DNS and DHCP Interactions

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Agenda

- DNS dynamic update
  - How it works
  - DHCP DDNS update strategies
  - Securing dynamic updates
  - Dynamic update troubleshooting

DNS dynamic updates

- The original DNS protocol was static, DNS data could only be changed by the DNS zones administrator in the zone file
- The introduction of dynamic host configuration made it necessary to allow changes to the DNS zone data via the DNS protocol

DNS dynamic updates

- DDNS (RFC 2136 dynamic DNS updates) should not be confused with out-of band DNS changes called "DynDns" used for Internet hosts with an changing IP Address

DDNS

- In DDNS, a dynamic DNS client sends DNS messages to the primary DNS server for a DNS zone with update commands

DNS dynamic updates

- A dynamic update can
    - Add one or more records to a zone
    - Delete one or more records from a zone
        - One specific record
        - All records of a certain type owned by a domain name
        - All records owned by a domain name

DDNS

- The update can be made contingent on meeting certain prerequisites
    - The existence or non-existence of
        - A particular record
        - Records of a certain type owned by a domain name

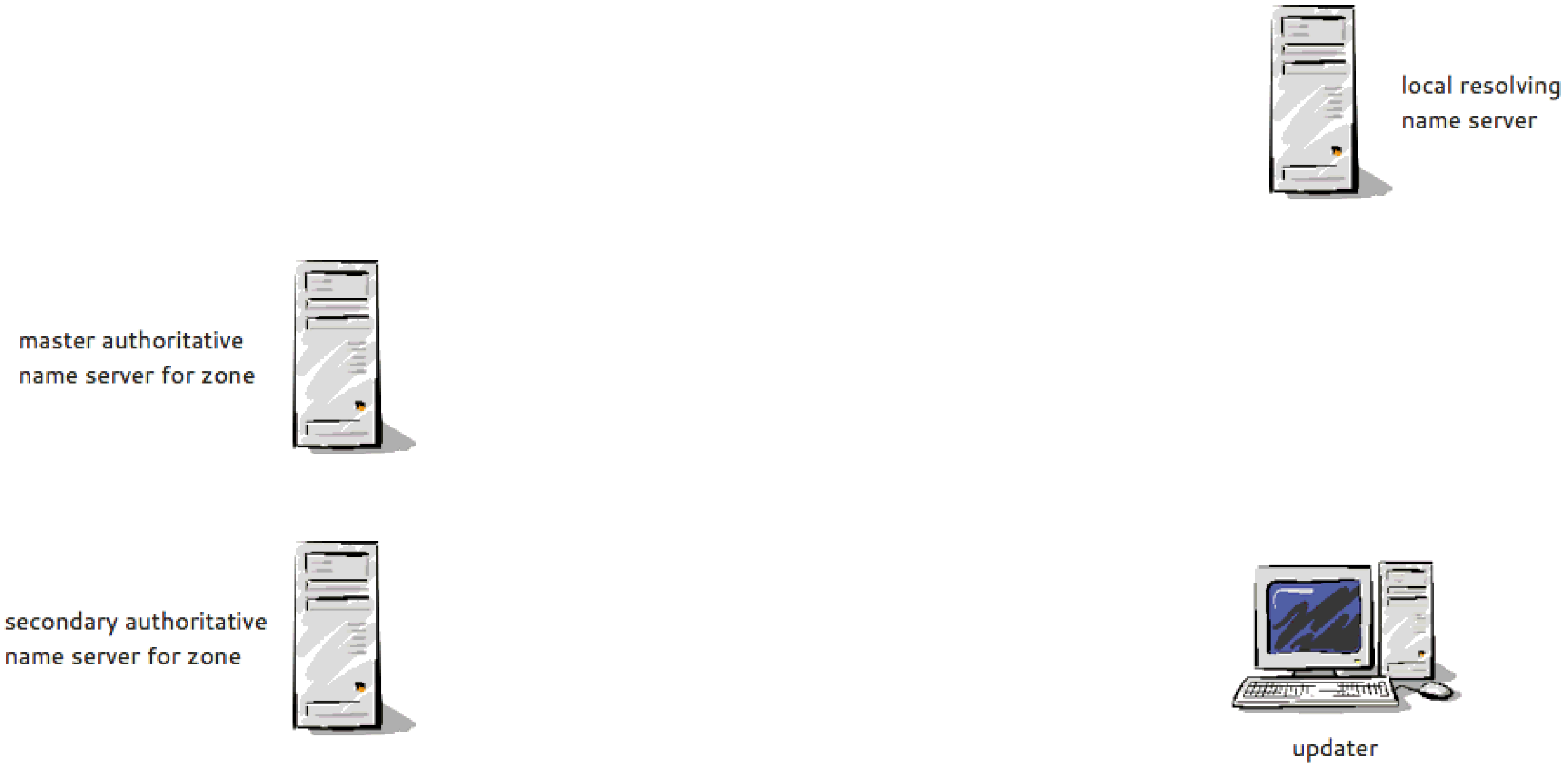
DDNS

- Updaters try to send their updates to a zone's primary name server
    - Most compare the **mname** field or the zone's SOA record to the zone's NS records
        - If the **mname** field matches one of the domain names in an NS record, the updater sends the update there
        - Otherwise, it chooses a domain name from an NS record and sends the update there

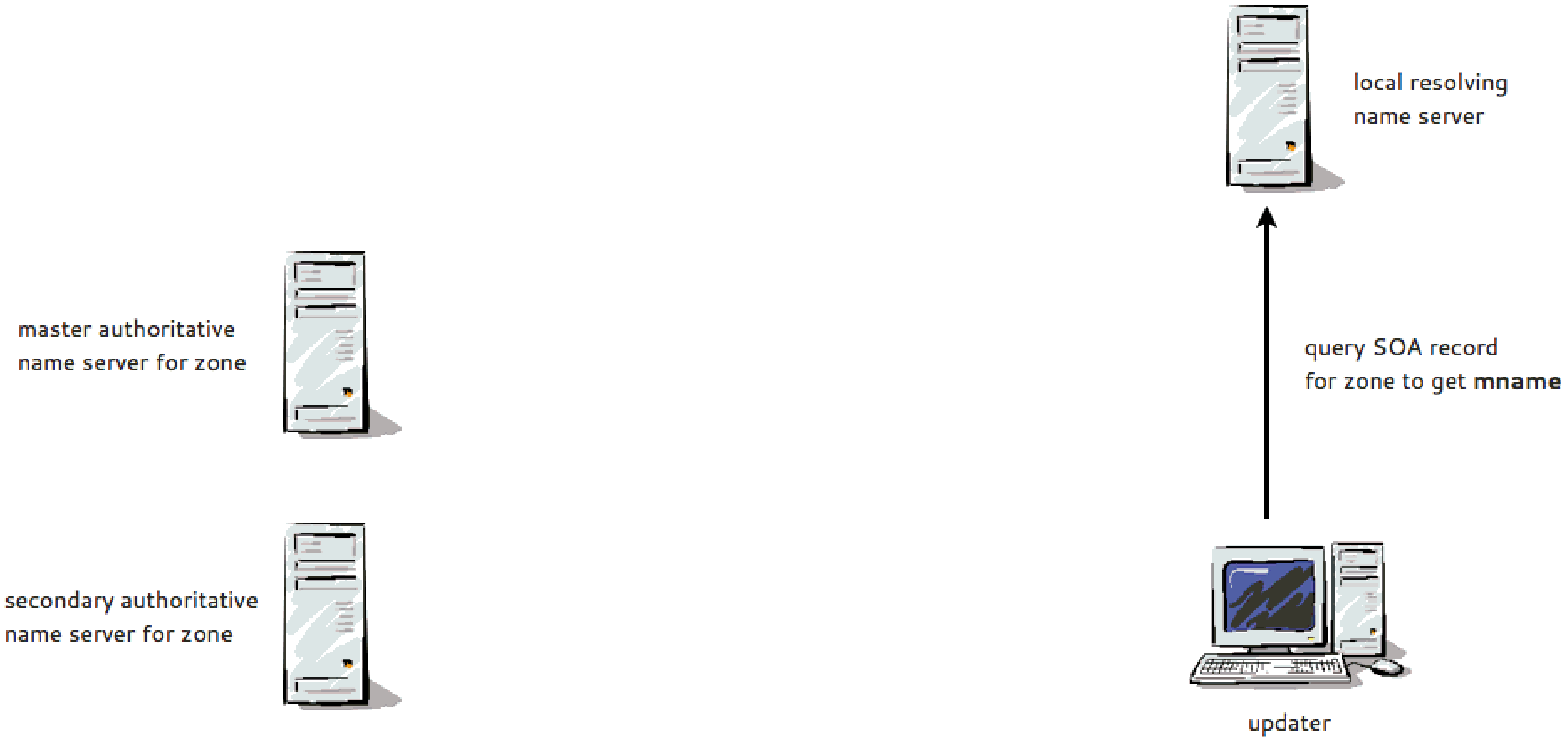
DDNS

```
; <<>> DiG 9.7.1-P2 <<>> soa example.com
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 5600
;; flags: qr aa rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 4, ADDITIONAL: 3

;; QUESTION SECTION:
;example.com.           IN  SOA

;; ANSWER SECTION:
example.com.        86400   IN  SOA dns1.example.com. (
                                    hostmaster.example.com.
                                    2010050501 900 300 604800 900 )
```

Dynamic Update in Pictures



Dynamic Update in Pictures



local resolving name server

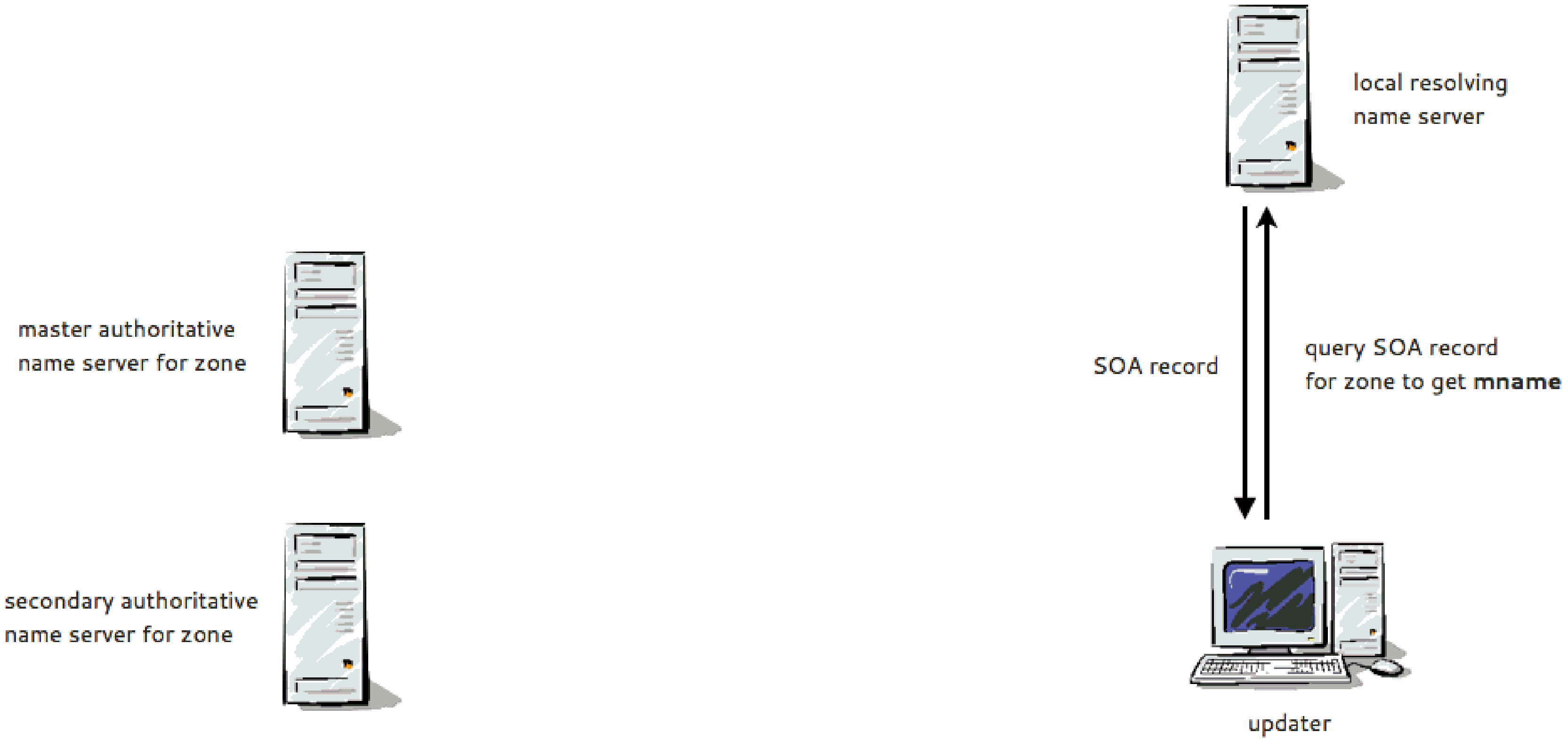
master authoritative name server for zone

query SOA record for zone to get **mname**

secondary authoritative name server for zone

updater

Dynamic Update in Pictures



local resolving name server

master authoritative name server for zone

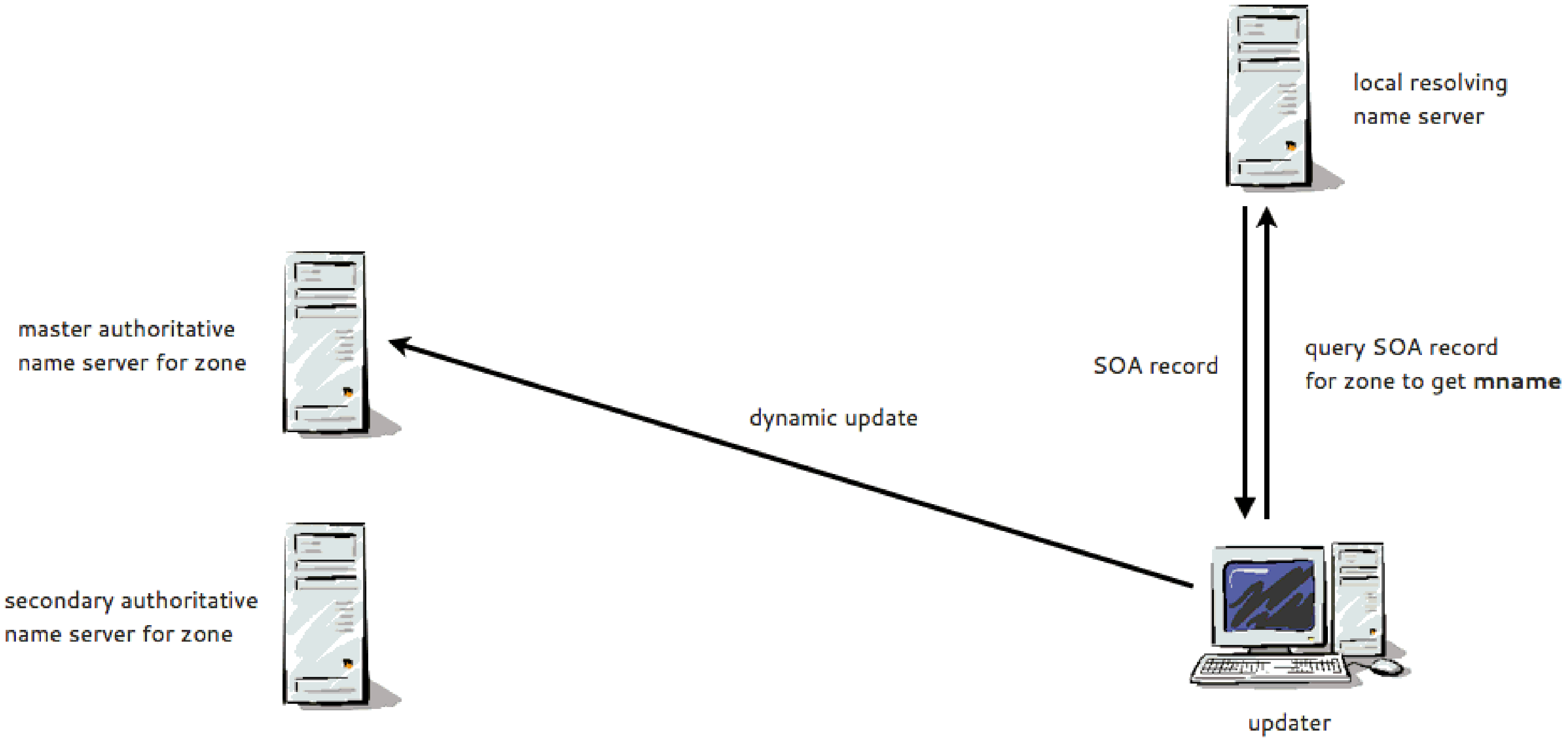
SOA record

query SOA record for zone to get **mname**

secondary authoritative name server for zone

updater

Dynamic Update in Pictures



Configuring Dynamic Update

- To allow any dynamic updates from a particular IP address or ACL (BIND DNS `named.conf`):

```
acl dhcp-server { 192.0.2.10; };
zone "example.com" {
   type primary;
   file "example.com";
   allow-update { dhcp-server; };
};
```

- *Allowing dynamic updates based on IP-addresses is insecure and should not be used! Use TSIG-Authenticated updates instead.*

Configuring Dynamic Update

- To enable update forwarding (on a secondary name server; BIND DNS `named.conf`):

```
zone "example.com" {
   type slave;
   primaries { 192.0.2.110; };
   file "bak.example.com";
   allow-update-forwarding { dhcp-server; };
};
```

Dynamic DNS Update with DHCP

- DHCP Server can be configured to send update messages to update a dynamic DNS zone
  - For non-dynamic DNS clients
    - DHCP server updates the A and PTR record

Dynamic DNS Update with DHCP

- DHCP Server can be configured to send update messages to update a dynamic DNS zone
  - For dynamic DNS clients (eg. Windows 2000 - Windows 11)
    - Client updates the A record
    - DHCP server updates the PTR record
    - Requires the Client FQDN option, Client provides a FQDN to the DHCP server

