Latency and Performance Analysis of different Public DNS server's resolution result

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***Abstract*— In this project, we analyze the DNS queries toward several public DNS servers and compare the content access performance difference by DNS resolution result. Then, we get the summary of the best public DNS resolver for specific domain name and the market proportion of the ISP and CDN provider (by AS number). The result shows the best latency performance by IP resolved between each Public DNS server eventually distributed. Each Public Server would nearly be serving approximately 10%~ of lowest latency IP per domains. No matter the domain is operated under CDN providers, if the DNS Server does not provide the lowest latency IP result, the performance still not be the optimal.**

Keywords—Internet, CDN, DNS, Latency, AS Path, reachability, contents.

I. INTRODUCTION

The current Internet infrastructure become complex and performance orientated for user experience, at the last digital era, the server platform design is more related to load sharing, balancing for dividing the access request to multiple physical devices at originate server farm. However, the technical improvement of Internet lets the content delivery under several content (CDN) provider or proxy caching to be common, and the advance DNS forwarding method creates low access latency.

In this project, we study the DNS queries toward several public DNS servers and compare the content access performance difference by the DNS resolution result. Then, we get the summary of the best public DNS resolver for specific domain name and the market proportion of the ISP and CDN provider (by AS number).

II. MOTIVIATION

After the evolution of internet and telecommunication, CDN, Proxy Caching and DNS are main components of internet application content access. It affects the user's experience of application access response time. Those can help for shorten the access latency between the client device and the originate server.

High-speed internet access, mobile access (4G,5G) would not be able to solve the long-distance physical propagation delay and massive internetwork path to access originate server. Therefore, internet service provider (ISP) may co-operate with certain contents provider to enhance the user experience. The most common method is to deploy CDN server or Proxy Cache server at ISP infrastructure and perform the advance DNS forwarding technique to influence the actual user query result for destination server redirection.

However, although client user is able to access the server which physical closer, we still cannot guarantee that which server contains the best performance between all content servers, no matter the server is under the same location, regions or physically same area [13, Page 699]. Under this assumption, sometimes, we cannot get the best performance of accessing the contents due to number of client users, network path congestion, destination server's loading, content caching expiration etc. There are many criteria of concerns.

As some of the major content delivery or service provider, they co-operate with Internet Service Provider for content node deployment and operate under advance DNS techniques. Like Akamai Accelerated Network Partner Program [14], the server cluster installed at service provider network and provide contents access redirection by client's DNS Server IP [14].

Also, in this measurement, we need to cater about the content / originate server which operating by IP ANYCAST. The main idea is several same IP address servers deploy over the internetwork to provide service to achieve the aim of load sharing [15, Page 236]. This type of deployment do not only provide service for specific group of clients (e.g. ISP subscribers). It matches the Public DNS server approach if the Content Delivery Server deployment scope in a large area scale (Any internet users). The other approach called EDNS [16] which is used to include the client IP in DNS Queries to DNS server. DNS Server based on that field information to define the policy for DNS IP resolution.

Currently, there are several major DNS servers open for public query, for example Google, Cloudflare, OpenDNS etc. In this project, we launch multiple DNS query to those DNS servers, and then to measure the latency and web access performance under those DNS query result. We categorize that information with destination AS number, average ping latency and the query result difference.

III. METHODOLOGY

In this project, we get the live data for the DNS query measurement, the following component used.

1: Capture the DNS request by client users over self-build Proxy Cache server (Squid [11])

2: By the Domain list captured by Squid [11], launch DNS queries to Public DNS Servers.

3: Launch HTTP request header to the resolved IP address (server) and get the request response time.

4: Check IP's AS number

5: Summarize the result of Highest and Lowest access latency, IP belongs to which AS.

6 (Optional): Deploy the Domain name forward policy at Bind Server.

