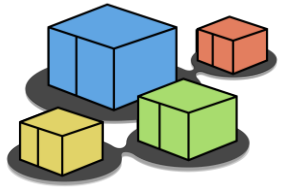
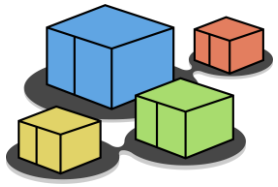


Kathará

kathara lab

DNS

Version	2.1
Author(s)	L. Ariemma, T. Caiazzi, G. Di Battista, M. Patrignani, M. Pizzonia, F. Ricci, M. Rimondini
E-mail	contact@kathara.org
Web	http://www.kathara.org/
Description	using the domain name system – kathara version of an existing netkit lab



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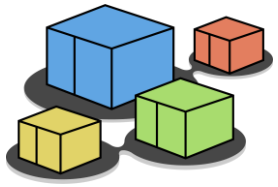
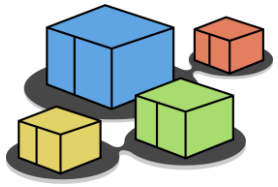


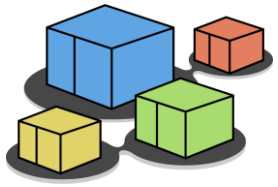
purpose of this lab

- get familiar with DNS
- observe the behavior of name servers and their interactions
- learn simple DNS configurations



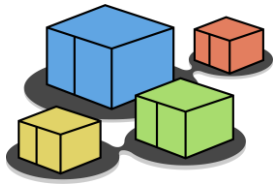
lab limitations

- DNS security issues and protocols are not covered
  - we use a version of Bind, which currently is the most widely used domain name server software, that allows ignoring security aspects
- all IP addresses are IPv4



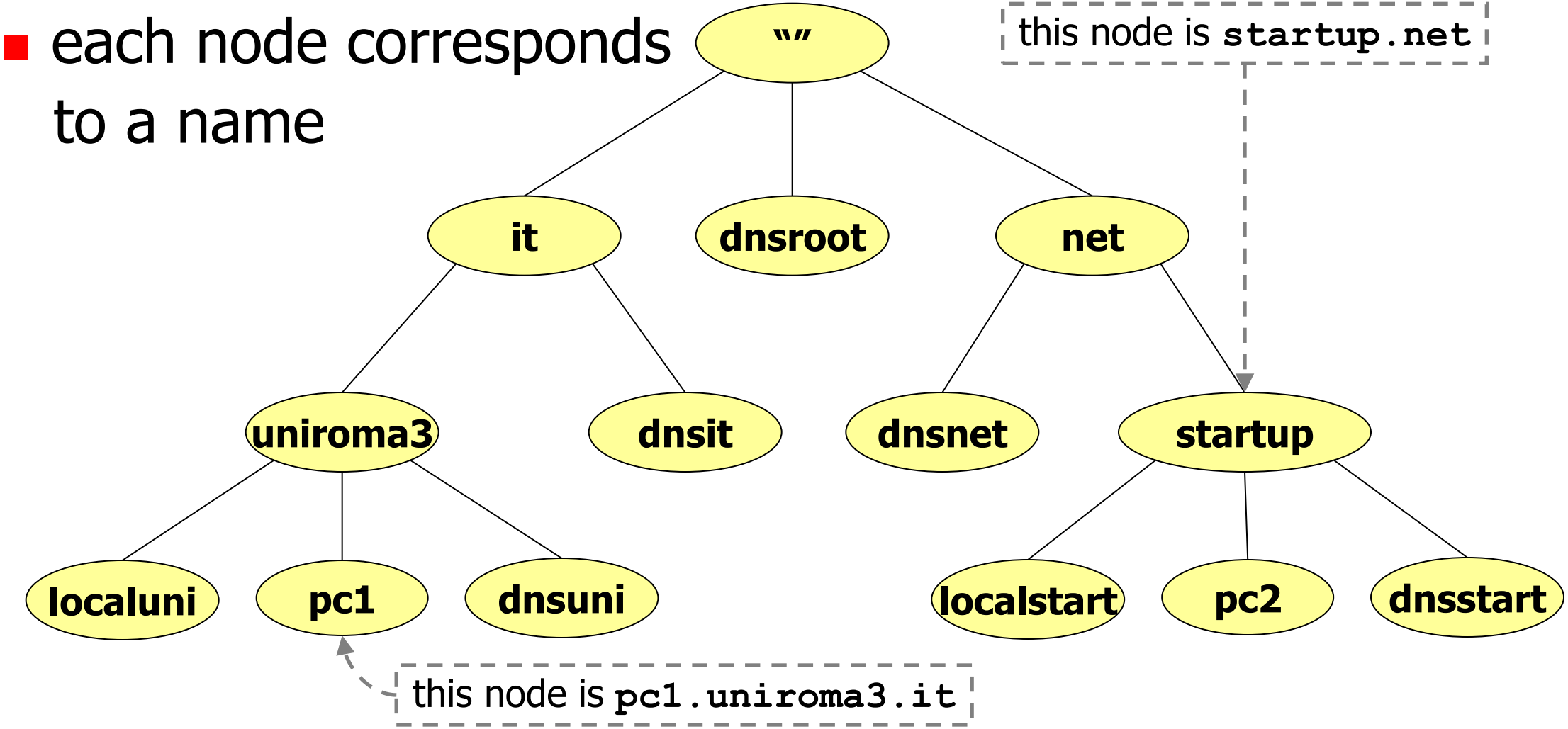
about the DNS

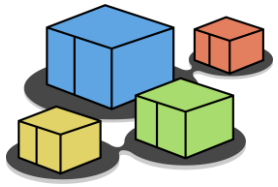
- takes care of associating names with IP addresses
- the name system is distributed over several nodes (hosts) that are hierarchically organized to form a tree
- each node in the hierarchy corresponds to a name
- a domain in the name system is a subtree
- a node in the hierarchy may be delegated to handle names for a particular zone
  - such a node is an authoritative server for that zone
- a zone is a domain which is devoid of those nodes having a different authoritative server (i.e., a tree without subtrees)



the DNS name hierarchy

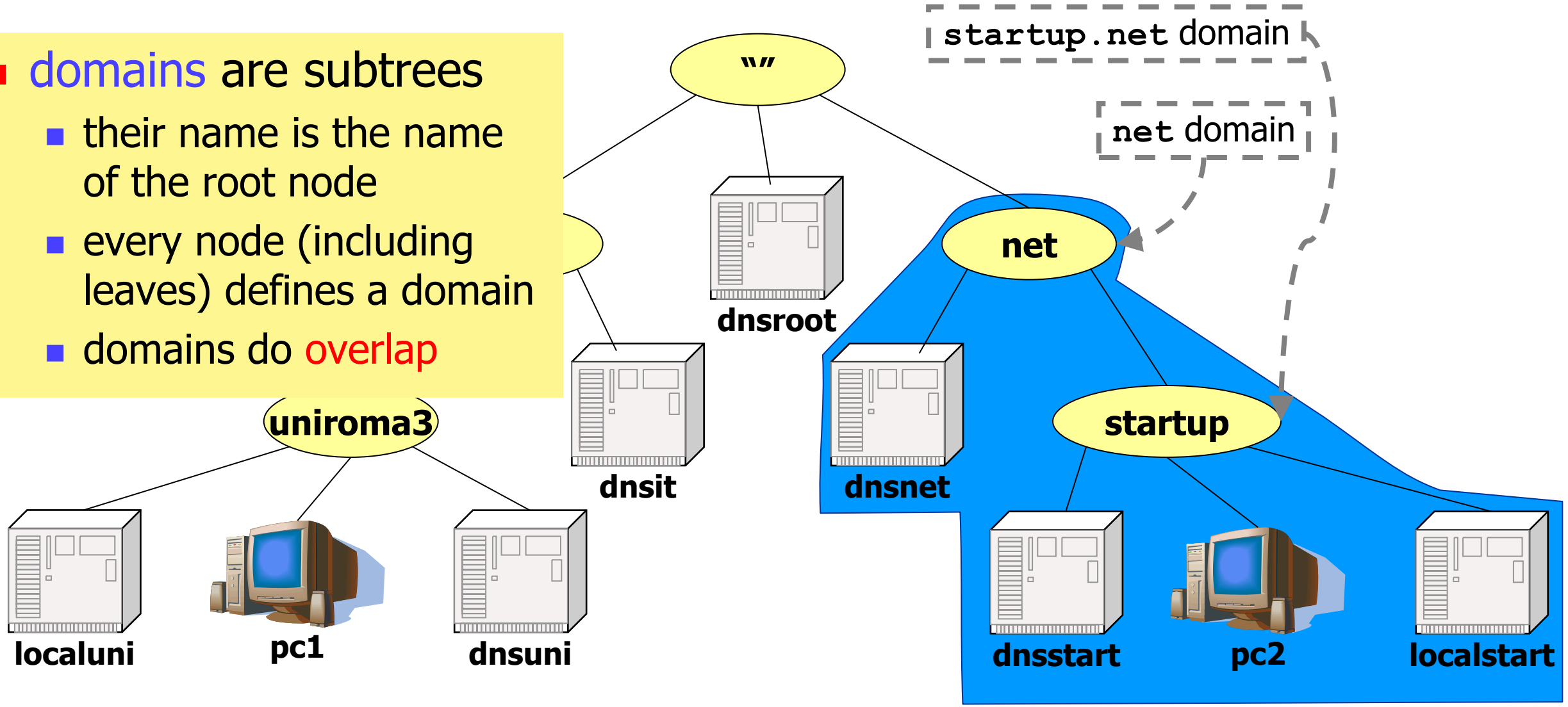
- each node corresponds to a name

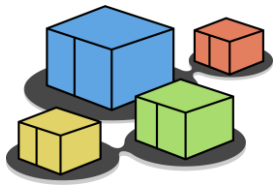




the DNS name hierarchy

- domains are subtrees
  - their name is the name of the root node
  - every node (including leaves) defines a domain
  - domains do overlap

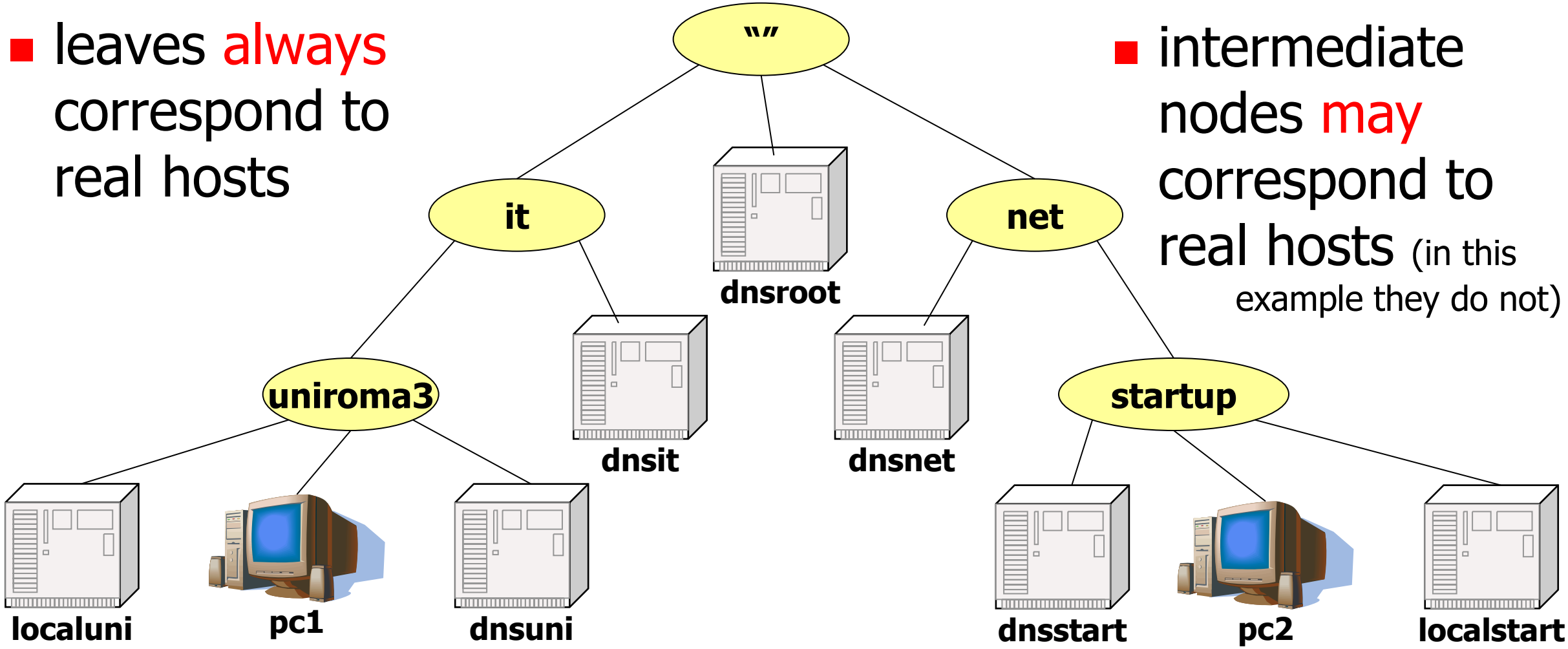


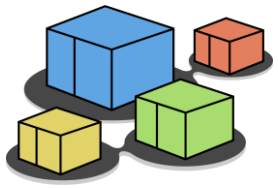


the DNS name hierarchy

- leaves always correspond to real hosts

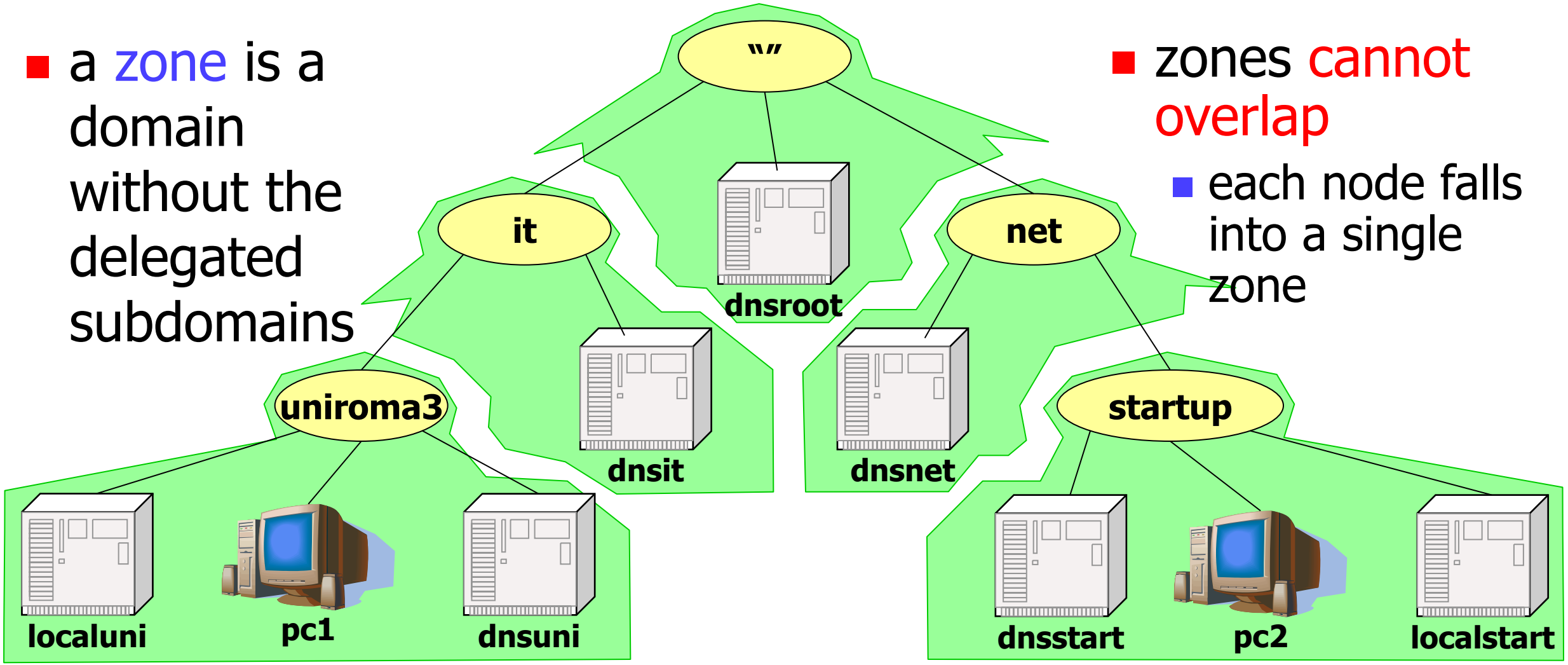
- intermediate nodes may correspond to real hosts (in this example they do not)



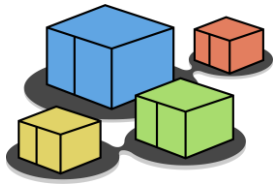


zones

- a zone is a domain without the delegated subdomains

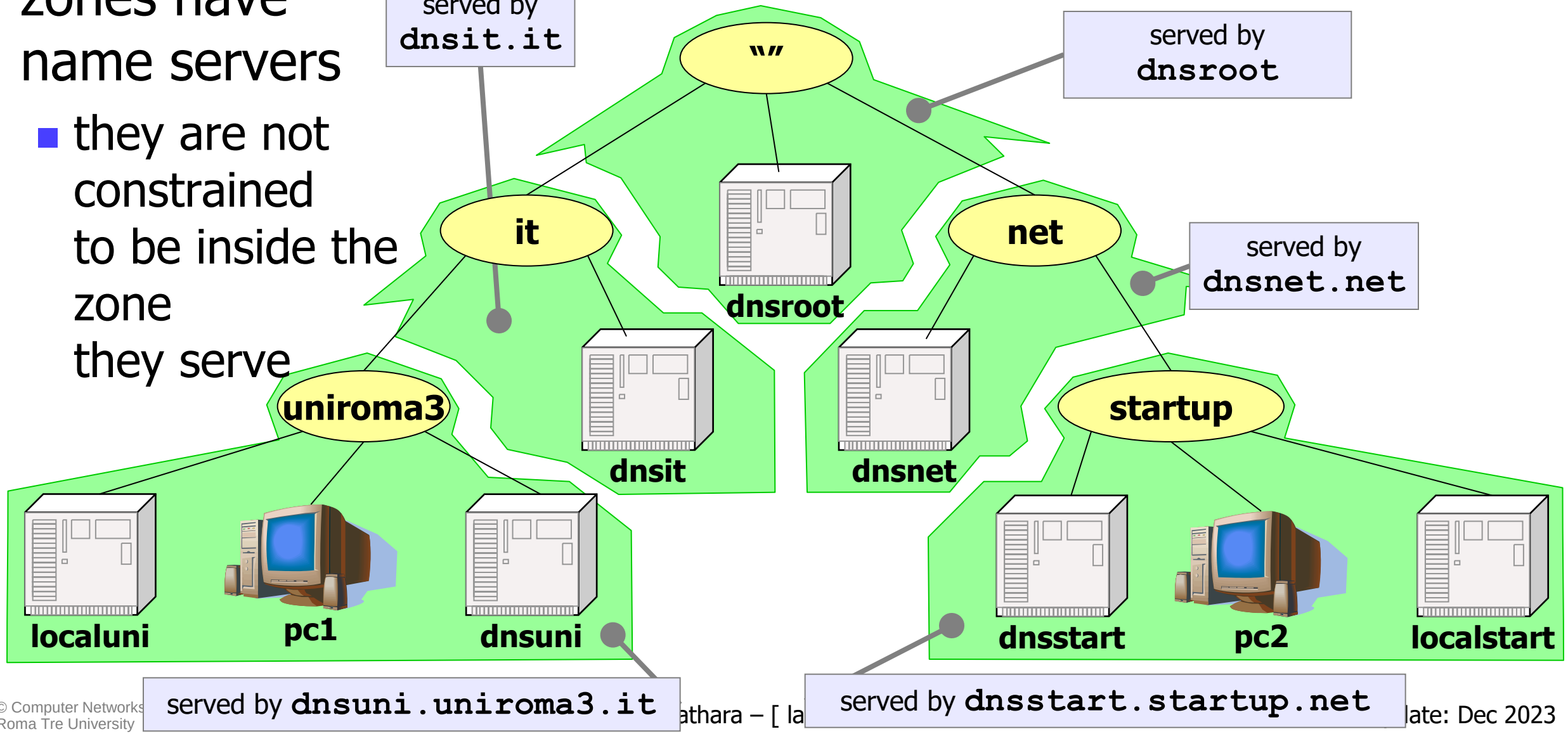


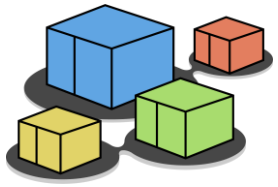
- zones cannot overlap
  - each node falls into a single zone



zones

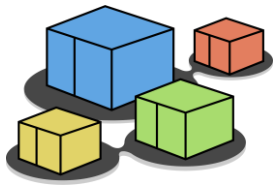
- zones have name servers
  - they are not constrained to be inside the zone they serve



