An Experiment in Implementing a Stateless TCP DNS Server

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APNIC

IP Networking 101

There are two major transport protocols in IP:

- TCP when reliable data transfer is needed
- UDP for simple lightweight transactions

IP Networking 102

Coping with large responses for transactions – What happens when the response size exceeds the path MTU?

- Use UDP with IP level fragmentation and reassembly to rebuild the protocol data unit
  - but firewalls often drop trailing IP fragments
  - IPv6 UDP path MTU handling is not well suited to transaction apps
- Use TCP segmentation and reassembly to rebuild the protocol data unit
  - switching to TCP implies additional load on the server, introduces limits on server transaction throughput, and adds additional delay in the elapsed time for the transaction

IP Networking 666

Fire up the Bad Idea Factory

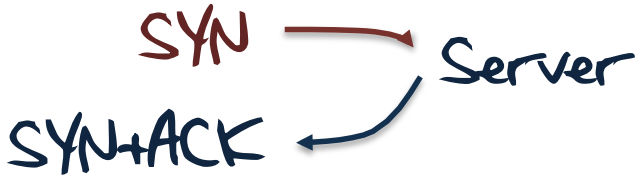
Why not combine UDP with TCP segmentation and reassembly?

- The client runs a conventional TCP application
- The server runs a stateless UDP-style application, but formats its output using TCP framing

  i.e. “Stateless TCP”

The Server's Perspective

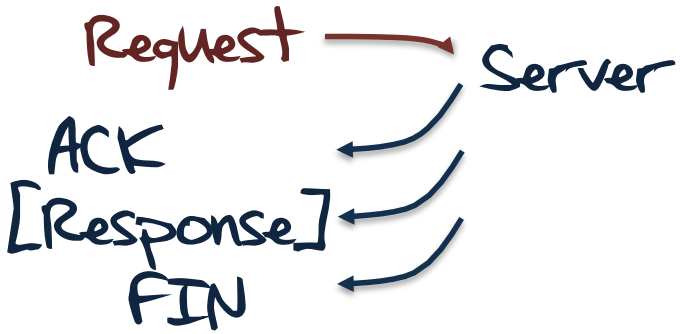
1. SYN Response



Flip the IP source and destination fields
Flip the TCP source and destination ports
Use any old sequence number
Offer a reasonable MSS (1220)
Offer no other TCP options

The Server's Perspective

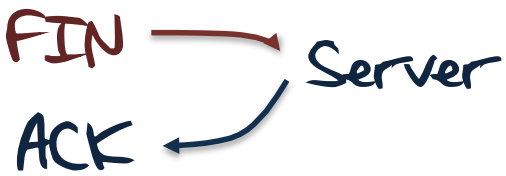
2. Request Response



Start with a sequence numbers given in the Request
Send an ACK
[Generate the response PDU]
Chop the response into 512 octet segments – add TCP headers
Send the response packet train back to back
Send a FIN

The Server's Perspective

3. FIN Response



Flip the IP addrs, TCP ports and ack/sequence fields
increment ack field
send ACK