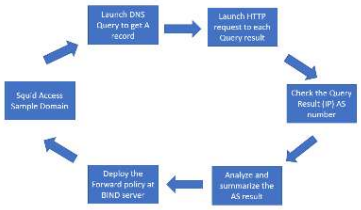

Fig. 1. Measurement Methodology

A. *Proxy Server "Squid"*

To get the actual live data for best measurement, we deploy an "Squid Proxy Server" [11] to get the historical web domain access record for measurement used. For those client IP access, we would not disclose it under privacy concern and NO client access information be analyzed. For domain queries (DNS queries), we redirect all queries to the server itself (127.0.0.1) bind server.

Squid DNS Configuration:

dns_nameservers 127.0.0.1

B. *DNS Server "Bind" and "Python DNS library - dns.resolver"*

As Squid will redirect all DNS queries to itself Bind Server, we could capture those bind log's domains information, then, we use the python DNS library - dns.resolver to query the several domains to obtain the IP result. We only grep with A (IP) query record at queries log. The "Bind" DNS Server use for query from the "Root" and TLD downward to originate server result recursively.

Bind example Log:

13-Oct-2020 07:51:13.818 queries: info: client @0x650f1ec0 127.0.0.1#55510 (<DOMAIN>): query: <DOMAIN> IN A + (127.0.0.1)

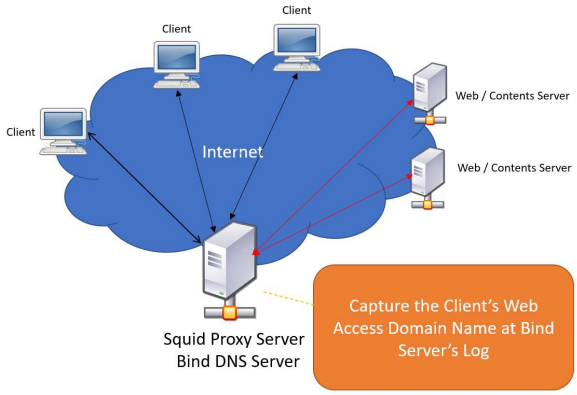

Fig. 2. Domain name capturing

C. *Public DNS Servers*

We launch the DNS query to several Public DNS Servers for measurement. DNS server's setting may relate under each organization's internal fine tuning, policy, IP addressing, political issues, filtering, service redundancy concern etc. The DNS IP resolve result may be similar or may be totally different of each domain. For the Self build DNS server, it queries the domain under the recursive mode from TLD to Domain NS server.

DNS server Provider	Server IP address
Self-build DNS Server (under ISP PCCW)	127.0.0.1
Cloudflare [1]	1.1.1.1
CNNIC [2]	1.2.4.8
Verisign [3]	64.6.64.6
Google [4]	8.8.8.8
Quad9 - IBM,PCH,Global Cyber Alliance [5]	9.9.9.9
OpenDNS [6]	208.67.222.222
Hurricane Electric [7]	74.82.42.42
Level 3 [8]	4.2.2.2
Alibaba (US) [9]	223.5.5.5

Fig. 3. List of DNS Server

D. *Python HTTP request script*

Python HTTP request script to get the content access result in term of time. As we assume that the traffic may be under TLS / SSL session, the initial stage of the session exchange between server and client would still be under clear text. The traffic header is the original HTTP header and dataset. [18, Page 146]. Therefore, launch the HTTP Header request to specific server for measurement.

After get the domain name list, launch the HTTP request, we use the python http request library (requests.head) with the IP address which resolved by the public DNS server and get the access response time (request.elapsed.total_seconds()). For each domain name, we perform 5 times requests to server and get the "AVERAGE" for more accurate access time reference.

$$\text{Average access latency (second)} = \sum_{i=1}^{5} \text{access request } i \,/\, 5$$

Fig. 4. Average access latency Calculation

E. *IP's Originate AS number*

We get the actual IP's AS number by latest route table. A script develops by PERL which use to extract the AS number of IP subnet from the "Route table" download from APNIC Geoff Huston/bgp.potaroo.net [10]. Data summarized to several files which is similar with MAXMIND [19,20] GeoIP databases. We have considered to use the WHOIS database, however, we try to study the information by live route tables information. Then, to prepare this route table extract script.

E.g. AS4134 CHINANET-BACKBONE No.31,Jin-rong Street, CN
58.99.128.0/17 4608 7575 **4134**

We summarize the market proportion of ISP, CDN provider which serving the most sampled number of domains.