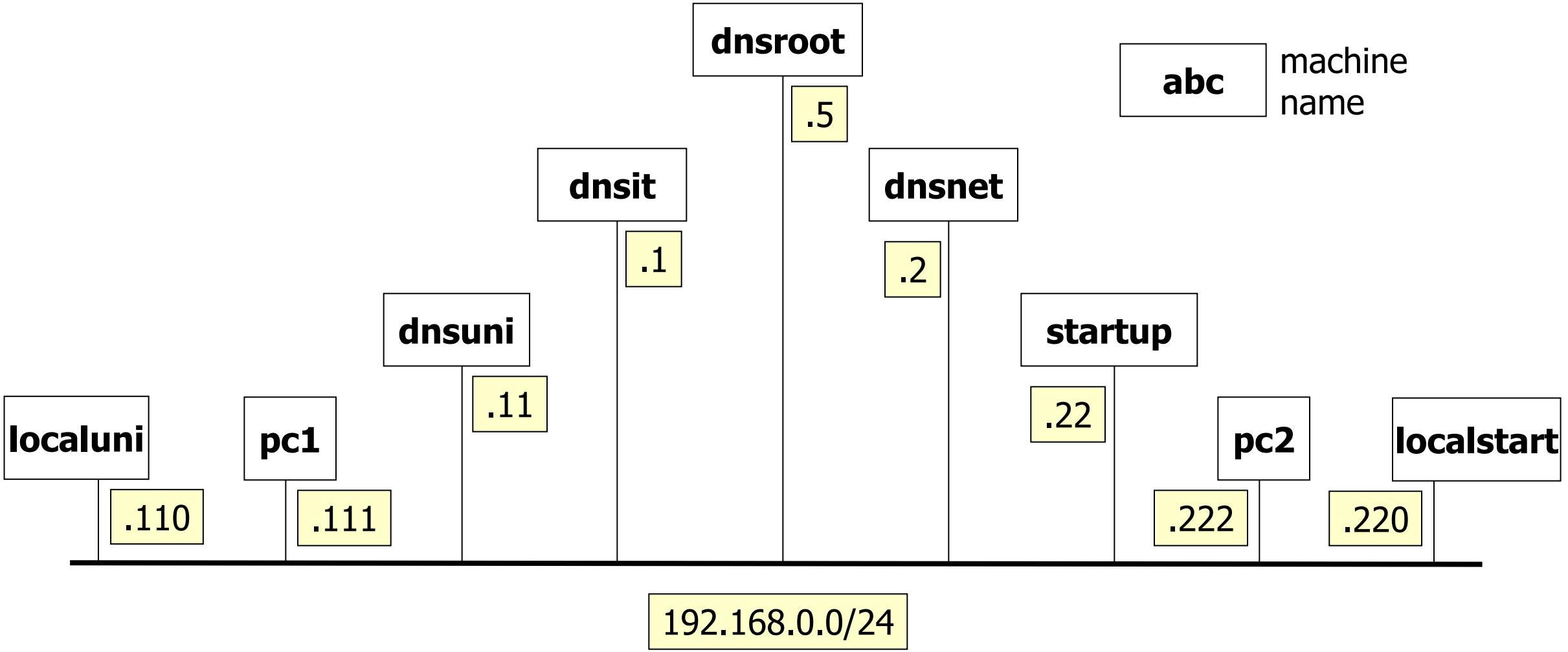


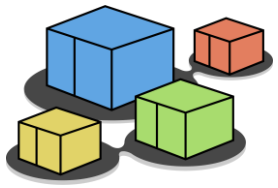
more about the DNS

- the dns hierarchy is largely orthogonal with respect to the actual network topology
- in order to focus on the behavior of the dns we choose a flat topology, consisting of a single collision domain

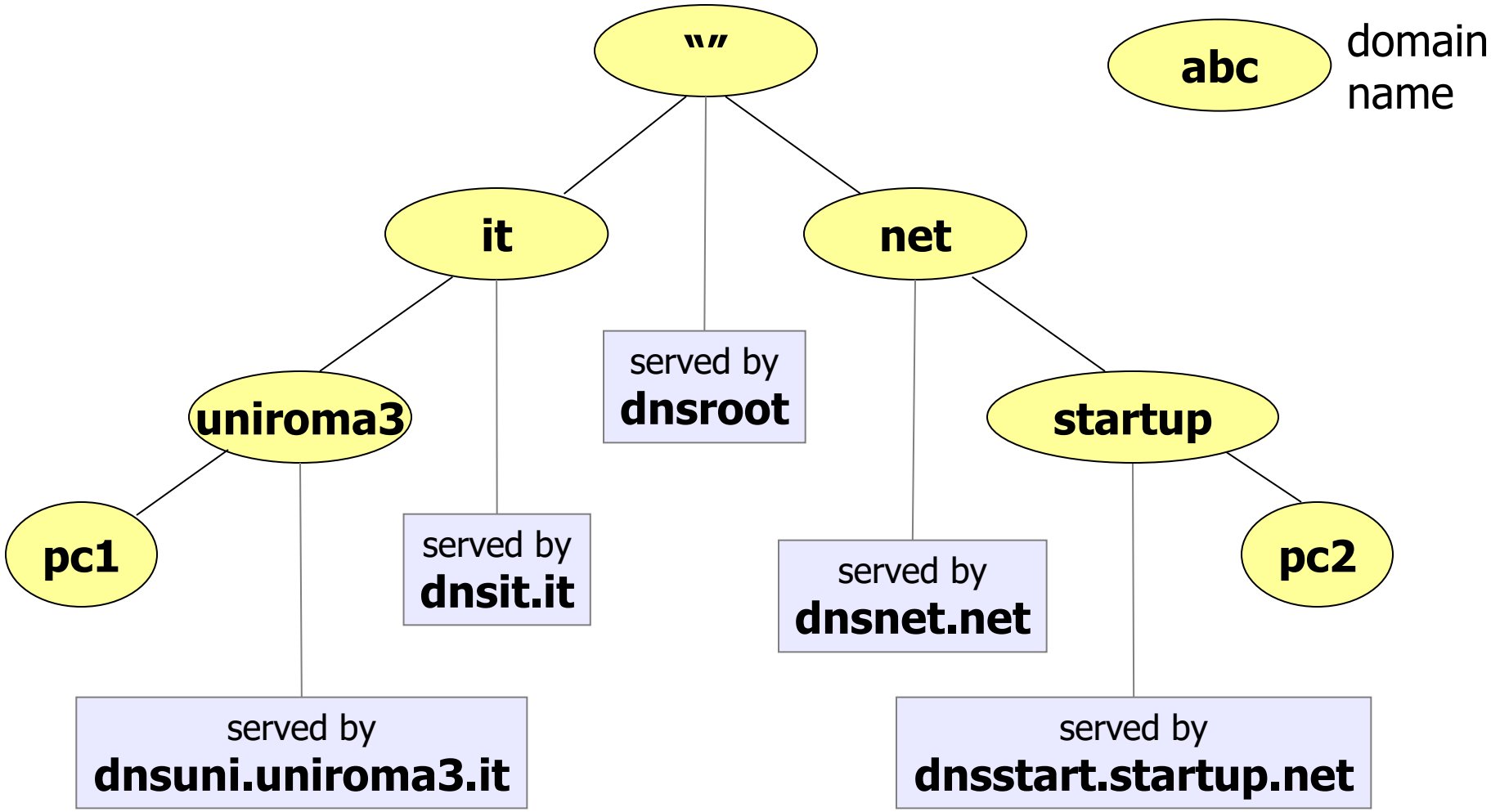


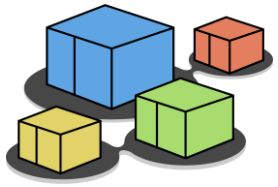
step 1 – network topology





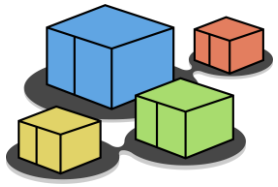
step 1 – DNS (zone) hierarchy





step 2 – starting the lab

- the lab is configured to
  - start all the 9 devices
  - automatically configure network interfaces (IPv4 only)
  - automatically configure the authoritative name servers
  - automatically configure name servers offering a recursive resolution service
  - automatically start the name server software (*bind*) on each name server
    - the daemon corresponding to bind is called *named*



step 2 – exploring the configuration

- configuration on the PCs consists of the specification of the *default* name server

```
root@pc1:~$ cat /etc/resolv.conf
nameserver 192.168.0.110
search uniroma3.it
options single-request
```

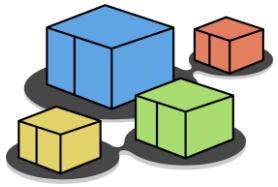
perform first IPv4 and then IPv6 queries

localuni.uniroma3.it

suffix to append to unqualified names (e.g., asking to resolve **dummy** results in querying for **dummy.uniroma3.it**)

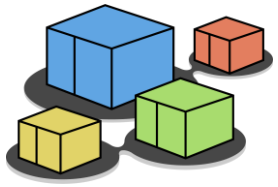
```
root@pc2:~$ cat /etc/resolv.conf
nameserver 192.168.0.220
search startup.net
options single-request
```

localstart.startup.net



step 2 – exploring the configuration

- configuration on the name servers specifies
  - associations between zones and name servers
  - information about the root name servers
  - authoritative information
    - associations between names and IP addresses
  - authorization to resolve recursive queries



step 2 – exploring the configuration

- configuration on the name servers specifies
  - associations between zones and name servers

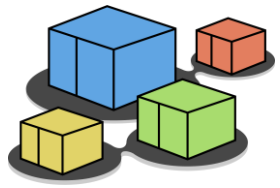
```
root@dnsuni:~$ cat /etc/bind/named.conf
include "/etc/bind/named.conf.options";

zone "." {
    type hint;
    file "/etc/bind/db.root";
};

zone "uniroma3.it" {
    type master;
    file "/etc/bind/db.it.uniroma3";
};
```

include some additional configuration

where to find information about the root name server

we are the primary master for zone **uniroma3.it**

where to find data about the names in this zone

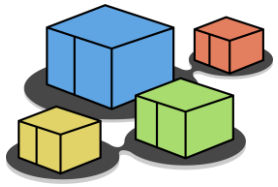


step 2 – exploring the configuration

- configuration on the name servers specifies
  - additional configuration

```
root@dnsuni:~$ cat /etc/bind/named.conf.options
options {
    directory "/var/cache/bind";
};
```

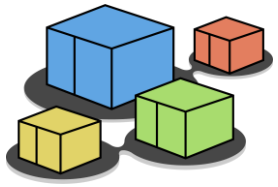
use this folder to store the cache.
COMPULSORY, otherwise, named wont 't start



format of a resource record

```
<domain> <class> <type> <rdata>
```

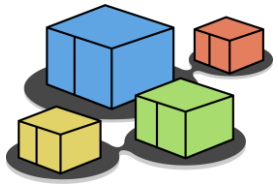
- domain: the record owner (=domain to which the record refers)
- class: usually IN (=Internet system); may be HS (=hesiod) or CH (=chaos)
- type: see next slide...
- rdata: record data (depends on the record type)



step 2 – exploring the configuration

available record types

A	**a host address.**
A6	Obsolete format of IPv6 address.
AAAA	**an IPv6 address.**
AFSDB	(x) location of AFS database servers. Experimental.
CERT	holds a digital certificate.
CNAME	**identifies the canonical name of an alias.**
DNAME	for delegation of reverse addresses. Replaces the domain name specified with another name to be looked up. Described in RFC 2672.
GPOS	Specifies the global position. Superseded by LOC.
HINFO	identifies the CPU and OS used by a host.
ISDN	(x) representation of ISDN addresses. Experimental.
KEY	stores a public key associated with a DNS name.
KX	identifies a key exchanger for this DNS name.
LOC	(x) for storing GPS info. See RFC 1876. Experimental.
MX	**identifies a mail exchange for the domain. See RFC 974 for details.**
NAPTR	name authority pointer.
NSAP	a network service access point.
NS	**the authoritative nameserver for the domain.**
NXT	used in DNSSEC to securely indicate that RRs with an owner name in a certain name interval do not exist in a zone and indicate what R
PTR	a pointer to another part of the domain name space.
PX	provides mappings between RFC 822 and X.400 addresses.
RP	(x) information on persons responsible for the domain. Experimental.
RT	(x) route-through binding for hosts that do not have their own direct wide area network addresses. Experimental.
SIG	("signature") contains data authenticated in the secure DNS. See RFC 2535 for details.
SOA	**identifies the start of a zone of authority.**
SRV	information about well known network services (replaces WKS).
TXT	text records.
WKS	(h) information about which well known network services, such as SMTP, that a domain supports. Historical, replaced by newer RR SRV.
X25	(x) representation of X.25 network addresses. Experimental

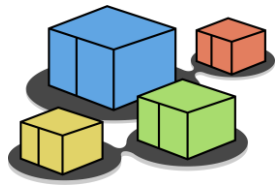


step 2 – exploring the configuration

- configuration on the name servers specifies
  - information about the root name servers

```
root@dnsuni:~$ cat /etc/bind/db.root
.                       IN  NS    ROOT-SERVER.
ROOT-SERVER.            IN  A     192.168.0.5
```

a **resource record**

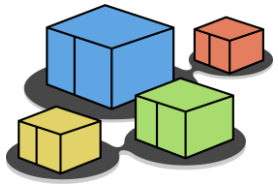


step 2 – exploring the configuration

- configuration on the name servers specifies
  - authoritative information

```
root@dnsuni:~$ cat /etc/bind/db.it.uniroma3
$TTL    60000
```

time to live, in seconds
(determines how long a resource record should be cached)



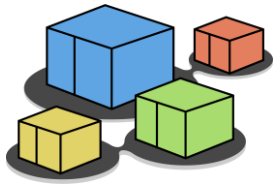
step 2 – exploring the configuration

- configuration on the name servers specifies
  - authoritative information

```
root@dnsuni:~$ cat /etc/bind/db.it.uniroma3
$TTL    60000
@               IN      SOA     dnsuni.uniroma3.it.
root.dnsuni.uniroma3.it. (
                        2006031201 ; serial
                        28 ; refresh
                        14 ; retry
                        3600000 ; expire
                        0 ; negative cache ttl
                        )
```

Start of Authority record

- must be all on a single line; line breaks can only be introduced when using parentheses
- a zone data file can contain only one SOA record



step 2 – exploring the configuration

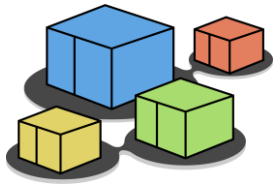
- configuration on the name servers specifies
  - authoritative information

```
root@dnsuni:~$ cat /etc/bind/db.it.uniroma3
$TTL    60000
@                       IN
root.dnsuni.uniroma3.it.
```

this record is referred to the current origin (`uniroma3.it`)

- all domain names in this data file that are not fully qualified (do not end with a '.') are relative to the *origin*
- the *origin* is the domain name in the *zone* statement of the server configuration file:

```
zone "uniroma3.it" {
        type master;
        file "/etc/bind/db.it.uniroma3";
};
```

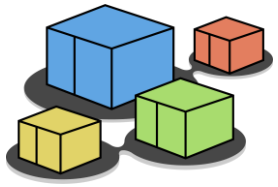


step 2 – exploring the configuration

- configuration on the name servers specifies
  - authoritative information

```
root@dnsuni:~$ cat /etc/bind/db.it.uniroma3
$TTL    60000
@               IN      SOA     dnsuni.uniroma3.it.
root.dnsuni.uniroma3.it. (
                        20060312        serial
                        28 ;
```

primary master (=authority) server for this zone (**dnsuni.uniroma3.it**);
don't forget the trailing dot, or the origin name (**uniroma3.it**) would be appended!



