The Root of the Matter: A Discussion of DNS Security Part 2

Mark Allman

International Computer Science Institute

EECS 325 / 425

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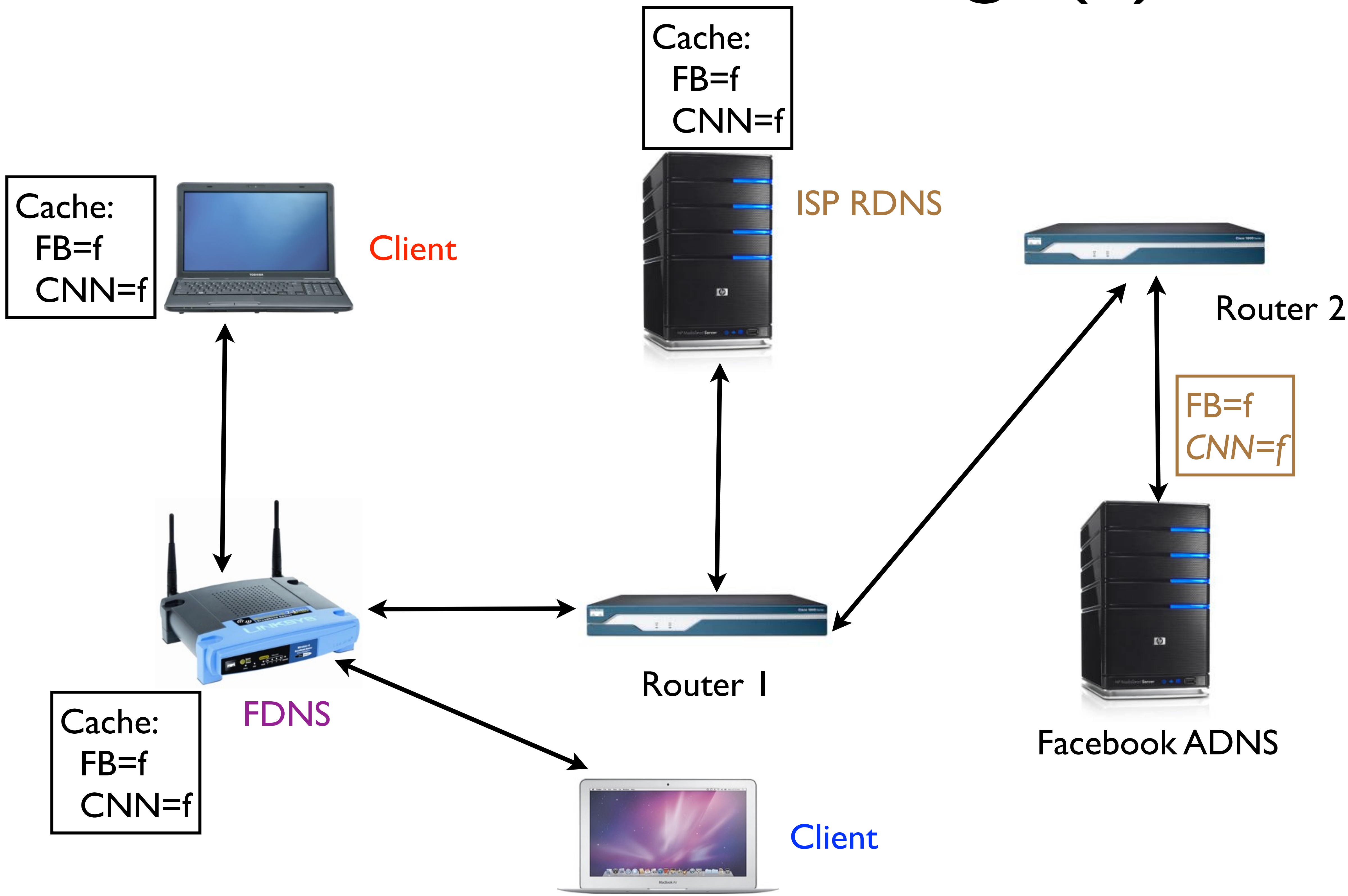
"Like a preacher stealin' hearts in a travelin' show …"

What Can Go Wrong? (1)



