Attacks on DNS

D. J. Bernstein
University of Illinois at Chicago

The Domain Name System

`cert.org` wants to see `http://www.lsec.be`.

Browser at `cert.org`

↑ "The web server `www.lsec.be` has IP address 81.246.94.54."

Administrator at `lsec.be`

Now `cert.org` retrieves web page from IP address 81.246.94.54.

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Mail client at

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"The mail
`lsec`
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80.92.66

Administrator

Now `cert.org`
delivers mail to
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Same for Internet mail.

`cert.org` has mail
to deliver to `someone@lse`

Mail client at `cert.or`

↑

“The mail server for
`lsec.be`
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Administrator at `lsec.b`

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Real postcard fro

From: lsec.be adr
To: cert.org
The mail server for
IP address 80.92.66
to have informed yo

Forged postcard

From: lsec.be adr
To: cert.org
The mail server for
IP address 157.22.2
to have informed yo

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"Can attackers do that?"
— Yes.

"Really?" — Yes.

"Don't the clients check who's sending information?"

— Yes, but the attacker forges the sender address; as easy as forging address on a physically mailed postcard.

Real postcard from admini

From: `lsec.be` admin

To: `cert.org` mail client

The mail server for `lsec.be` ha
IP address 80.92.66.174. Hopin
to have informed you sufficiently

Forged postcard from attac

From: `lsec.be` admin

To: `cert.org` mail client

The mail server for `lsec.be` ha
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Real postcard from administrator:

> From: `lsec.be` admin
>
> To: `cert.org` mail client
>
> ---
>
> The mail server for `lsec.be` has IP address 80.92.66.174. Hoping to have informed you sufficiently!

Forged postcard from attacker:

> From: `lsec.be` admin
>
> To: `cert.org` mail client
>
> ---
>
> The mail server for `lsec.be` has IP address 157.22.245.20. Hoping to have informed you sufficiently!

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From: `lsec.be` adr

To: `cert.org`

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IP address 80.92.66

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To: `cert.org` mail client

The mail server for `lsec.be` has IP address 157.22.245.20. Hoping to have informed you sufficiently!

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"Is the client always listening for the address of `lsec.be`?"

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Forged `lsec.be` information is effective *if* it arrives at this time.

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Many ways for attackers to time forgeries properly:

1. Attack repeatedly. One of the forgeries will arrive at the right time.

2. Poke the client to trigger a known lookup.

3. Attack caches a long time in advance.

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Sniff the network.

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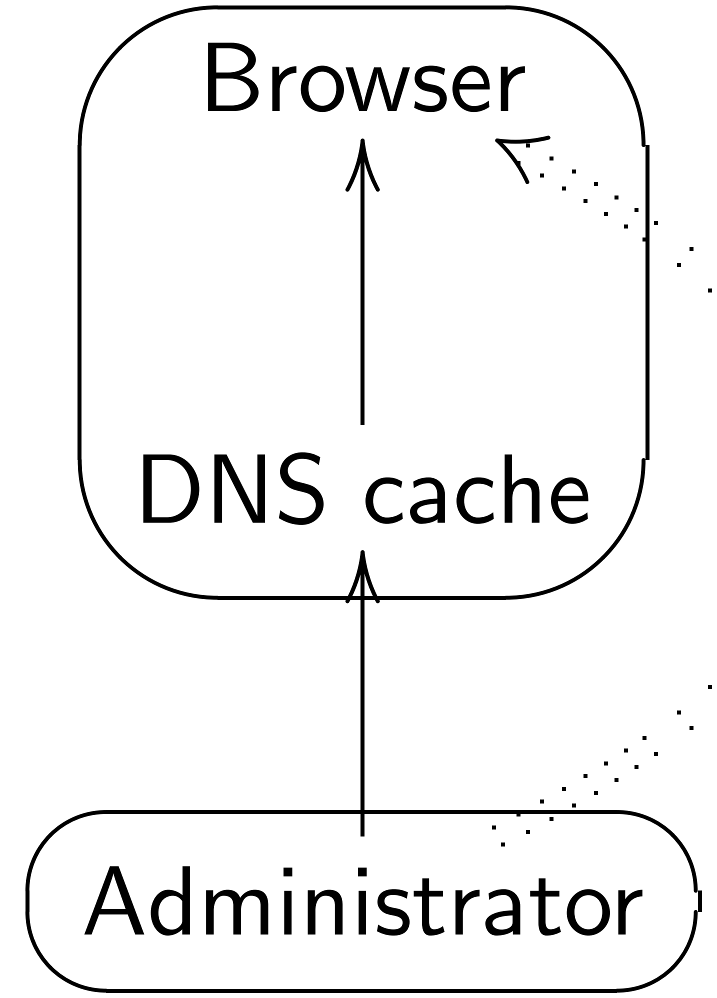

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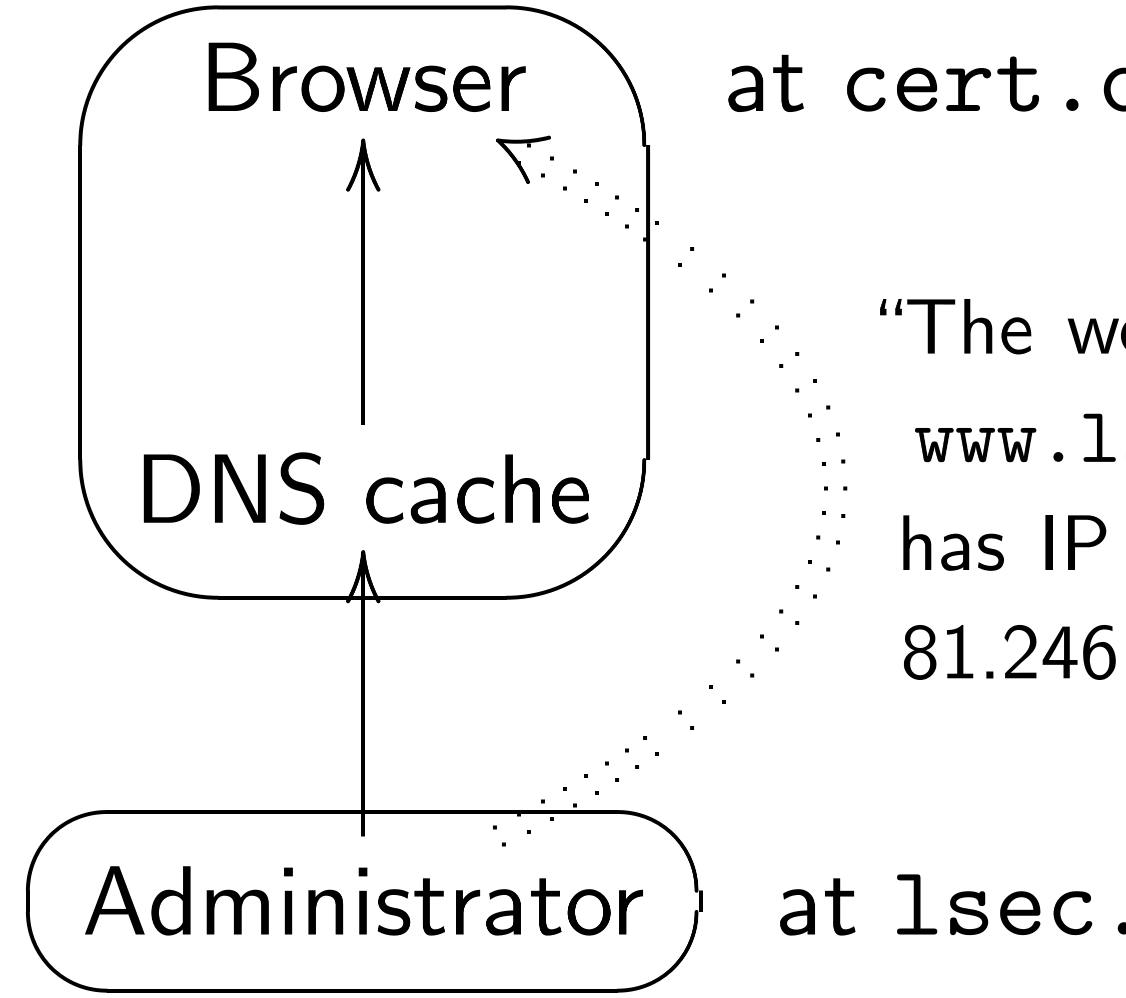

Browser pulls data from DNS cache at `cert.org`.

Cache pulls data from administrator *if* it doesn't already have the da

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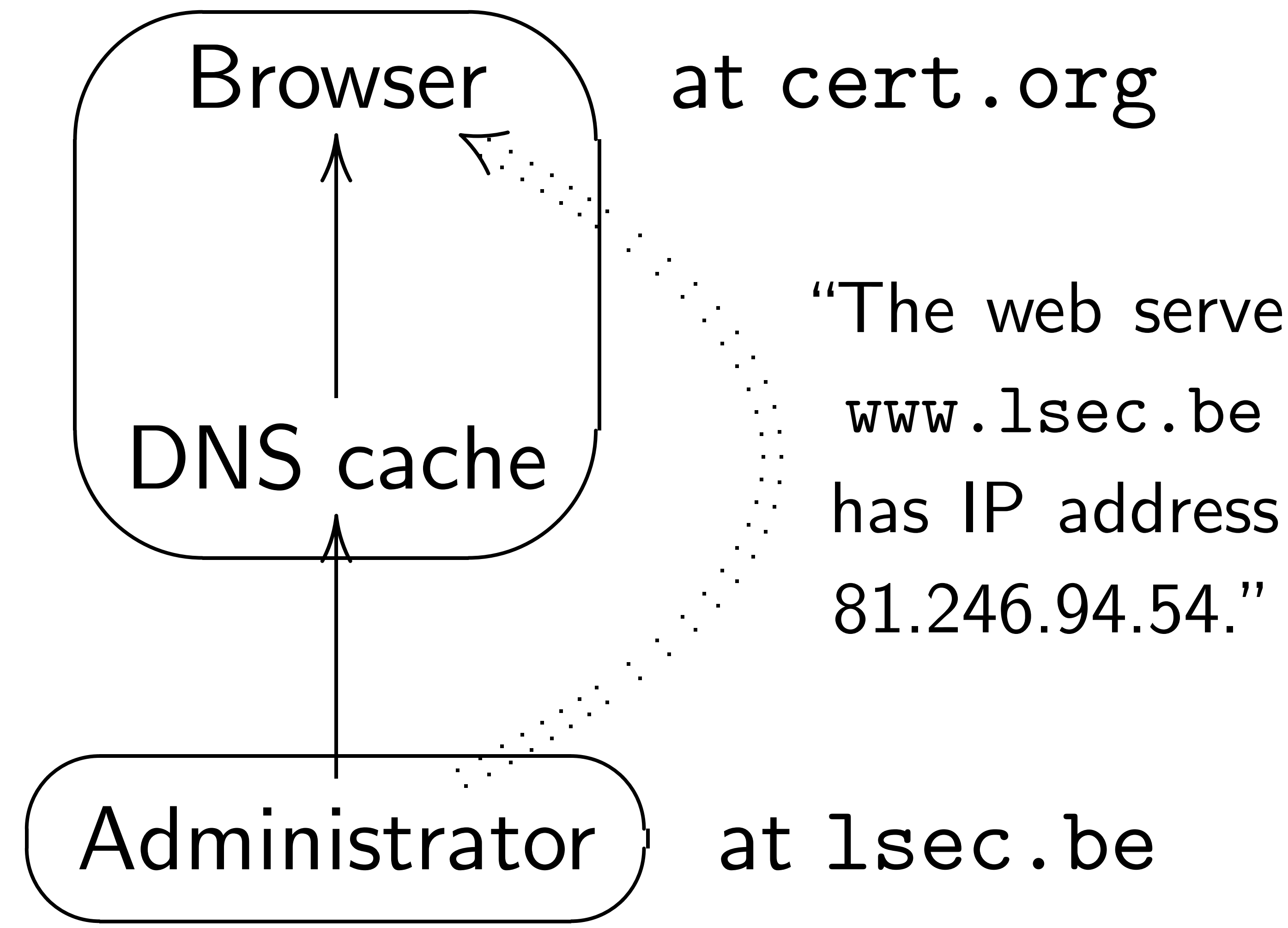

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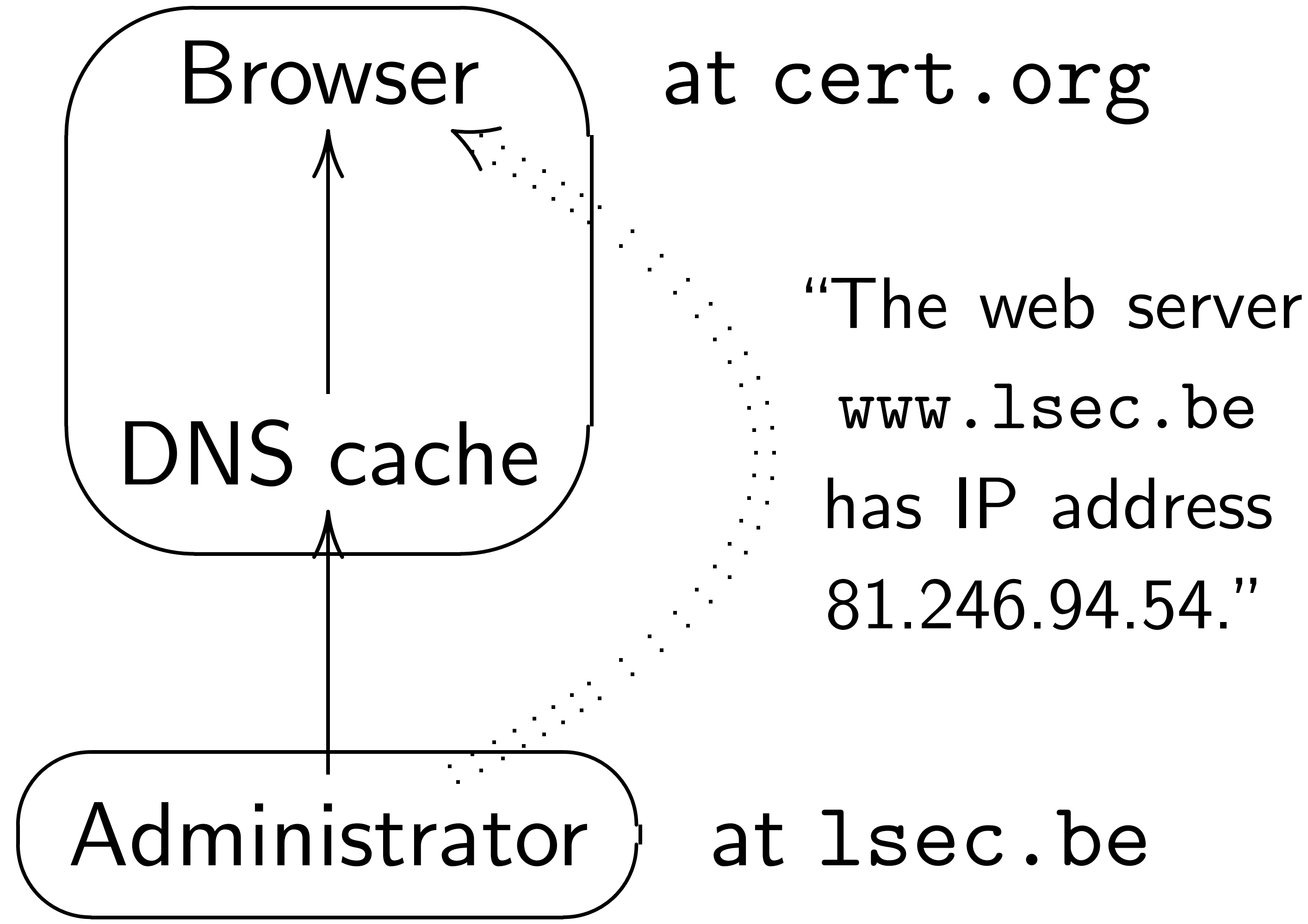

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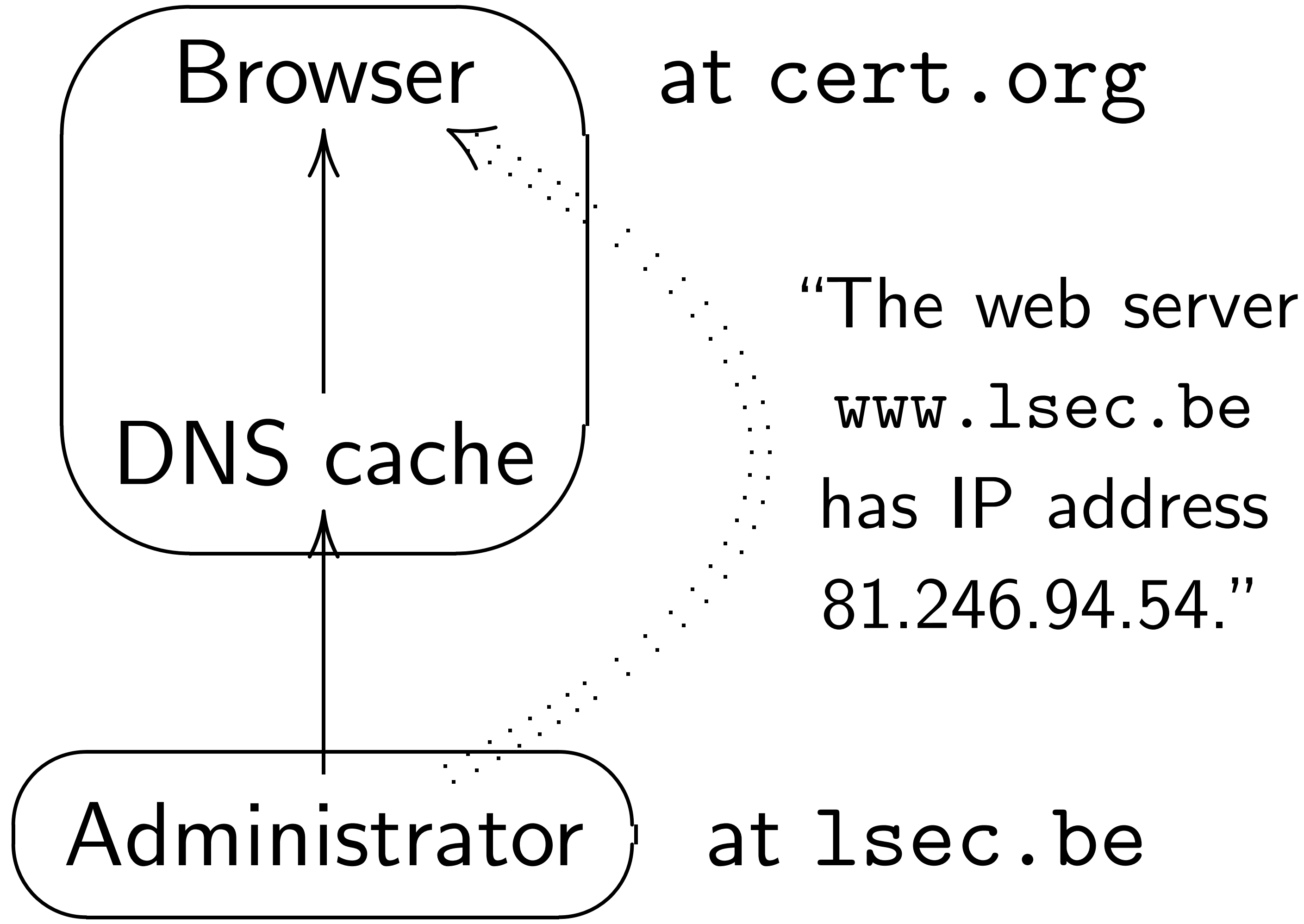

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A typical blind at

Attacker sets up
`supersecurityt`
including an inlin
from `www.lsec.`

Victim asks brow
`supersecurityt`

Attacker sees HT
sends web page t
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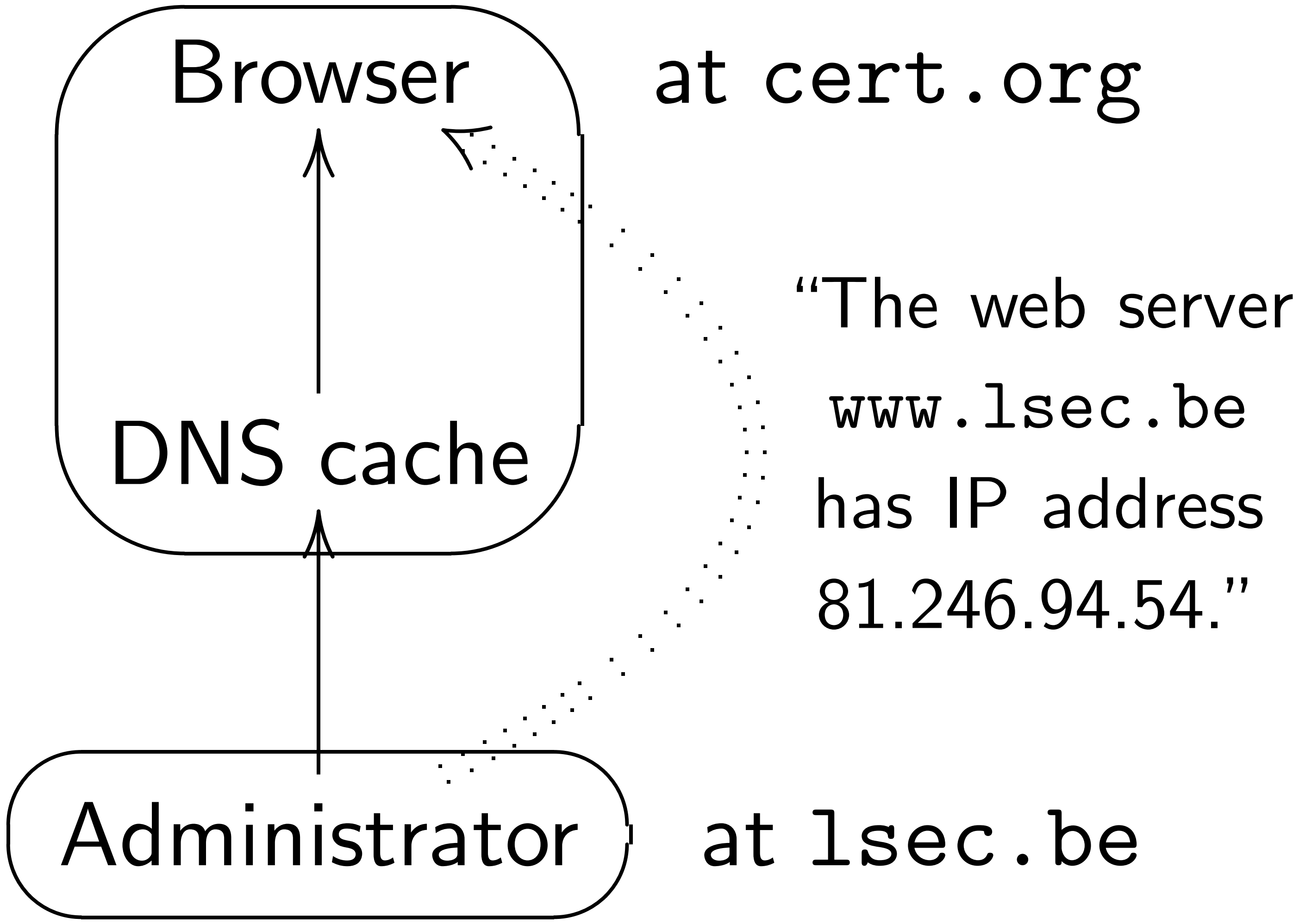

Browser pulls data from DNS cache at `cert.org`.