F. *Powerful SBC Raspberry PI*

This project run over the Single Broad Computer – Raspberry PI [12] for measurement, analysis, and result summarization. The measurement is under single internet provider (PCCW 500Mbps Service). For further work, we can install and connect several Raspberry PI at different service provider to perform the measurement like for "Overlay network". It would contain more details network analysis.

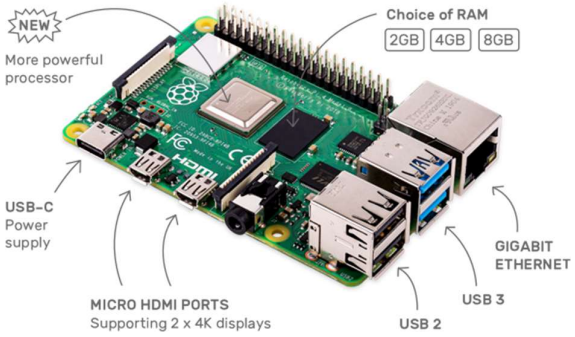

Fig. 5. Raspberry PI 4B

IV. Project Result Analysis

For Squid Web Caching Server, it opens service to public for several weeks. Then, we obtain the access log for analysis, we do not check with client IP address, we only capture the domain name for measurement. As Squid redirect all DNS query to self's Bind DNS Server, we capture all domain queries at BIND Server query log. The domain capture period for this project measurement within **14 Oct 2020 – 05 Nov 2020** with total **87,662** domain names. The Linux command "AWK" used for domain counting. (Capture Domain Result file name: result_20201105)

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cat /var/log/named/queries | grep "IN A +" | awk '{print $8}' | awk '{gsub(/\([|\)|:|^\(|\.\):$/,"");if($1 != "") print $1}' | sort -n | uniq -c | sort -nr*

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Access Count	Domain
12932	httpbin.org
7551	www.hzyotoy.com
7342	i.instagram.com
7219	api.steampowered.com
7104	clk.flymobi.biz
6289	l9bjkkhaycw6f8f4.soundcloud.com
6134	www.instagram.com
6084	steamcommunity.com
5992	www.amazon.com
5861	ios.prod.ftl.netflix.com

Fig. 6. Top 10 domain queries

As each domain, the program performs **5 times** http request test to specific DNS resolved server. Therefore, total over **400000** tests under **25 threads** launched for whole measurement.

According to the resolved IP address, the IP would be the same over different DNS server, for highest and lowest access latency, we only compare the latency result with the different resolved IP and output to the "Summary" file.

cat /mnt/usbdisk/python/measure_result/different_xa | awk '{**if ($9 !~ $21)** print $4,$7,$9,$10,$14,$19,$21,$22,$26,$28}' | sort -k 10nr > /mnt/usbdisk/python/measure_result/summary*

Domain		DNS Server	IP	AS	Late(s)	**Diff %**
secure.accorhotels.com	H	1.2.4.8	157.240.12.35	32934	0.79	
	L	9.9.9.9	152.199.43.123	15133	0.02	**97.70**

Fig. 7. Example Output

A. *Lowest HTTP Request Latency by Resolved Result – Per DNS Servers*

Lowest HTTP Request Latency resolved count per DNS Servers, compare the measured latency of highest and lowest result if these 2 IP addresses are not the same.

*Total **20040** Domain result measured.*

Ranks (Smaller the best)	DNS Server	# of Domain	Proportion
1	1.1.1.1 - Cloudflare [1]	2509	12.52%
2	4.2.2.2 - Level 3 [8]	2231	11.13%
3	208.67.222.222 - OpenDNS [6]	2159	10.77%
4	64.6.64.6 - Verisign [3]	2121	10.58%
5	127.0.0.1 – Self Server (TLD)	2103	10.49%
6	8.8.8.8 - Google [4]	2046	10.21%
7	74.82.42.42 - Hurricane Electric [7]	1937	9.67%
8	1.2.4.8 - CNNIC [2]	1727	8.62%
9	223.5.5.5 - Alibaba (US) [9]	1684	8.40%
10	9.9.9.9 - Quad9 [5]	1523	7.60%
		20040	100%

Fig. 8. Lowest HTTP Request Latency by Resolved Result – Per DNS Servers

B. *Highest HTTP Request Latency by Resolved Result – Per DNS Servers*

Highest HTTP Request Latency resolved count per DNS Server, compare the measured latency of highest and lowest result if these 2 IP addresses are not the same.