Hostnames in Links

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```
lynx -dump -listonly http://www.cnn.com | […] |sort -u
```

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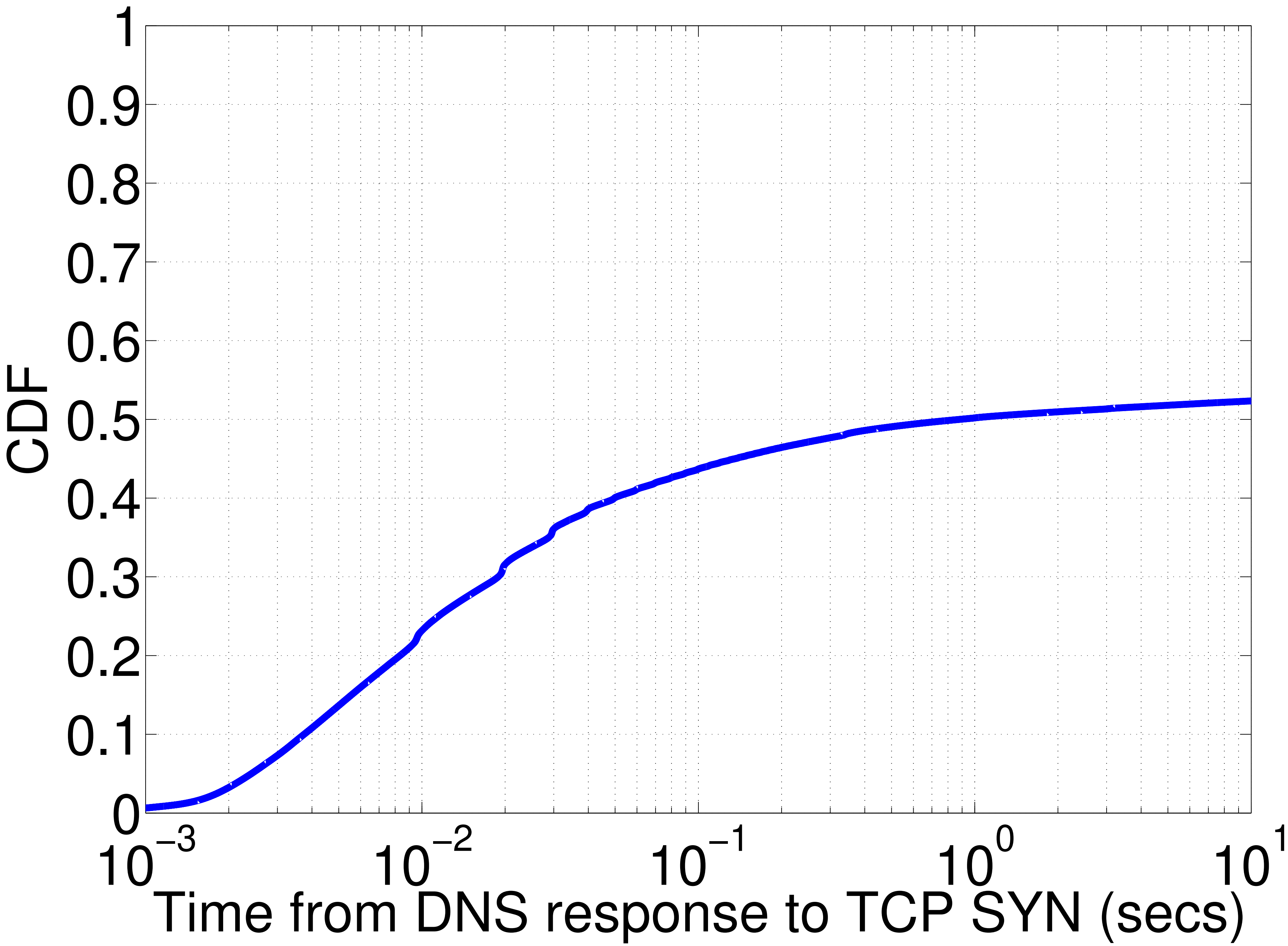
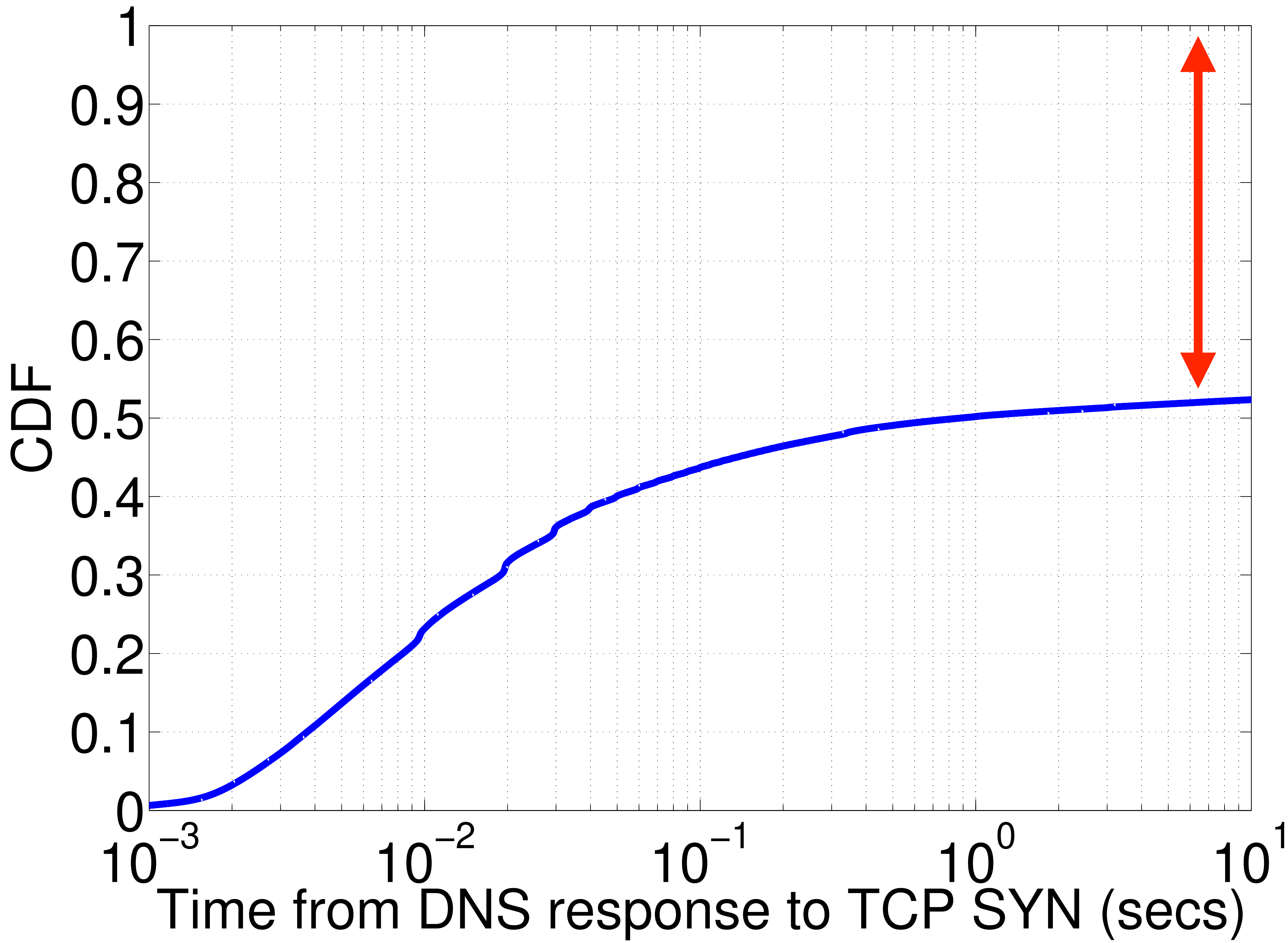
bleacherreport.com
cnn.it
cnnnewsource.com
collection.cnn.com
com.cnn.mobile.android.phone
coupons.cnn.com
edition.cnn.com
instagram.com
money.cnn.com
plus.google.com
store.cnn.com
tours.cnn.com
twitter.com
www.cnn.com
www.facebook.com
www.turner.com
www.turnerjobs.com
```

Using DNS Responses



Using DNS Responses



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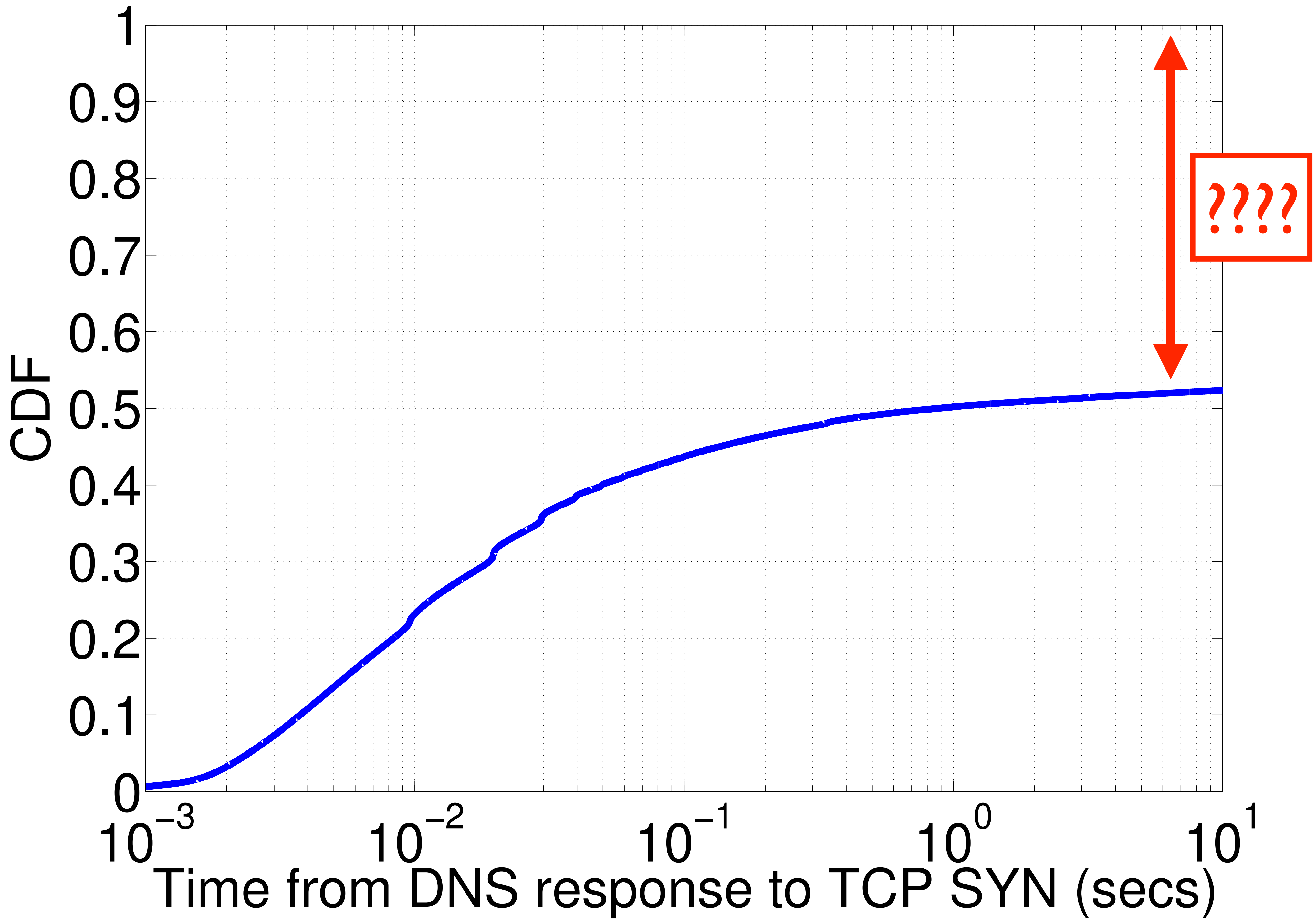