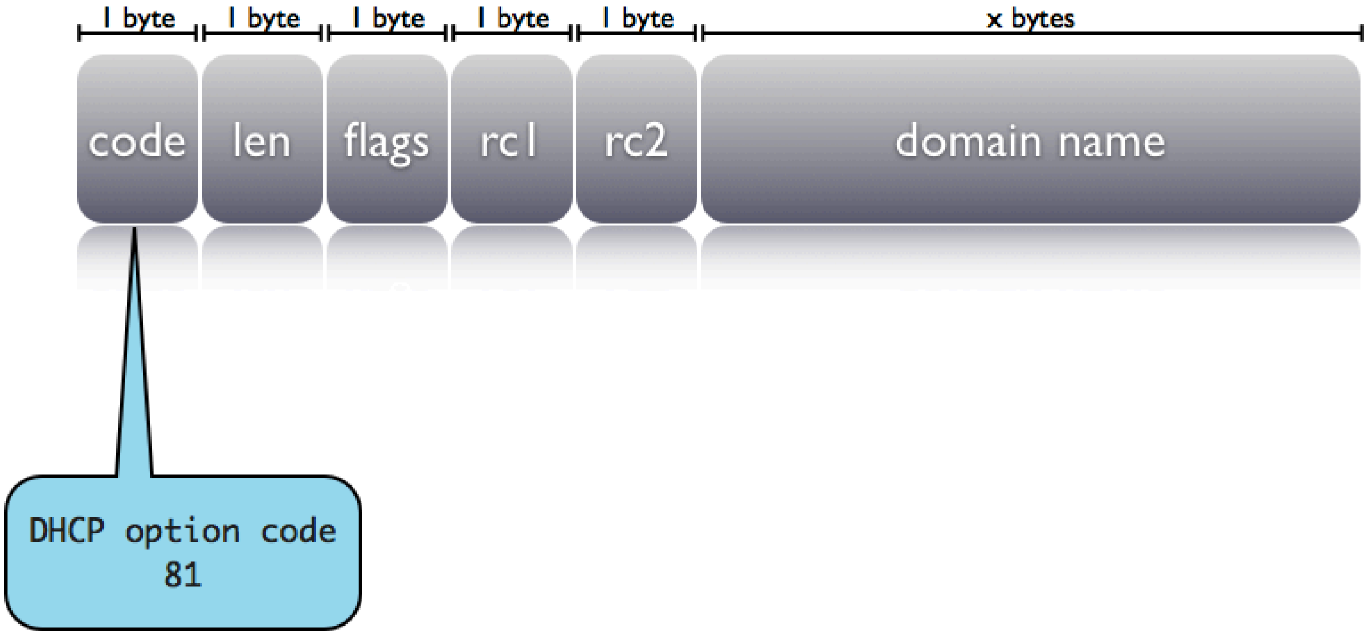
Dynamic DNS Update with DHCP

- Administrators can implement different dynamic update policies
    - DHCP Server updates both A/AAAA and PTR record
    - DHCP Server updates the PTR record, Client updates the A/AAAA record
    - the client updates both the A/AAAA and the PTR record

The FQDN Option

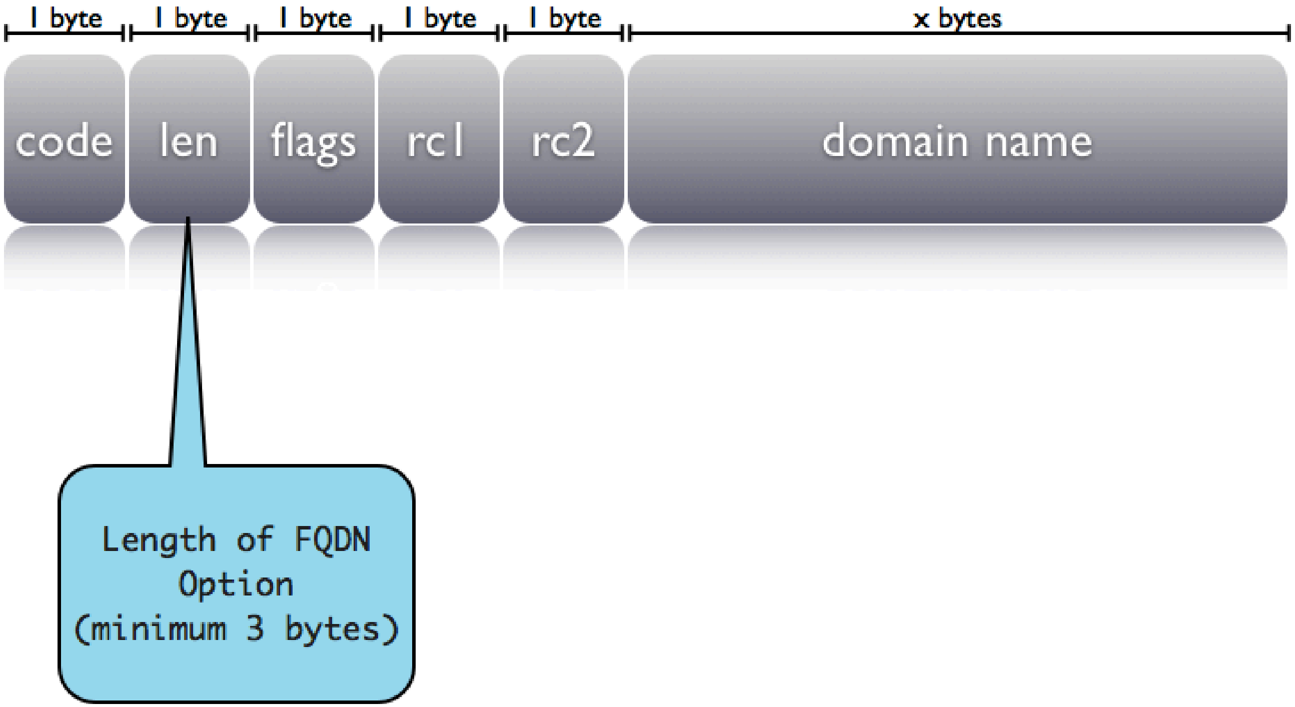
- Fully Qualified Domain Name Option (81):
    - Allows client to request the update policy
    - Allows the server to overrule the update policy requested by the client

The FQDN Option



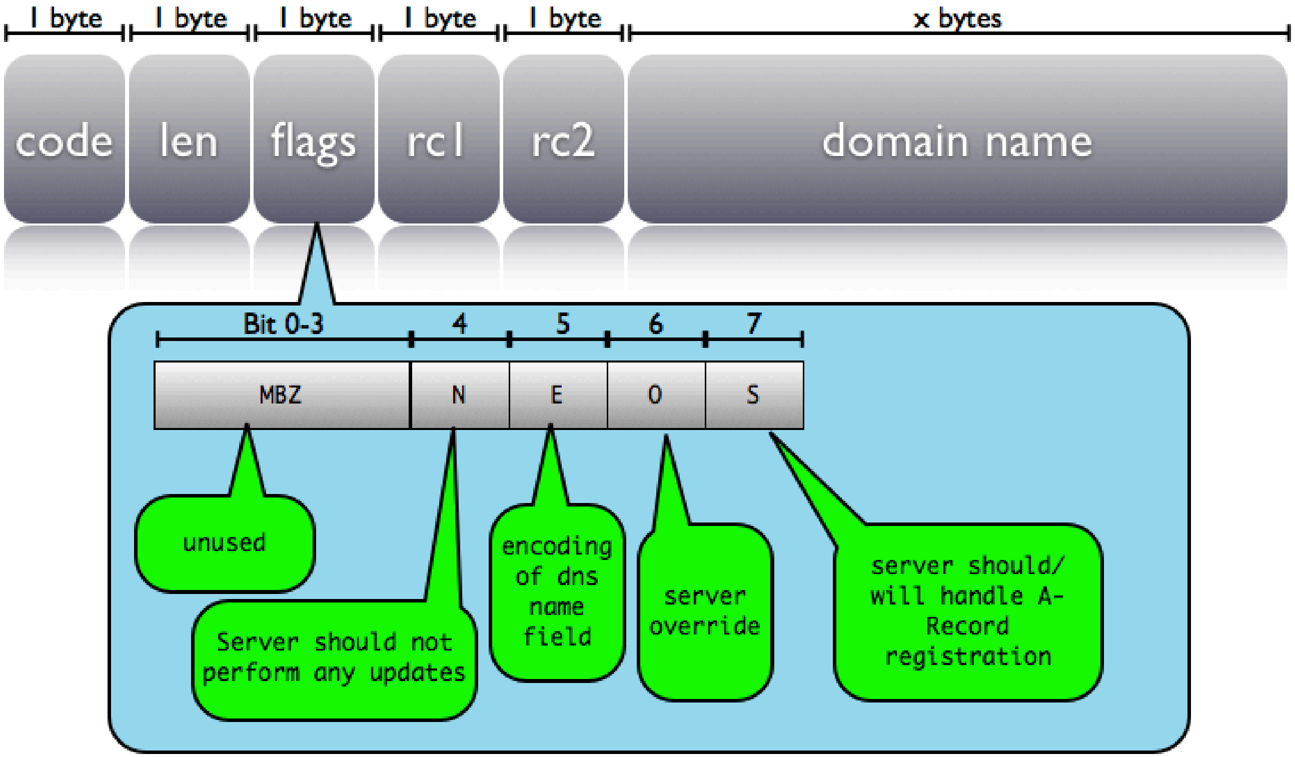
DHCP option code
81

The FQDN Option

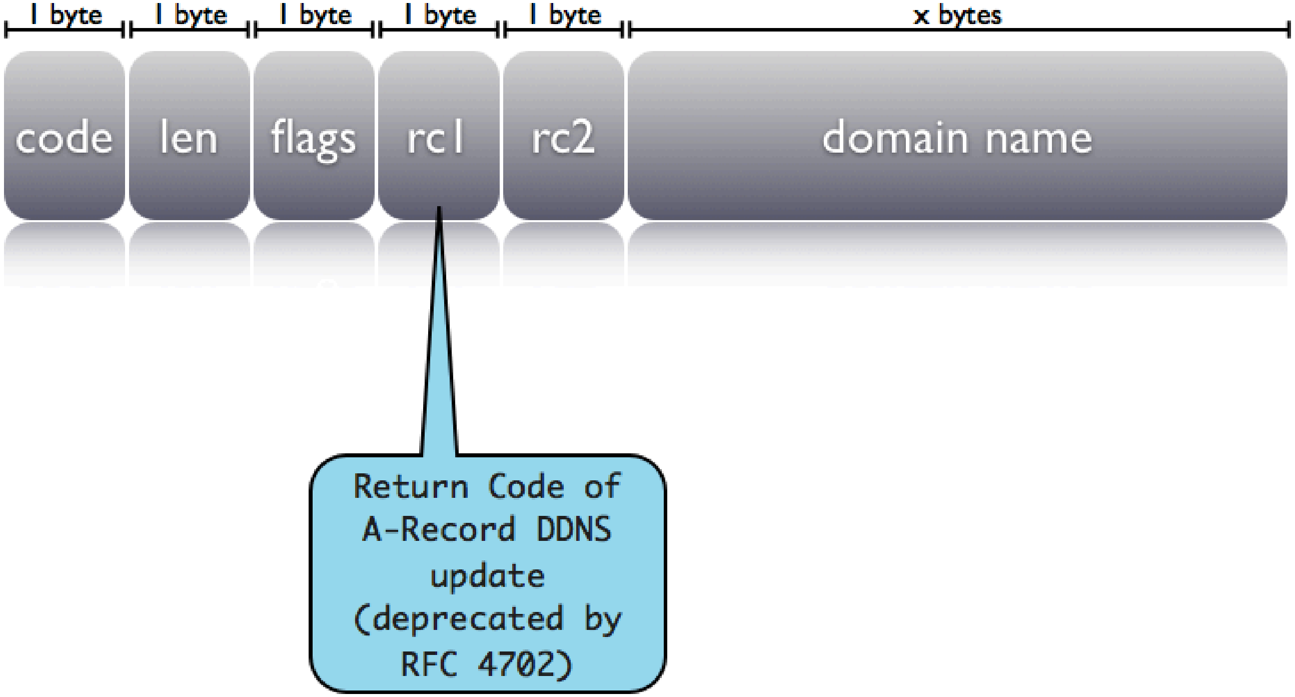


Length of FQDN Option (minimum 3 bytes)

The FQDN Option

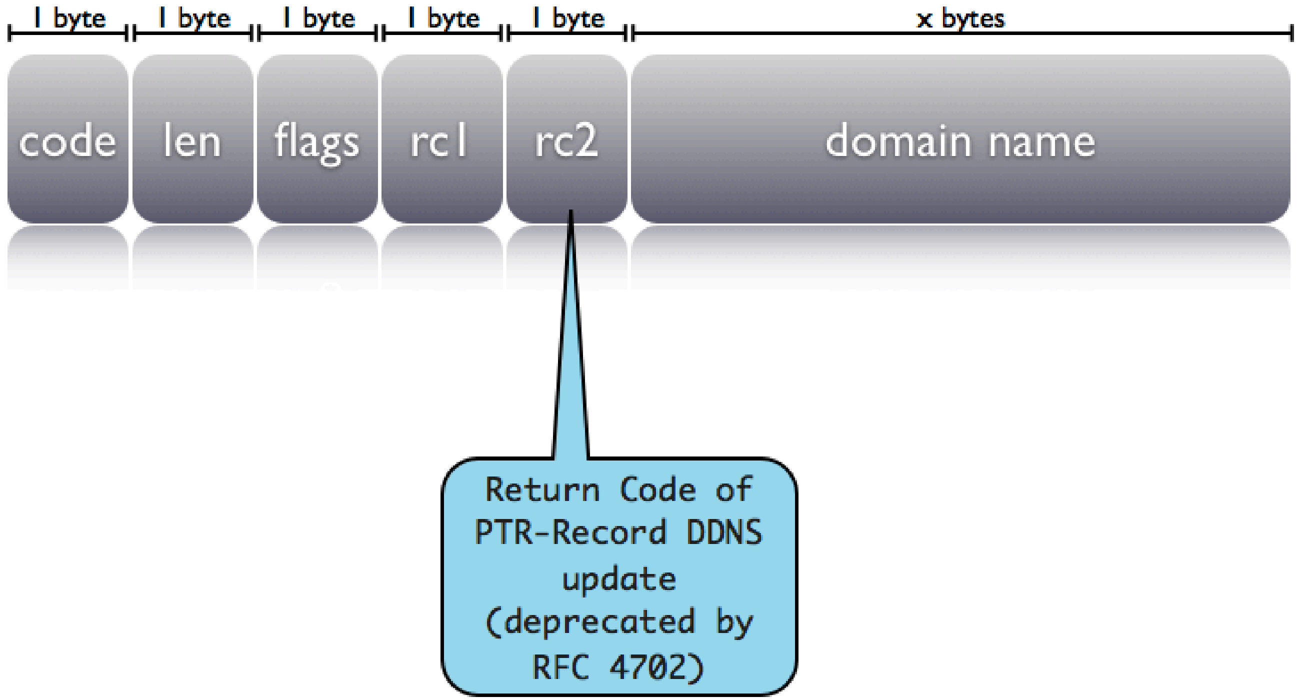

1 byte
1 byte
1 byte
1 byte
1 byte
x bytes
code
len
flags
rc1
rc2
domain name
Bit 0-3
4
5
6
7
MBZ
N
E
O
S
unused
Server should not perform any updates
encoding of dns name field
server override
server should/ will handle A-Record registration

The FQDN Option



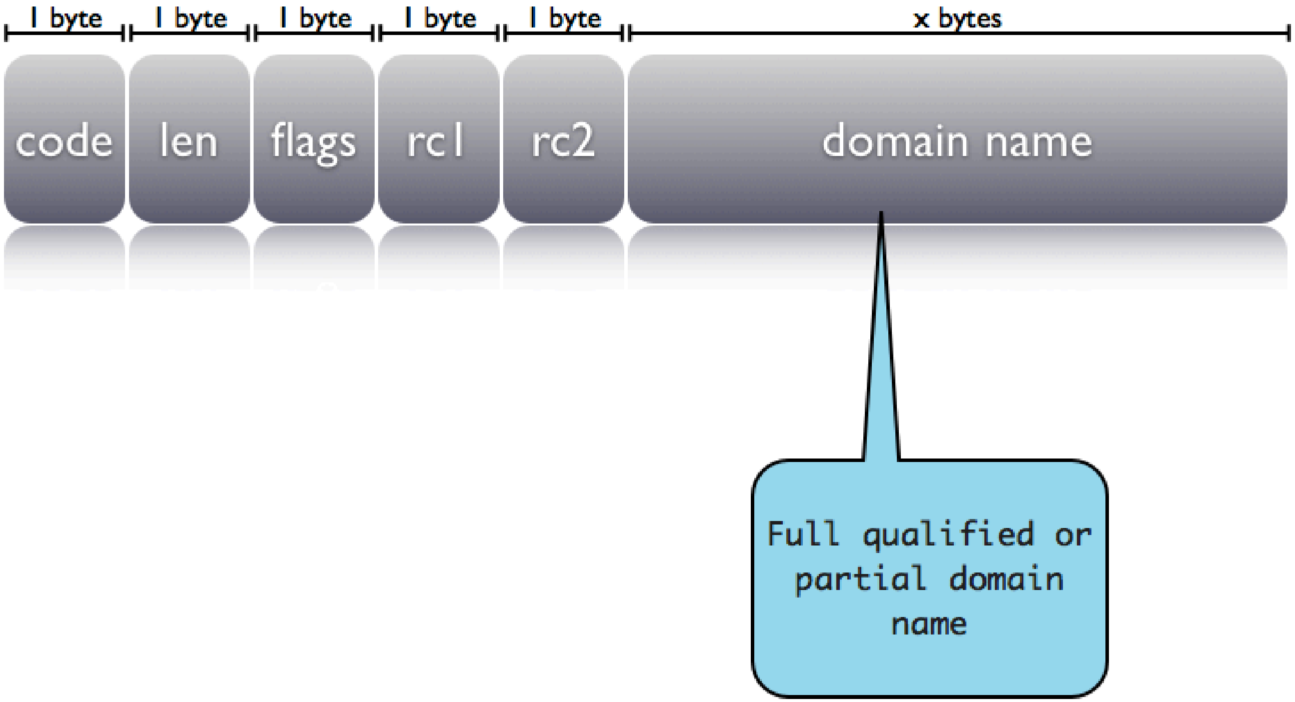
Return Code of A-Record DDNS update (deprecated by RFC 4702)