*Total **20040** Domain result measured*

Ranks (Smaller the worst)	DNS Server	# of Domain	Proportion
1	223.5.5.5 - Alibaba (US) [9]	3070	15.32%
2	9.9.9.9 - Quad9 [5]	3008	15.01%
3	74.82.42.42 - Hurricane Electric [7]	2576	12.85%
4	1.2.4.8 - CNNIC [2]	2403	11.99%
5	4.2.2.2 - Level 3 [8]	1908	9.52%
6	1.1.1.1 - Cloudflare [1]	1568	7.82%
7	127.0.0.1 – Self Server (TLD)	1482	7.40%
8	64.6.64.6 - Verisign [3]	1358	6.78%
9	8.8.8.8 - Google [4]	1351	6.74%
10	208.67.222.222 - OpenDNS [6]	1316	6.57%
		20040	100%

Fig. 9. Highest HTTP Request Latency by Resolved Result – Per DNS Servers

C. *Performance Gain per-domain by Comparison*

Highest and Lowest HTTP request latency difference Per-Domain in Percentage. In terms of HTTP request Latency, there are ***2618 Domains could get 90%*** performance improvement. ***2733 domains would get 80%*** performance gain.

Percentages = ((highest Latency-Lowest Latency) / highest Latency) x 100%

10284 Domains (over 50% performance gain) can get the overall improvement if the best DNS server selected for query.

> different Percentages	Count	Proportion
90	2618	13.06%
80	2733	13.64%
70	2975	14.85%
60	1239	6.18%
50	719	3.59%
40	918	4.58%
30	1395	6.96%
20	2091	10.43%
10	2892	14.43%
0	2460	12.28%
	20040	100%

Fig. 10. Performance Gain per-domain by Comparison

Under the below table, the public DNS servers resolve different IP per-domain. The HTTP request latency have the most competitive comparison result. It may relate to the ISP internet infrastructure, CDN Servers deployed in ISP infrastructure internally, quality of service or actual loading of destination server.

For example, the AS4760 is "PCCW / HKT", the Internet service provider of this test. The domain "cdn.livechatinc.com" is resolved the IP address 219.76.14.10 by DNS server 208.67.222.222. As this IP is belongs to PCCW/HKT, we suppose this server would be co-operated by CDN provider, cache service or HKT self-build server.

Domain	Req	DNS Server	IP	AS	Late(s)	Diff %
secure.accorhotels.com	H	1.2.4.8	157.240.12.35	32934	0.79	
	L	9.9.9.9	152.199.43.123	15133	0.02	**97.70**
postfiles.pstatic.net	H	9.9.9.9	2.19.60.40	20940	0.50	
	L	8.8.8.8	184.84.122.4	20940	0.01	**97.51**
cdn.livechatinc.com	H	9.9.9.9	2.16.162.98	20940	0.51	
	L	**208.67.222.222**	**219.76.14.10**	**4760**	**0.01**	**97.45**
ads-juicyads.com	H	1.2.4.8	92.223.122.229	199524	0.57	
	L	223.5.5.5	92.223.95.95	199524	0.02	**97.34**
appdl-2-drcn.dbankcdn.com	H	1.2.4.8	101.71.72.24	4837	0.57	
	L	8.8.8.8	119.28.164.234	132203	0.02	**97.32**
www.kummarimatrimony.com	H	9.9.9.9	104.106.197.206	20940	0.47	
	L	208.67.222.222	184.84.113.121	20940	0.01	**97.31**
www.gotogate.at	H	9.9.9.9	104.84.251.42	20940	0.48	
	L	208.67.222.222	184.84.112.184	20940	0.01	**97.26**
a.espncdn.com	H	9.9.9.9	2.22.146.138	20940	0.51	
	L	127.0.0.1	219.76.10.202	4760	0.01	**97.25**
www.whyallanewsonline.com.au	H	9.9.9.9	88.221.135.35	20940	0.49	
	L	208.67.222.222	219.76.10.3	4760	0.01	**97.25**
www.dcdapp.com	H	9.9.9.9	163.181.57.230	24429	0.51	
	L	74.82.42.42	163.181.33.224	24429	0.01	**97.24**