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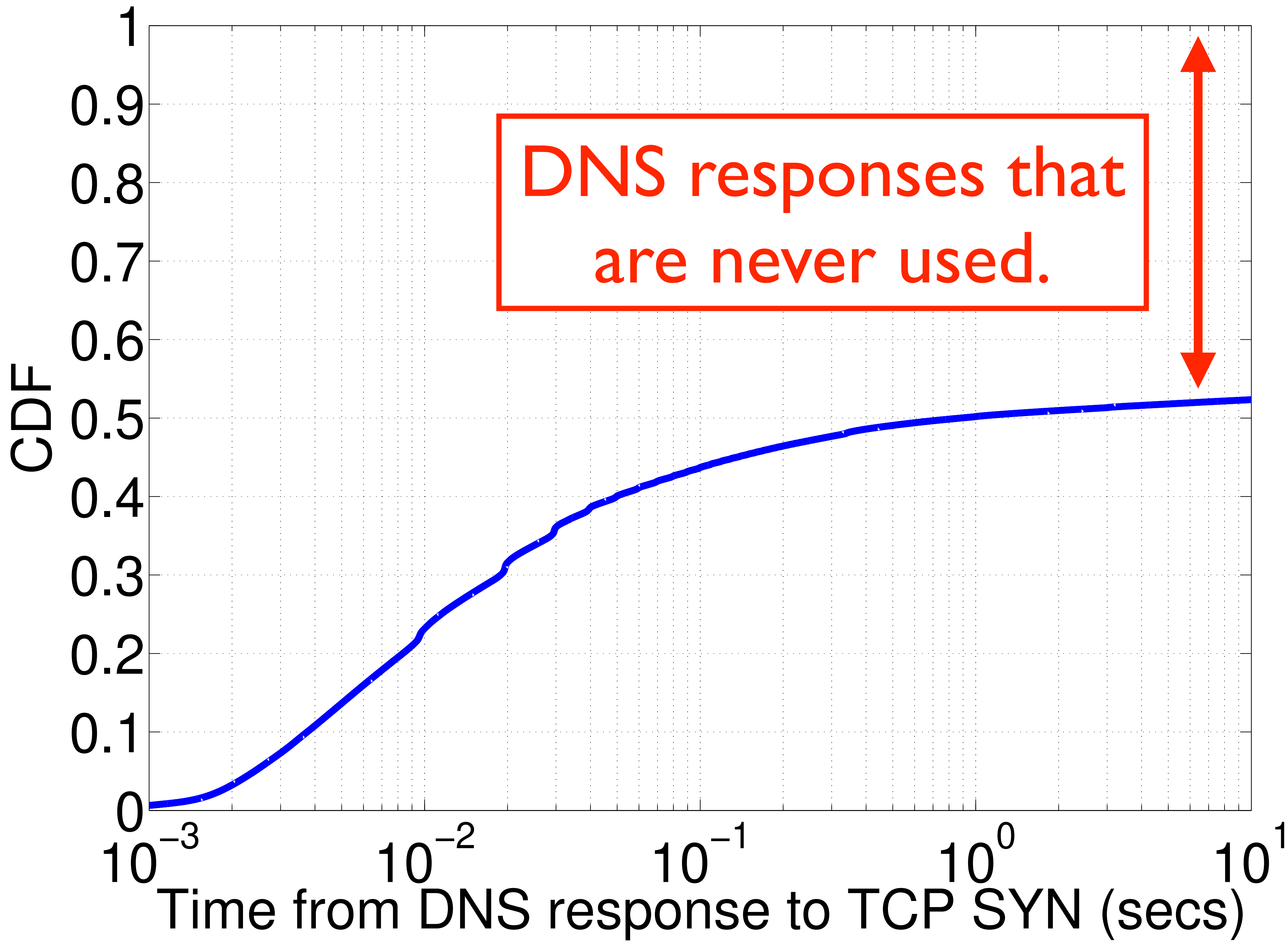

DNS Prefetching

- DNS prefetching is an optimization widely used by modern web browsers
  - (can be disabled)

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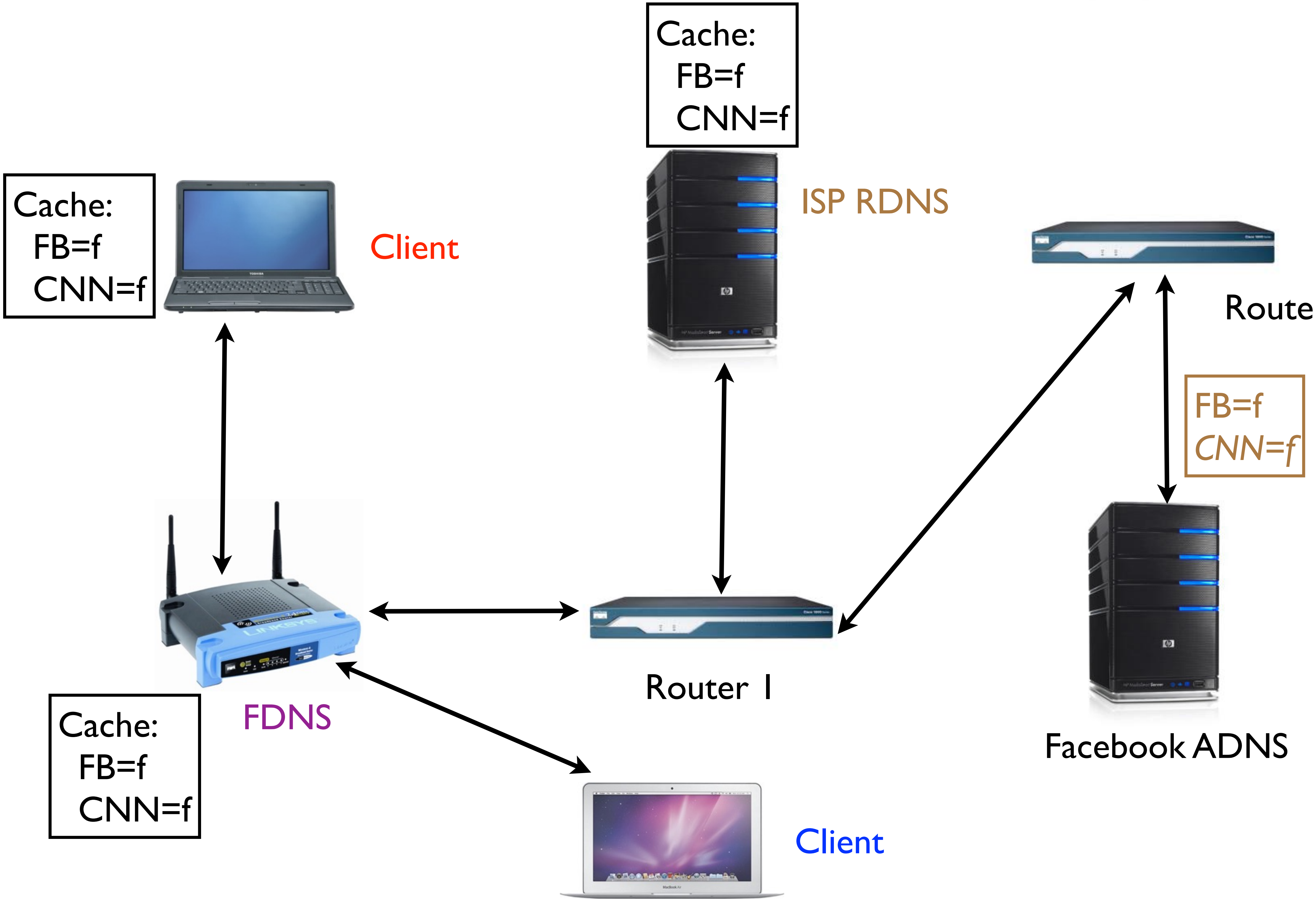