The FQDN Option



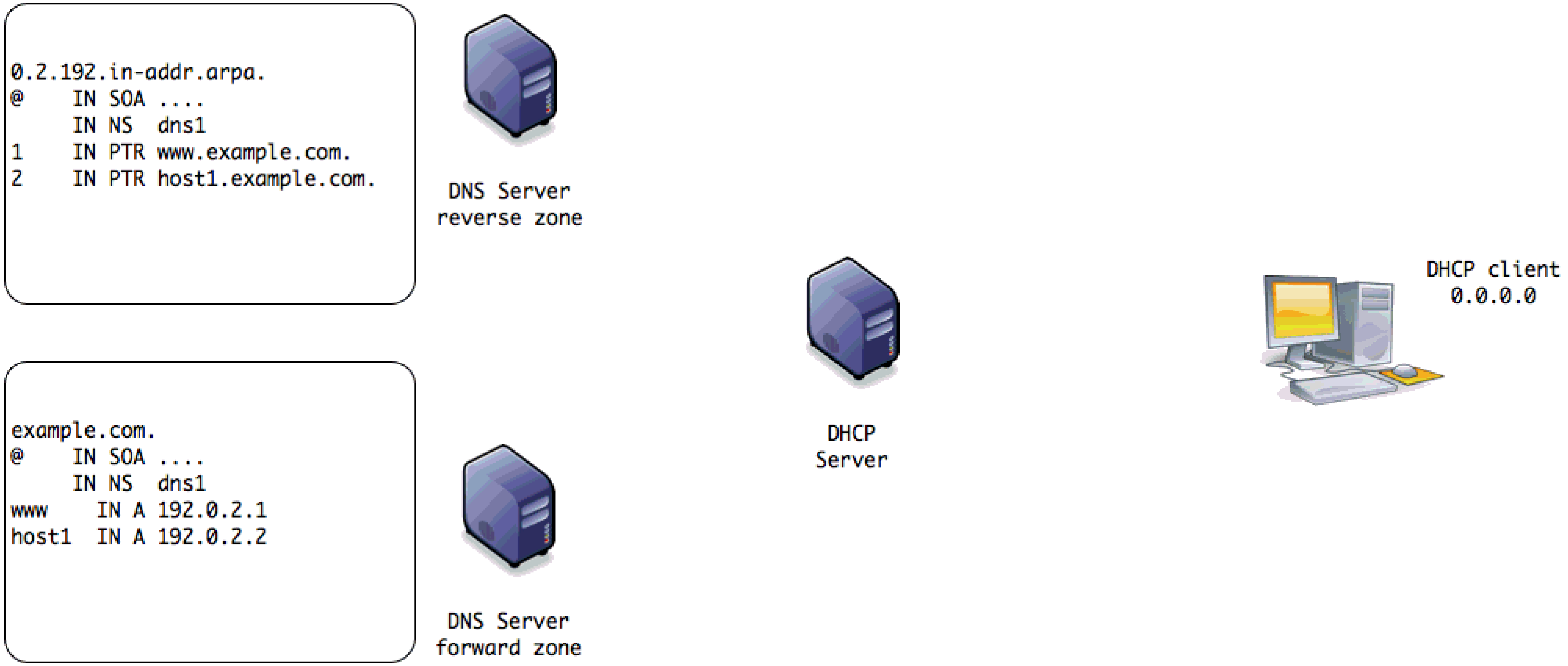
Return Code of PTR-Record DDNS update (deprecated by RFC 4702)

The FQDN Option



Full qualified or partial domain name

dynamic DNS with DHCP



```
0.2.192.in-addr.arpa.
@     IN SOA ....
      IN NS  dns1
1     IN PTR www.example.com.
2     IN PTR host1.example.com.
```

DNS Server
reverse zone

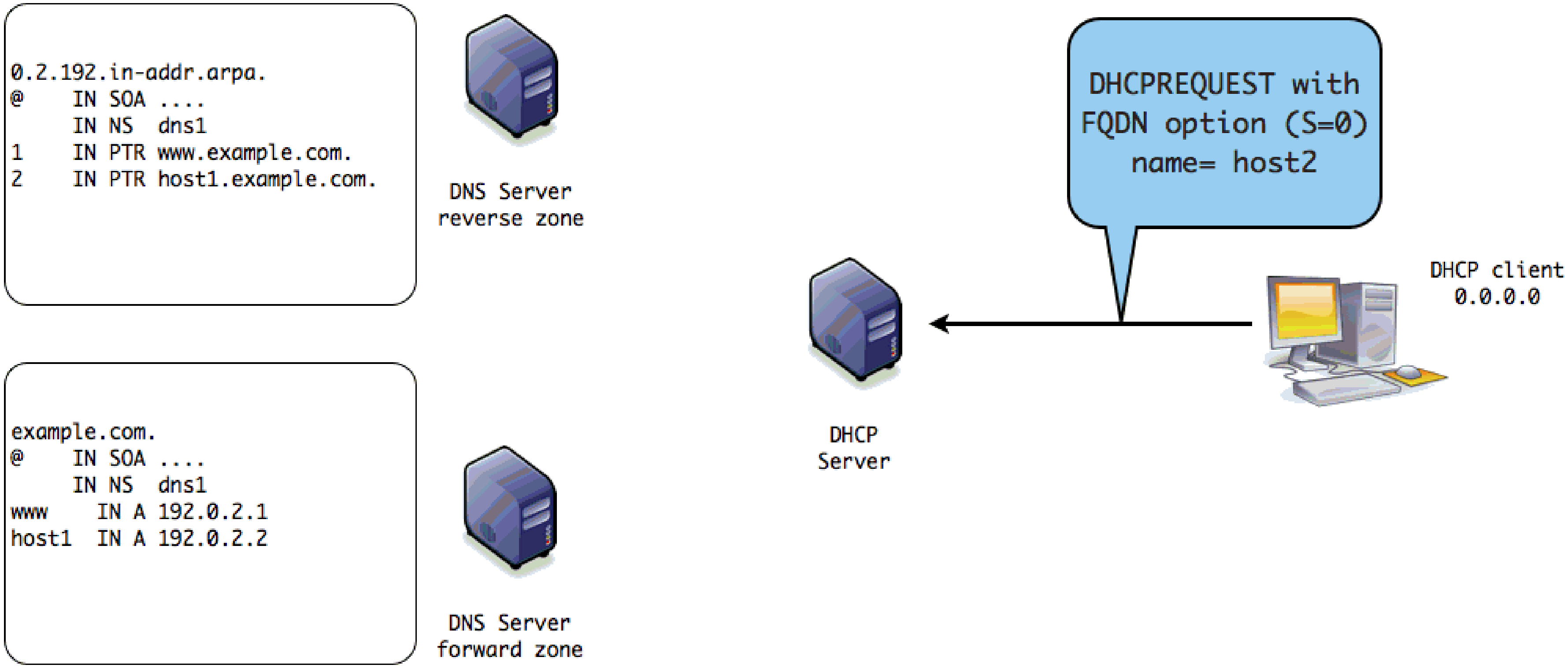
```
example.com.
@     IN SOA ....
      IN NS  dns1
www     IN A 192.0.2.1
host1   IN A 192.0.2.2
```

DNS Server
forward zone

DHCP
Server

DHCP client
0.0.0.0

dynamic DNS with DHCP



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```

```
example.com.
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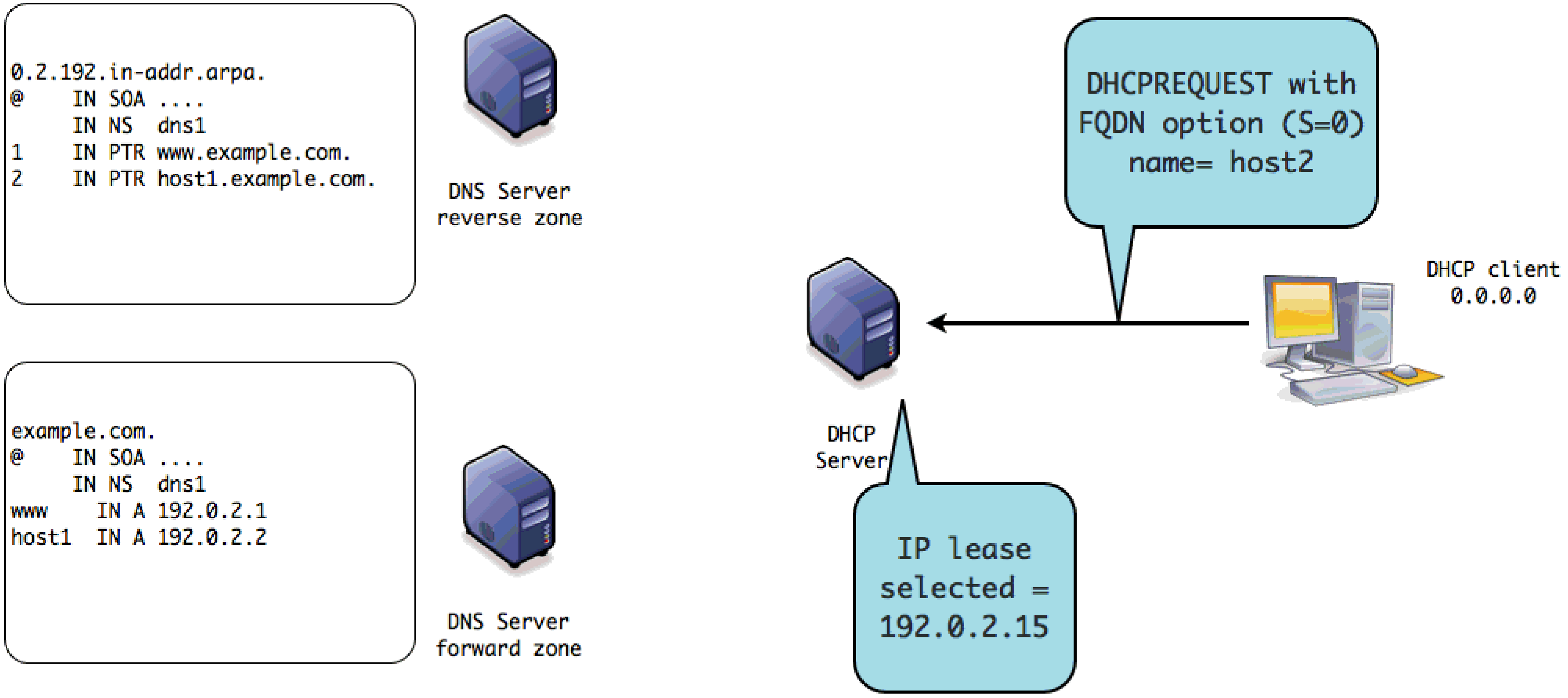
      IN NS  dns1
www     IN A 192.0.2.1
host1   IN A 192.0.2.2
```

DHCPREQUEST with FQDN option (S=0) name= host2

dynamic DNS with DHCP



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```

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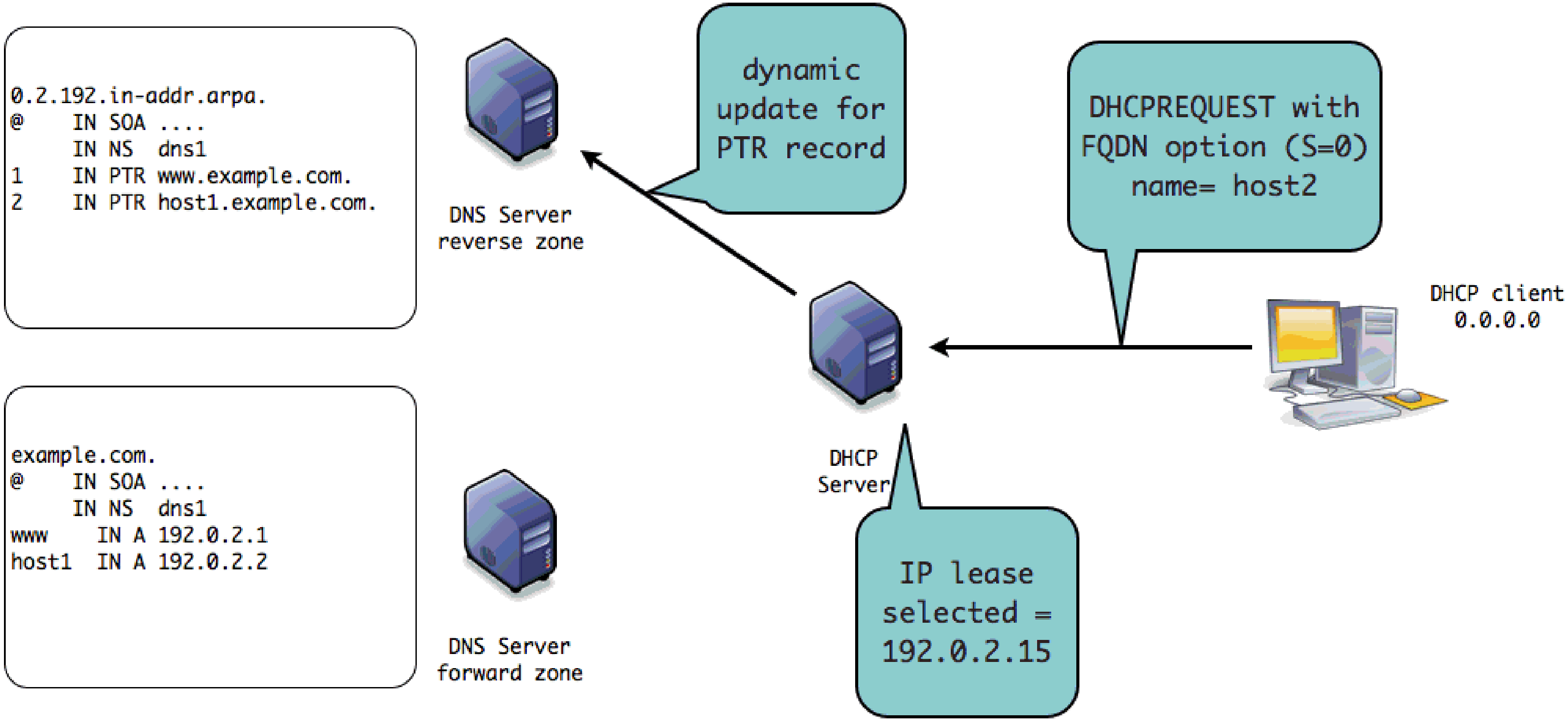
example.com.
@     IN SOA ....
      IN NS  dns1
www     IN A 192.0.2.1
host1   IN A 192.0.2.2
```

DNS Server
reverse zone
DNS Server
forward zone
DHCPREQUEST with FQDN option (S=0) name= host2
DHCP client
0.0.0.0
DHCP Server
IP lease selected = 192.0.2.15

dynamic DNS with DHCP



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example.com.
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host1   IN A 192.0.2.2
```
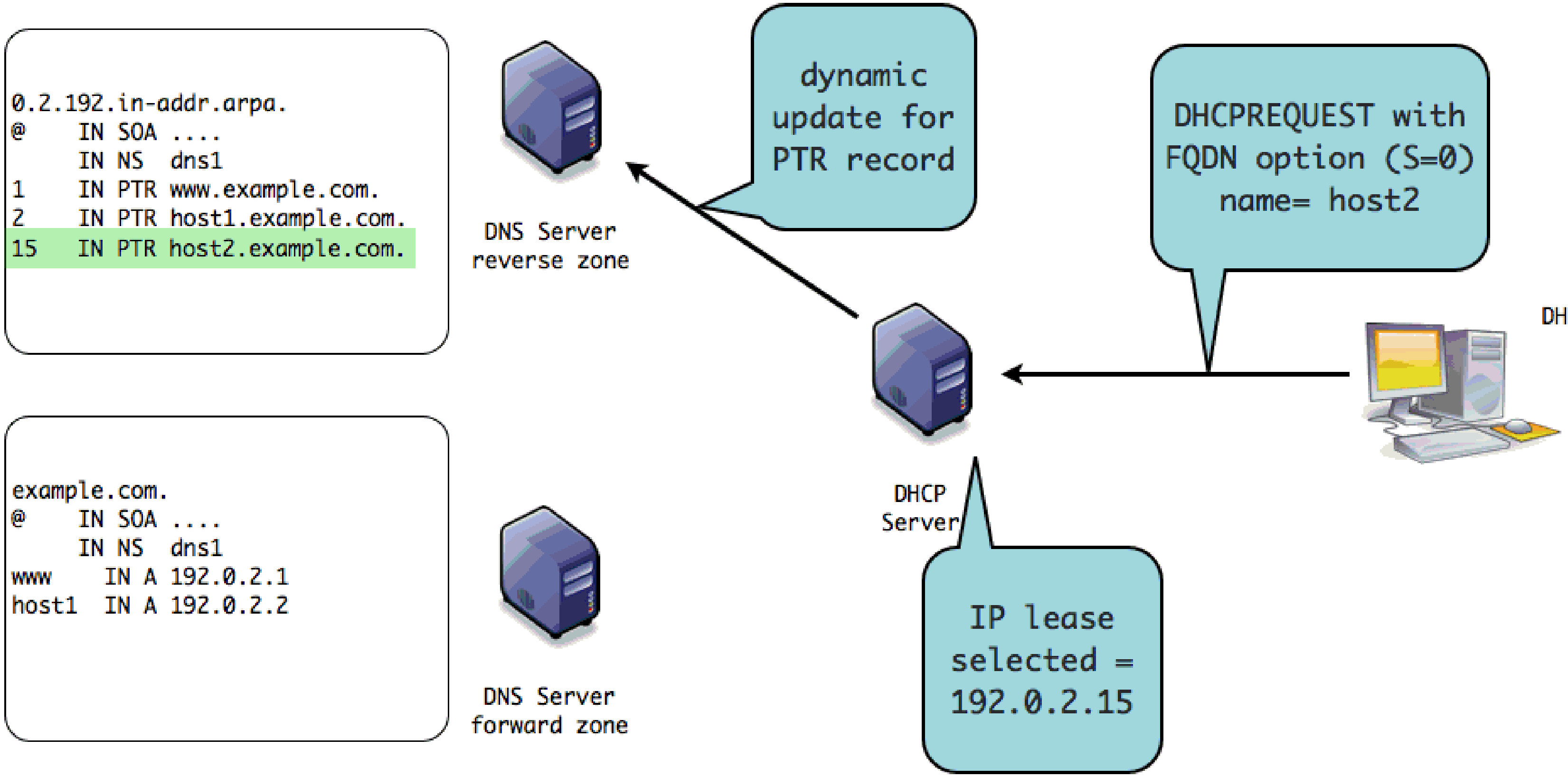

dynamic update for PTR record

DHCPREQUEST with FQDN option (S=0) name= host2

IP lease selected = 192.0.2.15

dynamic DNS with DHCP



```
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@     IN SOA ....
      IN NS  dns1
1     IN PTR www.example.com.
2     IN PTR host1.example.com.
15    IN PTR host2.example.com.
```

DNS Server reverse zone

```
example.com.
@     IN SOA ....
      IN NS  dns1
www     IN A 192.0.2.1
host1   IN A 192.0.2.2
```