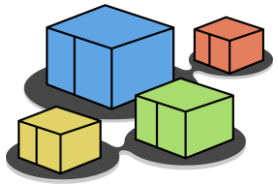
step 2 – exploring the configuration

- configuration on the name servers specifies
  - authoritative information

```
root@dnsuni:~$ cat /etc/bind/db.it.uniroma3
$TTL    60000
@               IN      SOA     dnsuni.uniroma3.it.
root.dnsuni.uniroma3.it. (
                        2006031201 ; serial
                                   ire
                                   cache ttl
```

mail address of the person that is responsible for the zone (**root@dnsuni.uniroma3.it**)

- the first '.' must be replaced by a '@'
- only meant to be used by humans; has no use within the dns service

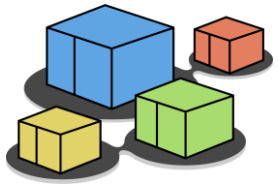


step 2 – exploring the configuration

- configuration on the name servers specifies
  - authoritative information

```
root@dnsuni:~$ cat /etc/bind/db.it.uniroma3
$TTL    60000
@               IN      SOA     dnsuni.uniroma3.it.
root.dnsuni.uniroma3.it. (
                        2006031201 ; serial
                        28 ; refresh
                        14 ; retry
                        3600000 ; expire
                        0 ; negative cache ttl
                        )
```

makes sense for master/slave server configurations



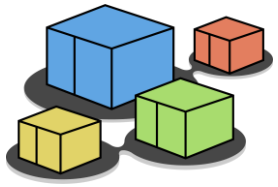
step 2 – exploring the configuration

- configuration on the name servers specifies
  - authoritative information

```
root@dnsuni:~$ cat /etc/bind/db.it.uniroma3
$TTL    60000
@               IN      SOA     dnsuni.uniroma3.it.
root.dnsuni.uniroma3.it. (
                        2006031201 ; serial
                        28 ; refresh
```

serial number

- determines how recent the information is
- influences all data within the zone
- conventional format:
  YYYYMMDDNN (year, month, day, # of changes within that day)



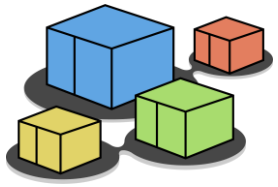
step 2 – exploring the configuration

- configuration on the name servers specifies
  - authoritative information

```
root@dnsuni:~$ cat /etc/bind/db.it.uniroma3
$TTL    60000
@               IN      SOA     dnsuni.uniroma3.it.
root.dnsuni.uniroma3.it. (
                        2006031201 ; serial
                        28 ; refresh
                        14 ; retry
                        3600000 ; expire
```

refresh interval (seconds)

tells a slave how often to check that the data for this zone is up to date

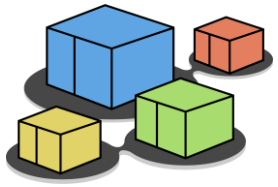


step 2 – exploring the configuration

- configuration on the name servers specifies
  - authoritative information

```
root@dnsuni:~$ cat /etc/bind/db.it.uniroma3
$TTL    60000
@               IN      SOA     dnsuni.uniroma3.it.
root.dnsuni.uniroma3.it. (
                        2006031201 ; serial
                        28 ; refresh
                        14 ; retry
                        3600000 ; expire
                        0 ; negative cache ttl
                        )
```

interval (seconds) between subsequent attempts to contact the master



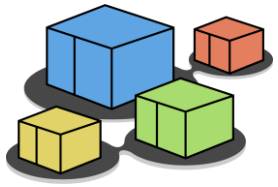
step 2 – exploring the configuration

- configuration on the name servers specifies
  - authoritative information

```
root@dnsuni:~$ cat /etc/bind/db.it.uniroma3
$TTL    60000
@                       I
root.dnsuni.unir
                              28 ; refresh
                              14 ; retry
                              3600000 ; expire
                              0 ; negative cache ttl
                              )
```

if the slave fails to contact the master for this amount of time, it considers the zone data too old and stops giving answers about it

slave expire time (seconds)

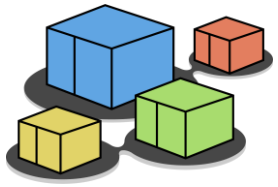


step 2 – exploring the configuration

- configuration on the name servers specifies
  - authoritative information

```
root@dnsuni:~$ cat /etc/bind/db.it.uniroma3
$TTL    60000
@               IN      SOA     dnsuni.uniroma3.it.
root.dnsuni.uniroma3.it. (
                        2006031201 ; serial
                        28 ; refresh
                        14 ; retry
                        3600000 ; expire
                        0 ; negative cache ttl
                        )
```

ttl for negative responses from authoritative name servers



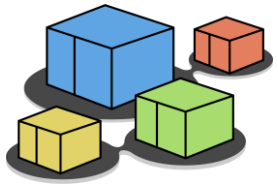
step 2 – exploring the configuration

- configuration on the name servers specifies
  - associations between names and ip addresses

```
root@dnsuni:~$ cat /etc/bind/db.it.uniroma3
$TTL    60000
@               IN      SOA     dnsuni.uniroma3.it.
r       t@dnsuni.uniroma3.it. (
                                2006031201 ;
                                28 ; refresh
                                14 ; retry
                                3600000 ; exp
                                0 ; negative cache ttl
                                )
@                       IN      NS      dnsuni.uniroma3.it.
dnsuni.uniroma3.it.     IN      A       192.168.0.11
pc1.uniroma3.it.        IN      A       192.168.0.111
```

record type NS (name server)

the authoritative name server for this zone (**uniroma3.it**) is **dnsuni.uniroma3.it**



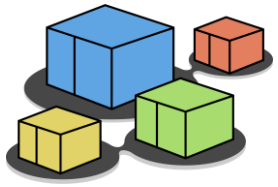
step 2 – exploring the configuration

- configuration on the name servers specifies
  - associations between names and ip addresses

```
root@dnsuni:~$ cat /etc/bind/db.it.uniroma3
$TTL    60000
@               IN      SOA     dnsuni.uniroma3.it.
root.dnsuni.uniroma3.it. (
                        2006031201 ; serial
                        28 ; refresh
                        14 ; retry
                        3600000 ; exp
                        0 ; negative
                        )
@                       IN      NS      dnsuni.uniroma3.it.
dnsuni.uniroma3.it.     IN      A       192.168.0.11
pc1.uniroma3.it.        IN      A       192.168.0.111
```

record type A (address)

two machines in this zone:
dnsuni.uniroma3.it
pc1.uniroma3.it



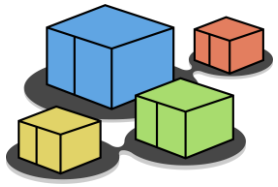
step 2 – exploring the configuration

- configuration on the name servers specifies
  - associations between names and ip addresses

```
root@dnsit:~$ tail -n 5 /etc/bind/db.it
@                       IN      NS      dnsit.it.
dnsit.it.               IN      A       192.168.0.1

uniroma3.it.            IN      NS      dnsuni.uniroma3.it.
dnsuni.uniroma3.it.     IN      A       192.168.0.11
```

dnsit.it is the authority for this zone (**it**)

dnsuni.uniroma3.it is the authority for zone **uniroma3(.it)**



step 2 – exploring the configuration

- configuration on the name servers specifies
  - allowing recursive queries and disabling dnssec

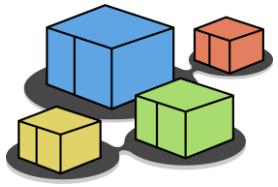
```
root@localuni:~$ cat /etc/bind/named.conf.options
options {
    directory "/var/cache/bind";
    allow-recursion { 192.168.0.0/24; };
    auto-dnssec off;
    dnssec-validation no;
    dnssec-enable no;
    dnssec-lookaside no;
    filter-aaaa-on-v4 yes;
    send-cookie no;
};
```

disable dnssec

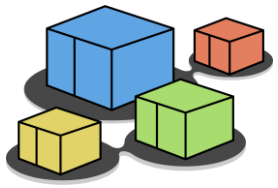
filter AAAA addresses on IPv4 only

allow recursive queries from `192.168.0.0/24`

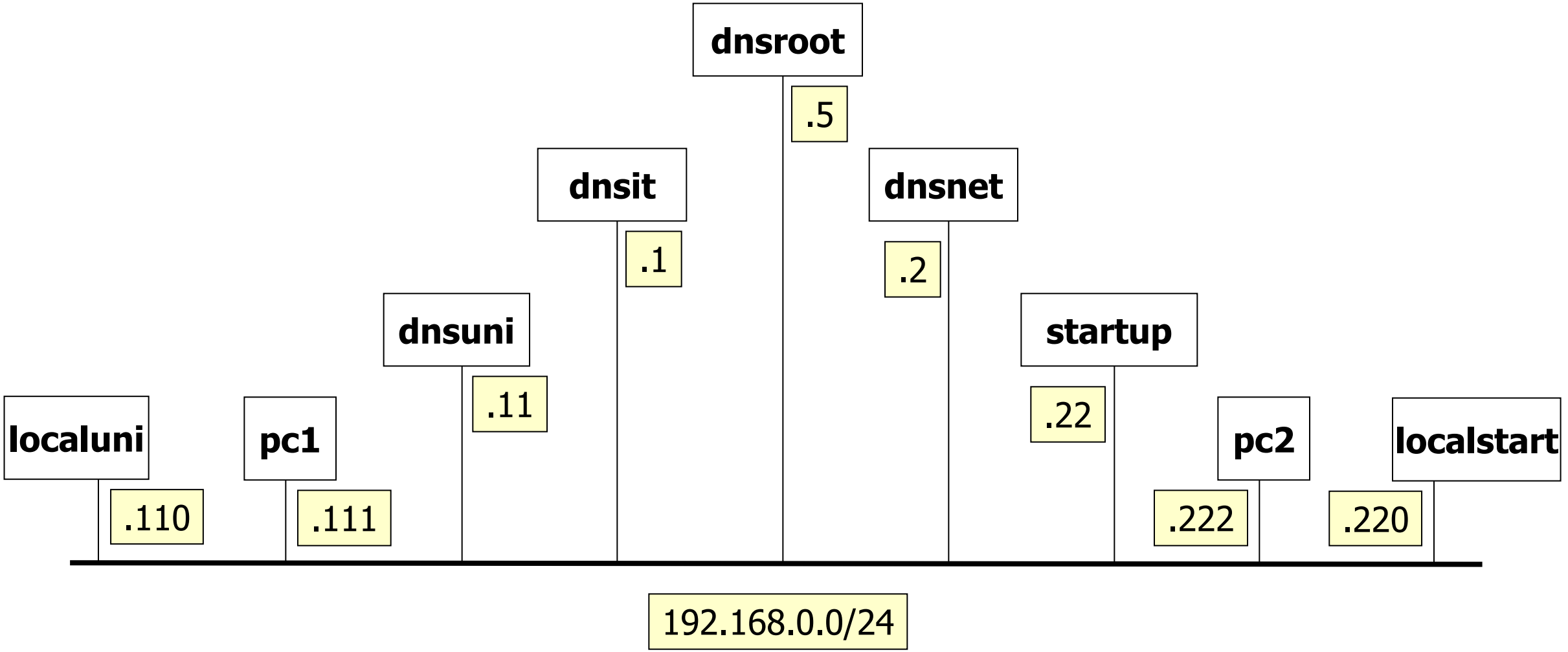
Do not send DNS cookies

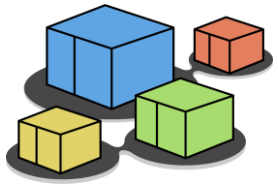


let’s start the lab



step 3 – experiment setting



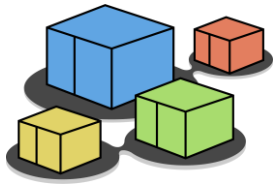


sniff the traffic

- connect the wireshark device to collision domain A

```
user@localhost:~/kathara-lab_dns$ kathara lconfig -n wireshark --add A
```

- open any browser on the host machine
  - on **localhost:3000**
  - sniff eth1



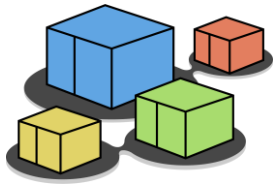
step 3 – ping from pc1

- execute a ping command towards pc2

Numeric output only. No attempt will be made to lookup symbolic names for host addresses.

pc1

```
root@pc1:/# ping -n pc2.startup.net
PING pc2.startup.net (192.168.0.222) 56(84) bytes of data.
64 bytes from 192.168.0.222: icmp_seq=1 ttl=64 time=1.50 ms
64 bytes from 192.168.0.222: icmp_seq=2 ttl=64 time=0.580 ms
64 bytes from 192.168.0.222: icmp_seq=3 ttl=64 time=0.525 ms
--- pc2.startup.net ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2010ms
rtt min/avg/max/mdev = 0.525/0.867/1.496/0.445 ms
```



step 3 – the sniffer output

eth1

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

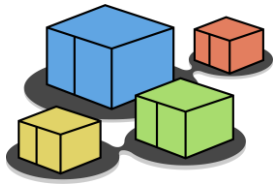
dns

No.	Time	Source	Destination	Protocol	Length	Info
3	0.000433391	192.168.0.111	192.168.0.110	DNS	75	Standard query 0xb5d4 A pc2.startup.net
6	0.003975910	192.168.0.110	192.168.0.5	DNS	86	Standard query 0x8ff1 A pc2.startup.net OPT
7	0.004044955	192.168.0.110	192.168.0.5	DNS	70	Standard query 0x7d19 NS <Root> OPT
8	0.004896721	192.168.0.5	192.168.0.110	DNS	123	Standard query response 0x8ff1 A pc2.startup.net NS dnsnet.net A 192.168.0.2 OPT
9	0.005024653	192.168.0.5	192.168.0.110	DNS	110	Standard query response 0x7d19 NS <Root> NS ROOT-SERVER A 192.168.0.5 OPT
12	0.006382260	192.168.0.110	192.168.0.2	DNS	86	Standard query 0x5ac0 A pc2.startup.net OPT
13	0.008519351	192.168.0.2	192.168.0.110	DNS	125	Standard query response 0x5ac0 A pc2.startup.net NS dnsstart.startup.net A 192.168.0.22 OPT
16	0.009507968	192.168.0.110	192.168.0.22	DNS	86	Standard query 0x4bba A pc2.startup.net OPT
17	0.009914852	192.168.0.22	192.168.0.110	DNS	102	Standard query response 0x4bba A pc2.startup.net A 192.168.0.222 OPT
18	0.010656291	192.168.0.110	192.168.0.111	DNS	130	Standard query response 0xb5d4 A pc2.startup.net A 192.168.0.222 NS dnsstart.startup.net A 192.168.0.22
19	0.010932933	192.168.0.111	192.168.0.110	DNS	75	Standard query 0xeccb AAAA pc2.startup.net
20	0.011471405	192.168.0.110	192.168.0.22	DNS	86	Standard query 0x722b AAAA pc2.startup.net OPT
21	0.011875739	192.168.0.22	192.168.0.110	DNS	136	Standard query response 0x722b AAAA pc2.startup.net SOA dnsstart.startup.net OPT
22	0.012129873	192.168.0.110	192.168.0.111	DNS	125	Standard query response 0xeccb AAAA pc2.startup.net SOA dnsstart.startup.net

```
▸ Frame 3: 75 bytes on wire (600 bits), 75 bytes captured (600 bits) on interface et
▸ Ethernet II, Src: 92:93:6c:69:91:fc (92:93:6c:69:91:fc), Dst: ee:d6:b8:29:cf:ae (e
▸ Internet Protocol Version 4, Src: 192.168.0.111, Dst: 192.168.0.110
▸ User Datagram Protocol, Src Port: 39838, Dst Port: 53
▾ Domain Name System (query)
    Transaction ID: 0xb5d4
  ▸ Flags: 0x0100 Standard query
    Questions: 1
    Answer RRs: 0
    Authority RRs: 0
    Additional RRs: 0
  ▸ Queries
    [Response In: 18]
```

```
0000  ee d6 b8 29 cf ae 92 93  6c 69 91 fc 08 00 45 00   ···)···· li····E·
0010  00 3d fa ef 40 00 40 11  bd 92 c0 a8 00 6f c0 a8   ·=··@·@· ·····o··
0020  00 6e 9b 9e 00 35 00 29  f5 86 b5 d4 01 00 00 01   ·n···5·) ········
0030  00 00 00 00 00 00 03 70  63 32 07 73 74 61 72 74   ·······p c2·start
0040  75 70 03 6e 65 74 00 00  01 00 01                  up·net·· ···
```

Domain Name System: Protocol — Packets: 40 · Displayed: 14 (35.0%) — Profile: Default



ste sniffer output

filter to only show DNS packets

File Edit View Go Capture Analyze Statistics Telephony

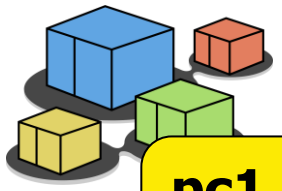
dns

No.	Time	Source	Destination	Protocol	Length	Info
3	0.000433391	192.168.0.111	192.168.0.110	DNS	75	Standard query 0xb5d4 A pc2.startup.net
6	0.003975910	192.168.0.110	192.168.0.5	DNS	86	Standard query 0x8ff1 A pc2.startup.net OPT
7	0.004044955	192.168.0.110	192.168.0.5	DNS	70	Standard query 0x7d19 NS <Root> OPT
8	0.004896721	192.168.0.5	192.168.0.110	DNS	123	Standard query response 0x8ff1 A pc2.startup.net NS dnsnet.net A 192.168.0.2 OPT
9	0.005024653	192.168.0.5	192.168.0.110	DNS	110	Standard query response 0x7d19 NS <Root> NS ROOT-SERVER A 192.168.0.5 OPT
12	0.006382260	192.168.0.110	192.168.0.2	DNS	86	Standard query 0x5ac0 A pc2.startup.net OPT
13	0.008519351	192.168.0.2	192.168.0.110	DNS	125	Standard query response 0x5ac0 A pc2.startup.net NS dnsstart.startup.net A 192.168.0.22 OPT
16	0.009507968	192.168.0.110	192.168.0.22	DNS	86	Standard query 0x4bba A pc2.startup.net OPT
17	0.009914852	192.168.0.22	192.168.0.110	DNS	102	Standard query response 0x4bba A pc2.startup.net A 192.168.0.222 OPT
18	0.010656291	192.168.0.110	192.168.0.111	DNS	130	Standard query response 0xb5d4 A pc2.startup.net A 192.168.0.222 NS dnsstart.startup.net A 192.168.0.22
19	0.010932933	192.168.0.111	192.168.0.110	DNS	75	Standard query 0xeccb AAAA pc2.startup.net
20	0.011471405	192.168.0.110	192.168.0.22	DNS	86	Standard query 0x722b AAAA pc2.startup.net OPT
21	0.011875739	192.168.0.22	192.168.0.110	DNS	136	Standard query response 0x722b AAAA pc2.startup.net SOA dnsstart.startup.net OPT
22	0.012129873	192.168.0.110	192.168.0.111	DNS	125	Standard query response 0xeccb AAAA pc2.startup.net SOA dnsstart.startup.net

```
▸ Frame 3: 75 bytes on wire (600 bits), 75 bytes captured (600 bits) on interface et
▸ Ethernet II, Src: 92:93:6c:69:91:fc (92:93:6c:69:91:fc), Dst: ee:d6:b8:29:cf:ae (e
▸ Internet Protocol Version 4, Src: 192.168.0.111, Dst: 192.168.0.110
▸ User Datagram Protocol, Src Port: 39838, Dst Port: 53
▾ Domain Name System (query)
    Transaction ID: 0xb5d4
  ▸ Flags: 0x0100 Standard query
    Questions: 1
    Answer RRs: 0
    Authority RRs: 0
    Additional RRs: 0
  ▸ Queries
    [Response In: 18]
```