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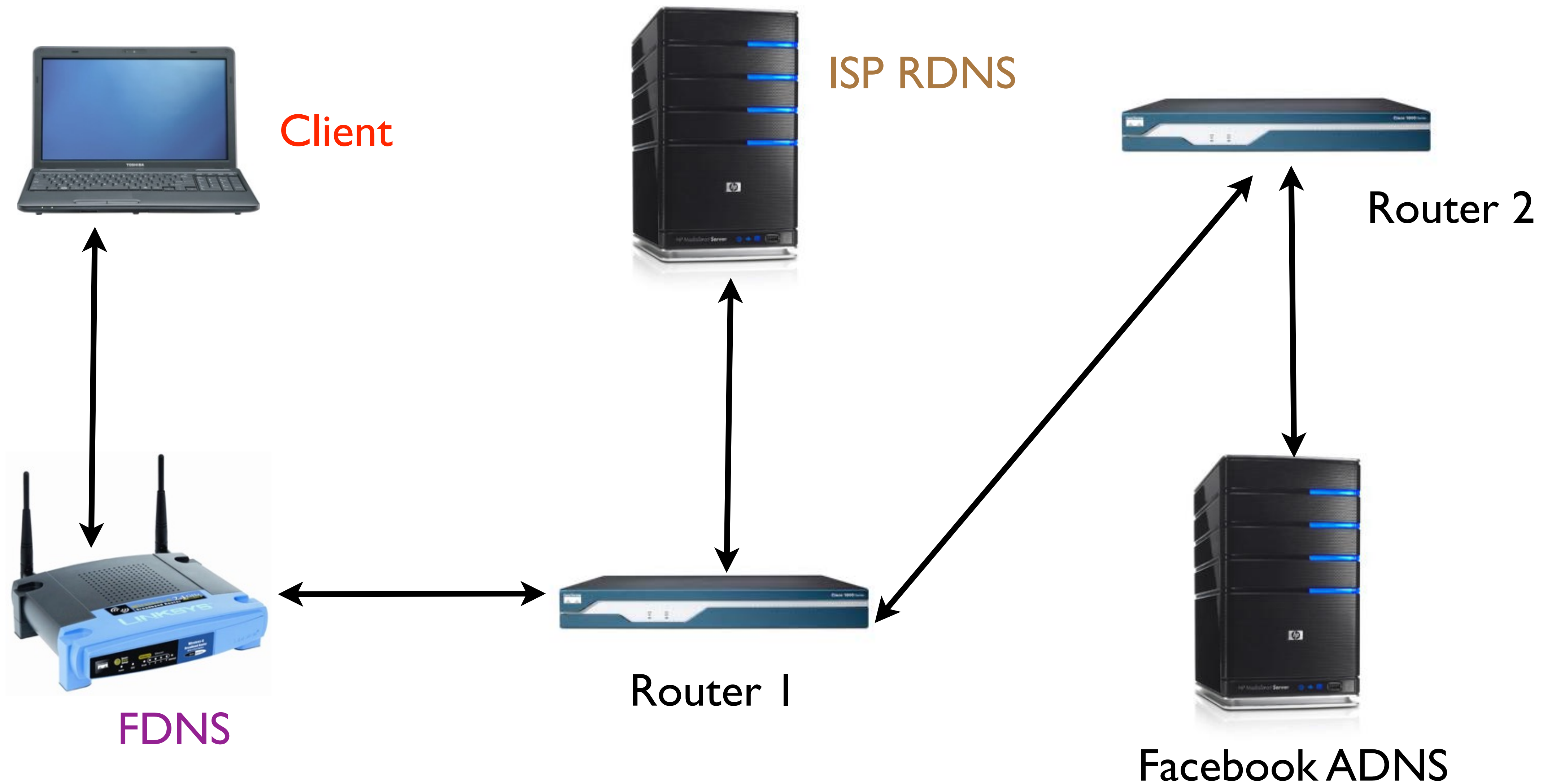

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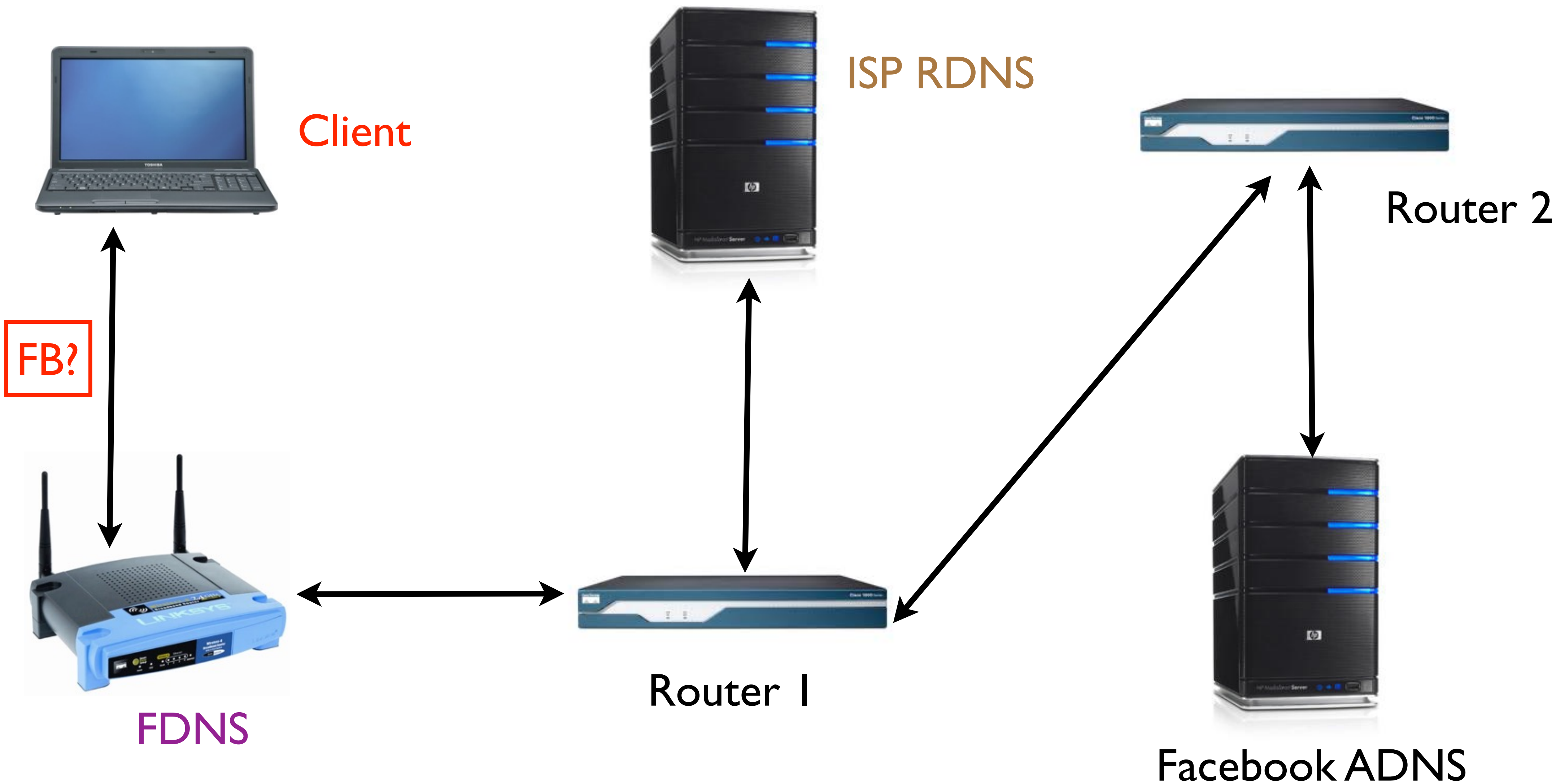

