DNS Security: Fundamentals

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Advanced DNS Security Training Program
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Agenda

- DNS Basics
- Architecture
- Forward and Backward Resolution

Need for DNS

Application Layer

- HTTP/HTTPS
- www.coednssecurity.in

Transport Layer

- TCP
- Source Port: 87878
- Destination Port: 80/443

Network Layer

- Source IP: 202.141.136.152
- Destination IP: ?

Data Link Layer

- Source Mac: aa:bb:cc:dd:ee:ff
- DMAC: MAC of gateway

What does DNS do?

- Translates Domain names to IP Addresses:
  - www.cdac.in. → 196.1.113.45
  - www.cdac.in. → 2405:8a00:6029::45
- ... and back:
  - 196.1.113.45 → www.cdac.in.
  - 5.4.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.9.2.0.6.0.0.a.8.5.0.4.2.ip6.arpa. → www.cdac.in.

DNS Fundamentals

- Application Layer protocol
- Runs over **UDP** and user port 53 (for queries and responses)
- Uses TCP for zone data transfers (between master and slave)
- Used by other Application Layer Protocols such as HTTP, FTP, SMTP for name resolution
- No single server in the World has all of the mappings for all of the hosts in the Internet

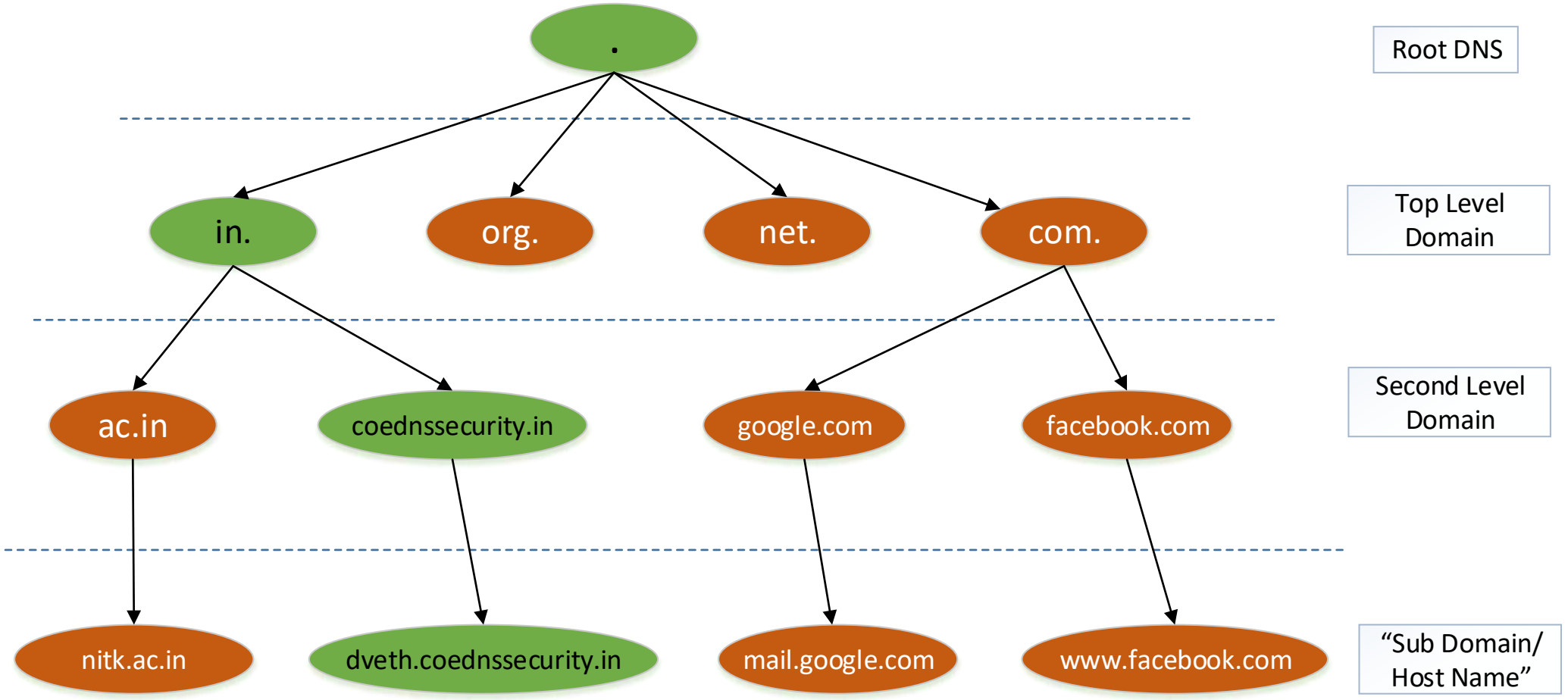
DNS Fundamentals

- Consistent hierarchical name space for referring to resources
  - Nodes at same level cannot have same names
  - Tree Structure
- A critical component of the Internet Infrastructure
- Globally Distributed, Scalable, and Reliable Database

Structure of DNS

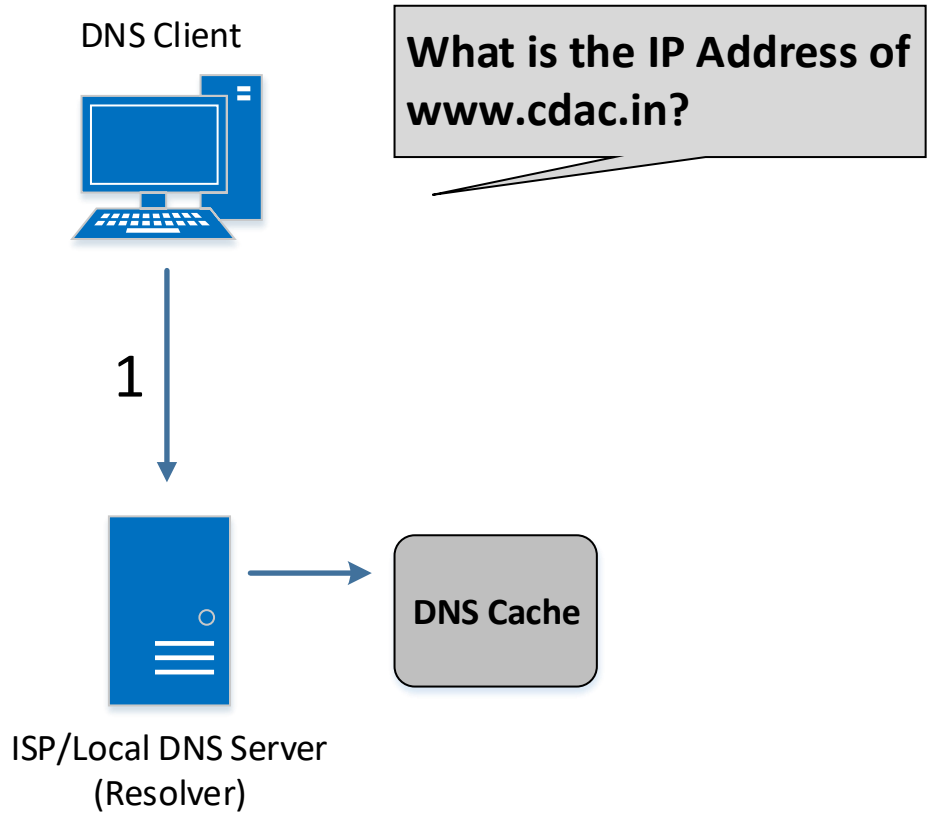
- Decentralized *naming* system
- DNS *administration* is shared – no single central entity administrates all DNS data
- This distribution of the administration is called *delegation*

Structure of DNS



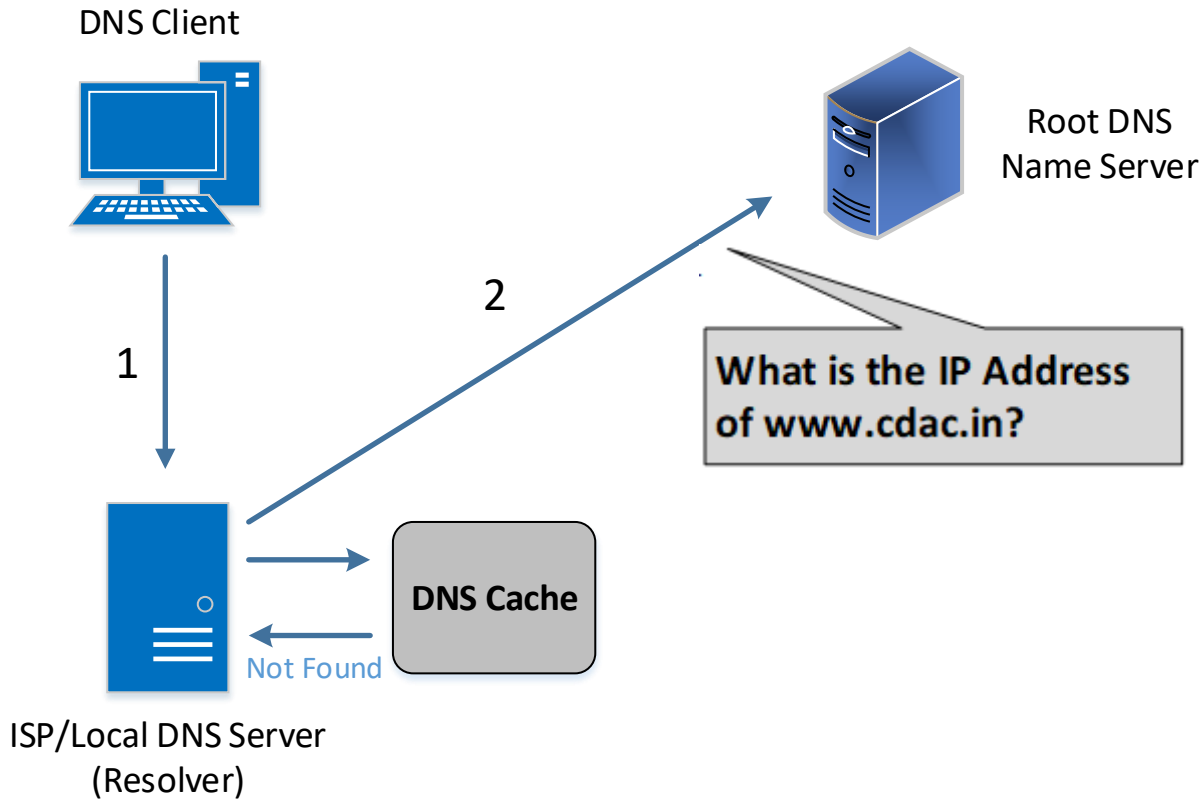
How DNS Works?

1. Client asks to Local/ISP DNS server for lookup.



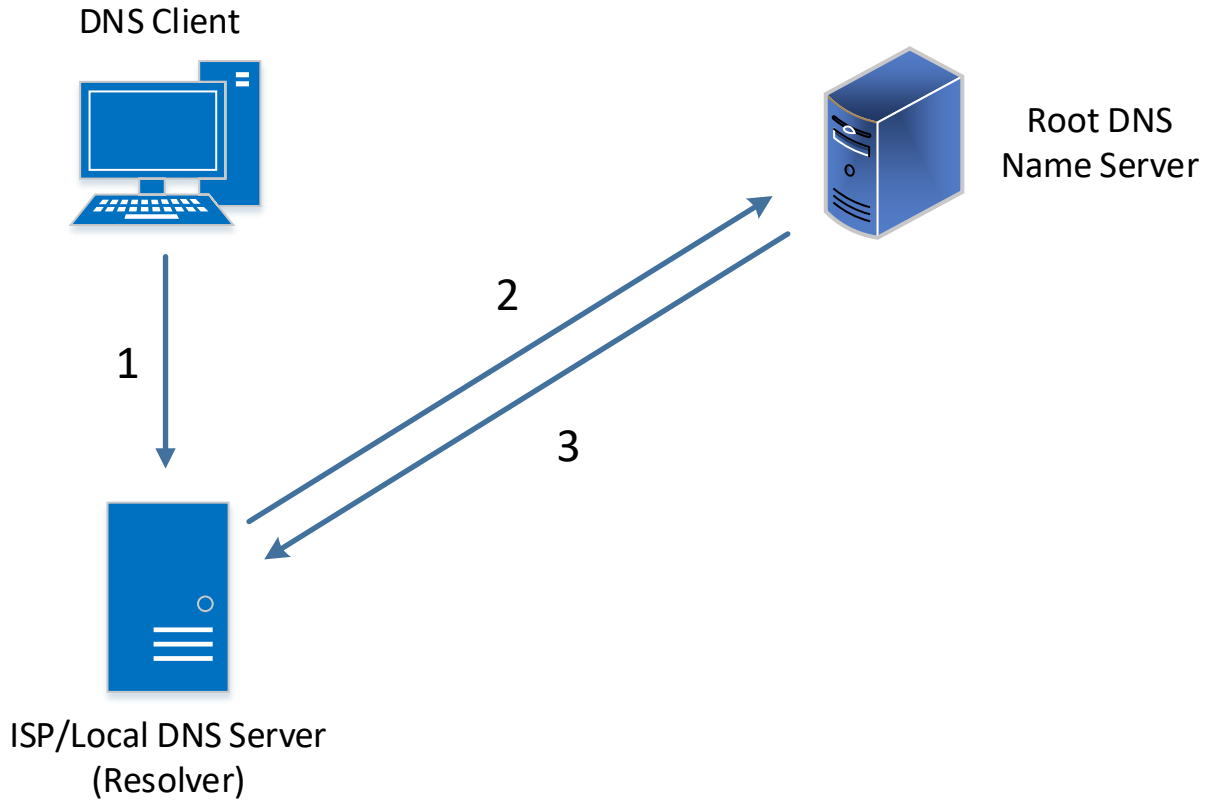
How DNS Works?

2.Local/ISP DNS Server asks Root DNS server.



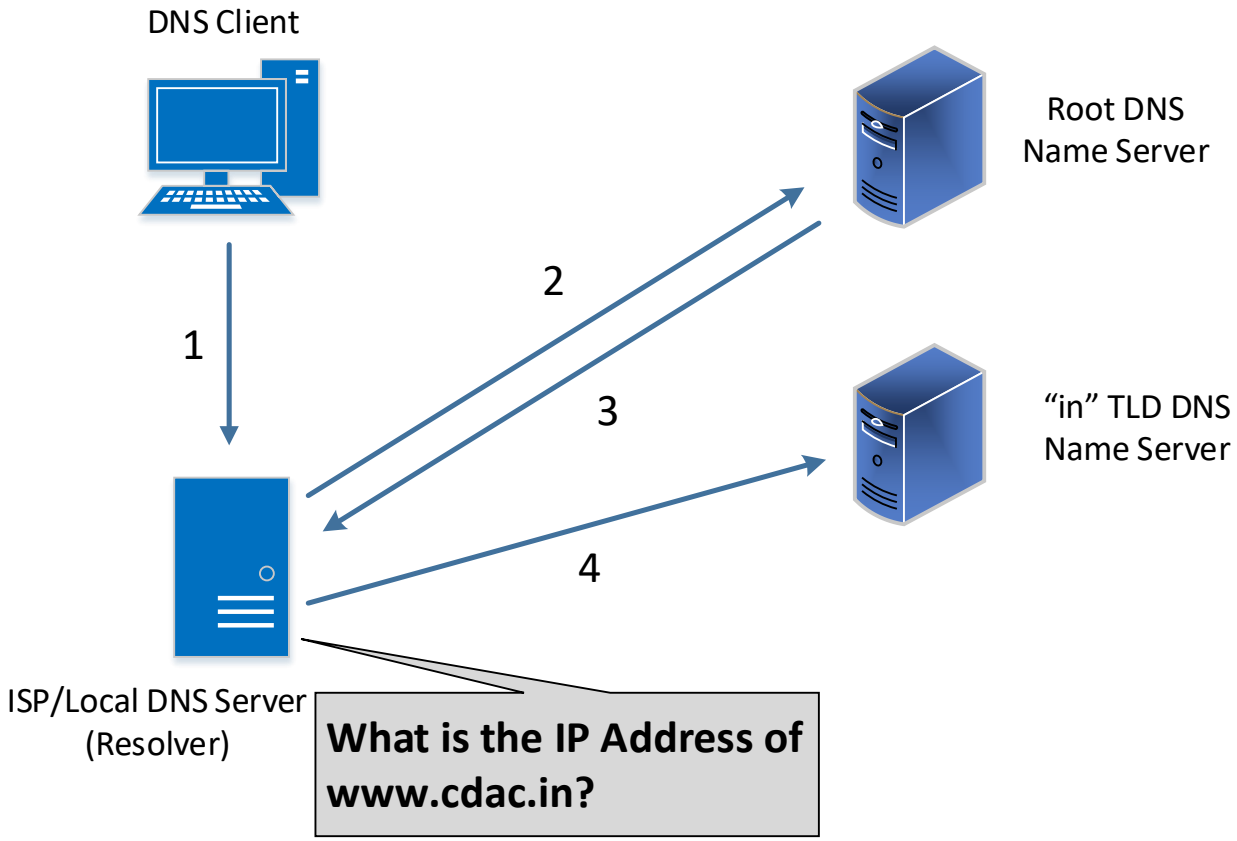
How DNS Works?