Cache pulls data from administrator *if* it doesn't already have the data.

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Victim asks browser to view
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Attacker sees HTTP reque
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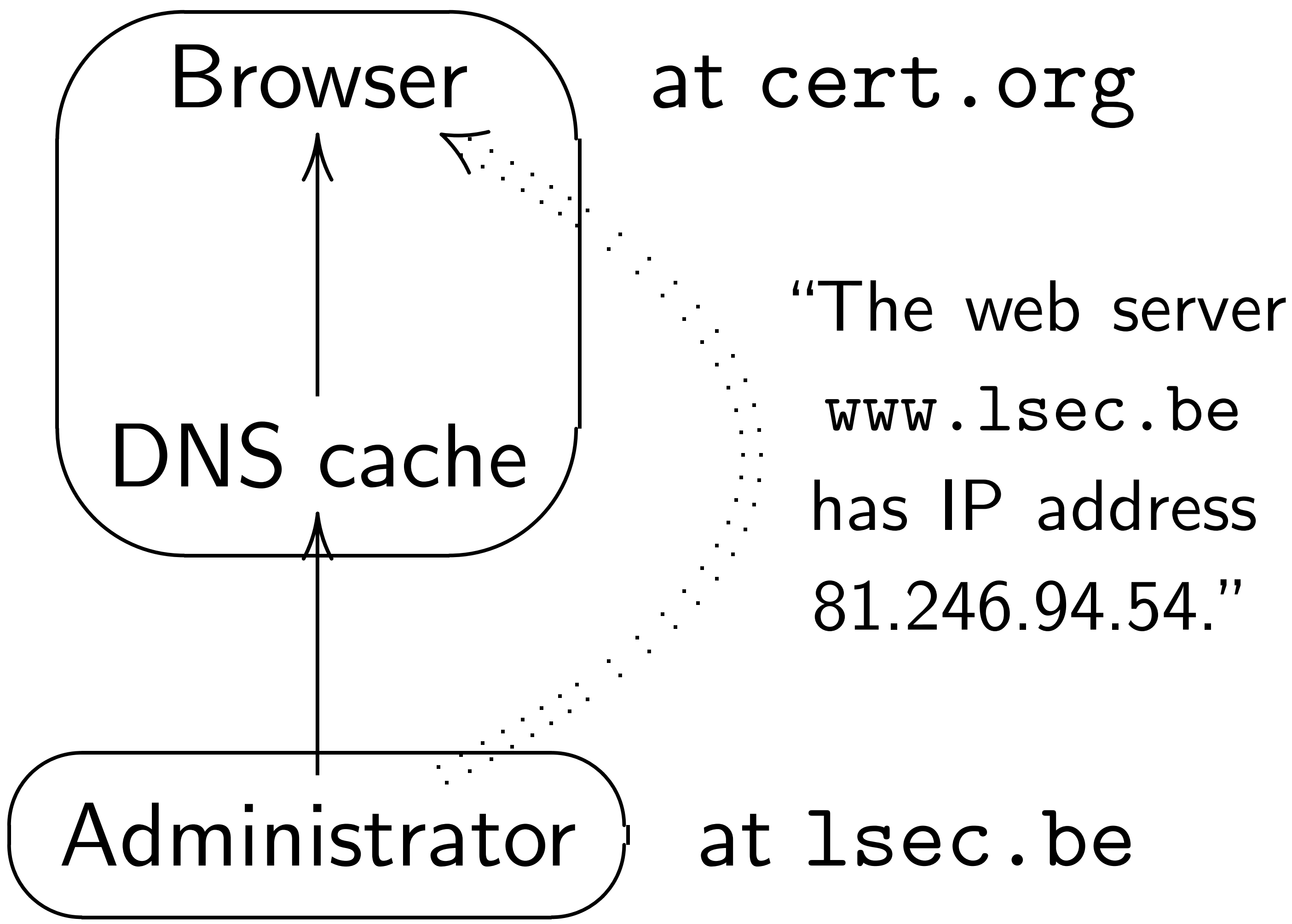

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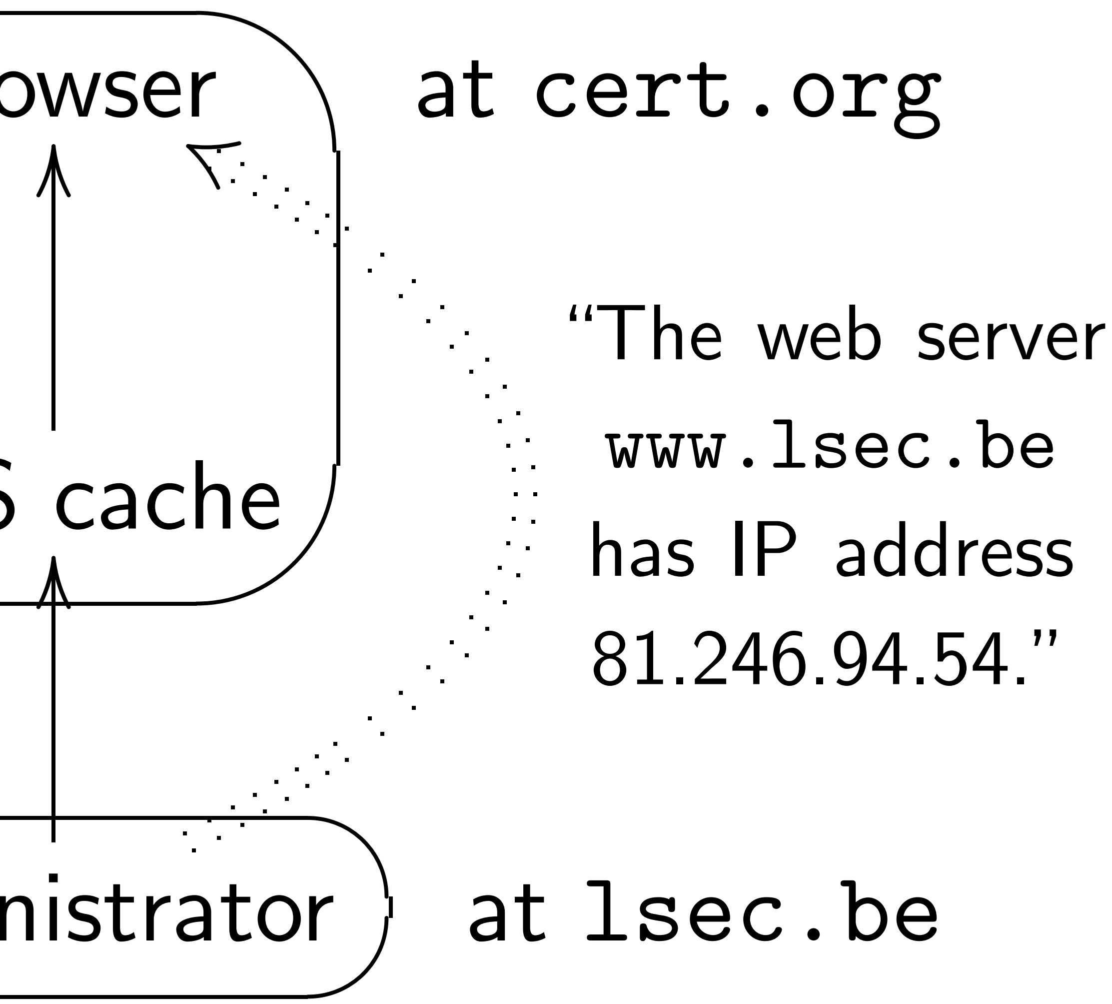

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Cache's DNS query packet
contains a 16-bit ID.

RFC 1035 (1987): "This identifier is copied [to the] reply and can be used by the requester to match up replies to outstanding queries."

Traditional ID sequence:
1, 2, 3, 4, 5, etc.

Cache discards any reply
that has the wrong ID.

"How does the attacker
guess the right ID?"

Attacker sets up
`supersecurityt`
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from `www.lsec.`

Attacker provides
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Victim asks brow
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Attacker sees cache’s ID for supersecuritytools.to DNS query. Attacker then predicts ID for lsec.be query.

“ID 47603: SST.to?”

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“http://SST.to”

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“`ID 47603: SST.to?`”

Cache → Attacker

Cache ← Attacker

“`ID 47603: SST.to 157.22.245.20`
`(and please don't cache this)`”

“`http://SST.to`”

Browser → Attacker

Browser ← Attacker

“`... lsec.be ...`”

Cache ← Attacker

“ID 47604: `lsec.be 157.22.245.20`”

Cache ← Attacker

“ID 47604: `lsec.be 157.22.245.20`”

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“`ID 47603: SST.to?`”

Cache $\xrightarrow{\hspace{3em}}$ Attacker
Cache $\xleftarrow{\hspace{3em}}$ Attacker

“`ID 47603: SST.to 157.22.245.20`
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“`http://SST.to`”

Browser $\xrightarrow{\hspace{3em}}$ Attacker
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“`... lsec.be ...`”

Cache $\xleftarrow{\hspace{3em}}$ Attacker
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Can use any good stream c
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“`ID 47603: SST.to?`”

Cache $\longrightarrow$ Attacker
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Output is very hard to predict: attacker has no idea what the next ID will be, even after seeing entire sequence of previous IDs.

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Client can randomize
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in `djbdns` since 1999,
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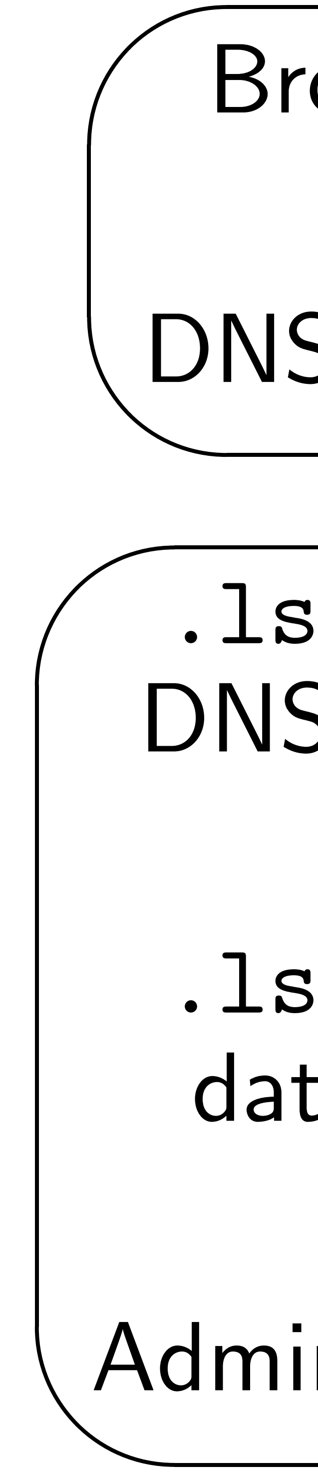

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For performance reasons, administrators sometimes set up third-party DNS servers.

e.g. The `rsa.com` administrator set up two `rsa.com` servers: one of his own computers and a third-party computer.

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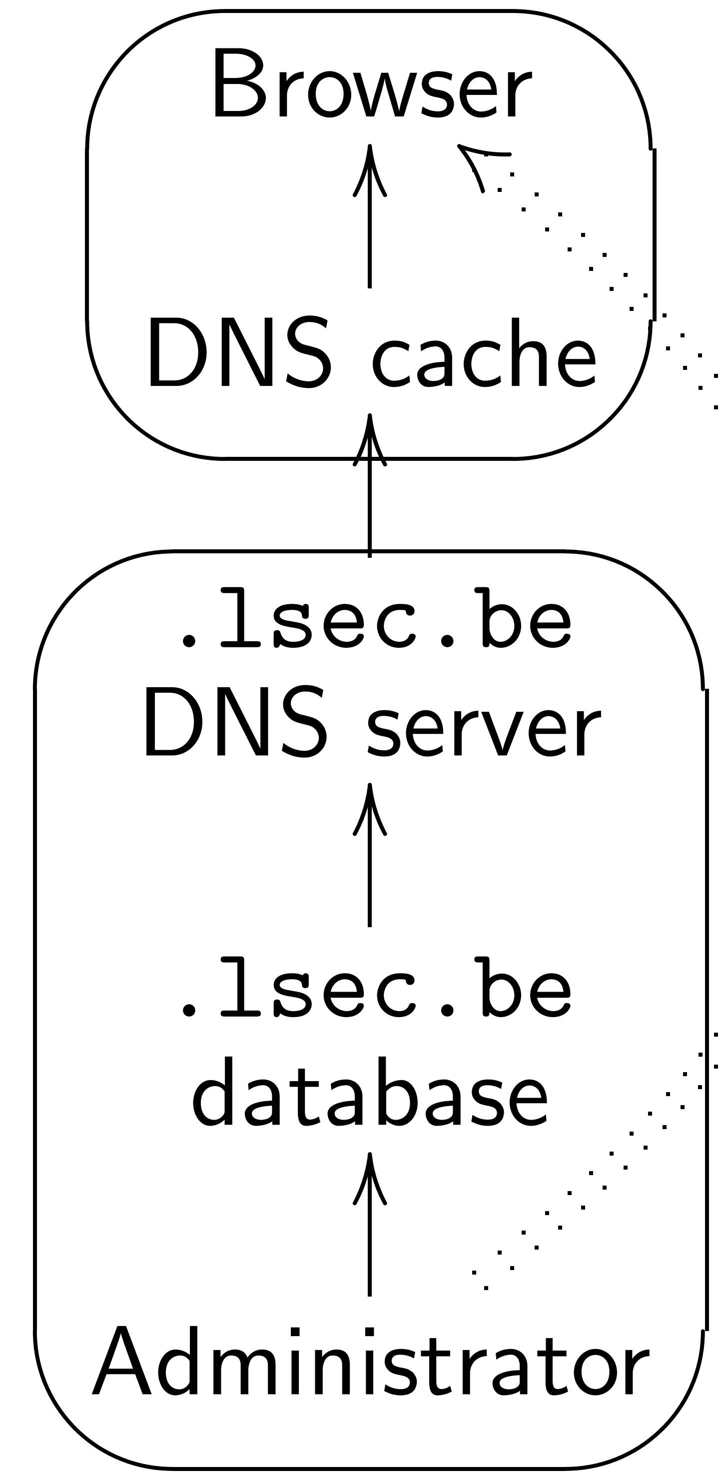

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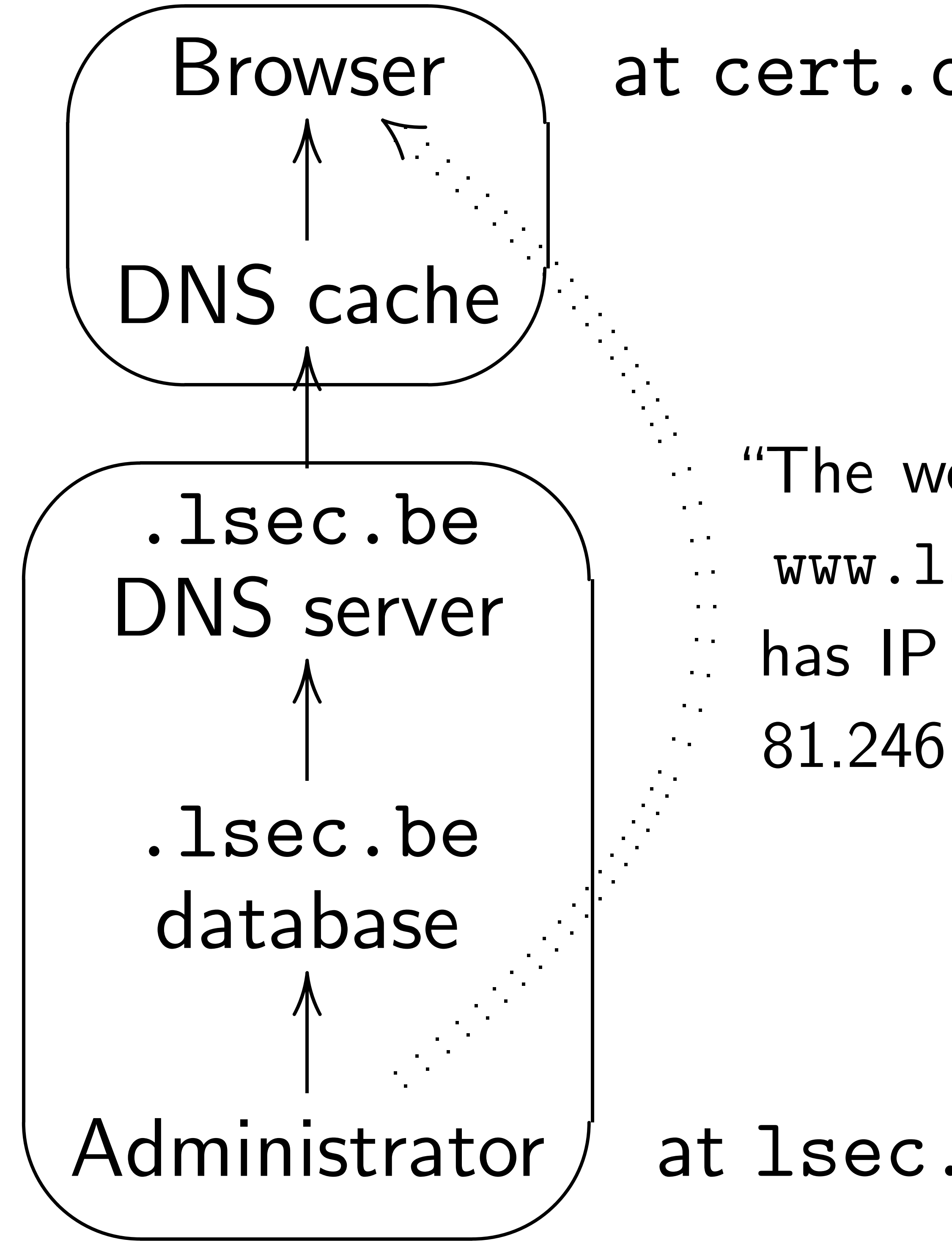

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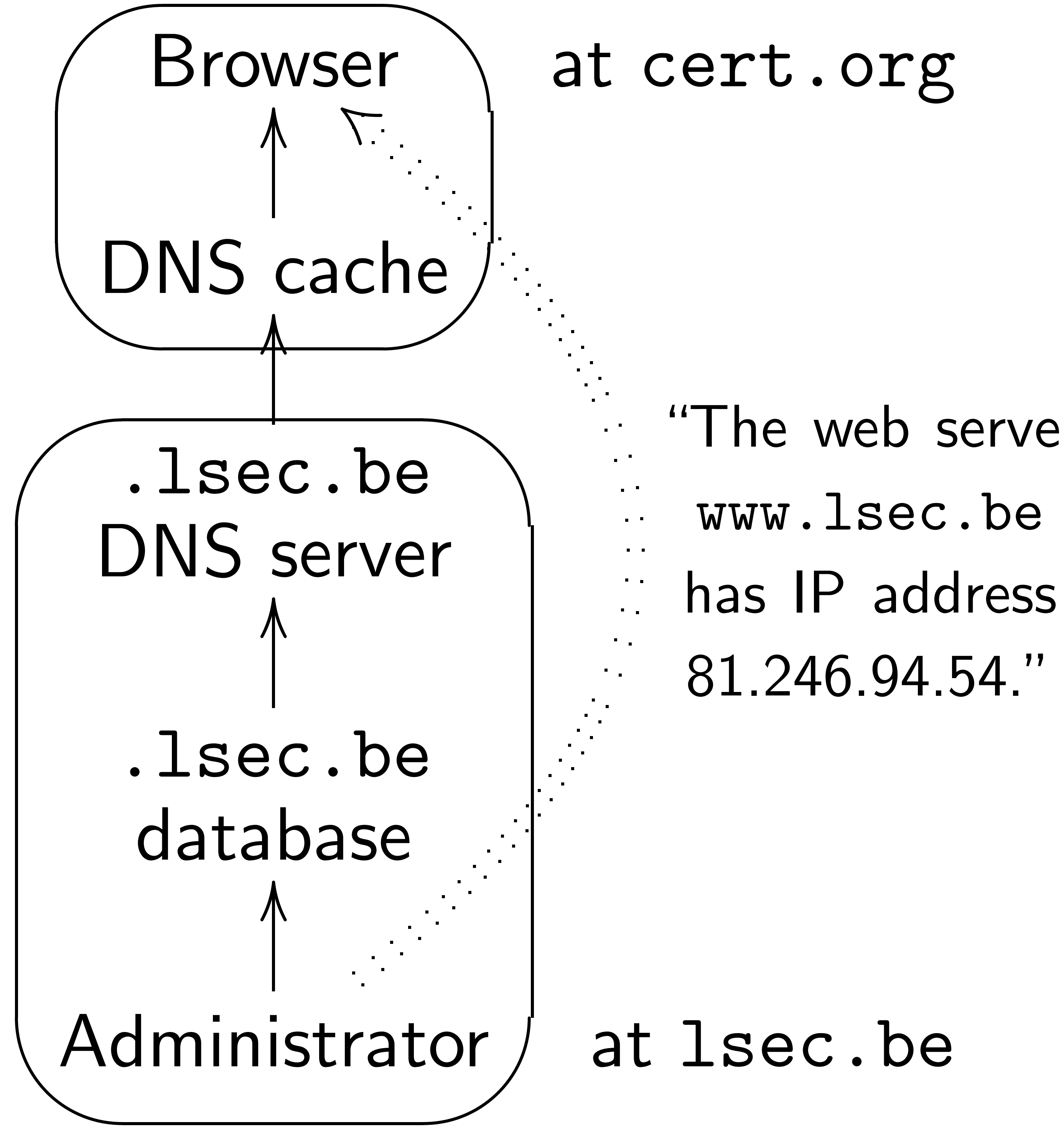