Fig. 11. Top 10 Difference Table in terms of Domains

D. *Resolved IP, AS number and CDN provider relationship*

The destination servers operated under which AS / CDN / ISP company. This summarized result based on Lowest Latency IP and its AS number. There is total **639 AS number** captured. The following table shows Top 20 DOMAIN Resolved IP's AS Number (Lowest Latency)

AS Number	AS / CDN / ISP Company	Count	Proportion
AS13335	Cloudflare,Inc	7594	37.89%
AS15169	Google LLC	2319	11.57%
AS16509	Amazon.com, Inc.	1418	7.08%
AS54994	QUANTIL NETWORKS INC	714	3.56%
AS20940	Akamai International B.V.	599	2.99%
AS54113	Fastly	580	2.89%
AS16625	Akamai Technologies, Inc.	425	2.12%
AS2635	Automattic, Inc	381	1.90%
AS132203	Tencent Building, Kejizhongyi Avenue	351	1.75%
AS14618	Amazon.com, Inc.	336	1.68%
AS24429	Zhejiang Taobao Network Co.,Ltd	279	1.39%
AS4760	**HKT Limited**	**210**	**1.05%**
AS4134	CHINANET-BACKBONE	207	1.03%
AS37963	Hangzhou Alibaba Advertising Co.,Ltd.	177	0.88%
AS134771	China Telecom - WENZHOU, ZHEJIANG Province, P.R.China.	149	0.74%

AS62221	Amayama Auto Co., Ltd.	144	0.72%
AS60781	LeaseWeb Netherlands B.V.	127	0.63%
AS15133	MCI Communications Services, Inc. d/b/a Verizon Business	124	0.62%
AS4837	CHINA UNICOM China169 Backbone	121	0.60%
AS16276	OVH SAS	116	0.58%

Fig. 12. Top 20 DOMAIN Resolved IP's AS Number (Lowest Latency)

This summarized result based on Highest Latency IP and its AS number. There is total **649 AS number** captured. The following table shows top 20 DOMAIN Resolved IP's AS Number (Highest Latency).

AS Number	AS / CDN / ISP Company	Count	Proportion
AS13335	Cloudflare,Inc	7478	37.32%
AS15169	Google LLC	2300	11.48%
AS16509	Amazon.com, Inc.	1402	7.00%
AS16625	Akamai Technologies, Inc.	627	3.13%
AS54113	Fastly	563	2.81%
AS20940	Akamai International B.V.	492	2.46%
AS2635	Automattic, Inc	386	1.93%
AS14618	Amazon.com, Inc.	375	1.87%
AS4837	CHINA UNICOM China169 Backbone	348	1.74%
AS54994	QUANTIL NETWORKS INC	310	1.55%
AS132203	Tencent Building, Kejizhongyi Avenue	284	1.42%
AS4788	TM Net, Internet Service Provider	282	1.41%
AS37963	Hangzhou Alibaba Advertising Co.,Ltd.	211	1.05%
AS9808	Guangdong Mobile Communication Co.Ltd.	201	1.00%
AS24429	Zhejiang Taobao Network Co.,Ltd	181	0.90%
AS58461	CT-HangZhou-IDC	147	0.73%
AS62221	Amayama Auto Co., Ltd.	144	0.72%
AS16276	OVH SAS	139	0.69%
AS30633	Leaseweb USA, Inc.	131	0.65%
AS4134	CHINANET-BACKBONE	128	0.64%

Fig. 13. Top 20 DOMAIN Resolved IP's AS Number (Highest Latency)

According to the above result, it can summarize that no matter the domain operated under CDN, all performance still depends on the resolved IP address under DNS server redirection. As we can see the first 3 Ranks of lowest and highest latency are under CDN operator.