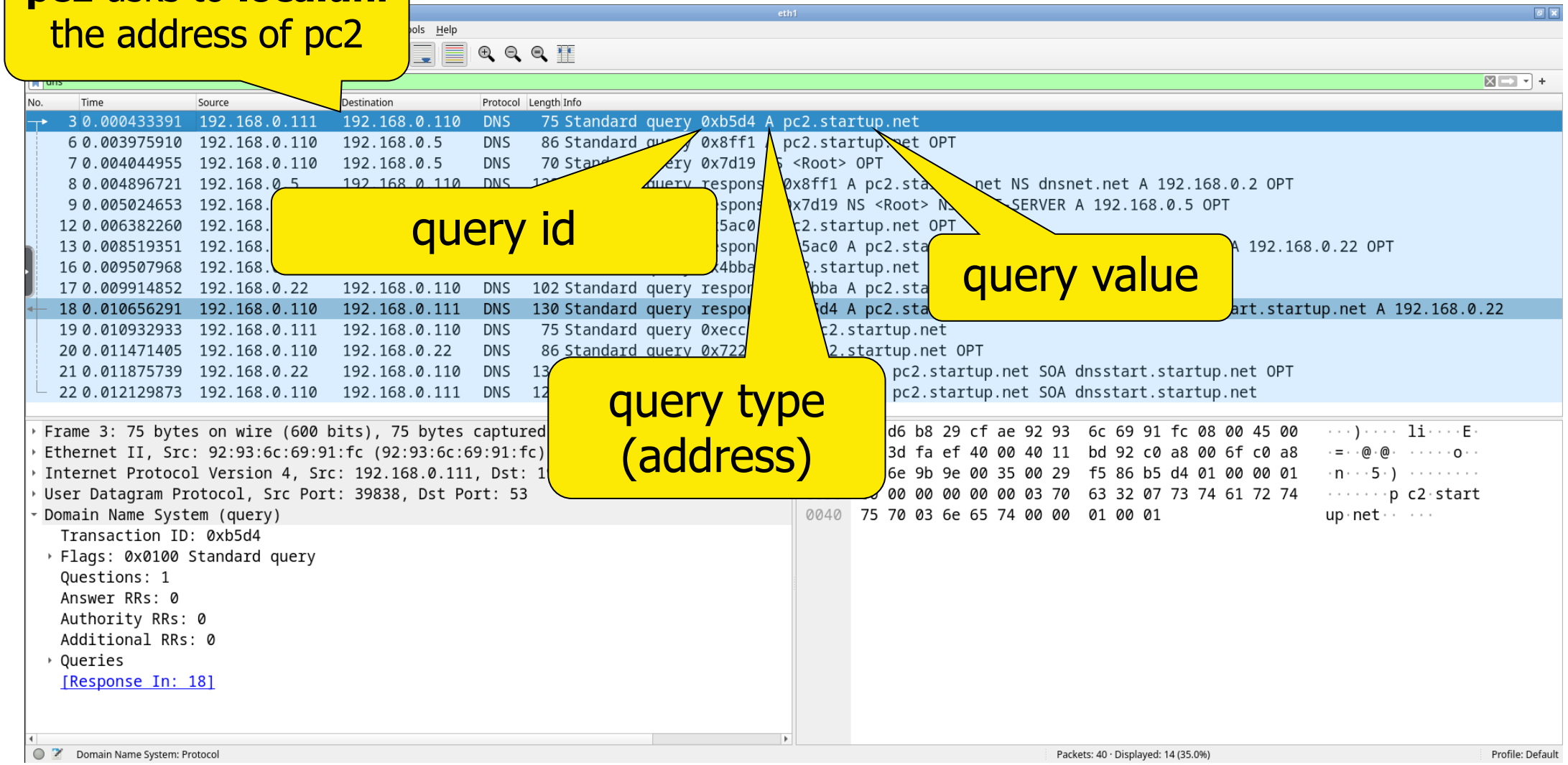
```
0000  ee d6 b8 29 cf ae 92 93  6c 69 91 fc 08 00 45 00   ···)···· li····E·
0010  00 3d fa ef 40 00 40 11  bd 92 c0 a8 00 6f c0 a8   ·=··@·@· ·····o··
0020  00 6e 9b 9e 00 35 00 29  f5 86 b5 d4 01 00 00 01   ·n···5·) ········
0030  00 00 00 00 00 00 03 70  63 32 07 73 74 61 72 74   ·······p c2·start
0040  75 70 03 6e 65 74 00 00  01 00 01                  up·net·· ···
```

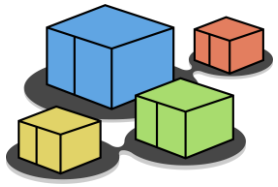
Domain Name System: Protocol — Packets: 40 · Displayed: 14 (35.0%) — Profile: Default



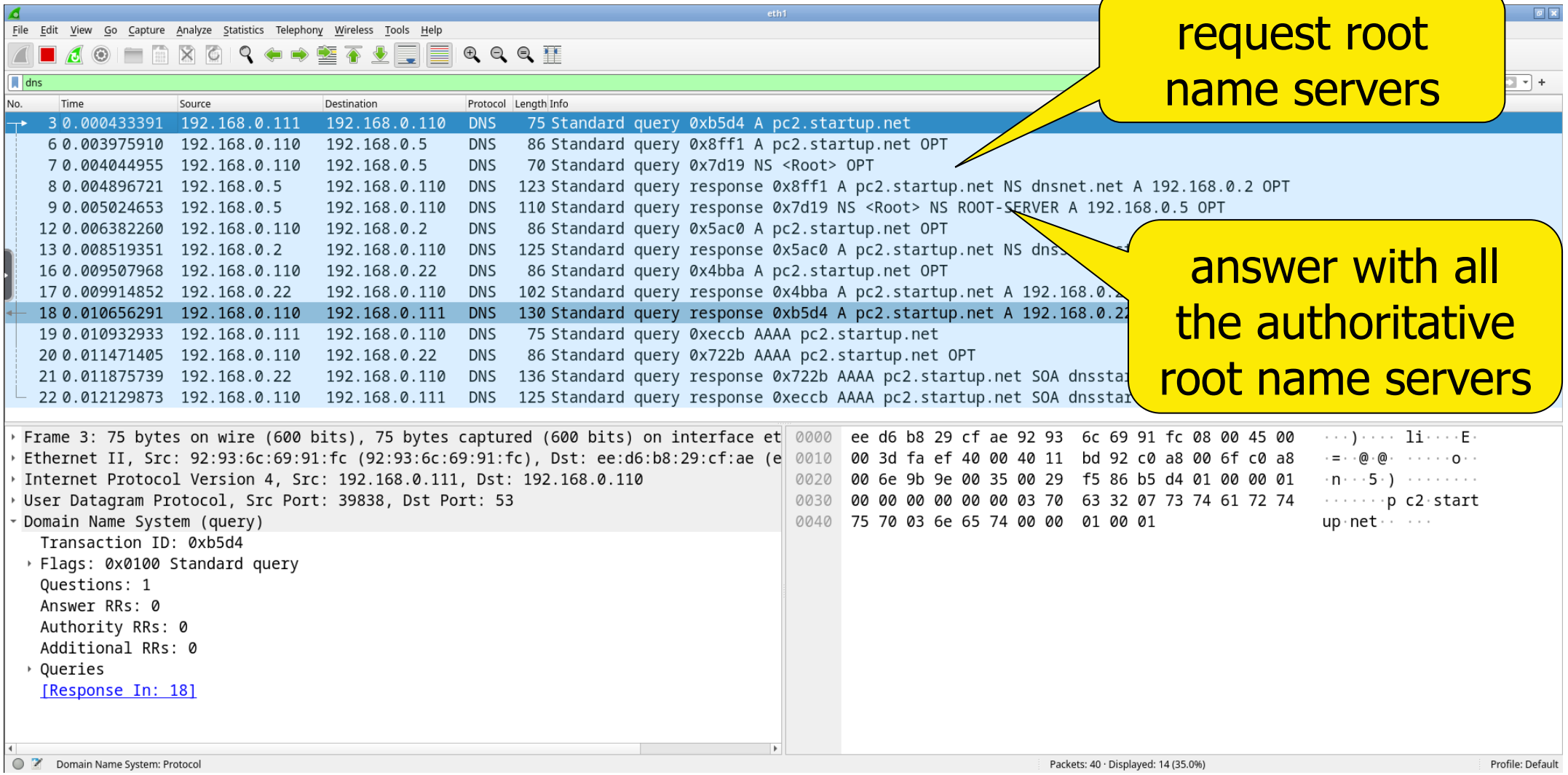
step 3 – the sniffer output

pc1 asks to **localuni** the address of pc2





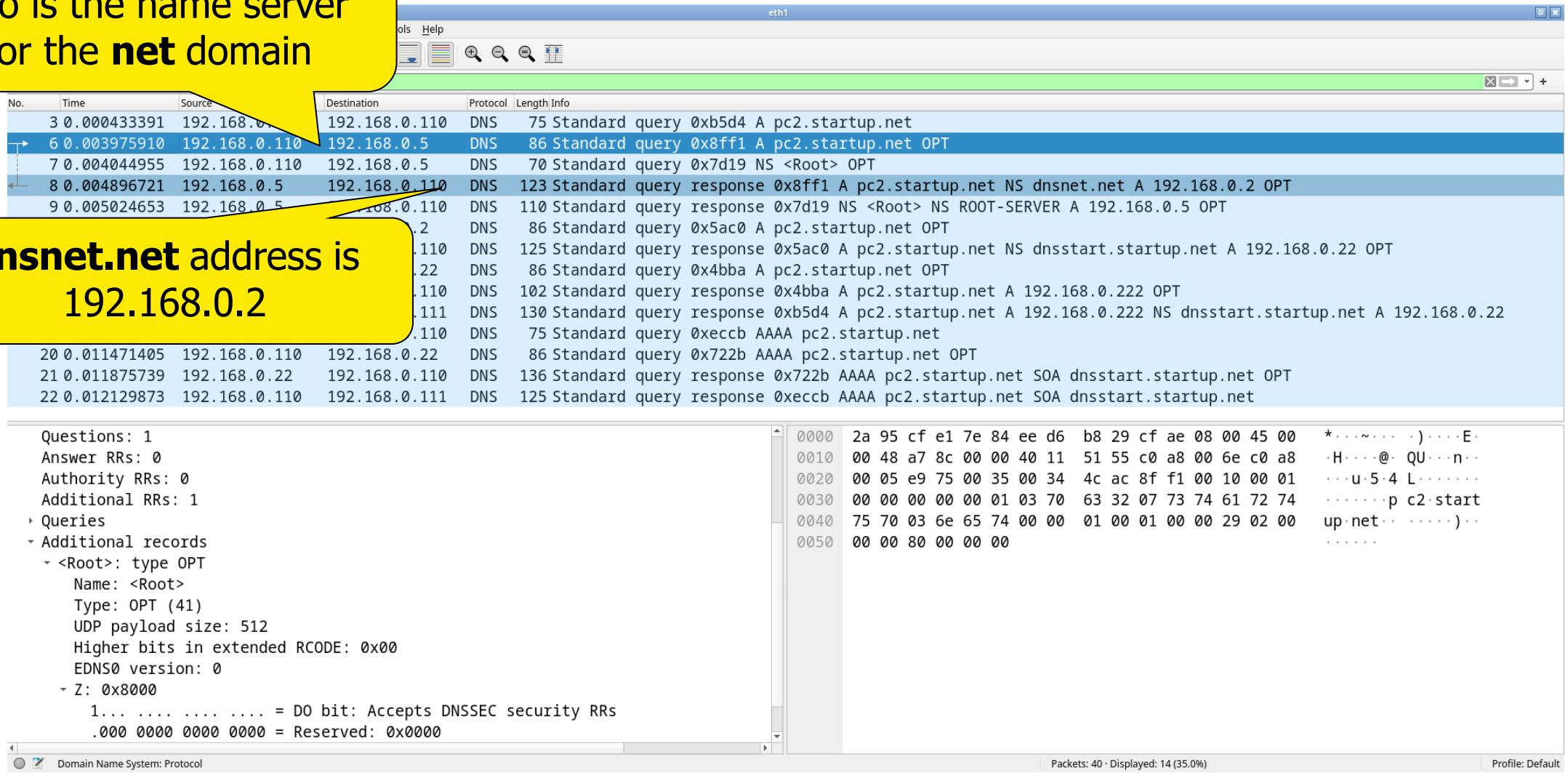
step 3 – the sniffer output

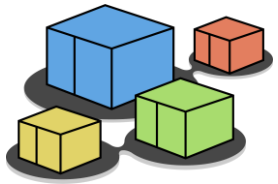


step 3 – the sniffer output

localuni asks **dnsroot** who is the name server for the **net** domain

dnsnet.net address is 192.168.0.2





step 3 – the sniffer output

localuni asks **dnsnet** who is the name server for the **startup.net** domain

dnsstart.startup.net address is 192.168.0.22

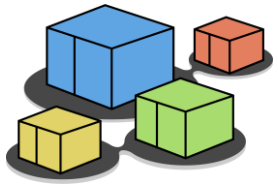
eth1

				Protocol	Length	Info
				DNS	75	Standard query 0xb5d4 A pc2.startup.net
				DNS	86	Standard query 0x8ff1 A pc2.startup.net OPT
				DNS	70	Standard query 0x7d19 NS <Root> OPT
8	0.004896721	192.168.0	.168.0.110	DNS	123	Standard query response 0x8ff1 A pc2.startup.net NS dnsnet.net A 192.168.0.2 OPT
9	0.005024653	192.168.0.5	.168.0.110	DNS	110	Standard query response 0x7d19 NS <Root> NS ROOT-SERVER A 192.168.0.5 OPT
12	0.006382260	192.168.0.110	192.168.0.2	DNS	86	Standard query 0x5ac0 A pc2.startup.net OPT
13	0.008519351	192.168.0.2	192.168.0.110	DNS	125	Standard query response 0x5ac0 A pc2.startup.net NS dnsstart.startup.net A 192.168.0.22 OPT
16	0.009507968	192.168.0.110	192.168.0.22	DNS	86	Standard query 0x4bba A pc2.startup.net OPT
17	0.009914852	192.168.0.22	192.168.0.110	DNS	102	Standard query response 0x4bba A pc2.startup.net A 192.168.0.222 OPT
18	0.010656291	192.168.0.11				xb5d4 A pc2.startup.net A 192.168.0.222 NS dnsstart.startup.net A 192.168.0.22
19	0.010932933	192.168.0.11				A pc2.startup.net
20	0.011471405	192.168.0.11				A pc2.startup.net OPT
21	0.011875739	192.168.0.22				x722b AAAA pc2.startup.net SOA dnsstart.startup.net OPT
22	0.012129873	192.168.0.11				xeccb AAAA pc2.startup.net SOA dnsstart.startup.net

```
Questions: 1
Answer RRs: 0
Authority RRs: 0
Additional RRs: 1
▸ Queries
▾ Additional records
  ▾ <Root>: type OPT
      Name: <Root>
      Type: OPT (41)
      UDP payload size: 512
      Higher bits in extended RCODE: 0x00
      EDNS0 version: 0
    ▾ Z: 0x8000
        1... .... .... .... = DO bit: Accepts DNSSEC security RRs
        .000 0000 0000 0000 = Reserved: 0x0000
```

```
0000  62 ae ad 92 4c 64 ee d6  b8 29 cf ae 08 00 45 00   b···Ld··  ·)····E·
0010  00 48 98 26 00 00 40 11  60 be c0 a8 00 6e c0 a8   ·H·&··@·  `····n··
0020  00 02 c5 ac 00 35 00 34  a5 a9 5a c0 00 10 00 01   ·····5·4  ··Z·····
0030  00 00 00 00 00 01 03 70  63 32 07 73 74 61 72 74   ·······p  c2·start
0040  75 70 03 6e 65 74 00 00  01 00 01 00 00 29 02 00   up·net··  ·····)··
0050  00 00 80 00 00 00                                  ······
```

Domain Name System: Protocol — Packets: 40 · Displayed: 14 (35.0%) — Profile: Default



step 3 – the sniffer output

localuni asks **dnsstart** what is the address of **pc2.startup.net**

pc2.startup.net address is 192.168.0.222

eth1

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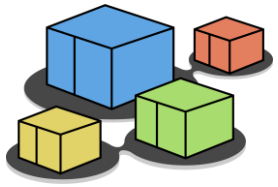
				Protocol	Length	Info
				DNS	75	Standard query 0xb5d4 A pc2.startup.net
				DNS	86	Standard query 0x8ff1 A pc2.startup.net OPT
				DNS	70	Standard query 0x7d19 NS <Root> OPT
				DNS	123	Standard query response 0x8ff1 A pc2.startup.net NS dnsnet.net A 192.168.0.2 OPT
9	0.005024653	192.168	168.0.110	DNS	110	Standard query response 0x7d19 NS <Root> NS ROOT-SERVER A 192.168.0.5 OPT
12	0.006382260	192.168.0.110	68.0.2	DNS	86	Standard query 0x5ac0 A pc2.startup.net OPT
13	0.008519351	192.168.0.2	0.110	DNS	125	Standard query response 0x5ac0 A pc2.startup.net NS dnsstart.startup.net A 192.168.0.22 OPT
16	0.009507968	192.168.0.110	192.168.0.22	DNS	86	Standard query 0x4bba A pc2.startup.net OPT
17	0.009914852	192.168.0.22	192.168.0.110	DNS	102	Standard query response 0x4bba A pc2.startup.net A 192.168.0.222 OPT
18	0.010656291	192.168.0.110	192.168.0.111	DNS	130	Standard response 0xb5d4 A pc2.startup.net A 192.168.0.222 NS dnsstart.startup.net A 192.168.0.22
19	0.010932933	192.168				eccb AAAA pc2.startup.net
20	0.011471405	192.1				2b AAAA pc2.startup.net OPT
21	0.011875739	192.1				onse 0x722b AAAA pc2.startup.net SOA dnsstart.startup.net OPT
22	0.012129873	192.1				onse 0xeccb AAAA pc2.startup.net SOA dnsstart.startup.net

```
Questions: 1
Answer RRs: 0
Authority RRs: 0
Additional RRs: 1
▸ Queries
▾ Additional records
  ▾ <Root>: type OPT
      Name: <Root>
      Type: OPT (41)
      UDP payload size: 512
      Higher bits in extended RCODE: 0x00
      EDNS0 version: 0
    ▾ Z: 0x8000
        1... .... .... .... = DO bit: Accepts DNSSEC security RRs
        .000 0000 0000 0000 = Reserved: 0x0000
```

```
0000  32 2f 57 e4 8d 25 ee d6  b8 29 cf ae 08 00 45 00   2/W··%·· ·)····E·
0010  00 48 2c ef 00 00 40 11  cb e1 c0 a8 00 6e c0 a8   ·H,···@· ·····n··
0020  00 16 ce 11 00 35 00 34  ac 36 4b ba 00 10 00 01   ·····5·4 ·6K·····
0030  00 00 00 00 00 01 03 70  63 32 07 73 74 61 72 74   ·······p c2·start
0040  75 70 03 6e 65 74 00 00  01 00 01 00 00 29 02 00   up·net·· ·····)··
0050  00 00 80 00 00 00                                  ·····
```

