Measuring ATR

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V6, the DNS and Fragmented UDP Responses

We used the Ad platform to enroll endpoints to attempt to resolve a DNS name that included a IPv6 fragmented UDP response when attempting to resolve the name server's name

Total number of tests: 10,851,323

Failure Rate in receiving a large response: 4,064,356

IPv6 Fragmentation Failure Rate: **38%**

The Internet has a problem …

- Instead of evolving to be more flexible and more capable, it appears that the Internet’s transport is becoming more ossified and more inflexible in certain aspects
- One of the major issues here is the handling of large IP packets and IP level packet fragmentation
- We are seeing a number of end-to-end paths on the network that no longer support the carriage of fragmented IP datagrams
- We are concerned that this number might be getting larger, not smaller

The Internet has a problem …

- What about the DNS?
  - One application that is making increasing use of large UDP packets is the DNS
  - This is generally associated with DNSSEC-signed responses (such as “dig +dnssec DNSKEY org”) but large DNS responses can be generated in other ways as well (such as “dig . ANY”)
  - In the DNS we appear to be relying on the successful transmission of fragmented UDP packets, but at the same time we see an increasing problem with the coherence in network and host handling of fragmented IP packets, particularly in IPv6

Changing the DNS?

- But don’t large DNS transactions use TCP anyway?
  - In the original DNS specification only small (smaller than 512 octets) responses are passed across UDP.
  - Larger DNS responses are truncated and the truncation is intended to trigger the client to re-query using TCP
  - EDNS(0) allowed a client to signal a larger truncation size threshold, and assumes that fragmented DNS is mostly reliable
  - But what if it’s not that reliable?

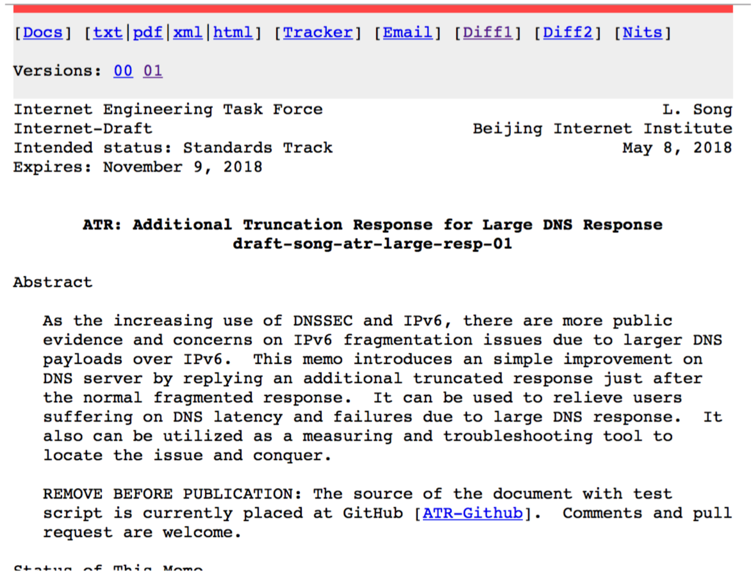
What is "ATR"?

- It stands for "Additional Truncated Response"

  Internet draft: draft-song-atr-large-resp-01

  May 2018

  Linjian (Davey) Song, Beijing Internet Institute



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Versions: 00 01

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Internet Engineering Task Force                                  L. Song
Internet-Draft                                Beijing Internet Institute
Intended status: Standards Track                             May 8, 2018
Expires: November 9, 2018
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ATR: Additional Truncation Response for Large DNS Response
draft-song-atr-large-resp-01

Abstract

As the increasing use of DNSSEC and IPv6, there are more public evidence and concerns on IPv6 fragmentation issues due to larger DNS payloads over IPv6. This memo introduces an simple improvement on DNS server by replying an additional truncated response just after the normal fragmented response. It can be used to relieve users suffering on DNS latency and failures due to large DNS response. It also can be utilized as a measuring and troubleshooting tool to locate the issue and conquer.

REMOVE BEFORE PUBLICATION: The source of the document with test script is currently placed at GitHub [ATR-Github]. Comments and pull request are welcome.