AS Number	AS / CDN / ISP Company	Count	Proportion
AS13335	Cloudflare,Inc	7594	37.89%
AS15169	Google LLC	2319	11.57%
AS16509	Amazon.com, Inc.	1418	7.08%

Fig. 14. Top 3 DOMAIN Resolved IP's AS Number (Lowest Latency)

AS Number	AS / CDN / ISP Company	Count	Proportion
AS13335	Cloudflare,Inc	7478	37.32%
AS15169	Google LLC	2300	11.48%
AS16509	Amazon.com, Inc.	1402	7.00%

Fig. 15. Top 3 DOMAIN Resolved IP's AS Number (Highest Latency)

The following table shows that, the domains are under CDN provider AS20940 – Akamai and AS24429 – Taobao (Alibaba Cloud). The content access performance would have big different if the IP resolved to the higher latency server.

Domain		DNS Server	IP	AS	Late(s)	Diff %
postfiles.pstatic.net	H	9.9.9.9	2.19.60.40	20940	0.50	
	L	8.8.8.8	184.84.122.4	20940	0.01	97.51
www.dcdapp.com	H	9.9.9.9	163.181.57.230	24429	0.51	
	L	74.82.42.42	163.181.33.224	24429	0.01	97.24

Fig. 16. Latency Different betweem IP under same AS number

As this measurement under PCCW network, AS4760 appeared at the top 20 lowest latency list which highest latency list not listed it out. We suppose that the Internal Cache or CDN co-operated server has been deployed at PCCW Network for shorten the contains access time. Due to this measurement only based on IP address, there is a chance that the "CNAME" may marked the CDN co-operated domain which facing PCCW/HKT located server may confirm this assumption.[17]

Domain		DNS Server	IP	AS	Late(s)	Diff%
cdn.livechatinc.com	H	9.9.9.9	2.16.162.98	20940	0.51	
	L	208.67.222.222	219.76.14.10	4760	0.01	97.45
a.espncdn.com	H	9.9.9.9	2.22.146.138	20940	0.51	
	L	127.0.0.1	219.76.10.202	4760	0.01	97.25
www.whyall anewsonline.com.au	H	9.9.9.9	88.221.135.35	20940	0.49	
	L	208.67.222.222	219.76.10.3	4760	0.01	97.248

Fig. 17. PCCW / HKT AS appear at lowest latency top 20

E. Resolved all the same IP with different public DNS Server

The result show us that it may match the ANYCAST [15, Page 236] approach of the Server deployment, or that Server has not been operated under any CDN network, or the service may operate under single IP server.

However, there may be some SPAM HTTP request over the squid server, the Dummy or Parking Site domain name queries by Client. Therefore, some DNS hosting provider like "GoDaddy.com" appearing on this list.

There are Total **67622** Domains captured with resolved all same IP address over different Public DNS Server. Total **3871** AS number has been captured. There are the Top 20 AS Number count pre-domain with all IP resolved the same result

AS Number	AS Company	Count	Proportion
AS46606	Unified Layer	3230	4.78%
AS15169	Google LLC	2733	4.04%
AS16276	OVH SAS	1992	2.95%
AS26496	GoDaddy.com, LLC	1725	2.55%
AS24940	Hetzner Online GmbH	1703	2.52%
AS37963	Hangzhou Alibaba Advertising Co.,Ltd.	1598	2.36%

AS16509	Amazon.com, Inc.	1472	2.18%
AS14618	Amazon.com, Inc.	1341	1.98%
AS8560	1&1 IONOS SE	1289	1.91%
AS4134	CHINANET-BACKBONE	1277	1.89%
AS40034	Confluence Networks Inc	997	1.47%
AS4837	CHINA UNICOM China169 Backbone	893	1.32%
AS14061	DigitalOcean, LLC	889	1.31%
AS13335	Cloudflare, Inc.	814	1.20%
AS23724	IDC, China Telecommunications Corporation	730	1.08%
AS32244	Liquid Web, L.L.C	720	1.06%
AS45102	Alibaba (US) Technology Co., Ltd.	596	0.88%
AS45090	Shenzhen Tencent Computer Systems Company Limited	571	0.84%
AS51167	Contabo GmbH	552	0.82%
AS43146	Domain names registrar REG.RU, Ltd	528	0.78%
~	~	~	~
	Total Domain =	67622	100%