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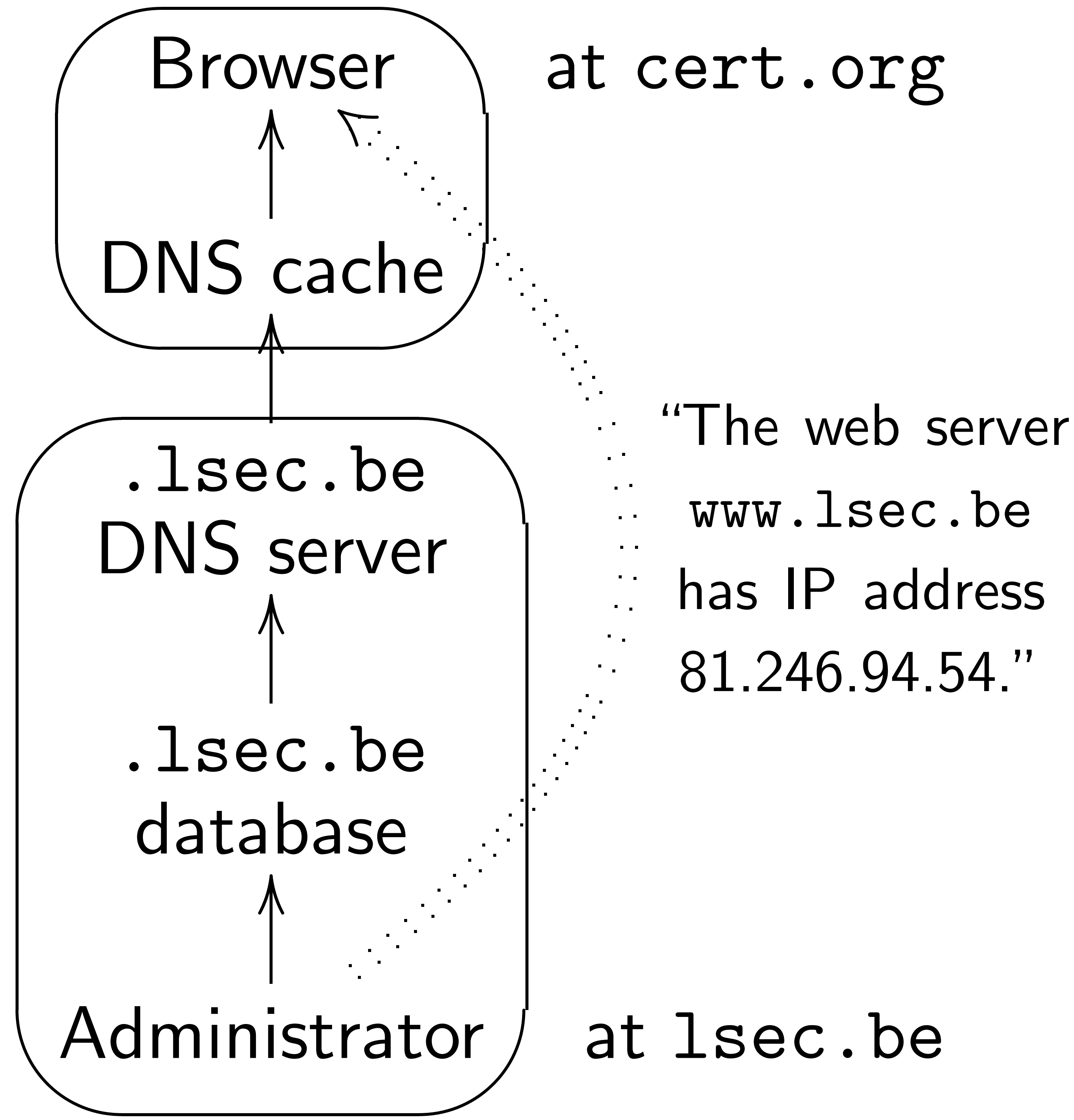

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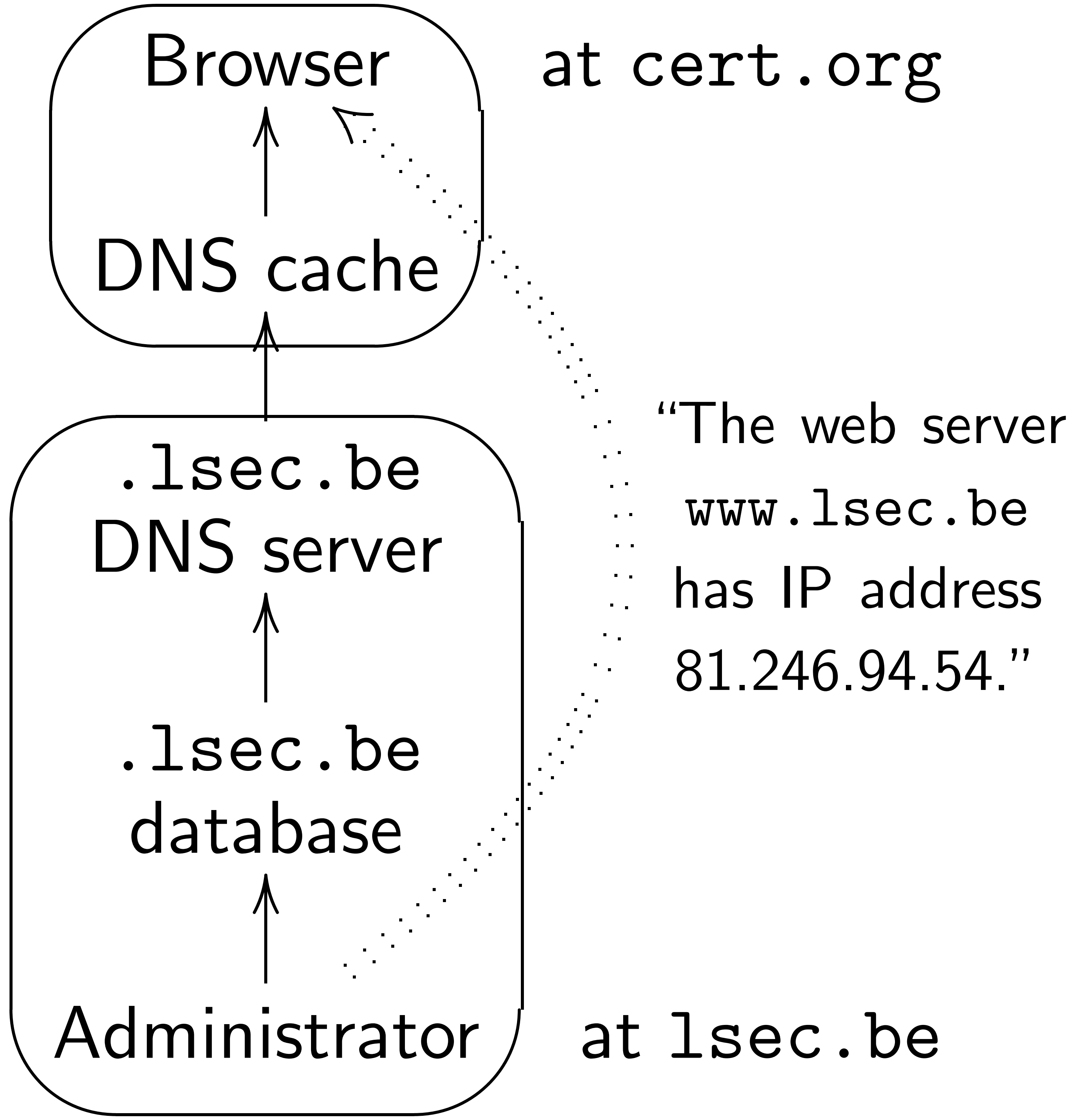

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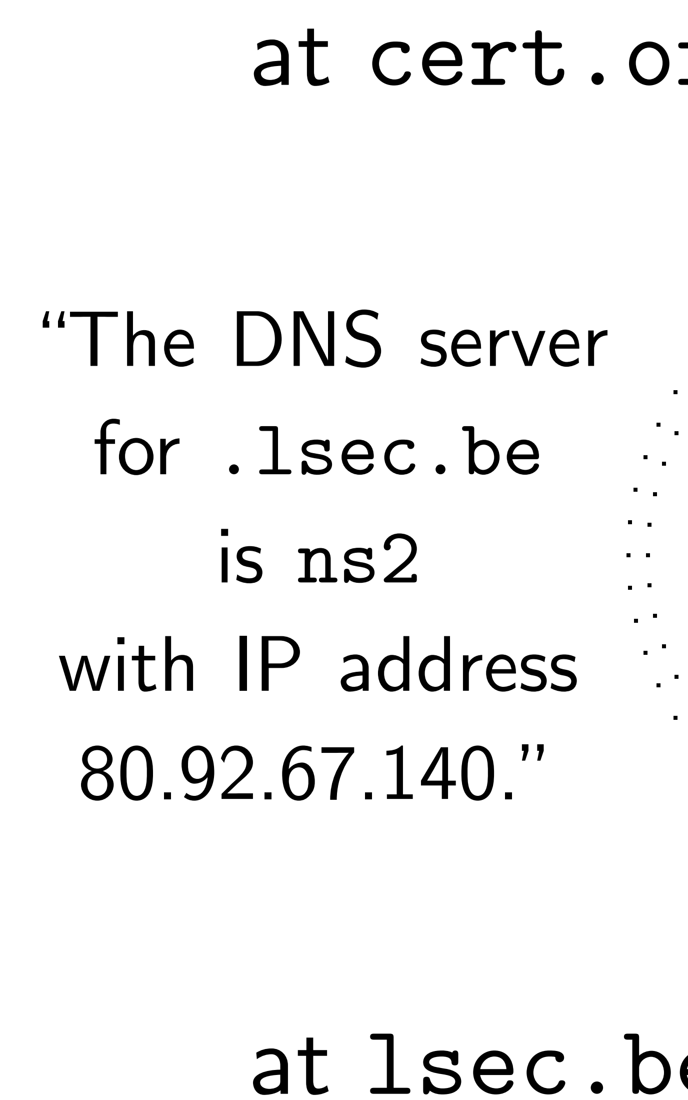

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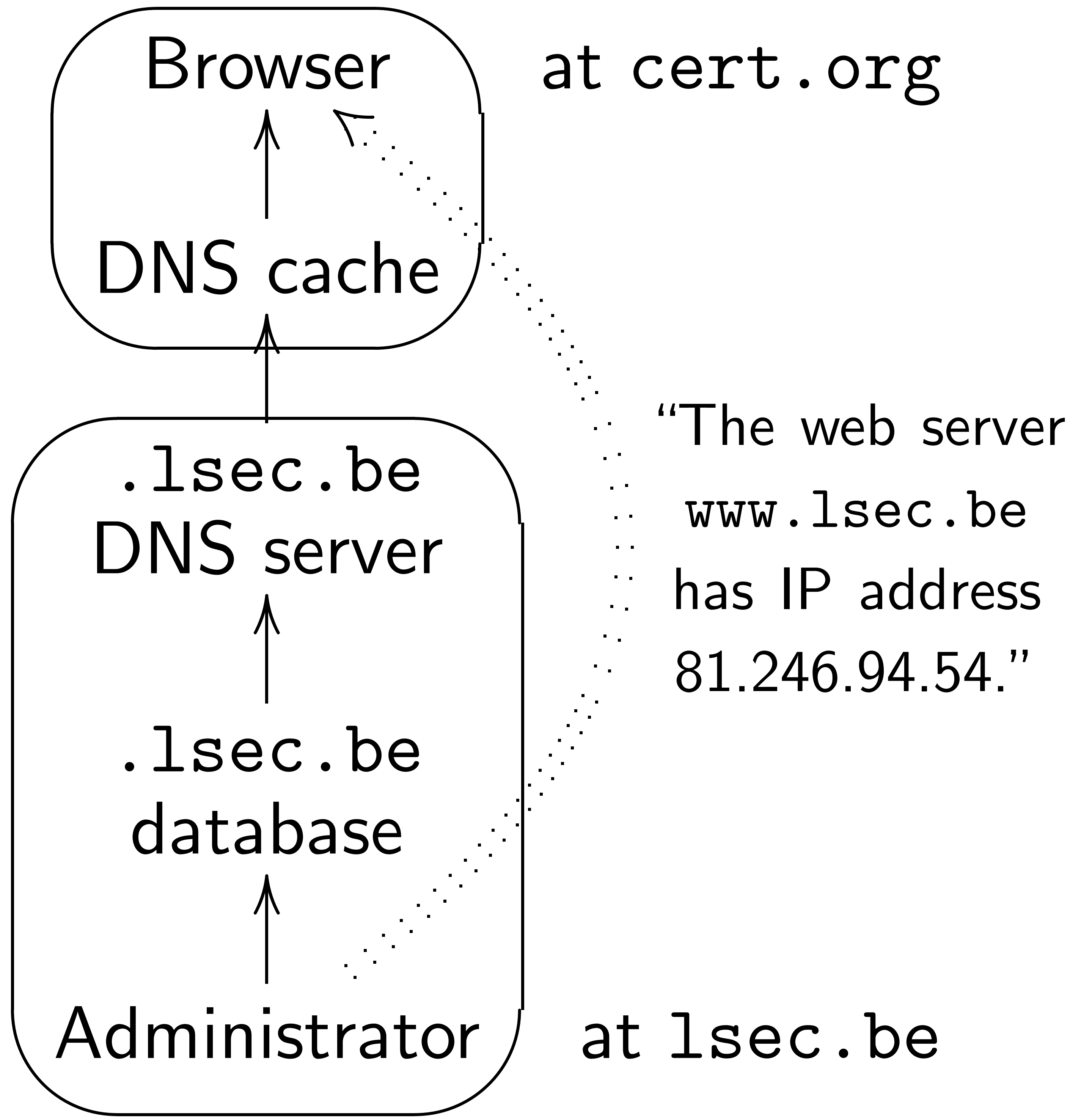

