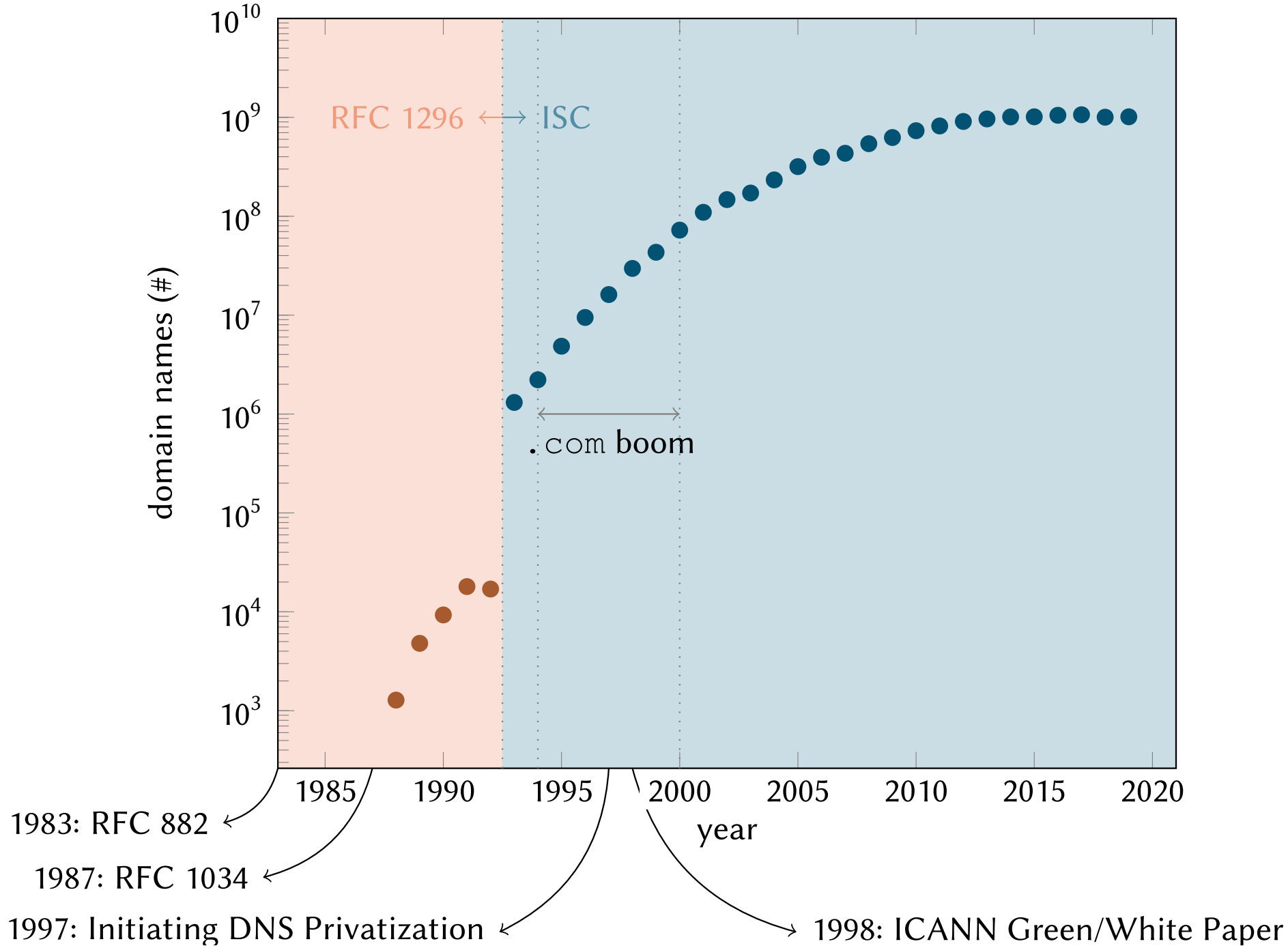
2010
2015
2020
year
1983: RFC 882
1987: RFC 1034
1997: Initiating DNS Privatization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domain names (#)
RFC 1296
ISC
.com boom
1985
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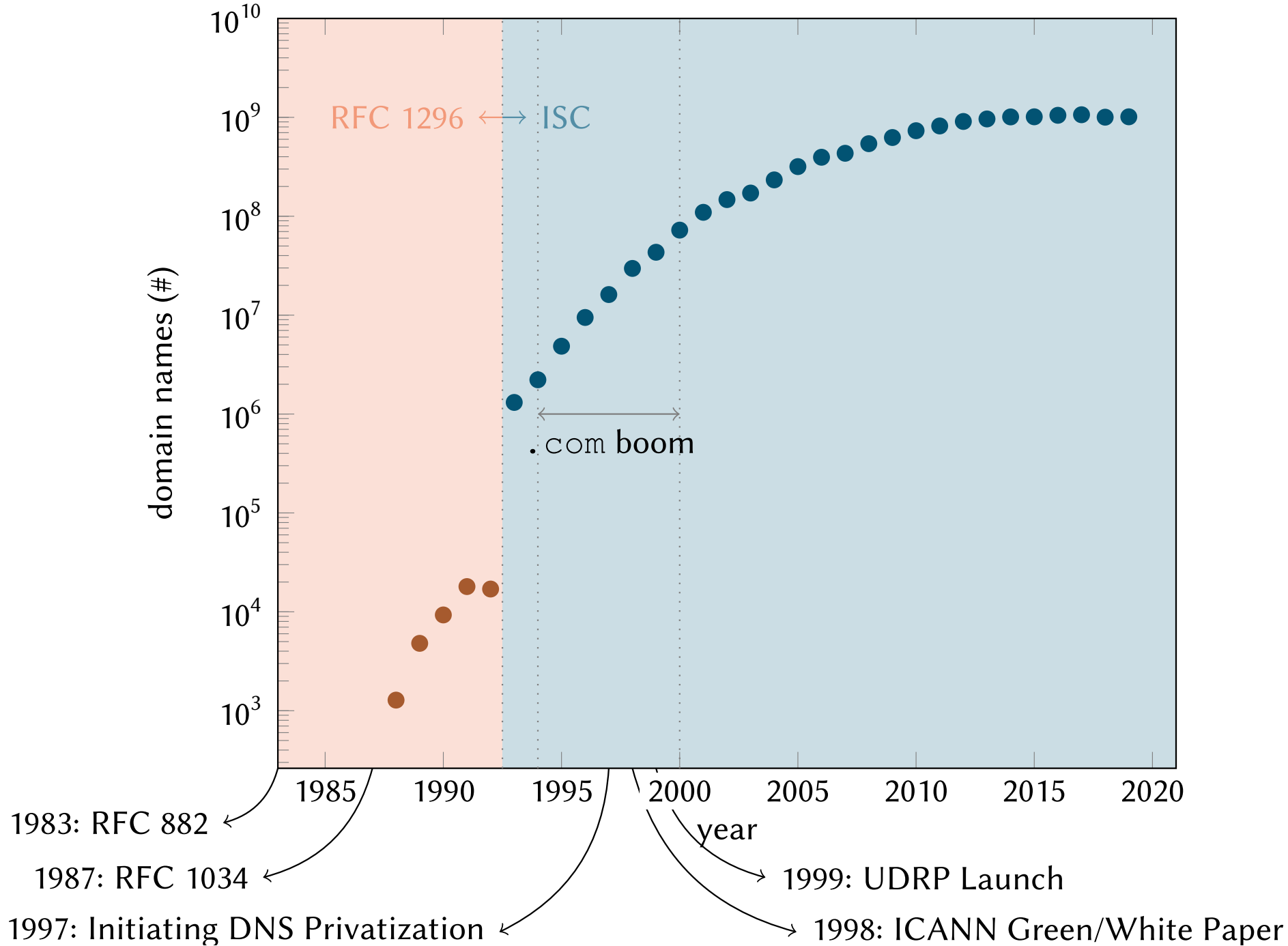
year
1983: RFC 882
1987: RFC 1034
1997: Initiating DNS Privatization
1998: ICANN Green/White Paper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domain names (#)
RFC 1296
ISC
.com boom
1985
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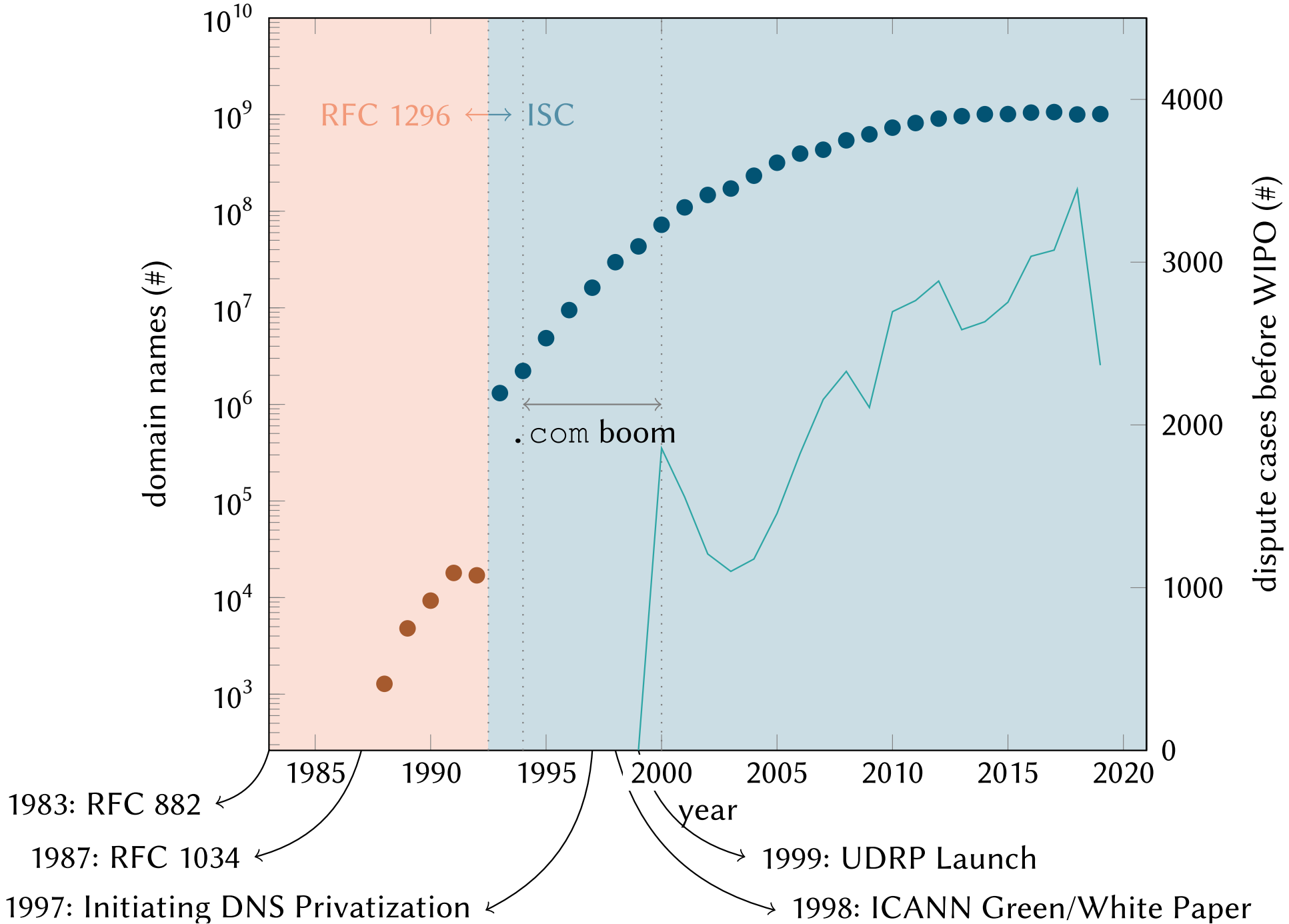
1983: RFC 882
1987: RFC 1034
1997: Initiating DNS Privatization
1998: ICANN Green/White Paper
1999: UDRP Launch