- It's a hybrid response to noted problems in IPv4 and IPv6 over handling of large UDP packets and IP fragmentation
- ATR adds an additional response packet to 'trail' a fragmented UDP response
- The additional response is just the original query with the Truncated bit set, and the sender delays this additional response packet by 10ms

The Intention of ATR

Today:

- If the client cannot receive large truncated responses then it will need to timeout from the original query,
- Then re-query using more resolvers,
- Timeout on these queries
- Then re-query using a 512 octet EDNS(0) UDP buffersize
- Then get a truncated response
- Then re-query using TCP

The Intention of ATR

ATR

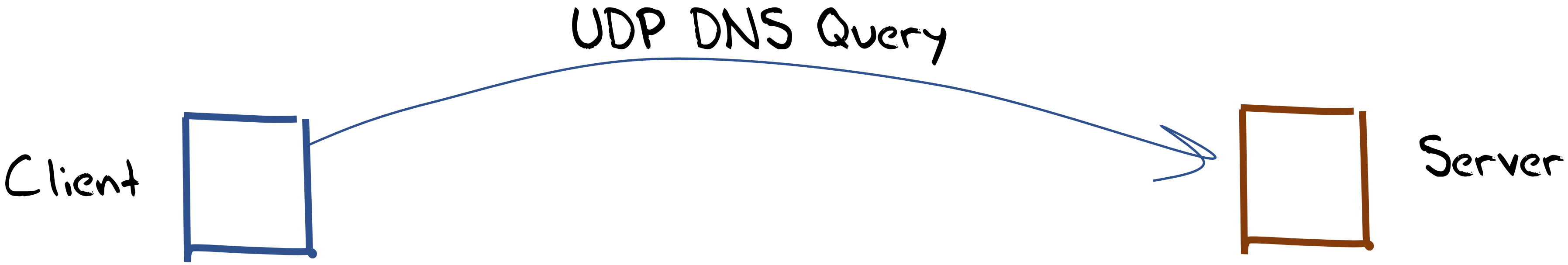
~~Today:~~

- If the client cannot receive large truncated responses then it will ~~need to timeout from the original query~~,
- ~~Then re-query using more resolvers,~~
- ~~Timeout on these queries~~
- ~~Then requery using a 512 octet EDNS(0) UDP buffersize~~
- ~~Then~~ get a truncated response within a few ms
- Then requery using TCP

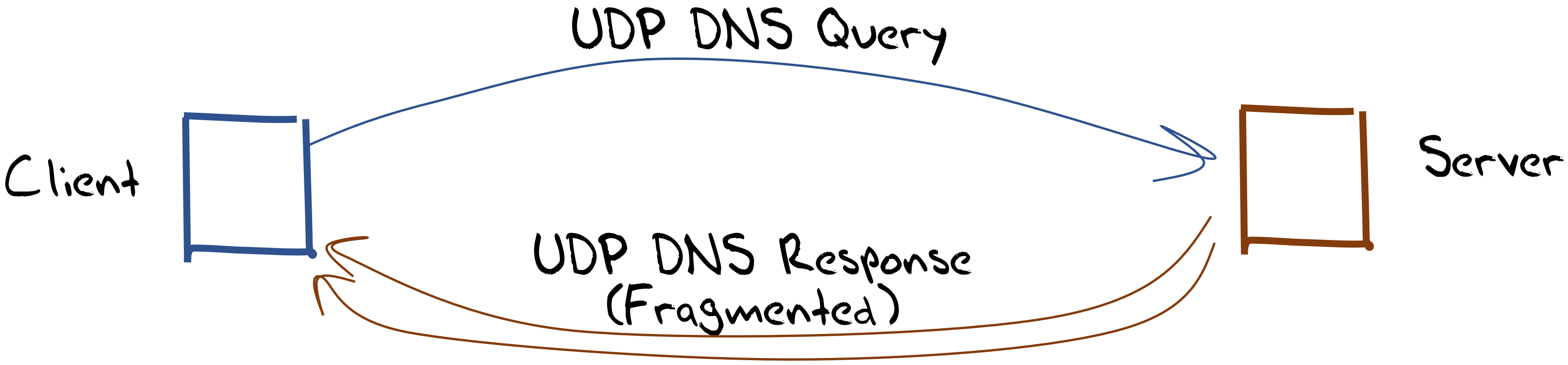
The Intention of ATR

- When a UDP DNS response is fragmented by the server, then the server will also send a delayed truncated UDP DNS response
  - The delay is proposed to be 10ms
- If the DNS client receives and reassembles the fragmented UDP response the ensuing truncated response will be ignored
- If the fragmented response is lost due to fragmentation loss, then the client will receive the short truncated response
- The truncation setting is intended to trigger the client to re-query using TCP without further delay

