

CS305 Lab assignment 5.3

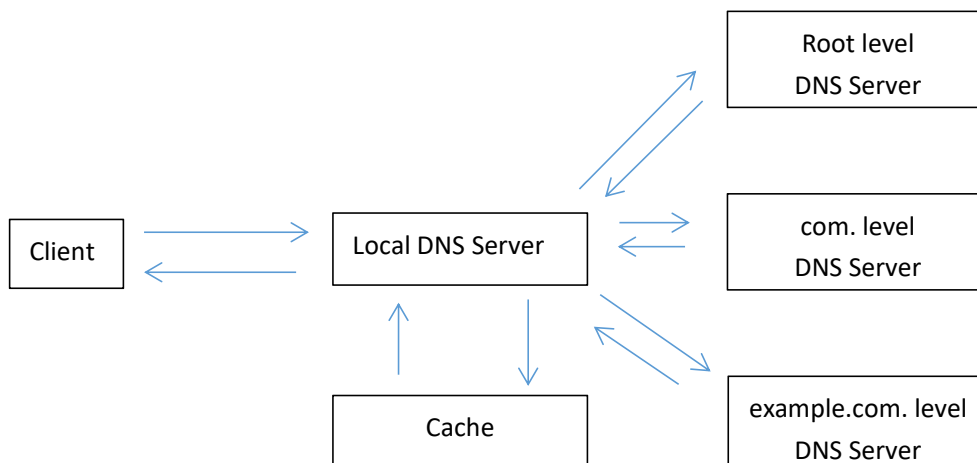
wangw6@sustech.edu.cn

Using python to implement a 'Local DNS Server'.

NOTES: the python source file should be named as 'LocalDNSServer.py' using UTF-8 as file coding, work on port 5353 of 127.0.0.1, there is no need to zip the source file, Comments in code is MUST.

1. The 'Local DNS Server' is expected work on port 5353 of 127.0.0.1, its function should include:
 - (1) Listen and accept DNS queries from client, support default query type: A type.
 - (2) Maintain a Cache:
 - ① Cache should be read.
 - ② Cache should be write while response is coming. While the query is new, cache the query and response.
 - (3) Maintain a list of records about the domain name and IPv4 address of Root DNS servers.
 - (4) Search related DNS response in Cache according to the received query.
 - (5) Invoke DNS queries to other DNS server if needed and cache the new response.
 - (6) Send the response to the client.
 - (optional): Sometimes, 'Local DNS Server' may just got CNAME item, if the query is A type, 'Local DNS server' will continue to do the query to name server(whose info could be found in the Authority RRs and Additional RRs) until getting IP address, both A type and CNAME type info are joint, then send to client as answer by 'Local DNS server'.
 - (7) EDNS: here 'Local DNS server' doesn't do special process on EDNS rrs, while it received a query with EDNS rr, it just send this special EDNS rr as an attachment of the following queries and responses.
2. TESTING suggestion:
 - (1) using 'dig' as client to communicate with 'Local DNS Server'.
 - (2) using 'Wireshark' to trace the communication between client, 'Local DNS Server' and other DNS servers.

3. Take a DNS query to "www.example.com" as an example:



- (1) Client send an DNS query about “www.example.com” to ‘Local DNS server’
- (2) ‘Local DNS server’ search its answer in Cache
 - ① if the answer is found in cache, ‘Local DNS Server’ send this answer to Client as DNS response.
 - ② if the answer is not found:
 - a. ‘Local DNS Server’ send the query to Root level DNS Server, got the DNS response message about the list of com level Name server and its ip address.
 - b. ‘Local DNS Server’ send the query to com. level DNS Server, got the DNS response message about the list of example.com level Name server and its ip address.
 - c. ‘Local DNS Server’ send the query to example.com. level DNS Server, got the DNS response message about the answer of the original DNS query.
 - d. ‘Local DNS Server’ cache the query and answer to Cache.
- (3) ‘Local DNS Server’ send the DNS response message to Client.

TIPS:

1. Using ‘dig’ to invoke a DNS query, ‘rd’ field of query is set 1 by default.
2. While ‘Local DNS Server’ receive a DNS query with ‘rd’ field set as 1, it will send several DNS queries to other DNS server, the value of ‘rd’ field of all these queries is set as 0.
3. There will be several pairs of query and response while the answer is not in the Cache, response message share the same transaction ID with query in a pair.

Following is a list of captured packets :Client(42) send query to ‘Local DNS server’(217), ‘Local DNS server’ do the queries and finally get answer, ‘Local DNS server’ send the answer in DNS response to Client.