3.Root DNS server reply with referral to TLD DNS “in”.



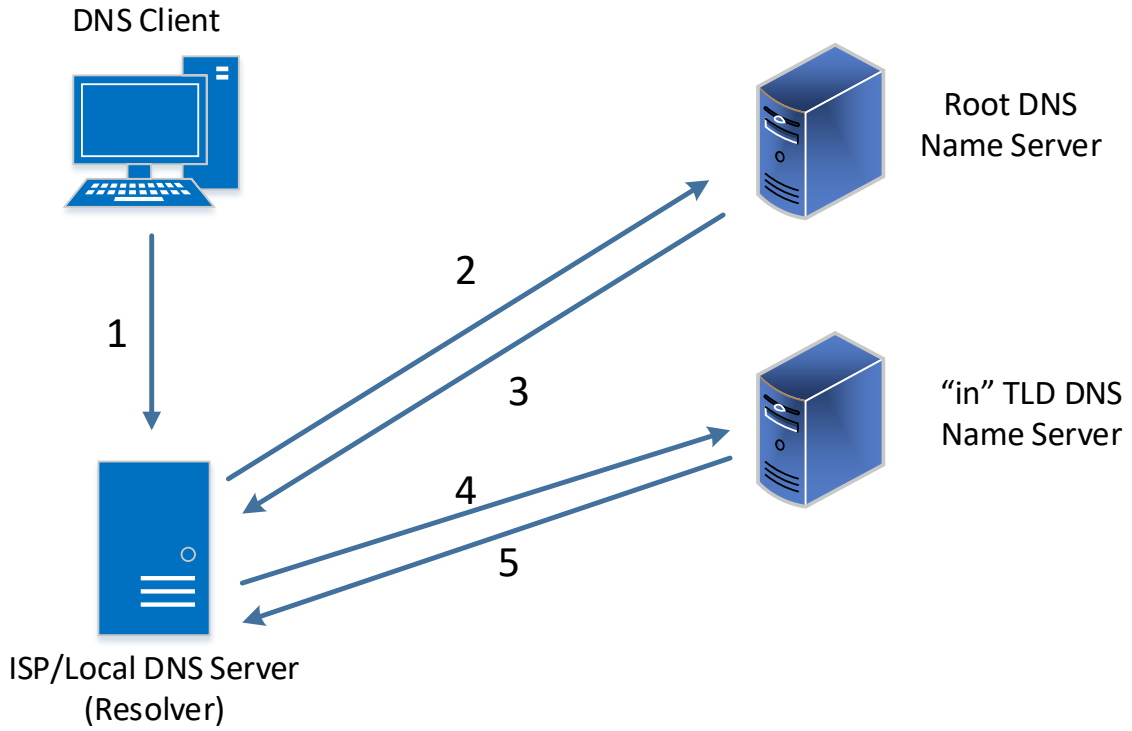
How DNS Works?

4.ISP/Local DNS Server queries TLD DNS.



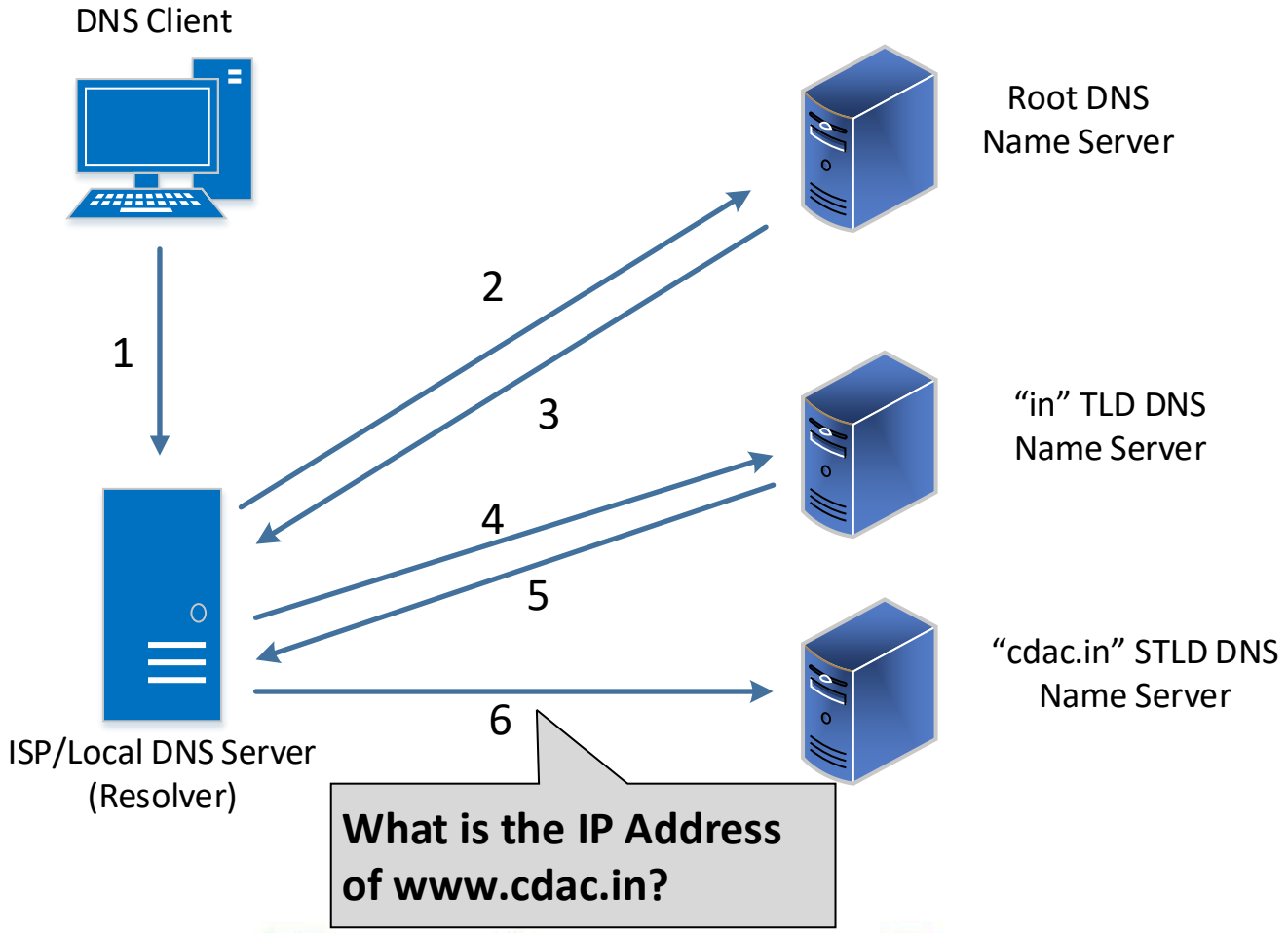
How DNS Works?

5.TLD DNS reply with referral to STLD DNS “cdac.in”.



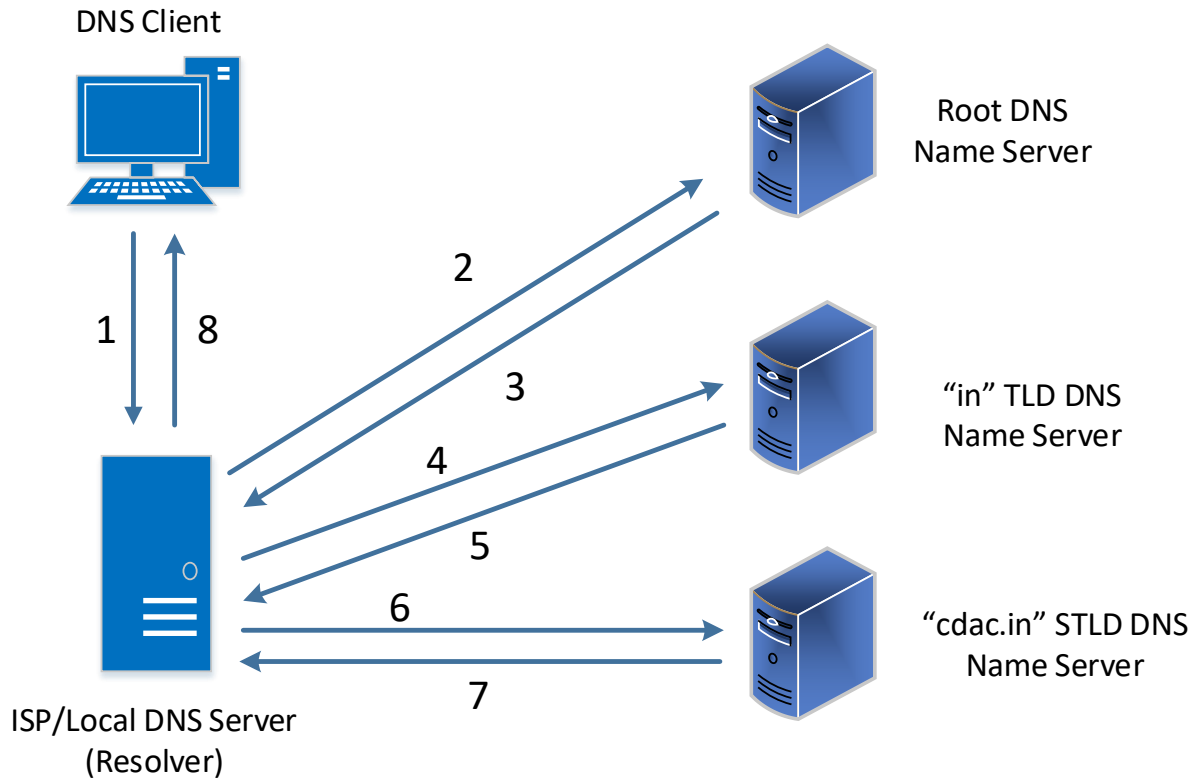
How DNS Works?

6.ISP/Local DNS Server queries STLD DNS.



How DNS Works?

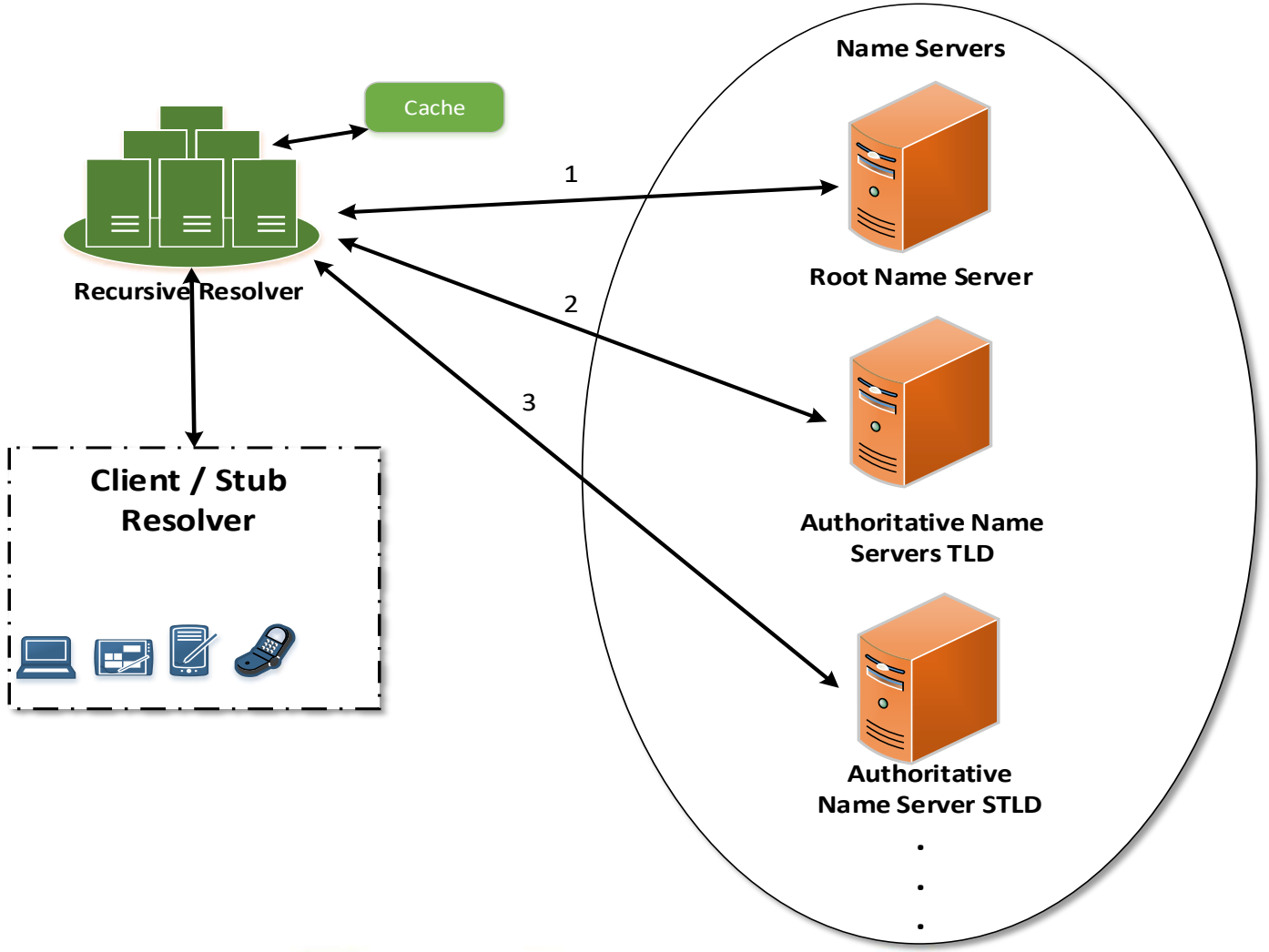
7. ”cdac.in” STLD DNS Server gives the reply - i.e IP address of “www.cdac.in”



Elements of DNS

- Domain Name Space and Resource Records
  - A tree structure name space and data associated with the names
- Name Servers
  - Programs that hold information about the domain's tree structure
- Resolvers
  - Programs that extract information from name servers to respond to client's requests.

DNS Ecosystem



Stub Resolver

- DNS Client is called Stub Resolver.
- Always Queries RR.
- RR Replied back to the Stub Resolver.

Authoritative Name Server

- They serve the actual reply – i.e., the final translation of the ***FQDN*** to the IP address, as they are the authoritative source for the domain in question.
- DNS hosting companies typically manage the authoritative DNS servers for a domain name which, the users query through recursive resolvers.
- Master and Slave Configurations are maintained to increase availability

Recursive Resolver

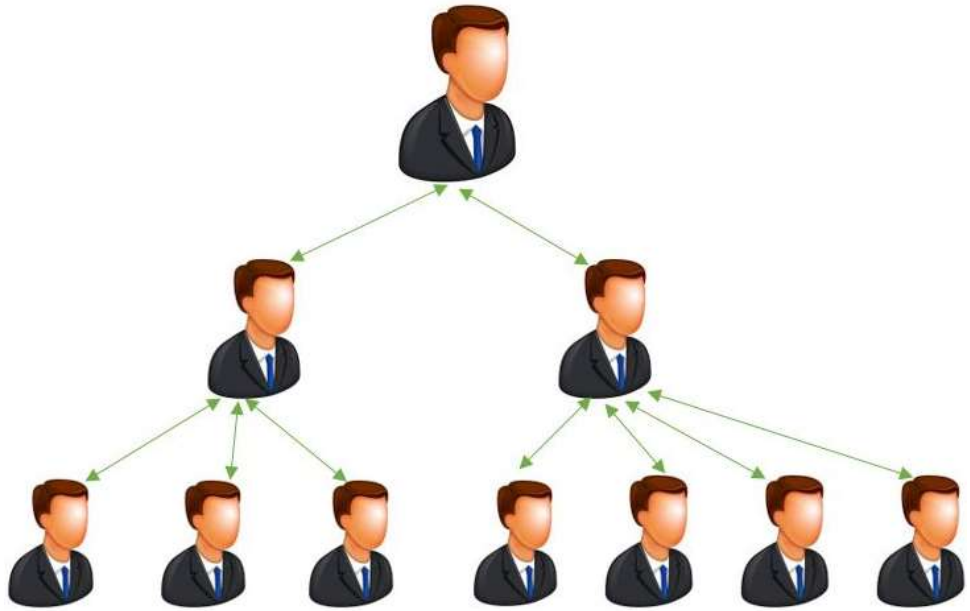
- Also called as recursive DNS Server.
- The user queries to RR for domain lookup.
- RR queries the entire DNS Hierarchy for the final result.
- RR can also be Authoritative for some domains

DNS Server Types

- Root DNS Server
  - Root Servers(A to M)
  - Instances
- Authoritative DNS Server
  - Master
  - Slave
- Recursive DNS Server
- Stub Resolver

DNS Centralized or Decentralized ?