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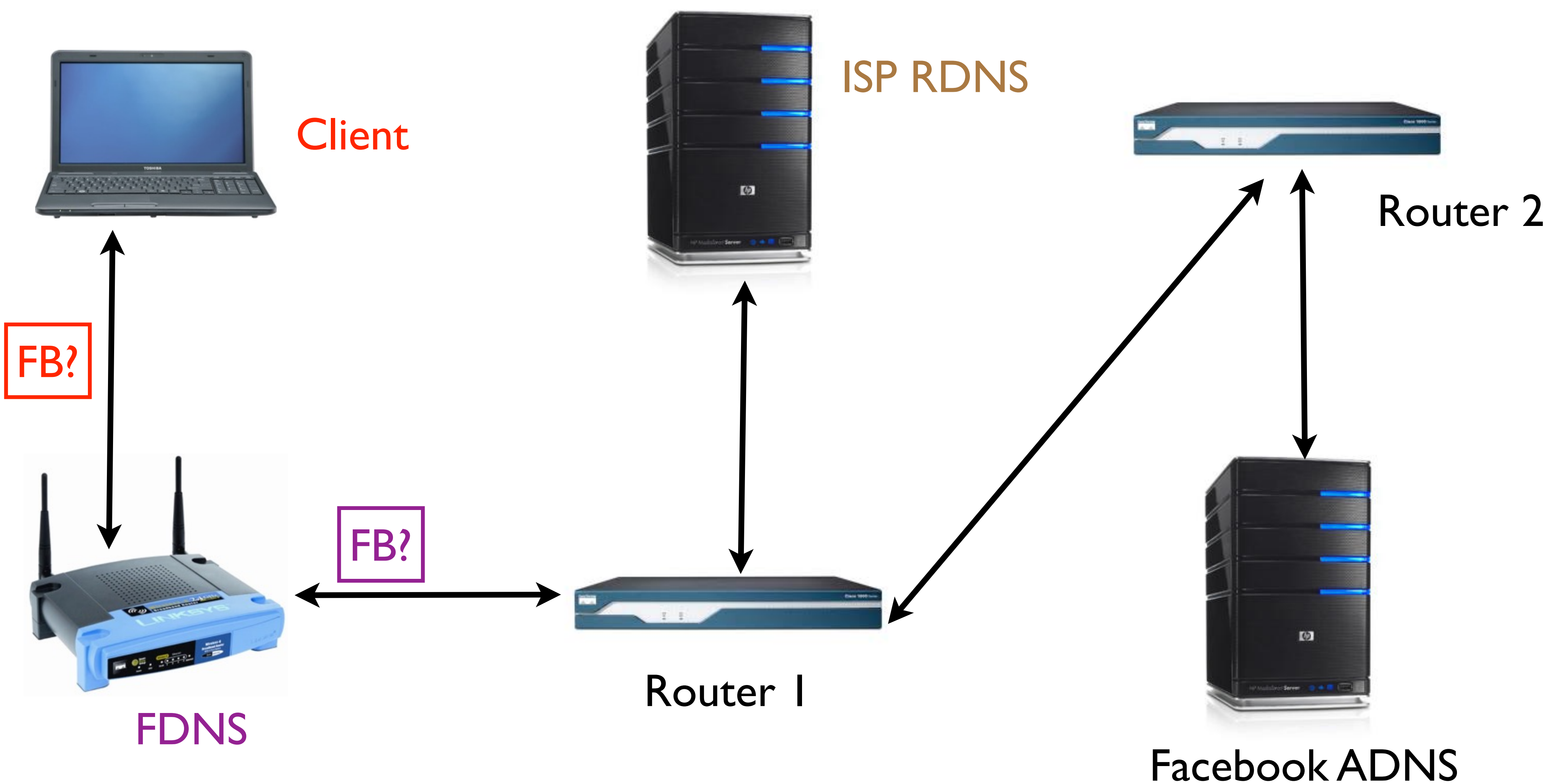

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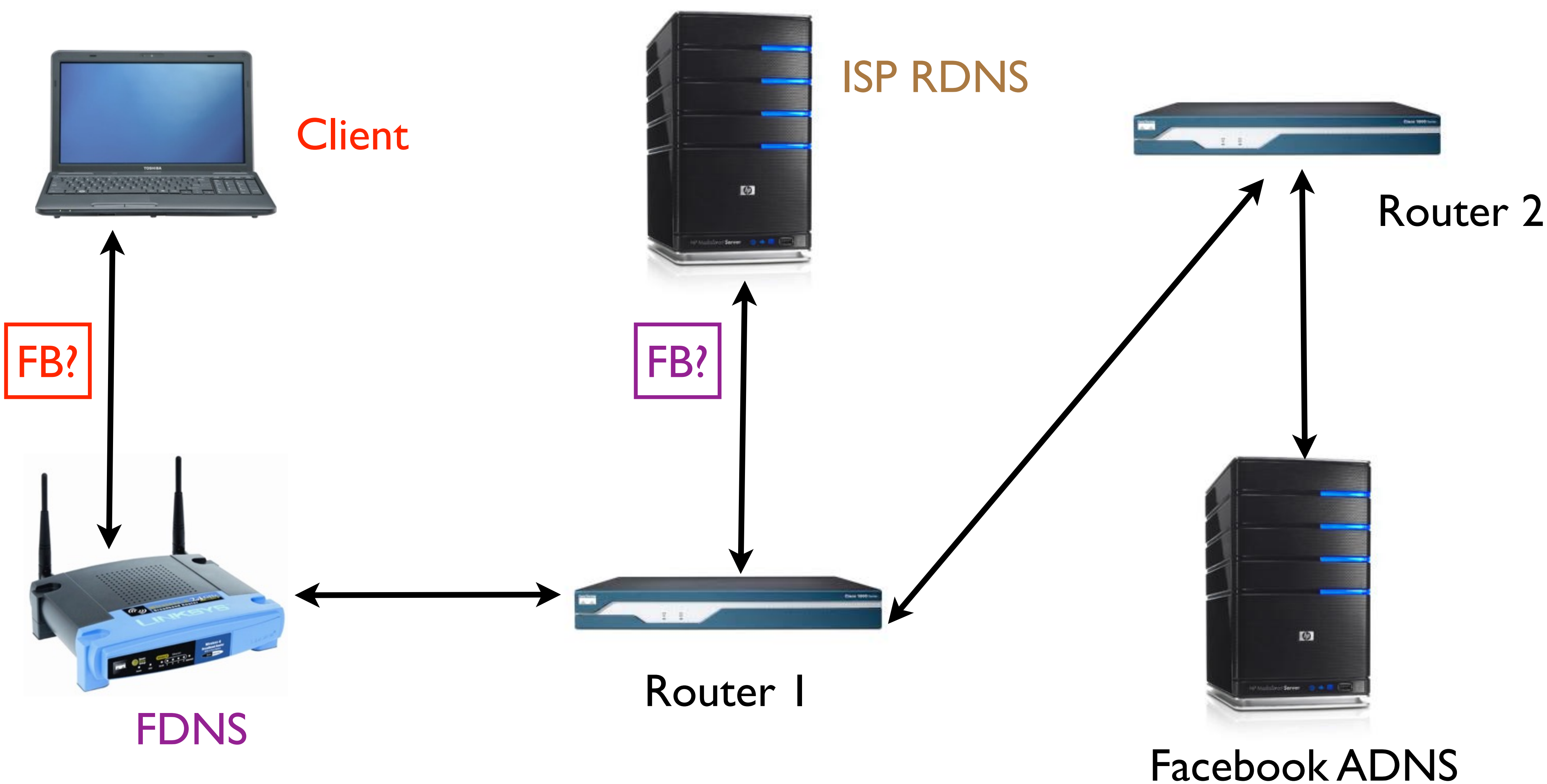