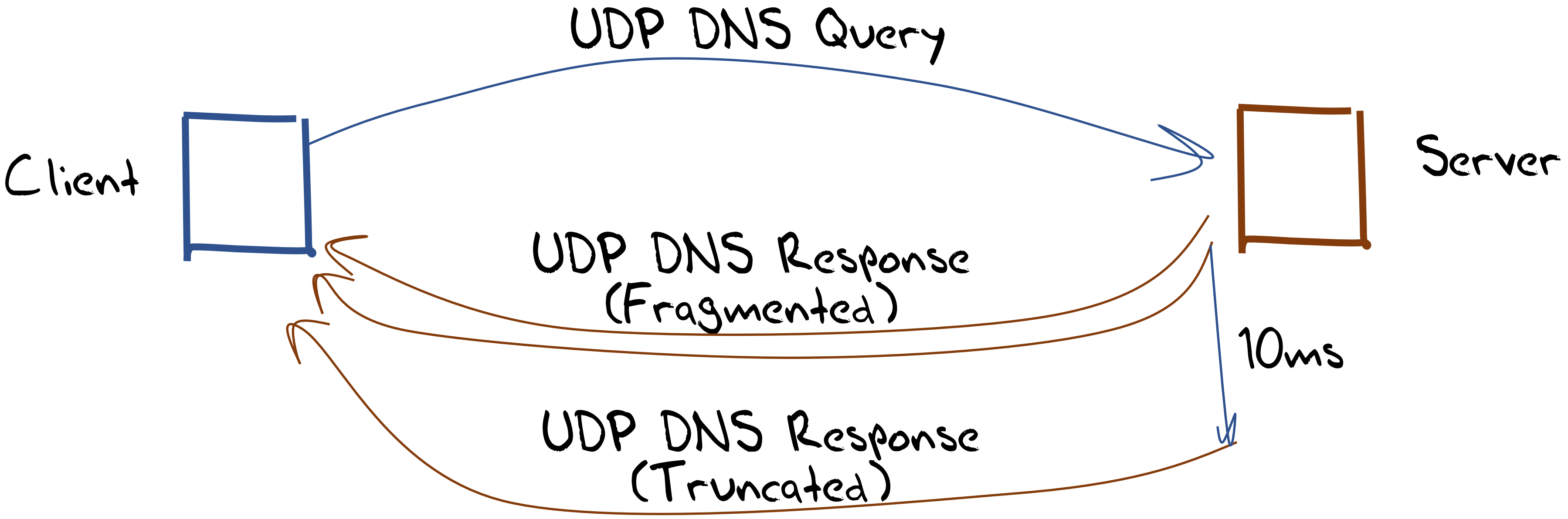
ATR Operation



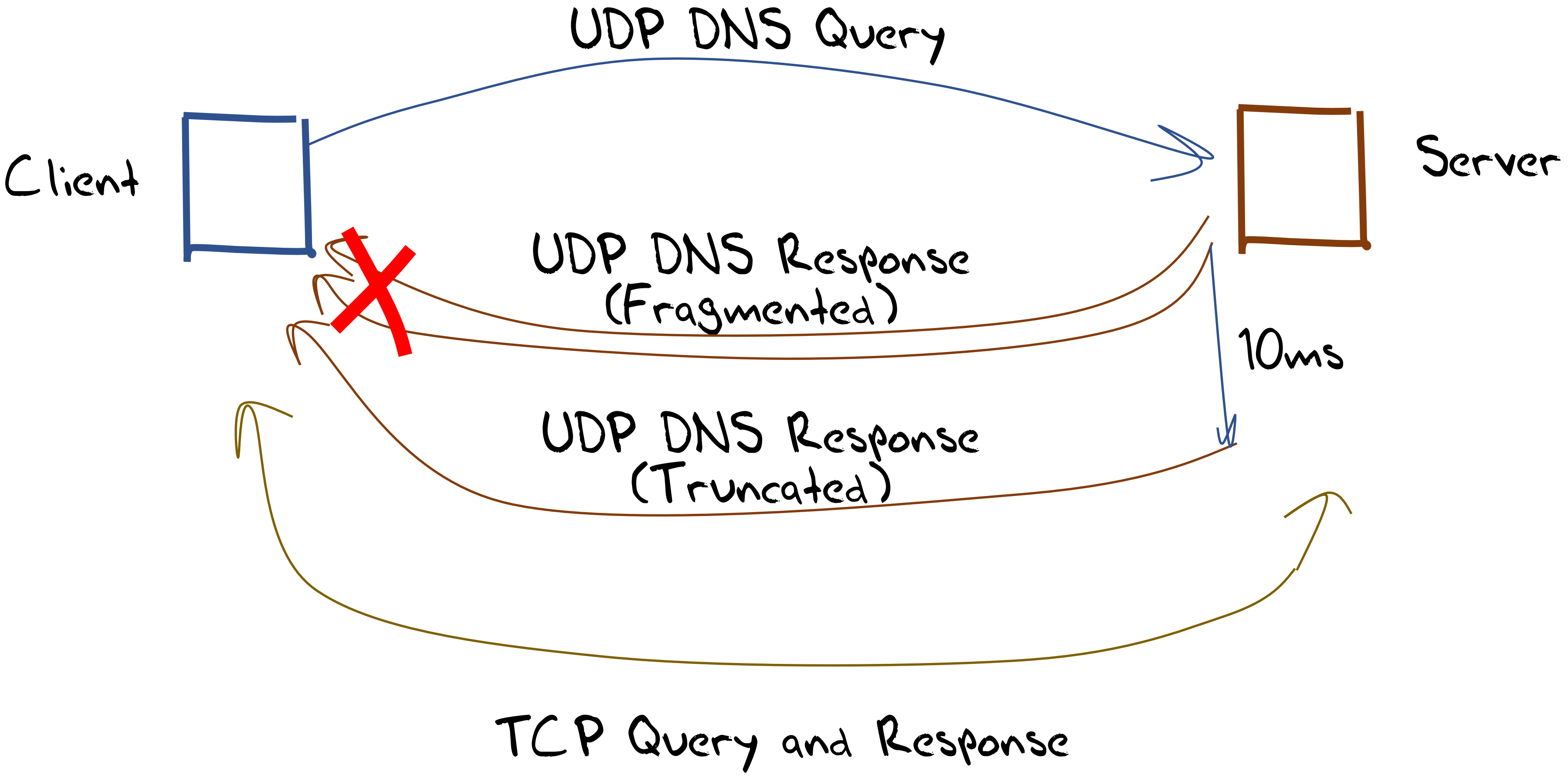
ATR Operation



ATR Operation



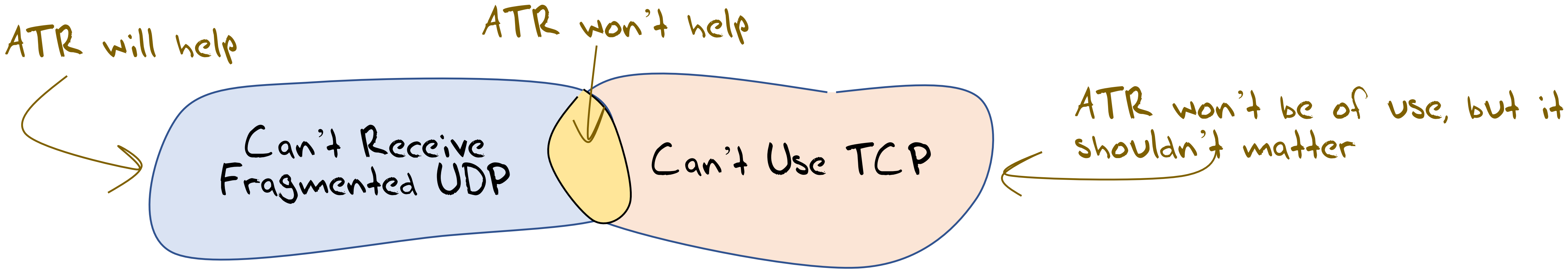
ATR Operation



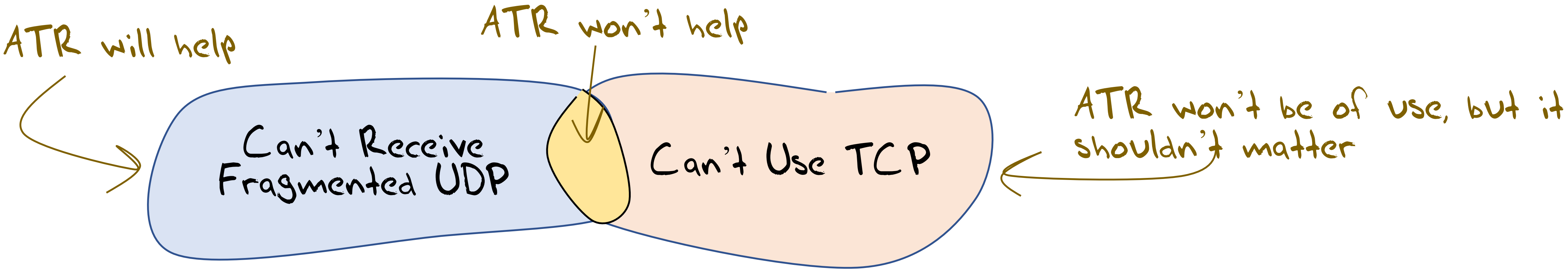
What could possibly go wrong?

- Network level packet re-ordering may cause the shorter truncated response packet to overtake the fragmented response, causing an inflated TCP load, and the potential for TCP loss to be triggered
- Not every client DNS system supports using TCP to emit queries

ATR and Resolver Behaviour



ATR and Resolver Behaviour



How big are each of these pools?
What proportion of users are impacted?

Experiment Details

- Use 6 tests:
  - 2 tests use ATR responses – one is DNS over IPv4, the other is DNS over IPv6
  - 2 tests use only truncated responses – IPv4 and IPv6
  - 2 tests use large fragmented UDP responses - IPv4 and IPv6

- Performed 55M experiments