RFC 1296
ISC
.com boom
domain names (#)
dispute cases before WIPO (#)
year
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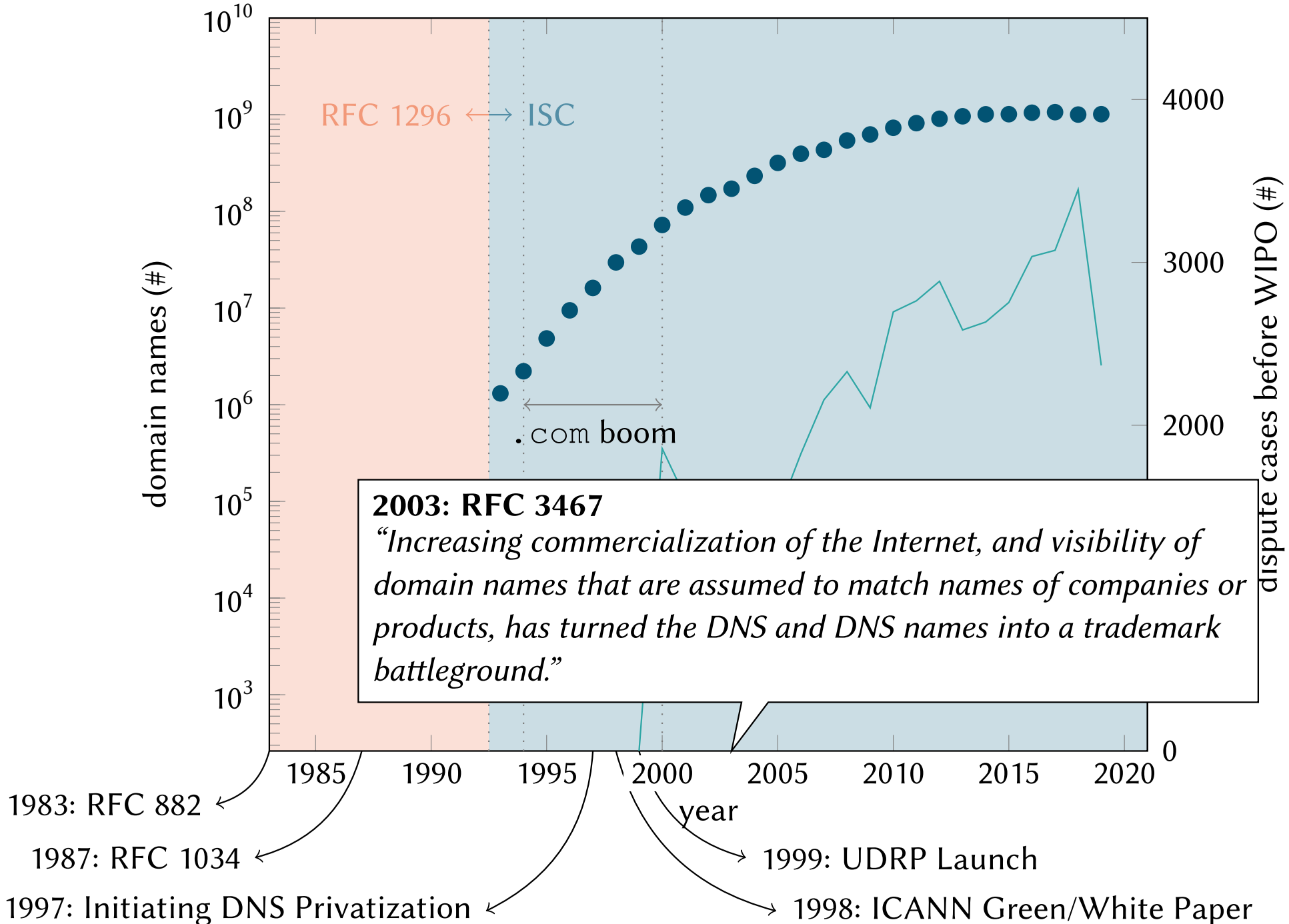
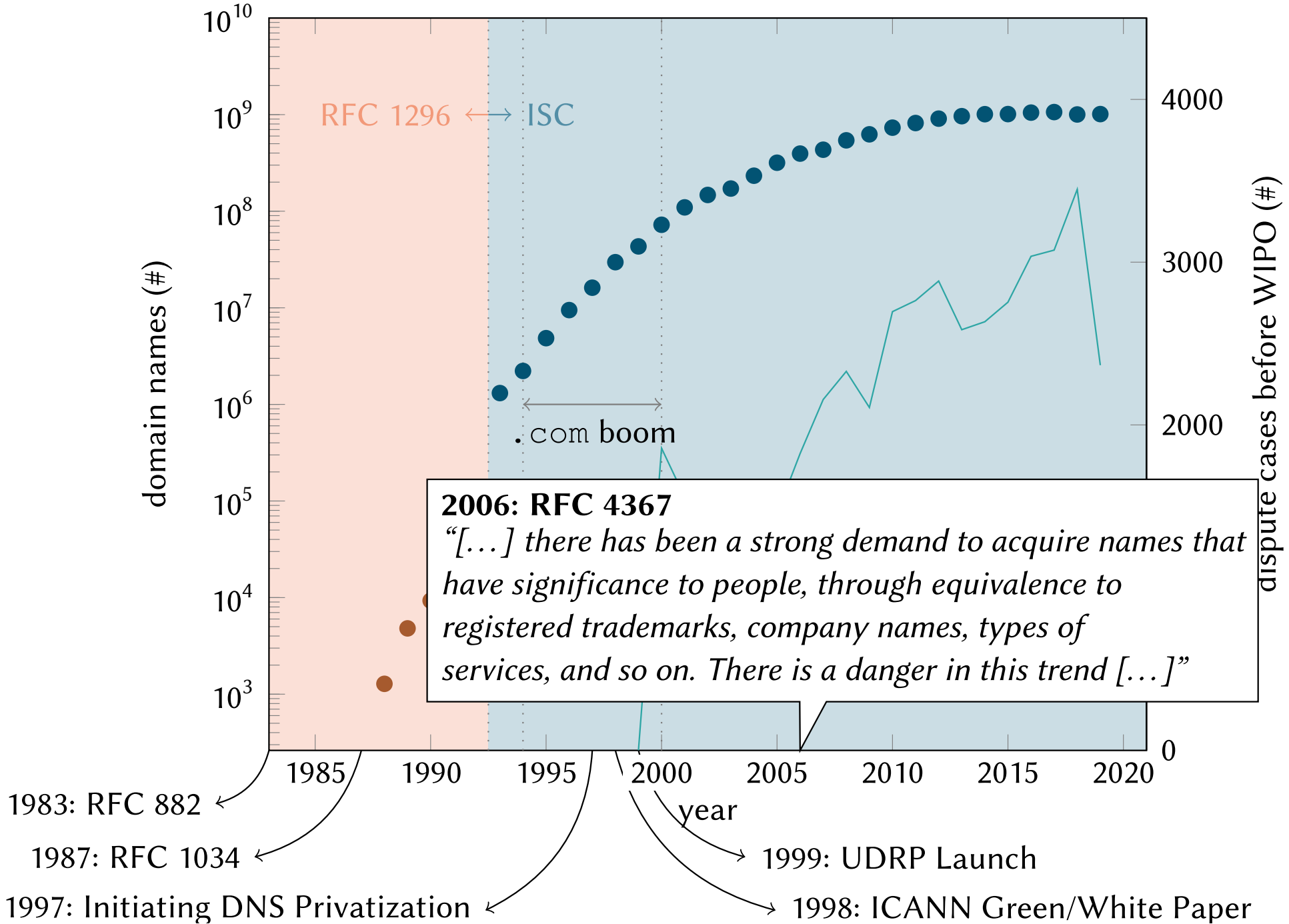
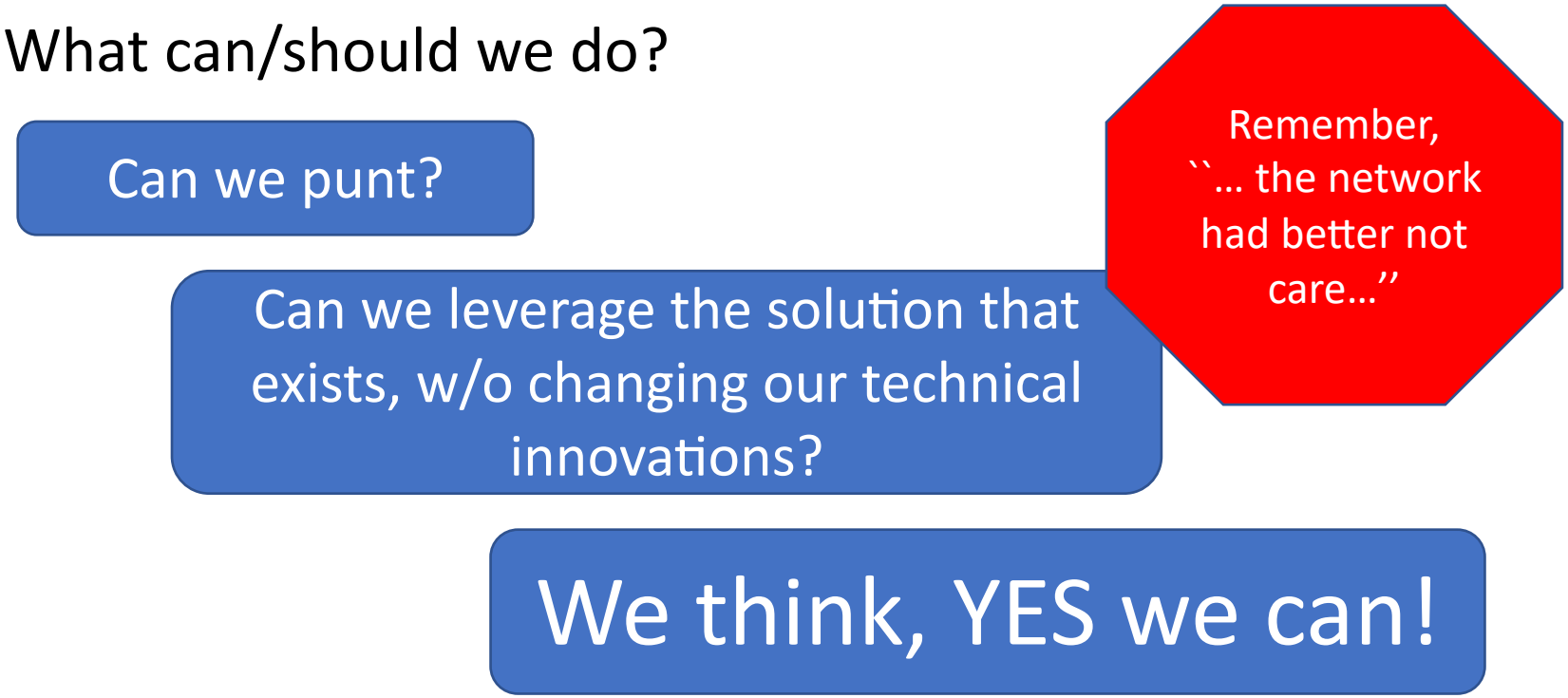
1983: RFC 882
1987: RFC 1034
1997: Initiating DNS Privatization
1998: ICANN Green/White Paper
1999: UDRP Launch