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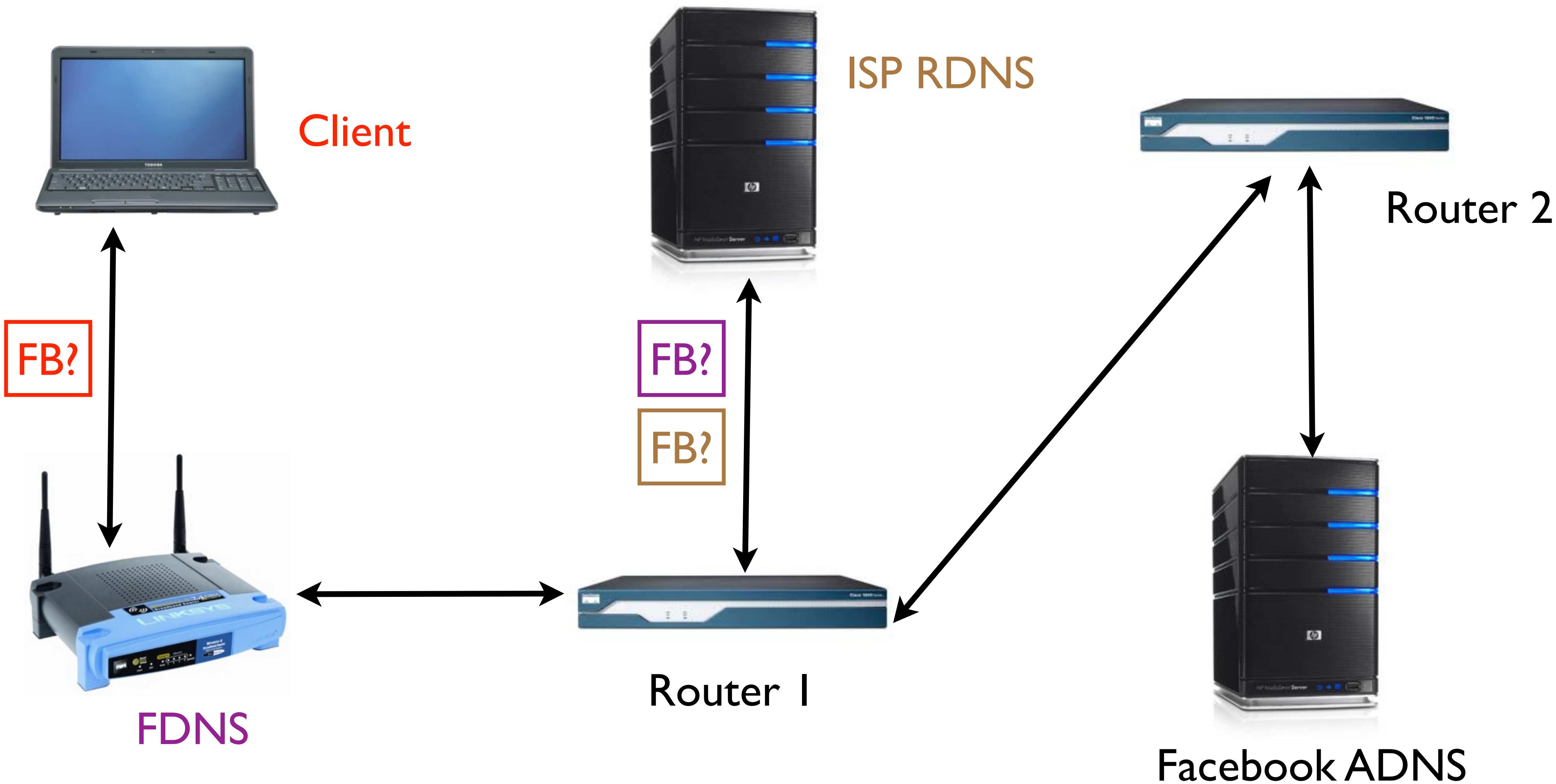

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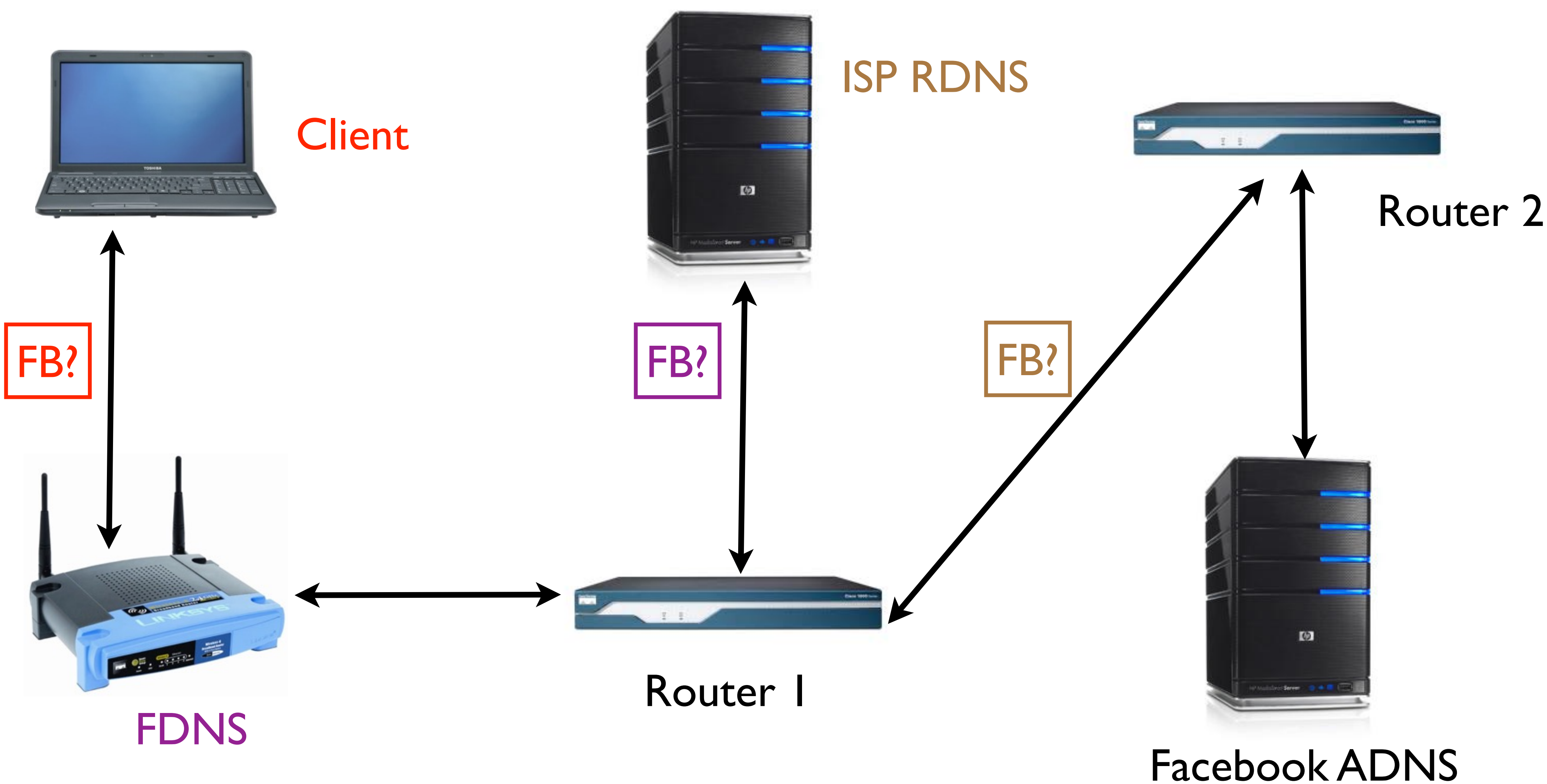