DNS Server forward zone

dynamic update for PTR record

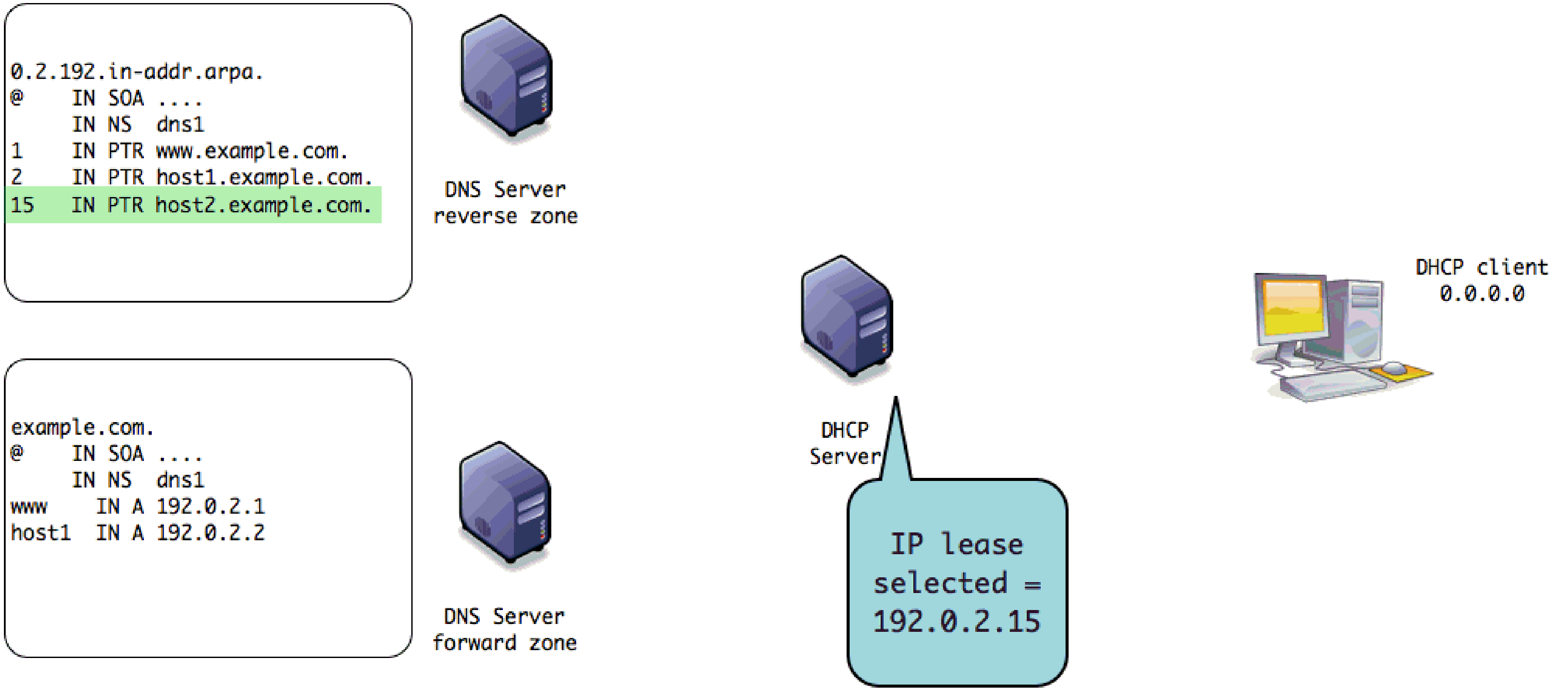
DHCPREQUEST with FQDN option (S=0) name= host2

DHCP client 0.0.0.0

DHCP Server

IP lease selected = 192.0.2.15

dynamic DNS with DHCP



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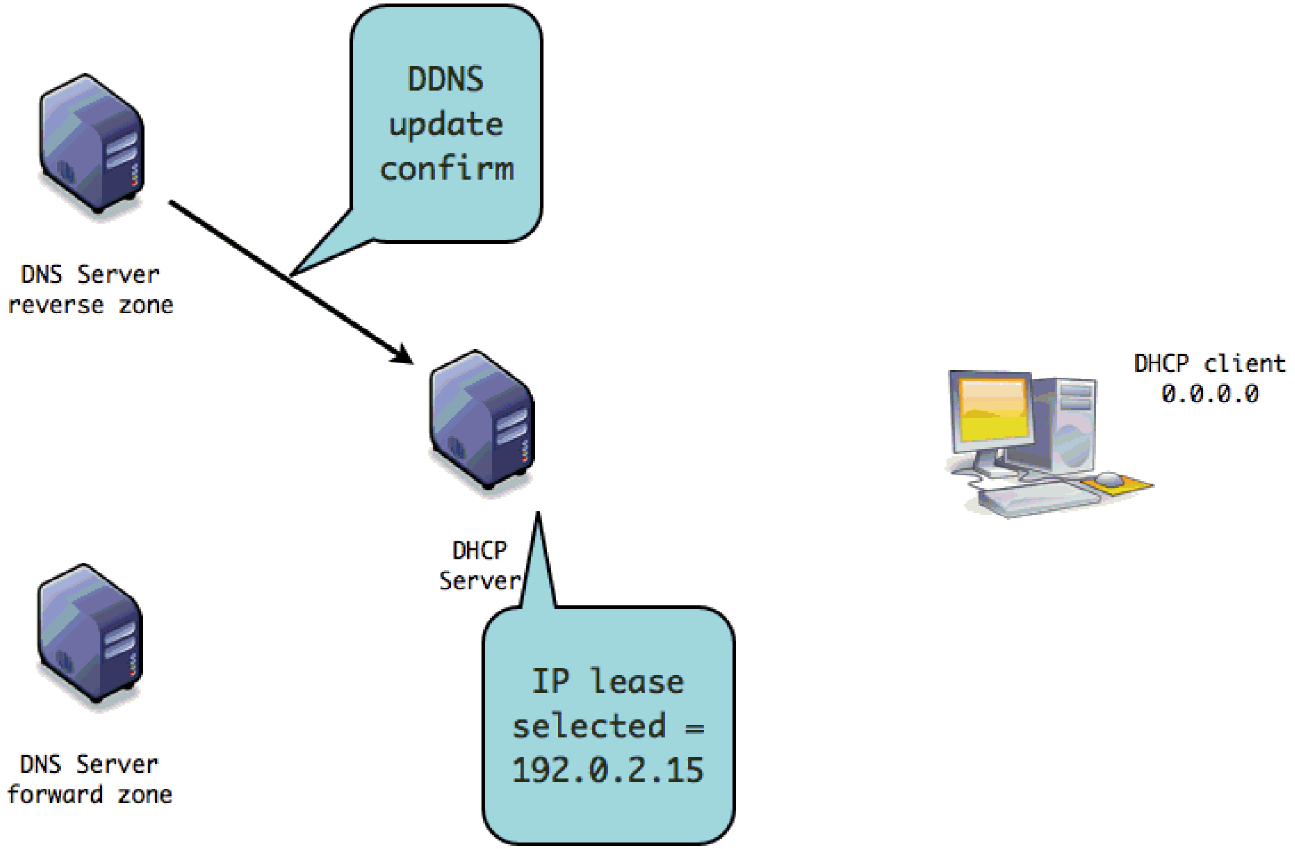
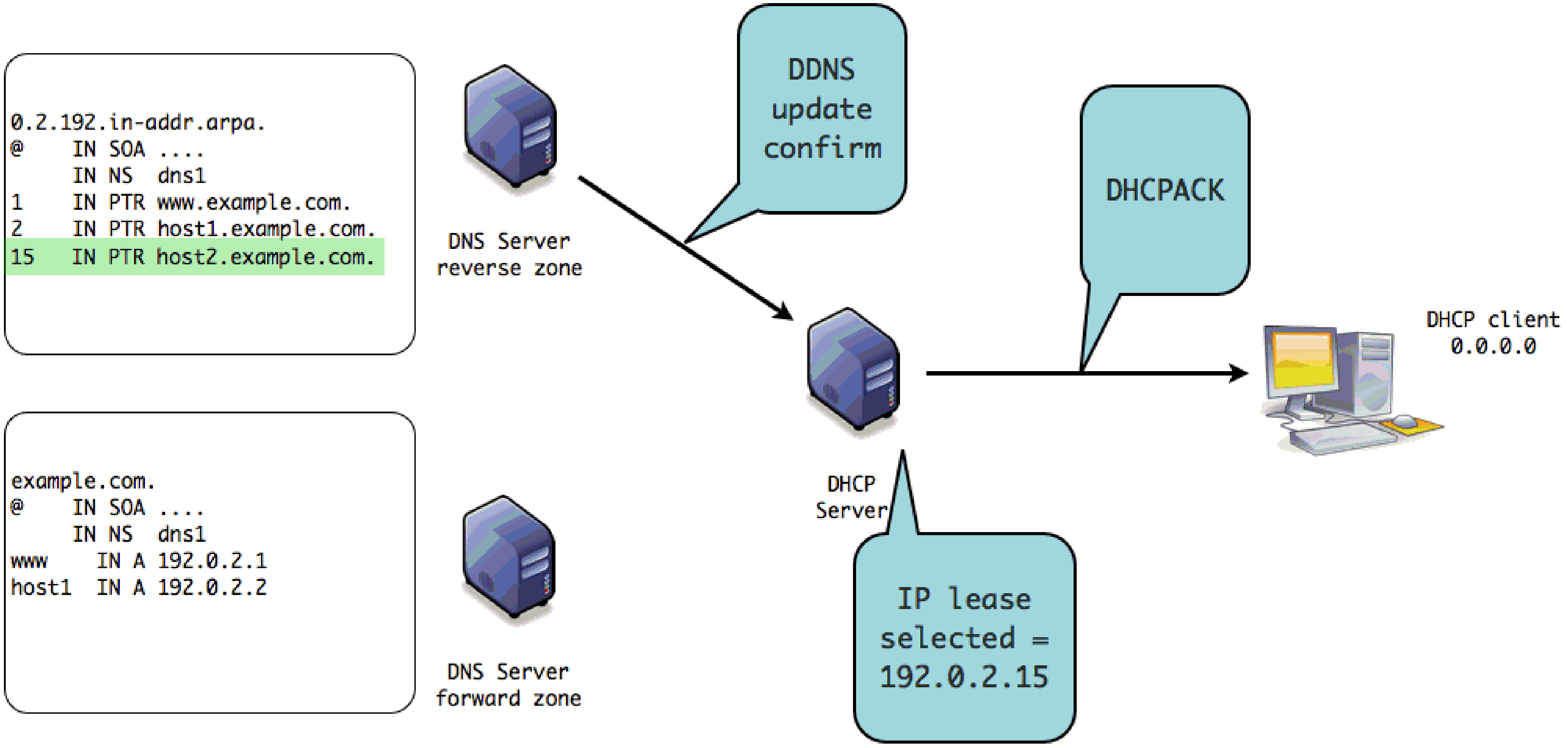


dynamic DNS with DHCP



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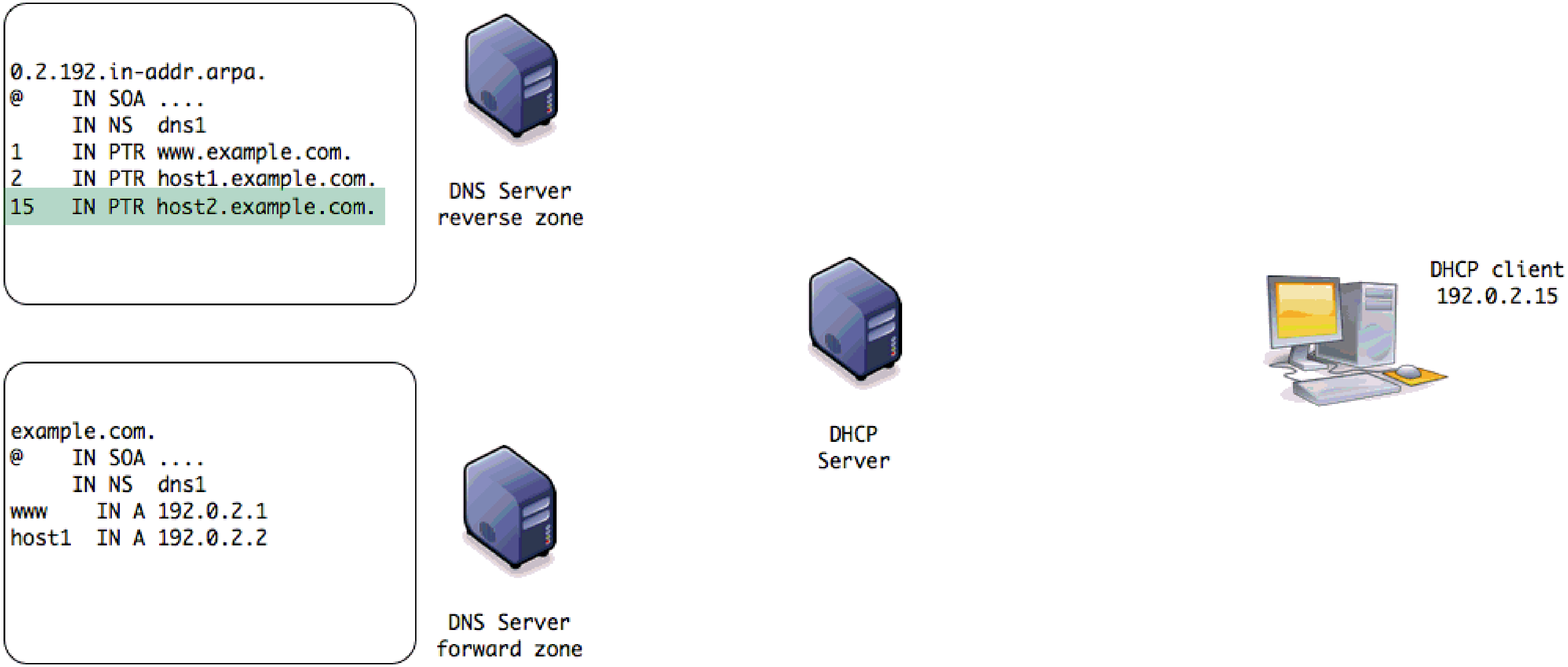

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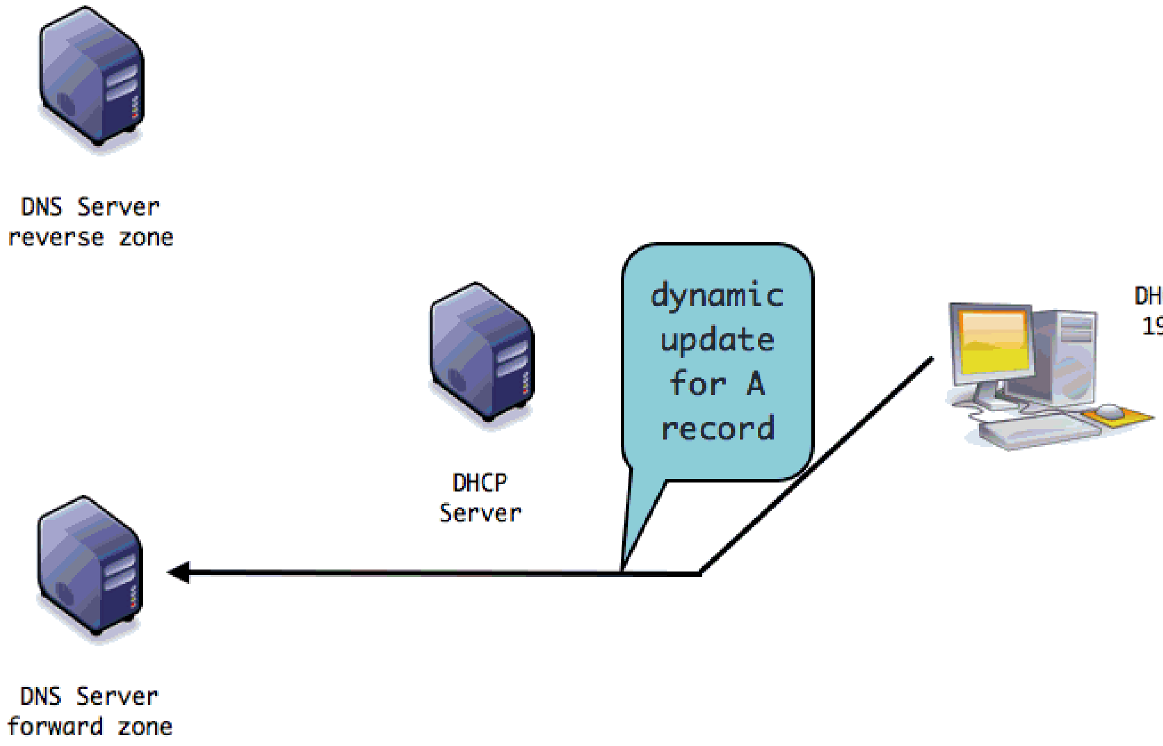
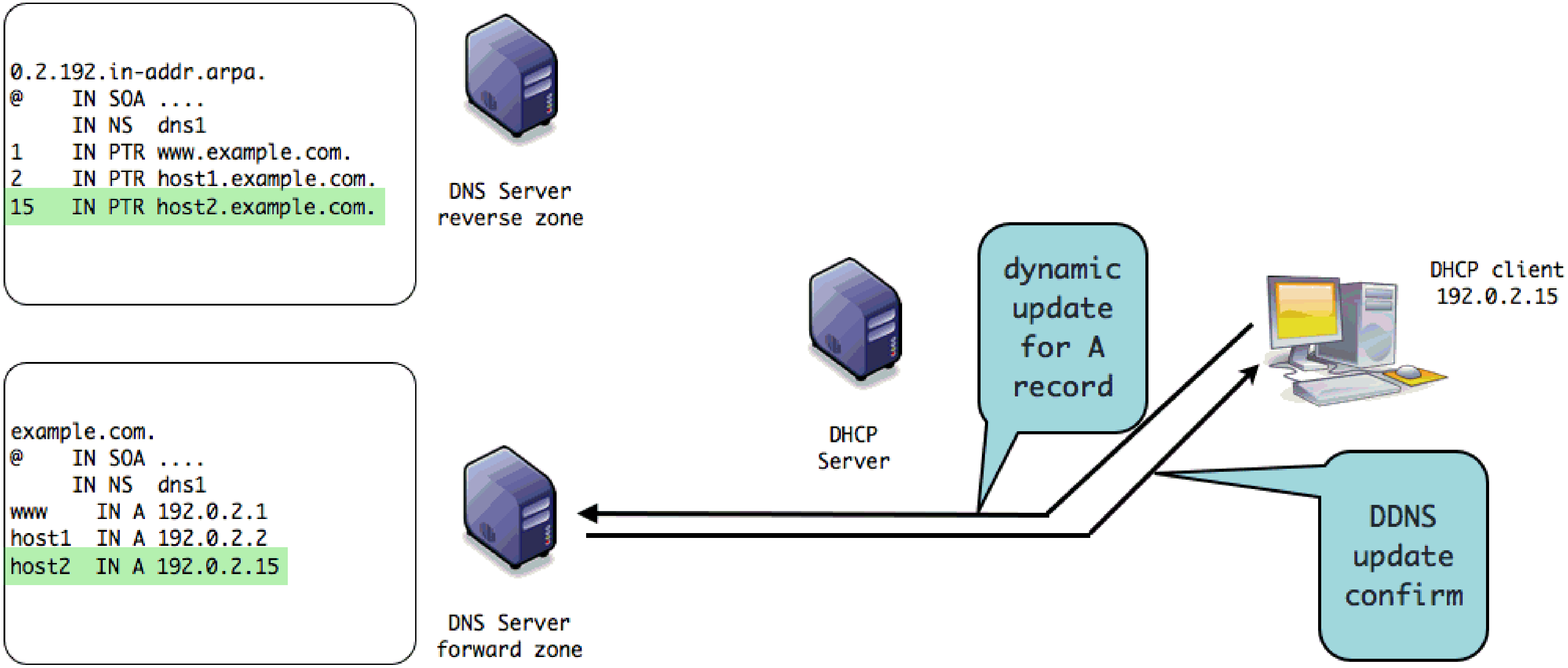