RFC 1296
ISC
.com boom
domain names (#)
dispute cases before WIPO (#)
year
2003: RFC 3467
"Increasing commercialization of the Internet, and visibility of domain names that are assumed to match names of companies or products, has turned the DNS and DNS names into a trademark battleground."
1983: RFC 882
1987: RFC 1034
1997: Initiating DNS Privatization
1998: ICANN Green/White Paper
1999: UDRP Launch


RFC 1296 ⟷ ISC
.com boom
2006: RFC 4367
"[…] there has been a strong demand to acquire names that have significance to people, through equivalence to registered trademarks, company names, types of services, and so on. There is a danger in this trend […]"
domain names (#)
dispute cases before WIPO (#)
year
1983: RFC 882
1987: RFC 1034
1997: Initiating DNS Privatization
1998: ICANN Green/White Paper
1999: UDRP Launch

ICN will be successful!

- If the past is prolog, we will encounter similar (the same?) problems
- What can/should we do?



- We think we *can* synergize the technical design with a separate policy function

Our proposed solution

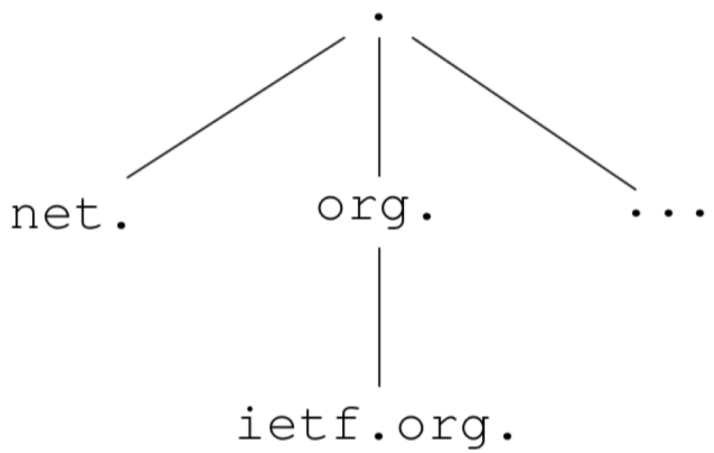
- Namespace

  "set of names from which all names for a given collection of objects are taken" [3, §8]

- Namespace Management

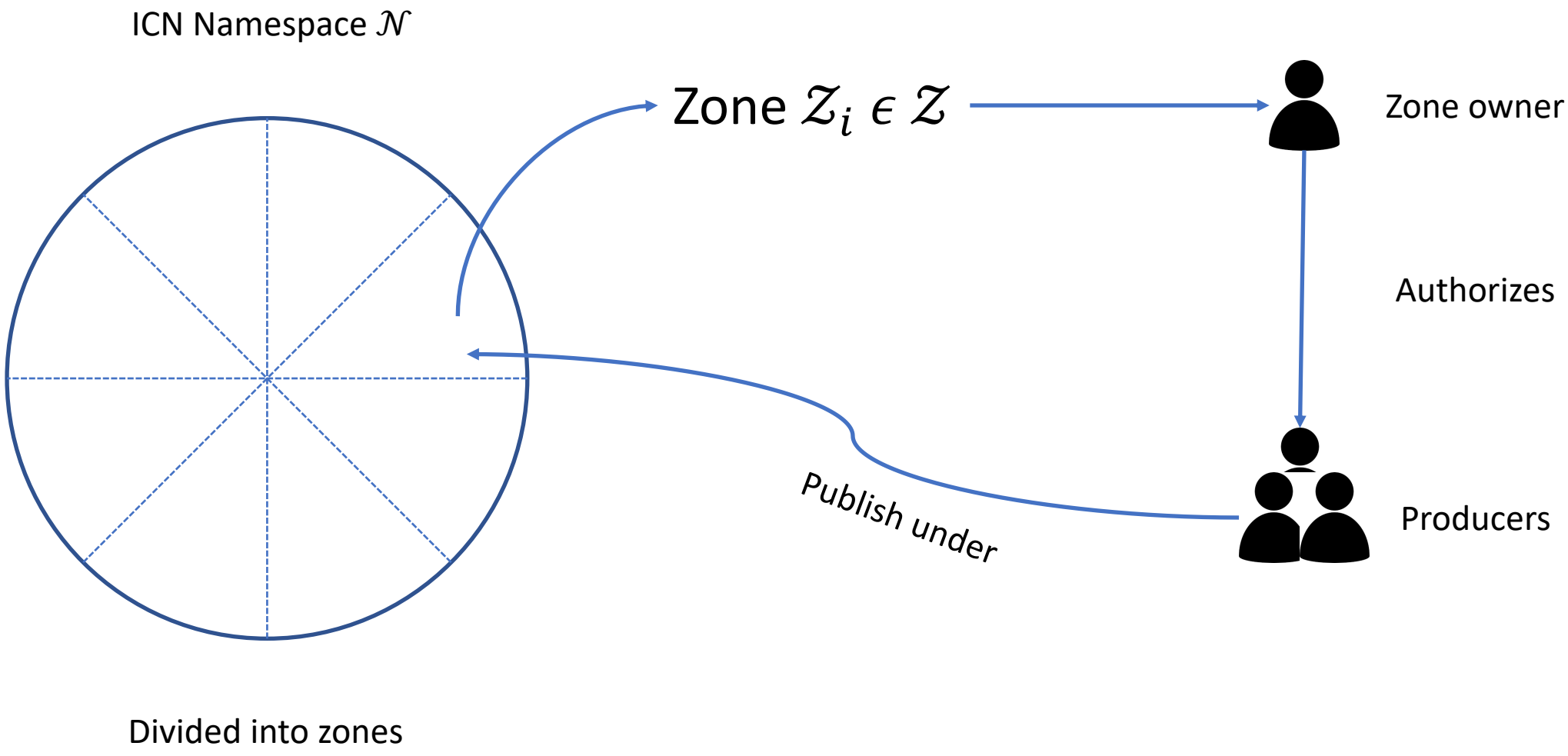
  a (decentralized) namespace management scheme partitions a namespace into management units, zones [6, §6], which are owned and maintained by an authoritative entity.

