



# COMPUTER NETWORKS

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## Application Layer

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## Unit – 2 Application Layer

2.1 Principles of Network Applications

2.2 Web, HTTP and HTTPS

**2.3 The Domain Name System**

2.4 P2P Applications

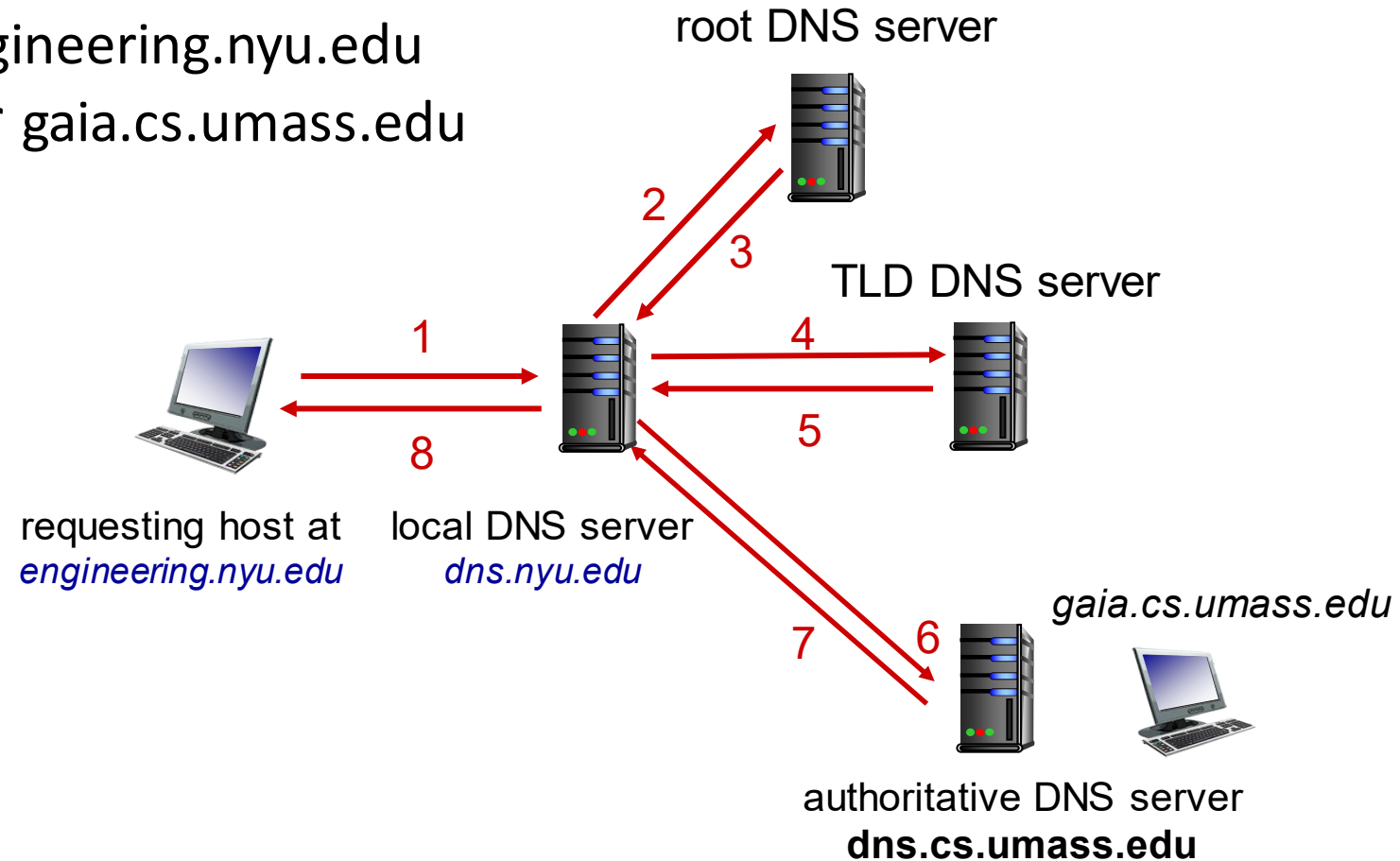
2.5 Socket Programming with TCP & UDP

2.6 Other Application Layer Protocols

**Example:** host at `engineering.nyu.edu`  
wants IP address for `gaia.cs.umass.edu`

### Iterated query:

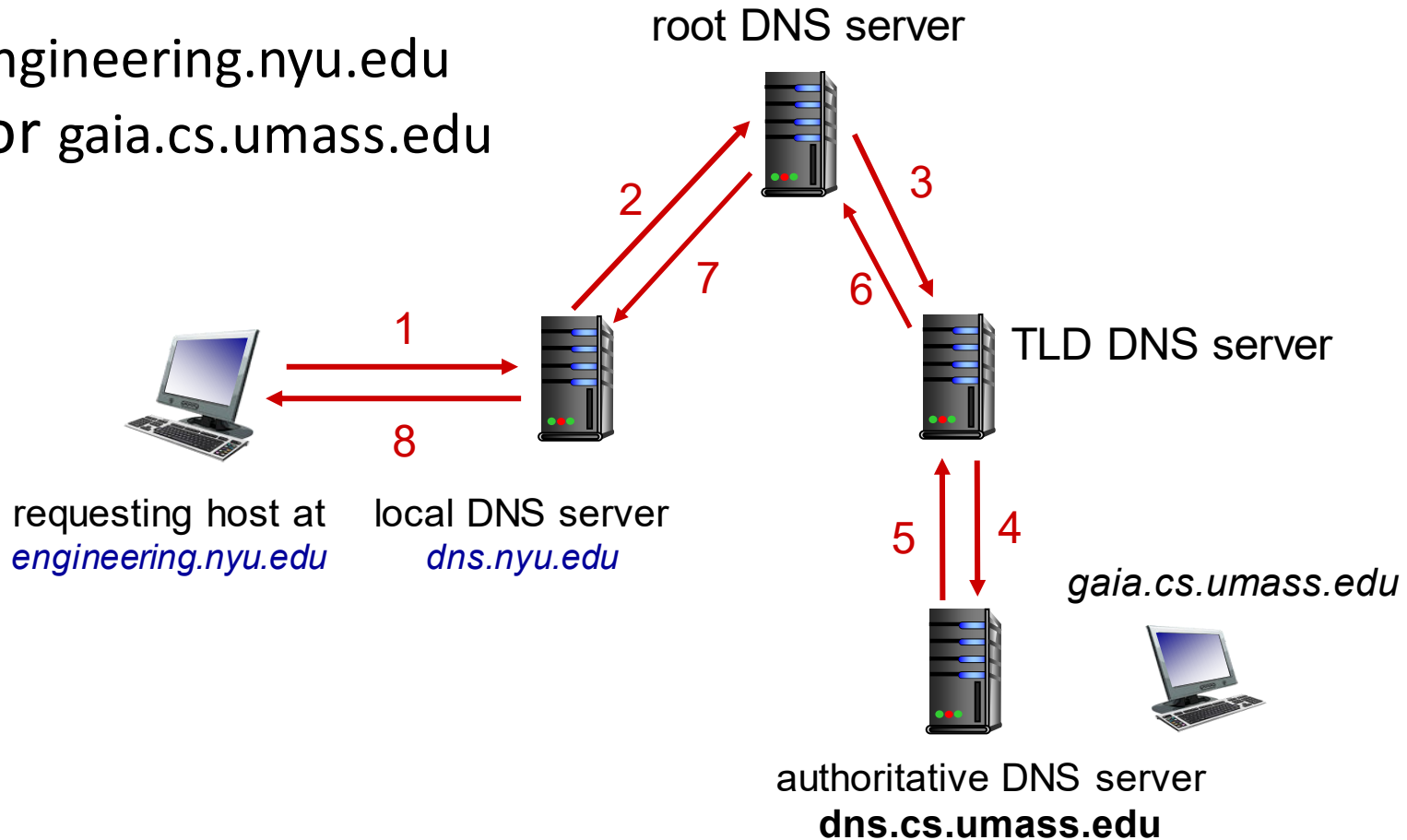
- contacted server replies with name of server to contact
- “I don’t know this name, but ask this server”



**Example:** host at `engineering.nyu.edu` wants IP address for `gaia.cs.umass.edu`

### Recursive query:

- puts burden of name resolution on contacted name server
- heavy load at upper levels of hierarchy?



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## Caching and Updating DNS Records

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- Suppose that a host **apricot.nyu.edu** queries **dns.nyu.edu** for the IP address for the hostname **cnn.com**. After an hour later, another NYU host, say, **kiwi.nyu.edu**, also queries **dns.nyu.edu**.
- once (any) name server learns mapping, it *caches* mapping
  - cache entries timeout (disappear) after some time (TTL)
  - TLD servers typically cached in local name servers
    - thus root name servers not often visited
- cached entries may be *out-of-date* (best-effort name-to-address translation!)
  - if name host changes IP address, may not be known Internet-wide until all TTLs expire!
- update/notify mechanisms proposed IETF standard
  - RFC 2136