Looking at Resolvers

We are looking at resolvers who demonstrated that they received responses of each test type:

Protocol	Resolvers	ATR	Large UDP	TCP
IPv4	113,087	71.2%	60.1%	79.4%
IPv6	20,878	55.4%	50.0%	55.1%

Looking at Resolvers

We are looking at resolvers who demonstrated that they received responses of each test type:

Inversely, lets report on the FAILURE rate of resolvers

Protocol	Resolvers	Fail ATR	Fail Large UDP	Fail TCP
IPv4	113,087	28.8%	39.9%	20.6%
IPv6	20,878	44.6%	50.0%	44.9%

Seriously?

- More than one third of the ”visible” IPv4 resolvers are incapable of receiving a large fragmented packet
- And one half of the ”visible” IPv6 resolvers are incapable of receiving a large fragmented packet

ASNs of **IPv4** Resolvers that do not followup when given a **large UDP** Response – Top 10

ASN	Use	Exp	AS Name	CC
AS9644	0.78%	447,019	SK Telecom	KR
AS701	0.70%	400,798	UUNET - MCI Communications Services	US
AS17853	0.62%	357,335	LGTELECOM	KR
AS4766	0.59%	340,334	Korea Telecom	KR
AS4134	0.47%	267,995	CHINANET-BACKBONE	CN
AS31034	0.47%	267,478	ARUBA-ASN	IT
AS3786	0.39%	225,296	DACOM Corporation	KR
AS36692	0.38%	217,306	OPENDNS - OpenDNS	US
AS3215	0.33%	189,810	Orange	FR
AS812	0.30%	169,699	ROGERS COMMUNICATIONS	CA

ASNs of **IPv6** Resolvers that do not followup when given a **large UDP** Response – Top 10

ASN	Use	Exp	AS Name	CC
AS15169	40.60%	10,006,596	Google	US
AS5650	0.90%	221,493	Frontier Communications	US
AS36692	0.84%	206,143	OpenDNS	US
AS812	0.78%	193,073	Rogers Communications Canada	CA
AS20057	0.46%	114,440	AT&T Mobility LLC	US
AS3352	0.38%	92,925	TELEFONICA_DE_ESPANA	ES
AS852	0.35%	85,043	TELUS Communications Inc.	CA
AS55644	0.32%	80,032	Idea Cellular Limited	IN
AS3320	0.25%	61,938	DTAG Internet service provider operations	DE
AS4761	0.24%	60,019	INDOSAT-INP-AP INDOSAT Internet Network Provider	ID