No.	Ti	Source	Destination	Proto	Length	Info
5	...	client: 42	server: 217	DNS	95	Standard query 0xd1ed A www.sohu.com OPT
6	...	server: 217	192.42.93.30	DNS	83	Standard query 0x452c A www.sohu.com OPT
7	...	192.42.93.30	server: 217	DNS	842	Standard query response 0x452c A www.sohu.com
8	...	server: 217	125.254.154.167	DNS	83	Standard query 0x85a3 A www.sohu.com OPT
9	...	125.254.154.167	server: 217	DNS	370	Standard query response 0x85a3 A www.sohu.com
...	...	server: 217	111.230.159.13	DNS	84	Standard query 0x9b31 A gs.a.sohu.com OPT
...	...	111.230.159.13	server: 217	DNS	386	Standard query response 0x9b31 A gs.a.sohu.com
...	...	server: 217	client: 42	DNS	148	Standard query response 0xd1ed A www.sohu.com

More details:

- (1) Client (42) send query to ‘Local DNS server’(217)

```
No.  Ti Source                Destination                Proto Length  Info
→ 5 ... ..142                ...217                    DNS      95 Standard query 0xd1ed A www.sohu.com OPT
< client Local DNS server >

v Domain Name System (query)
  Transaction ID: 0xd1ed
  v Flags: 0x0120 Standard query
    0... .. = Response: Message is a query
    .000 0... .. = Opcode: Standard query (0)
    ...0... .. = Truncated: Message is not truncated
    ....1... .. = Recursion desired: Do query recursively
    .... ..0... .. = Z: reserved (0)
    .... ..1... .. = AD bit: Set
    .... ..0... .. = Non-authenticated data: Unacceptable

  Questions: 1
  Answer RRs: 0
  Authority RRs: 0
  Additional RRs: 1

  v Queries
    v www.sohu.com: type A, class IN
      Name: www.sohu.com
      [Name Length: 12]
      [Label Count: 3]
      Type: A (Host Address) (1)
      Class: IN (0x0001)

  v Additional records
    v <Root>: type OPT
      Name: <Root>
      Type: OPT (41)
      UDP payload size: 4096
      Higher bits in extended RCODE: 0x00
      EDNS0 version: 0
      > Z: 0x0000
      Data length: 12
      > Option: COOKIE
```

(2) 'Local DNS server'(217) invoke DNS query to 192.42.93.30.

No.	Ti	Source	Destination	Proto	Length	Info
6	...	10.0.0.115.217	192.42.93.30	DNS	83	Standard query 0x452c A www.sohu.com OPT

Domain Name System (query)

Transaction ID: 0x452c

Flags: 0x0000 Standard query

0... .. = Response: Message is a query

.000 0... .. = Opcode: Standard query (0)

.... ..0. = Truncated: Message is not truncated

.... ..0 = Recursion desired: Don't do query recursively

....0. = Z: reserved (0)

....0 = Non-authenticated data: Unacceptable

Questions: 1

Answer RRs: 0

Authority RRs: 0

Additional RRs: 1

Queries

www.sohu.com: type A, class IN

Name: www.sohu.com

[Name Length: 12]

[Label Count: 3]

Type: A (Host Address) (1)

Class: IN (0x0001)

Additional records

<Root>: type OPT

Name: <Root>

Type: OPT (41)

UDP payload size: 4000

Higher bits in extended RCODE: 0x00

EDNS0 version: 0

Z: 0x8000

1... .. = DO bit: Accepts DNSSEC security RRs

.000 0000 0000 0000 = Reserved: 0x0000

Data length: 0

(3) 'Local DNS server' received DNS response from 192.42.93.30.

No.	Ti	Source	Destination	Proto	Length	Info
7	...	192.42.93.30	125.254.154.167	DNS	842	Standard query response 0x452c A www.sohu.com NS ns11.sohu.com
<						
Domain Name System (response)						
Transaction ID: 0x452c						
Flags: 0x8000 Standard query response, No error						
1... .. = Response: Message is a response						
.000 0... .. = Opcode: Standard query (0)						
.... 0... .. = Authoritative: Server is not an authority for domain						
.... ..0... .. = Truncated: Message is not truncated						
.... ..0... .. = Recursion desired: Don't do query recursively						
.... ..0... .. = Recursion available: Server can't do recursive queries						
.... ..0... .. = Z: reserved (0)						
.... ..0... .. = Answer authenticated: Answer/authority portion was not authenticated by the server						
.... ..0... .. = Non-authenticated data: Unacceptable						
.... ..0000 = Reply code: No error (0)						
Questions: 1						
Answer RRs: 0						
Authority RRs: 10						
Additional RRs: 7						
Queries						
www.sohu.com: type A, class IN						
Name: www.sohu.com						
[Name Length: 12]						
[Label Count: 3]						
Type: A (Host Address) (1)						
Class: IN (0x0001)						
Authoritative nameservers						
sohu.com: type NS, class IN, ns ns11.sohu.com						
Name: sohu.com						
Type: NS (authoritative Name Server) (2)						
Class: IN (0x0001)						
Time to live: 172800 (2 days)						
Data length: 7						
Name Server: ns11.sohu.com						