- Centralized or Decentralized ??



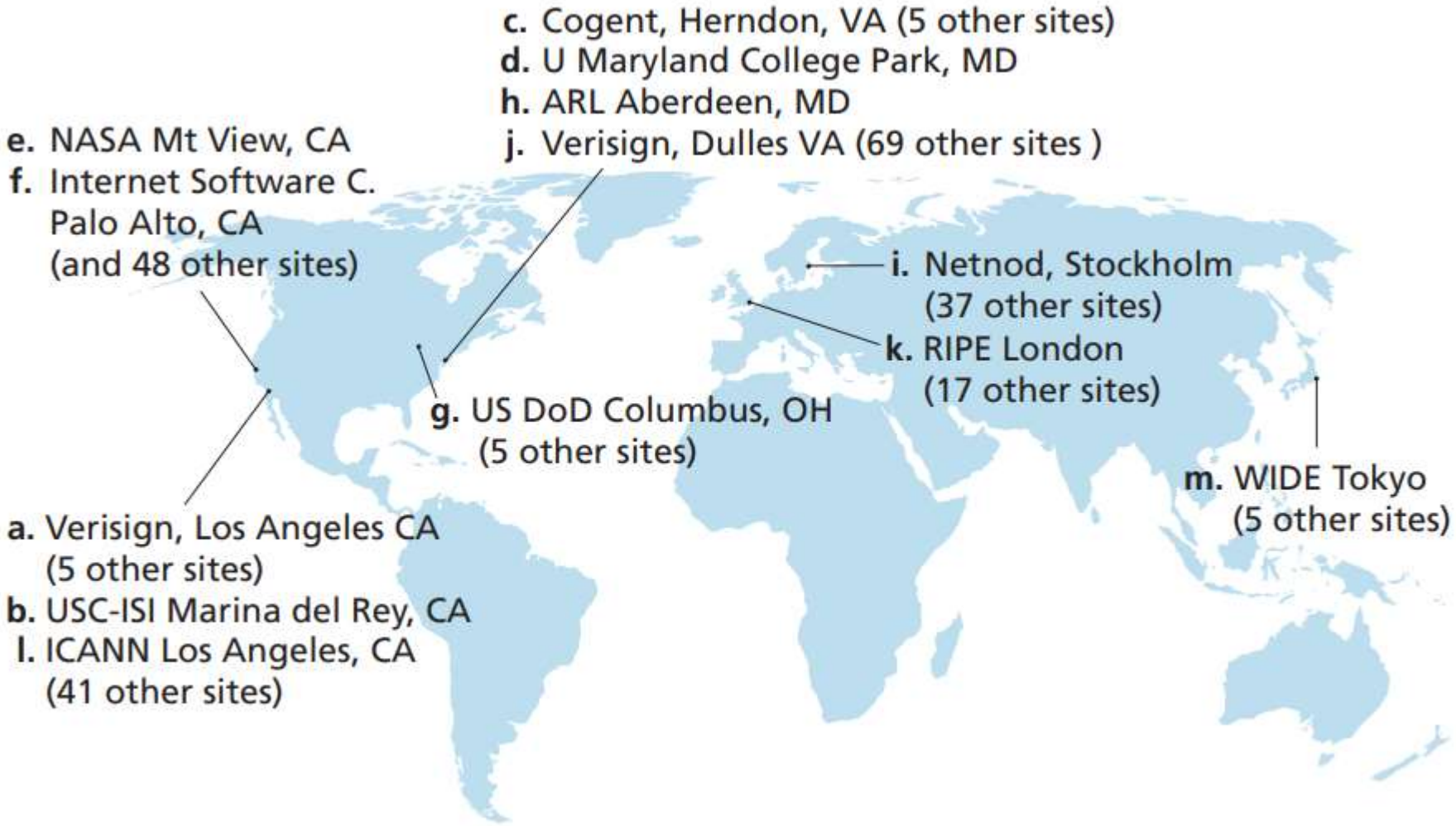
DNS Root Server

- Top of the DNS Hierarchy.
- Contains the information(root zone) of all TLD (e.g. in, org, com, gov etc).
- There are 13 root Name Servers, named A to M, maintained by 12 independent organisations.
  - Each root server is a copy and none of them are special.
  - There are several **instances** (997 as of Jul 2019) of all the root Servers across the World.
  - In India we have **instances** of **D,E,F,I,J,K,L** Root Servers across the country.
- Root name server operations currently provided by volunteer efforts by a very diverse set of organizations

Why 13 root servers?

- Historic Reasons
  - In IPv4, routers tend to fragment packets if the next receiver cannot receive a packet beyond a certain size
    - All IP protocol implementations should minimally support packet size of 576 bytes (including 20 byte header)
    - So if a packet is of <= 576 bytes, it can be transmitted without fragmentation
    - Even if it were part of a large packet, and fragmented, it can always be reassembled, as the size of the DNS packet is fixed at 512 bytes (in the first RFC of DNS).
    - Initially all the root servers did not have commonality in their names, varying from 15 bytes to 31 bytes; - 'NS' record;
    - 'A' record – the address record includes the root server operator also, and can be represented by 16 bytes;
    - 14 name servers could have fit in; However it was decided to stick with 13, to allow room for future expansions and to add 'options'

Root Name Servers

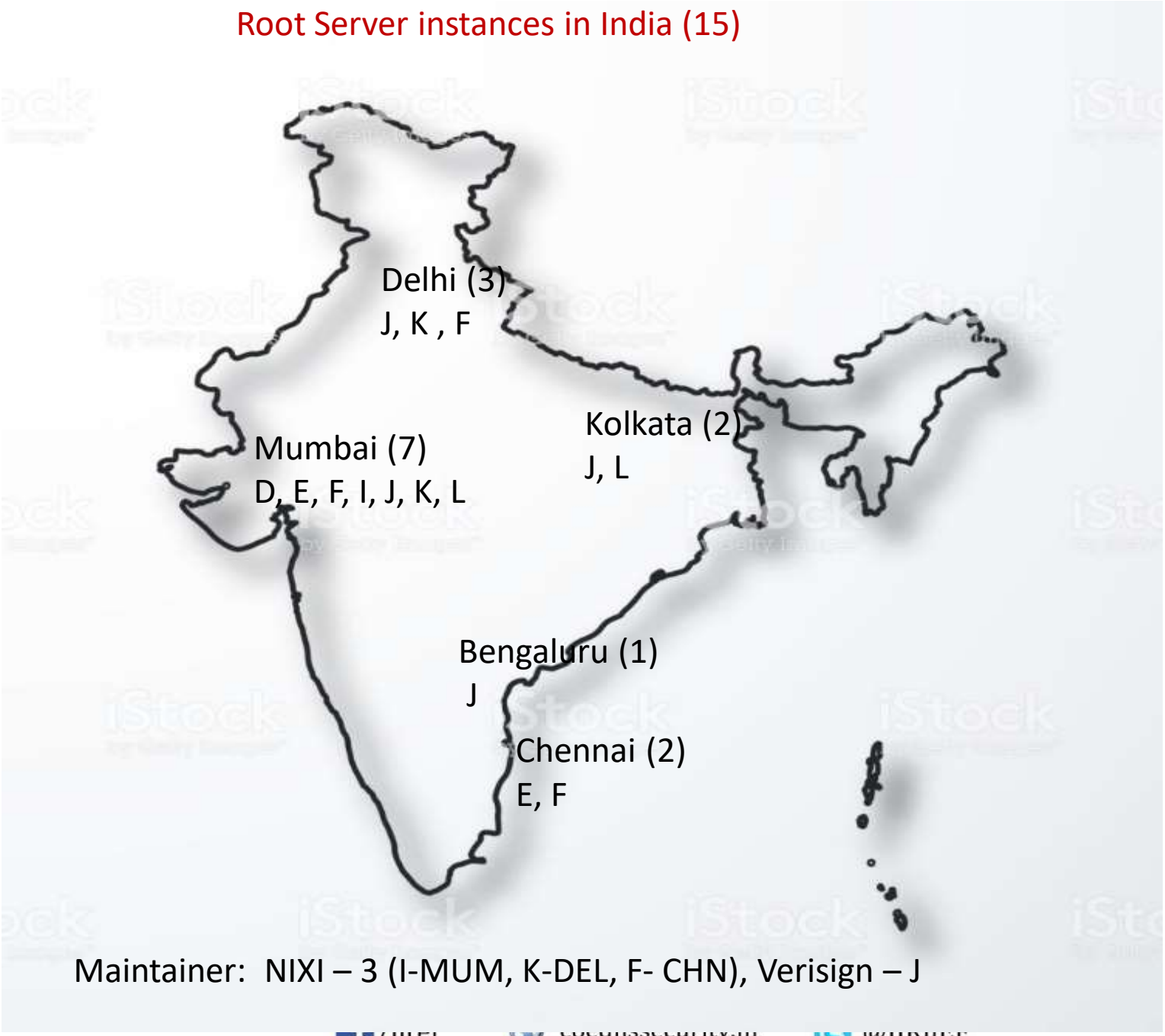


Courtesy: Computer Networking: A Top-Down Approach by James Kurose and Keith Ross, 6th Edition, 2013

Root Name Server Operators

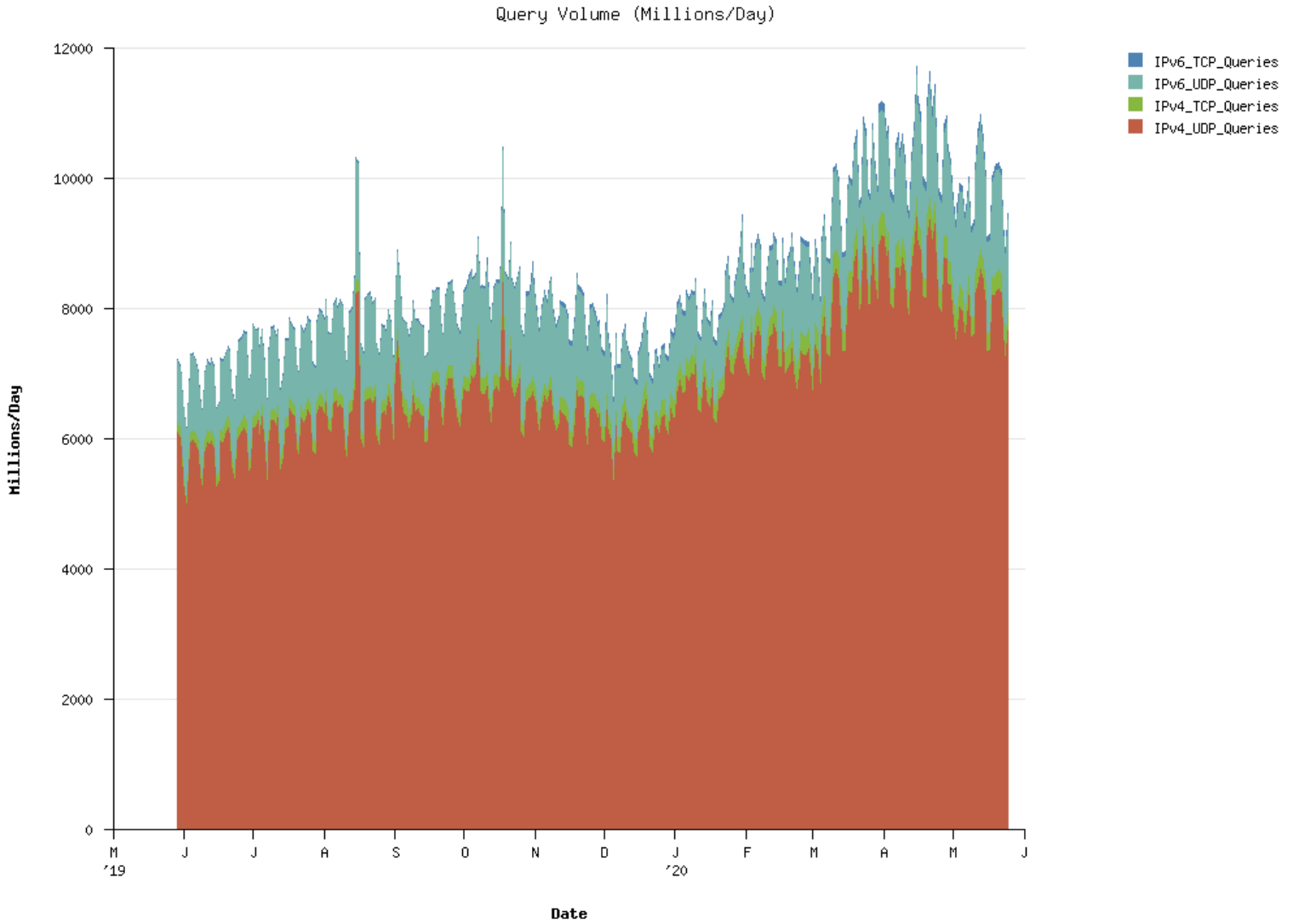
Hostname	IP Addresses	Manager
a.root-servers.net	198.41.0.4, 2001:503:ba3e::2:30	VeriSign, Inc.
b.root-servers.net	192.228.79.201, 2001:500:200::b	University of Southern California (ISI)
c.root-servers.net	192.33.4.12, 2001:500:2::c	Cogent Communications
d.root-servers.net	199.7.91.13, 2001:500:2d::d	University of Maryland
e.root-servers.net	192.203.230.10, 2001:500:a8::e	NASA (Ames Research Center)
f.root-servers.net	192.5.5.241, 2001:500:2f::f	Internet Systems Consortium, Inc.
g.root-servers.net	192.112.36.4, 2001:500:12::d0d	US Department of Defense (NIC)
h.root-servers.net	198.97.190.53, 2001:500:1::53	US Army (Research Lab)
i.root-servers.net	192.36.148.17, 2001:7fe::53	Netnod
j.root-servers.net	192.58.128.30, 2001:503:c27::2:30	VeriSign, Inc.
k.root-servers.net	193.0.14.129, 2001:7fd::1	RIPE NCC
l.root-servers.net	199.7.83.42, 2001:500:9f::42	ICANN
m.root-servers.net	202.12.27.33, 2001:dc3::35	WIDE Project

Root Server instances in India (15)



Maintainer: NIXI – 3 (I-MUM, K-DEL, F- CHN), Verisign – J

Query Volumes in “A” Root Server



Courtesy: A-Root Server - http://a.root-servers.org/metrics/index.html

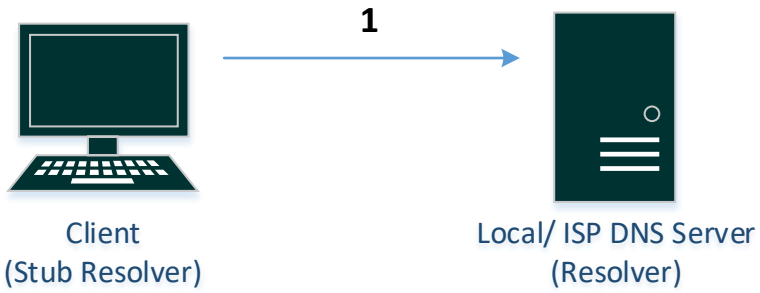
DNS Record Types

- A Record
  - Maps a FQDN to an IP address; Most often used record type
- NS Record
  - Indicate which name servers are authoritative for the Zone / domain
- TXT Record
  - Type of Resource Record;
  - Associates arbitrary text with a host
  - Typically used for verification and email validation
- MX Record
  - Used by Mailservers to determine where to deliver email
  - Used in conjunction with 'A' record;
  - Should point to the mail server, (should point to the 'A' record, which will give the IP address; and should not directly give the IP address);
- PTR Record
  - Resolves an IP address to a domain or host name
  - Should be separately configured and hosted