dynamic DNS with DHCP



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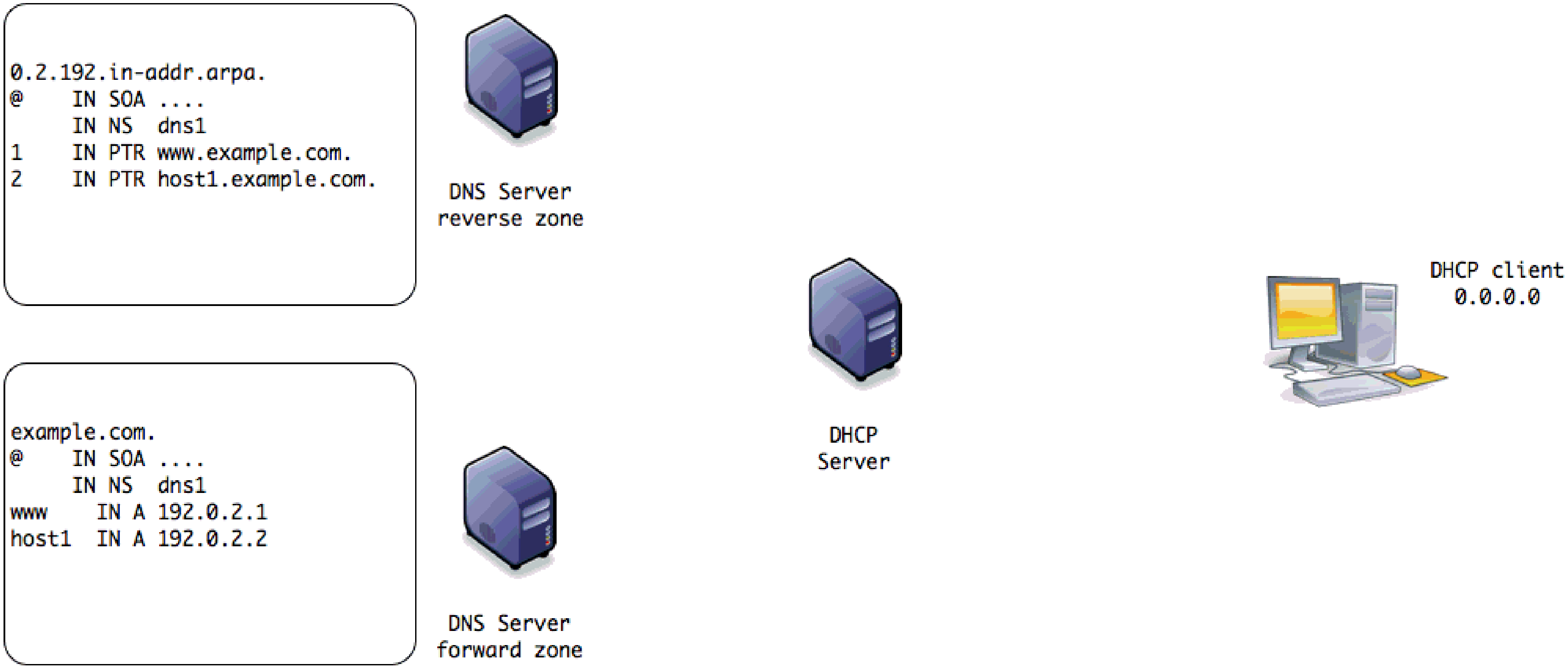
dynamic DNS with DHCP



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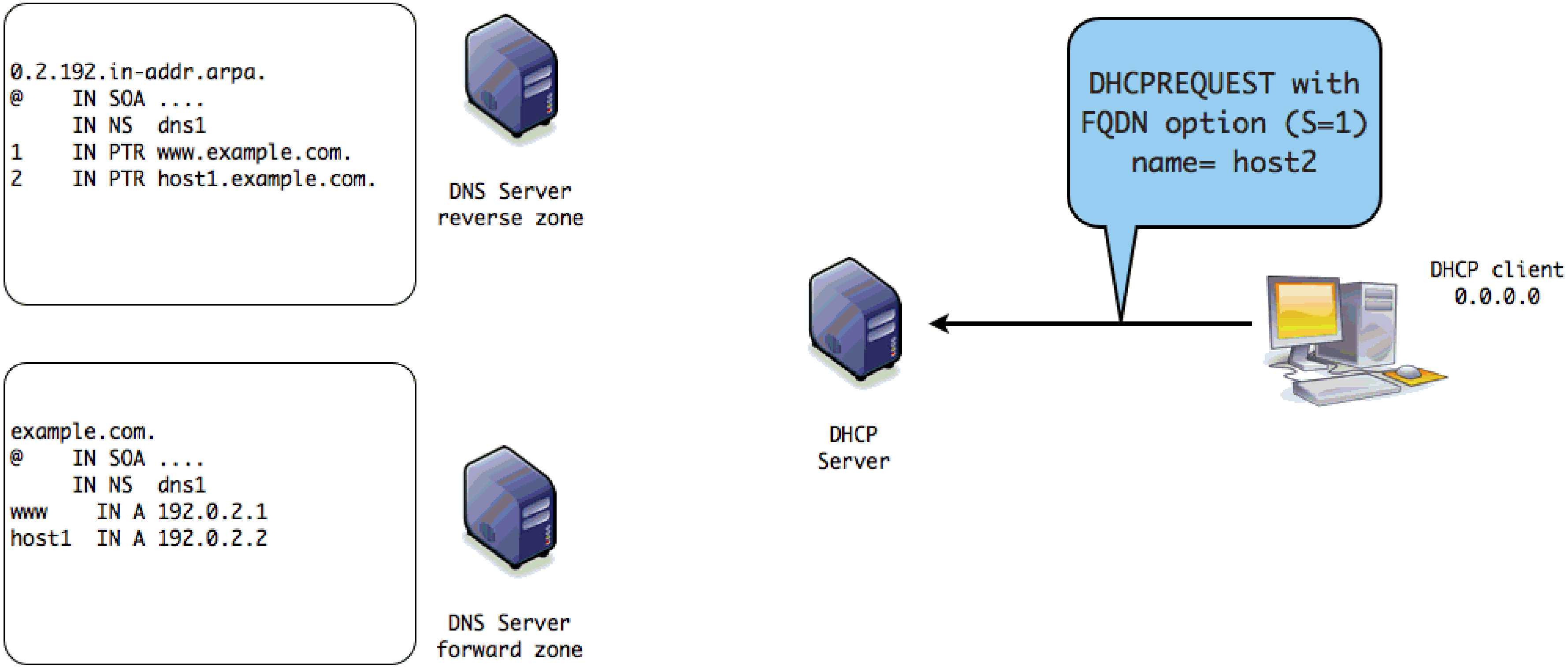
dynamic DNS with DHCP



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DNS Server
reverse zone

```
example.com.
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www     IN A 192.0.2.1
host1  IN A 192.0.2.2
```

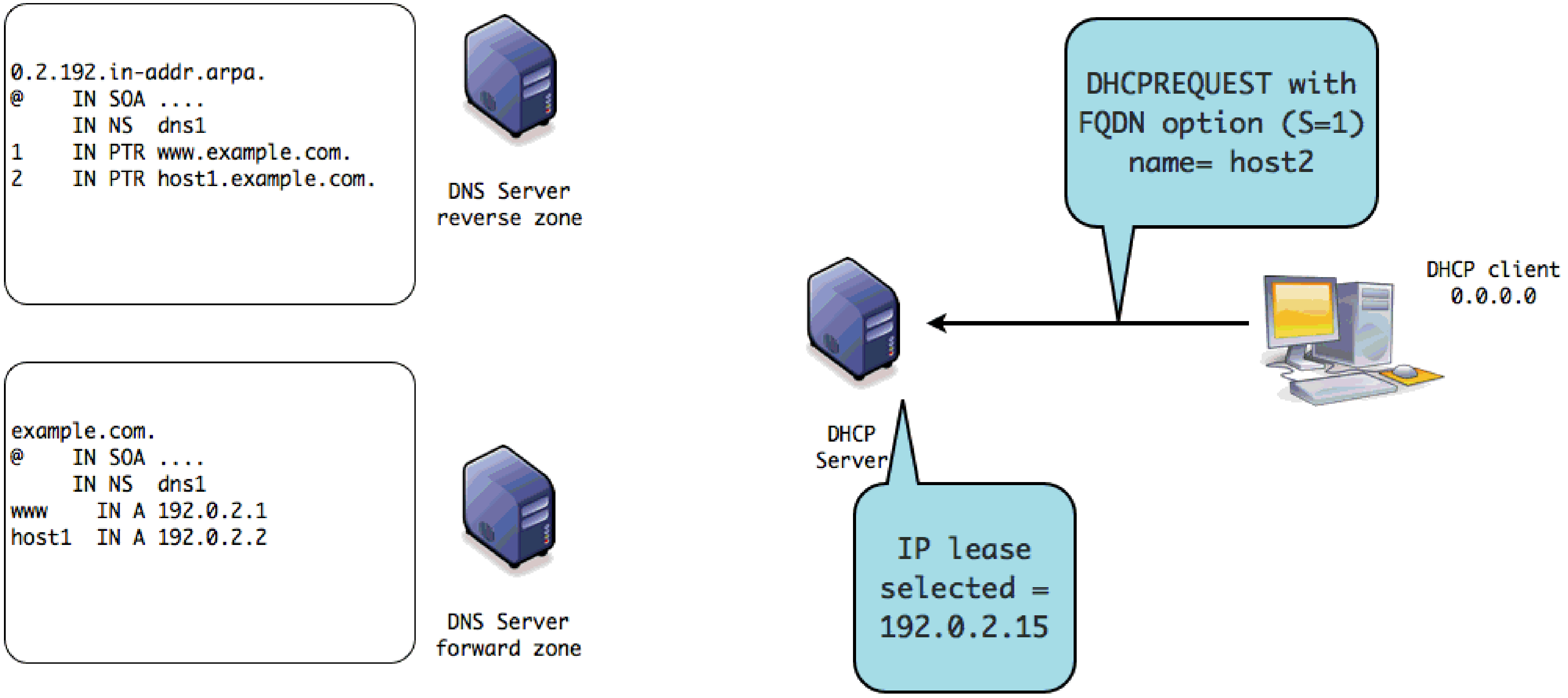
DNS Server
forward zone

DHCP
Server

DHCPREQUEST with
FQDN option (S=1)
name= host2

DHCP client
0.0.0.0

dynamic DNS with DHCP



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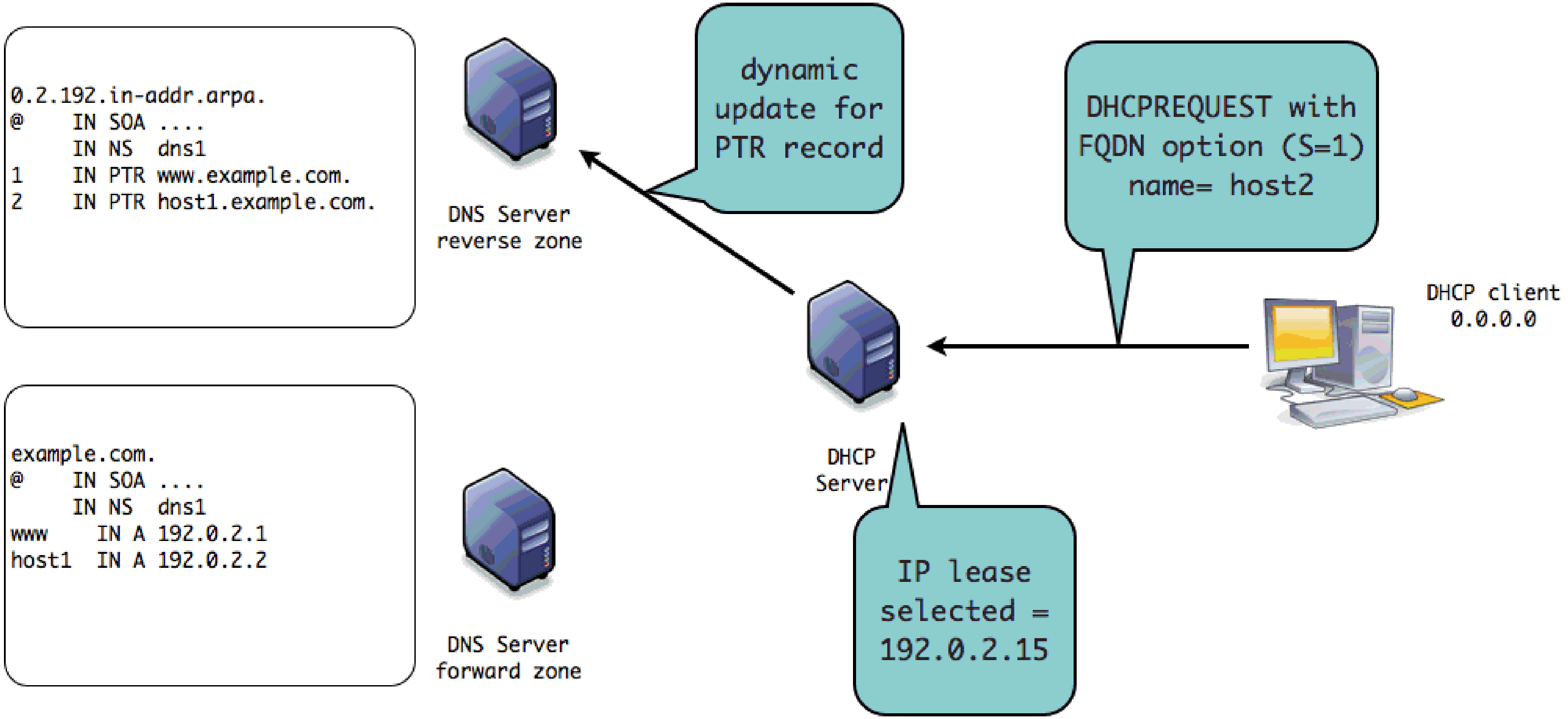
DNS Server
reverse zone
DNS Server
forward zone
DHCPREQUEST with FQDN option (S=1) name= host2
DHCP client
0.0.0.0
DHCP
Server
IP lease selected = 192.0.2.15

dynamic DNS with DHCP



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```

DNS Server
reverse zone
DNS Server
forward zone
dynamic update for PTR record
DHCPREQUEST with FQDN option (S=1) name= host2
DHCP client
0.0.0.0
DHCP
Server
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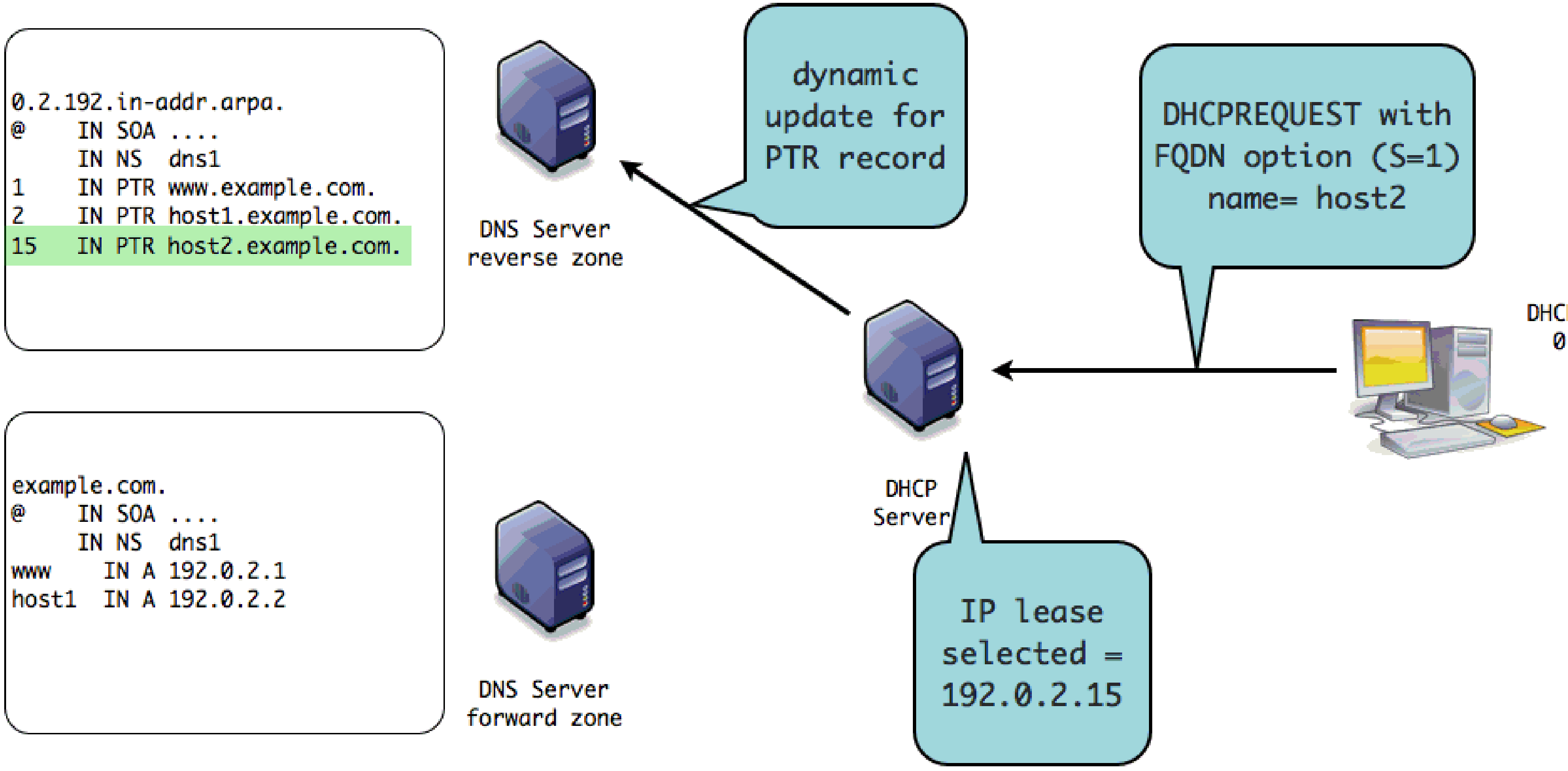
dynamic DNS with DHCP