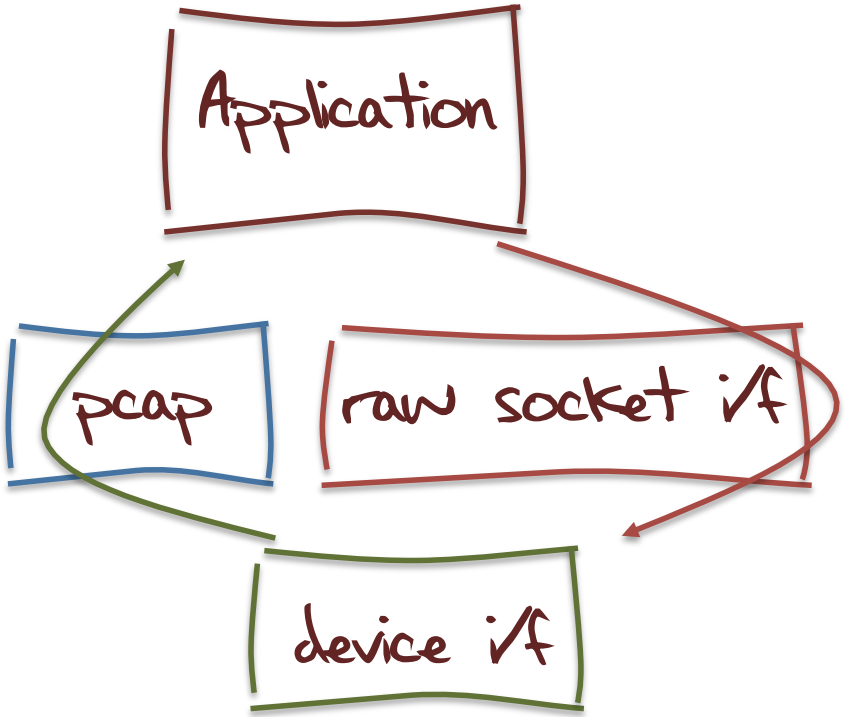
The Server's Perspective

4. all else

No server response

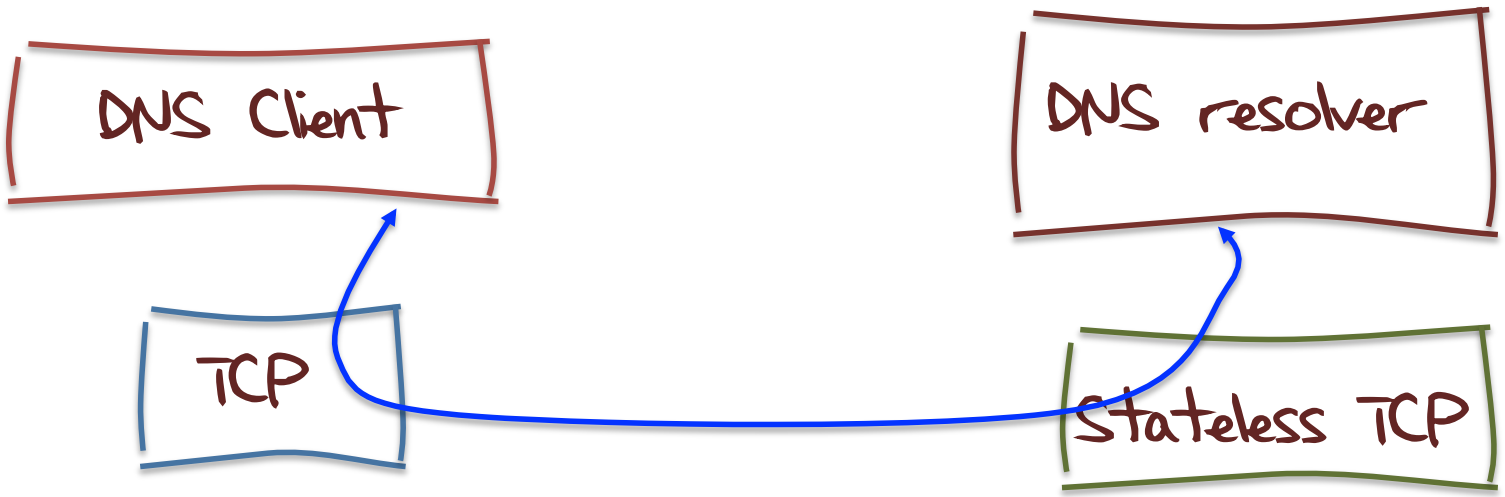
Can this be coded?

A user space implementation of a stateless DNS TCP server that avoids kernel TCP processing



So far so good..

Can we use the same approach to create a hybrid model of a TCP DNS client speaking to a stateless TCP DNS resolver?