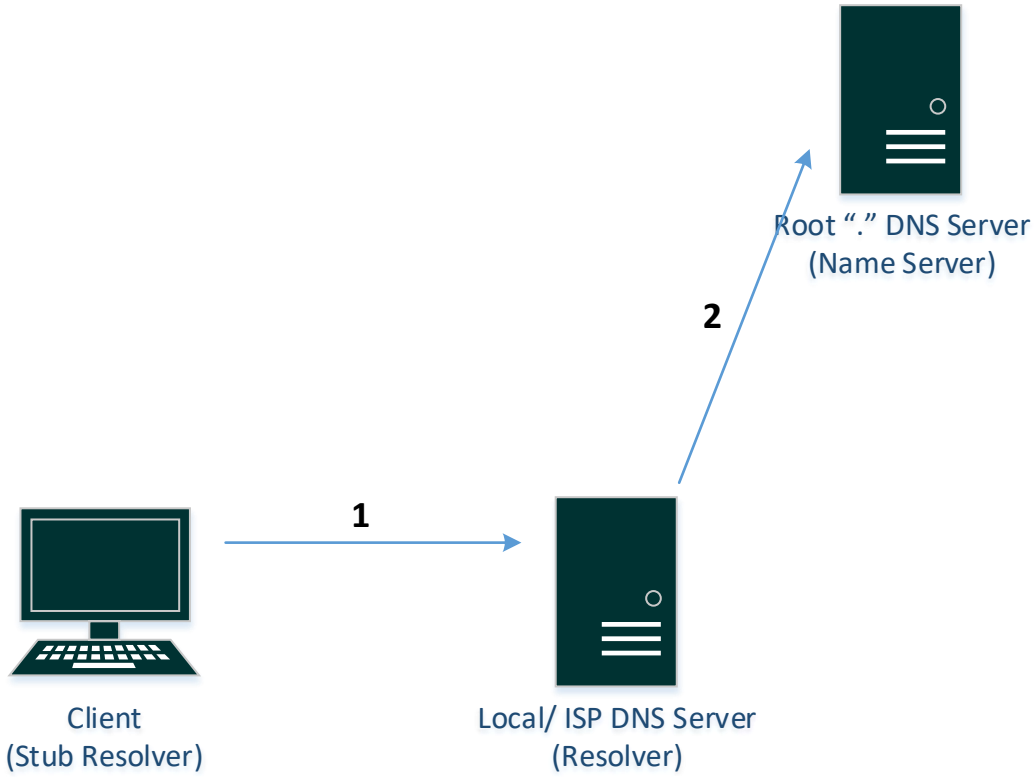
DNS Query Types

- Recursive Query
- Iterative Query
- Inverse (Reverse) Query

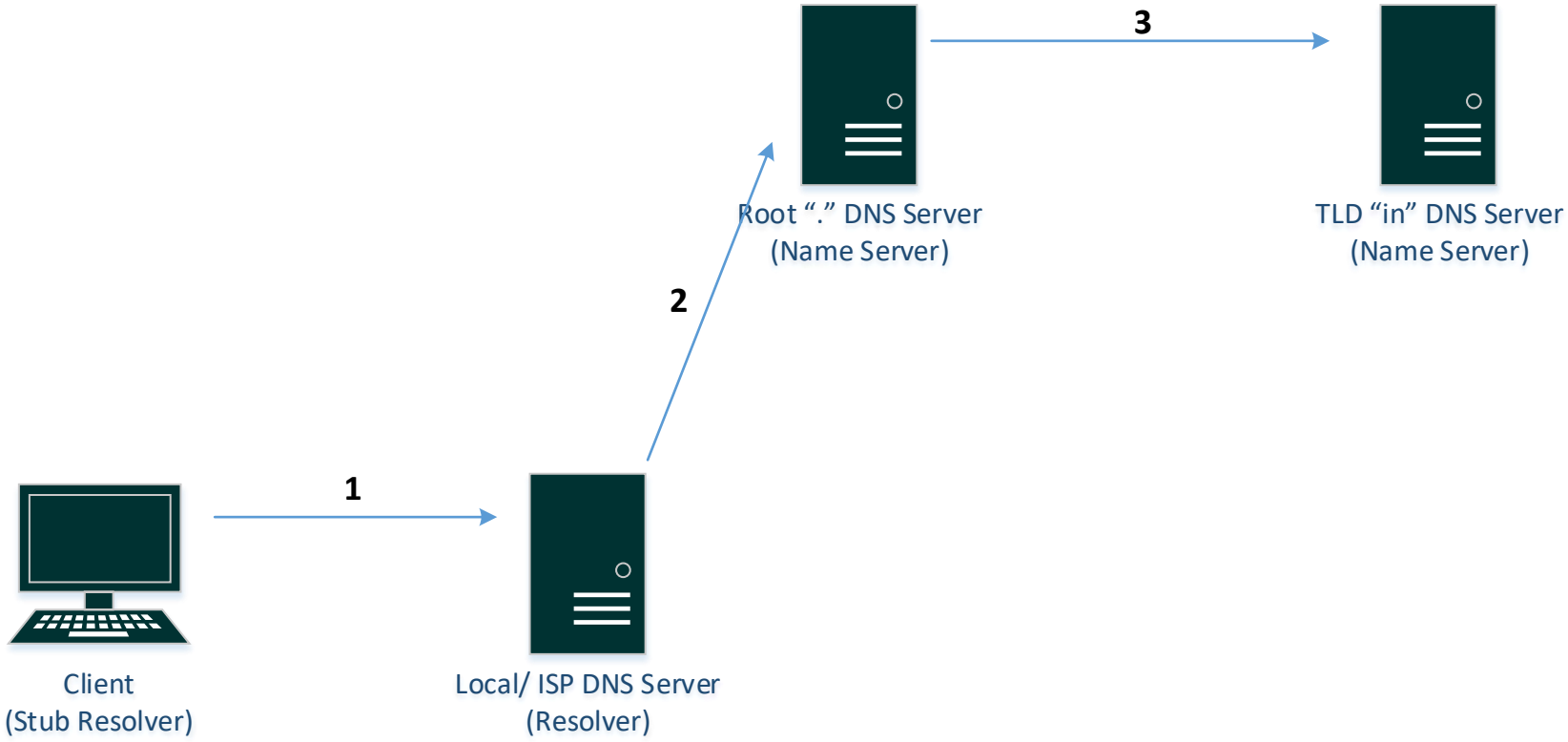
Recursive Query - Illustration



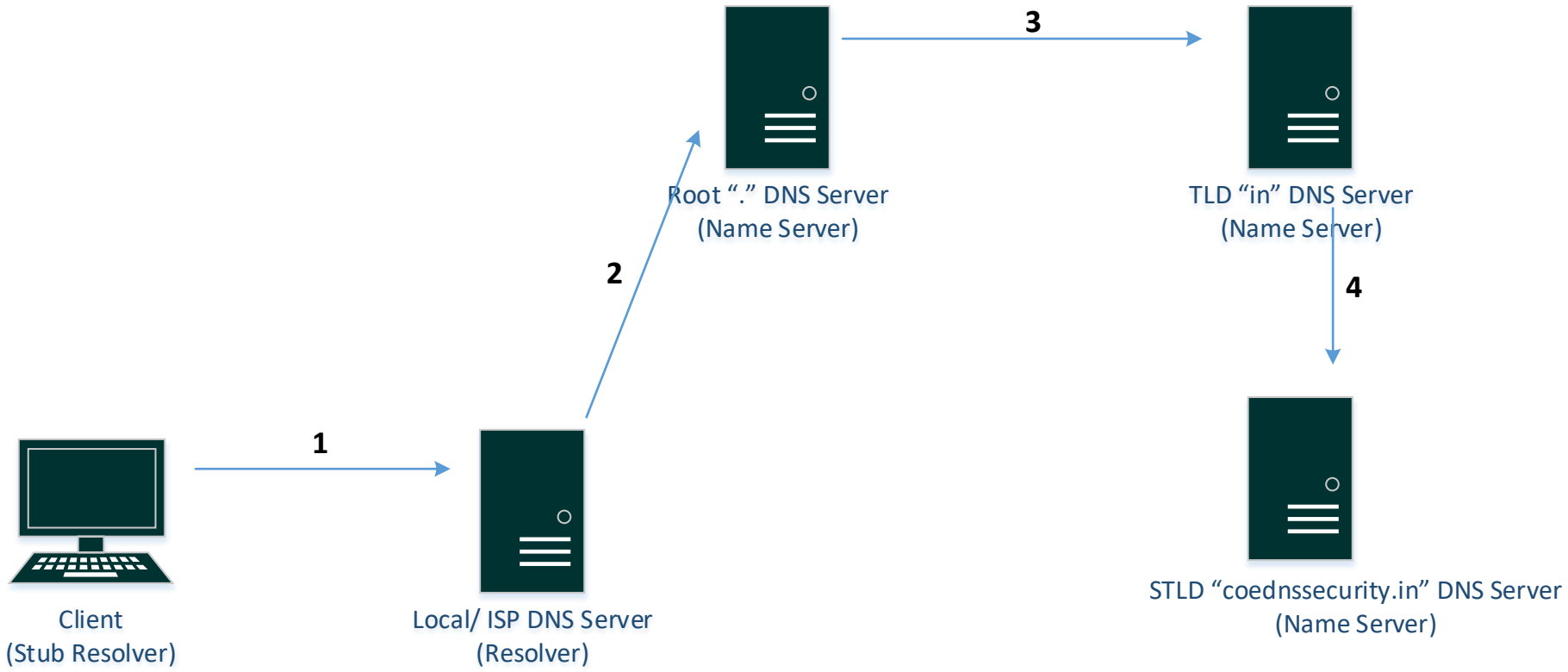
Recursive Query



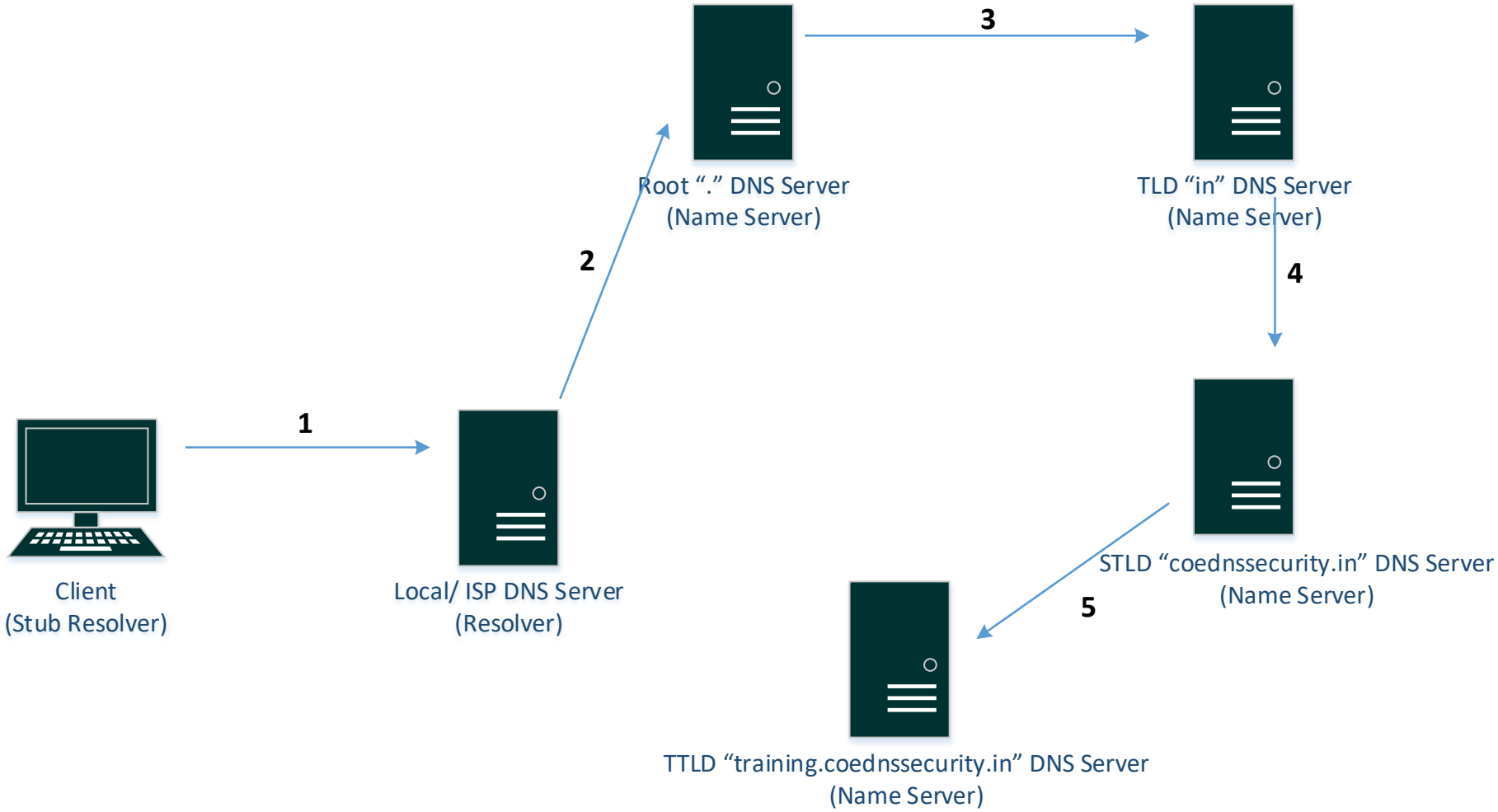
Recursive Query



Recursive Query



Recursive Query