Example



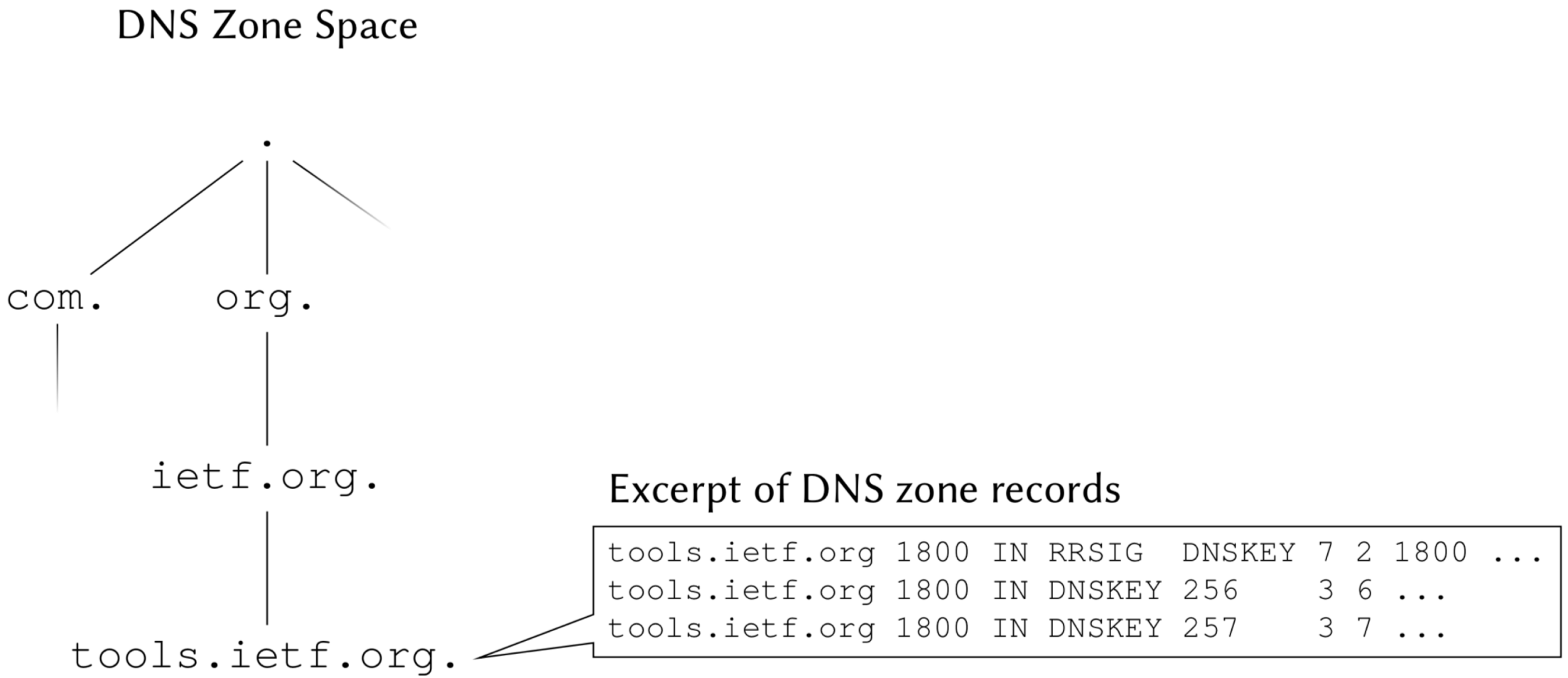

```
ietf.org.   300    IN MX 0 mail.ietf.org.
ietf.org.   300    IN A 4.31.198.44
```

Namespace management concept



Namespace Management Concept

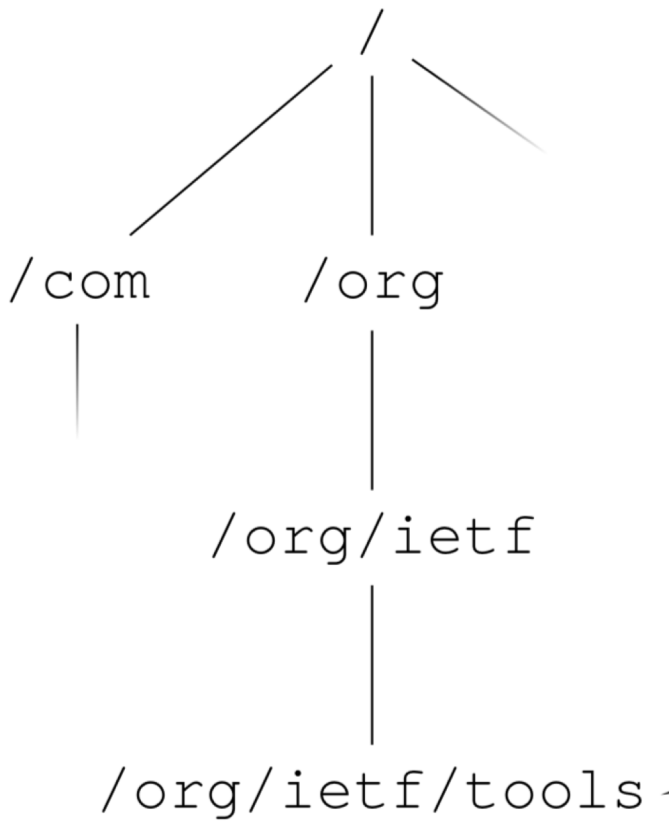
NDNSSEC



Namespace Management Concept

NDNSSEC: DNS Zone Appropriation for NDN

ndnified DNS Zone Space



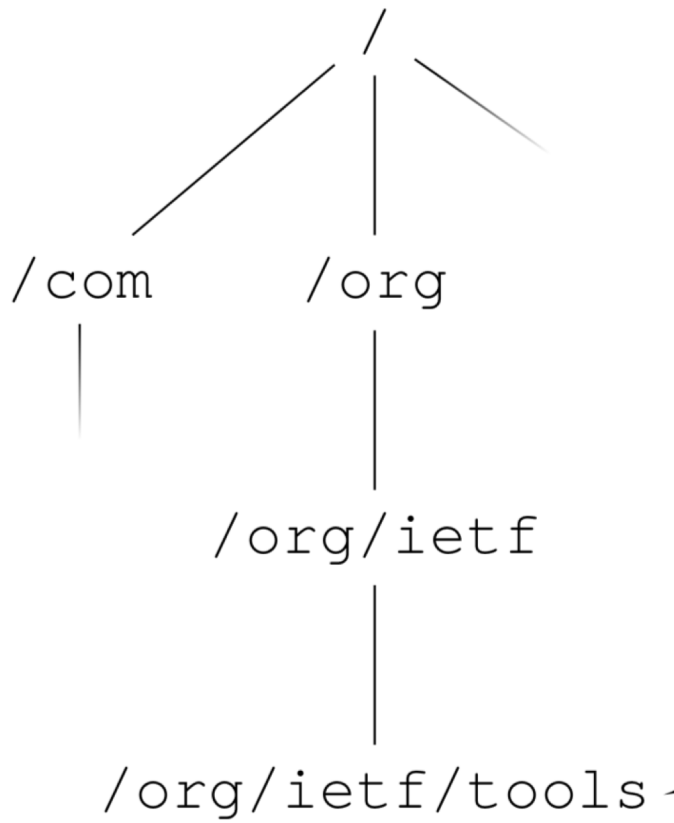
Excerpt of DNS zone records

```
tools.ietf.org 1800 IN RRSIG  DNSKEY 7 2 1800 ...
tools.ietf.org 1800 IN DNSKEY 256    3 6 ...
tools.ietf.org 1800 IN DNSKEY 257    3 7 ...
```