No.	Ti	Source	Destination	Proto	Length	Info
7	...	192.42.93.30	125.254.154.167	DNS	842	Standard query response 0x452c A www.sohu.com NS ns11.sohu.com
<						
Authoritative nameservers						
sohu.com: type NS, class IN, ns ns11.sohu.com						
Name: sohu.com						
Type: NS (authoritative Name Server) (2)						
Class: IN (0x0001)						
Time to live: 172800 (2 days)						
Data length: 7						
Name Server: ns11.sohu.com						
> sohu.com: type NS, class IN, ns ns12.sohu.com						
> sohu.com: type NS, class IN, ns ns13.sohu.com						
> sohu.com: type NS, class IN, ns ns14.sohu.com						
> sohu.com: type NS, class IN, ns ns15.sohu.com						
> sohu.com: type NS, class IN, ns ns16.sohu.com						
> CK0P0JMG874LJREF7EFN8430QVIT8BSM.com: type NSEC3, class IN						
> CK0P0JMG874LJREF7EFN8430QVIT8BSM.com: type RRSIG, class IN						
> 77KDVTDM2B13KROTCQKQEK5QJ0CTJALK.com: type NSEC3, class IN						
> 77KDVTDM2B13KROTCQKQEK5QJ0CTJALK.com: type RRSIG, class IN						
Additional records						
ns11.sohu.com: type A, class IN, addr 111.202.126.2						
Name: ns11.sohu.com						
Type: A (Host Address) (1)						
Class: IN (0x0001)						
Time to live: 172800 (2 days)						
Data length: 4						
Address: 111.202.126.2						
> ns12.sohu.com: type A, class IN, addr 110.43.83.56						
> ns13.sohu.com: type A, class IN, addr 14.18.240.23						
> ns14.sohu.com: type A, class IN, addr 111.230.159.11						
> ns15.sohu.com: type A, class IN, addr 125.254.154.167						
> ns16.sohu.com: type A, class IN, addr 101.227.172.66						
> <Root>: type OPT						
[Request ID: 0]						

(4) 'Local DNS server'(217) send query to 125.254.154.167.

No.	Ti	Source	Destination	Proto	Length	Info
8	125.254.154.167	DNS	83	Standard query 0x85a3 A www.sohu.com OPT

< >

▼ Domain Name System (query)

Transaction ID: 0x85a3

▼ Flags: 0x0000 Standard query

0... .. = Response: Message is a query

.000 0... .. = Opcode: Standard query (0)

.... .0. = Truncated: Message is not truncated

.... ..0 = Recursion desired: Don't do query recursively

....0.. = Z: reserved (0)

....0 = Non-authenticated data: Unacceptable

Questions: 1

Answer RRs: 0

Authority RRs: 0

Additional RRs: 1

▼ Queries

▼ www.sohu.com: type A, class IN

Name: www.sohu.com

[Name Length: 12]

[Label Count: 3]

Type: A (Host Address) (1)

Class: IN (0x0001)

▼ Additional records

> <Root>: type OPT

[\[Response In: 9\]](#)

(5) 'Local DNS server'(217) received response from 125.254.154.167.

No.	Ti	Source	Destination	Proto	Length	Info
9	...	125.254.154.167	...	DNS	370	Standard query response 0x85a3 A www.sohu.com

< >

▼ Domain Name System (response)

Transaction ID: 0x85a3

▼ Flags: 0x8400 Standard query response, No error

- 1... .. = Response: Message is a response
- .000 0... .. = Opcode: Standard query (0)
-1.. = Authoritative: Server is an authority for domain
-0.. = Truncated: Message is not truncated
-0 = Recursion desired: Don't do query recursively
- 0... .. = Recursion available: Server can't do recursive queries
-0.. = Z: reserved (0)
-0. = Answer authenticated: Answer/authority portion was not authenticated by t
-0 = Non-authenticated data: Unacceptable
- 0000 = Reply code: No error (0)