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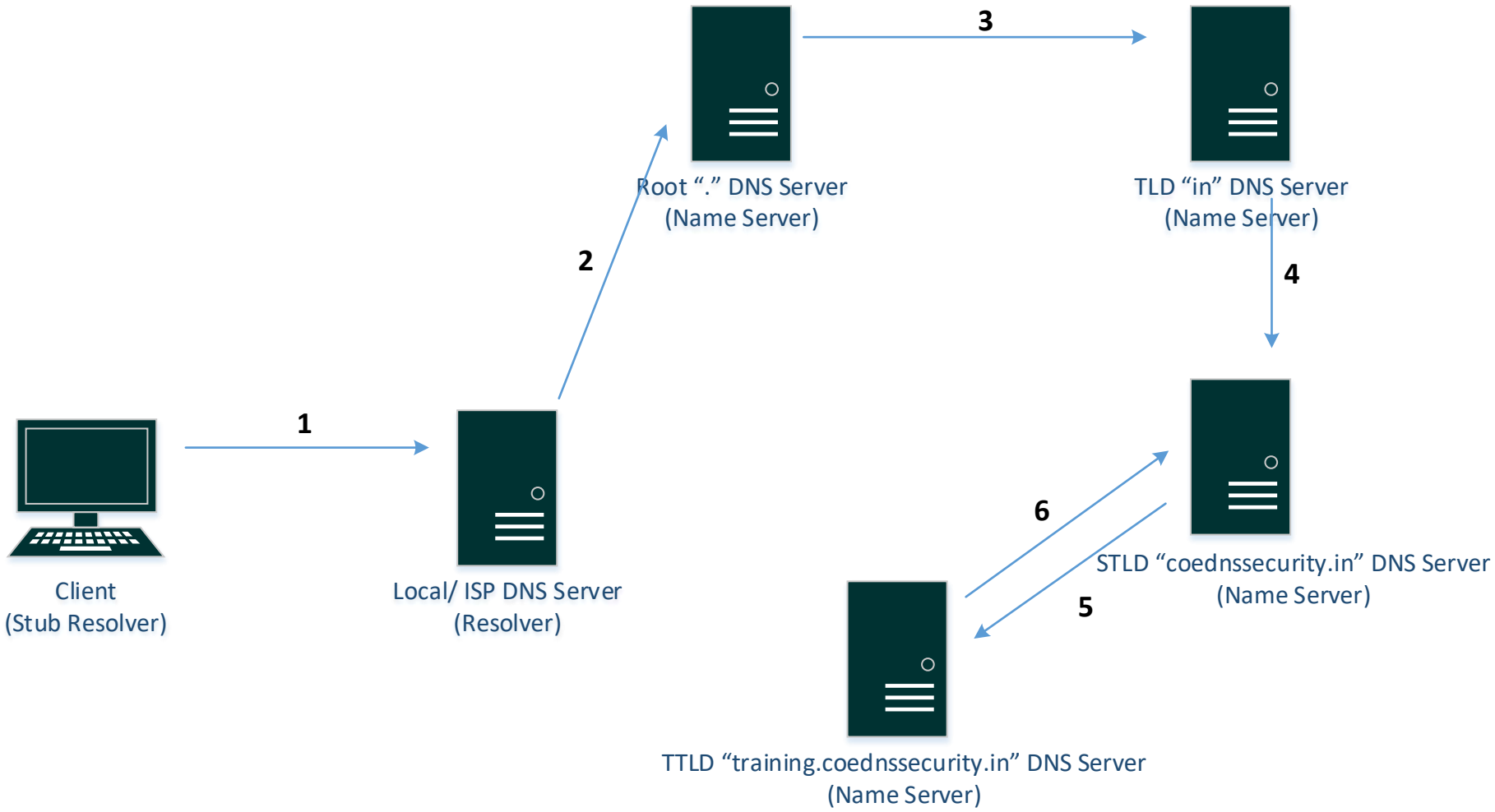
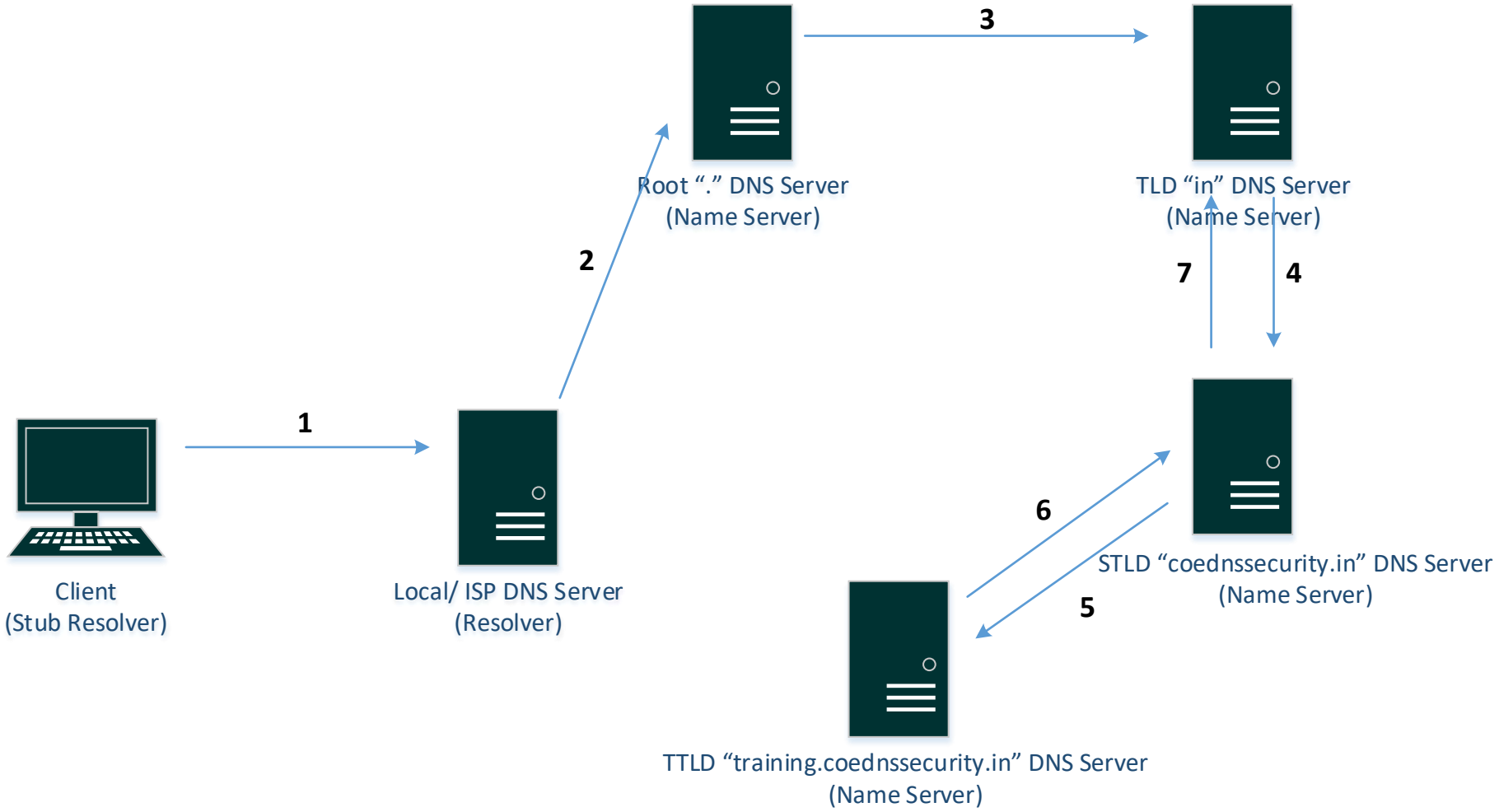
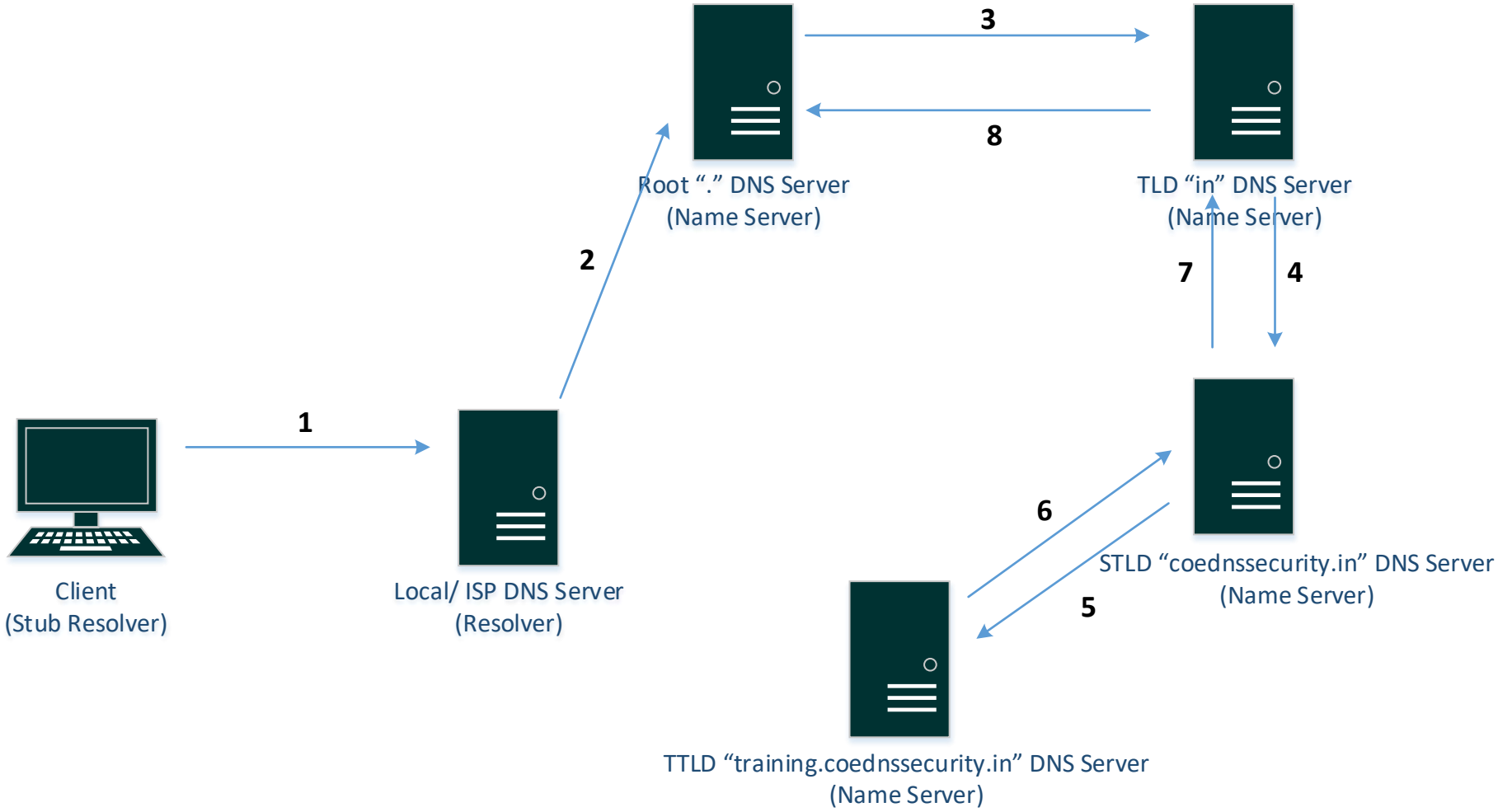


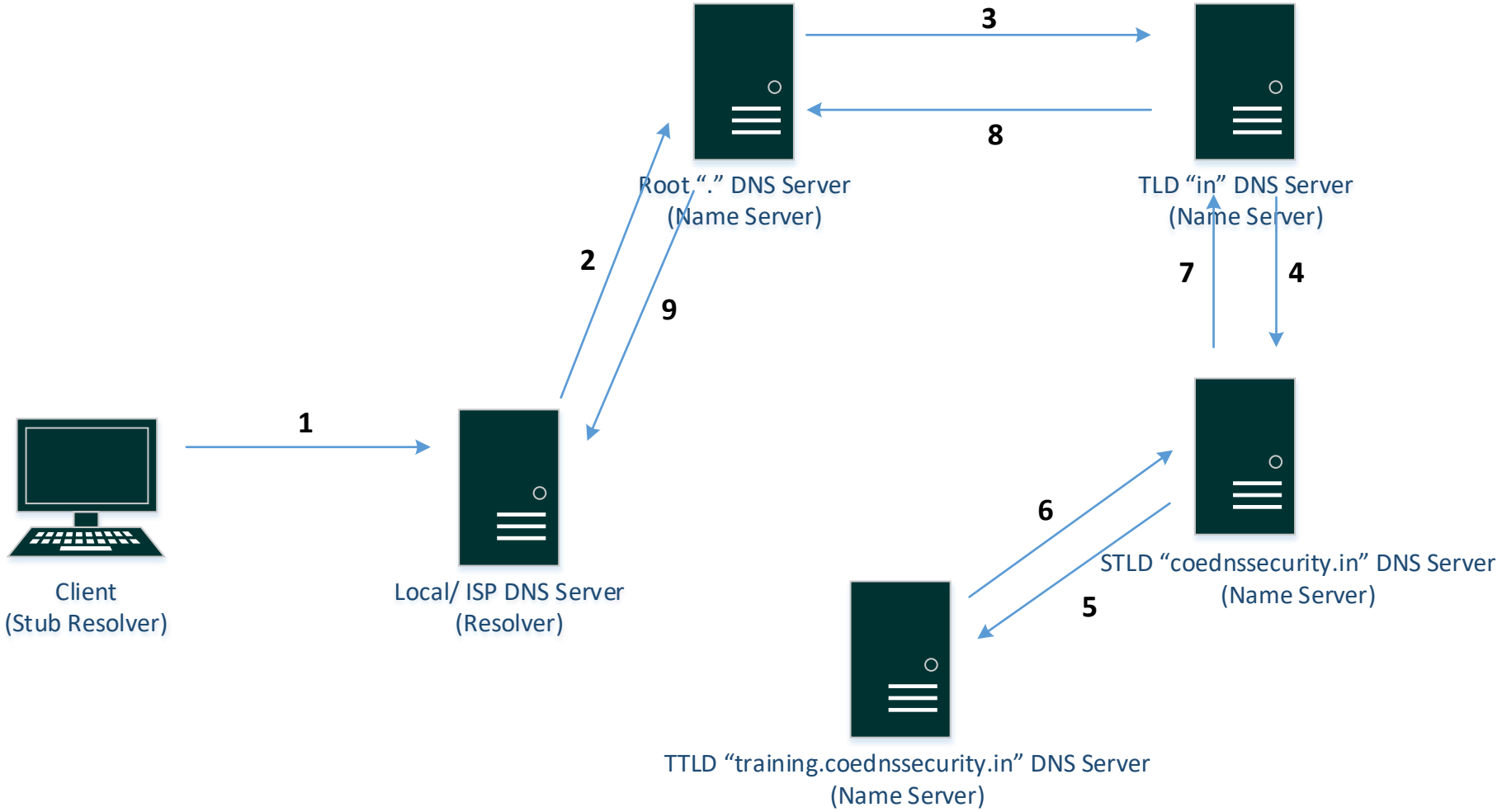
Recursive Query



Recursive Query



Recursive Query



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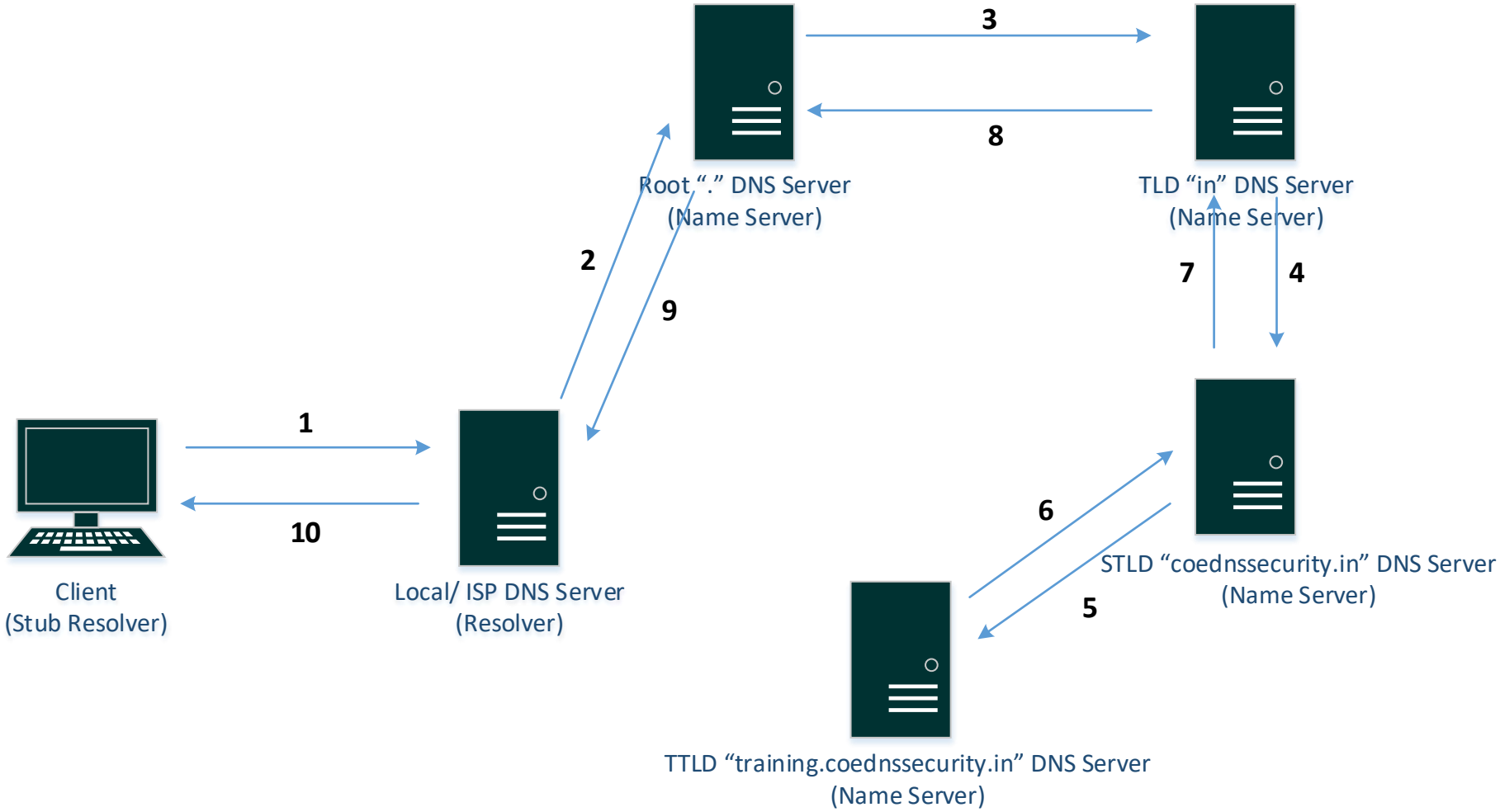
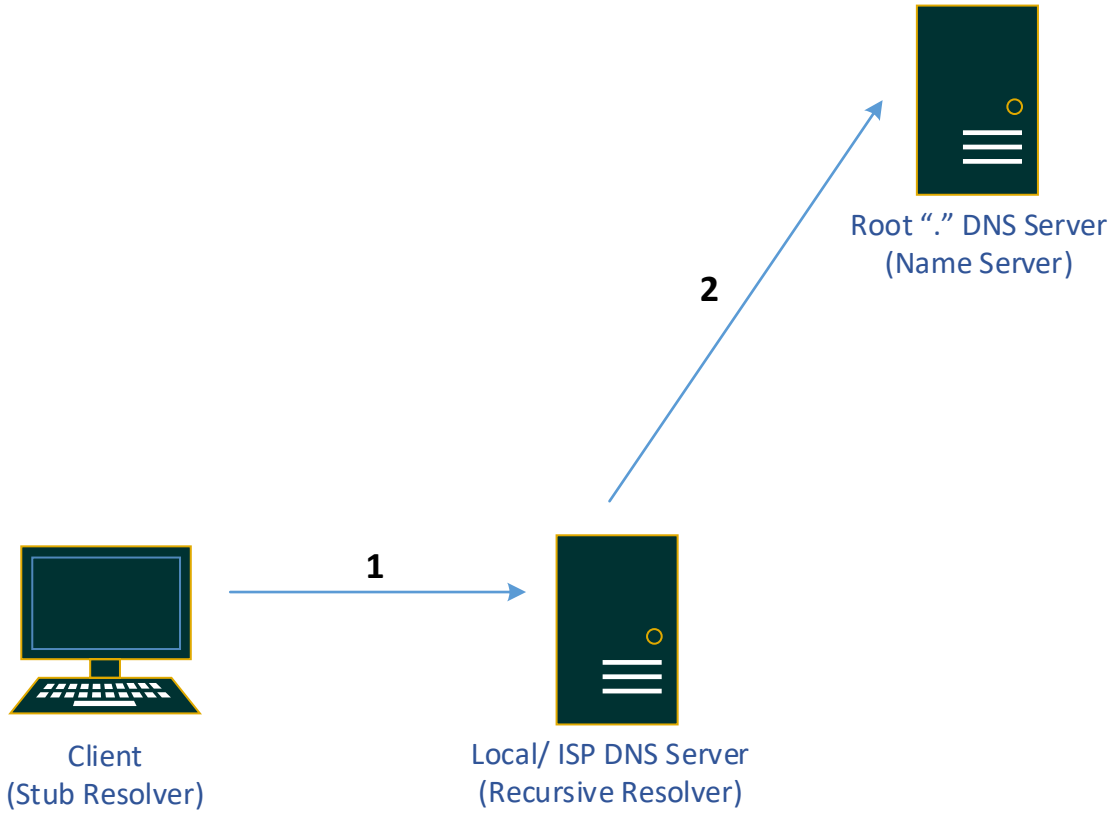