Namespace Management Concept

NDNSSEC: Producer Authorization

ndnified DNS Zone Space



Producer

Zone Owner

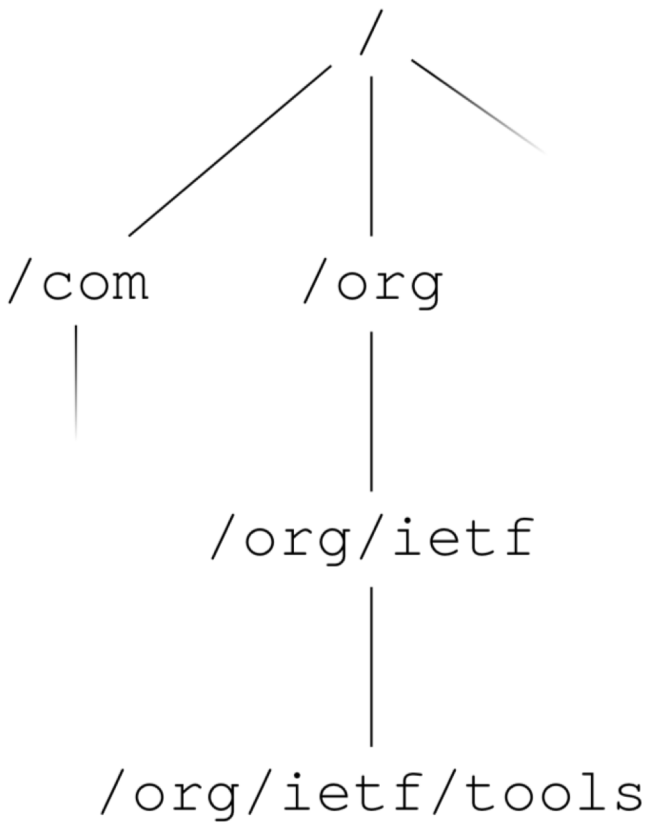
Excerpt of DNS zone records

```
tools.ietf.org 1800 IN RRSIG  DNSKEY 7 2 1800 ...
tools.ietf.org 1800 IN DNSKEY 256    3 6 ...
tools.ietf.org 1800 IN DNSKEY 257    3 7 ...
tools.ietf.org 1800 IN DNSKEY XXX    X X ...
```

Namespace Management Concept

NDNSSEC: Producer Authorization

ndnified DNS Zone Space



Excerpt of DNS zone records

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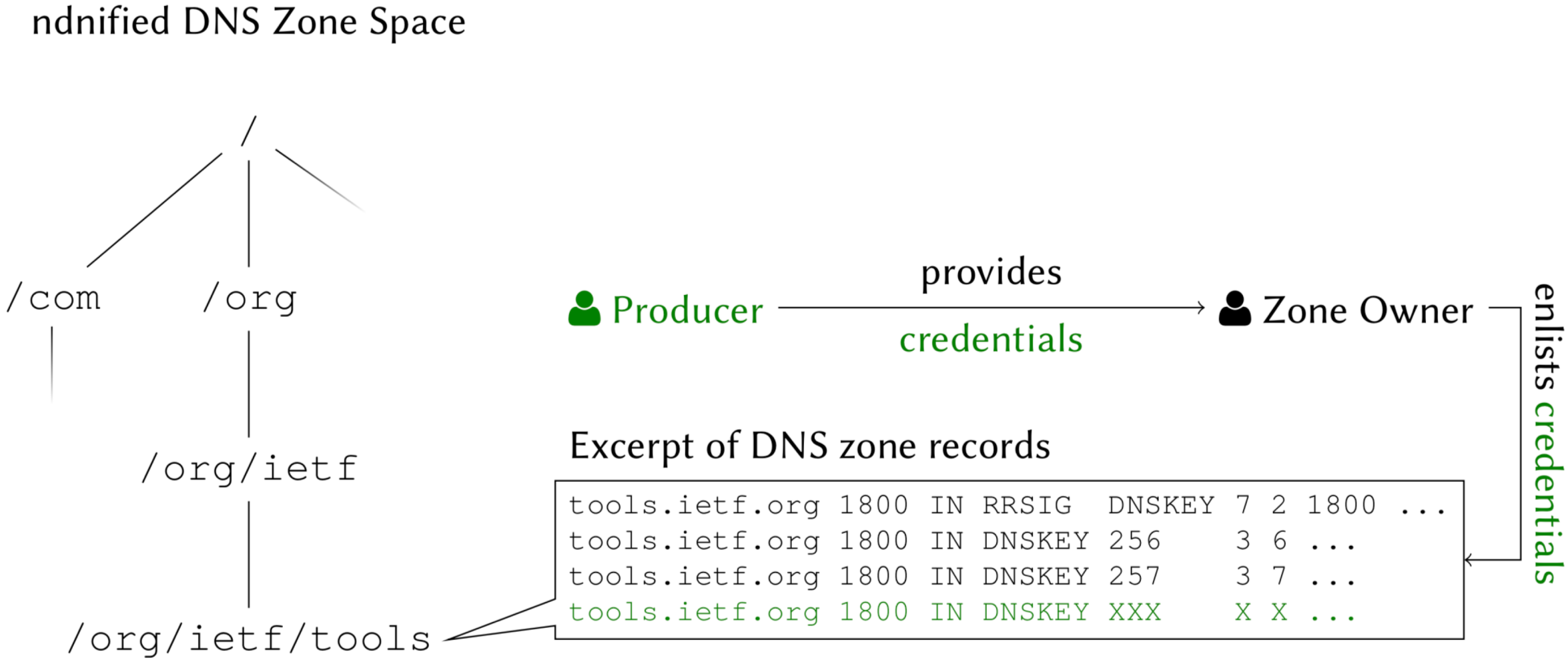
tools.ietf.org 1800 IN RRSIG  DNSKEY 7 2 1800 ...
tools.ietf.org 1800 IN DNSKEY 256    3 6 ...
tools.ietf.org 1800 IN DNSKEY 257    3 7 ...
tools.ietf.org 1800 IN DNSKEY XXX    X X ...
```

Namespace Management Concept

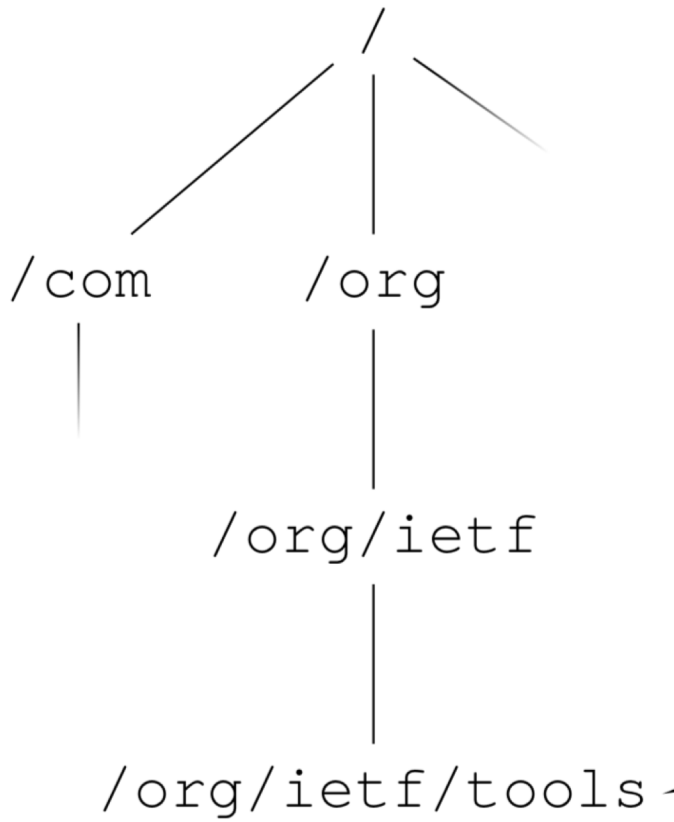
NDNSSEC: Producer Authorization



Namespace Management Concept

NDNSEC: Data Publishing

ndnified DNS Zone Space



Data Packet

/html/rfc882
Meta Info
Content

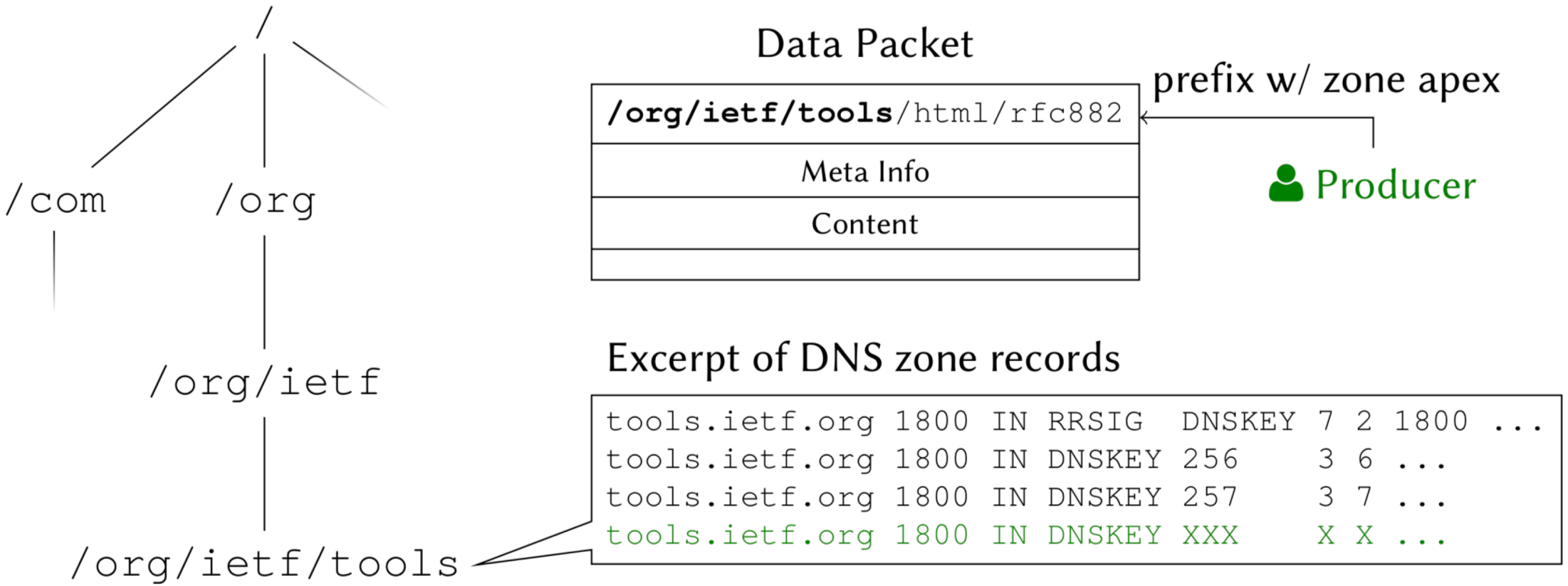
Producer

Excerpt of DNS zone records