Domain Name System: Protocol — Packets: 40 · Displayed: 14 (35.0%) — Profile: Default



step 3 – the sniffer output

localuni reports to **pc1** the addres of **pc2.startup.net**

eth1

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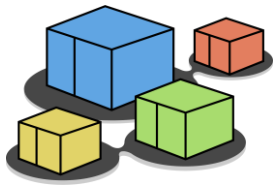
dns

No.	Time	Source	Destination	Protocol	Length	Info
				DNS	75	Standard query 0xb5d4 A pc2.startup.net
				DNS	86	Standard query 0x8ff1 A pc2.startup.net OPT
				DNS	70	Standard query 0x7d19 NS <Root> OPT
				DNS	123	Standard query response 0x8ff1 A pc2.startup.net NS dnsnet.net A 192.168.0.2 OPT
				DNS	110	Standard query response 0x7d19 NS <Root> NS ROOT-SERVER A 192.168.0.5 OPT
				DNS	86	Standard query 0x5ac0 A pc2.startup.net OPT
13	0.008519351	192.1	.168.0.110	DNS	125	Standard query response 0x5ac0 A pc2.startup.net NS dnsstart.startup.net A 192.168.0.22 OPT
16	0.009507968	192.168.0	92.168.0.22	DNS	86	Standard query 0x4bba A pc2.startup.net OPT
17	0.009914852	192.168.0.22	192.168.0.110	DNS	102	Standard query response 0x4bba A pc2.startup.net A 192.168.0.222 OPT
18	0.010656291	192.168.0.110	192.168.0.111	DNS	130	Standard query response 0xb5d4 A pc2.startup.net A 192.168.0.222 NS dnsstart.startup.net A 192.168.0.22
19	0.010932933	192.168.0.111	192.168.0.110	DNS	75	Standard query 0xeccb AAAA pc2.startup.net
20	0.011471405	192.168.0.110	192.168.0.22	DNS	86	Standard query 0x722b AAAA pc2.startup.net OPT
21	0.011875739	192.168.0.22	192.168.0.110	DNS	136	Standard query response 0x722b AAAA pc2.startup.net SOA dnsstart.startup.net OPT
22	0.012129873	192.168.0.110	192.168.0.111	DNS	125	Standard query response 0xeccb AAAA pc2.startup.net SOA dnsstart.startup.net

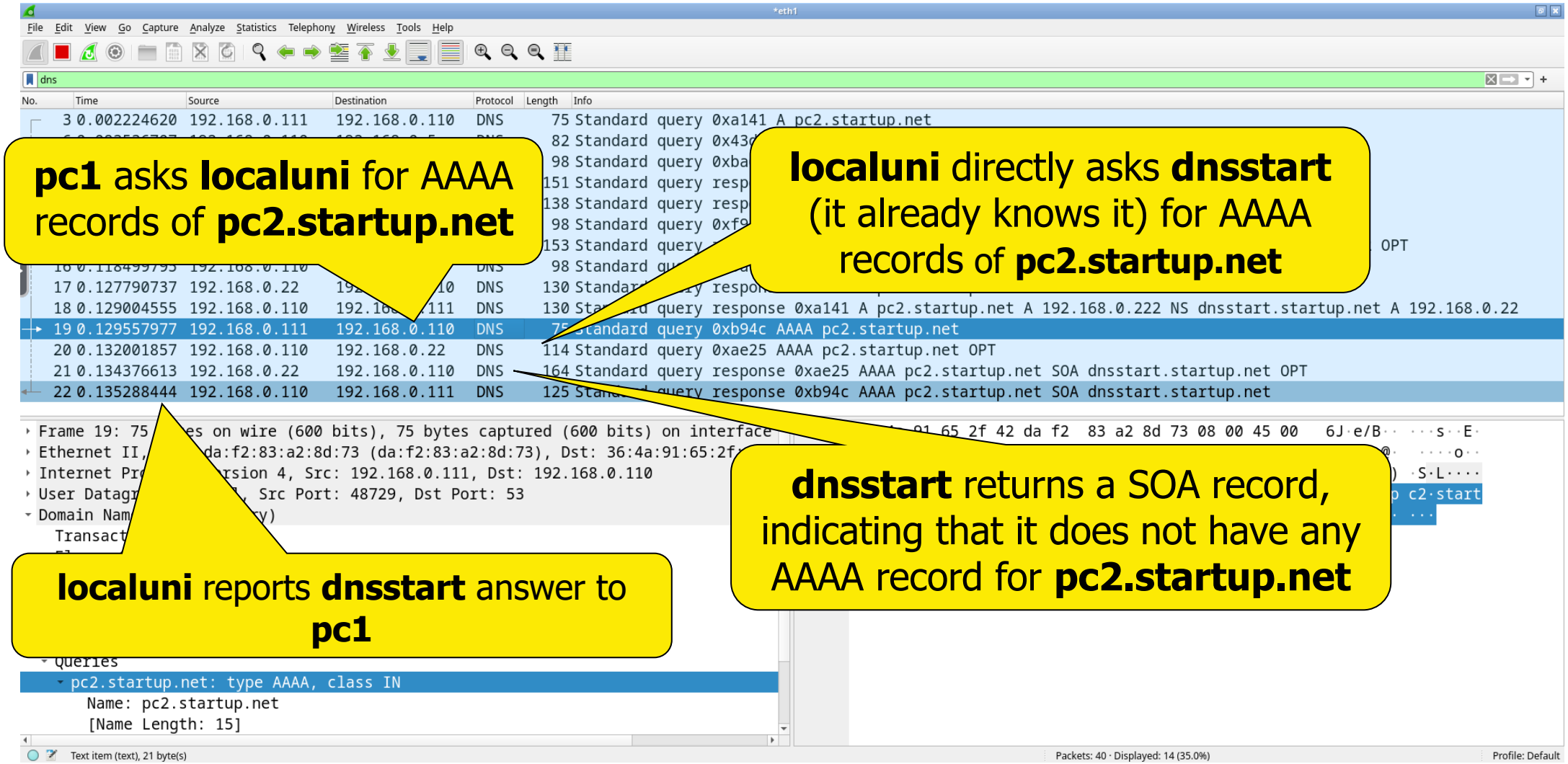
```
Questions: 1
Answer RRs: 1
Authority RRs: 1
Additional RRs: 1
▸ Queries
▾ Answers
  ▾ pc2.startup.net: type A, class IN, addr 192.168.0.222
      Name: pc2.startup.net
      Type: A (Host Address) (1)
      Class: IN (0x0001)
      Time to live: 60000 (16 hours, 40 minutes)
      Data length: 4
      Address: 192.168.0.222
▾ Authoritative nameservers
  ▾ startup.net: type NS, class IN, ns dnsstart.startup.net
```

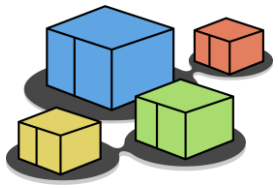
```
0000  92 93 6c 69 91 fc ee d6  b8 29 cf ae 08 00 45 00   ··li····  ·)····E·
0010  00 74 9d 5b 00 00 40 11  5a f0 c0 a8 00 6e c0 a8   ·t·[··@·  Z····n··
0020  00 6f 00 35 9b 9e 00 60  10 4b b5 d4 81 80 00 01   ·o·5···`  ·K······
0030  00 01 00 01 00 01 03 70  63 32 07 73 74 61 72 74   ·······p  c2·start
0040  75 70 03 6e 65 74 00 00  01 00 01 c0 0c 00 01 00   up·net··  ···· ····
0050  01 00 00 ea 60 00 04 c0  a8 00 de c0 10 00 02 00   ····`···  ···· ····
0060  01 00 00 ea 60 00 0b 08  64 6e 73 73 74 61 72 74   ····`···  dnsstart
0070  c0 10 c0 3d 00 01 00 01  00 00 ea 60 00 04 c0 a8   ···=····  ···`····
0080  00 16                                             ··
```

Text item (text), 16 byte(s) — Packets: 40 · Displayed: 14 (35.0%) — Profile: Default