Fig. 18. Top 20 AS Number (pre-domain) with all IP resolved the same

F. Most CDN /AS Serving Domain / Web Application

Summarized all resolved IP result operated under which AS number. Refer to the Fig.11, we may know that some domain would operate under different AS (per IP resolved). We count the AS number based on the lowest latency HTTP request IP and all same resolved IP for summarization.

AS Number	AS Company	Count	Proportion
AS13335	Cloudflare, Inc.	8430	9.62%
AS15169	Google LLC	5065	5.78%
AS46606	Unified Layer	3234	3.69%
AS16509	Amazon.com, Inc.	2925	3.34%
AS16276	OVH SAS	2138	2.44%
AS26496	GoDaddy.com, LLC	1830	2.09%
AS37963	Hangzhou Alibaba Advertising Co.,Ltd.	1782	2.03%
AS24940	Hetzner Online GmbH	1756	2.00%
AS14618	Amazon.com, Inc.	1718	1.96%
AS4134	CHINANET-BACKBONE	1573	1.79%
AS8560	1&1 IONOS SE	1293	1.47%
AS4837	CHINA UNICOM China169 Backbone	1279	1.46%
AS40034	Confluence Networks Inc	997	1.14%
AS14061	DigitalOcean, LLC	939	1.07%
AS54113	Fastly	929	1.06%
AS23724	IDC, China Telecommunications Corporation	869	0.99%
AS54994	QUANTIL NETWORKS INC	828	0.94%
AS32244	Liquid Web, L.L.C	769	0.88%
AS20940	Akamai International B.V.	733	0.84%
AS45102	Alibaba (US) Technology Co., Ltd.	721	0.82%
~	~	~	~
	Total Domain =	87662	100%

Fig. 19. Top 20 CDN / AS number serving Domain under the test

V. PROJECT SUMMARY

After the result study, we can conclude that the result of the public DNS resolver for specific domain name is affecting the access performance. However, **the domain resolves with shorten latency IP address of each Public DNS server eventually distributed. Each Public Server would nearly be serving approximately 10%~ of lowest latency IP for domains.**

The result shows that no matter the domain is operated under CDN providers, **if the DNS Server do not provide the appropriated IP result to client, the performance still not be the optimal**.

By measurement, there are total **10284 Domains would have over 50% performance gain** if the client DNS query forward to the suitable DNS Server to get the best IP resolve result. However, it will also depend on the ISP internet transit status, CDN or proxy device deployment over the network.

Bind DNS Server can individually update the forwarding policy for each domain name to specific DNS server to obtain the best access performance for client user. Based on the lowest http request latency result, we can automate the process to perform configuration at BIND Server. It **will come up to get and forward to domain to best destination server (by DNS query) to improve the overall network performance.**

Add forward statement to /etc/bind/named.conf.options (depends on bind server configuration).
zone "Specific Domain" IN
{ type forward; forward only; forwarders { *BEST DNS resolver*;}; };

To comparing the AS number result**, we can summarize which provider (by AS) servicing the sampled domain service site (capture by Squid / Bind) and application most**.

AS Number	AS Company	Count	Proportion
AS13335	Cloudflare, Inc.	8430	9.62%
AS15169	Google LLC	5065	5.78%
AS46606	Unified Layer	3234	3.69%
AS16509	Amazon.com, Inc.	2925	3.34%
	Total Domain =	87662	100%

Fig. 20. Provider (by AS) servicing the sampled domain service site

Due to this project is under a single ISP for the measurement client point, the current resource does not allow us to perform the measurement under multiple ISP, Internet transit, IP address as those may affect the DNS resolver reply. This project can be follow-up by continues measurement over several internet probes under different Internet Service Provider.

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