```
tools.ietf.org 1800 IN RRSIG  DNSKEY 7 2 1800 ...
tools.ietf.org 1800 IN DNSKEY 256    3 6 ...
tools.ietf.org 1800 IN DNSKEY 257    3 7 ...
tools.ietf.org 1800 IN DNSKEY XXX    X X ...
```

Namespace Management Concept

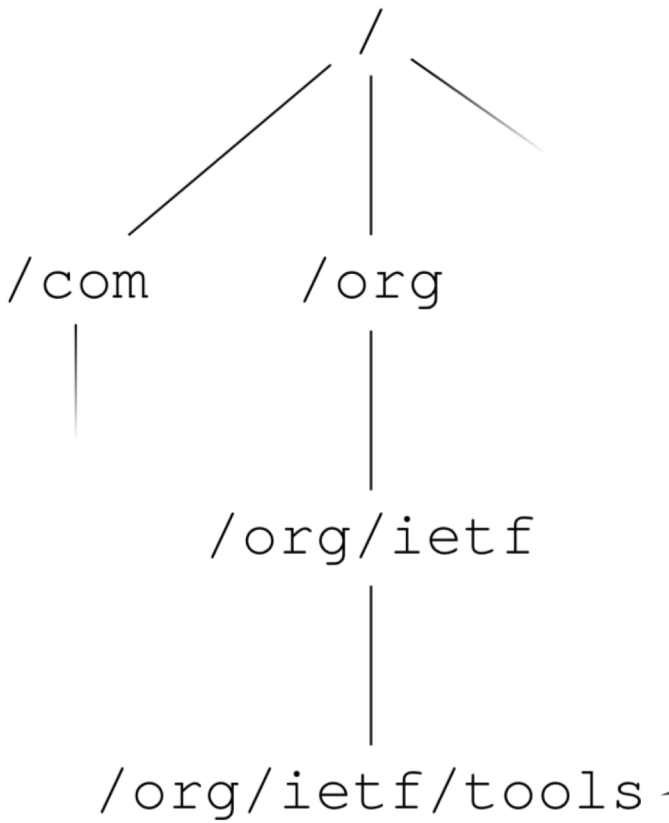
NDNSSEC: Data Publishing



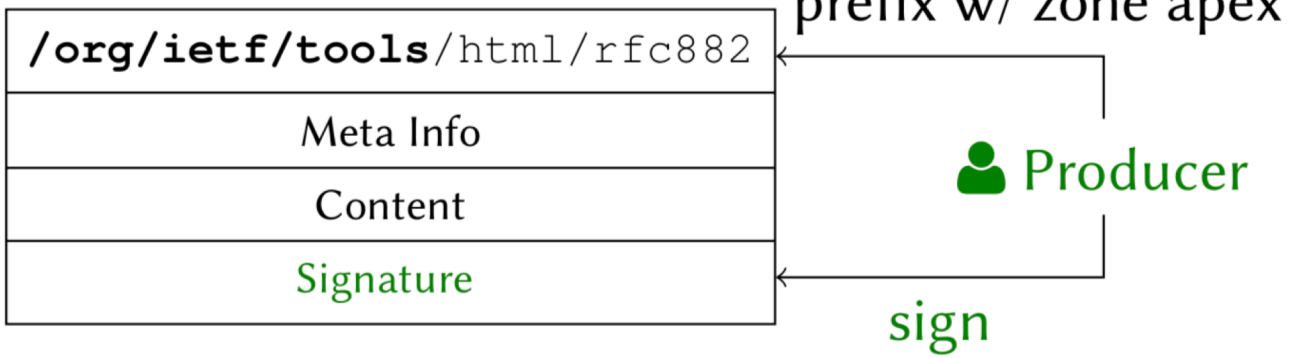
Namespace Management Concept

NDNSSEC: Data Publishing

ndnified DNS Zone Space



Data Packet

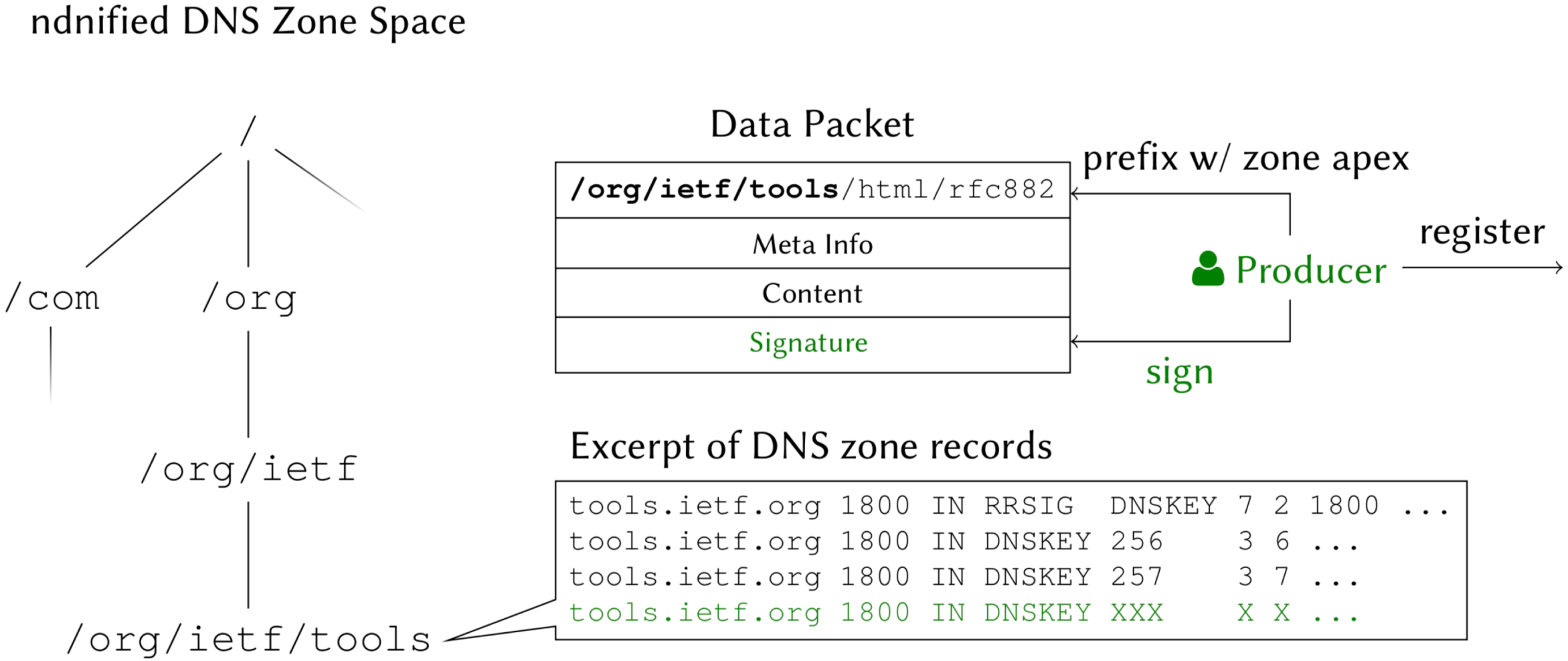


Excerpt of DNS zone records