**DNS:** distributed database storing resource records (RR)

RR format: (name, value, type, ttl)

### type=A

- name is hostname
- value is IP address

**relayl.bar.foo.com, 145.37.93.126, A**

### type=NS

- name is domain (e.g., foo.com)
- value is hostname of authoritative name server for this domain

**foo.com, dns.foo.com, NS**

### type=CNAME

- name is alias name for some “canonical” (the real) name
- www.ibm.com is really servereast.backup2.ibm.com
- value is canonical name

**ibm.com, servereast.backup2.ibm.com, CNAME**

### type=MX

- value is canonical name of a mailserver associated with alias hostname name

**example.com, mail.example.com, MX**

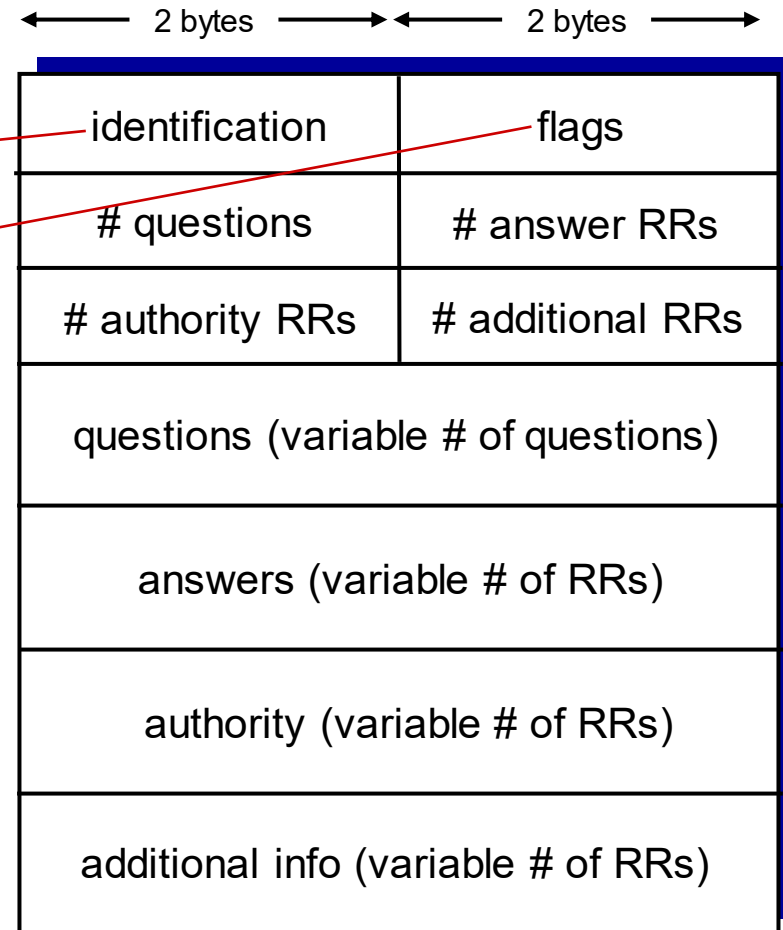
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## DNS Protocol Messages

DNS *query* and *reply* messages, both have same *format*:

message header:

- **identification**: 16 bit # for query, reply to query uses same #
- **flags**:
  - query or reply (1-bit)
  - recursion desired
  - recursion available
  - reply is authoritative



**12 bytes**

Name, type fields for a query

RRs in response to query

Records for authoritative servers

Additional "helpful" info that may be used



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## DNS Protocol Messages



DNS *query* and *reply* messages, both have same *format*:

← 2 bytes → ← 2 bytes →

identification	flags
# questions	# answer RRs
# authority RRs	# additional RRs
questions (variable # of questions)	
answers (variable # of RRs)	
authority (variable # of RRs)	
additional info (variable # of RRs)	

name, type fields for a query

RRs in response to query

records for authoritative servers

additional “helpful” info that  
may be used

Type (for example, A, NS, CNAME, and MX), the Value, and the TTL.

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## Emulating Local DNS Server (Step 1: Ask Root)



Directly send the query to this server.

```
seed@ubuntu:~$ dig @a.root-servers.net www.example.net
```

(Only a portion of the reply is shown here)

```
;; QUESTION SECTION:
```

```
;www.example.net.          IN      A
```

```
;; AUTHORITY SECTION:
```

```
net.      172800  IN      NS      m.gtld-servers.net.  
net.      172800  IN      NS      l.gtld-servers.net.  
net.      172800  IN      NS      k.gtld-servers.net.
```

```
;; ADDITIONAL SECTION:
```

```
m.gtld-servers.net.  172800  IN      A      192.55.83.30  
l.gtld-servers.net.  172800  IN      A      192.41.162.30  
k.gtld-servers.net.  172800  IN      A      192.52.178.30
```

No answer (the root does not know the answer)

Go ask them!