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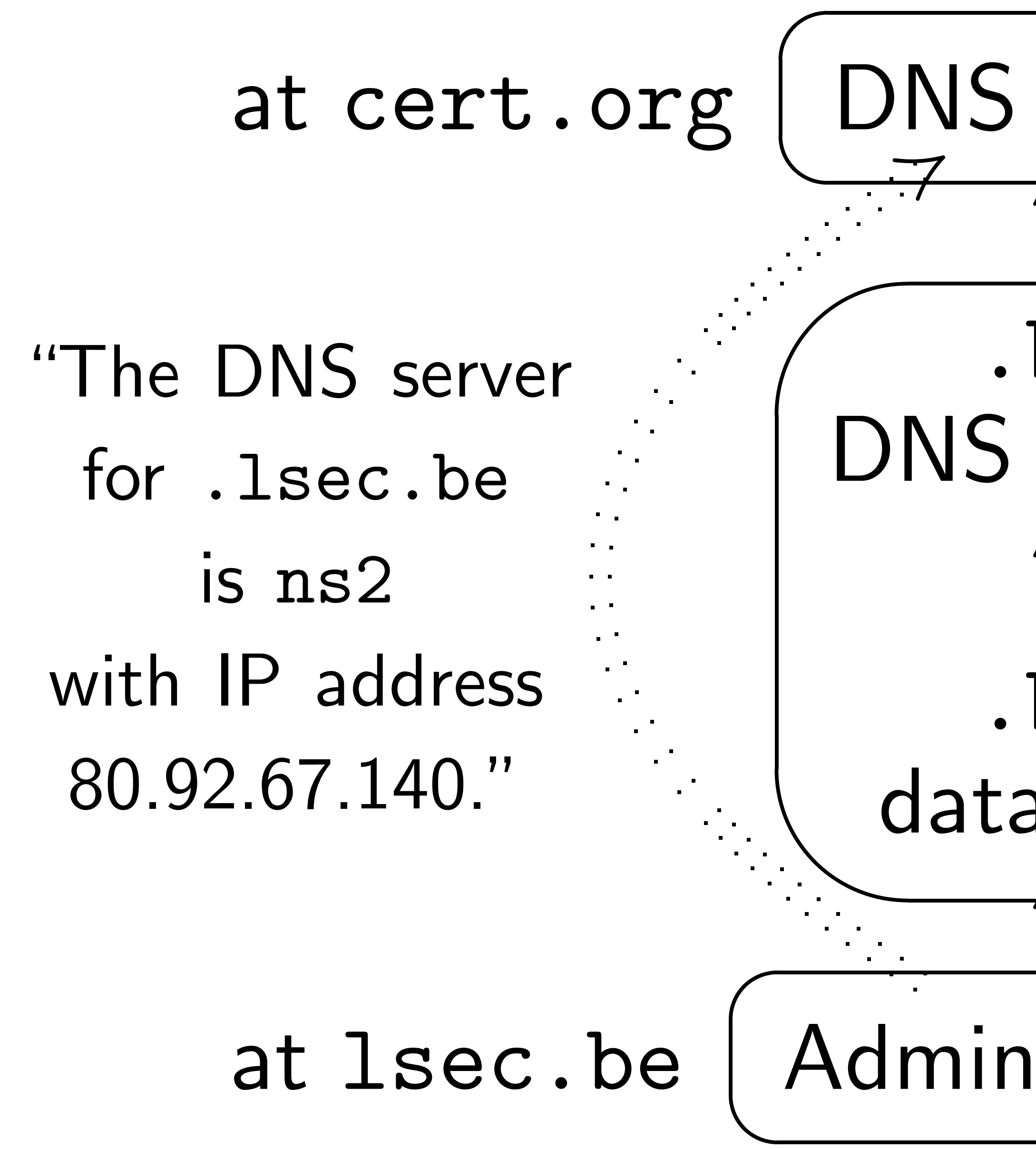
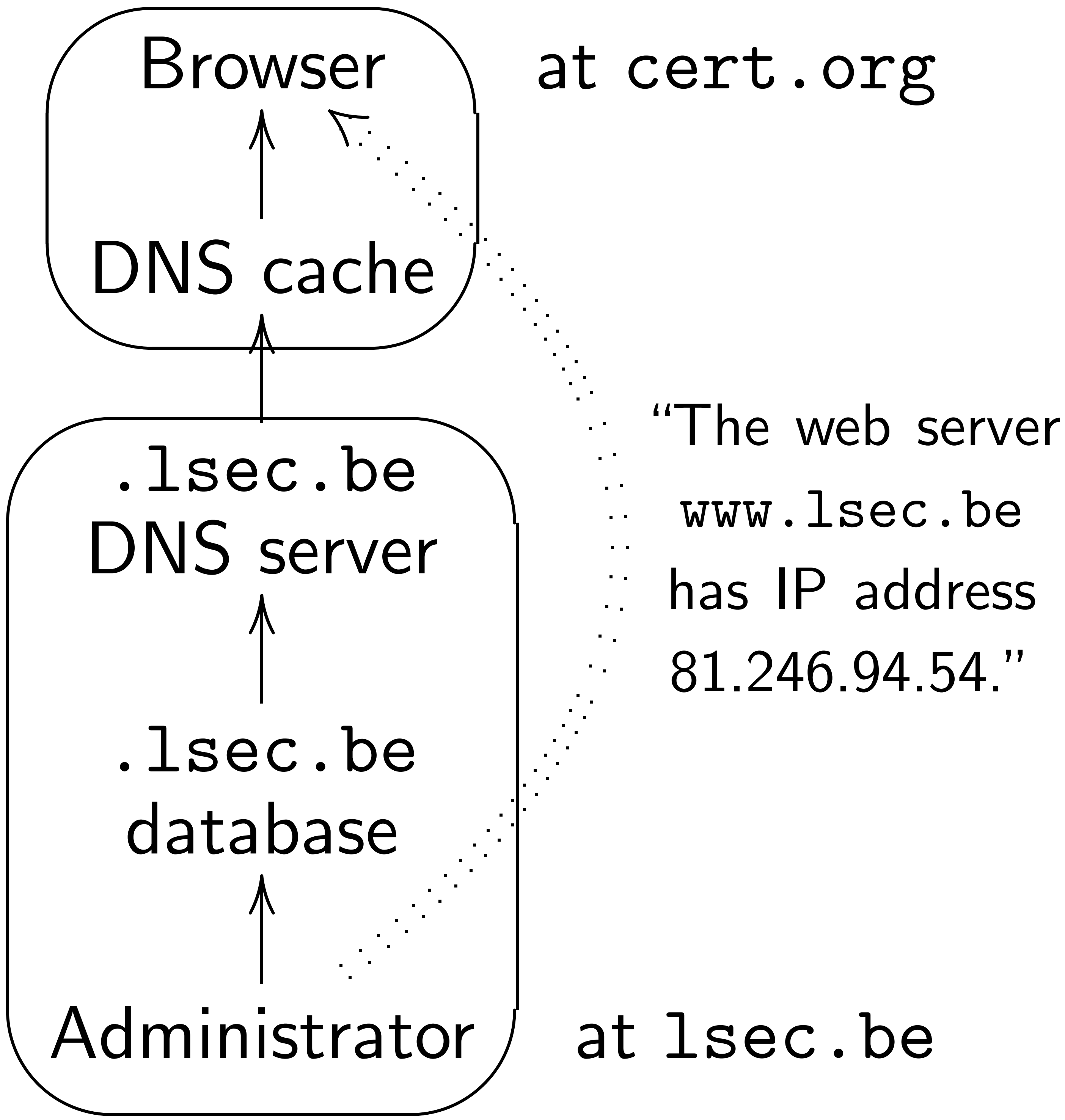
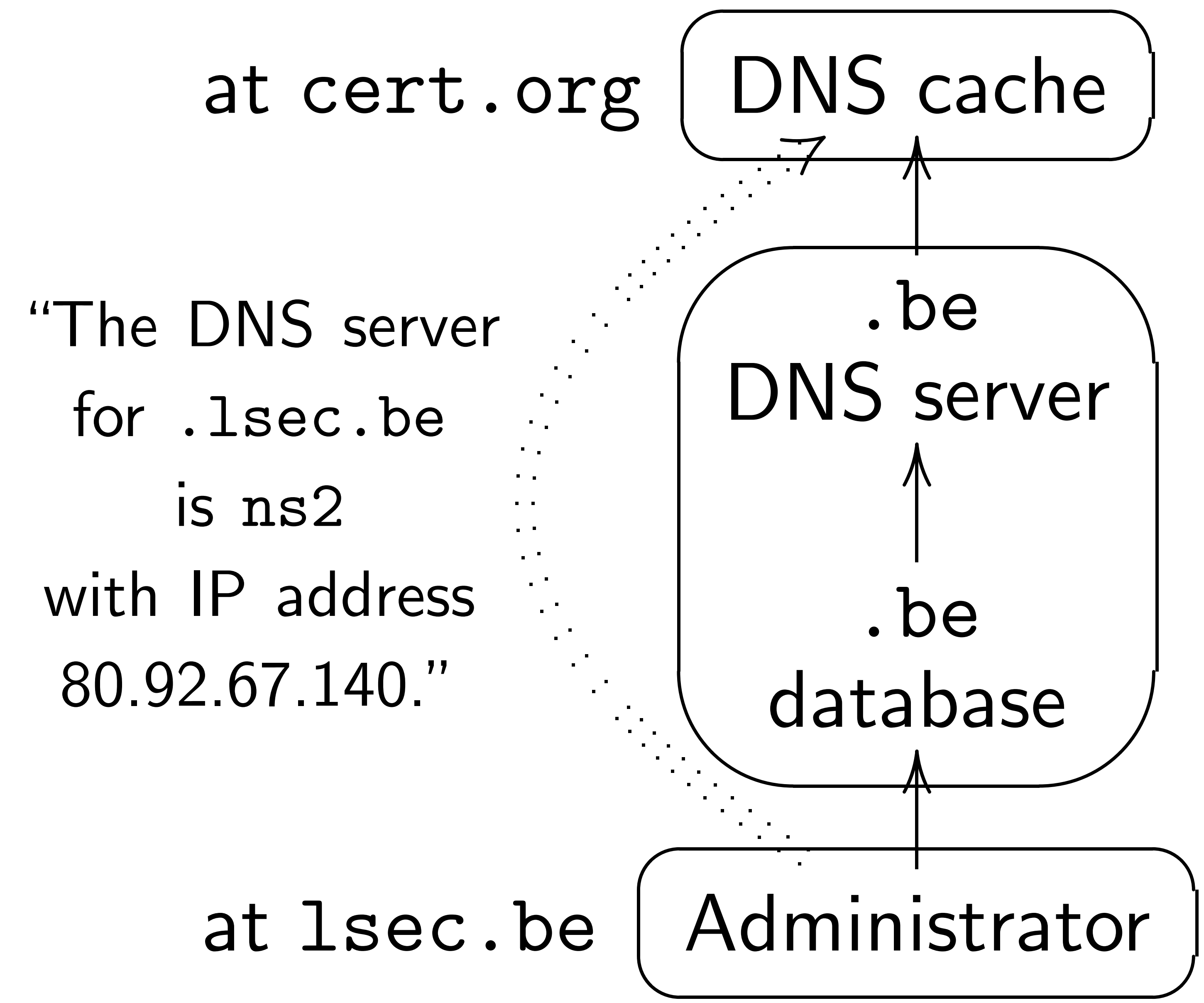
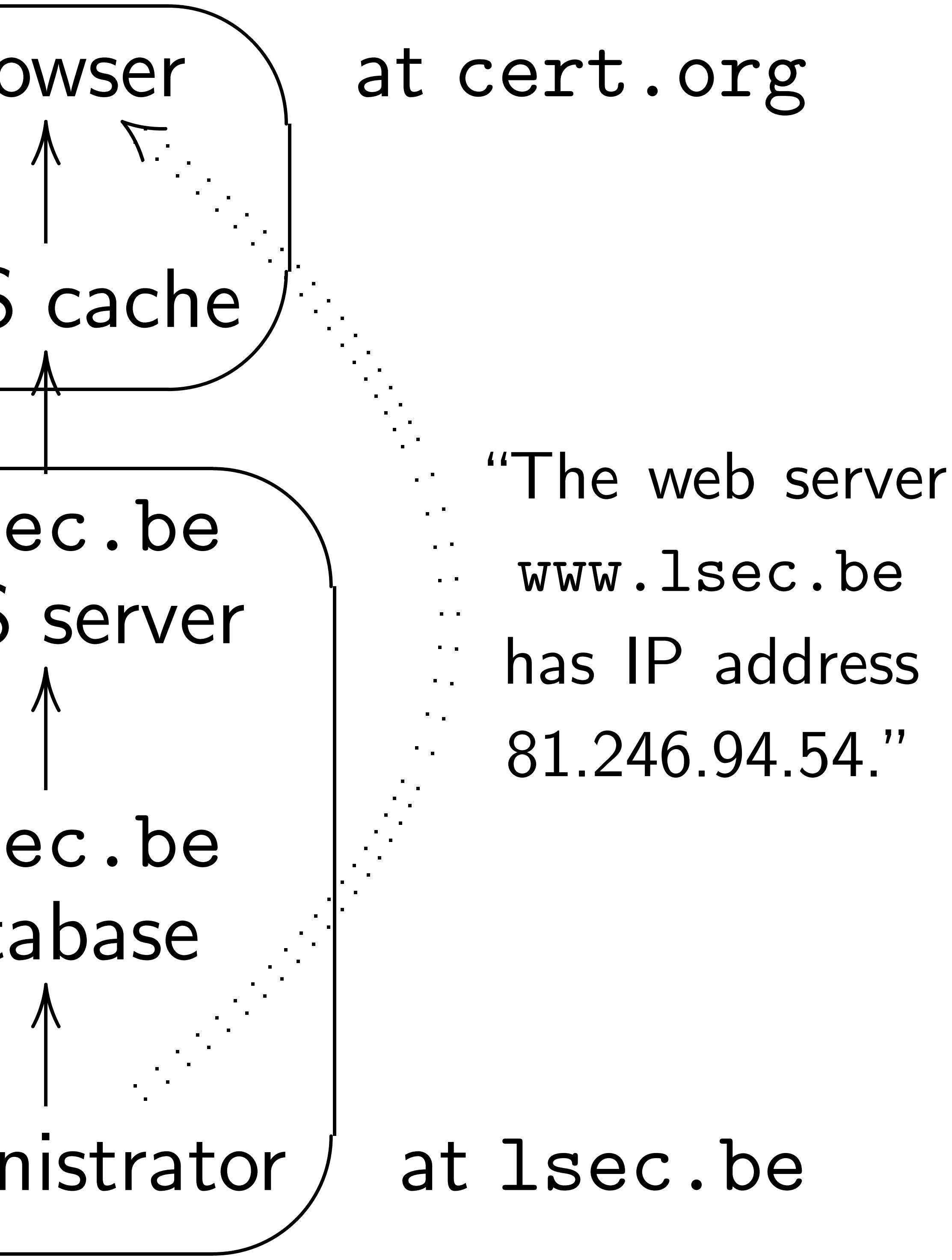




DNS cache learns location of `.lsec.be` DNS server from `.be` DNS server:





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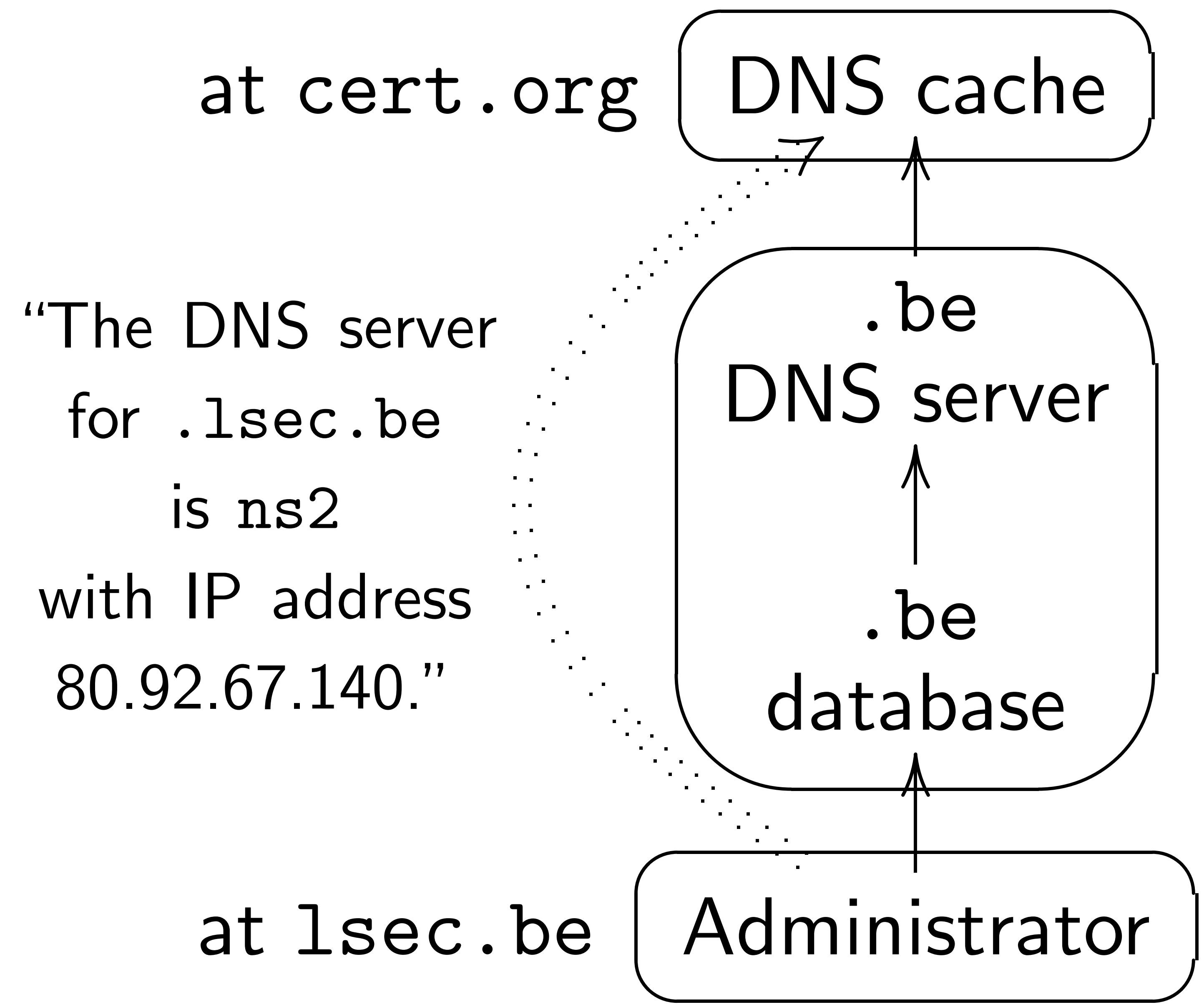

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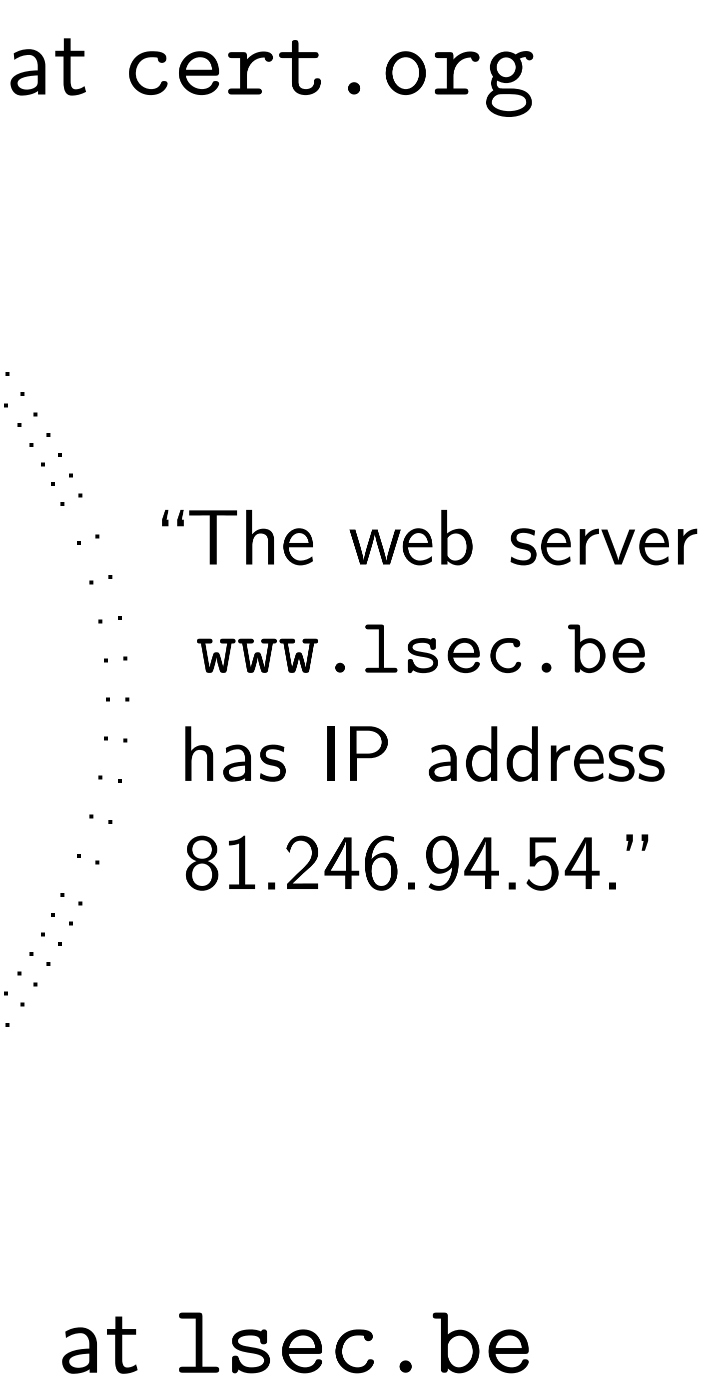

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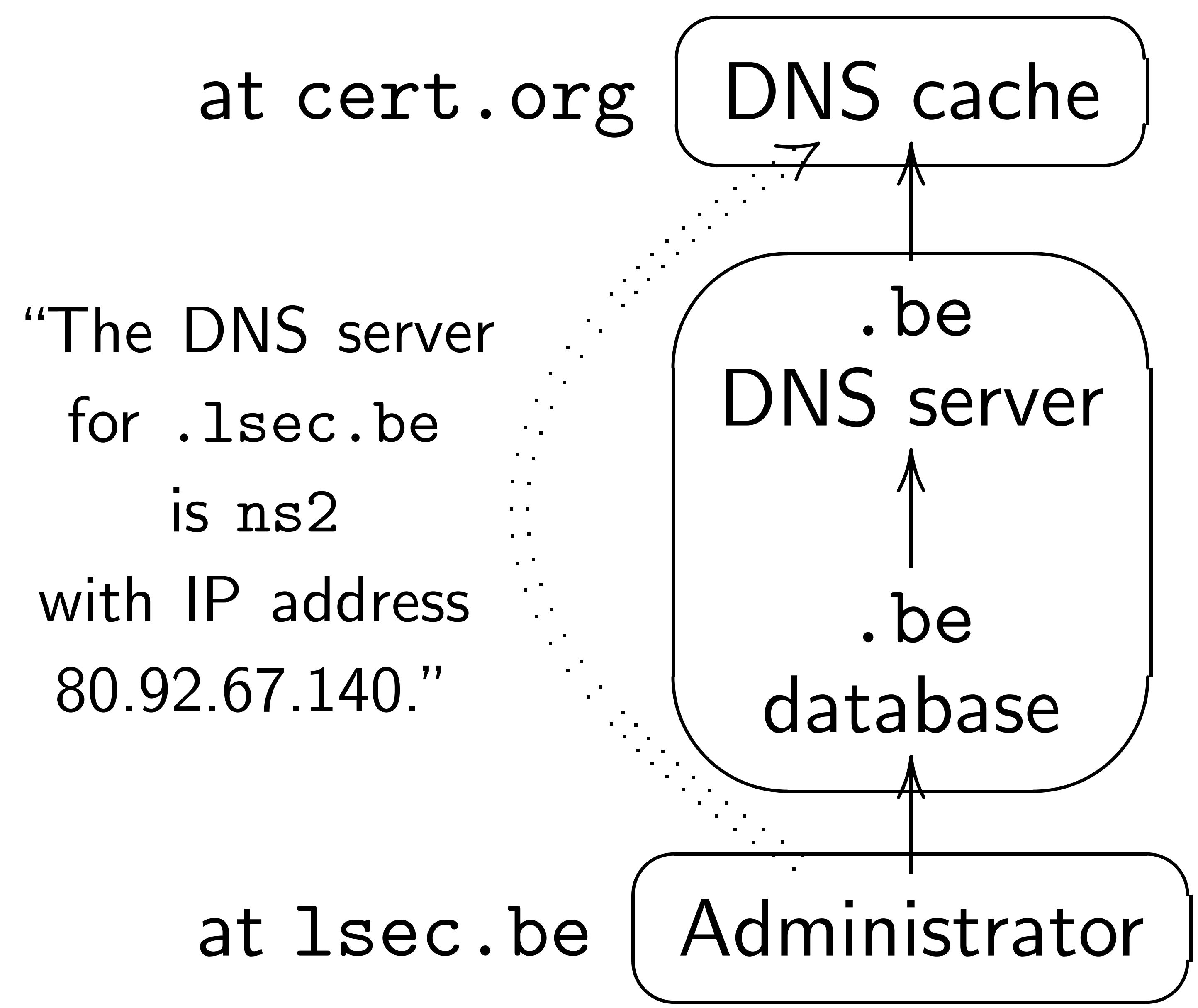

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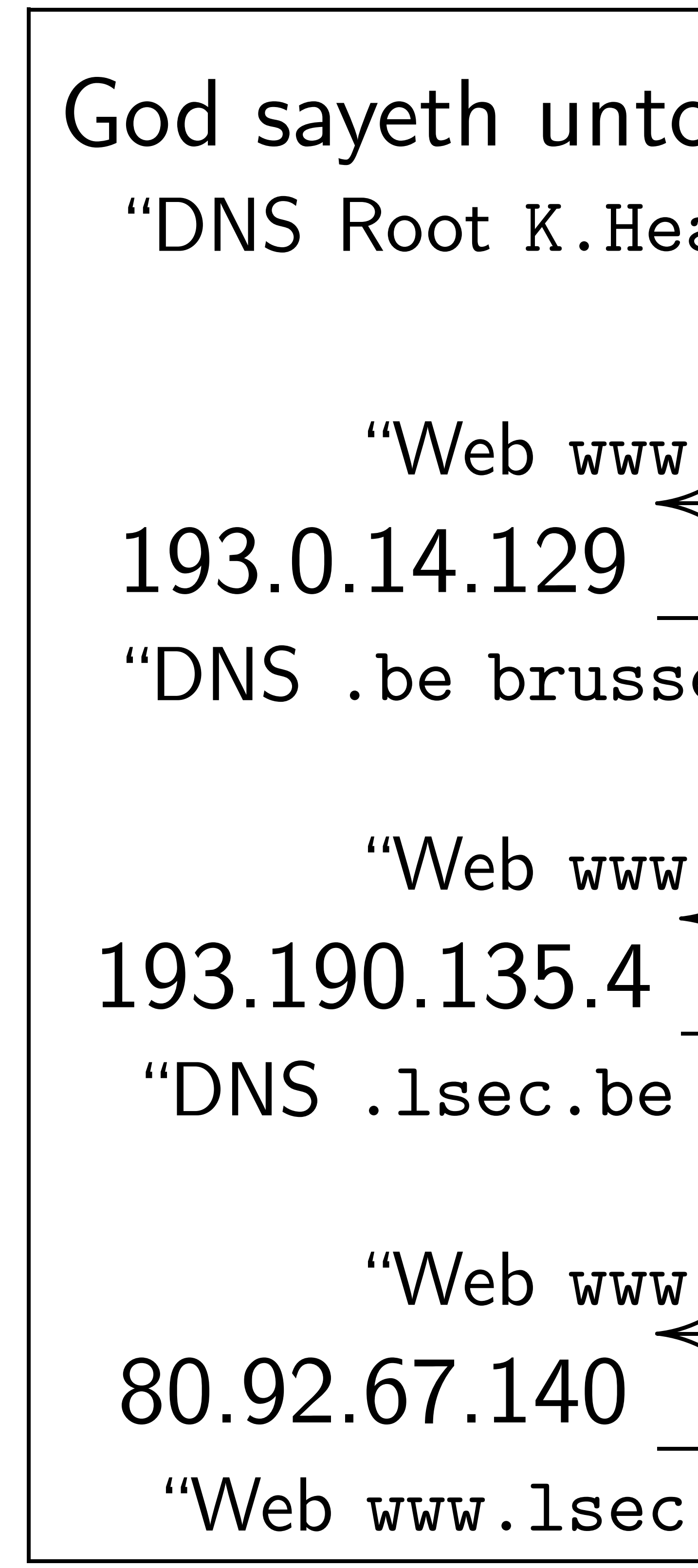