Iterative Query

Iterative Query



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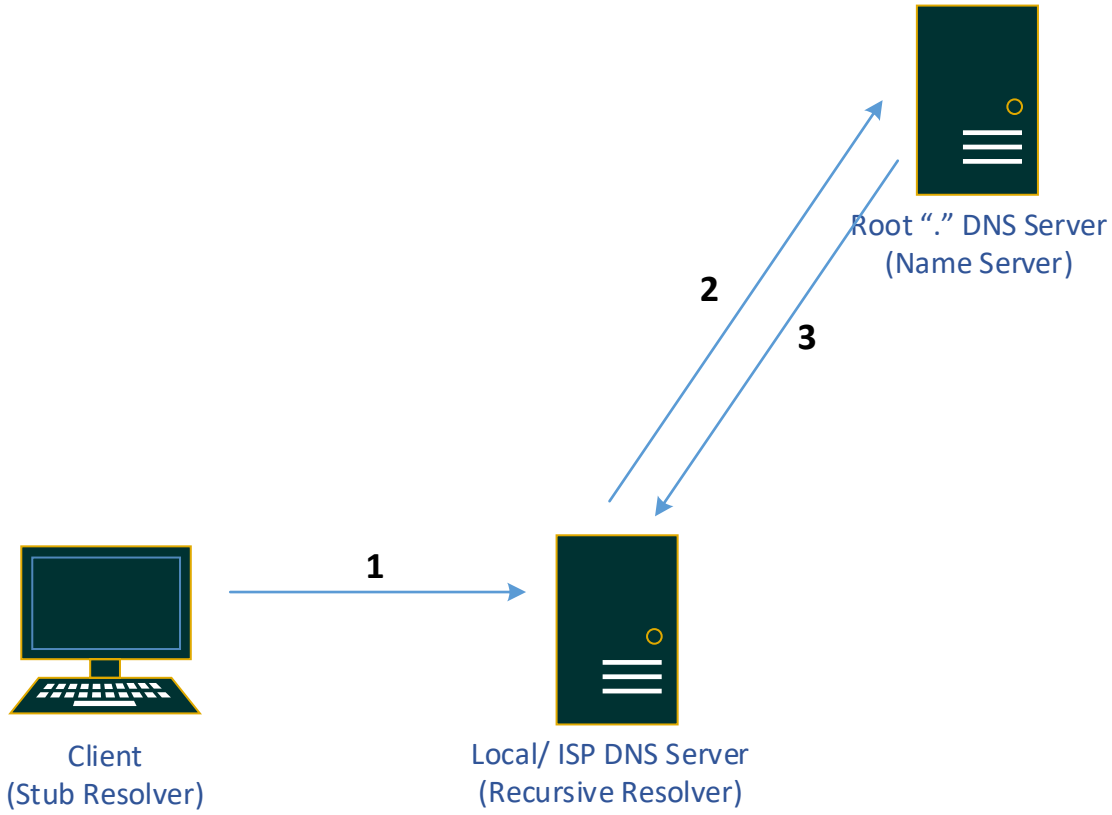

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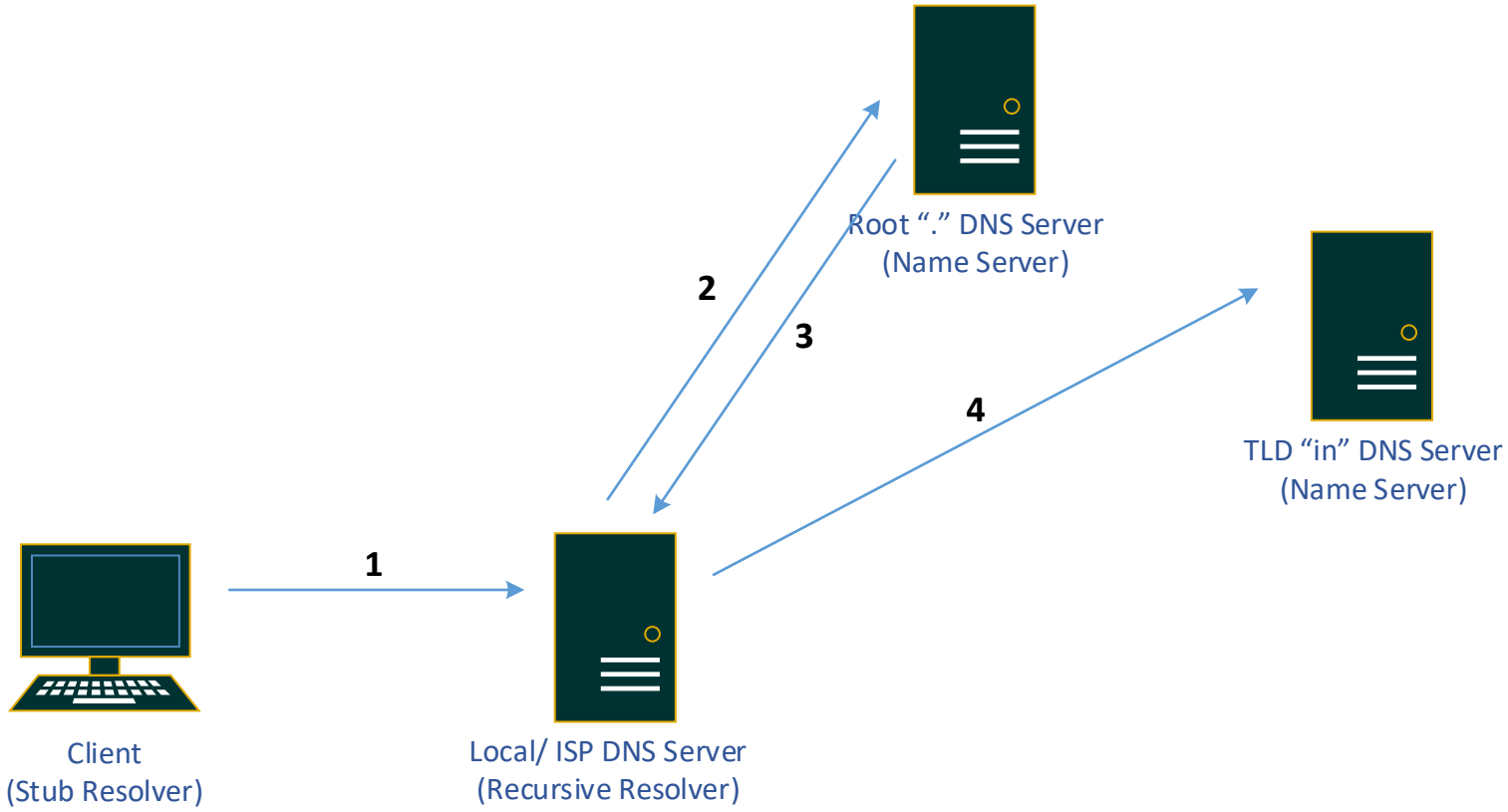

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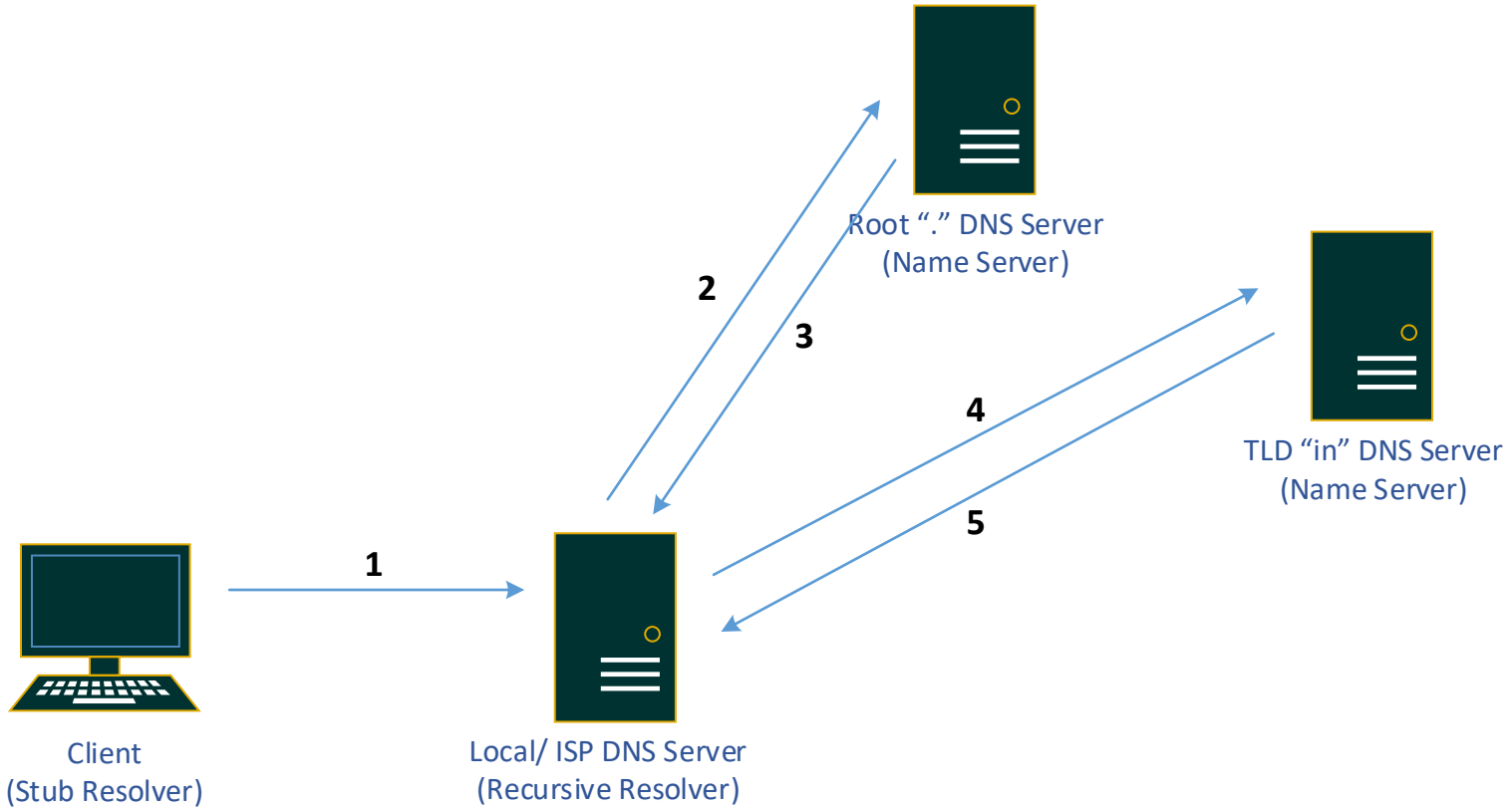

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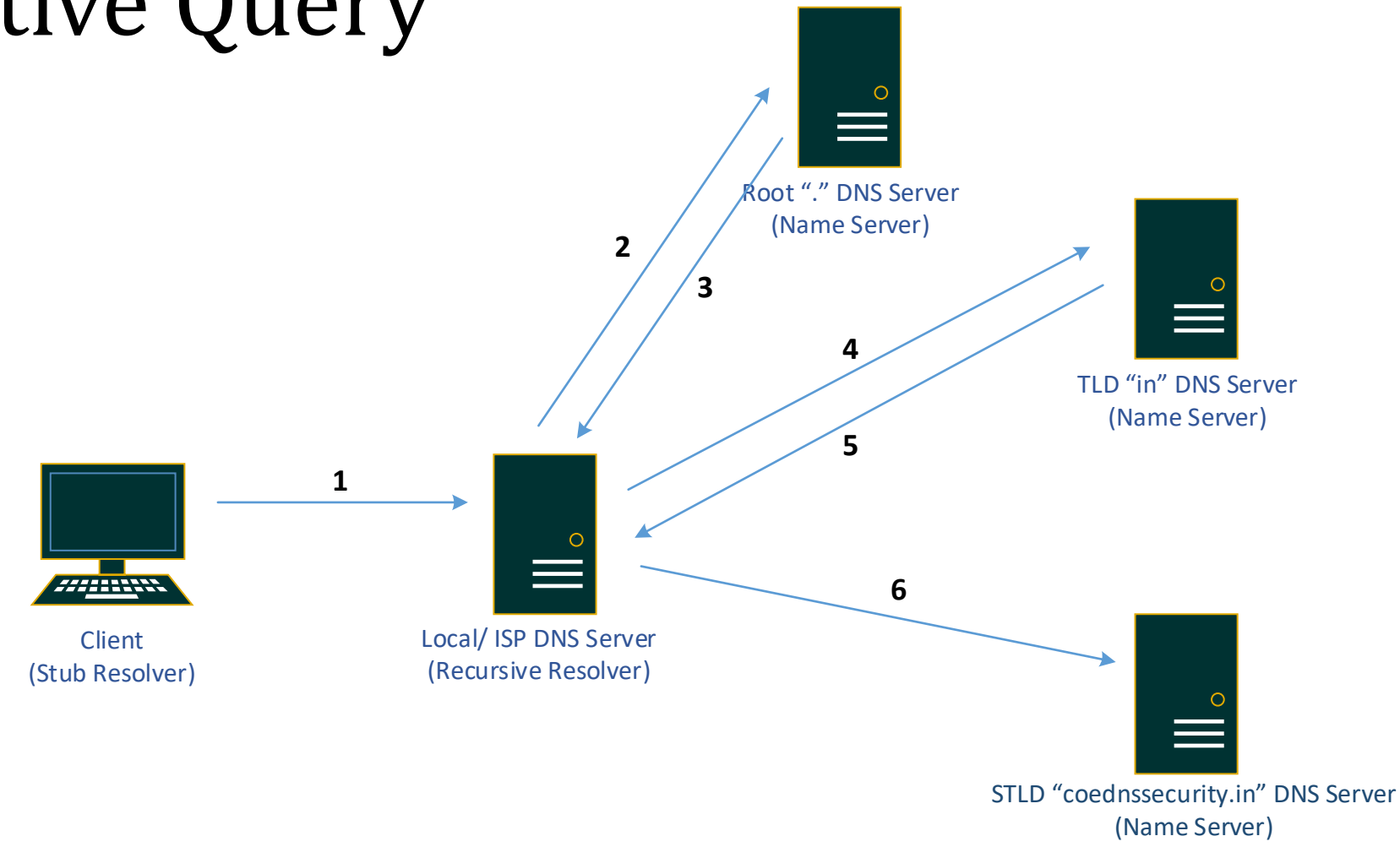