ASNs of **IPv4** Resolvers that do not followup in **TCP** when given a truncated UDP Response – Top 10

ASN	Use	Exp	AS Name	CC
AS9299	0.55%	252,653	Philippine Long Distance Telephone	PH
AS24560	0.34%	155,908	Bharti Airtel	IN
AS3352	0.29%	132,924	TELEFONICA_DE_ESPANA	ES
AS9498	0.19%	84,754	BHARTI Airtel	IN
AS9121	0.14%	61,879	TTNET	TR
AS23944	0.13%	58,102	SKYBroadband	PH
AS9644	0.11%	51,750	SK Telecom	KR
AS24499	0.11%	51,108	Telenor Pakistan	PK
AS3215	0.10%	43,614	Orange	FR
AS23700	0.09%	39,697	Fastnet	ID

ASNs of **IPv6** Resolvers that do not followup in **TCP** when given a truncated UDP Response – Top 10

ASN	Use	Exp	AS Name	CC	
AS15169	4.15%	961,287	Google	US	
AS21928	1.72%	399,129	T-Mobile USA	US	
AS7922	1.57%	364,596	Comcast Cable	US	
AS3352	0.54%	126,146	TELEFONICA_DE_ESPANA	ES	
AS22773	0.38%	87,723	Cox Communications Inc.	US	
AS55644	0.35%	80,844	Idea Cellular Limited	IN	
AS20115	0.31%	71,831	Charter Communications	US	
AS20057	0.30%	70,518	AT&T Mobility	US	
AS6713	0.20%	46,196	IAM-AS	MA	
AS8151	0.20%	45,754	Uninet S.A. de C.V.	MX	

What's the impact?

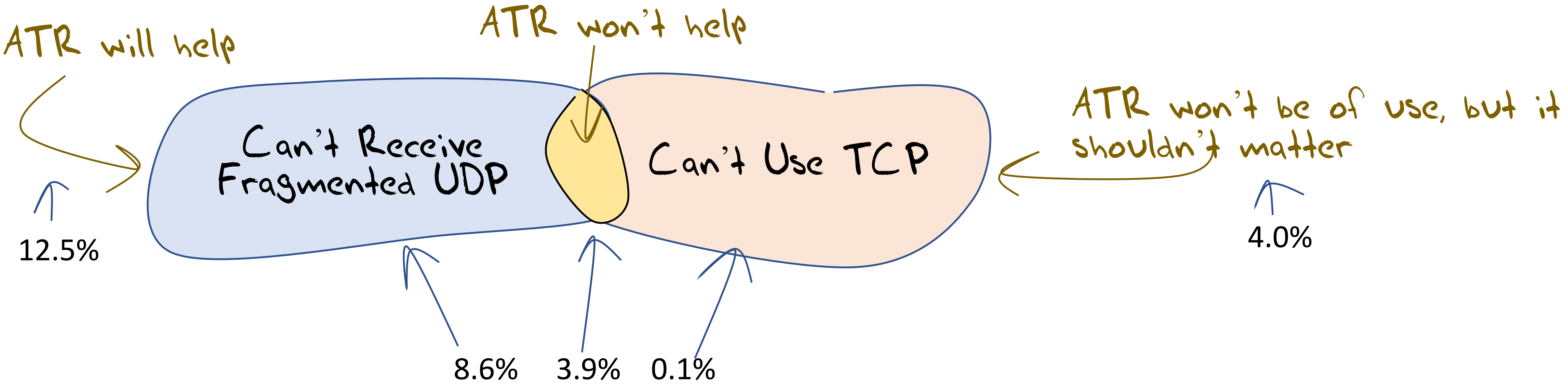
Counting resolvers is NOT the same as counting users!