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example.com.
@     IN SOA ....
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host1   IN A 192.0.2.2
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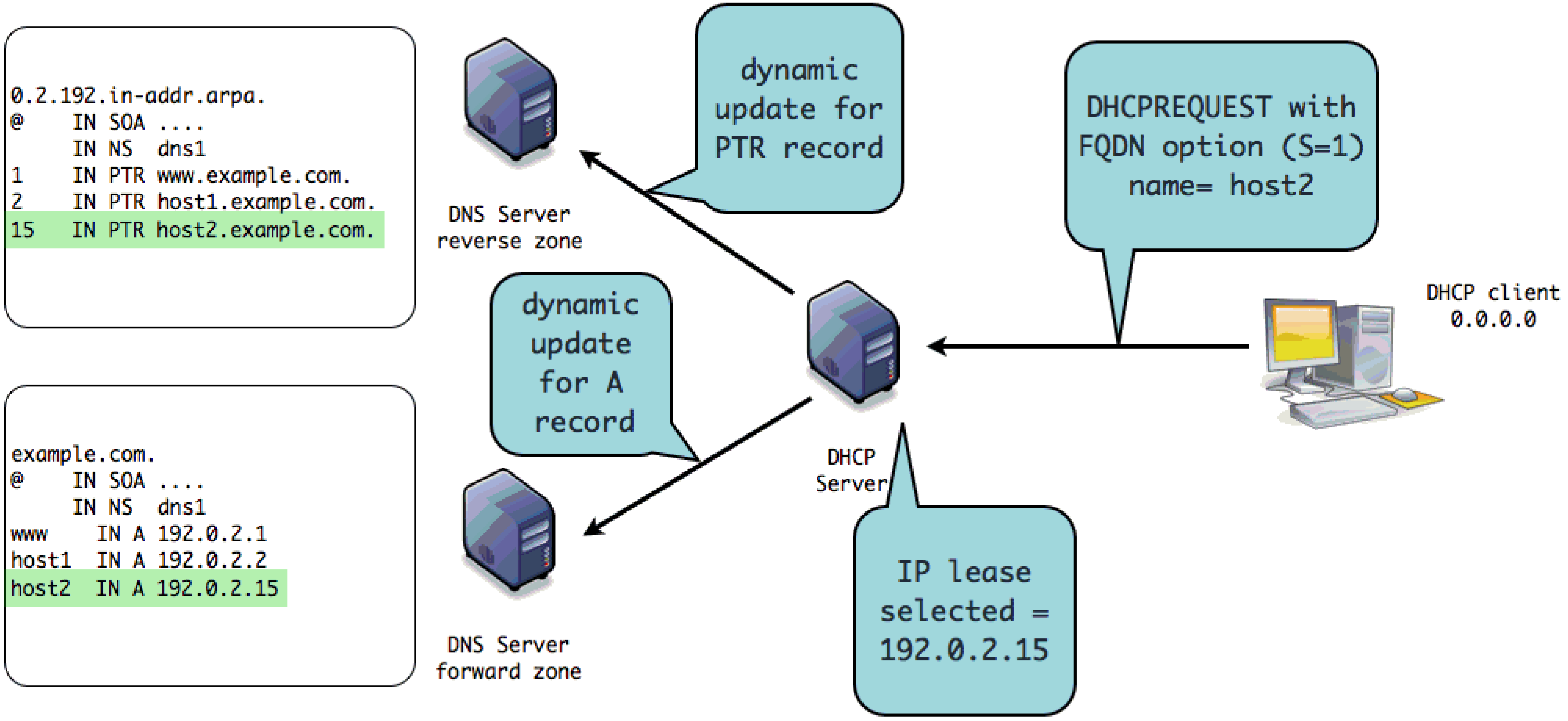
DNS Server
reverse zone
DNS Server
forward zone
dynamic update for PTR record
DHCPREQUEST with FQDN option (S=1) name= host2
DHCP client
0.0.0.0
DHCP Server
IP lease selected = 192.0.2.15

dynamic DNS with DHCP



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      IN NS  dns1
1     IN PTR www.example.com.
2     IN PTR host1.example.com.
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```

```
example.com.
@     IN SOA ....
      IN NS  dns1
www     IN A 192.0.2.1
host1   IN A 192.0.2.2
host2   IN A 192.0.2.15
```

DNS Server
reverse zone

dynamic update for PTR record

DHCPREQUEST with FQDN option (S=1) name= host2

DHCP client
0.0.0.0

dynamic update for A record

DHCP Server

IP lease selected = 192.0.2.15

DNS Server
forward zone

dynamic DNS with DHCP

```
0.2.192.in-addr.arpa.
@     IN SOA ....
      IN NS  dns1
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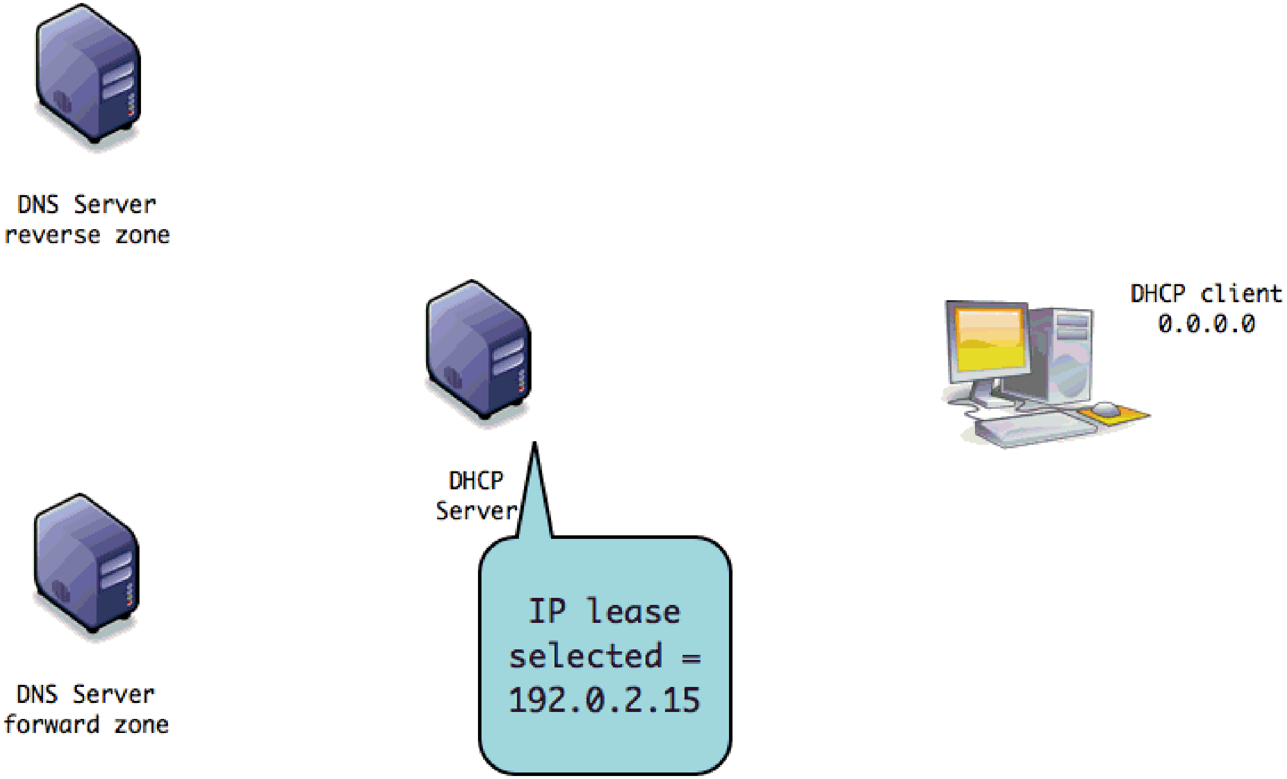
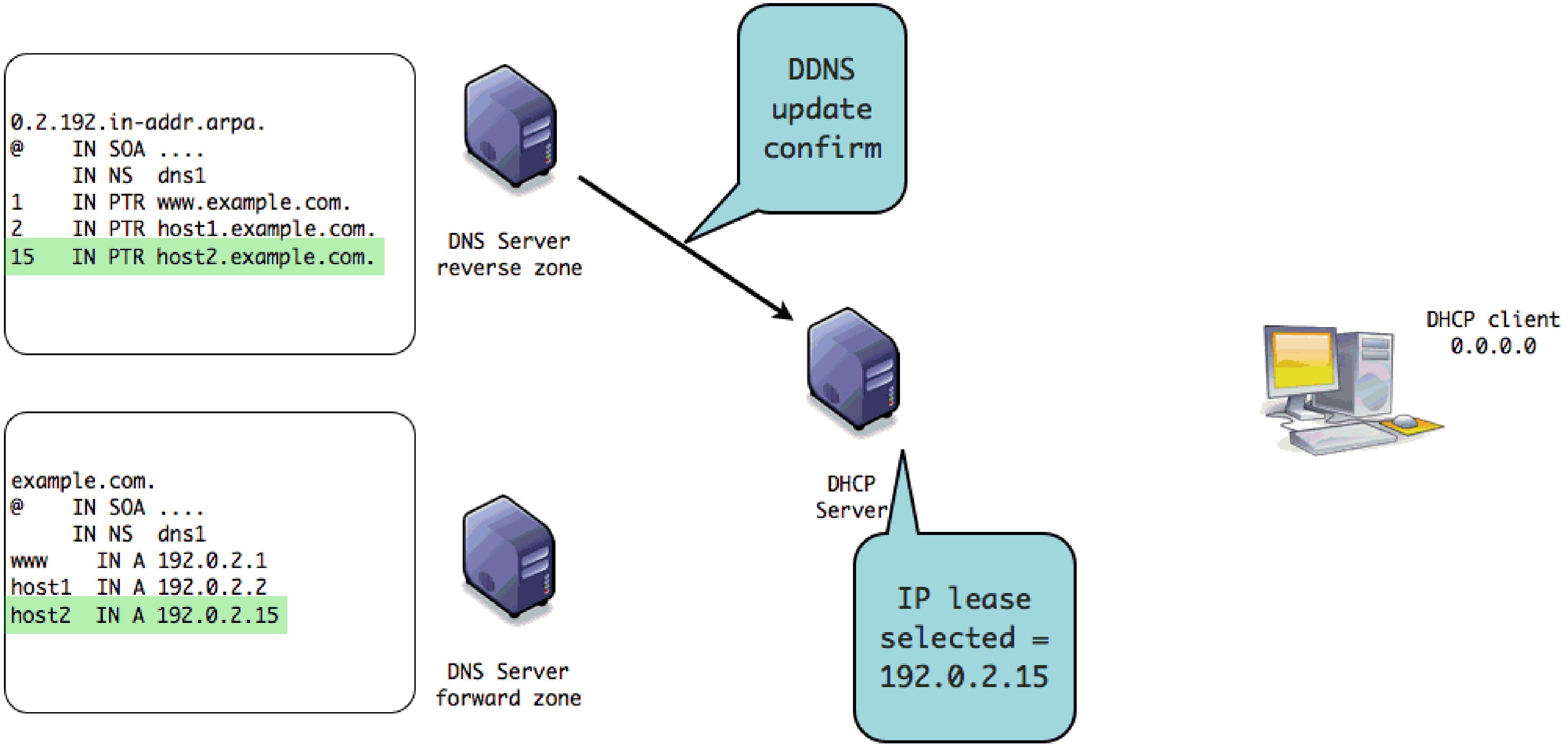


dynamic DNS with DHCP



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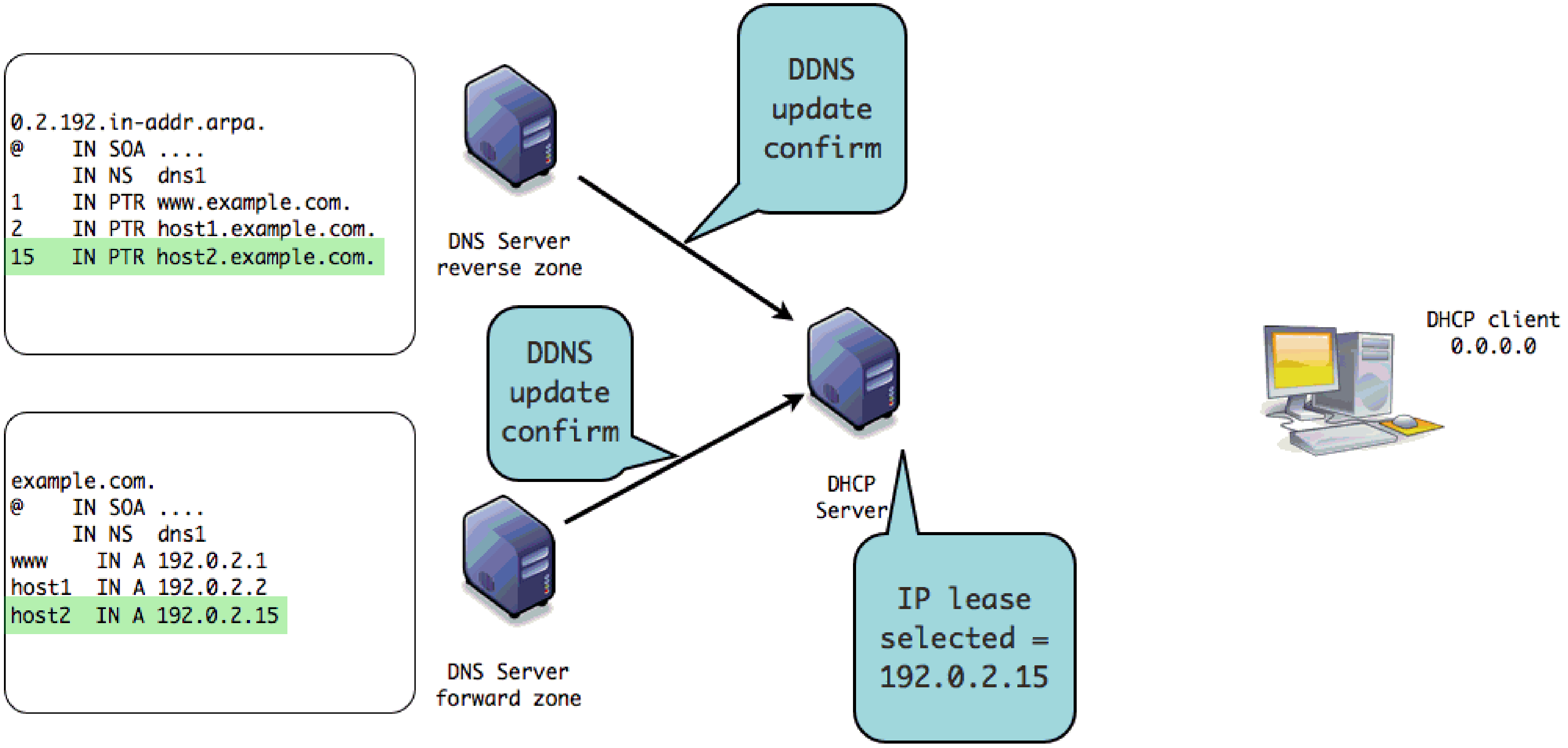
dynamic DNS with DHCP



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dynamic DNS with DHCP

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example.com.
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host2   IN A 192.0.2.15
```
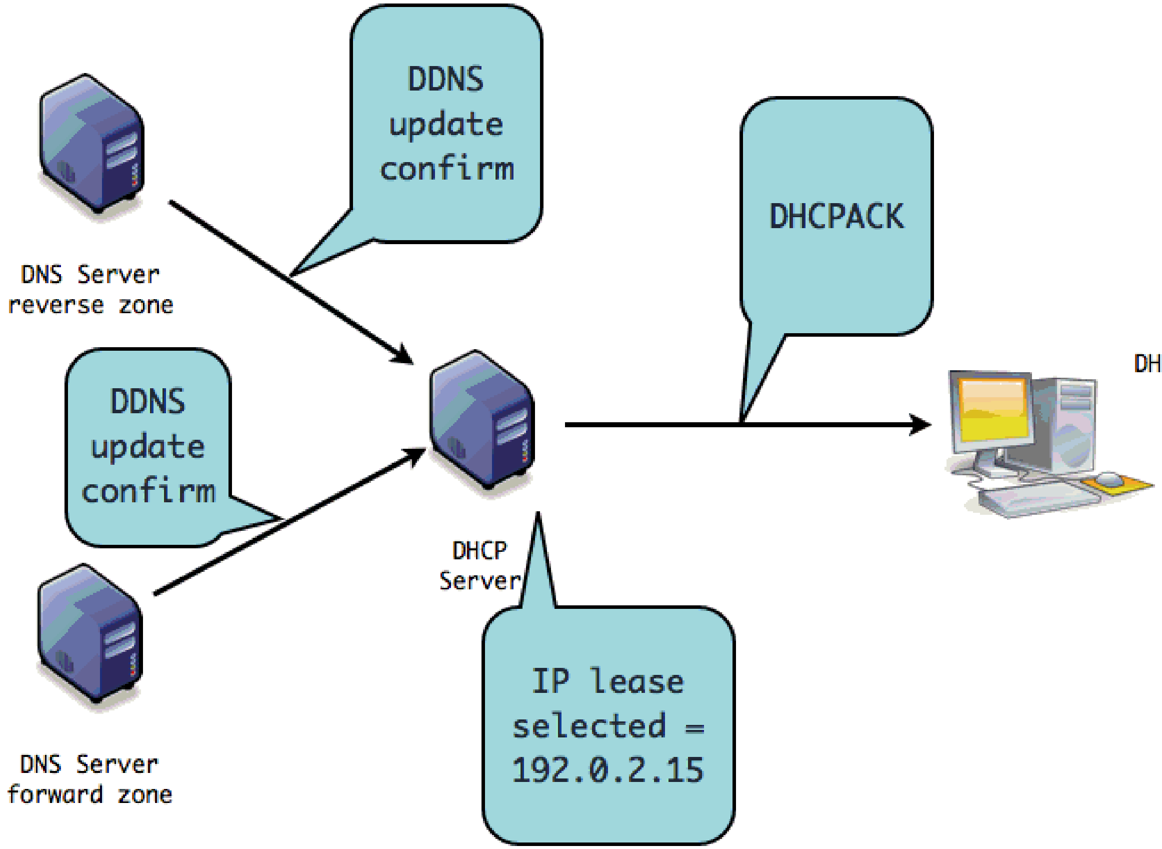