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DNS cache learns location of
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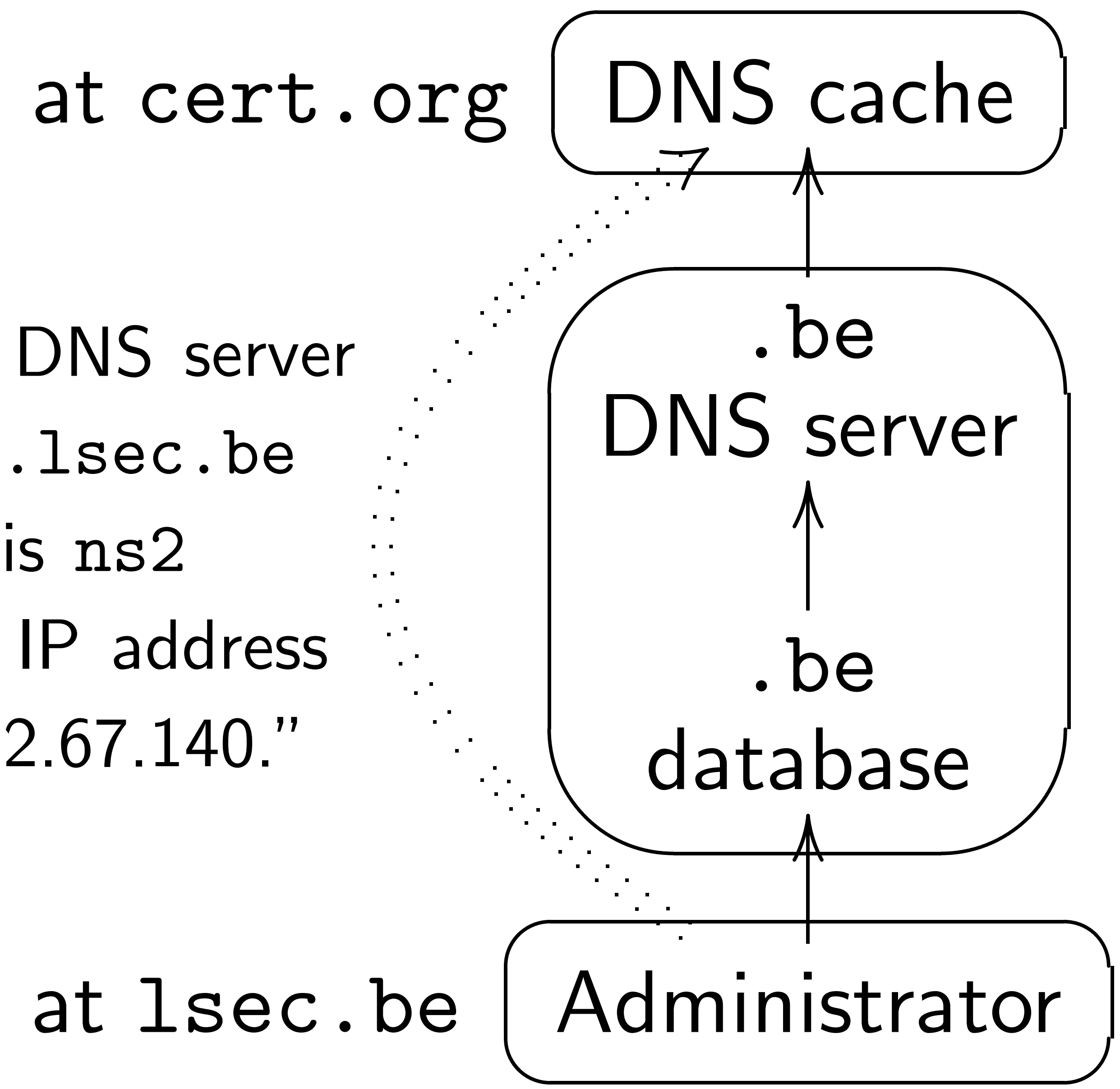


All packets to/from DNS c

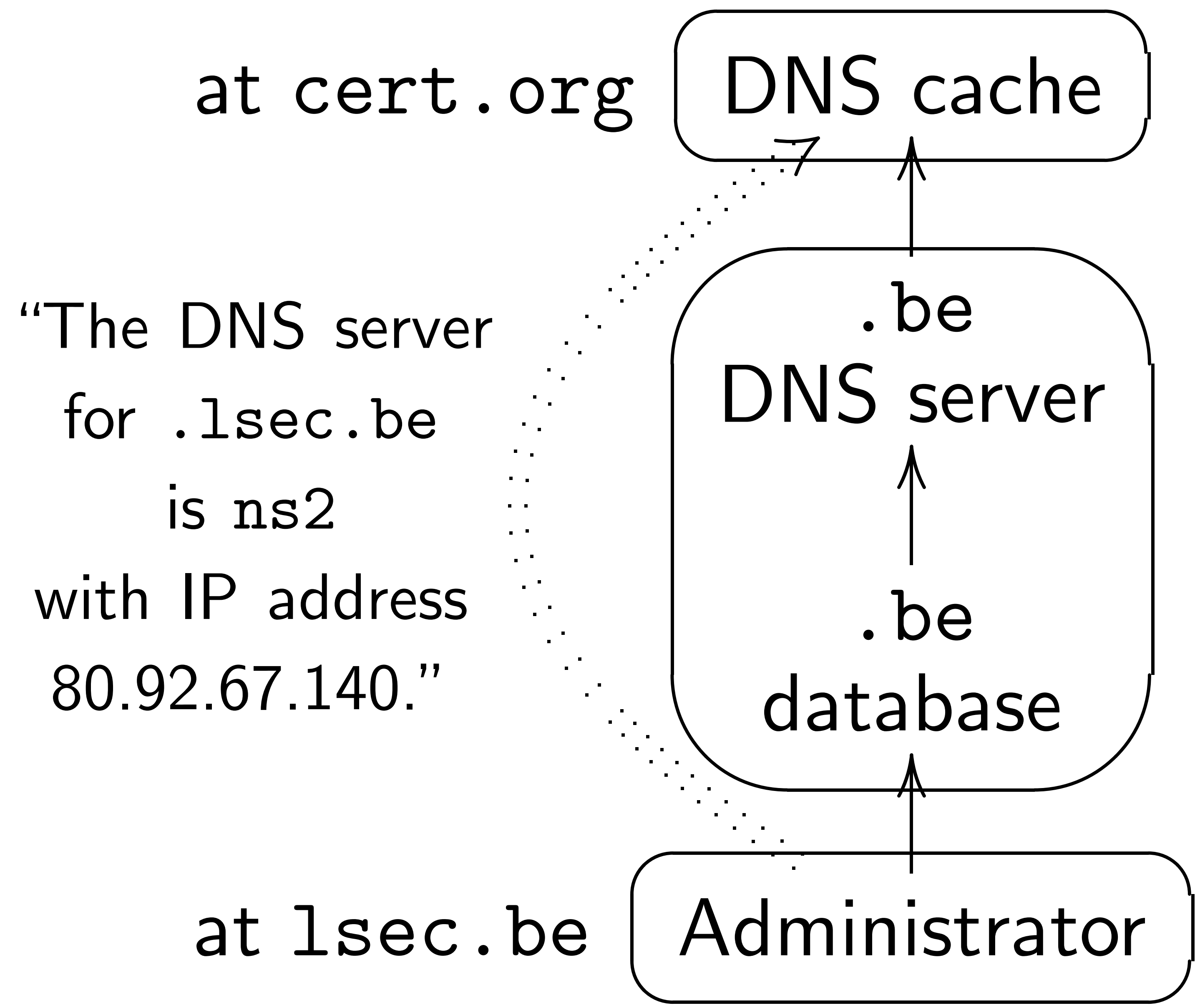
God sayeth unto the DNS
“DNS Root K.Heaven 193.0.1

“Web www.lsec.be?”
193.0.14.129 DNS c
“DNS .be brussels 193.190

“Web www.lsec.be?”
193.190.135.4 DNS c
“DNS .lsec.be ns2 80.92.6

“Web www.lsec.be?”
80.92.67.140 DNS c
“Web www.lsec.be 81.246.9

DNS cache learns location of `.lsec.be` DNS server from `.be` DNS server:



All packets to/from DNS cache:

God sayeth unto the DNS cache:
"DNS Root `K.Heaven` 193.0.14.129"

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193.0.14.129 ⟶ DNS cache
"DNS `.be brussels` 193.190.135.4"

"Web `www.lsec.be`?"
193.190.135.4 ⟵ DNS cache
193.190.135.4 ⟶ DNS cache
"DNS `.lsec.be ns2` 80.92.67.140"

"Web `www.lsec.be`?"
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ache learns location of
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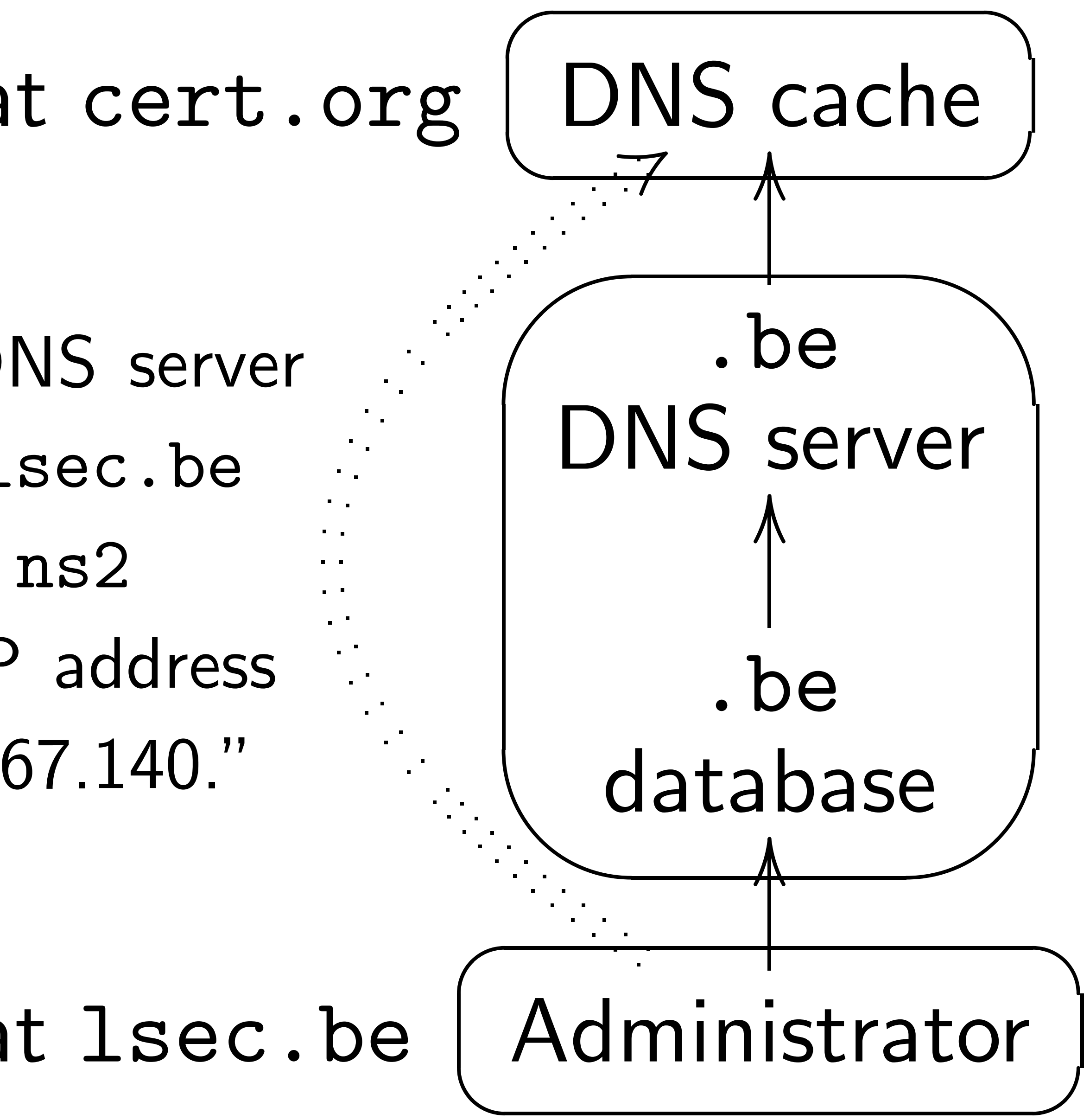

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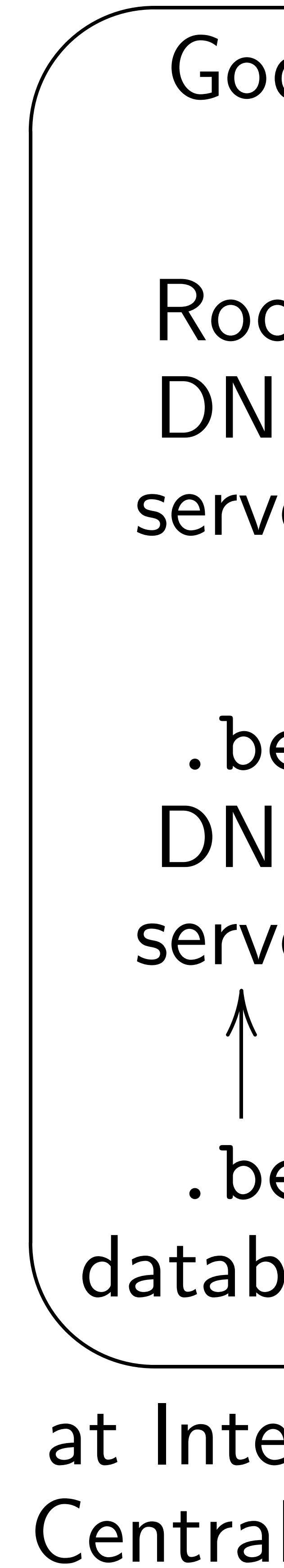

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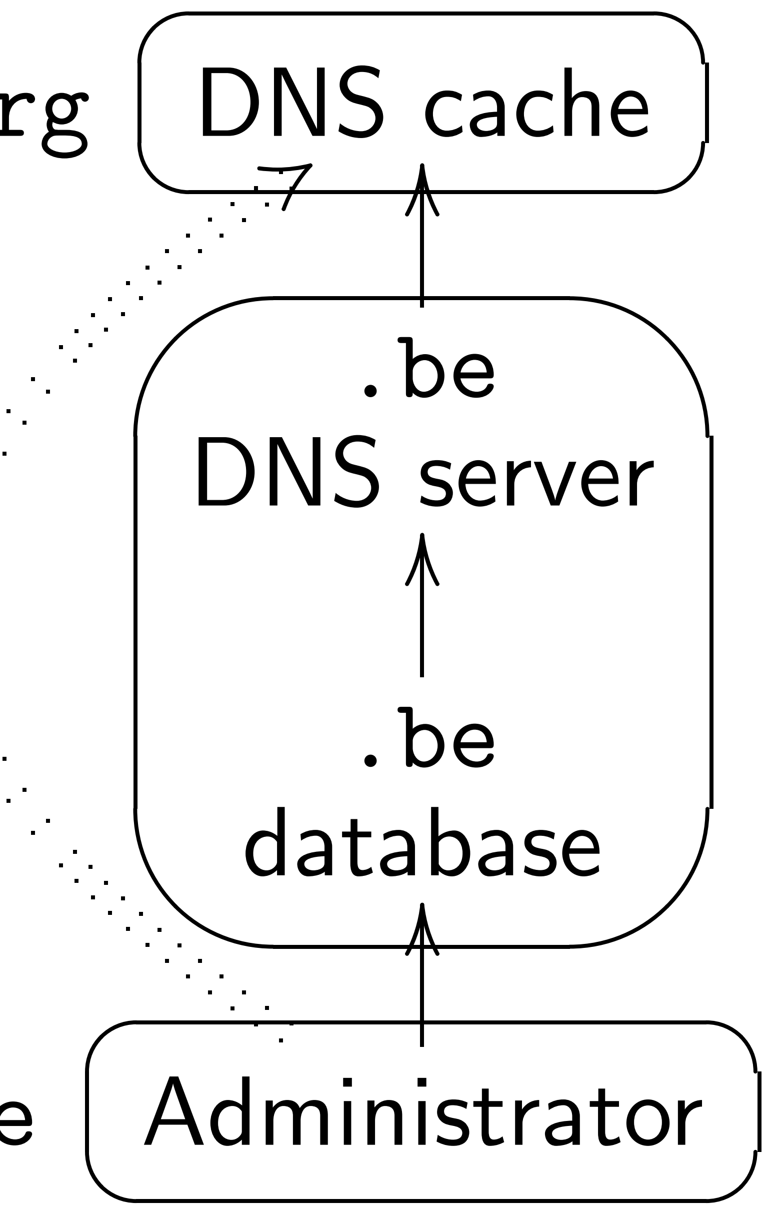

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"Web `www.lsec.be`?"
193.190.135.4 ← → DNS cache
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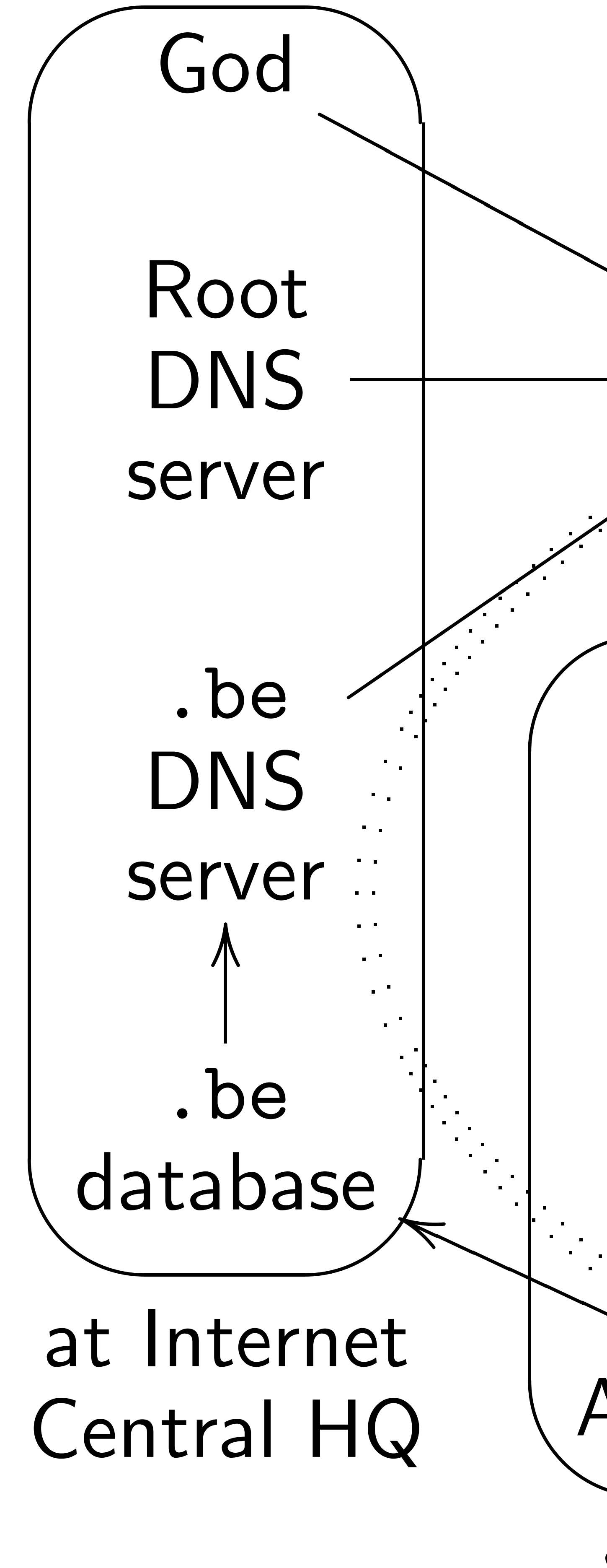
"Web `www.lsec.be`?"
80.92.67.140 ← → DNS cache
"Web `www.lsec.be` 81.246.94.54"



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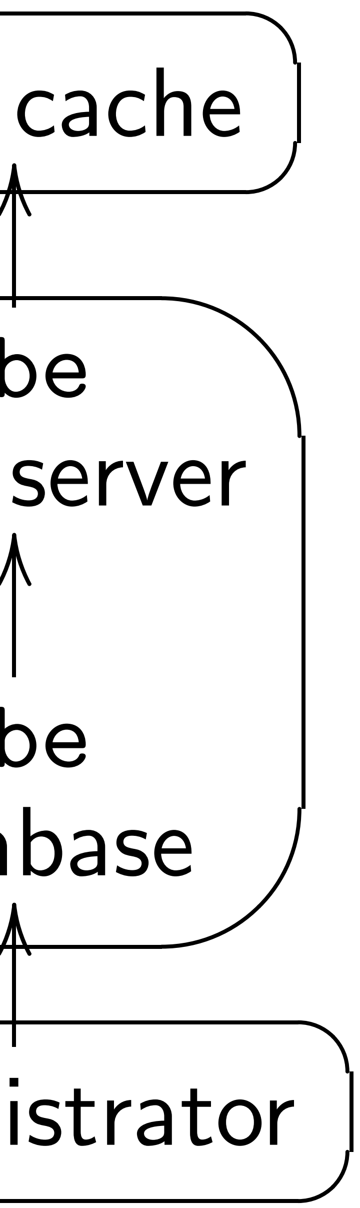