- Failure in the DNS is often masked by having multiple resolvers in the clients local configuration
- And the distribution of users to visible recursive resolvers is heavily skewed (10,000 resolvers by IP address handle the DNS queries of some 90% of all end users)
- To assess the user impact let's look at the results by counting user level success / failure

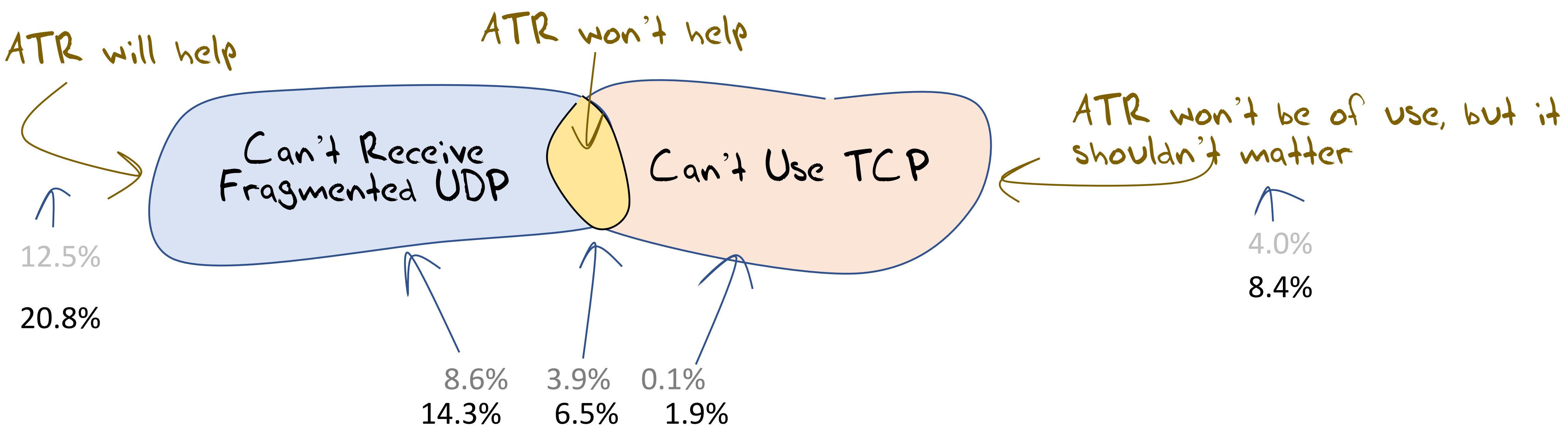
Looking at **Users** - Failure Probabilities

IPv4			**IPv6**	
UDP Frag:	12.5%		UDP Frag:	20.8%
TCP:	4.0%		TCP:	8.4%
ATR	**3.9%**		**ATR**	**6.5%**

ATR and Resolver Behaviour – IPv4



ATR and Resolver Behaviour – IPv4 IPv6



ATR Impact: Net Change in User Failure Rates

IPv4

Fragged UDP Loss: 12.5%

ATR Loss Rate: 3.9%

IPv6

Fragged UDP Loss: 20.8%

ATR Loss Rate: 6.5%

Why use ATR?

- Allows those resolvers that can receive large fragmented UDP packets to do so without being pushed into using TCP
  - In this case the trailing truncated packet is ignored

    (or, at worst, generates an ICMP Port Unreachable message back to the server)
- Faster resolution when fragmented UDP responses are blocked
  - The ATR switchover to TCP happens immediately rather than waiting for local timeouts to perform EDNS(0) UDP Buffer Size hunting to trigger a truncated response
    - Less time to resolve, fewer packets to resolve

Why NOT use ATR?

- Large UDP responses are used in DDOS attacks - adding an additional packet to the response adds to the DDOS amplification factor
- The trailing UDP packet may generate ICMP Port Unreachable messages back to the server
  - (This IMCP message occurs about at a rate of approximately 1 in 5 responses in our experiments)
- Potential DDOS vector for the server
  - (unless the server limits the queue of delayed packets to some arbitrary ceiling)
- Potential re-ordering of the responses in flight may cause an unnecessary delay and an additional TCP local component
  - (This can be reduced by using a longer delay, but too long a delay will allow for clients to requery)
- One more straw to add to the back of the DNS camel!

ATR Assessment

- Is this level of benefit worth the additional server and traffic load when sending large responses?
  - Is this load smaller than resolver hunting in response to packet drop?
  - Is the faster fallback to TCP for large responses a significant benefit?
- Do we have any better ideas about how to cope with large responses in the DNS?

Thanks!