DNS and Stateless TCP

To test if this approach could work I used a prototype config of a stateless TCP facing the client, and a UDP referral to a DNS resolver as the back end

It Worked!

```
$ dig +tcp @server rand.apnic.net in any

client.55998 > server.domain: S, cksum 0x9159 (correct), 2201103970:2201103970(0) win 65535 <mss 1460>
server.domain > client.55998: S, cksum 0x82b9 (correct), 1256795928:1256795928(0) ack 2201103971 win 65535 <mss 1220>
client.55998 > server.domain: ., cksum 0x9986 (correct), 1:1(0) ack 1 win 65535
client.55998 > server.domain: P, cksum 0x41b2 (correct), 1:35(34) ack 1 win 6553530304+ ANY? rand.apnic.net. (32)
server.domain > client.55998: ., cksum 0x9964 (correct), 1:1(0) ack 35 win 65535
server.54054 > backend.domain: 30304+ ANY? rand.apnic.net. (32)
backend.domain > server.54054: 30304* q: ANY? rand.apnic.net. 6/0/2 rand.apnic.net. SOA mirin.apnic.net. research.apnic.net.
                    2009051502 3600 900 3600000 3600, rand.apnic.net. NS mirin.apnic.net., rand.apnic.net. NS sec3.apnic.net.,
                    rand.apnic.net. MX kombu.apnic.net. 100, rand.apnic.net. MX karashi.apnic.net. 200, rand.apnic.net. MX
                    fennel.apnic.net. 300 ar: sec3.apnic.net. A sec3.apnic.net, sec3.apnic.net. AAAA sec3.apnic.net (229)
server.domain > client.55998: ., cksum 0x421a (correct), 1:232(231) ack 35 win 6553530304* q: ANY? rand.apnic.net. 6/0/2
                    rand.apnic.net. SOA mirin.apnic.net. research.apnic.net.
                    2009051502 3600 900 3600000 3600, rand.apnic.net. NS mirin.apnic.net., rand.apnic.net. NS sec3.apnic.net.,
                    rand.apnic.net. MX kombu.apnic.net. 100, rand.apnic.net. MX karashi.apnic.net. 200, rand.apnic.net. MX
                    fennel.apnic.net. 300 ar: sec3.apnic.net. A sec3.apnic.net, sec3.apnic.net. AAAA sec3.apnic.net (229)
server.domain > client.55998: F, cksum 0x987c (correct), 232:232(0) ack 35 win 65535
client.55998 > server.domain: ., cksum 0x987d (correct), 35:35(0) ack 232 win 65535
client.55998 > server.domain: ., cksum 0x987c (correct), 35:35(0) ack 233 win 65535
client.55998 > server.domain: F, cksum 0x987b (correct), 35:35(0) ack 233 win 65535
server.domain > client.55998: ., cksum 0x987c (correct), 232:232(0) ack 36 win 65535
```

It Worked!

1. TCP handshake

dig +tcp @server rand.apnic.net in any

client.55998 > server.domain: S, cksum 0x9159 (correct), 2201103970:2201103970(0) win 65535 <mss 1460>
server.domain > client.55998: S, cksum 0x82b9 (correct), 1256795928:1256795928(0) ack 2201103971 win 65535 <mss 1220>
client.55998 > server.domain: ., cksum 0x9986 (correct), 1:1(0) ack 1 win 65535
client.55998 > server.domain: P, cksum 0x41b2 (correct), 1:35(34) ack 1 win 6553530304+ ANY? rand.apnic.net. (32)
server.domain > client.55998: ., cksum 0x9964 (correct), 1:1(0) ack 35 win 65535
server.54054 > backend.domain: 30304+ ANY? rand.apnic.net. (32)
backend.domain > server.54054: 30304* q: ANY? rand.apnic.net. 6/0/2 rand.apnic.net. SOA mirin.apnic.net. research.apnic.net.
2009051502 3600 900 3600000 3600, rand.apnic.net. NS mirin.apnic.net., rand.apnic.net. NS sec3.apnic.net.,
rand.apnic.net. MX kombu.apnic.net. 100, rand.apnic.net. MX karashi.apnic.net. 200, rand.apnic.net. MX
fennel.apnic.net. 300 ar: sec3.apnic.net. A sec3.apnic.net, sec3.apnic.net. AAAA sec3.apnic.net (229)
server.domain > client.55998: ., cksum 0x421a (correct), 1:232(231) ack 35 win 6553530304* q: ANY? rand.apnic.net. 6/0/2
rand.apnic.net. SOA mirin.apnic.net. research.apnic.net.
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rand.apnic.net. MX kombu.apnic.net. 100, rand.apnic.net. MX karashi.apnic.net. 200, rand.apnic.net. MX
fennel.apnic.net. 300 ar: sec3.apnic.net. A sec3.apnic.net, sec3.apnic.net. AAAA sec3.apnic.net (229)
server.domain > client.55998: F, cksum 0x987c (correct), 232:232(0) ack 35 win 65535
client.55998 > server.domain: ., cksum 0x987d (correct), 35:35(0) ack 232 win 65535
client.55998 > server.domain: ., cksum 0x987c (correct), 35:35(0) ack 233 win 65535
client.55998 > server.domain: F, cksum 0x987b (correct), 35:35(0) ack 233 win 65535
server.domain > client.55998: ., cksum 0x987c (correct), 232:232(0) ack 36 win 65535