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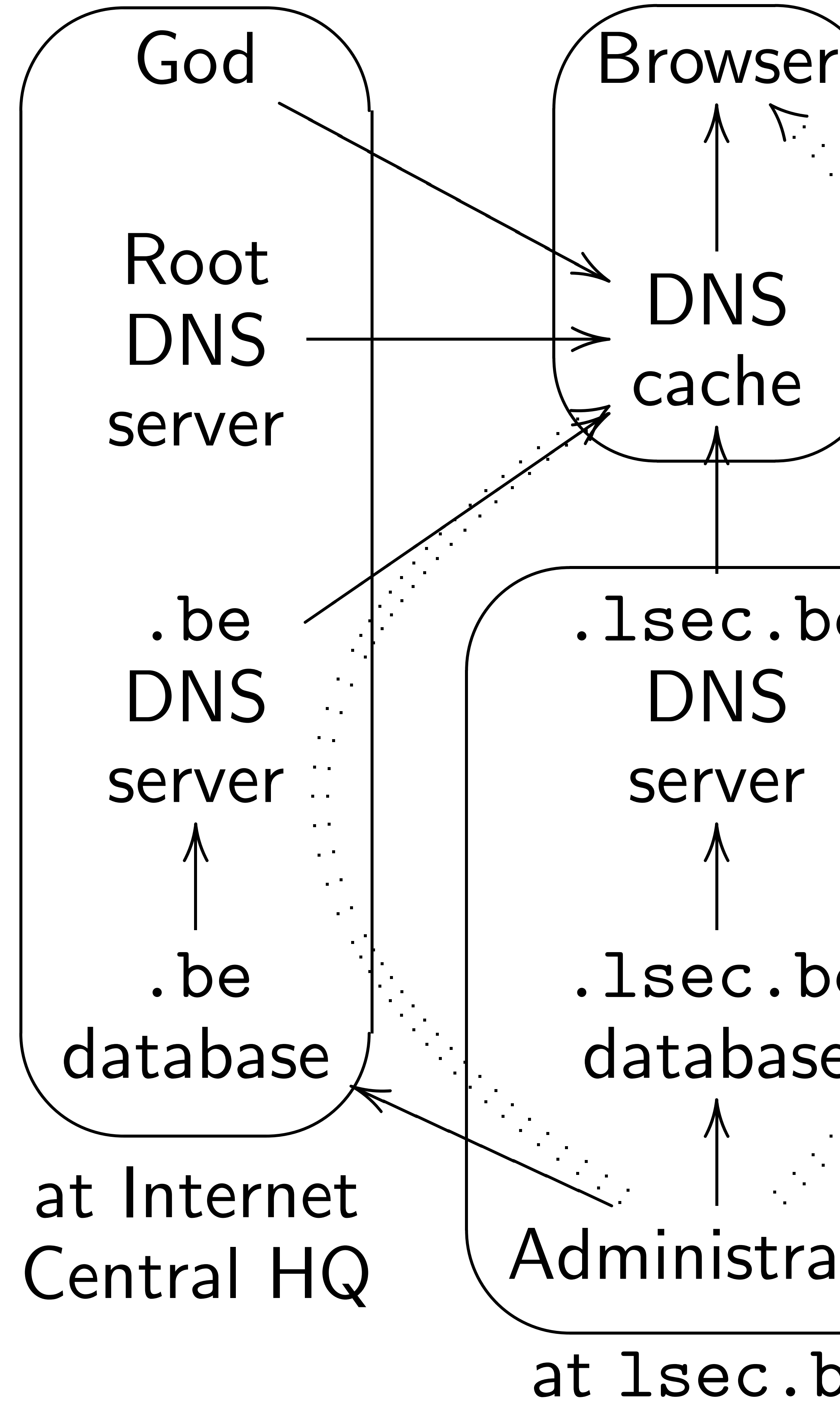

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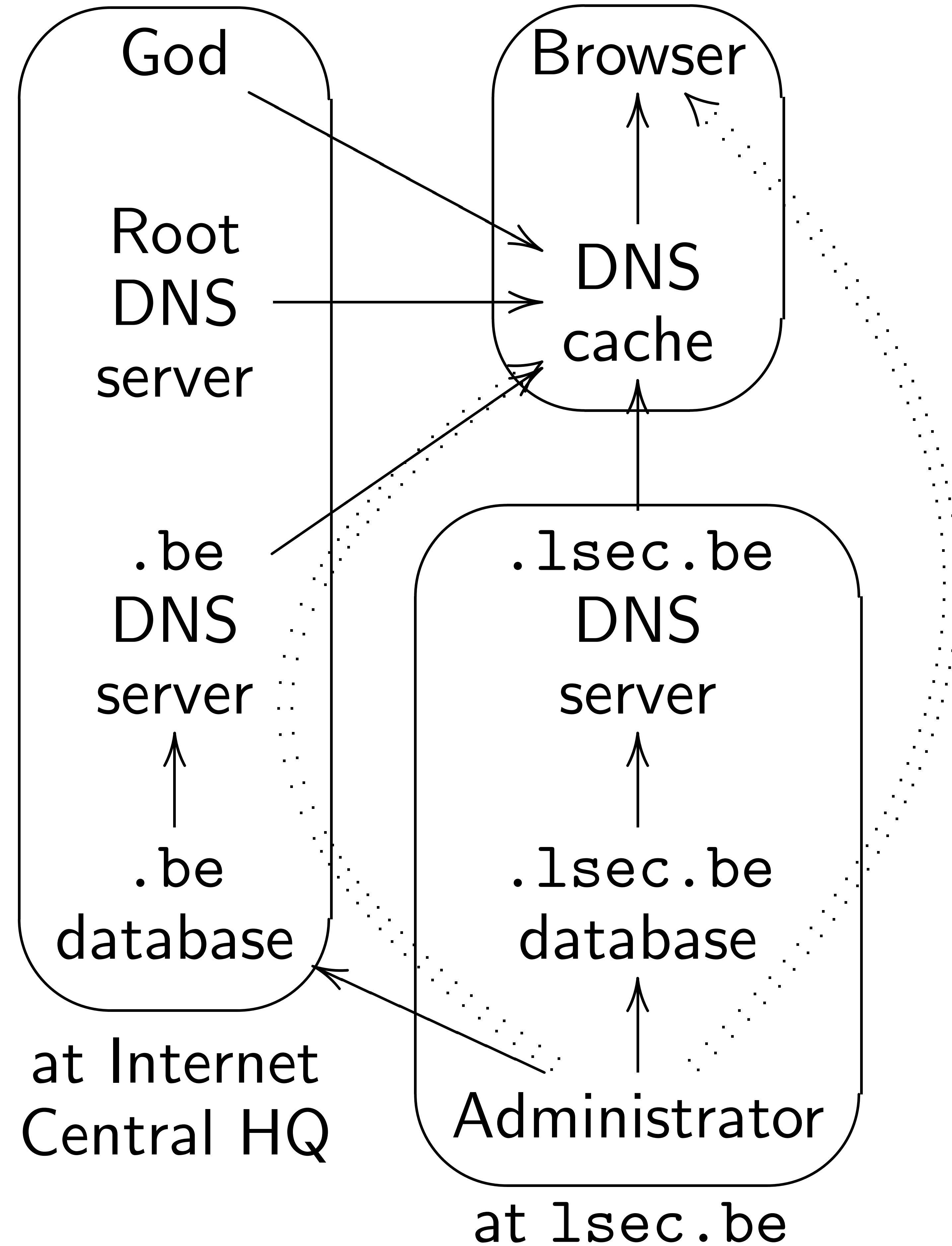

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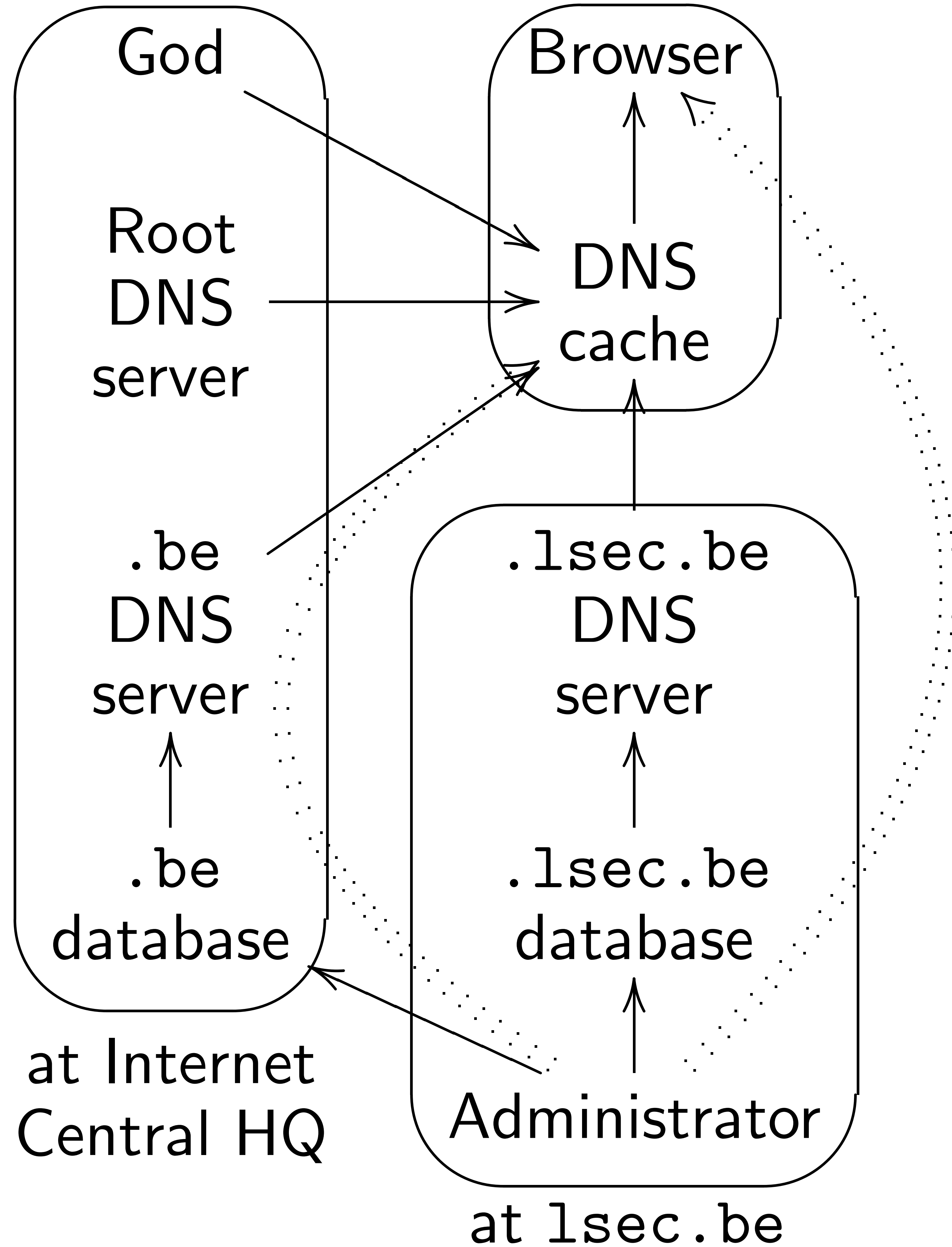
“Web `www.lsec.be`?”
.90.135.4 $\longleftarrow$ $\longrightarrow$ DNS cache
S `.lsec.be ns2` 80.92.67.140”

“Web `www.lsec.be`?”
2.67.140 $\longleftarrow$ $\longrightarrow$ DNS cache
b `www.lsec.be` 81.246.94.54”



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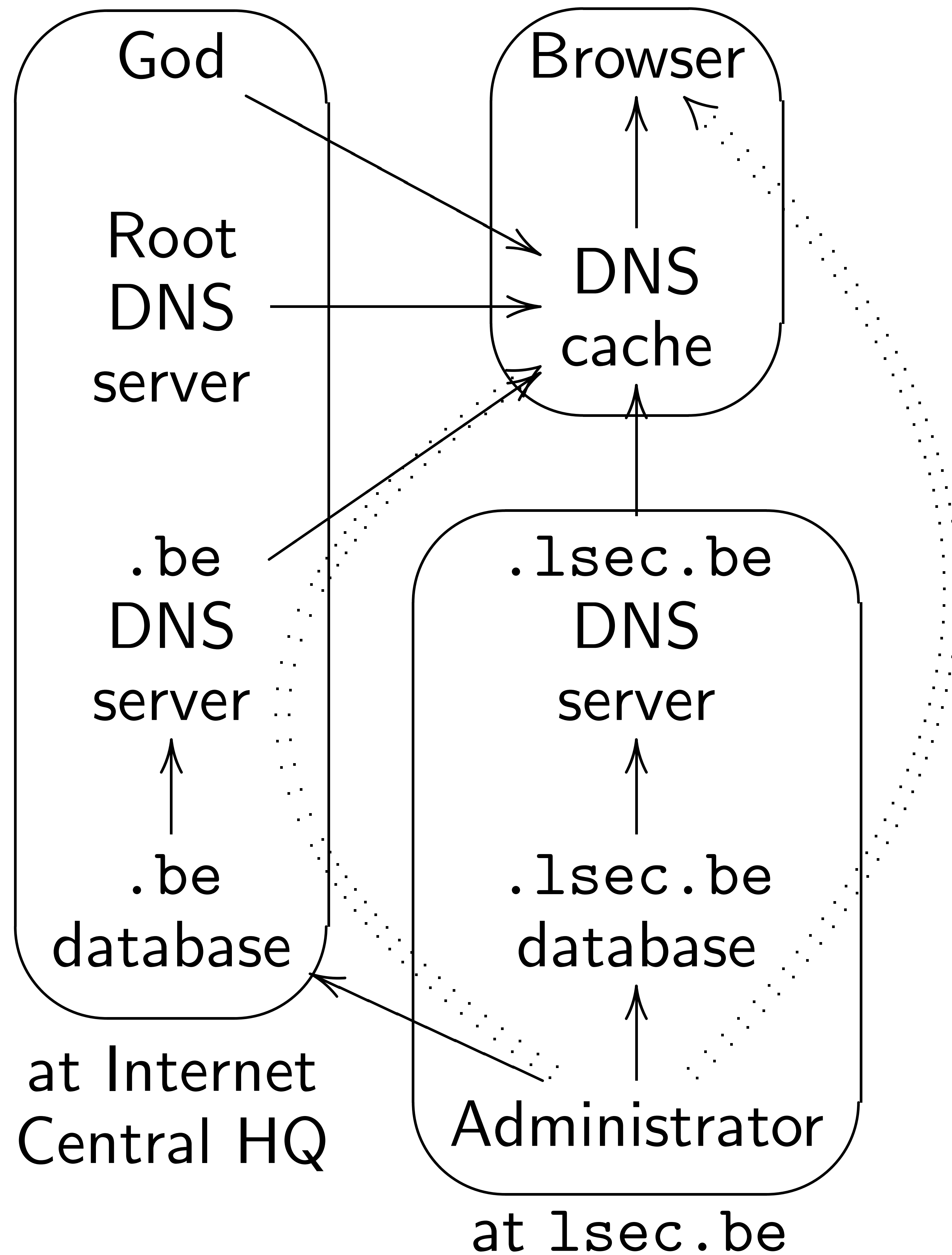

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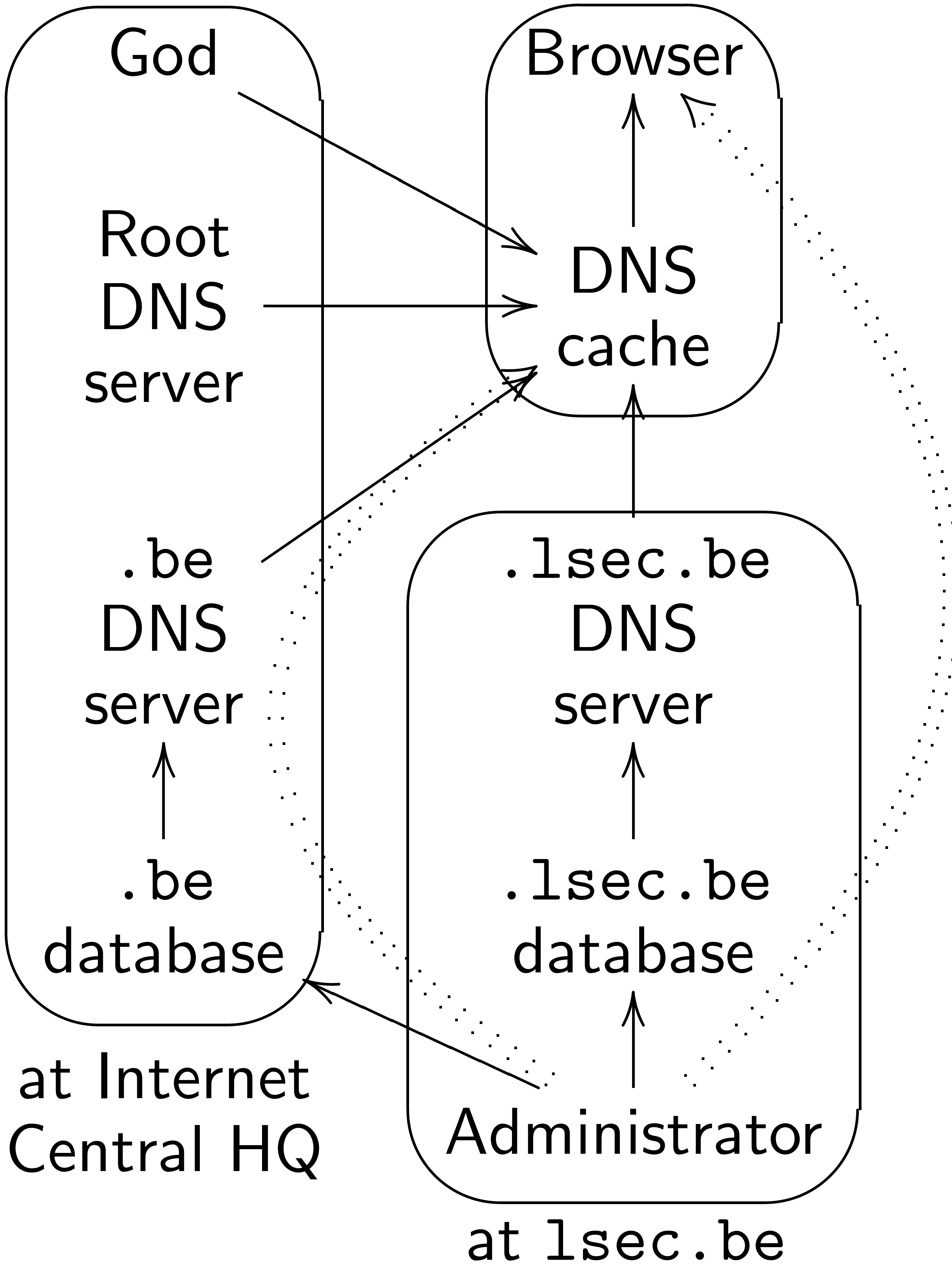

This architecture means th
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e.g. 2001 incident:
An attacker fooled
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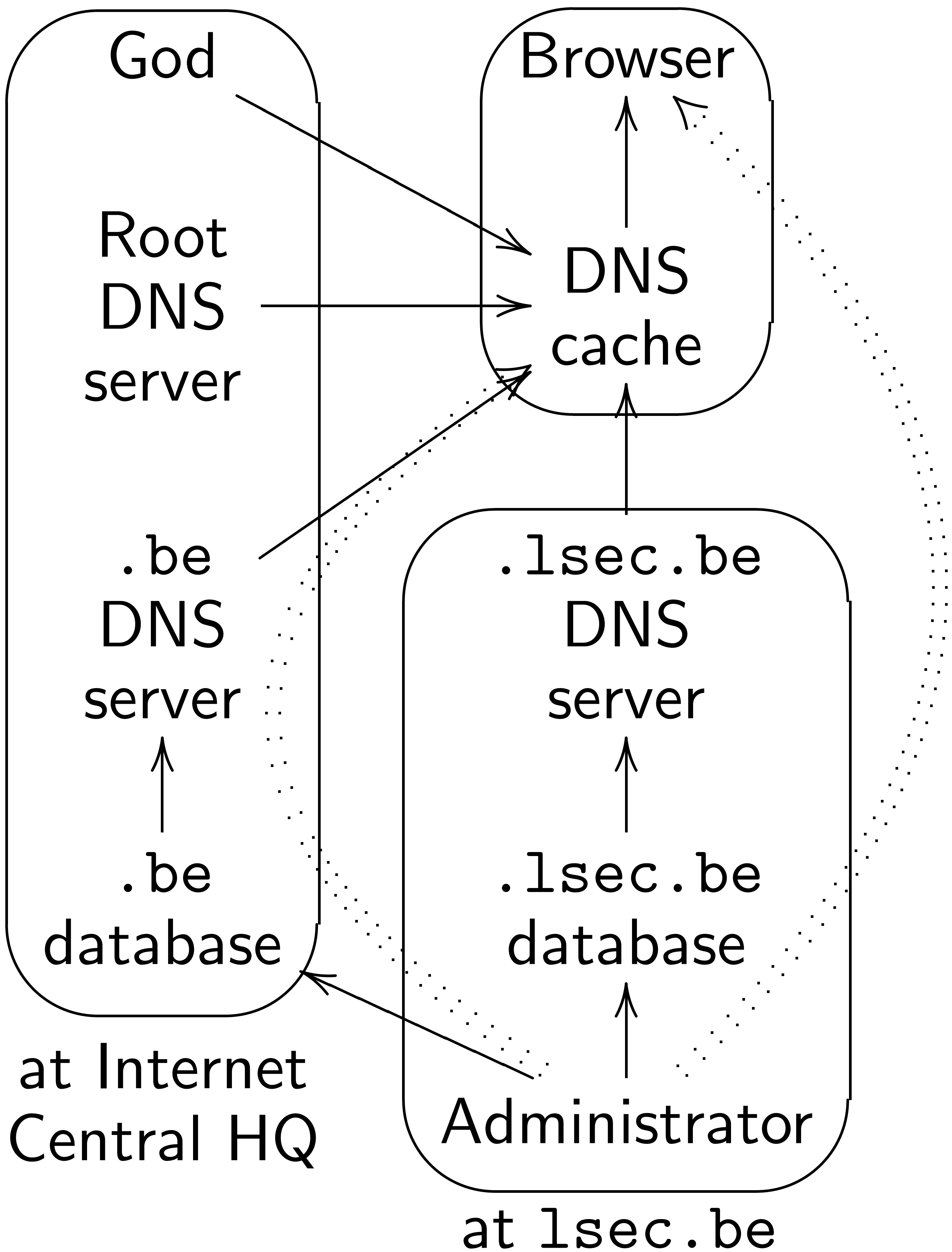