Questions: 1

Answer RRs: 1

Authority RRs: 6

Additional RRs: 11

▼ Queries

▼ www.sohu.com: type A, class IN

- Name: www.sohu.com
- [Name Length: 12]
- [Label Count: 3]
- Type: A (Host Address) (1)
- Class: IN (0x0001)

▼ Answers

▼ www.sohu.com: type CNAME, class IN, cname gs.a.sohu.com

- Name: www.sohu.com
- Type: CNAME (Canonical NAME for an alias) (5)
- Class: IN (0x0001)
- Time to live: 1800 (30 minutes)
- Data length: 7
- CNAME: gs.a.sohu.com

No.	Ti	Source	Destination	Proto	Length	Info
9	...	125.254.154.167	...217	DNS	370	Standard query response 0x85a3 A www.sohu.com
<div> <div>Additional RRs: 11</div> <div> <div>> Queries</div> <div> <div>▼ Answers</div> <div> <div>▼ www.sohu.com: type CNAME, class IN, cname gs.a.sohu.com</div> <div> <div>Name: www.sohu.com</div> <div>Type: CNAME (Canonical NAME for an alias) (5)</div> <div>Class: IN (0x0001)</div> <div>Time to live: 1800 (30 minutes)</div> <div>Data length: 7</div> <div>CNAME: gs.a.sohu.com</div> </div> </div> </div> <div>▼ Authoritative nameservers</div> <div> <div>> a.sohu.com: type NS, class IN, ns ns4.a.sohu.com</div> <div>> a.sohu.com: type NS, class IN, ns ns2.a.sohu.com</div> <div>> a.sohu.com: type NS, class IN, ns ns6.a.sohu.com</div> <div>> a.sohu.com: type NS, class IN, ns ns5.a.sohu.com</div> <div>> a.sohu.com: type NS, class IN, ns ns1.a.sohu.com</div> <div>> a.sohu.com: type NS, class IN, ns ns3.a.sohu.com</div> </div> <div>▼ Additional records</div> <div> <div>> ns1.a.sohu.com: type A, class IN, addr 111.202.126.1</div> <div>> ns2.a.sohu.com: type A, class IN, addr 110.43.83.57</div> <div>> ns2.a.sohu.com: type A, class IN, addr 101.227.172.65</div> <div>> ns3.a.sohu.com: type A, class IN, addr 14.18.240.33</div> <div>> ns3.a.sohu.com: type A, class IN, addr 14.18.240.49</div> <div>> ns4.a.sohu.com: type A, class IN, addr 39.156.83.208</div> <div>> ns5.a.sohu.com: type A, class IN, addr 125.254.154.166</div> <div>> ns5.a.sohu.com: type A, class IN, addr 211.159.191.13</div> <div>> ns6.a.sohu.com: type A, class IN, addr 125.254.154.165</div> <div>> ns6.a.sohu.com: type A, class IN, addr 111.230.159.13</div> <div>> <Root>: type OPT</div> </div> <div> [Request In: 8] [Time: 0.038269000 seconds] </div> </div> </div>						

(6) 'Local DNS server'(217) send query to 111.230.159.13.

No.	Ti	Source	Destination	Proto	Length	Info
...	...	111.230.159.13	111.230.159.13	DNS	84	Standard query 0x9b31 A gs.a.sohu.com OPT
<div> <div> Domain Name System (query) Transaction ID: 0x9b31 </div> <div> <div>Flags: 0x0000 Standard query</div> <div> 0... .. = Response: Message is a query .000 0... .. = Opcode: Standard query (0) 0. = Truncated: Message is not truncated 0 = Recursion desired: Don't do query recursively 0... .. = Z: reserved (0) 0... .. = Non-authenticated data: Unacceptable </div> </div> <div> Questions: 1 Answer RRs: 0 Authority RRs: 0 Additional RRs: 1 </div> <div> <div>Queries</div> <div> <div>gs.a.sohu.com: type A, class IN</div> <div> Name: gs.a.sohu.com [Name Length: 13] [Label Count: 4] Type: A (Host Address) (1) Class: IN (0x0001) </div> </div> <div> <div>Additional records</div> <div> <div><Root>: type OPT</div> <div> Name: <Root> Type: OPT (41) UDP payload size: 4000 Higher bits in extended RCODE: 0x00 EDNS0 version: 0 </div> </div> <div> <div>Z: 0x8000</div> <div> 1... .. = DO bit: Accepts DNSSEC security RRs .000 0000 0000 0000 = Reserved: 0x0000 </div> </div> <div> Data length: 0 </div> </div> </div> </div>						

(7) 'Local DNS server'(217) receive response from 111.230.159.13.