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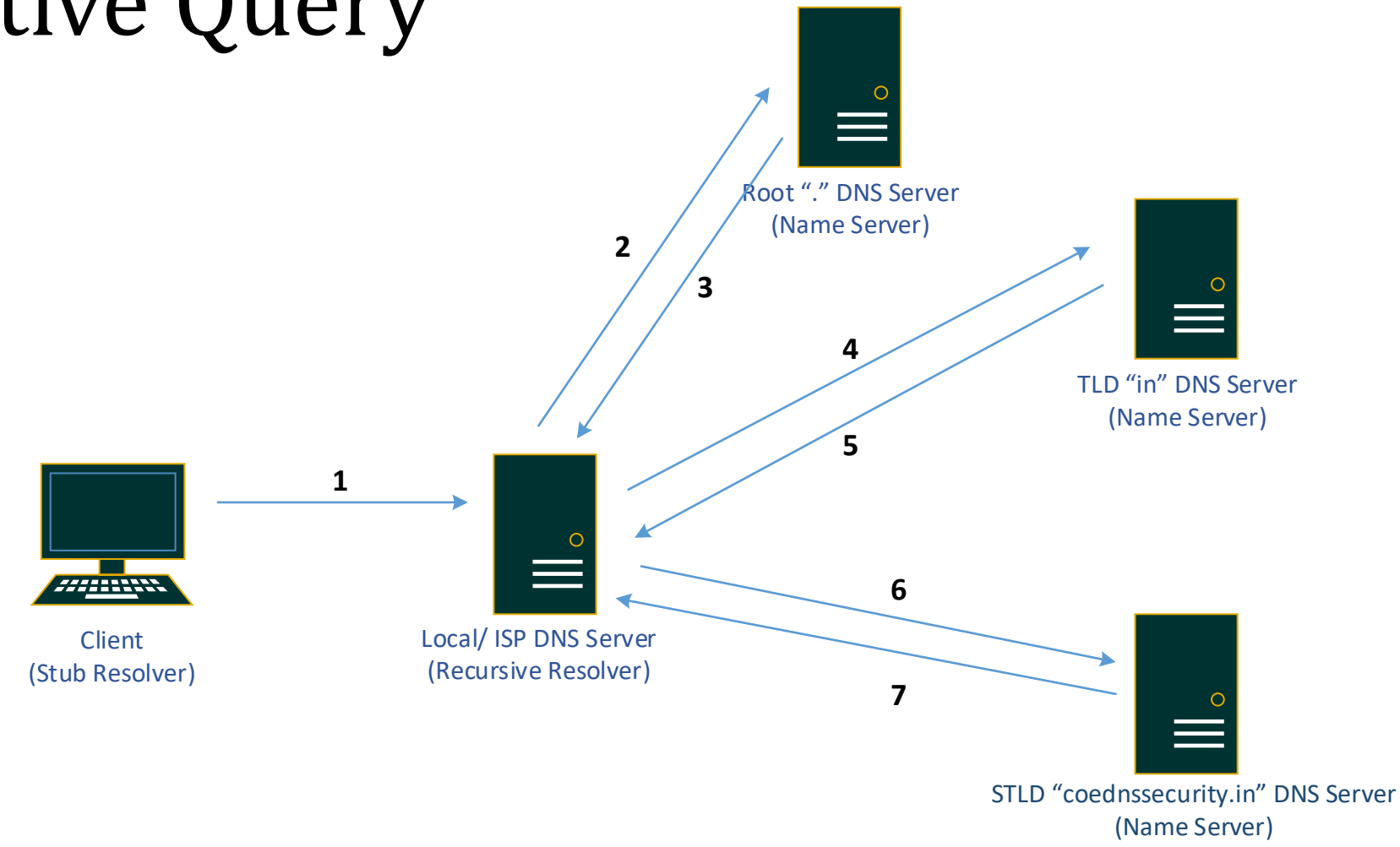
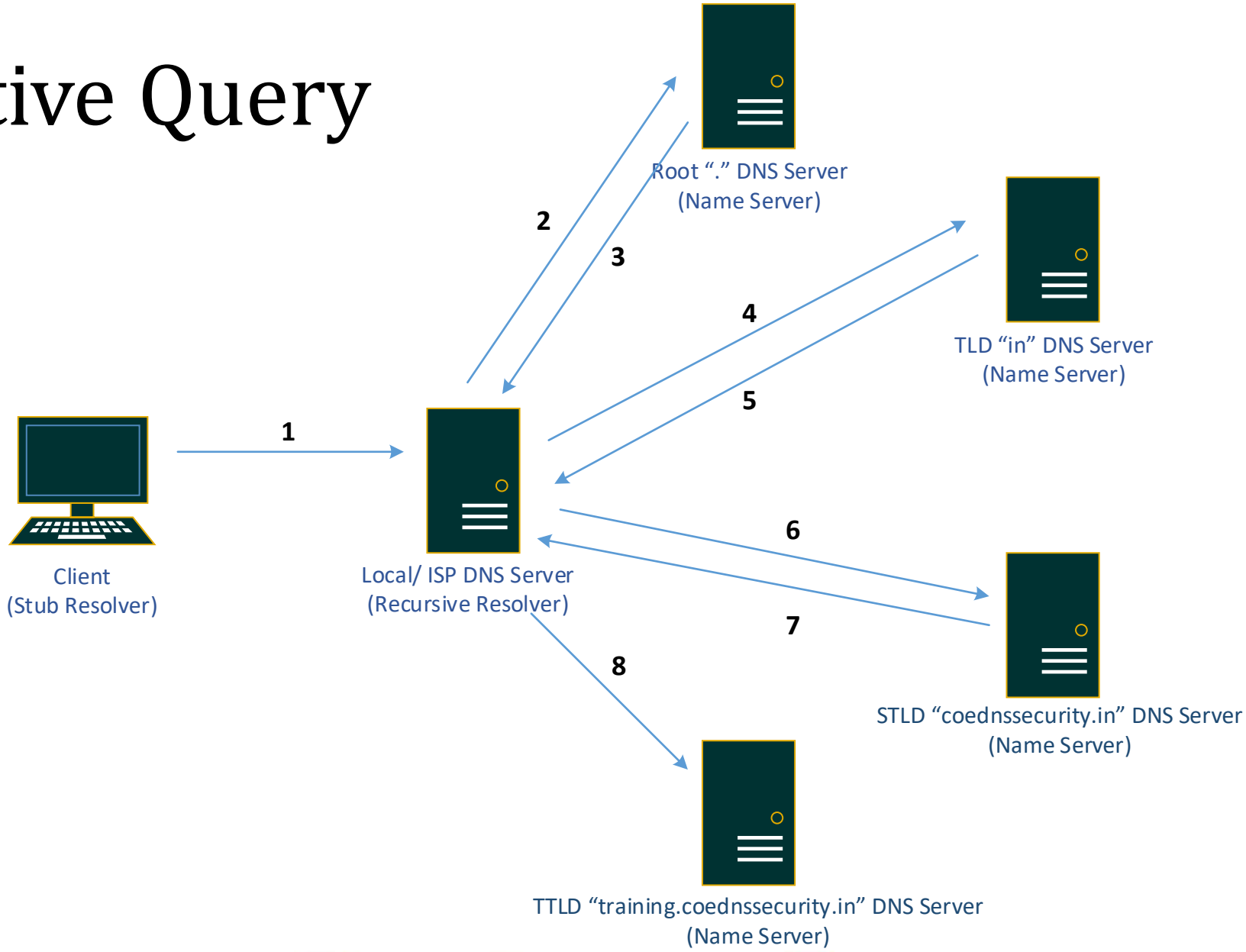


Iterative Query



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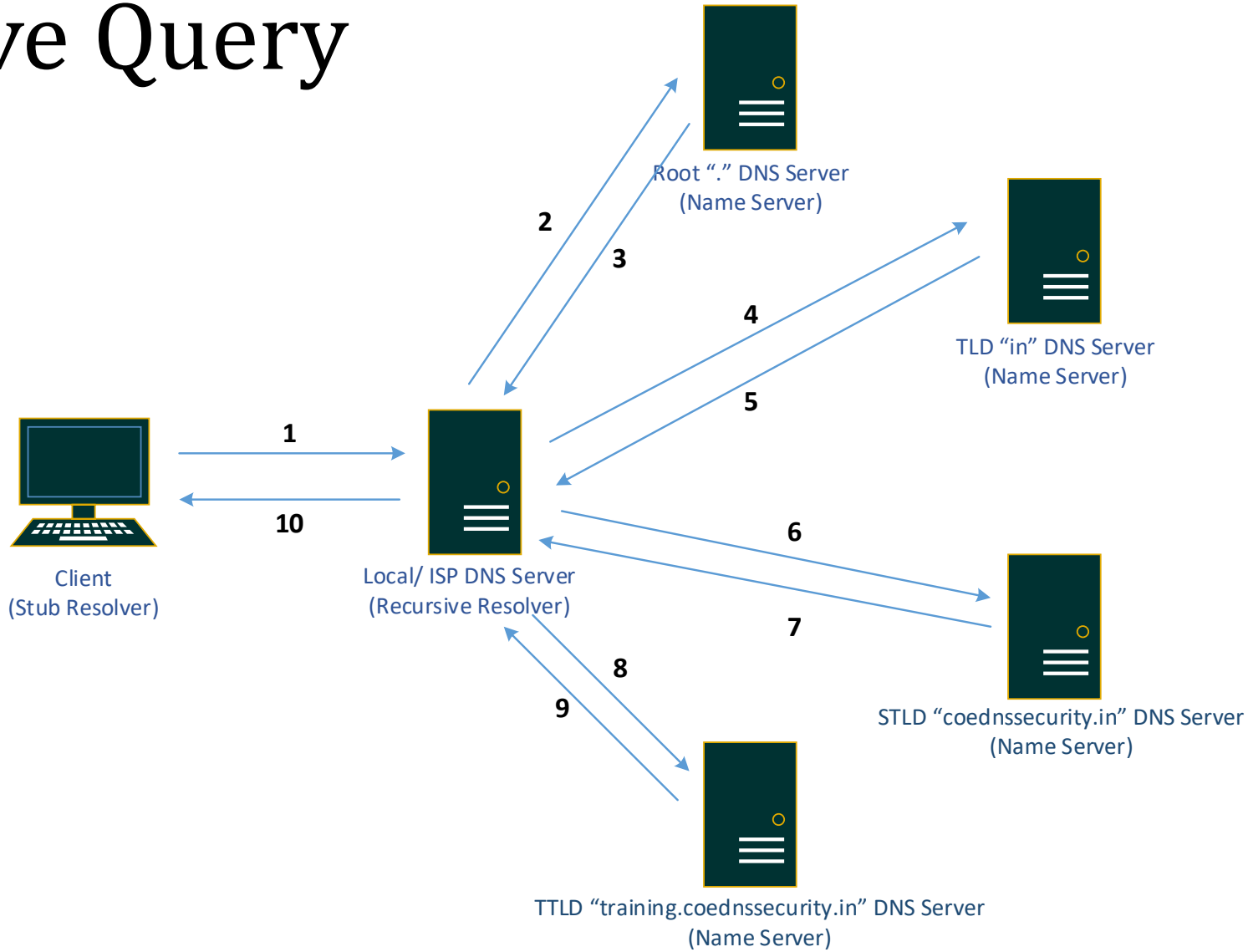
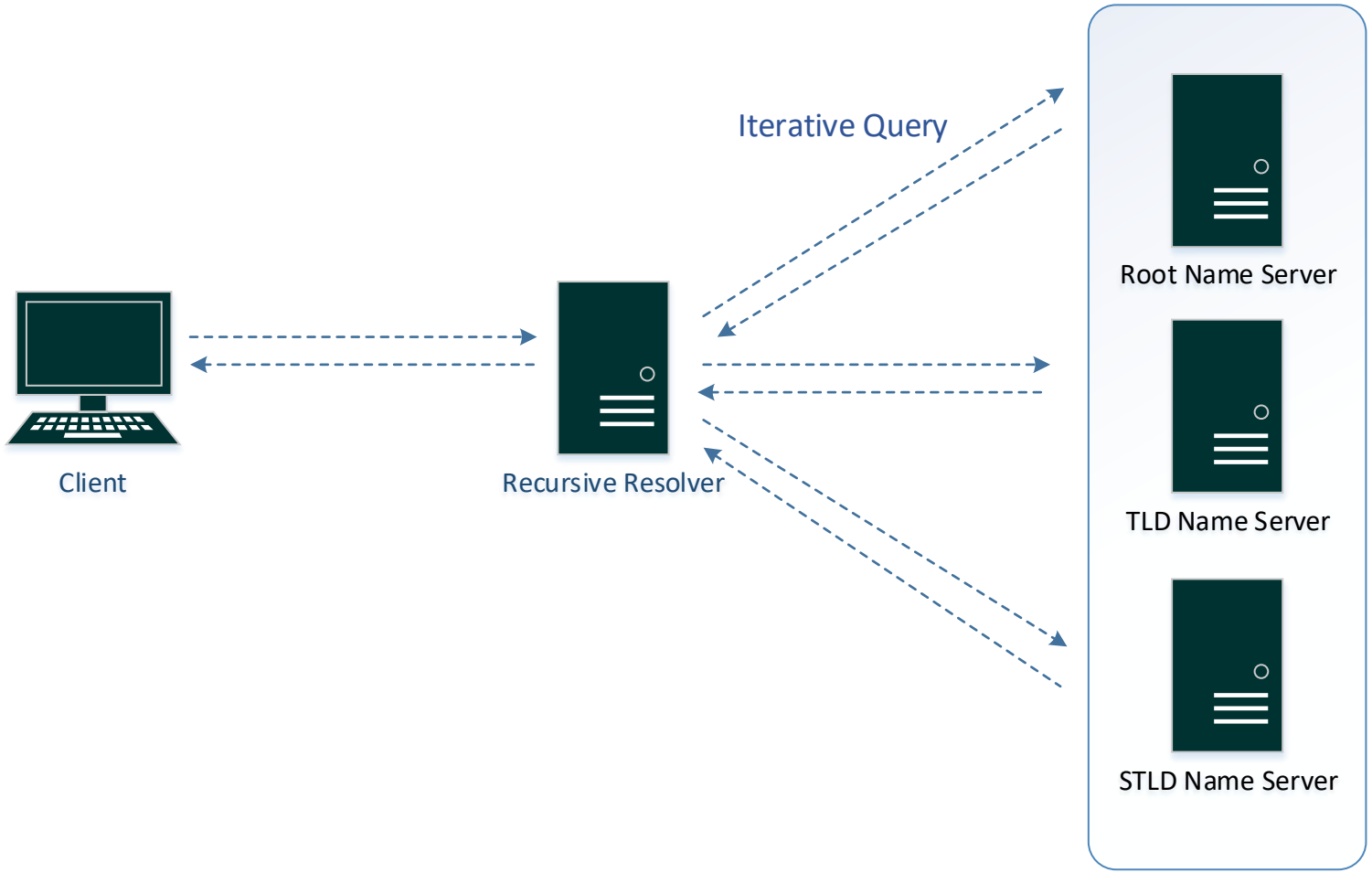
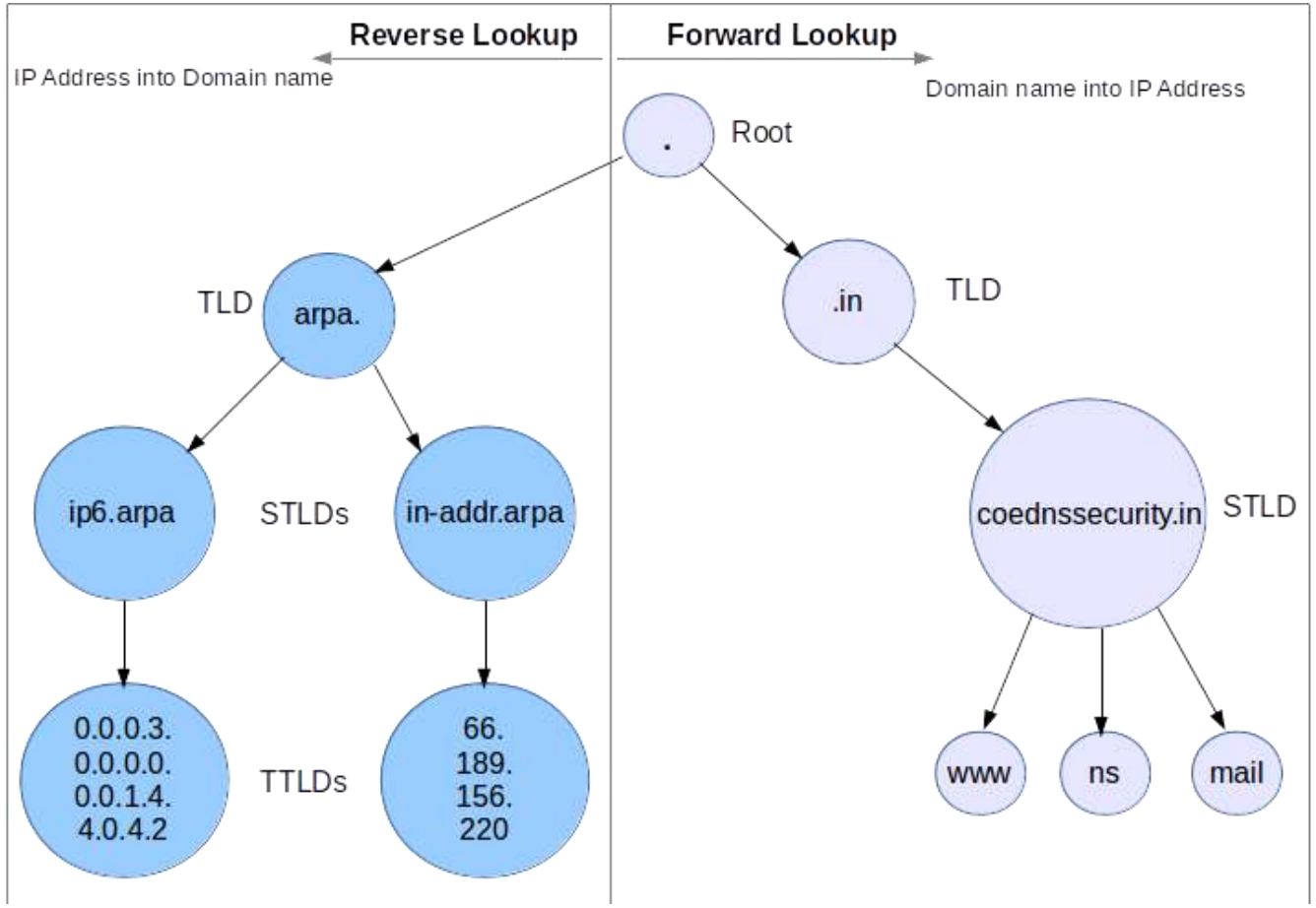