```
tools.ietf.org 1800 IN RRSIG  DNSKEY 7 2 1800 ...
tools.ietf.org 1800 IN DNSKEY 256    3 6 ...
tools.ietf.org 1800 IN DNSKEY 257    3 7 ...
tools.ietf.org 1800 IN DNSKEY XXX    X X ...
```

Namespace Management Concept

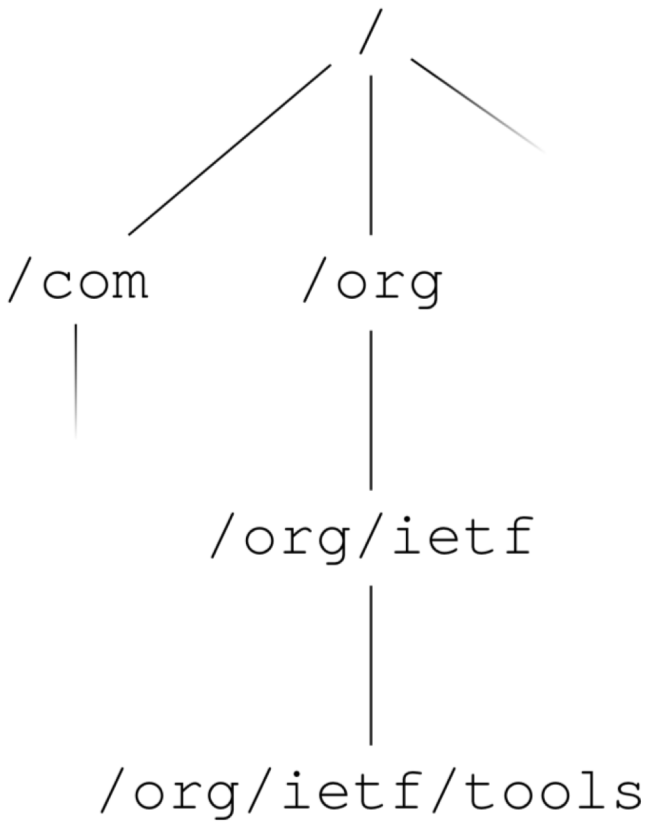
NDNSEC: Data Publishing



Namespace Management Concept

NDNSSEC: Producer Authentication

ndnified DNS Zone Space



Data Packet

/org/ietf/tools/html/rfc882
Meta Info
Content
Signature

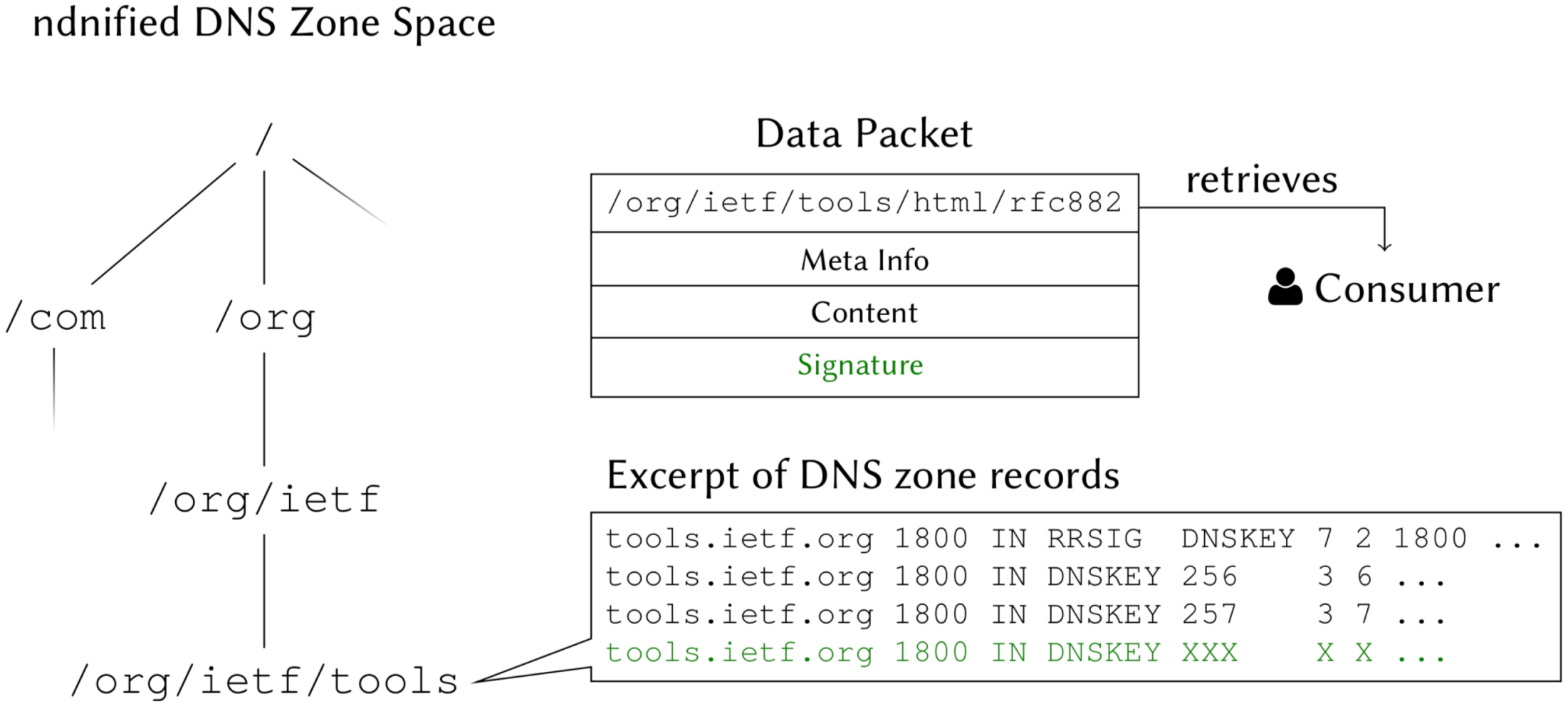
Consumer

Excerpt of DNS zone records