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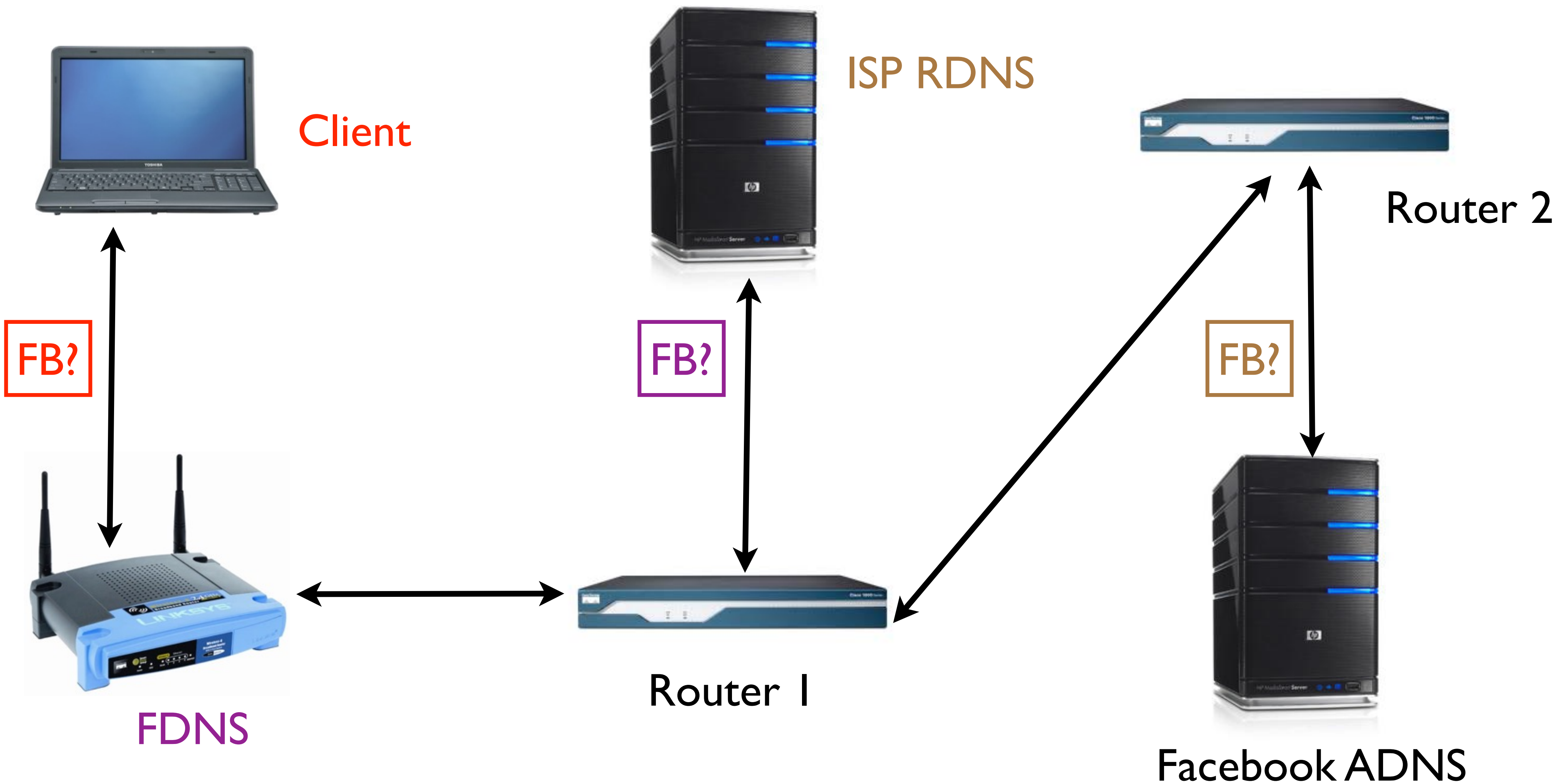

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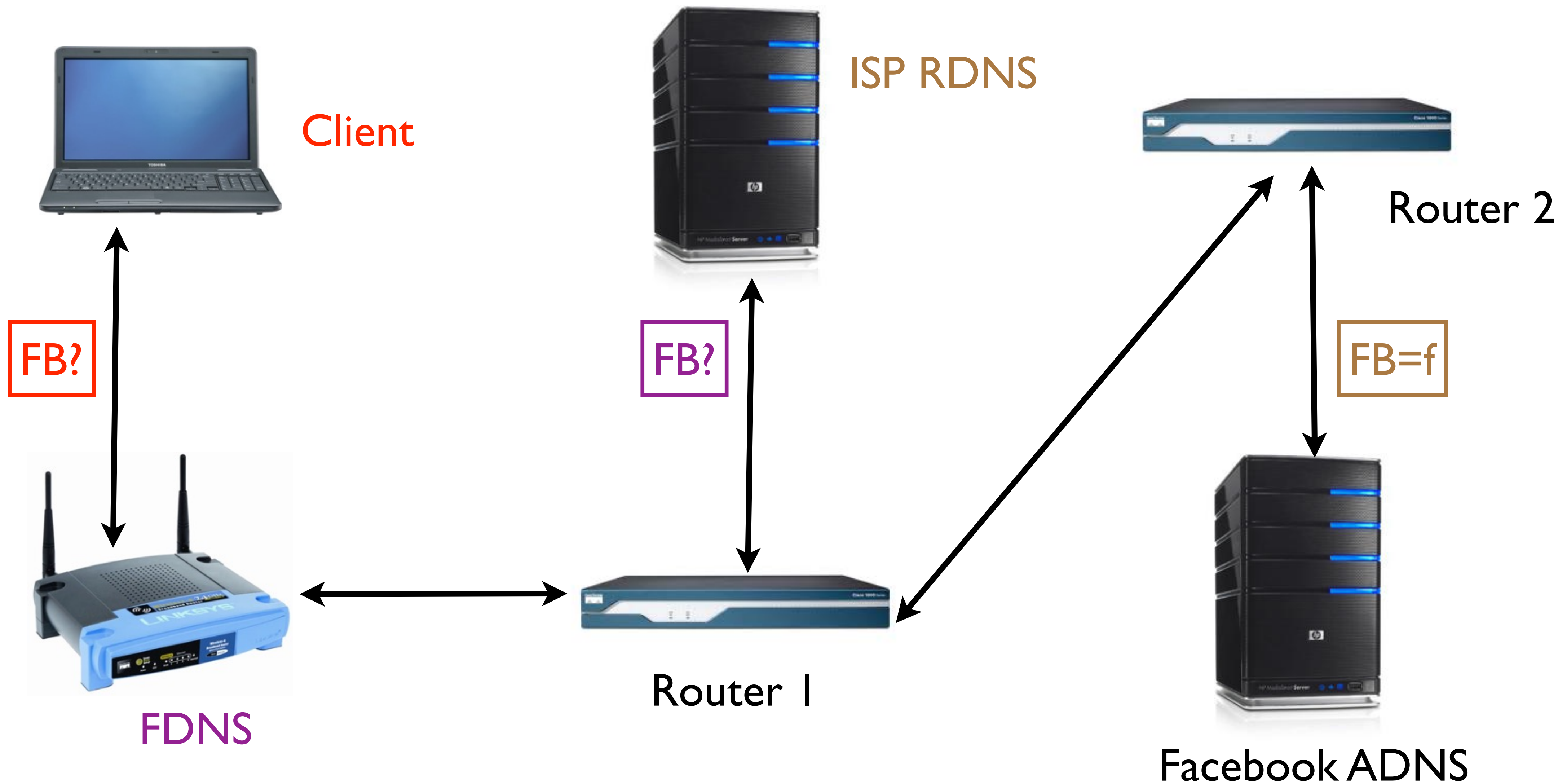