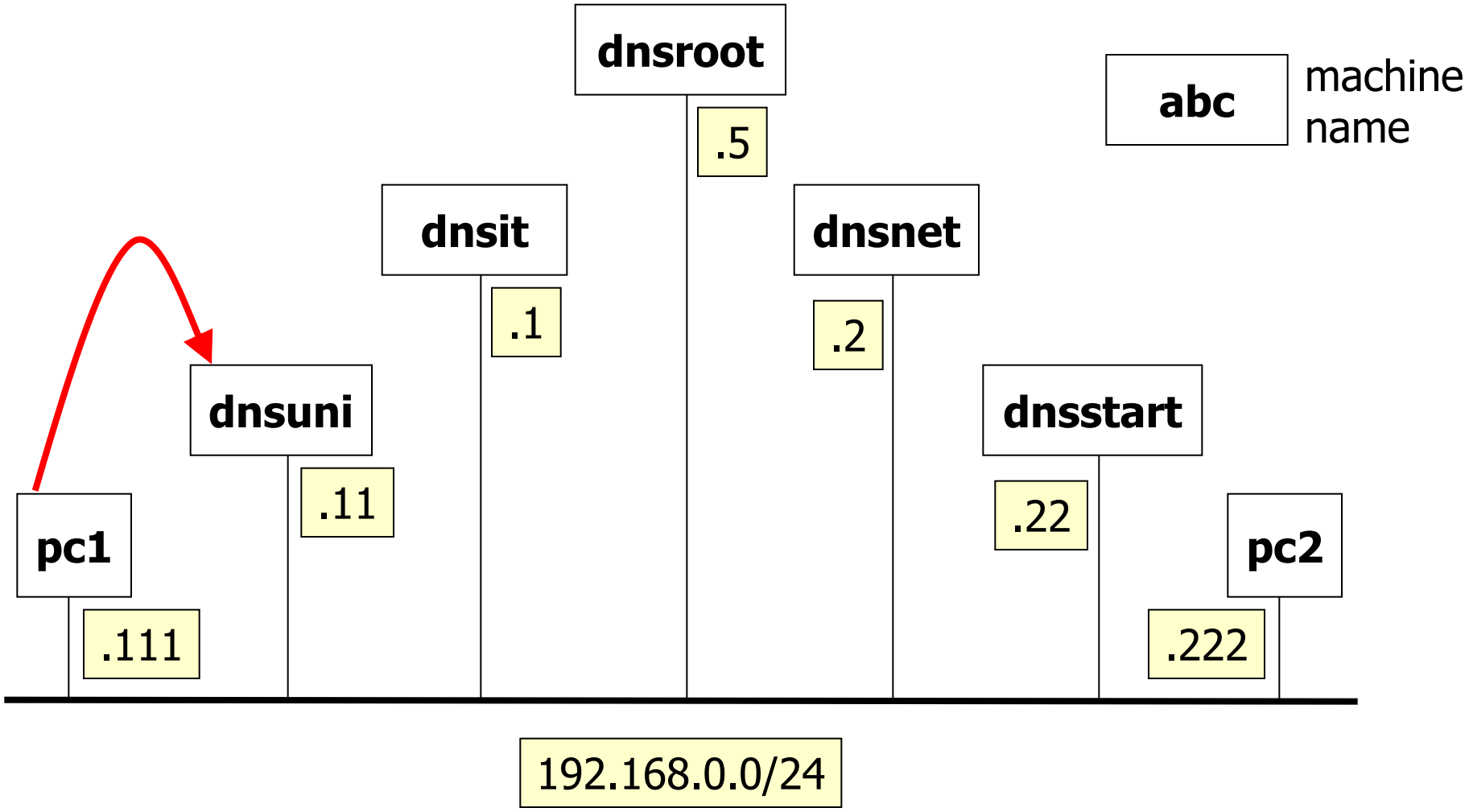


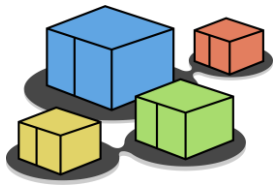
step 3 – the sniffer output



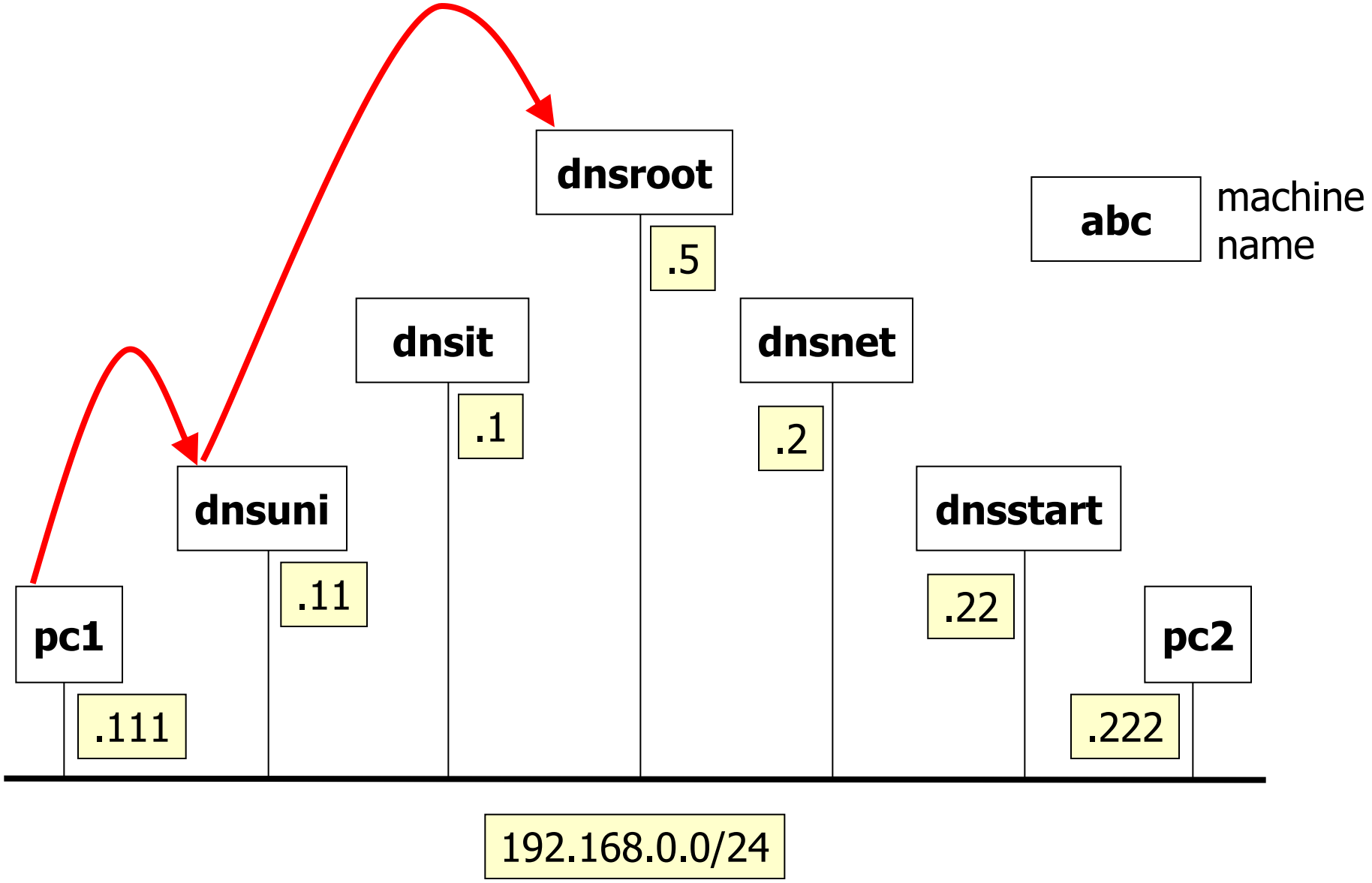


step 3 – exchanged messages

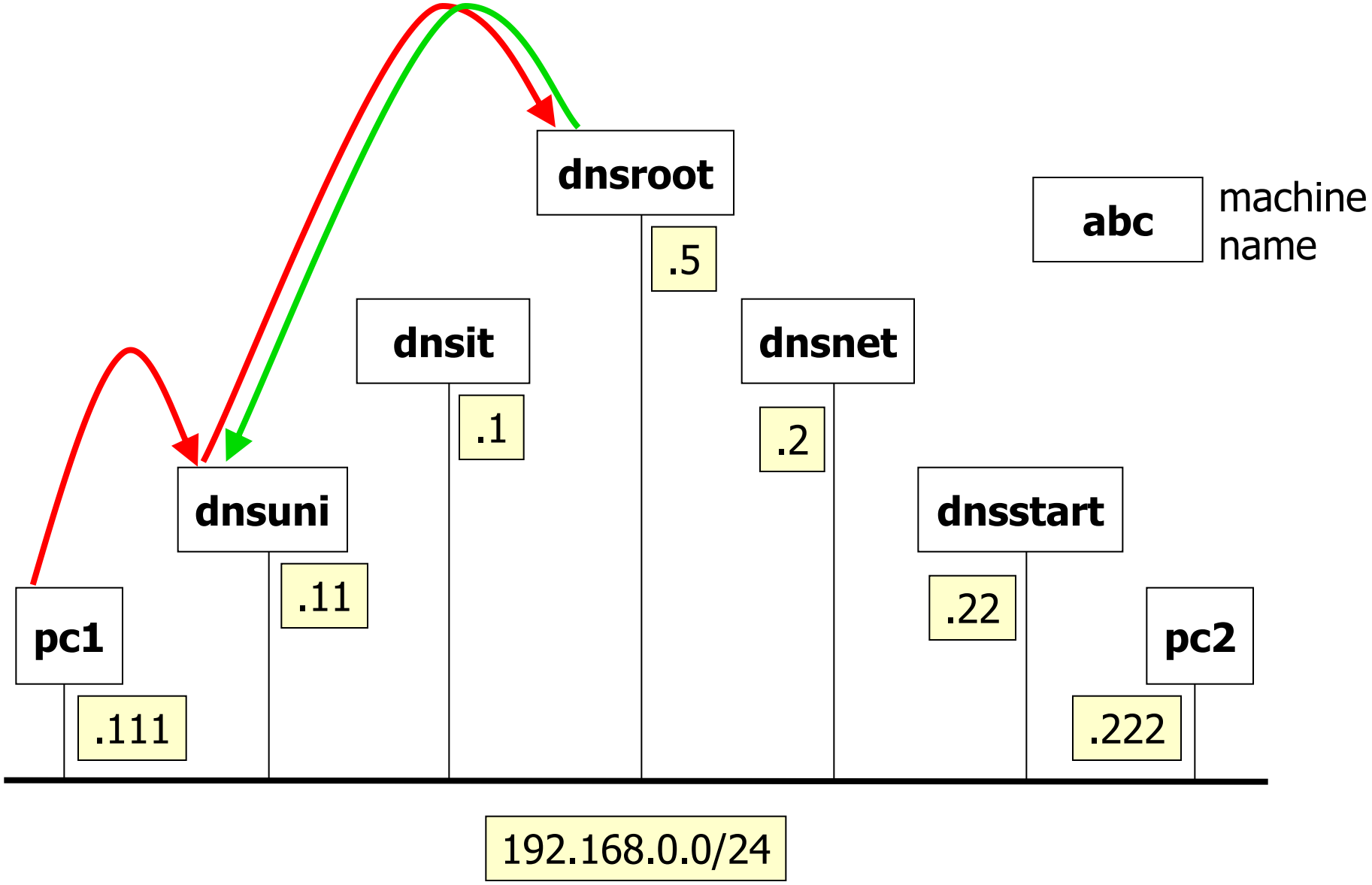




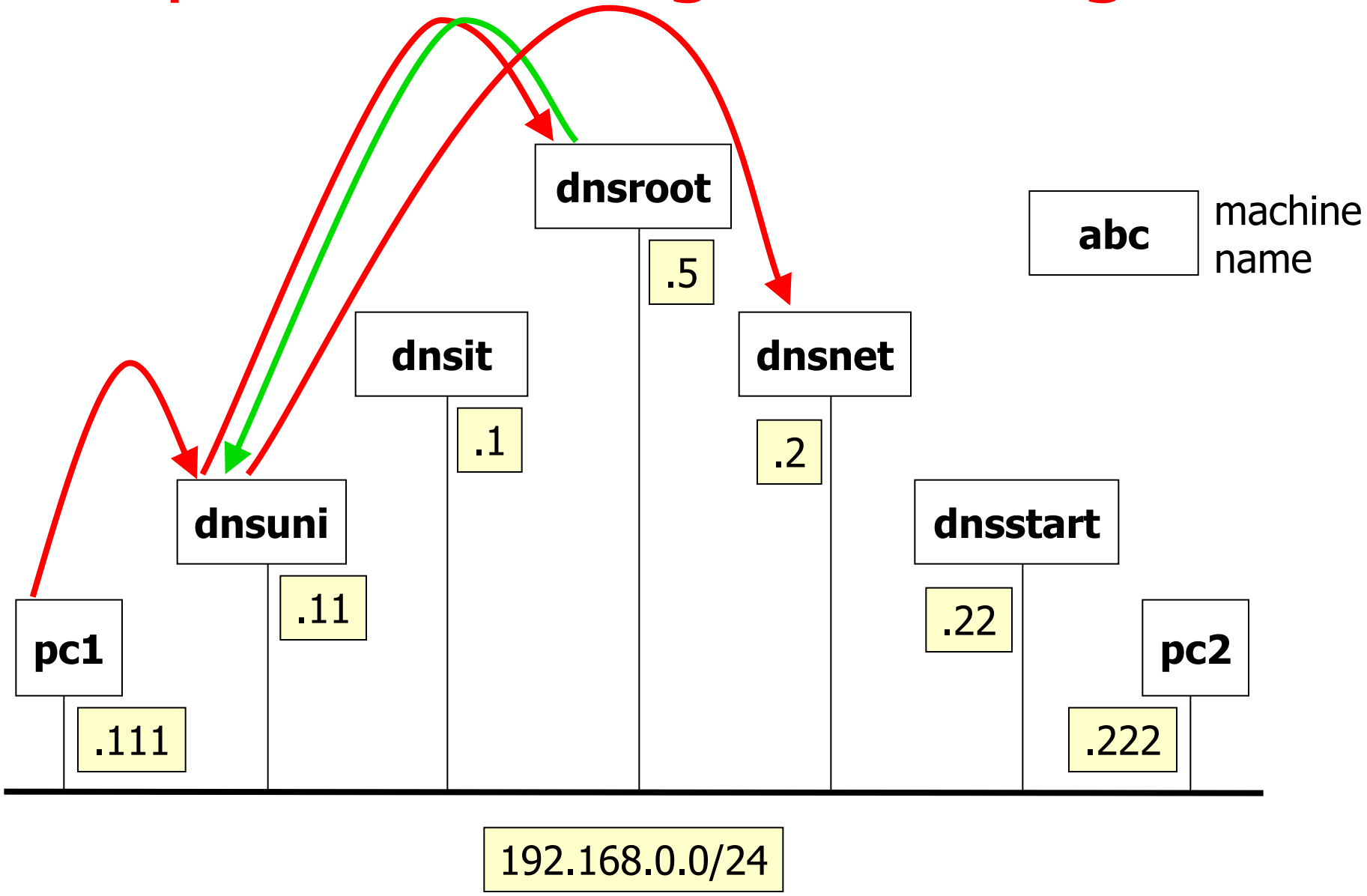
step 3 – exchanged messages

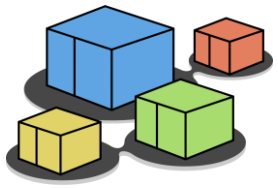


step 3 – exchanged messages

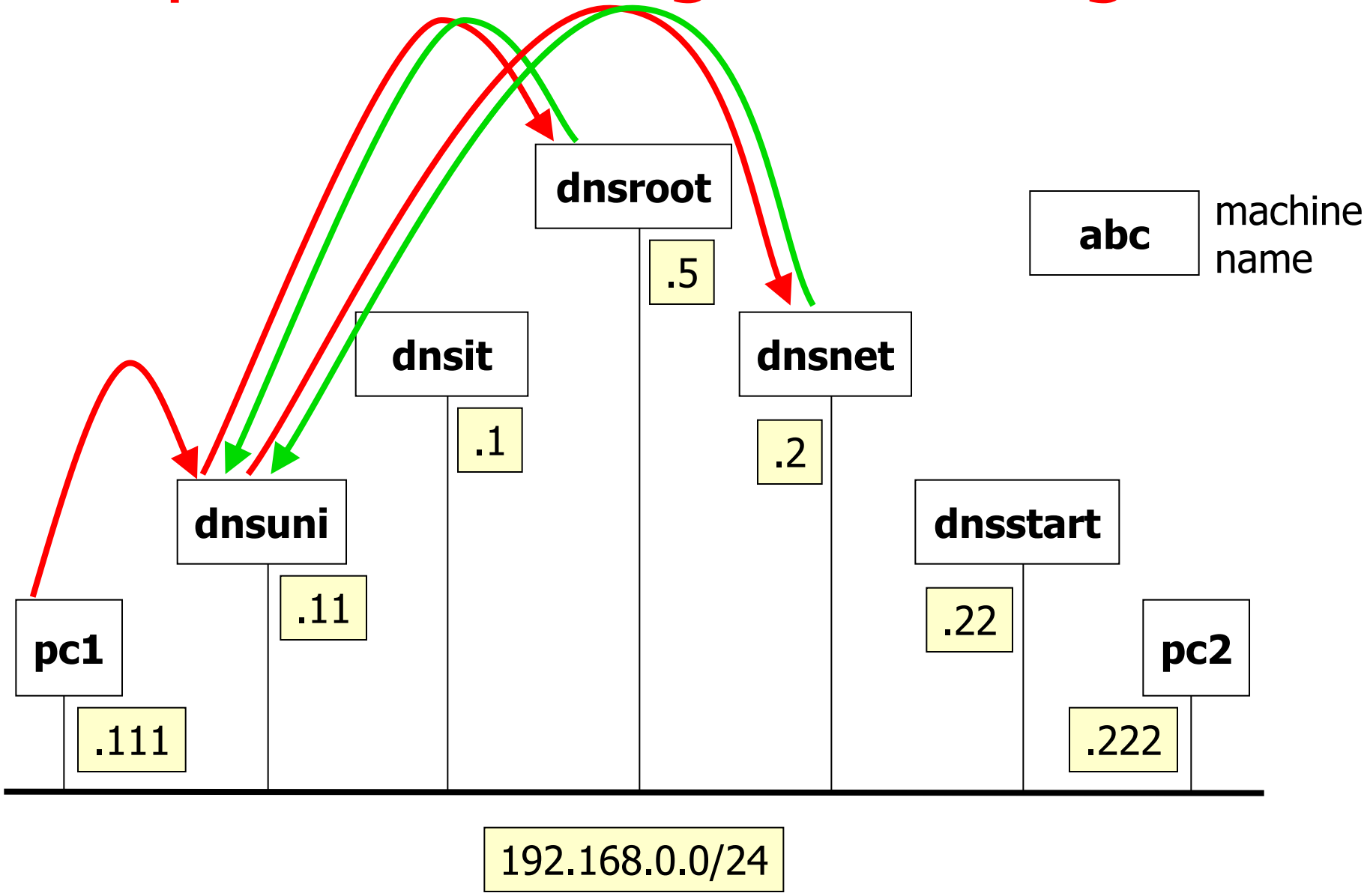


step 3 – exchanged messages

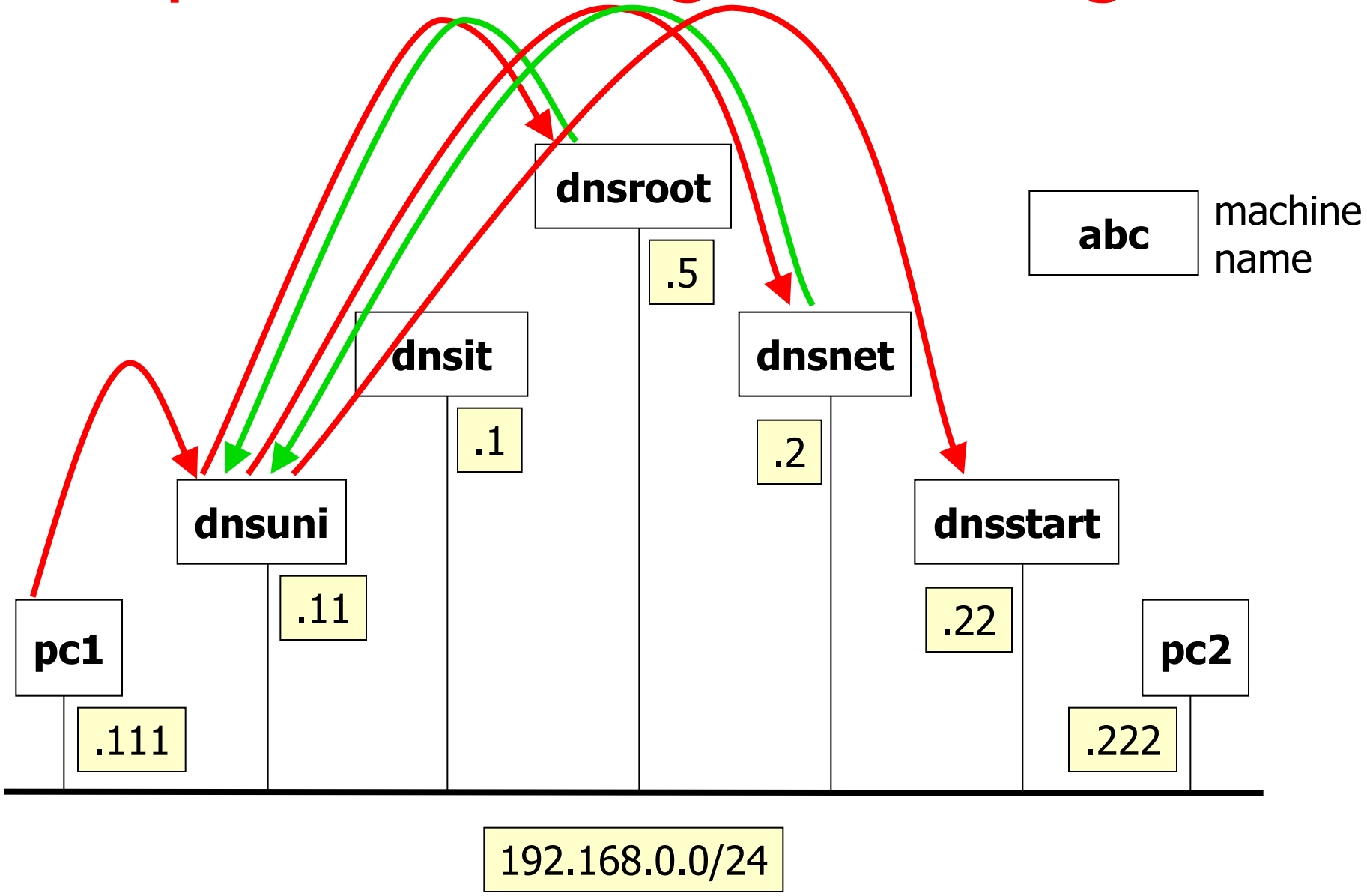




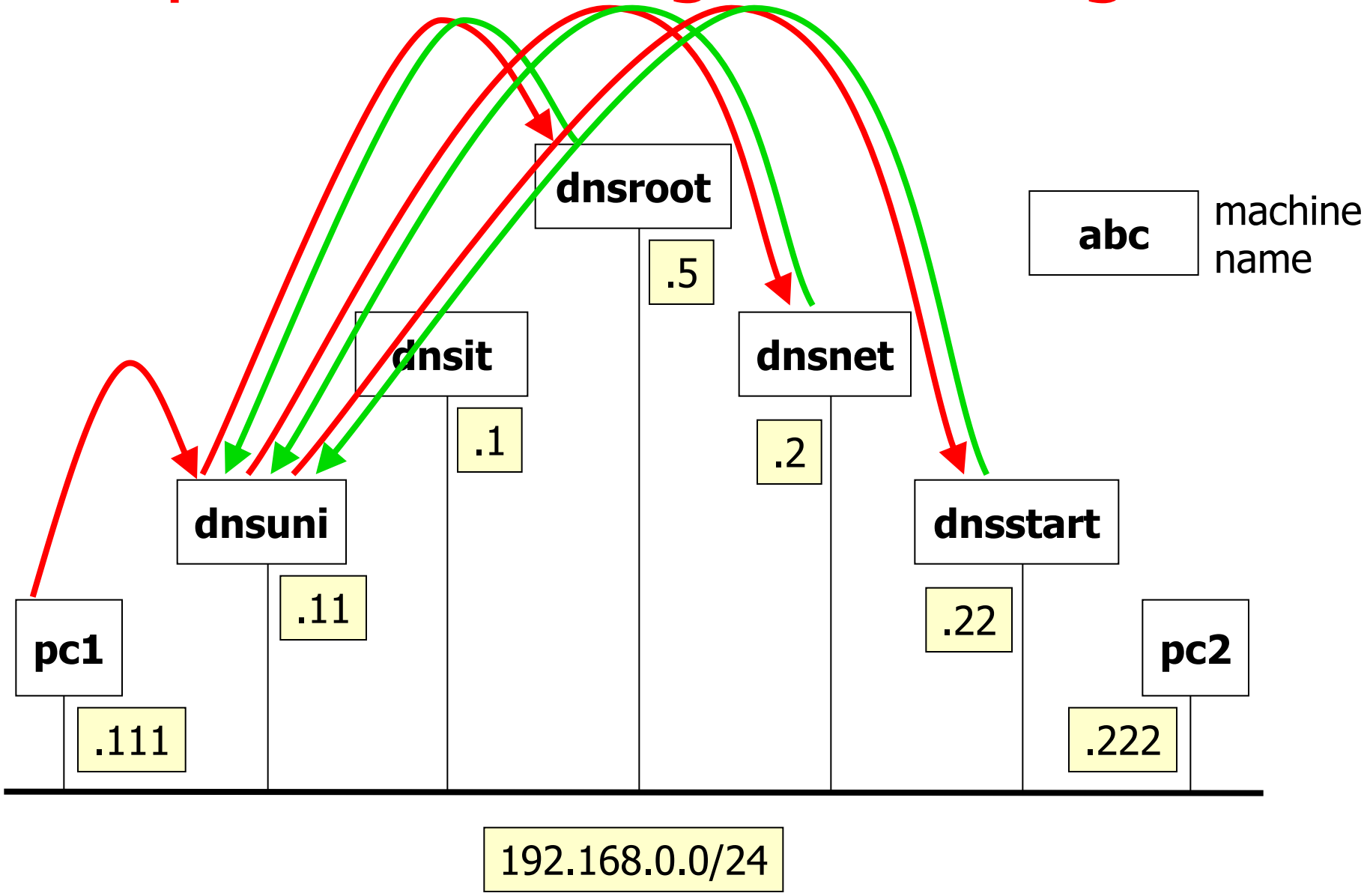
step 3 – exchanged messages



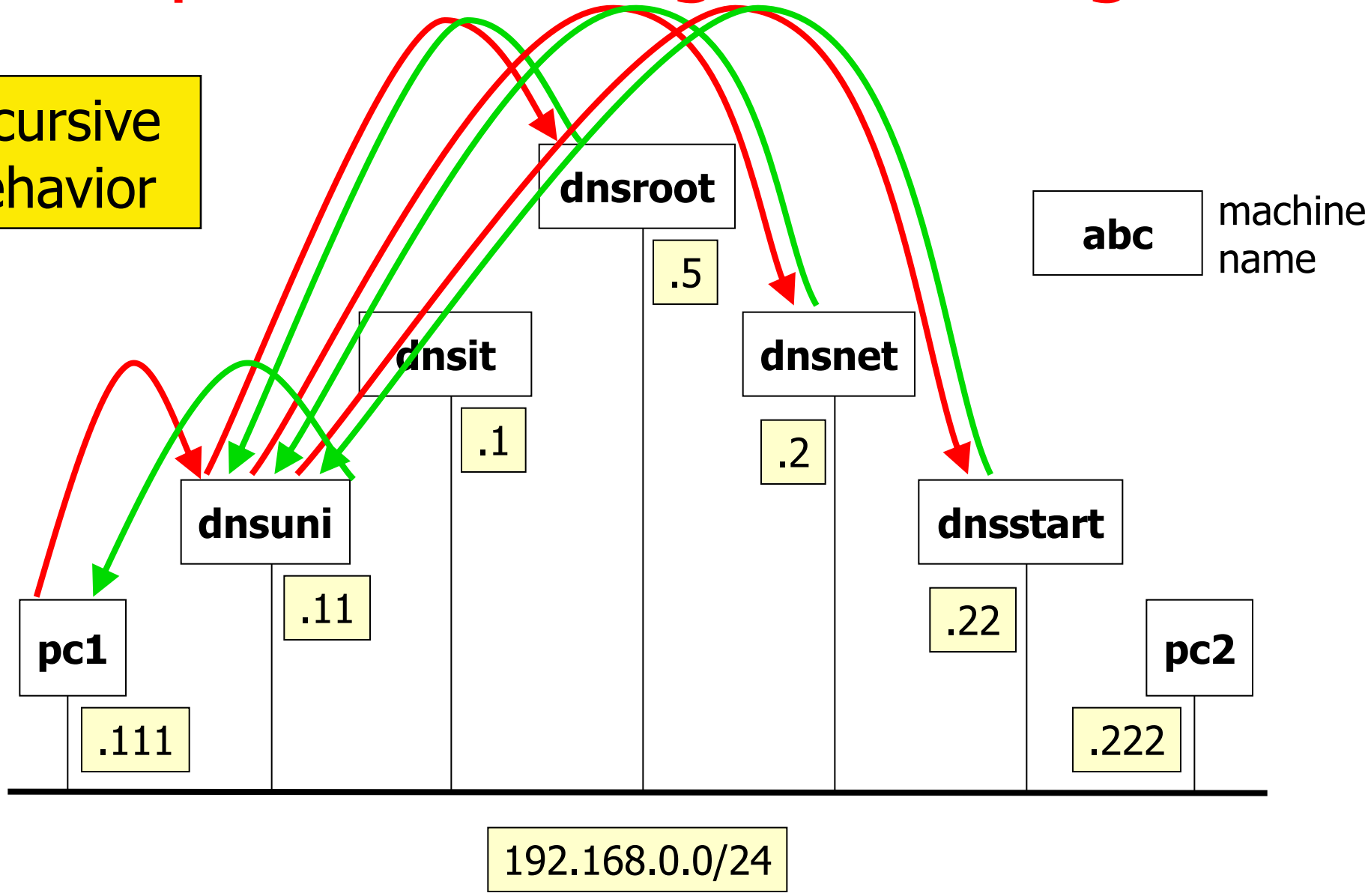
step 3 – exchanged messages

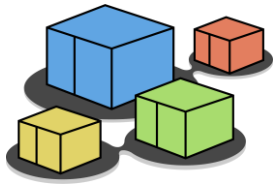


step 3 – exchanged messages



step 3 – exchanged messages



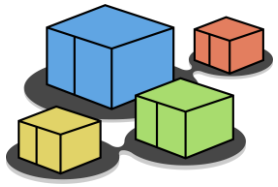


step 4 – repeating the experiment

- execute a ping command towards pc2

pc1

```
root@pc1:/# ping -n pc2.startup.net
PING pc2.startup.net (192.168.0.222) 56(84) bytes of data.
64 bytes from 192.168.0.222: icmp_seq=1 ttl=64 time=1.50 ms
64 bytes from 192.168.0.222: icmp_seq=2 ttl=64 time=0.580 ms
64 bytes from 192.168.0.222: icmp_seq=3 ttl=64 time=0.525 ms
--- pc2.startup.net ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2010ms
rtt min/avg/max/mdev = 0.525/0.867/1.496/0.445 ms
```



step 4 – repeating the experiment

Capturing from eth1

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dns

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	192.168.0.111	192.168.0.110	DNS	75	Standard query 0x591b A pc2.startup.net
2	0.001971994	192.168.0.110	192.168.0.111	DNS	130	Standard query response 0x591b A pc2.startup.net A 192.168.0.222 NS dnsstart.startup.net A 192.168.0.22
3	0.002335337	192.168.0.111	192.168.0.110	DNS	75	Standard query 0x9e05 AAAA pc2.startup.net
4	0.002768557	192.168.0.110	168.0.111	DNS	125	Standard query response 0x9e05 AAAA pc2.startup.net SOA dnsstart.startup.net