DNS Server
reverse zone

DDNS update confirm

DDNS update confirm

DNS Server
forward zone

DHCP Server

IP lease selected = 192.0.2.15

DHCPACK

DHCP client
0.0.0.0

DHCP DNS update RFCs

- DNS updates from DHCP clients and DHCP servers have been implemented for a long time (around 1994)
    - But the standardization has been finalized rather lately (October 2006)
    - RFC 4701 - RFC 4703

Resolving name conflicts during dynamic DNS updates

The DHCID Record

- When writing data to the DNS, a DHCP server will also add a DHCID records for the same domain name
    - The DHCID record contains a hash over the data that securely identifies a DHCP client
    - When updating or removing existing information, a DHCP server can detect if that information is for the same client, or for a different one with the same name

The DHCID Record

- The DHCID record is supported in ISC BIND 9.5.0 onwards
    - However some other DNS Server products do not support the DHCID record

- Example of a DHCID record:

```
host1.example.com.      A       192.0.2.2
host1.example.com.      DHCID   ( AAEBOSD+XR3Os/0LozeXVqcNc7FwCfQdWL3b/NaiUDlW2No= )
```

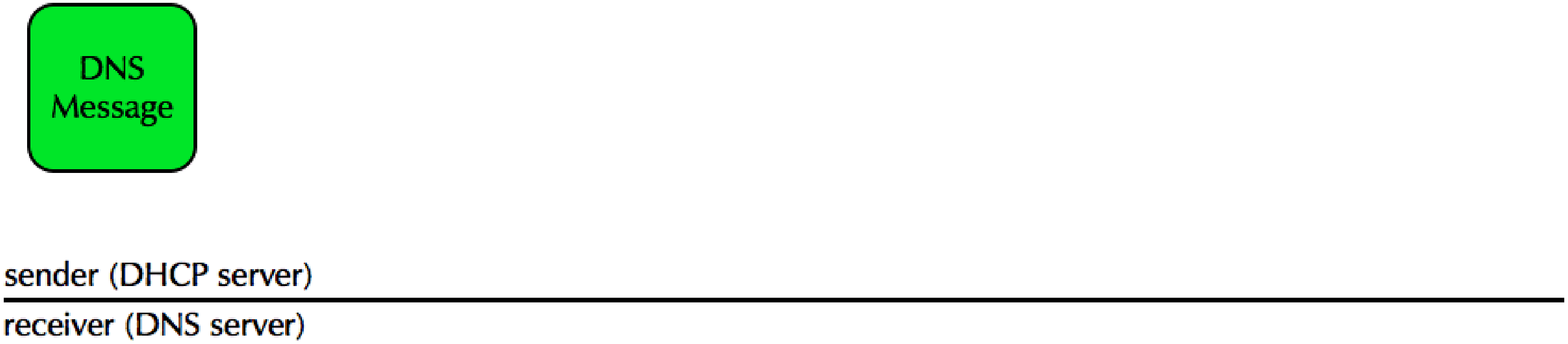
Securing dynamic DNS updates

- Unless both the DHCP Server and the DNS server are in an completely trustworthy network, the dynamic updates should be secured
- Using the TSIG DNS protocol extension protects the dynamic update
  - From un-authorized update messages
  - From changes on the transit of the update packet

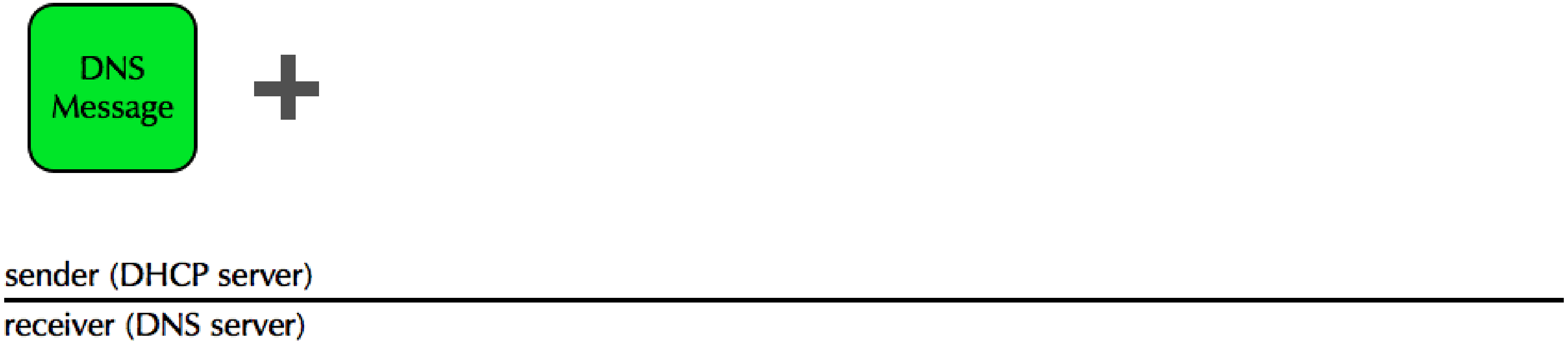
TSIG

- DNS messages are secured by adding a new record, called a TSIG record, to the additional data section
    - The TSIG record serves as a signature on the message
    - The endpoint sending the message calculates and adds the TSIG record
    - The endpoint receiving the messages removes and verifies the TSIG record

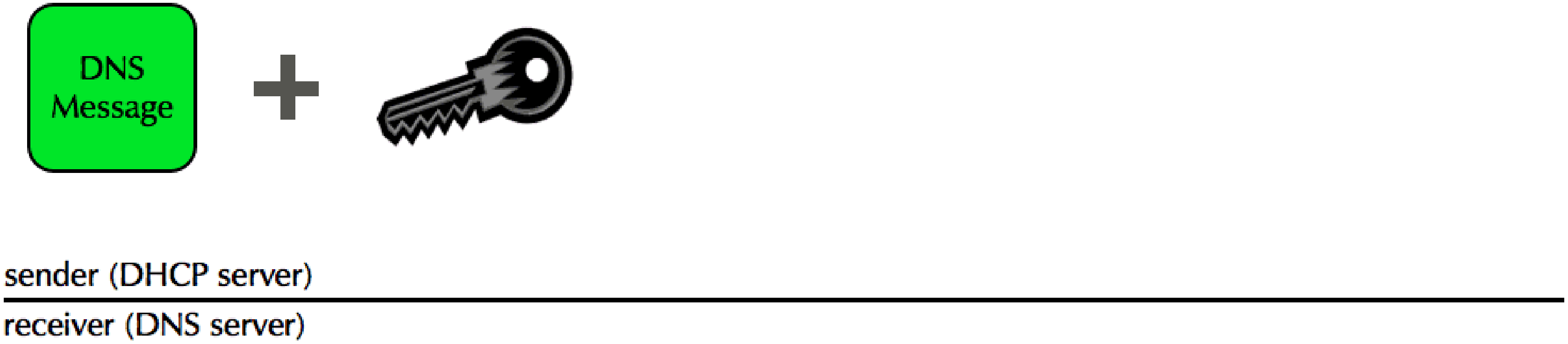
TSIG illustrated



TSIG illustrated



TSIG illustrated



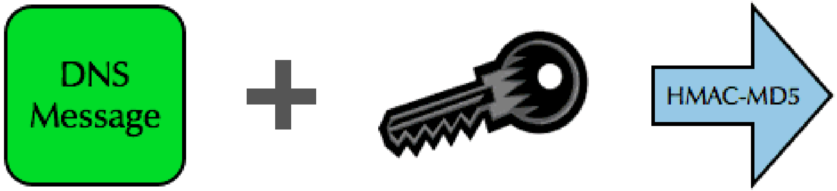
DNS Message

+

sender (DHCP server)

receiver (DNS server)

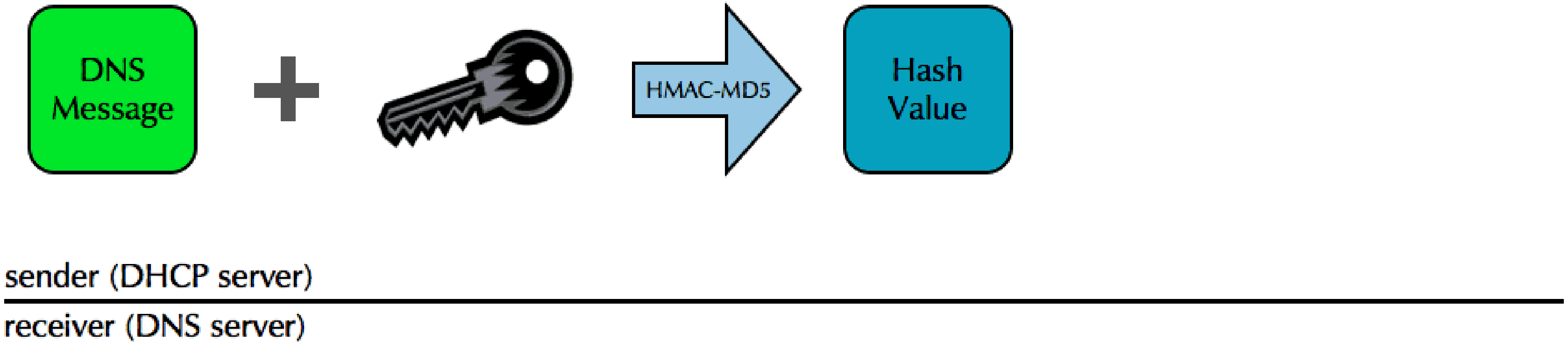
TSIG illustrated



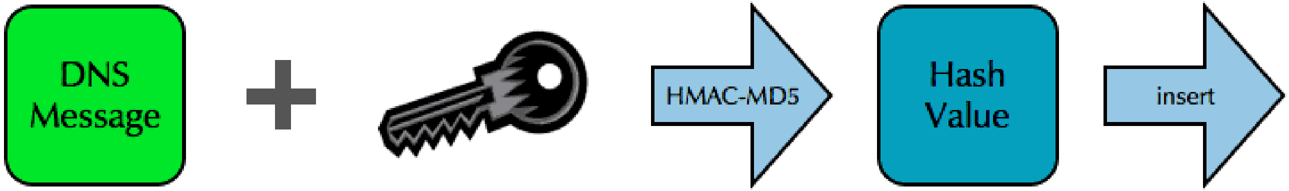
sender (DHCP server)

receiver (DNS server)

TSIG illustrated



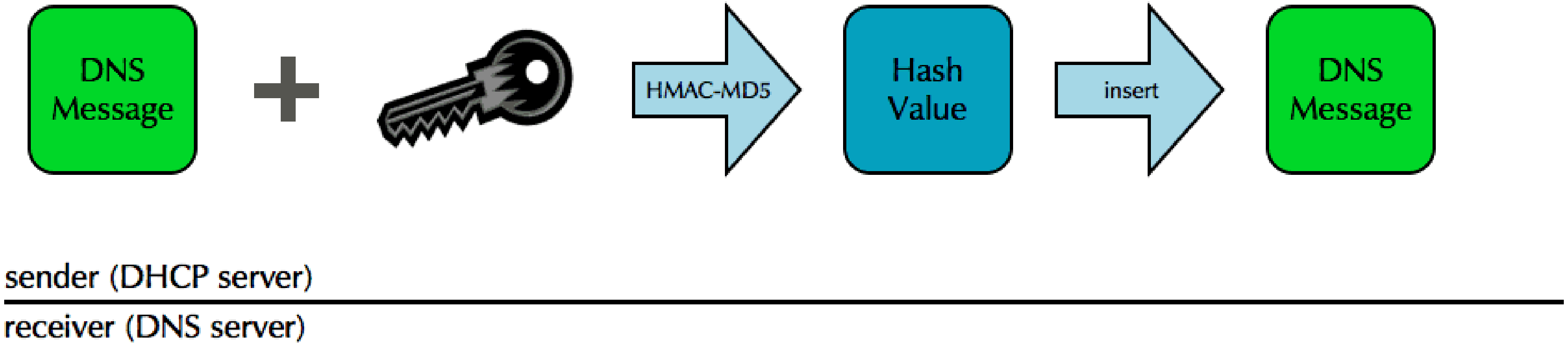
TSIG illustrated



sender (DHCP server)

receiver (DNS server)

TSIG illustrated

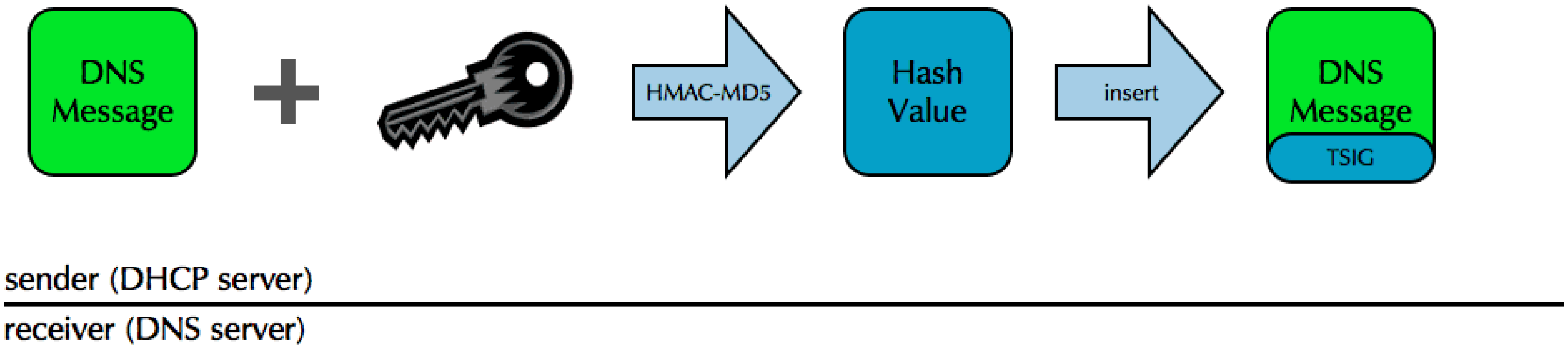


DNS Message + HMAC-MD5 Hash Value insert DNS Message

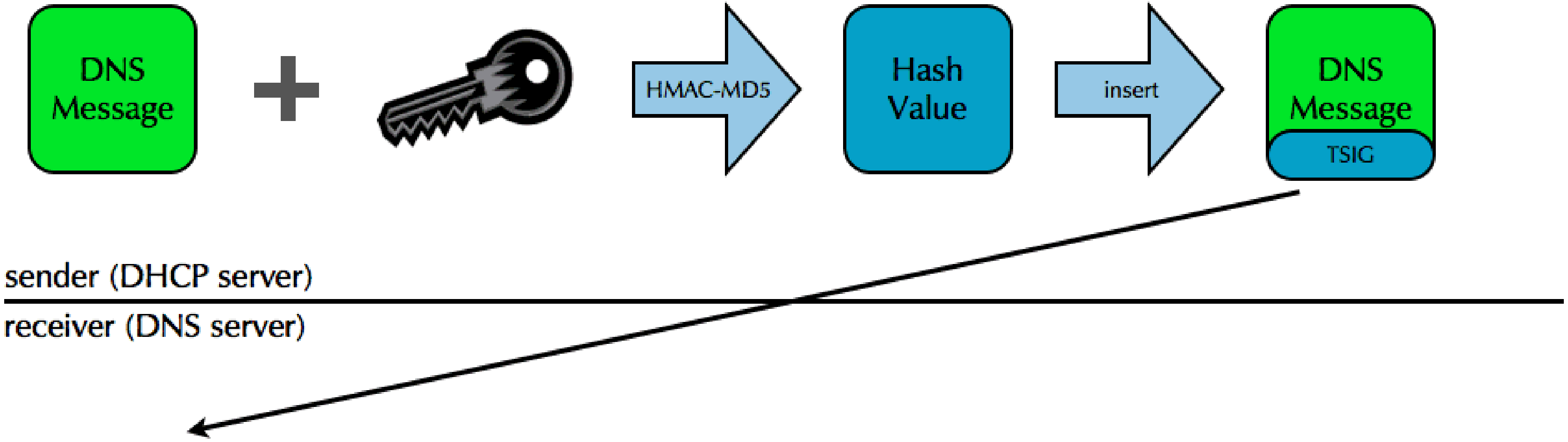
sender (DHCP server)

receiver (DNS server)