It Worked!

2. TCP request and referral to UDP DNS backend

dig +tcp @server rand.apnic.net in any

client.55998 > server.domain: S, cksum 0x9159 (correct), 2201103970:2201103970(0) win 65535 <mss 1460>
server.domain > client.55998: S, cksum 0x82b9 (correct), 1256795928:1256795928(0) ack 2201103971 win 65535 <mss 1220>
client.55998 > server.domain: ., cksum 0x9986 (correct), 1:1(0) ack 1 win 65535
client.55998 > server.domain: P, cksum 0x41b2 (correct), 1:35(34) ack 1 win 6553530304+ ANY? rand.apnic.net. (32)
server.domain > client.55998: ., cksum 0x9964 (correct), 1:1(0) ack 35 win 65535
server.54054 > backend.domain: 30304+ ANY? rand.apnic.net. (32)
backend.domain > server.54054: 30304* q: ANY? rand.apnic.net. 6/0/2 rand.apnic.net. SOA mirin.apnic.net. research.apnic.net.
2009051502 3600 900 3600000 3600, rand.apnic.net. NS mirin.apnic.net., rand.apnic.net. NS sec3.apnic.net.,
rand.apnic.net. MX kombu.apnic.net. 100, rand.apnic.net. MX karashi.apnic.net. 200, rand.apnic.net. MX
fennel.apnic.net. 300 ar: sec3.apnic.net. A sec3.apnic.net, sec3.apnic.net. AAAA sec3.apnic.net (229)
server.domain > client.55998: ., cksum 0x421a (correct), 1:232(231) ack 35 win 6553530304* q: ANY? rand.apnic.net. 6/0/2
rand.apnic.net. SOA mirin.apnic.net. research.apnic.net.
2009051502 3600 900 3600000 3600, rand.apnic.net. NS mirin.apnic.net., rand.apnic.net. NS sec3.apnic.net.,
rand.apnic.net. MX kombu.apnic.net. 100, rand.apnic.net. MX karashi.apnic.net. 200, rand.apnic.net. MX
fennel.apnic.net. 300 ar: sec3.apnic.net. A sec3.apnic.net, sec3.apnic.net. AAAA sec3.apnic.net (229)
server.domain > client.55998: F, cksum 0x987c (correct), 232:232(0) ack 35 win 65535
client.55998 > server.domain: ., cksum 0x987d (correct), 35:35(0) ack 232 win 65535
client.55998 > server.domain: ., cksum 0x987c (correct), 35:35(0) ack 233 win 65535
client.55998 > server.domain: F, cksum 0x987b (correct), 35:35(0) ack 233 win 65535
server.domain > client.55998: ., cksum 0x987c (correct), 232:232(0) ack 36 win 65535

It Worked!