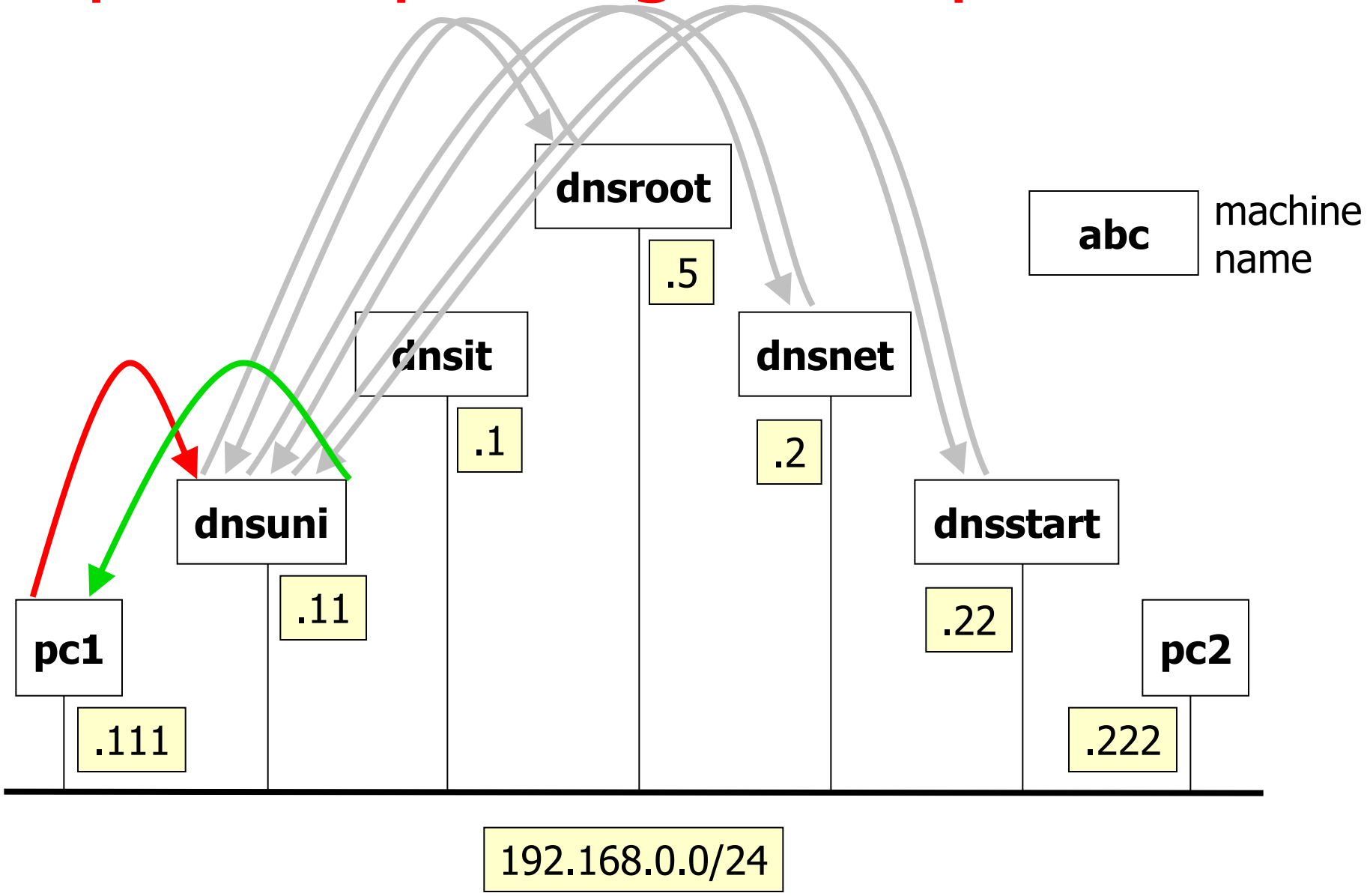
the name server cache helps reducing traffic

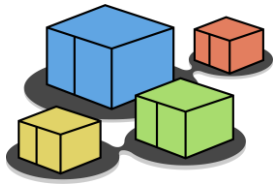
```
Frame 1: 75 bytes on wire (600 bits), 75 bytes captured (600 bits) on interface et
Ethernet II, Src: 92:93:6c:69:91:fc (92:93:6c:69:91:fc), Dst: ee:d6:b8:29:cf:ae (e
Internet Protocol Version 4, Src: 192.168.0.111, Dst: 192.168.0.110
User Datagram Protocol, Src Port: 35784, Dst Port: 53
Domain Name System (query)
    Transaction ID: 0x591b
  ▸ Flags: 0x0100 Standard query
    Questions: 1
    Answer RRs: 0
    Authority RRs: 0
    Additional RRs: 0
  ▸ Queries
    [Response In: 2]
```

```
0000  ee d6 b8 29 cf ae 92 93  6c 69 91 fc 08 00 45 00   ···)···· li····E·
0010  00 3d c8 0e 40 00 40 11  f0 73 c0 a8 00 6f c0 a8   ·=··@·@· ·s···o··
0020  00 6e 8b c8 00 35 00 29  62 16 59 1b 01 00 00 01   ·n···5·) b·Y·····
0030  00 00 00 00 00 00 03 70  63 32 07 73 74 61 72 74   ·······p c2·start
0040  75 70 03 6e 65 74 00 00  01 00 01                  up·net·· ···
```

eth1: <live capture in progress> Packets: 16 · Displayed: 4 (25.0%) Profile: Default

step 4 – repeating the experiment



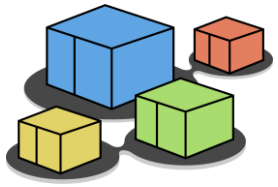


step 5 – cleaning the cache

localuni

```
root@localuni:/# rndc flush
```

- rndc controls the operation of a name server
- the flush command cleans up caches
  - a new client query triggers the complete sequence of iterative queries

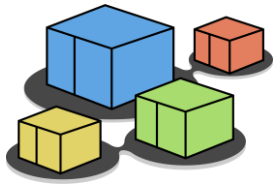


step 6 – ping non-existent target

- execute a ping command towards a non-existent target

pc1

```
root@pc1:/# ping pluto.startup.net
ping: pluto.startup.net: Name or service not known
```



step 6 – non-existent target

Capturing from eth1

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

dns

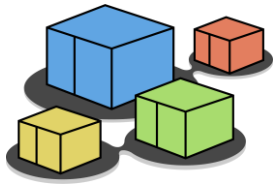
No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	192.168.0.111	192.168.0.110	DNS	77	Standard query 0x4078 A pluto.startup.net
2	0.001628683	192.168.0.110	192.168.0.5	DNS	88	Standard query 0xd571 A pluto.startup.net OPT
3	0.001981683	192.168.0.110	192.168.0.5	DNS	70	Standard query 0x06a0 NS <Root> OPT
4	0.002428475	192.168.0.5	192.168.0.110	DNS	125	Standard query response 0xd571 A pluto.startup.net NS dnsnet.net A 192.168.0.2 OPT
5	0.003002929	192.168.0.5	192.168.0.110	DNS	110	Standard query response 0x06a0 NS <Root> NS ROOT-SERVER A 192.168.0.5 OPT
6	0.003141461	192.168.0.110	192.168.0.2	DNS	88	Standard query 0x26a2 A pluto.startup.net OPT
7	0.004994595	192.168.0.2	192.168.0.110	DNS	127	Standard query response 0x26a2 A pluto.startup.net NS dnsstart.startup.net A 192.168.0.22 OPT
8	0.005616928	192.168.0.110	192.168.0.22	DNS	88	Standard query 0xa498 A pluto.startup.net OPT
9	0.0 44802	192.168.0.22	192.168.0.110	DNS	138	Standard query response 0xa498 No such name A pluto.startup.net SOA dnsstart.startup.net OPT
10	0.006	192.168.0.110	192.168.0.111	DNS	127	Standard query response 0x4078 No such name A pluto.startup.net SOA dnsstart.startup.net
11	0.006975	2.168.0.111	192.168.0.110	DNS	77	Standard query 0x9779 AAAA pluto.startup.net
12	0.007309311	.0.110	192.168.0.111	DNS	127	Standard query response 0x9779 No such name AAAA pluto.startup.net SOA dnsstart.startup.net
13	0.007565534	1 111	192.168.0.110	DNS	89	Standard query 0xbae6 A pluto.startup.net.uniroma3.it
14	0.008001079	192.	192.168.0.5	DNS	100	Standard query 0x54fc A pluto.startup.net.uniroma3.it OPT
15	0.008532074	192.168	168.0.110	DNS	136	Standard query response 0x54fc A pluto.startup.net.uniroma3.it NS dnsit.it A 192.168.0.1 OPT
16	0.008880605	192.168.0.	0.1	DNS	100	Standard query 0x78f7 A pluto.startup.net.uniroma3.it OPT
17	0.009754896	192				nse 0x78f7 A pluto.startup.net.uniroma3.it NS dnsuni.uniroma3.it A 192.168.0.11 OPT
18	0.010674359	19				A pluto.startup.net.uniroma3.it OPT
19	0.011492380	19				nse 0x2d50 No such name A pluto.startup.net.uniroma3.it SOA dnsuni.uniroma3.it OPT
20	0.011779118	19				nse 0xbae6 No such name A pluto.startup.net.uniroma3.it SOA dnsuni.uniroma3.it
21	0.011975705	19				AAAA pluto.startup.net.uniroma3.it
22	0.012145073	19				nse 0x99e4 No such name AAAA pluto.startup.net.uniroma3.it SOA dnsuni.uniroma3.it

all the iterative queries are performed again because of the cache flush

```
▸ Frame 1: 77 bytes c                                   ce e
▸ Ethernet II, Src: 92                                  ae (
▸ Internet Protocol Version 4, Src: 192.168.0.111, Dst: 192.168.0.110
▸ User Datagram Protocol, Src Port: 51934, Dst Port: 53
▾ Domain Name System (query)
    Transaction ID: 0x4078
  ▸ Flags: 0x0100 Standard query
    Questions: 1
```

```
0000  ee d6 b8 29 cf ae 92 93  6c 69 91 fc 08 00 45 00   ···)···· li····E·
0010  00 3f d3 35 40 00 40 11  e5 4a c0 a8 00 6f c0 a8   ·?·5@·@· ·J···o··
0020  00 6e ca de 00 35 00 2b  bb ec 40 78 01 00 00 01   ·n···5·+ ··@x····
0030  00 00 00 00 00 00 05 70  6c 75 74 6f 07 73 74 61   ·······p luto·sta
0040  72 74 75 70 03 6e 65 74  00 00 01 00 01           rtup·net ·····
```

eth1: <live capture in progress> Packets: 46 · Displayed: 22 (47.8%) Profile: Default



step 6 – non-existent target

Capturing from eth1

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

dns

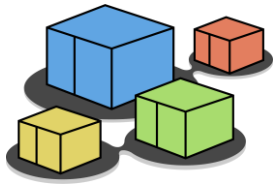
No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	192.168.0.111	192.168.0.110	DNS	77	Standard query 0x4078 A pluto.startup.net
2	0.001628683	192.168.0.110	192.168.0.5	DNS	88	Standard query 0xd571 A pluto.startup.net OPT
3	0.001981683	192.168.0.110	192.168.0.5	DNS	70	Standard query 0x06a0 NS <Root> OPT
4	0.002428475	192.168.0.5	192.168.0.110	DNS	125	Standard query response 0xd571 A pluto.startup.net NS dnsnet.net A 192.168.0.2 OPT
5	0.003002929	192.168.0.5	192.168.0.110	DNS	110	Standard query response 0x06a0 NS <Root> NS ROOT-SERVER A 192.168.0.5 OPT
6	0.003141461	192.168.0.110	192.168.0.2	DNS	88	Standard query 0x26a2 A pluto.startup.net OPT
7	0.004994595	192.168.0.2	192.168.0.110	DNS	127	Standard query response 0x26a2 A pluto.startup.net NS dnsstart.startup.net A 192.168.0.22 OPT
8	0.005616928	192.168.0.110	192.168.0.22	DNS	88	Standard query 0xa498 A pluto.startup.net OPT
9	0.006344802	192.168.0.22	192.168.0.110	DNS	138	Standard query response 0xa498 No such name A pluto.startup.net SOA dnsstart.startup.net OPT
10	0.006641766	192.168.0.110	192.168.0.111	DNS	127	Standard query response 0x4078 No such name A pluto.startup.net SOA dnsstart.startup.net
11	0.006975758	192.168.0.111	192.168.0.110	DNS	77	Standard que 0x9779 AAAA pluto.startup.net
12	0.007309311	192.168.0.110	192.168.0.111	DNS	127	Standard response 0x9779 No such name AAAA pluto.startup.net SOA dnsstart.startup.net
13	0.007565534	192.168.0.111	192.168.0.110	DNS	89	Standa y 0xbae6 A pluto.startup.net.uniroma3.it
14	0.008001079	192.168.0.110	192.168.0.5	DNS	100	Star ry 0x54fc A pluto.startup.net.uniroma3.it OPT
15	0.008532074	192.168.0.5	192.168.0.110	DNS	136	ry response 0x54fc A pluto.startup.net.uniroma3.it NS dnsit.it A 192.168.0.1 OPT
16	0.008880605	192.168.0.110	192.168.0.1	DNS	10	ery 0x78f7 A pluto.startup.net.uniroma3.it OPT
17	0.009754896	192				nse 0x78f7 A pluto.startup.net.uniroma3.it NS dnsuni.uniroma3.it A 192.168.0.11 OPT
18	0.010674359	19				0 A pluto.startup.net.uniroma3.it OPT
19	0.011492380	19				nse 0x2d50 No such name A pluto.startup.net.uniroma3.it SOA dnsuni.uniroma3.it OPT
20	0.011779118	19				nse 0xbae6 No such name A pluto.startup.net.uniroma3.it SOA dnsuni.uniroma3.it
21	0.011975705	19				4 AAAA pluto.startup.net.uniroma3.it
22	0.012145073	19				nse 0x99e4 No such name AAAA pluto.startup.net.uniroma3.it SOA dnsuni.uniroma3.it

the requested domain (**`pluto.startup.net`**) does not exist

```
Questions: 1
Answer RRs: 0
Authority RRs: 1
Additional RRs: 0
▸ Queries
▾ Authoritative nameservers
  ▾ startup.net: type SOA, class IN, mname dnsstart.startup.net
      Name: startup.net
```

```
0000  92 93 6c 69 91 fc ee d6  b8 29 cf ae 08 00 45 00   ··li···· ·)····E·
0010  00 71 0d a4 00 00 40 11  ea aa c0 a8 00 6e c0 a8   ·q····@· ·····n··
0020  00 6f 00 35 ca de 00 5d  1f 6b 40 78 81 83 00 01   ·o·5···] ·k@x····
0030  00 00 00 01 00 00 05 70  6c 75 74 6f 07 73 74 61   ·······p luto·sta
0040  72 74 75 70 03 6e 65 74  00 00 01 00 01 c0 12 00   rtup·net ········
0050  06 00 01 00 00 2a 30 00  26 08 64 6e 73 73 74 61   ·····*0· &·dnssta
0060  72 74 c0 12 04 72 6f 6f  74 c0 2f 77 91 9b 61 00   rt···roo t·/w··a·
0070  00 00 1c 00 00 38 40 00  36 ee 80 00 00 00 0f      ·····8@· 6·····
```

Text item (text), 50 byte(s) — Packets: 46 · Displayed: 22 (47.8%) — Profile: Default



step 6 – non-existent target

since the query has failed, **pc1** tries once more with the domain search path configured inside its **/etc/resolv.conf**:
nameserver 192.168.0.11
search uniroma3.it