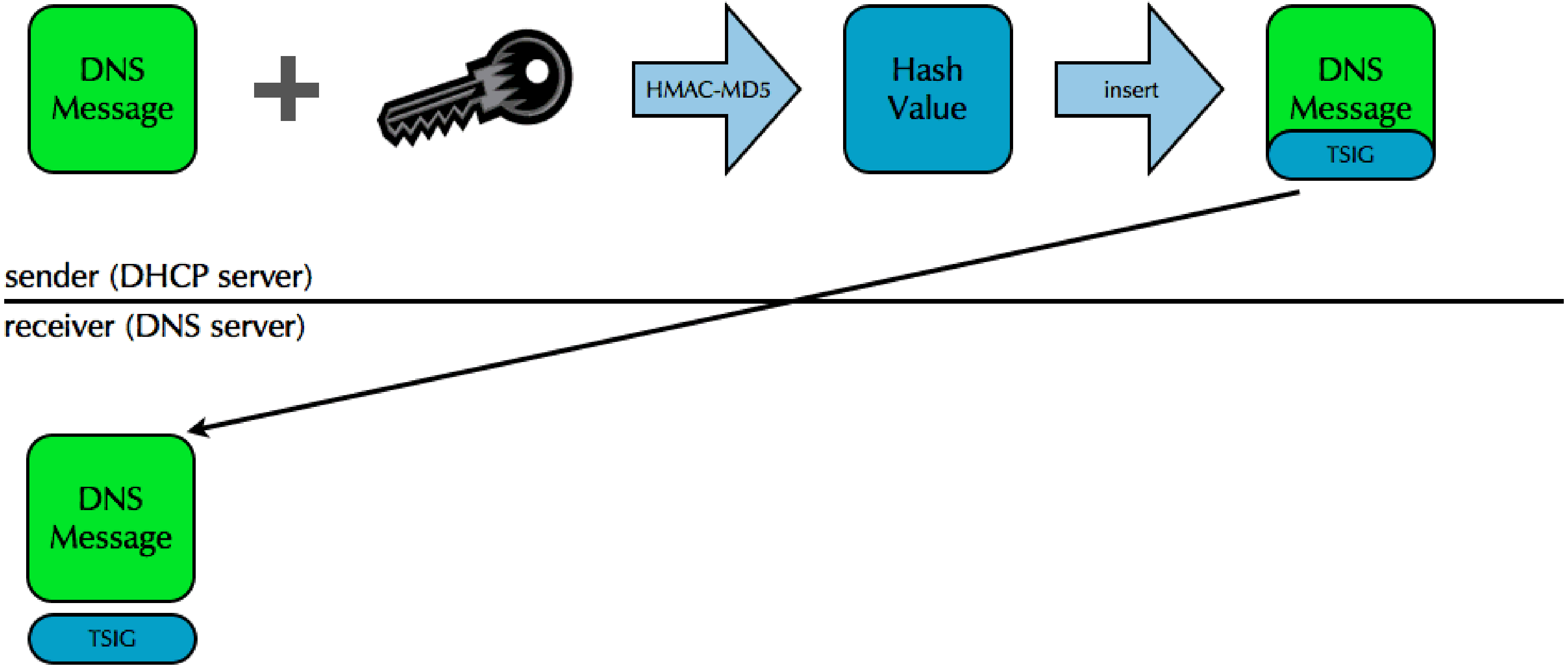
TSIG illustrated



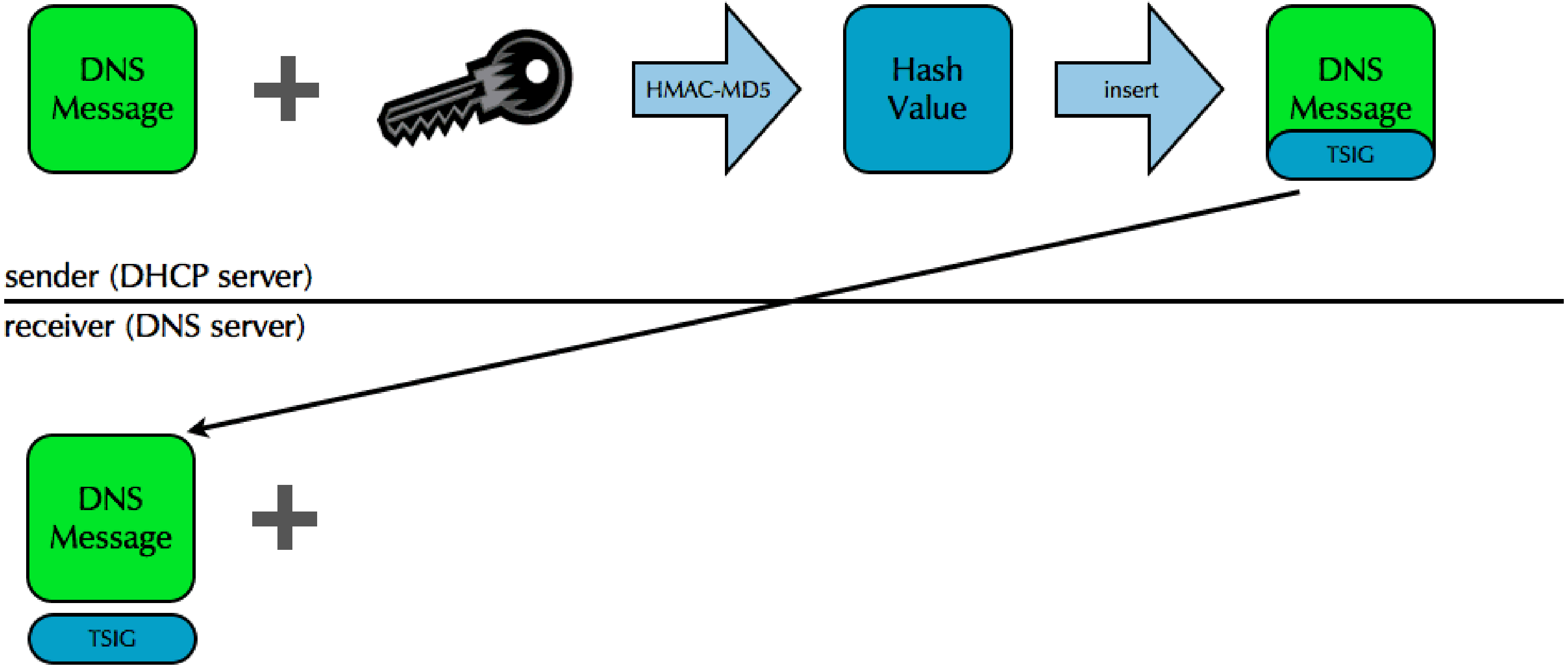
TSIG illustrated



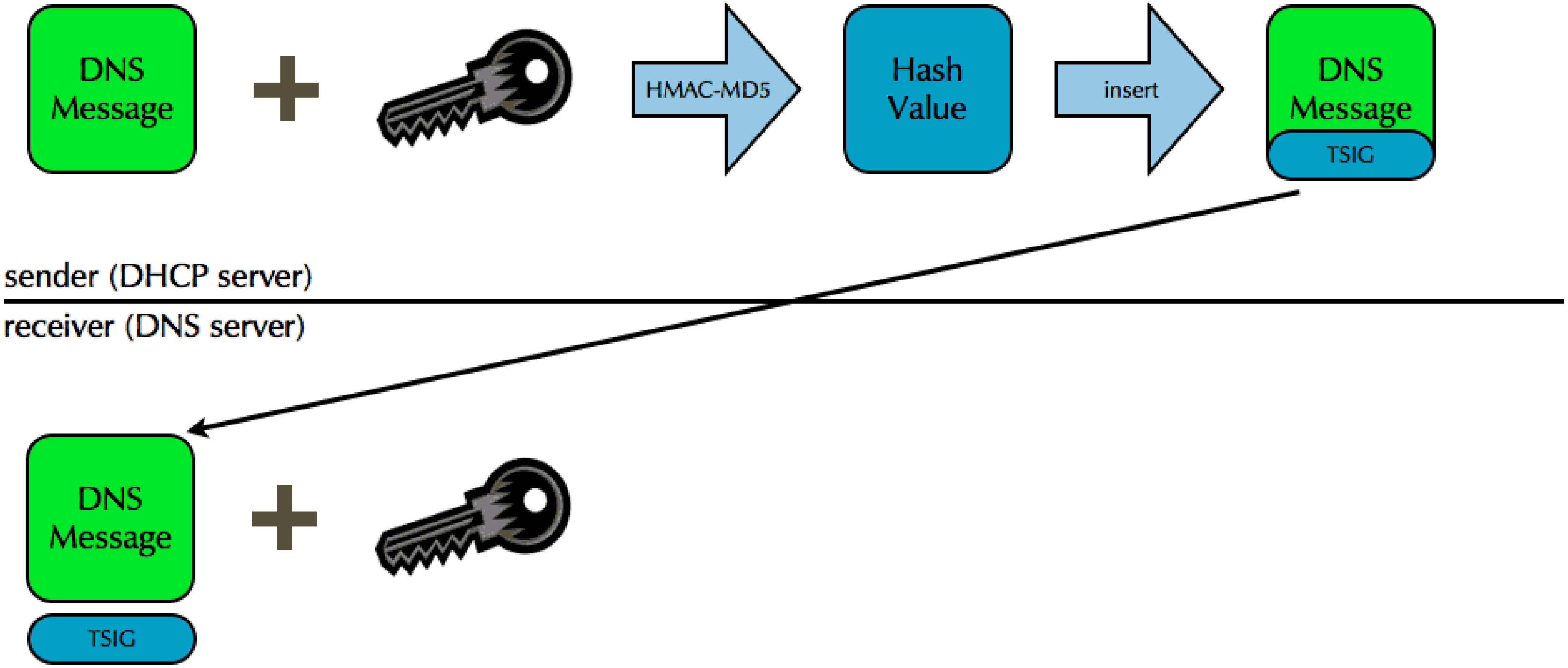
TSIG illustrated



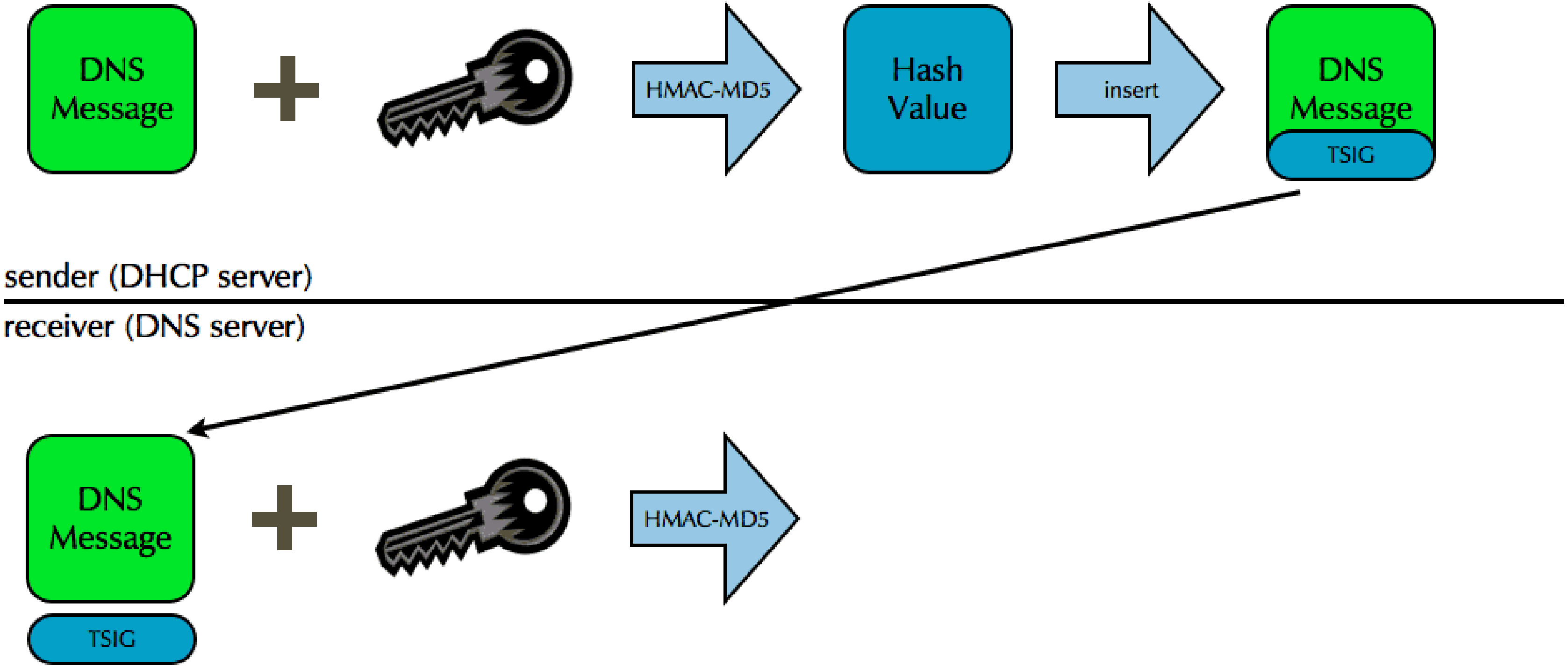
TSIG illustrated



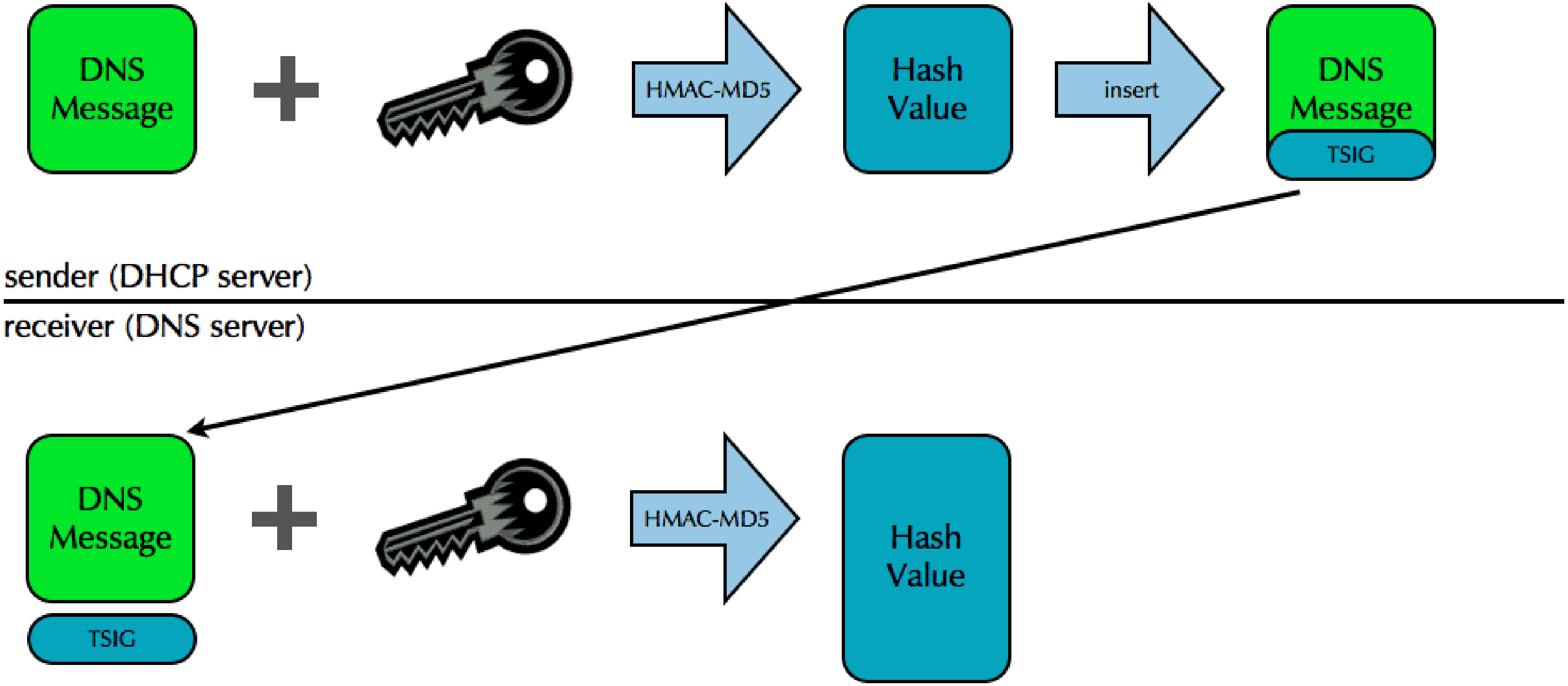
TSIG illustrated



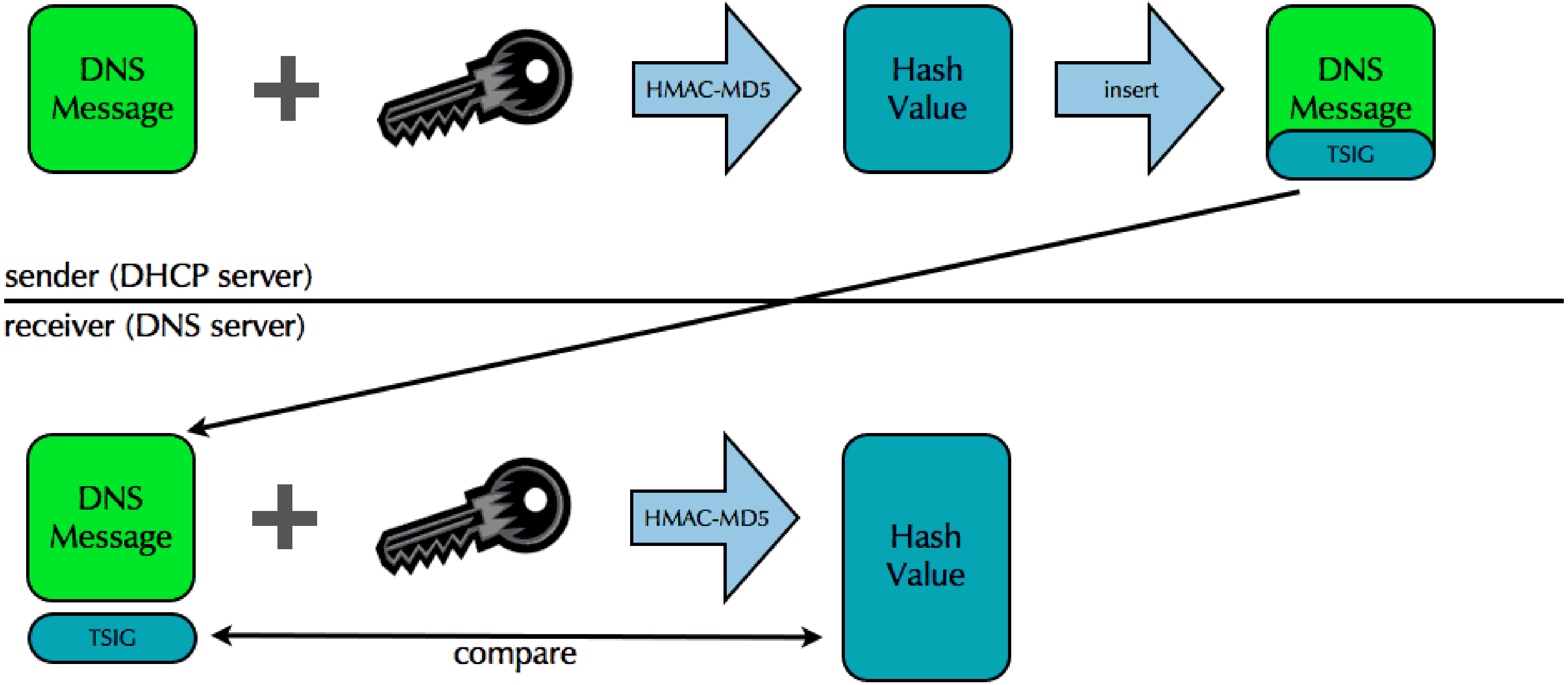
TSIG illustrated



TSIG illustrated



TSIG illustrated



TSIG benefits

- Verification of a DNS message's TSIG gives you
- Source authentication
    - The message must have come from an endpoint with the key
- Data integrity
    - The message must be the same one the endpoint signed

RFC 9664 - An EDNS(0) Option to Negotiate Leases on DNS Updates

- Traditionally, DNS records entered via dynamic DNS updates (RFC 2136) will stay until removed either manually or via another dynamic DNS update request
- With RFC 9664 (June 2025), DNS update clients can now send a lifetime (called "lease", as it will probably used in sync with DHCP leases) together with the DNS update that creates or updates a DNS record in a zone
- A DNS server supporting RFC 9664 will automatically remove the DNS records once the lease have run out.
- This new function will clean up DNS records after some defined time
- Details: RFC 9664