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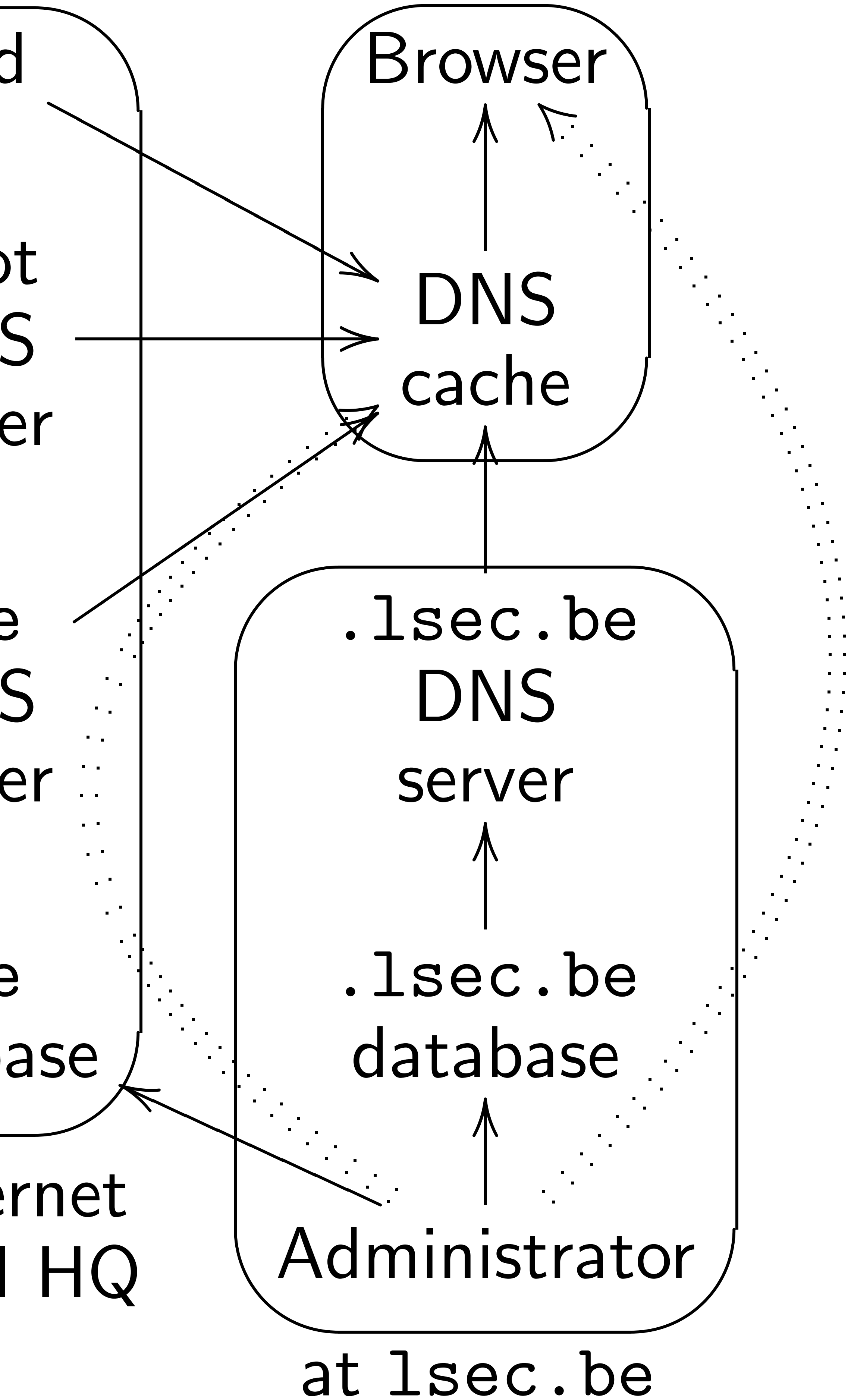

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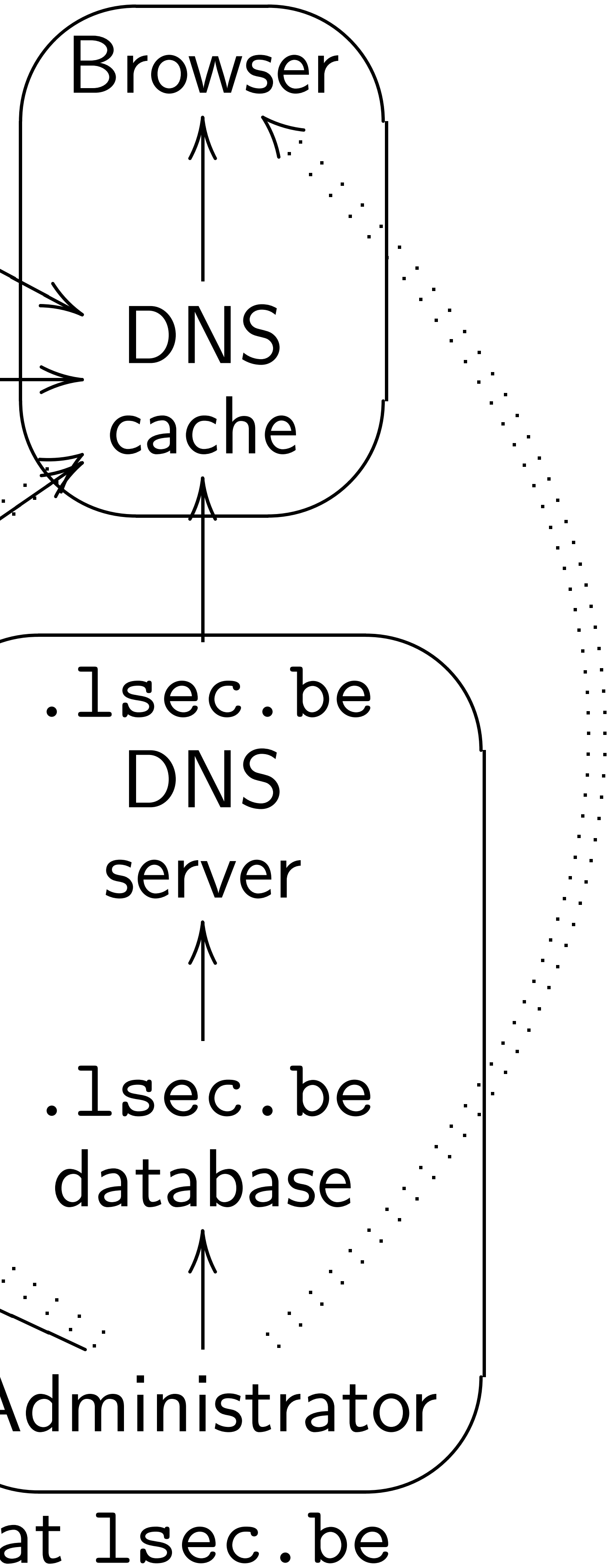

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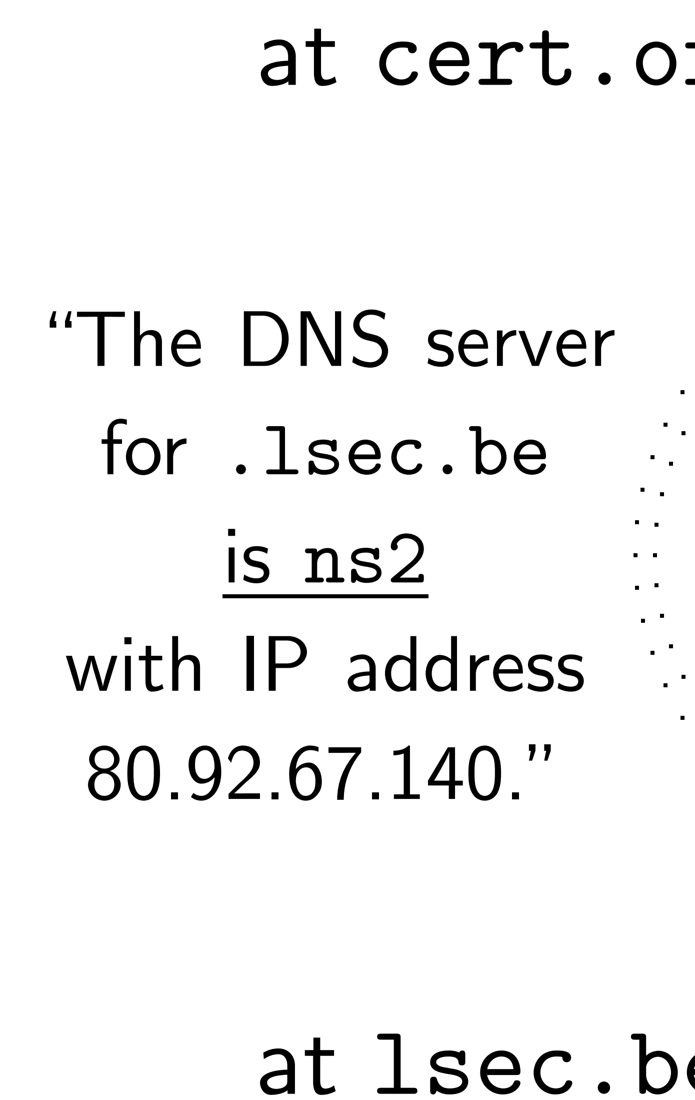

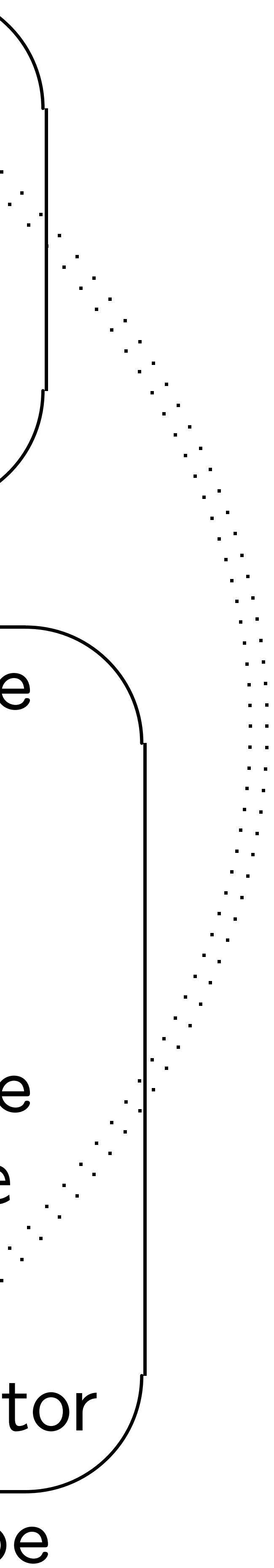

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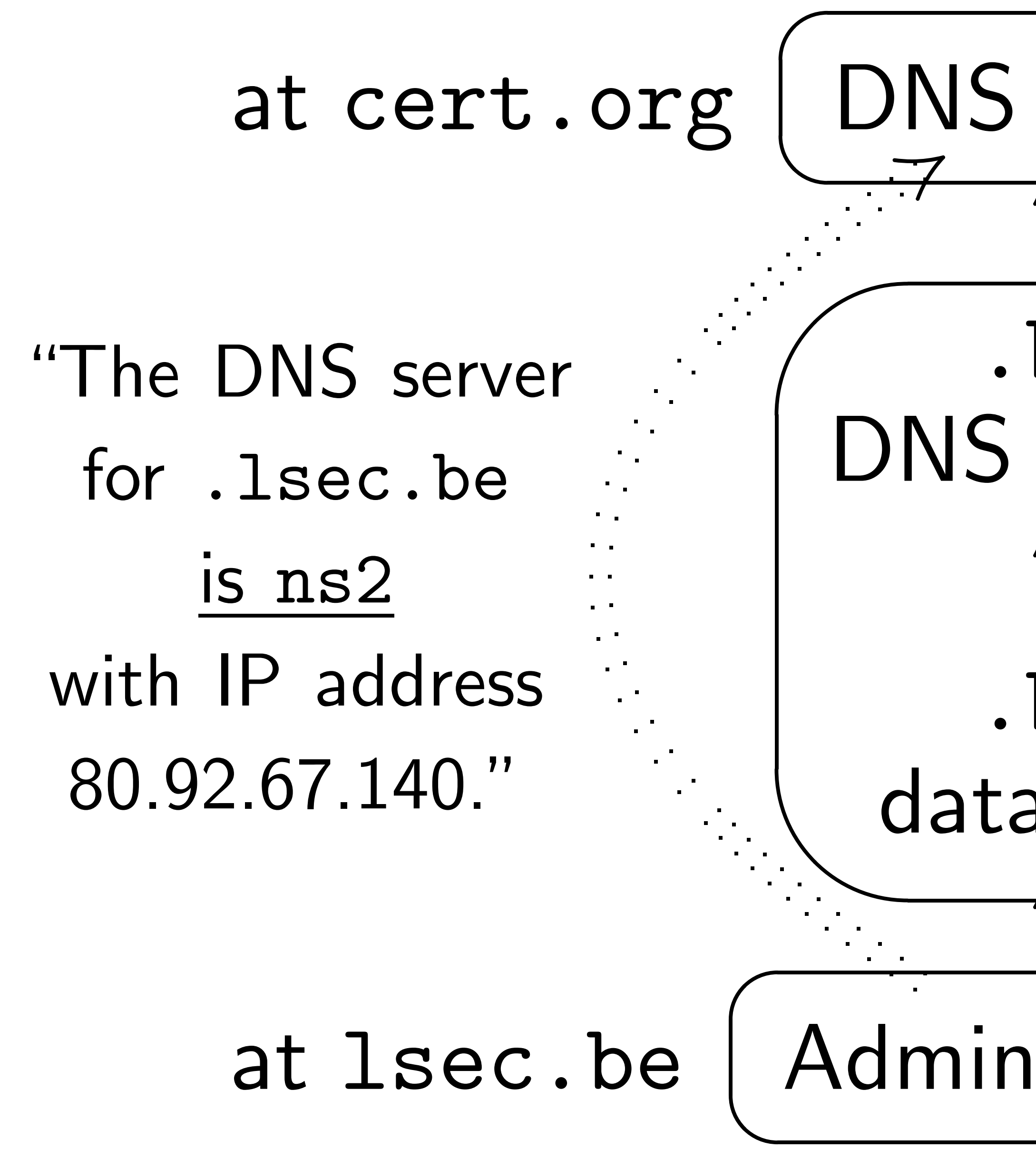
But wait, there's more!
Recall that the DNS server for `lsec.be` have names.



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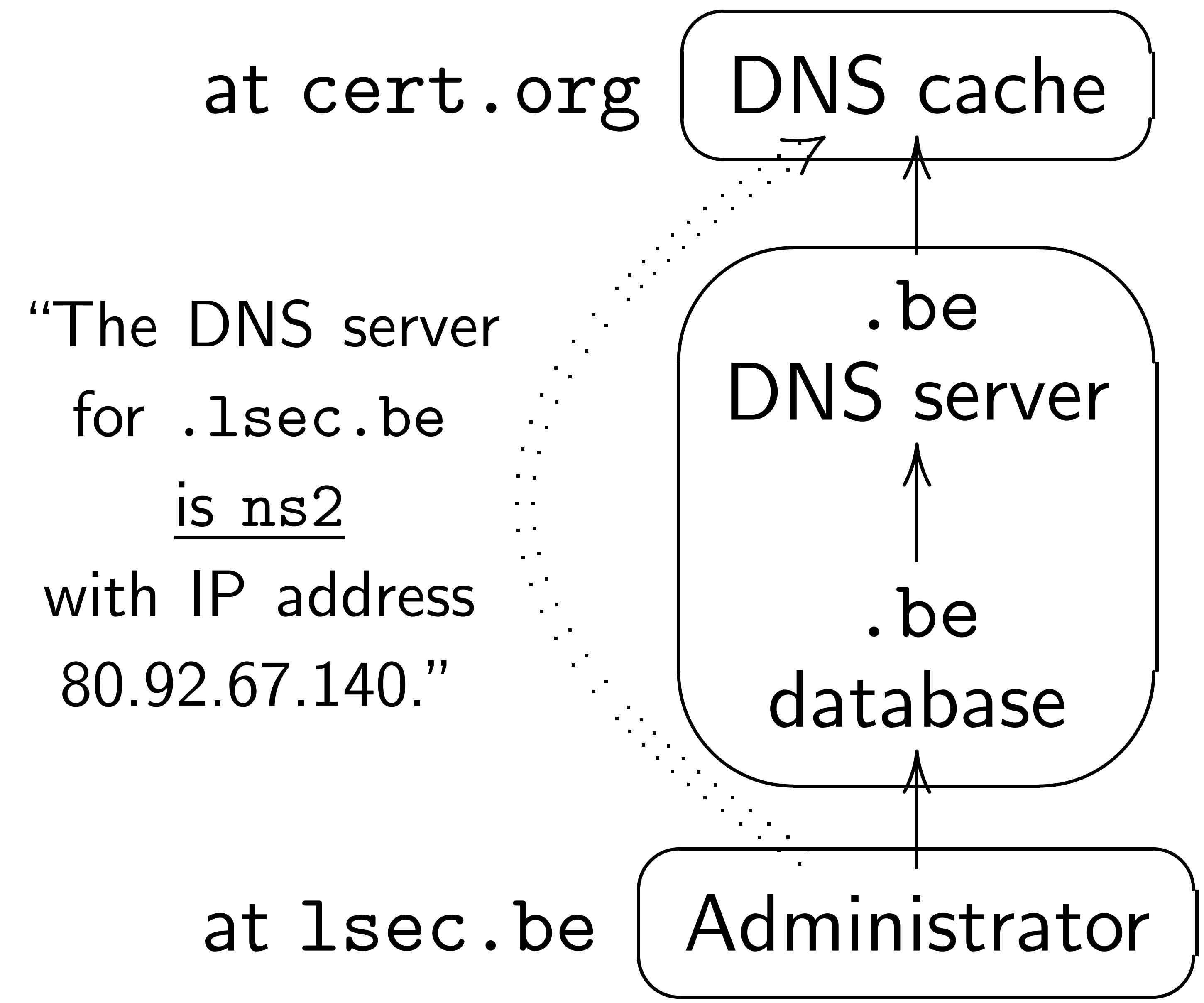

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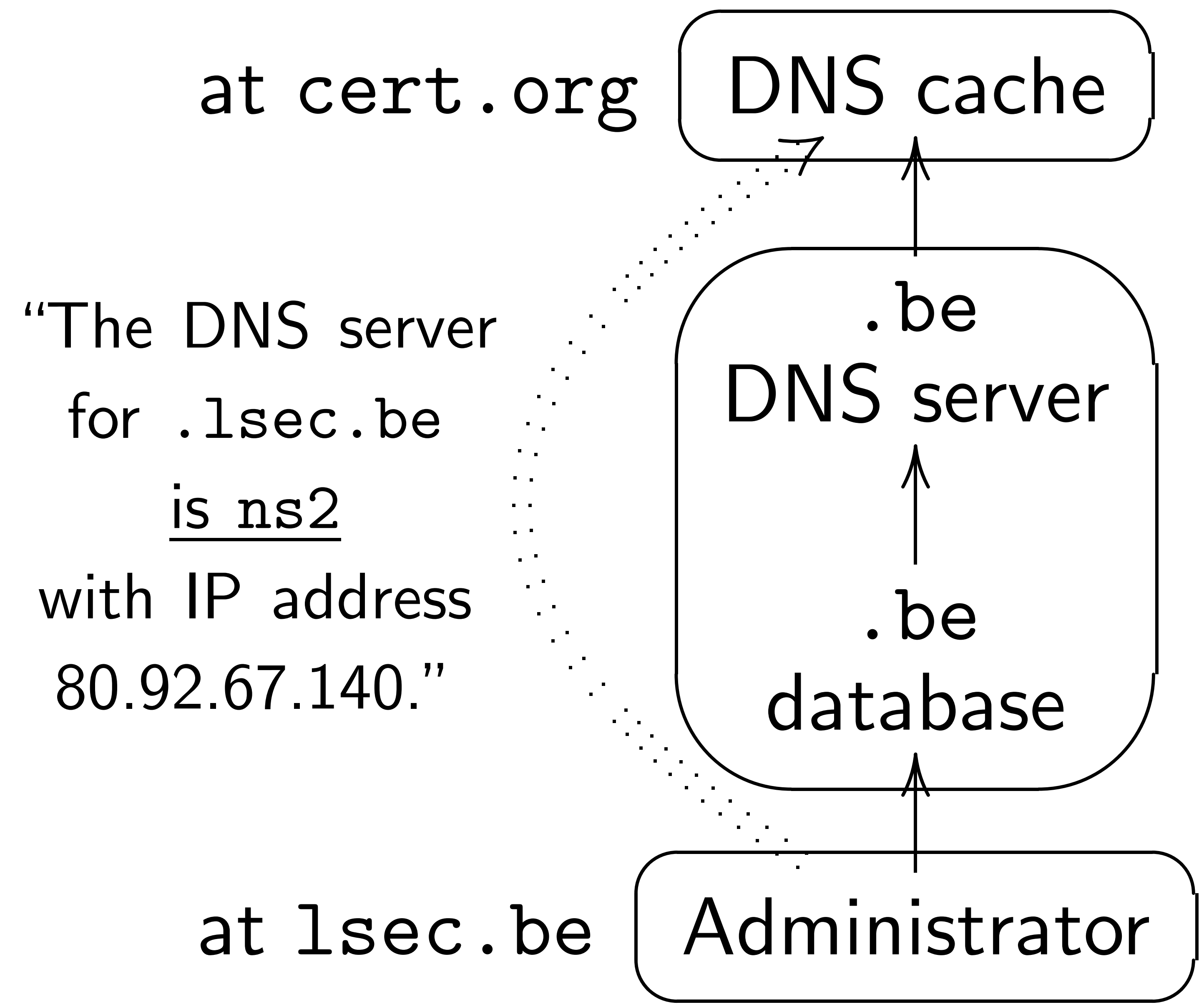