Capturing from eth1

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

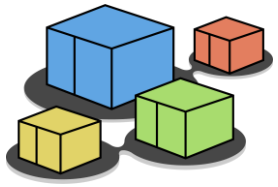
dns

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	192.168.0				
2	0.001628683	192.168.				
3	0.001981683	192.168.				
4	0.002428475	192.168.				.2 OPT
5	0.003002929	192.168.				
6	0.003141461	192.168.				
7	0.004994595	192.168.				192.168.0.22 OPT
8	0.005616928	192.168.				
9	0.006344802	192.168.0.				t.startup.net OPT
10	0.006641766	192.168.0.110	192.168			query response 0x4078 No such name A pluto.startup.net SOA dnsstart.startup.net
11	0.006975758	192.168.0.111	1		77	Standard query 0x9779 AAAA pluto.startup.net
12	0.007309311	192.168.0.1	.111	DNS	127	Standard query response 0x9779 No such name AAAA pluto.startup.net SOA dnsstart.startup.net
13	0.007565534	192.1	192.168.0.110	DNS	89	Standard query 0xbae6 A pluto.startup.net.uniroma3.it
14	0.008001079	.0.110	192.168.0.5	DNS	100	Standard query 0x54fc A pluto.startup.net.uniroma3.it OPT
15	0.008	192.168.0.5	192.168.0.110	DNS	136	Standard query response 0x54fc A pluto.startup.net.uniroma3.it NS dnsit.it A 192.168.0.1 OPT
16	0.008880605	192.168.0.110	192.168.0.1	DNS	100	Standard query 0x78f7 A pluto.startup.net.uniroma3.it OPT
17	0.009754896	192.168.0.1	192.168.0.110	DNS	137	Standard query response 0x78f7 A pluto.startup.net.uniroma3.it NS dnsuni.uniroma3.it A 192.168.0.11 OPT
18	0.010674359	192.168.0.110	192.168.0.11	DNS	100	Standard query 0x2d50 A pluto.startup.net.uniroma3.it OPT
19	0.011492380	192.168.0.11	192.168.0.110	DNS	148	Standard query response 0x2d50 No such name A pluto.startup.net.uniroma3.it SOA dnsuni.uniroma3.it OPT
20	0.011779118	192.168.0.110	192.168.0.111	DNS	137	Standard query response 0xbae6 No such name A pluto.startup.net.uniroma3.it SOA dnsuni.uniroma3.it
21	0.011975705	192.168.0.111	192.168.0.110	DNS	89	Standard query 0x99e4 AAAA pluto.startup.net.uniroma3.it
22	0.012145073	192.168.0.110	192.168.0.111	DNS	137	Standard query response 0x99e4 No such name AAAA pluto.startup.net.uniroma3.it SOA dnsuni.uniroma3.it

```
▸ Flags: 0x0100 Standard query
  Questions: 1
  Answer RRs: 0
  Authority RRs: 0
  Additional RRs: 0
▸ Queries
  [Response In: 20]
```

```
0000  ee d6 b8 29 cf ae 92 93  6c 69 91 fc 08 00 45 00   ···)···· li····E·
0010  00 4b 19 70 40 00 40 11  9f 04 c0 a8 00 6f c0 a8   ·K·p@·@· ·····o··
0020  00 6e ce 00 00 35 00 37  4b 1e ba e6 01 00 00 01   ·n···5·7 K·······
0030  00 00 00 00 00 00 05 70  6c 75 74 6f 07 73 74 61   ·······p luto·sta
0040  72 74 75 70 03 6e 65 74  08 75 6e 69 72 6f 6d 61   rtup·net ·uniroma
0050  33 02 69 74 00 00 01 00  01                       3·it···· ·
```

eth1: <live capture in progress> Packets: 46 · Displayed: 22 (47.8%) Profile: Default

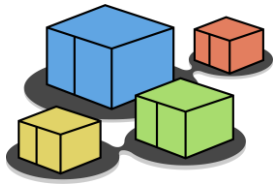


step 6 – ping non-existent target

- repeat the ping command towards the non-existent target

pc1

```
root@pc1:/# ping pluto.startup.net
ping: pluto.startup.net: Name or service not known
```



step 6 – ping non-existent target

the name server negative cache has stored the negative answer

as before, **pc1** tries once more with the domain search path configured inside its **/etc/resolv.conf**

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

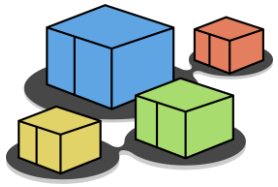
dns

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	192.168.0.111	192.168.0.110	DNS	77	Standard query 0xffe4 A pluto.startup.net
2	0.000630274	192.168.0.110	192.168.0.111	DNS	127	Standard query response 0xffe4 No such name A pluto.startup.net SOA dnsstart.startup.net
3	0.000812191	192.168.0.111	192.168.0.110	DNS	77	Standard query 0x9ae5 AAAA pluto.startup.net
4	0.001195322	192.168.0.110	192.168.0.111	DNS	127	Standard query response 0x9ae5 No such name AAAA pluto.startup.net SOA dnsstart.startup.net
5	0.001788267	192.168.0.111	192.168.0.110	DNS	89	Standard query 0xeacf A pluto.startup.net.uniroma3.it
6	0.002311232	192.168.0.110	192.168.0.111	DNS	137	Standard query response 0xeacf No su name A pluto.startup.net.uniroma3.it SOA dnsuni.uniroma3.it
7	0.002631008	192.168.0.111	192.168.0.110	DNS	89	Standard query 0x67cd AAAA pluto.sta net.uniroma3.it
8	0.003023075	192.168.0.110	192.168.0.111	DNS	137	Standard query response 0x67cd No su AAAA pluto.startup.net.uniroma3.it SOA dnsuni.uniroma3.it

```
Questions: 1
Answer RRs: 0
Authority RRs: 1
Additional RRs: 0
Queries
Authoritative nameservers
startup.net: type SOA, class IN, mname dnsstart.startup.net
```

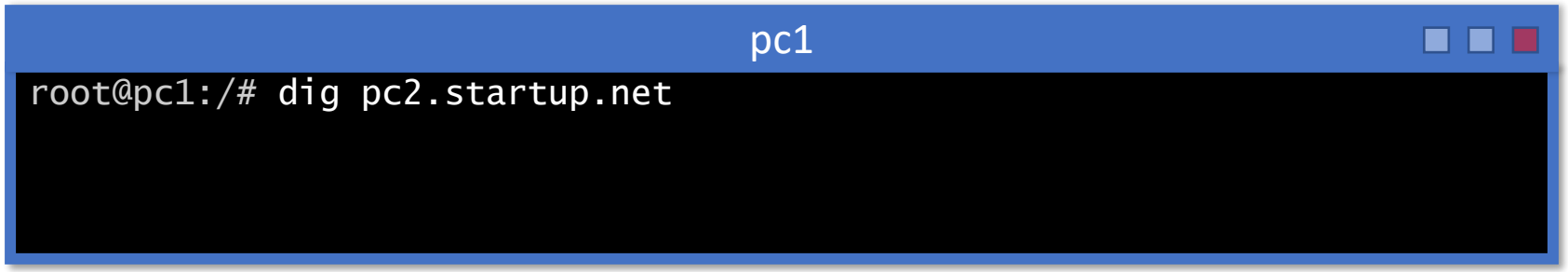
```
0000  92 93 6c 69 91 fc ee d6  b8 29 cf ae 08 00 45 00   ··li····  ·)····E·
0010  00 71 3c 57 00 00 40 11  bb f7 c0 a8 00 6e c0 a8   ·q<W··@·  ·····n··
0020  00 6f 00 35 b7 1c 00 5d  70 c2 ff e4 81 83 00 01   ·o·5···]  p·······
0030  00 00 00 01 00 00 05 70  6c 75 74 6f 07 73 74 61   ·······p  luto·sta
0040  72 74 75 70 03 6e 65 74  00 00 01 00 01 c0 12 00   rtup·net  ········
0050  06 00 01 00 00 28 33 00  26 08 64 6e 73 73 74 61   ·····(3·  &·dnssta
0060  72 74 c0 12 04 72 6f 6f  74 c0 2f 77 91 9b 61 00   rt···roo  t·/w··a·
0070  00 00 1c 00 00 38 40 00  36 ee 80 00 00 00 0f      ·····8@·  6·····
```

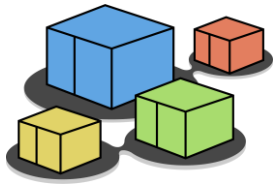
Text item (text), 50 byte(s) — Packets: 12 · Displayed: 8 (66.7%) — Profile: Default



step 7 – advanced queries

- resource records can be searched by using **`dig`**
  - highly customizable queries
  - detailed responses



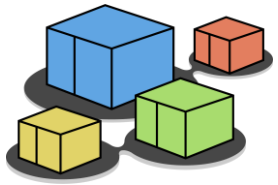


step 7 – advanced queries

answer flags:
qr: query response
rd: recursion desired (the user asked for a recursive lookup)
ra: recursion available (the server allows recursive lookups)

pc1

```
root@pc1:/# dig pc2.startup.net
; <<>> DiG 9.18.19-1~deb12u1-Debian <<>> pc2.startup.net
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 22137
;; flags: qr rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 1, ADDITIONAL: 2

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 4096
; COOKIE: b4c95f2012cf8905d705a97c657b10f314be1a5abe3ec74d (good)
;; QUESTION SECTION:
;pc2.startup.net.               IN      A

;; ANSWER SECTION:
pc2.startup.net.        60000   IN      A       192.168.0.222

;; AUTHORITY SECTION:
startup.net.            59173   IN      NS      dnsstart.startup.net.

;; ADDITIONAL SECTION:
dnsstart.startup.net.   59173   IN      A       192.168.0.22

;; Query time: 0 msec
;; SERVER: 192.168.0.110#53(192.168.0.110) (UDP)
;; WHEN: Thu Dec 14 14:28:03 UTC 2023
;; MSG SIZE  rcvd: 127
```

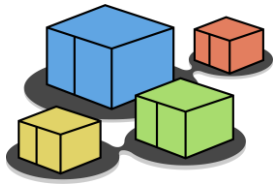


step 7 – advanced queries

these sections correspond to those contained in DNS packets

pc1

```
root@pc1:/# dig pc2.startup.net
; <<>> DiG 9.18.19-1~deb12u1-Debian <<>> pc2.startup.net
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 22137
;; flags: qr rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 1, ADDITIONAL: 2

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 4096
; COOKIE: b4c95f2012cf8905d705a97c657b10f314be1a5abe3ec74d (good)
;; QUESTION SECTION:
;pc2.startup.net.               IN      A

;; ANSWER SECTION:
pc2.startup.net.        60000   IN      A       192.168.0.222

;; AUTHORITY SECTION:
startup.net.            59173   IN      NS      dnsstart.startup.net.

;; ADDITIONAL SECTION:
dnsstart.startup.net.   59173   IN      A       192.168.0.22

;; Query time: 0 msec
;; SERVER: 192.168.0.110#53(192.168.0.110) (UDP)
;; WHEN: Thu Dec 14 14:28:03 UTC 2023
;; MSG SIZE  rcvd: 127
```



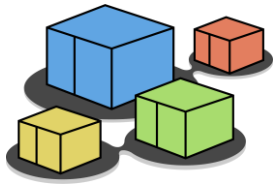
step 7 – advanced queries

records being searched (class: **IN**, type: **A** ⇒ address records)

a dns message never contains more than one question section

pc1

```
root@pc1:/# dig pc2.startup.net
; <<>> DiG 9.18.19-1~deb12u1-Debian <<>> pc2.startup.net
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 22137
;; flags: qr rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 1, ADDITIONAL: 2

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 4096
; COOKIE: b4c95f2012cf8905d705a97c657b10f314be1a5abe3ec74d (good)
;; QUESTION SECTION:
;pc2.startup.net.               IN      A

;; ANSWER SECTION:
pc2.startup.net.        60000   IN      A       192.168.0.222

;; AUTHORITY SECTION:
startup.net.            59173   IN      NS      dnsstart.startup.net.

;; ADDITIONAL SECTION:
dnsstart.startup.net.   59173   IN      A       192.168.0.22

;; Query time: 0 msec
;; SERVER: 192.168.0.110#53(192.168.0.110) (UDP)
;; WHEN: Thu Dec 14 14:28:03 UTC 2023
;; MSG SIZE  rcvd: 127
```



step 7 – advanced queries

records that form the answer to the question

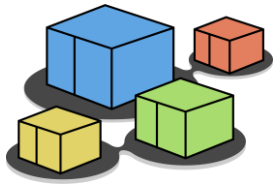
may be more than one

time to live of a resource record that is cached on the server

- try invoking **`dig`** once more to see it decreasing
- constant if the record is not cached (i.e., it is stored on the name server being queried – by default the one configured in **`/etc/resolv.conf`**)

pc1

```
root@pc1:/# dig pc2.startup.net
; <<>> DiG 9.18.19-1~deb12u1-Debian <<>> pc2.startup.net
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 22137
;; flags: qr rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 1, ADDITIONAL: 2

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 4096
; COOKIE: b4c95f2012cf8905d705a97c657b10f314be1a5abe3ec74d (good)
;; QUESTION SECTION:
;pc2.startup.net.               IN      A

;; ANSWER SECTION:
pc2.startup.net.        60000   IN      A       192.168.0.222

                                NS      dnsstart.startup.net.

                                A       192.168.0.22

                                0.110) (UDP)
;; WHEN: Thu Dec 14 14:28:03 UTC 2023
;; MSG SIZE  rcvd: 127
```



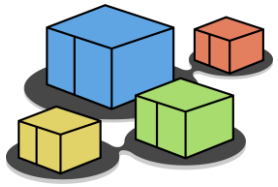
step 7 – advanced queries

pc1

```
root@pc1:/# dig pc2.startup.net
; <<>> DiG 9.18.19-1~deb12u1-Debian <<>> pc2.startup.net
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 22137
;; flags: qr rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 1, ADDITIONAL: 2

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 4096
; COOKIE: b4c95f2012cf8905d705a97c657b10f314be1a5abe3ec74d (good)
;; QUESTION SECTION:
;pc2.startup.net.               IN      A

;; ANSWER SECTION:
pc2.startup.net.        60000   IN      A       192.168.0.222

;; AUTHORITY SECTION:
startup.net.            59173   IN      NS      dnsstart.startup.net.

;; ADDITIONAL SECTION:
dnsstart.startup.net.   59173   IN      A       192.168.0.22

;; Query time: 0 msec
;; SERVER: 192.168.0.110#53(192.168.0.110) (UDP)
;; WHEN: Thu Dec 14 14:28:03 UTC 2023
;; MSG SIZE  rcvd: 127
```

records describing authoritative name servers are returned here

additional records are returned here



step 8 – an iterative query

- restart bind on the name server

localuni

```
root@localuni:/# systemctl restart bind9
```

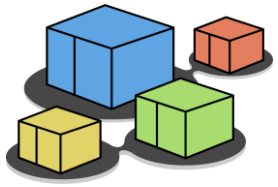
- perform an iterative query using **dig**

pc1

```
root@pc1:/# dig +noquestion +noadditional +norecurse pc2.startup.net
```

avoid displaying question and additional sections

disable recursion

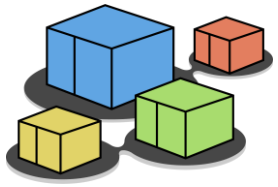


step 8 – an iterative query

the server answers by specifying the authoritative name server to be contacted to get the desired information

pc1

```
root@pc1:/# dig +noquestion +noadditional +norecurse pc2.startup.net

; <<>> DiG 9.18.19-1~deb12u1-Debian <<>> +noquestion +noadditional
+norecurse pc2.startup.net
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 15543
;; flags: qr ra; QUERY: 1, ANSWER: 0, AUTHORITY: 1, ADDITIONAL: 1

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 4096
; COOKIE: 5ea4ced6cdaf30599571a9e0657b15c2381005312bcc21e9 (good)
;; AUTHORITY SECTION:
.                       0       IN      NS      ROOT-SERVER.

;; Query time: 0 msec
;; SERVER: 192.168.0.110#53(192.168.0.110) (UDP)
;; WHEN: Thu Dec 14 14:48:34 UTC 2023
;; MSG SIZE  rcvd: 96
```



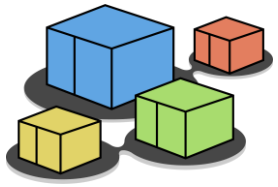
step 8 – an iterative query

query a specific name server (**dnsroot**)

dnsnet.net is the authoritative name server for zone **net**

pc1

```
root@pc1:/# dig +noquestion +noadditional +norecurse @192.168.0.5
pc2.startup.net

; <<>> DiG 9.18.19-1~deb12u1-Debian <<>> +noquestion +noadditional
+norecurse @192.168.0.5 pc2.startup.net
; (1 server found)
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 24163
;; flags: qr ra; QUERY: 1, ANSWER: 0, AUTHORITY: 1, ADDITIONAL: 2

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 4096
; COOKIE: 301c8e7f8267ad01ed2cc63e657b1736676e072f5ecd90bf (good)
;; AUTHORITY SECTION:
net.                    60000   IN      NS      dnsnet.net.

;; Query time: 0 msec
;; SERVER: 192.168.0.5#53(192.168.0.5) (UDP)
;; WHEN: Thu Dec 14 14:54:46 UTC 2023
;; MSG SIZE  rcvd: 109
```



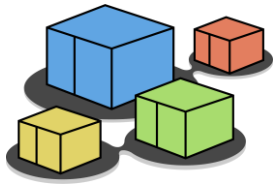
step 8 – an iterative query

query a specific name server (**dnsnet.net**)

dnsstart.startup.net is the authoritative name server for zone **startup.net**

pc1

```
root@pc1:/# dig +noquestion +noadditional +norecurse @192.168.0.2
pc2.startup.net


; <<>> DiG 9.18.19-1~deb12u1-Debian <<>> +noquestion +noadditional
+norecurse @192.168.0.2 pc2.startup.net
; (1 server found)
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 42339
;; flags: qr ra; QUERY: 1, ANSWER: 0, AUTHORITY: 1, ADDITIONAL: 2

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 4096
; COOKIE: d96ea5b92e6860aeed2cc63e657b1878e06d204302aa8149 (good)
;; AUTHORITY SECTION:
startup.net.            60000   IN      NS      dnsstart.startup.net.

;; Query time: 9 msec
;; SERVER: 192.168.0.2#53(192.168.0.2) (UDP)
;; WHEN: Thu Dec 14 15:00:08 UTC 2023
;; MSG SIZE  rcvd: 111
```



step 8 – an iterative query

query a specific name server (**dnsstart.startup.net**)

the address of **pc2.startup.net**

pc1

```
root@pc1:/# dig +noquestion +noadditional +norecurse @192.168.0.22
pc2.startup.net


; <<>> DiG 9.18.19-1~deb12u1-Debian <<>> +noquestion +noadditional
+norecurse @192.168.0.22 pc2.startup.net
; (1 server found)
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 49113
;; flags: qr aa ra; QUERY: 1, ANSWER: 1, AUTHORITY: 1, ADDITIONAL: 2

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 4096
; COOKIE: b119e8f8b644792eb3bafbd6657b17989cd95e340adb2072 (good)
;; ANSWER SECTION:
pc2.startup.net.        60000   IN      A       192.168.0.222

;; AUTHORITY SECTION:
startup.net.            60000   IN      NS      dnsstart.startup.net.

;; Query time: 0 msec
;; SERVER: 192.168.0.22#53(192.168.0.22) (UDP)
;; WHEN: Thu Dec 14 14:56:24 UTC 2023
;; MSG SIZE  rcvd: 127
```