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## Steps 2-3: Ask .net & example.net servers

```
seed@ubuntu:~$ dig @m.gtld-servers.net www.example.net
```

```
;; QUESTION SECTION:
```

```
;www.example.net.                IN      A
```

```
;; AUTHORITY SECTION:
```

```
example.net.      172800  IN      NS      a.iana-servers.net.
```

```
example.net.      172800  IN      NS      b.iana-servers.net.
```

```
;; ADDITIONAL SECTION:
```

```
a.iana-servers.net. 172800  IN      A      199.43.132.53
```

```
b.iana-servers.net. 172800  IN      A      199.43.133.53
```

← Ask a .net nameservers.

← Go ask them!

```
seed@ubuntu:$ dig @a.iana-servers.net www.example.net
```

```
;; QUESTION SECTION:
```

```
;www.example.net.                IN      A
```

```
;; ANSWER SECTION:
```

```
www.example.net.      86400   IN      A      93.184.216.34
```

← Ask an example.net nameservers.

← Finally got the answer

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## Summary

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Example: new startup “Network Utopia”

- register name **networkutopia.com** at *DNS registrar* (e.g., Network Solutions)
  - provide names, IP addresses of authoritative name server (primary and secondary)
  - registrar inserts NS, A RRs into .com TLD server:  
(networkutopia.com, dns1.networkutopia.com, NS)  
(dns1.networkutopia.com, 212.212.212.1, A)
- create authoritative server locally with IP address 212.212.212.1
  - type A record for www.networkutopia.com
  - type MX record for networkutopia.com

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## DNS Request - Wireshark Packet Capture

Microsoft: \Device\NPF\_{483C83F4-DCBA-4863-B523-3C4E1B03D06F} [Wireshark 1.8.5 (SVN Rev 47350 from /trunk-1.8)]

File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help

Filter: ip.addr == 10.36.41.43 Expression... Clear Apply Save

No.	Time	Source	Destination	Protocol	Length	Info
13	13:51:23.477657000	173.194.43.37	10.36.41.43	TCP	54	https > 62364 [FIN, ACK] Seq=103 Ack=2 win=63784 Len=0
14	13:51:23.477694000	10.36.41.43	173.194.43.37	TCP	54	62364 > https [ACK] Seq=3 Ack=104 win=16478 Len=0
15	13:51:23.491240000	173.194.43.37	10.36.41.43	TCP	54	https > 62364 [ACK] Seq=104 Ack=3 win=63784 Len=0
16	13:51:27.041610000	10.36.41.43	10.40.4.44	DNS	72	standard query 0x9f7d A www.ietf.org
17	13:51:27.160178000	10.40.4.44	10.36.41.43	DNS	473	standard query response 0x9f7d A 64.170.98.30
18	13:51:27.166692000	10.36.41.43	10.40.4.44	DNS	88	standard query 0x6028 A tunnel.cfw.trustedsource.org
19	13:51:27.167744000	10.40.4.44	10.36.41.43	DNS	104	standard query response 0x6028 A 8.21.161.7
20	13:51:27.180583000	10.36.41.43	8.21.161.7	TCP	62	62382 > https [SYN] Seq=0 win=8192 Len=0 MSS=1460 SACK_PERM=1
21	13:51:27.258985000	8.21.161.7	10.36.41.43	TCP	62	https > 62382 [SYN, ACK] Seq=0 Ack=1 win=5840 Len=0 MSS=1460 SACK
22	13:51:27.259111000	10.36.41.43	8.21.161.7	TCP	54	62382 > https [ACK] Seq=1 Ack=1 win=17520 Len=0
23	13:51:27.259472000	10.36.41.43	8.21.161.7	TLSv1	149	Client Hello
24	13:51:27.336962000	8.21.161.7	10.36.41.43	TCP	54	https > 62382 [ACK] Seq=1 Ack=96 win=5840 Len=0
25	13:51:27.337735000	8.21.161.7	10.36.41.43	TLSv1	1446	Server Hello, Certificate, Certificate Request, Server Hello Done
26	13:51:27.340425000	10.36.41.43	8.21.161.7	TLSv1	1005	Certificate, Client Key Exchange, Certificate verify, Change ciph
27	13:51:27.422036000	8.21.161.7	10.36.41.43	TLSv1	113	Change Cipher Spec, Encrypted Handshake Message
28	13:51:27.425726000	10.36.41.43	8.21.161.7	TLSv1	395	Application Data
29	13:51:27.502692000	8.21.161.7	10.36.41.43	TLSv1	192	Application Data, Application Data