```
tools.ietf.org 1800 IN RRSIG  DNSKEY 7 2 1800 ...
tools.ietf.org 1800 IN DNSKEY 256    3 6 ...
tools.ietf.org 1800 IN DNSKEY 257    3 7 ...
tools.ietf.org 1800 IN DNSKEY XXX    X X ...
```

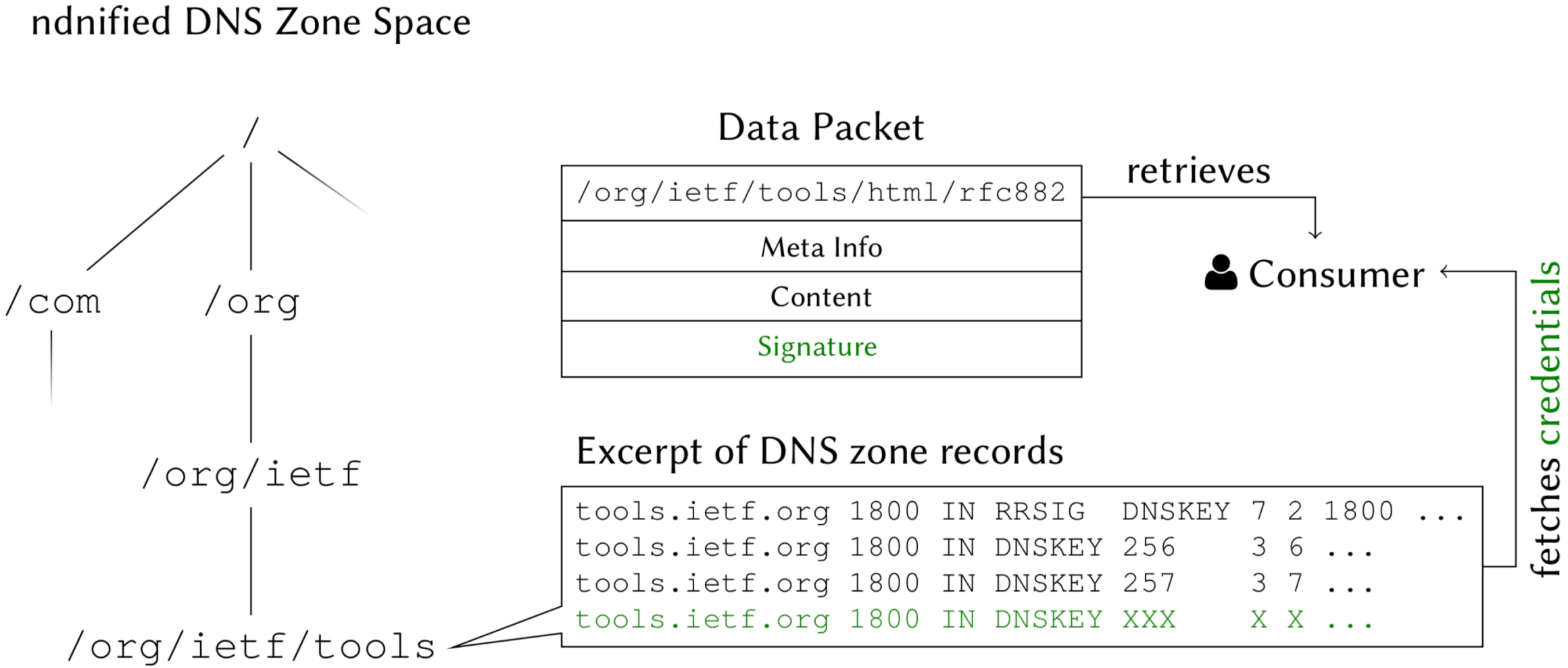
Namespace Management Concept

NDNSSEC: Producer Authentication



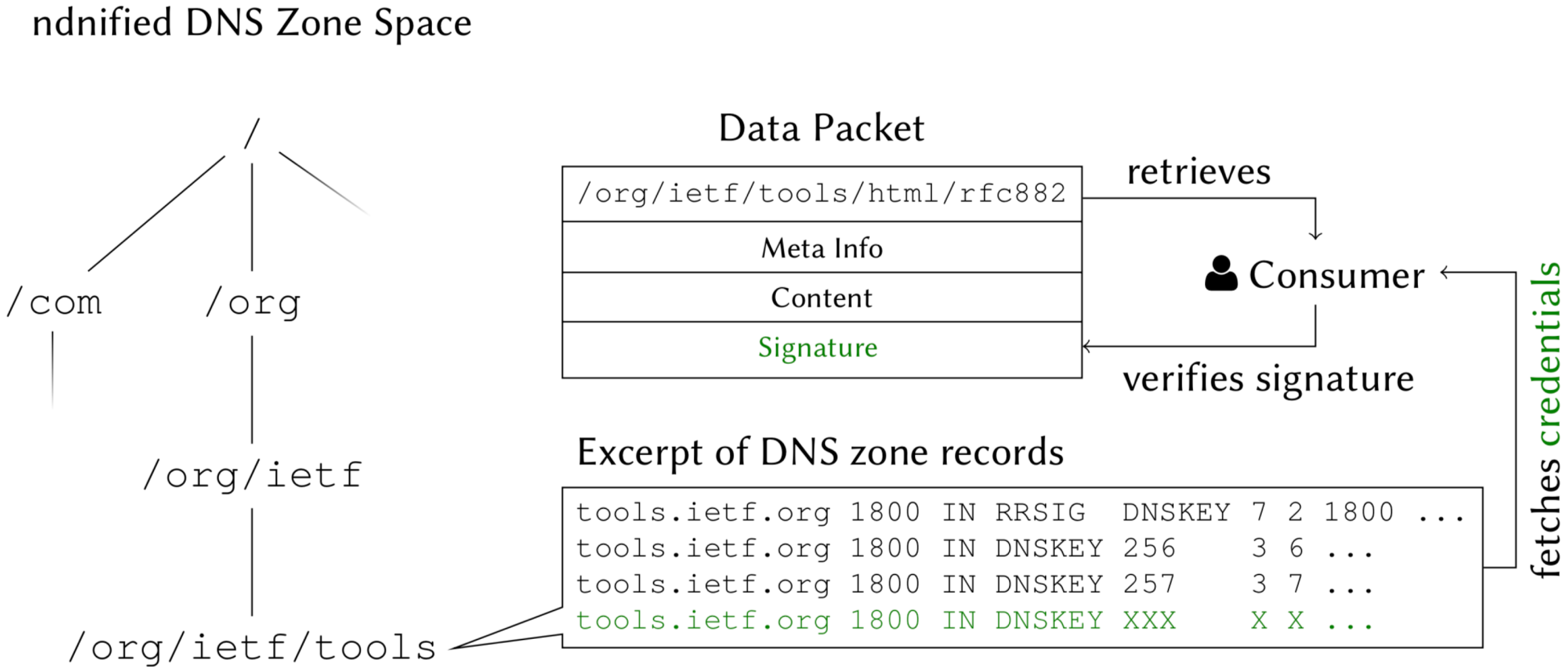
Namespace Management Concept

NDNSSEC: Producer Authentication



Namespace Management Concept

NDNSSEC: Producer Authentication



Conclusions and research roadmap

Where we are:

- Non-technical policy enforcement
- Synergized with ICN
- Deterministic authentication
- No additional infrastructure for certificate revocation

Where we're headed

- DNS data w/o DNS transport
- Evaluate performance (synchronization disparities, etc.)
- Evaluate with user studies
- Explore feasibility in use cases

Thank you

Questions?

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Backup

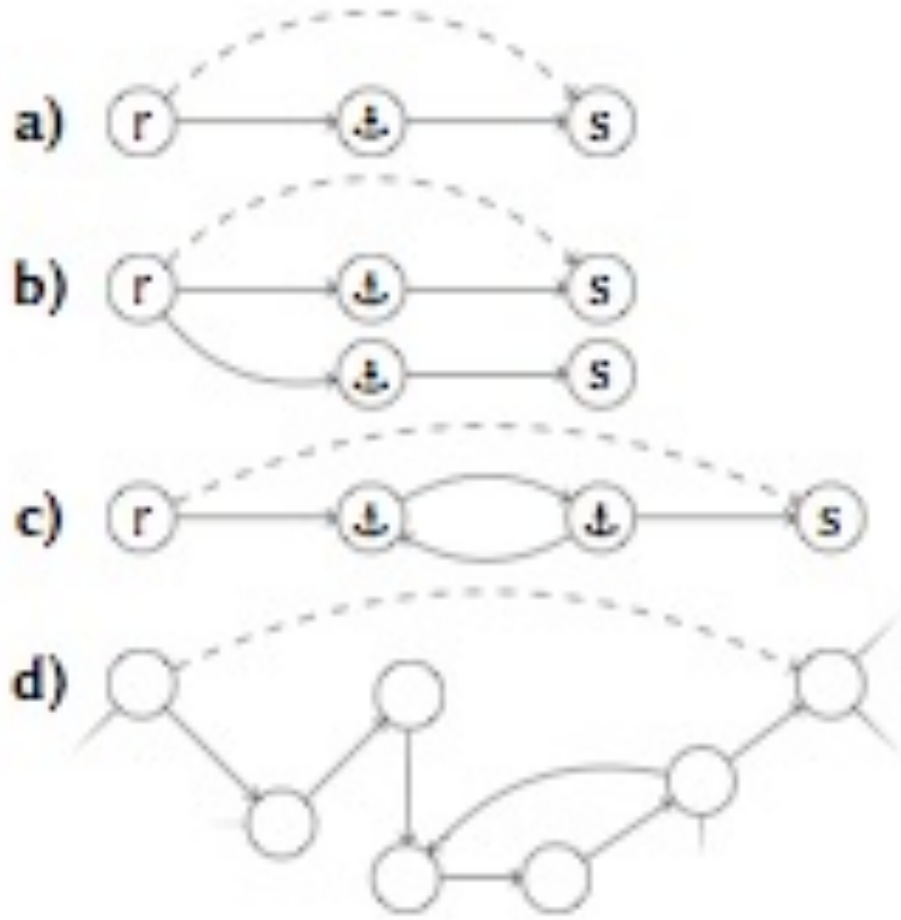
Industry's role in the Internet's history

- Commercial incentives have driven considerations in naming
- Successful companies rely on (among other things) name-recognition,
  - Trademarks and naming are important security elements

- DNS is a historical example of successful Internet name management
- Has had a very large component of non-technical innovations and protections

Trust Models

Transitive Trust



Trust Models

Certificate Chain Verification Complexity

	Level 1 (root)	Level i (interim)	Level n (leaf)	⚓
Trust Schema	⚓ C_0 ⟵ ⋯ ⟵ C_i ⟵ ⋯ ⟵ C_n			≥ 1
NDNS	⚓ $\texttt{KSK}_0$ → $\texttt{DSK}_0$ ⋰	$\texttt{DKEY}_i$ → $\texttt{KSK}_i$ → $\texttt{DSK}_i$ ⋰	$\texttt{DKEY}_n$ → $\texttt{KSK}_n$ → $\texttt{DSK}_n$ → $\texttt{APPCERT}_n$	≥ 1
NDNSSEC	⚓ $\texttt{DNSKEY}_0$ → $\texttt{NS}_0$ ⋮ $\texttt{DS}_0$	$\texttt{DNSKEY}_i$ → $\texttt{NS}_i$ ⋱ $\texttt{DS}_i$	→ $\texttt{DNSKEY}_n$	$= 1$

Related Work

	Authentication				
	$\mathcal{N} \rightarrow \mathcal{T}$	$\mathcal{N} \rightarrow \mathcal{Z}$	Self-auth	Zone Scope	Trust Relation
DNSSEC [10]	✓	✓	✘	$\mathcal{N}$	Decentralized
Detti et al. [4]	✓	✓	✓*	$\mathcal{I}$	Decentralized
Venkataramani et al. [11]	✓	✘	✓*	$\emptyset$	N/A
Farrell et al. [7]	✓	✘	✓	$\emptyset$	N/A
Wong and Nikander [12]	✓	✓	✘	$\mathcal{I}$	Centralized
Afanasyev [2, 1]	✓	✓	✘	$\mathcal{N}$	Decentralized
Mahadevan et al. [9]	✓	✓	✘	$\mathcal{N}$	Decentralized
DiBenedetto and Papadopoulos [5]	✓	✓	✘	$\mathcal{N}$	Decentralized
Zhang et al. [13]	✓	✓	✓*	$\mathcal{I}/\mathcal{N}$	Decentralized
Hamdane et al. [8]	✓	✓	✓*	$\mathcal{I}$	Decentralized

* Denotes *self-certification*