In Reality ...


Iterative Query
Root Name Server
TLD Name Server
STLD Name Server
Client
Recursive Resolver

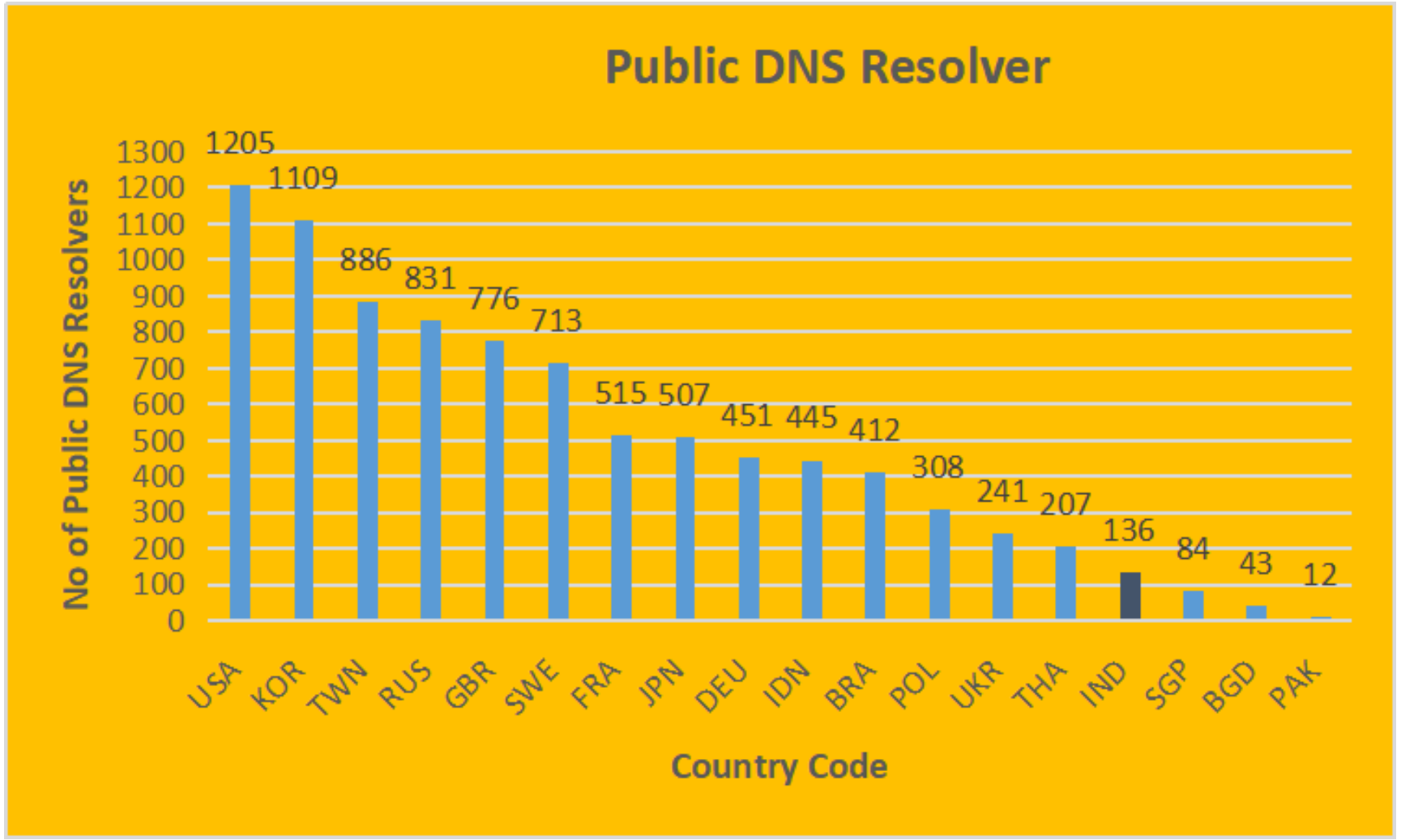
Forward and Reverse Lookup



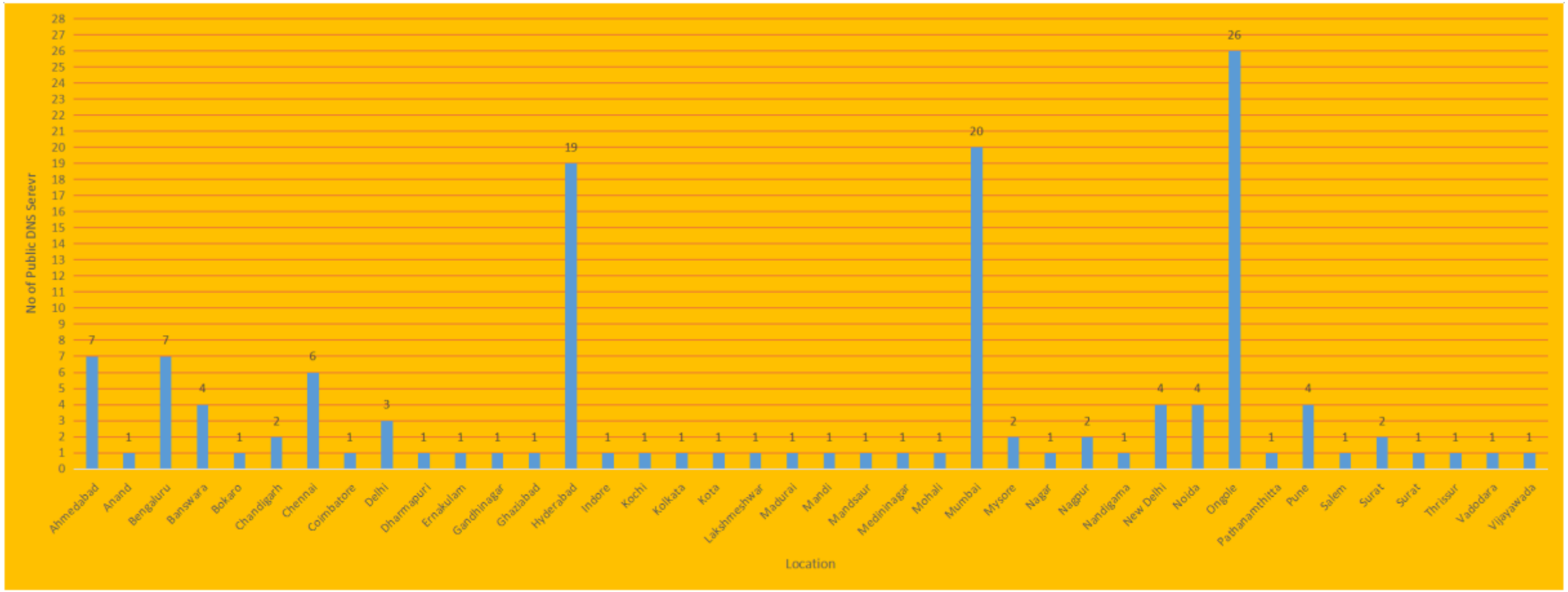
Public DNS Recursive Resolver

- DNS Resolvers are the critical components within the DNS Ecosystem
- Our Public DNS resolver for IPv4 and IPv6 is available at:
  - **IPv4: 223.31.121.171**
  - **IPv6: 2405:8a00:8001::20**
- Optimized Configuration
  - Compliance with RFC 7706

Public DNS Resolvers

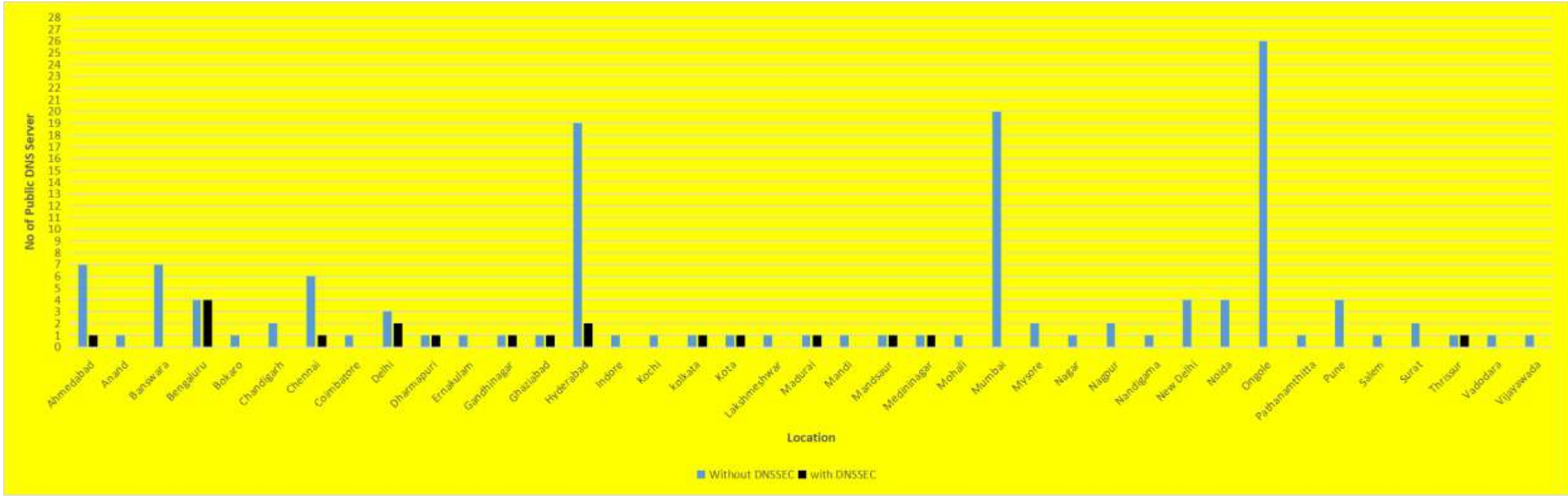


Public DNS Resolvers in India



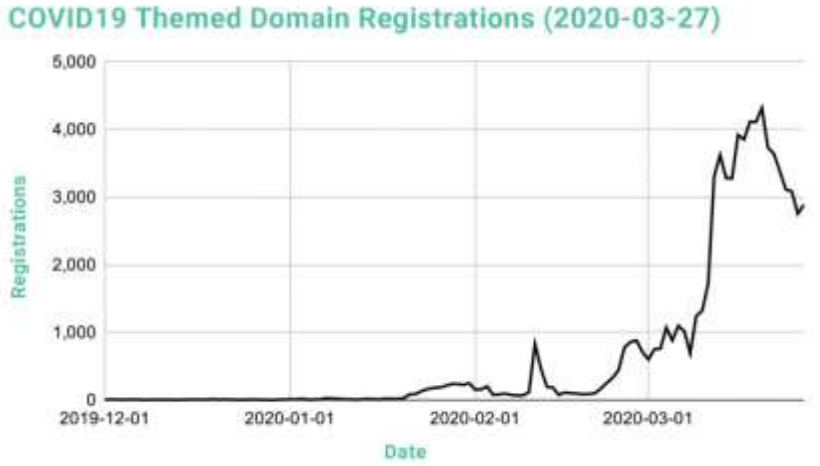
/iiref coednssecurity.in @IIRnEF

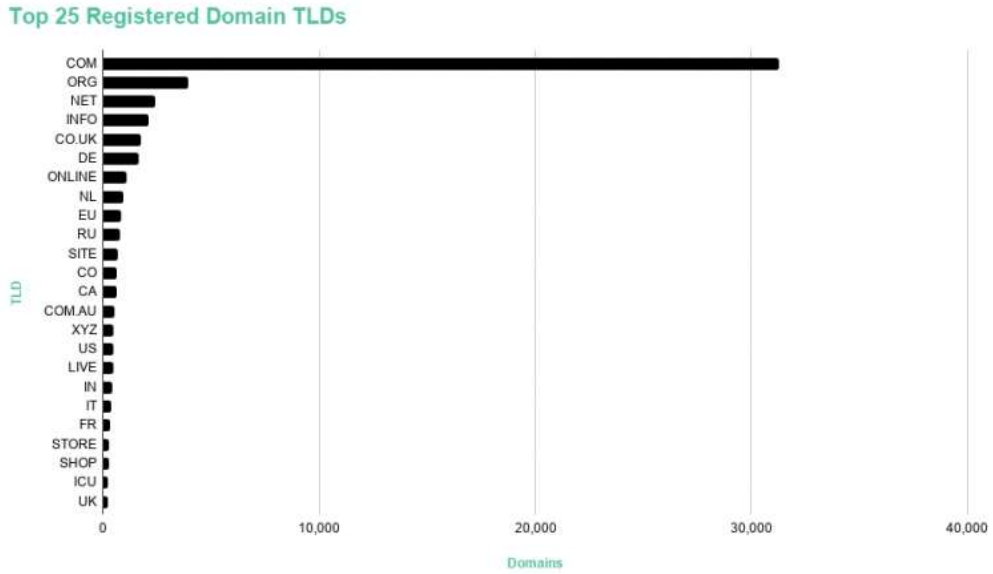
Indian Public DNS Resolvers – DNSSEC Stats



Analyzing Newly Registered Domains with Covid-19 Themes

- 136,000+ domains have been registered
- Many of the domains appear to be:
  - Offering Malicious Coronavirus-Related Maps
  - ‘Convenient’ Mobile Apps to Track COVID-19
  - Advertising Coronavirus Services, Products
  - Malvertising on Coronavirus News Stories
  - Fostering Panic via Disinformation
- 1065 domains are registered with ‘.in’
  - 700 are found to be malicious





Thank You