3. TCP response to client

```
dig +tcp @server rand.apnic.net in any

client.55998 > server.domain: S, cksum 0x9159 (correct), 2201103970:2201103970(0) win 65535 <mss 1460>
server.domain > client.55998: S, cksum 0x82b9 (correct), 1256795928:1256795928(0) ack 2201103971 win 65535 <mss 1220>
client.55998 > server.domain: ., cksum 0x9986 (correct), 1:1(0) ack 1 win 65535
client.55998 > server.domain: P, cksum 0x41b2 (correct), 1:35(34) ack 1 win 6553530304+ ANY? rand.apnic.net. (32)
server.domain > client.55998: ., cksum 0x9964 (correct), 1:1(0) ack 35 win 65535
server.54054 > backend.domain: 30304+ ANY? rand.apnic.net. (32)
backend.domain > server.54054: 30304* q: ANY? rand.apnic.net. 6/0/2 rand.apnic.net. SOA mirin.apnic.net. research.apnic.net.
                2009051502 3600 900 3600000 3600, rand.apnic.net. NS mirin.apnic.net., rand.apnic.net. NS sec3.apnic.net.,
                rand.apnic.net. MX kombu.apnic.net. 100, rand.apnic.net. MX karashi.apnic.net. 200, rand.apnic.net. MX
                fennel.apnic.net. 300 ar: sec3.apnic.net. A sec3.apnic.net, sec3.apnic.net. AAAA sec3.apnic.net (229)
server.domain > client.55998: ., cksum 0x421a (correct), 1:232(231) ack 35 win 6553530304* q: ANY? rand.apnic.net. 6/0/2
                rand.apnic.net. SOA mirin.apnic.net. research.apnic.net.
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                rand.apnic.net. MX kombu.apnic.net. 100, rand.apnic.net. MX karashi.apnic.net. 200, rand.apnic.net. MX
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client.55998 > server.domain: ., cksum 0x987c (correct), 35:35(0) ack 233 win 65535
client.55998 > server.domain: F, cksum 0x987b (correct), 35:35(0) ack 233 win 65535
server.domain > client.55998: ., cksum 0x987c (correct), 232:232(0) ack 36 win 65535
```

It Worked!

4. FIN close

```
dig +tcp @server rand.apnic.net in any

client.55998 > server.domain: S, cksum 0x9159 (correct), 2201103970:2201103970(0) win 65535 <mss 1460>
server.domain > client.55998: S, cksum 0x82b9 (correct), 1256795928:1256795928(0) ack 2201103971 win 65535 <mss 1220>
client.55998 > server.domain: ., cksum 0x9986 (correct), 1:1(0) ack 1 win 65535
client.55998 > server.domain: P, cksum 0x41b2 (correct), 1:35(34) ack 1 win 6553530304+ ANY? rand.apnic.net. (32)
server.domain > client.55998: ., cksum 0x9964 (correct), 1:1(0) ack 35 win 65535
server.54054 > backend.domain: 30304+ ANY? rand.apnic.net. (32)
backend.domain > server.54054: 30304* q: ANY? rand.apnic.net. 6/0/2 rand.apnic.net. SOA mirin.apnic.net. research.apnic.net.
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                    rand.apnic.net. MX kombu.apnic.net. 100, rand.apnic.net. MX karashi.apnic.net. 200, rand.apnic.net. MX
                    fennel.apnic.net. 300 ar: sec3.apnic.net. A sec3.apnic.net, sec3.apnic.net. AAAA sec3.apnic.net (229)
server.domain > client.55998: ., cksum 0x421a (correct), 1:232(231) ack 35 win 6553530304* q: ANY? rand.apnic.net. 6/0/2
                    rand.apnic.net. SOA mirin.apnic.net. research.apnic.net.
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                    rand.apnic.net. MX kombu.apnic.net. 100, rand.apnic.net. MX karashi.apnic.net. 200, rand.apnic.net. MX
                    fennel.apnic.net. 300 ar: sec3.apnic.net. A sec3.apnic.net, sec3.apnic.net. AAAA sec3.apnic.net (229)
server.domain > client.55998: F, cksum 0x987c (correct), 232:232(0) ack 35 win 65535
client.55998 > server.domain: ., cksum 0x987d (correct), 35:35(0) ack 232 win 65535
client.55998 > server.domain: ., cksum 0x987c (correct), 35:35(0) ack 233 win 65535
client.55998 > server.domain: F, cksum 0x987b (correct), 35:35(0) ack 233 win 65535
server.domain > client.55998: ., cksum 0x987c (correct), 232:232(0) ack 36 win 65535
```

But …

Its just like UDP in almost every respect:

- no reliability, no flow control, and absolutely no polite manners whatsoever!

And its really a Bad Idea!

Code and ACK

The FreeBSD code used here for the Stateless DNS proxy can be found at: http://www.potaroo.net/tools/useless

This Bad Idea was cooked up in collaboration with George Michaelson