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But wait, there's more!
Recall that the DNS servers
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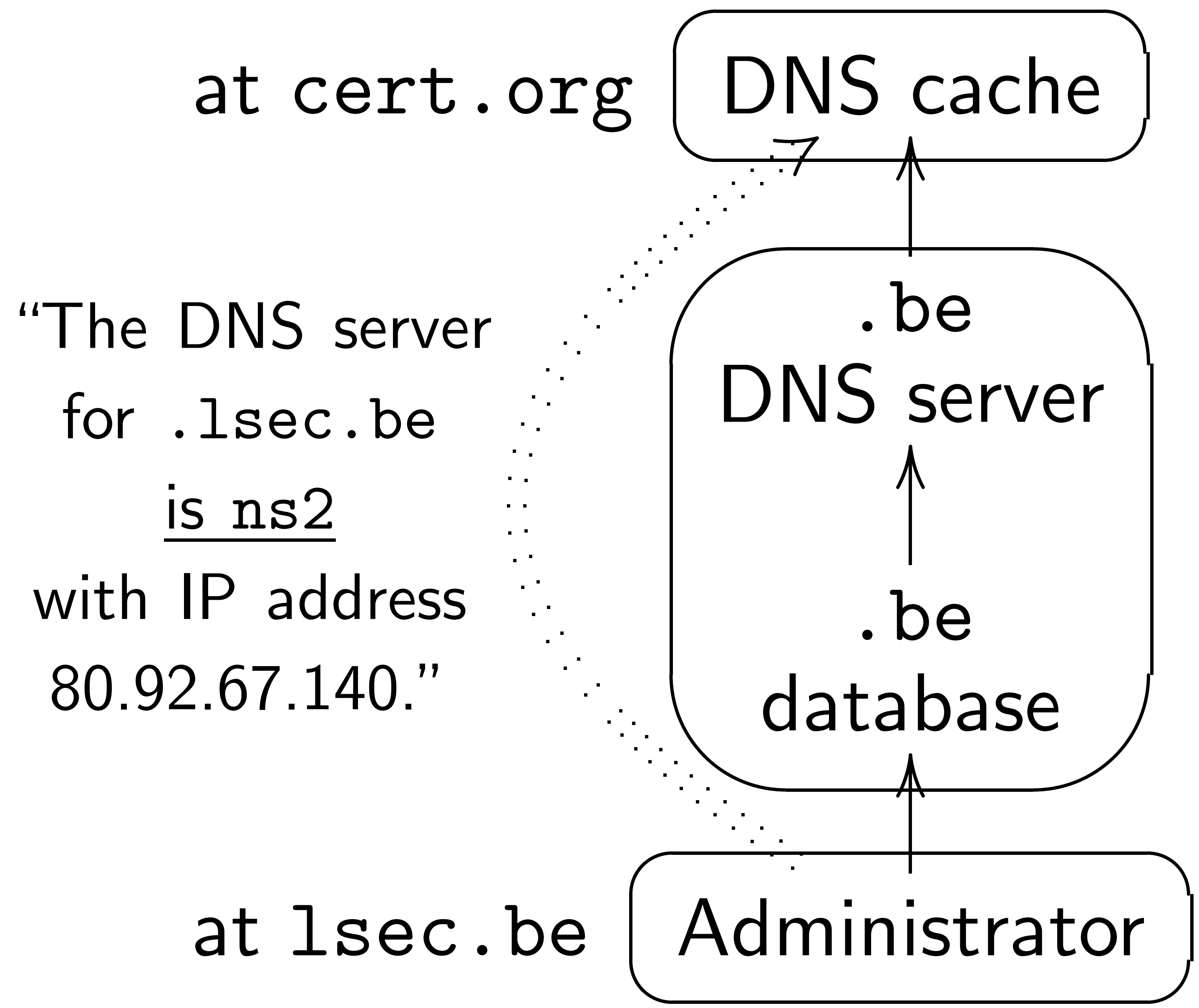

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One of the DNS
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`ns.eu.net`.

One of the DNS
for `eu.net` is nar
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But wait, there's more!
Recall that the DNS servers
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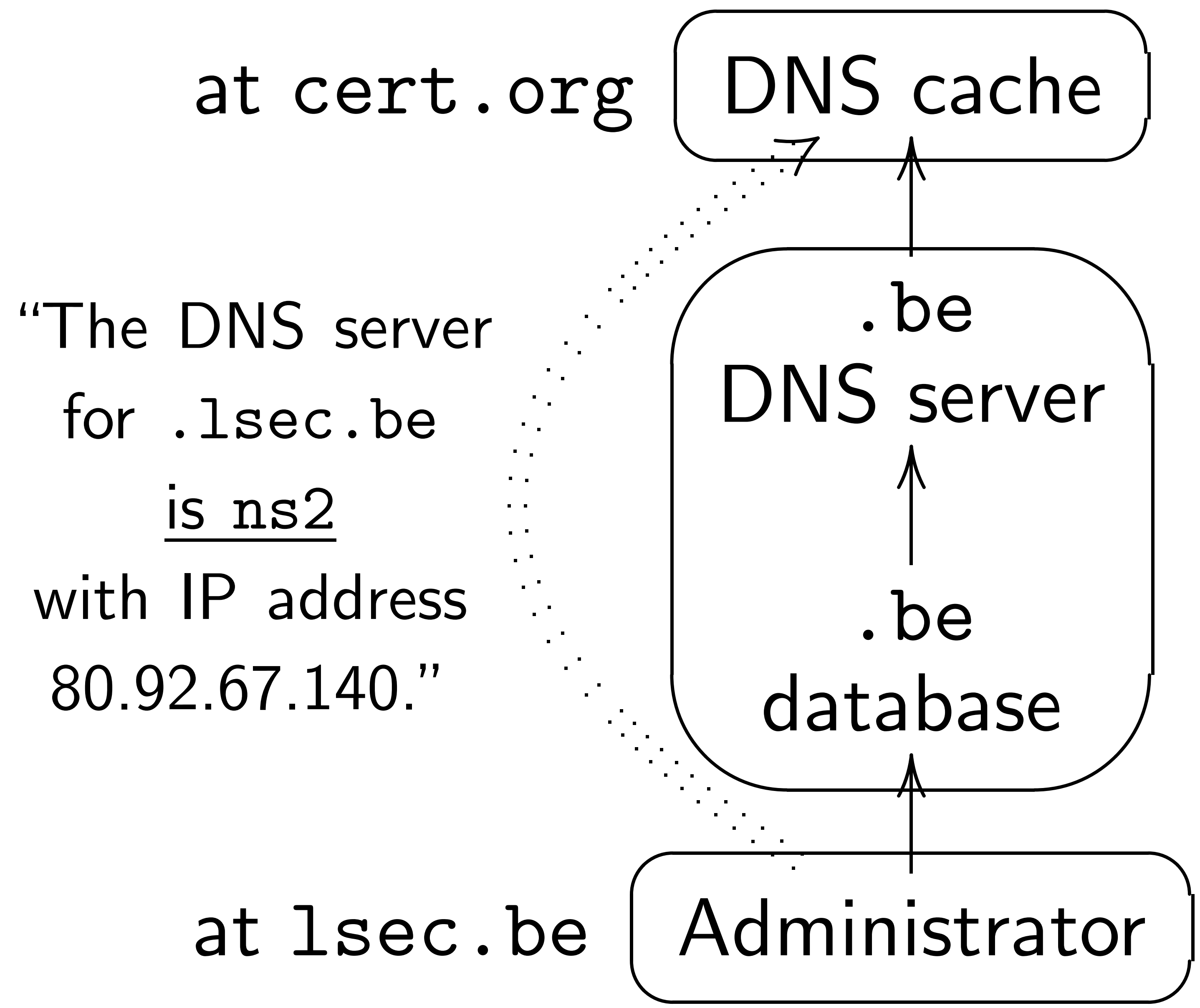


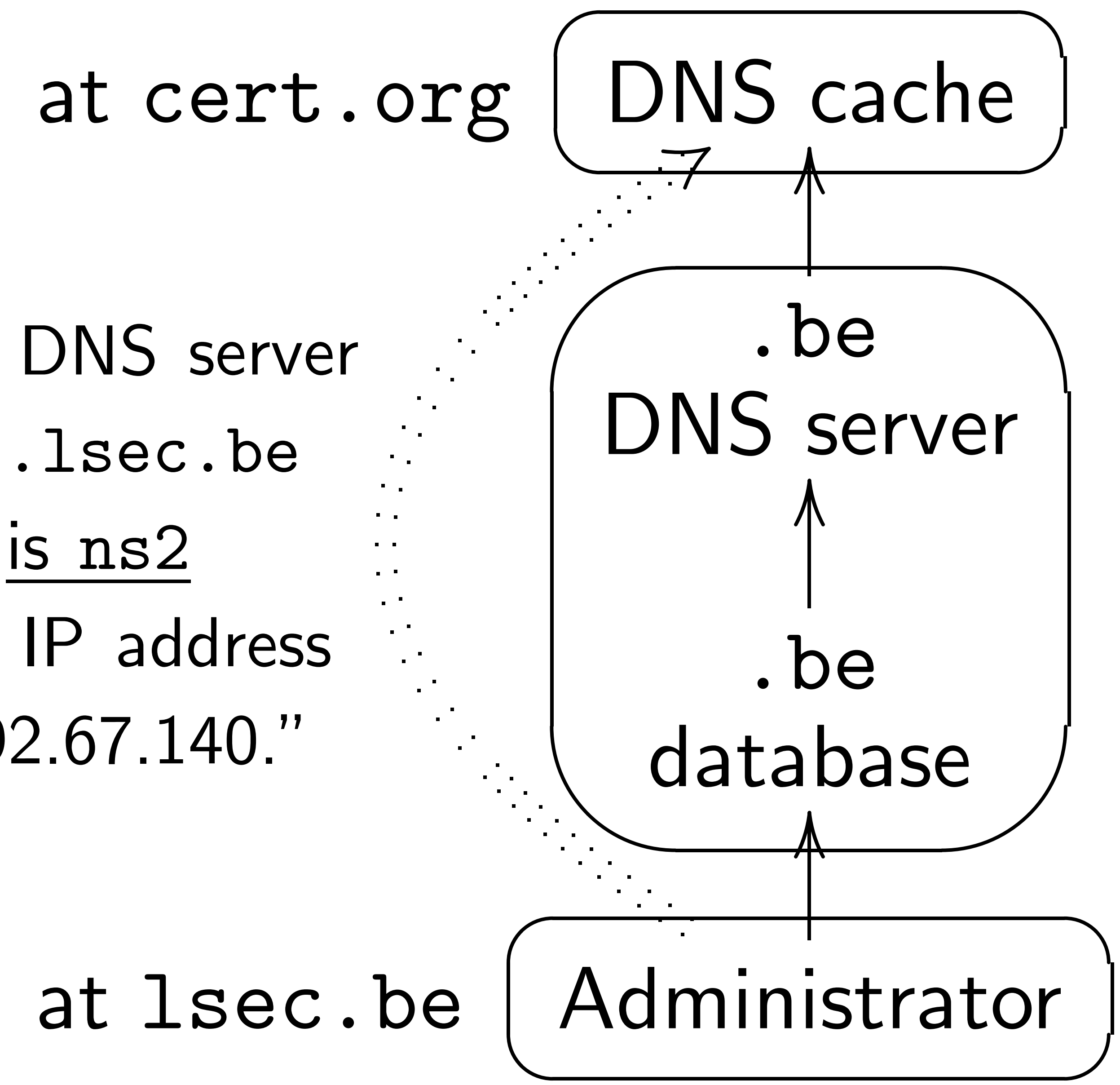
These names can be outside `lsec.be`.

One of the DNS servers for `w3.org` is named `w3csun1.cis.rl.ac.uk`.

One of the DNS servers for `ac.uk` is named `ns.eu.net`.

One of the DNS servers for `eu.net` is named `sunic.sunet.se`.

But wait, there's more!
Recall that the DNS servers
for `lsec.be` have names.



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`w3csun1.cis.rl.ac.uk`.

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nit, there's more!
that the DNS servers
ec.be have names.

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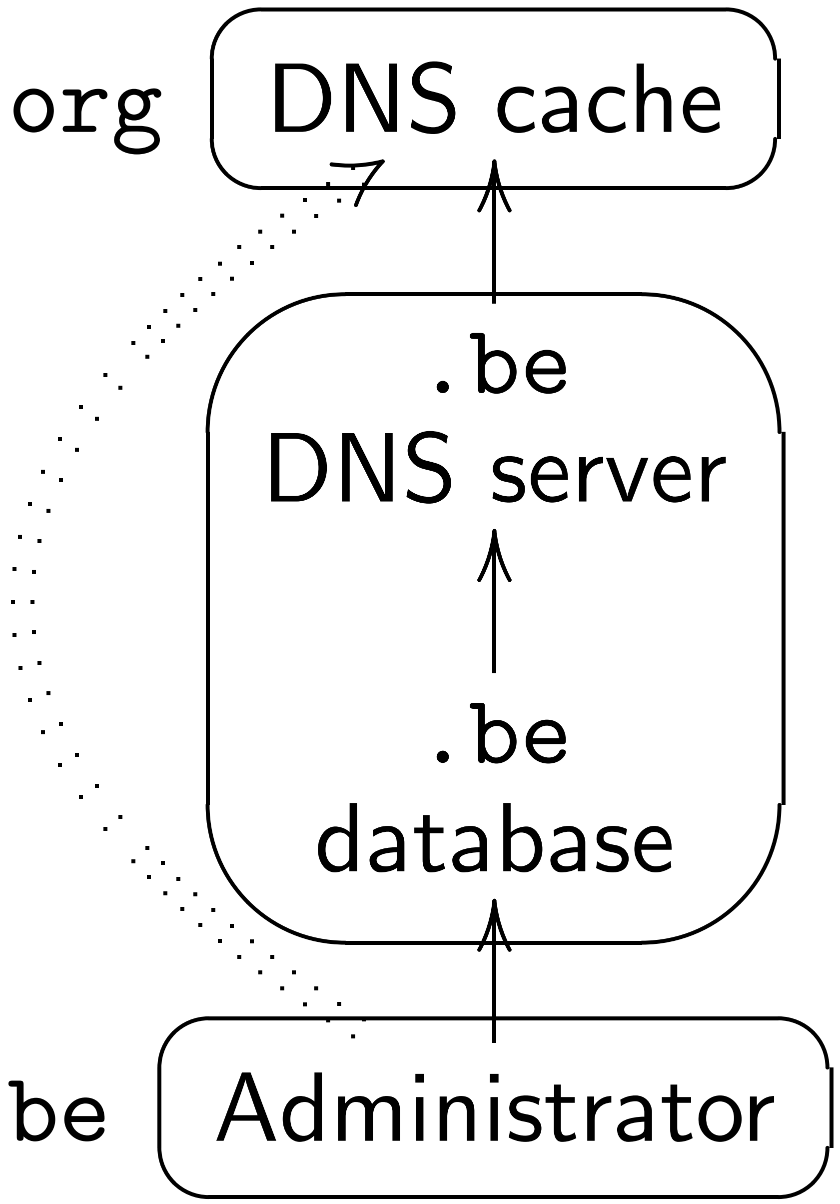

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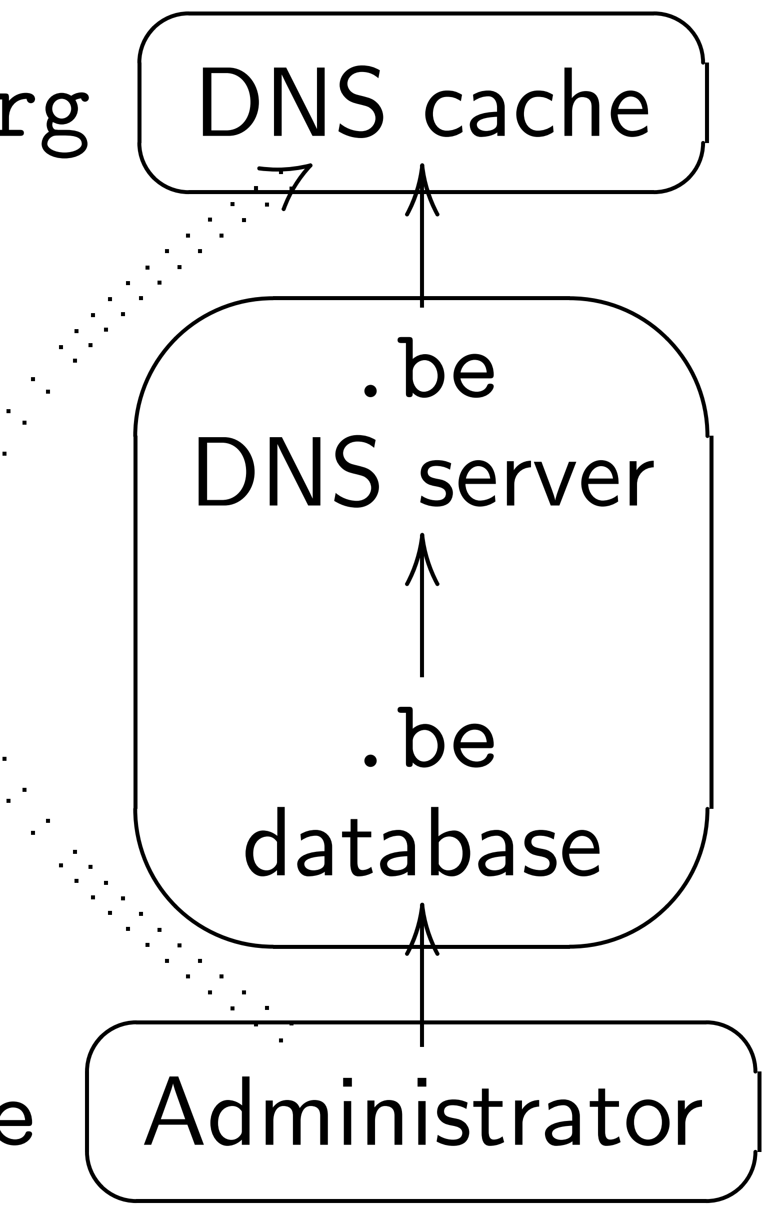

These names can be outside `lsec.be`.

One of the DNS servers for `w3.org` is named `w3csun1.cis.rl.ac.uk`.

One of the DNS servers for `ac.uk` is named `ns.eu.net`.

One of the DNS servers for `eu.net` is named `sunic.sunet.se`.

One of the DNS
for `sunet.se` is
`beer.pilsnet.s`
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Attacker takes co
`beer.pilsnet.s`
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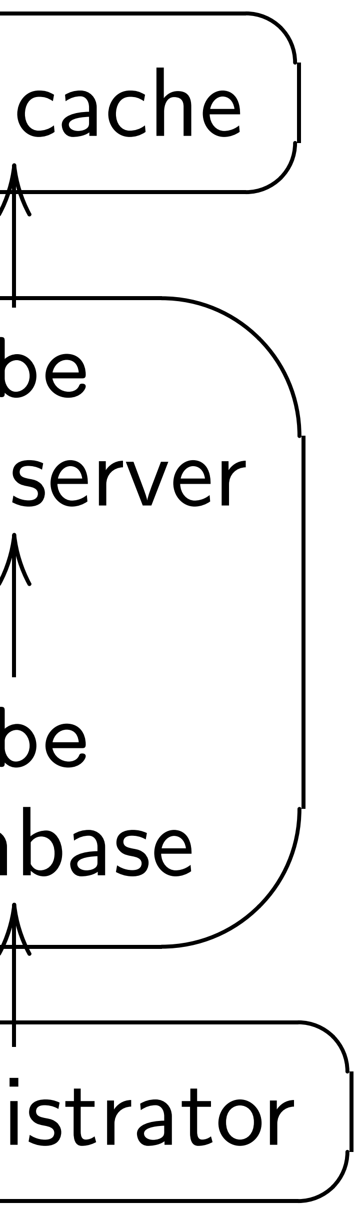

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One of the DNS servers for `sunet.se` is named `beer.pilsnet.sunet.se` and is horribly insecure.

Attacker takes control of `beer.pilsnet.sunet.se`;
tells DNS cache a fake ad
for `sunic.sunet.se`;
tells DNS cache a fake ad
for `ns.eu.net`;
tells DNS cache a fake ad
for `w3csun1.cis.rl.ac.u`
tells DNS cache a fake ad
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tells DNS cache a fake address for `ns.eu.net`;
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f the DNS servers
org is named
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uk is named
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f the DNS servers
net is named
.sunet.se.

One of the DNS servers for sunet.se is named beer.pilsnet.sunet.se and is horribly insecure.

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tells DNS cache a fake address for w3csun1.cis.rl.ac.uk;
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controlled by >200 compu
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Many of these computers
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`.com` was then fixed.
Eventually `w3.org` was fixe
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"Perils of transitive trust":
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One of the DNS servers for `sunet.se` is named `beer.pilsnet.sunet.se` and is horribly insecure.

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2000 Bernstein: `.com` etc. are controlled by > 200 computers via server-name server trust. Many of these computers run old breakable servers.

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`.com` was then fixed. Eventually `w3.org` was fixed; this example no longer works.

2006 Ramasubramanian–Sirer "Perils of transitive trust": Problem is still widespread.

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er takes control of
ilsnet.sunet.se;
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NS cache a fake address
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