Domain Name System (query)

[Response In: 17]

Transaction ID: 0x9f7d

Flags: 0x0100 Standard query

Questions: 1

Answer RRs: 0

Authority RRs: 0

Additional RRs: 0

Queries

www.ietf.org: type A, class IN

0000 00 1e 17 4c 01 3f cc a1 78 0a de 0b 08 00 45 00 ...La?... x..k...E.  
0010 00 3a 47 7d 00 00 80 11 b1 93 0a 24 29 2b 0a 28 ...G}..... \$)+..C



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## DNS Response - Wireshark Packet Capture

Filter: `ip.addr == 10.36.41.43` Expression... Clear Apply Save

No.	Time	Source	Destination	Protocol	Length	Info
13	13:51:23.477657000	173.194.43.37	10.36.41.43	TCP	54	https > 62364 [FIN, ACK] Seq=103 Ack=2 win=63784 Len=0
14	13:51:23.477694000	10.36.41.43	173.194.43.37	TCP	54	62364 > https [ACK] Seq=3 Ack=104 win=16478 Len=0
15	13:51:23.491240000	173.194.43.37	10.36.41.43	TCP	54	https > 62364 [ACK] Seq=104 Ack=3 win=63784 Len=0
16	13:51:27.041610000	10.36.41.43	10.40.4.44	DNS	72	Standard query 0x9f7d A www.ietf.org
17	13:51:27.160178000	10.40.4.44	10.36.41.43	DNS	473	Standard query response 0x9f7d A 64.170.98.30
18	13:51:27.166692000	10.36.41.43	10.40.4.44	DNS	88	Standard query 0x6028 A tunnel.cfw.trustedsource.org
19	13:51:27.167744000	10.40.4.44	10.36.41.43	DNS	104	Standard query response 0x6028 A 8.21.161.7
20	13:51:27.180583000	10.36.41.43	8.21.161.7	TCP	62	62382 > https [SYN] Seq=0 win=8192 Len=0 MSS=1460 SACK_PER
21	13:51:27.258985000	8.21.161.7	10.36.41.43	TCP	62	https > 62382 [SYN, ACK] Seq=0 Ack=1 win=5840 Len=0 MSS=14

Flags: 0x8180 Standard query response, No error

Questions: 1

Answer RRs: 1

Authority RRs: 6

Additional RRs: 11

Queries

www.ietf.org: type A, class IN

Name: www.ietf.org

Type: A (Host address)

Answers

www.ietf.org: type A, class IN, addr 64.170.98.30

Authoritative nameservers

ietf.org: type NS, class IN, ns ns1.yyz1.afiliastx.net

ietf.org: type NS, class IN, ns ns0.ietf.org

ietf.org: type NS, class IN, ns ns1.sea1.afiliastx.net

ietf.org: type NS, class IN, ns ns1.ams1.afiliastx.net

ietf.org: type NS, class IN, ns ns1.mia1.afiliastx.net

```
000  cc af 78 0a de 6b 00 1e f7 4c 61 3f 08 00 45 00  ..x..k.. .La?...E.
010  01 cb 63 b4 40 00 7e 11 55 cb 0a 28 04 2c 0a 24  ..c.@.~. U..(..$.
020  29 2b 00 35 c3 d5 01 b7 1a 58 9f 7d 81 80 00 01  )+.5.... .X.}....
030  00 01 00 06 00 0b 03 77 77 77 04 69 65 74 66 03  .....w ww.ietf.
040  6f 72 67 00 00 01 00 01 c0 0c 00 01 00 01 00 00  org.....
050  07 08 00 04 40 aa 62 1e c0 10 00 02 00 01 00 00  ....@.b. ....
060  07 08 00 04 40 aa 62 1e c0 10 00 02 00 01 00 00  ....@.b. ....
0070  69 6c 69 61 73 2d 6e 73 74 04 69 6e 66 6f 00 c0  ilias-ns t'info
```

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## Suggested Readings

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- DNS (Domain Name System) – Explained – <https://youtu.be/JkEYOt08-rU>
- How a DNS Server (Domain Name System) works – <https://youtu.be/rdVPfIECed8>
- Wireshark Lab: DNS v7.0 – [http://www-net.cs.umass.edu/wireshark-labs/Wireshark\\_DNS\\_v7.0.pdf](http://www-net.cs.umass.edu/wireshark-labs/Wireshark_DNS_v7.0.pdf)



**Thank You**  
For Your Attention





**THANK YOU**

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