No.	Ti	Source	Destination	Proto	Length	Info
...	111.230.159.13	DNS	386	Standard query response 0x9b31 A gs.a.sohu

< >

▼ Domain Name System (response)

Transaction ID: 0x9b31

▼ Flags: 0x8400 Standard query response, No error

- 1... .. = Response: Message is a response
- .000 0... .. = Opcode: Standard query (0)
-1... .. = Authoritative: Server is an authority for domain
-0... .. = Truncated: Message is not truncated
-0... .. = Recursion desired: Don't do query recursively
-0... .. = Recursion available: Server can't do recursive queries
-0... .. = Z: reserved (0)
-0... .. = Answer authenticated: Answer/authority portion was not authenticated b
-0... .. = Non-authenticated data: Unacceptable
- 0000 = Reply code: No error (0)

Questions: 1

Answer RRs: 2

Authority RRs: 6

Additional RRs: 11

> Queries

▼ Answers

- ▼ gs.a.sohu.com: type CNAME, class IN, cname fgz.a.sohu.com
 - Name: gs.a.sohu.com
 - Type: CNAME (Canonical NAME for an alias) (5)
 - Class: IN (0x0001)
 - Time to live: 7200 (2 hours)
 - Data length: 6
 - CNAME: fgz.a.sohu.com
- ▼ fgz.a.sohu.com: type A, class IN, addr 14.18.240.22
 - Name: fgz.a.sohu.com
 - Type: A (Host Address) (1)
 - Class: IN (0x0001)
 - Time to live: 120 (2 minutes)
 - Data length: 4

No.	Ti	Source	Destination	Proto	Length	Info
42	...	111.230.159.13	111.230.159.217	DNS	386	Standard query response 0x9b31 A gs.a.sohu.com
< >						
v Domain Name System (response) <ul style="list-style-type: none"> Transaction ID: 0x9b31 > Flags: 0x8400 Standard query response, No error Questions: 1 Answer RRs: 2 Authority RRs: 6 Additional RRs: 11 > Queries 						
v Answers <ul style="list-style-type: none"> v gs.a.sohu.com: type CNAME, class IN, cname fgz.a.sohu.com <ul style="list-style-type: none"> Name: gs.a.sohu.com Type: CNAME (Canonical NAME for an alias) (5) Class: IN (0x0001) Time to live: 7200 (2 hours) Data length: 6 CNAME: fgz.a.sohu.com v fgz.a.sohu.com: type A, class IN, addr 14.18.240.22 <ul style="list-style-type: none"> Name: fgz.a.sohu.com Type: A (Host Address) (1) Class: IN (0x0001) Time to live: 120 (2 minutes) Data length: 4 Address: 14.18.240.22 						
v Authoritative nameservers <ul style="list-style-type: none"> v a.sohu.com: type NS, class IN, ns ns3.a.sohu.com <ul style="list-style-type: none"> Name: a.sohu.com Type: NS (authoritative Name Server) (2) Class: IN (0x0001) Time to live: 86400 (1 day) Data length: 6 Name Server: ns3.a.sohu.com 						

(8) 'Local DNS server'(217) send response to client(42).

```
No.  Ti  Source                Destination                Proto Length  Info
4    18  192.168.1.217             192.168.1.42             DNS      148 Standard query response 0xd1ed A www.sohu.com

Local DNS server client

v Domain Name System (response)
  Transaction ID: 0xd1ed
  > Flags: 0x8180 Standard query response, No error
  Questions: 1
  Answer RRs: 3
  Authority RRs: 0
  Additional RRs: 1
  > Queries
  v Answers
    v www.sohu.com: type CNAME, class IN, cname gs.a.sohu.com
      Name: www.sohu.com
      Type: CNAME (Canonical NAME for an alias) (5)
      Class: IN (0x0001)
      Time to live: 1799 (29 minutes, 59 seconds)
      Data length: 7
      CNAME: gs.a.sohu.com
    v gs.a.sohu.com: type CNAME, class IN, cname fgz.a.sohu.com
      Name: gs.a.sohu.com
      Type: CNAME (Canonical NAME for an alias) (5)
      Class: IN (0x0001)
      Time to live: 7199 (1 hour, 59 minutes, 59 seconds)
      Data length: 6
      CNAME: fgz.a.sohu.com
    v fgz.a.sohu.com: type A, class IN, addr 14.18.240.22
      Name: fgz.a.sohu.com
      Type: A (Host Address) (1)
      Class: IN (0x0001)
      Time to live: 119 (1 minute, 59 seconds)
      Data length: 4
      Address: 14.18.240.22
  v Additional records
```