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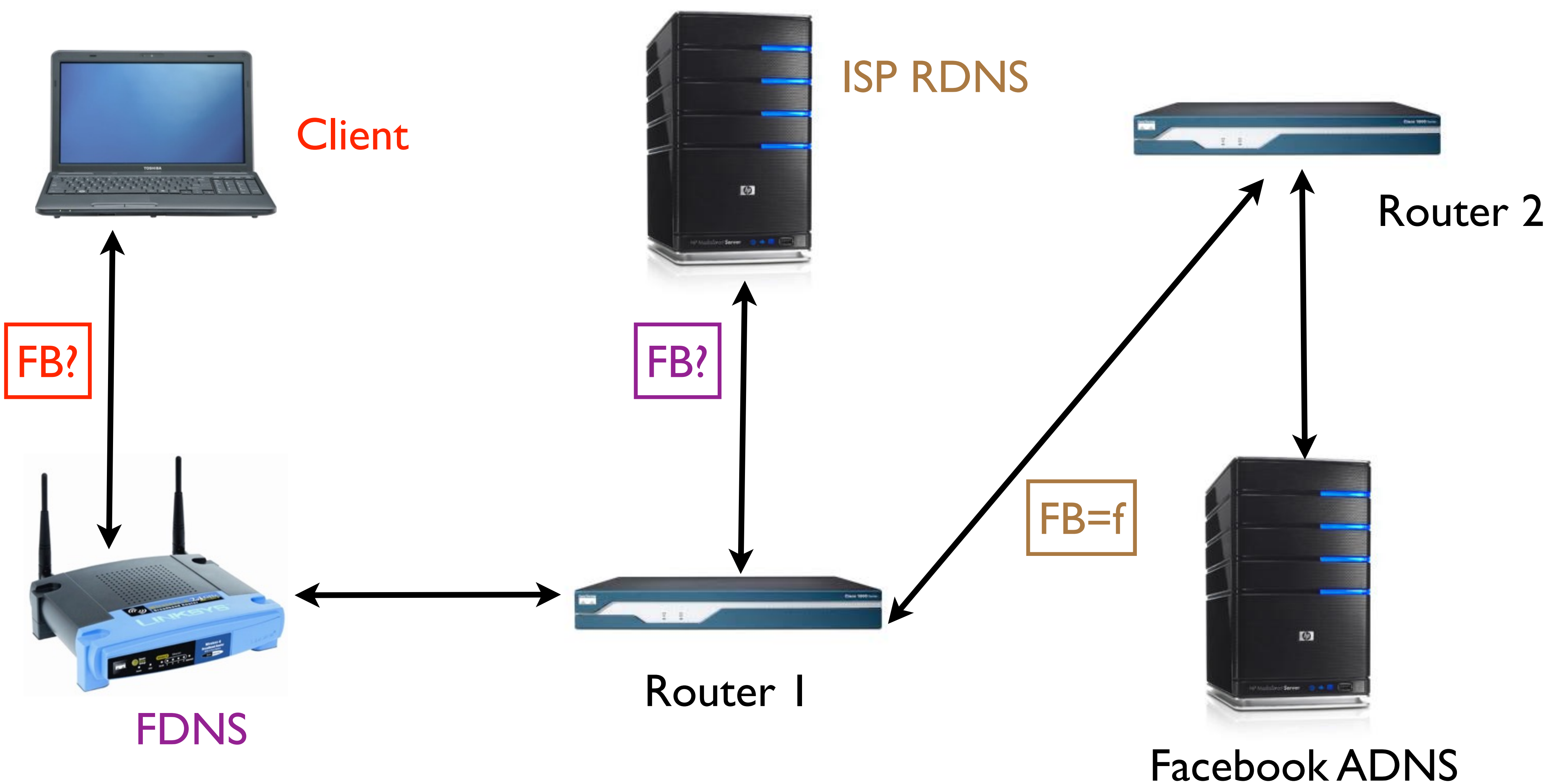

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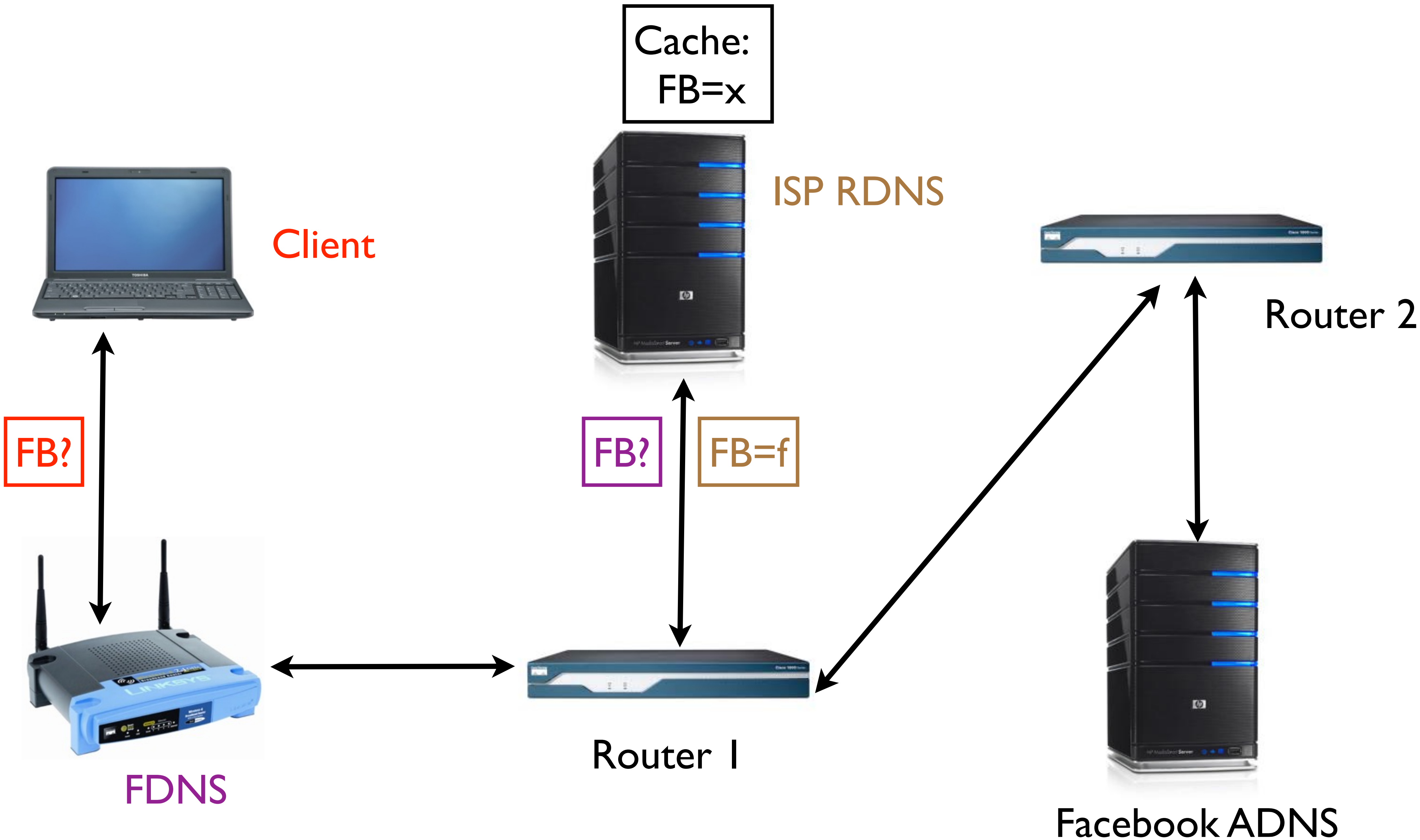

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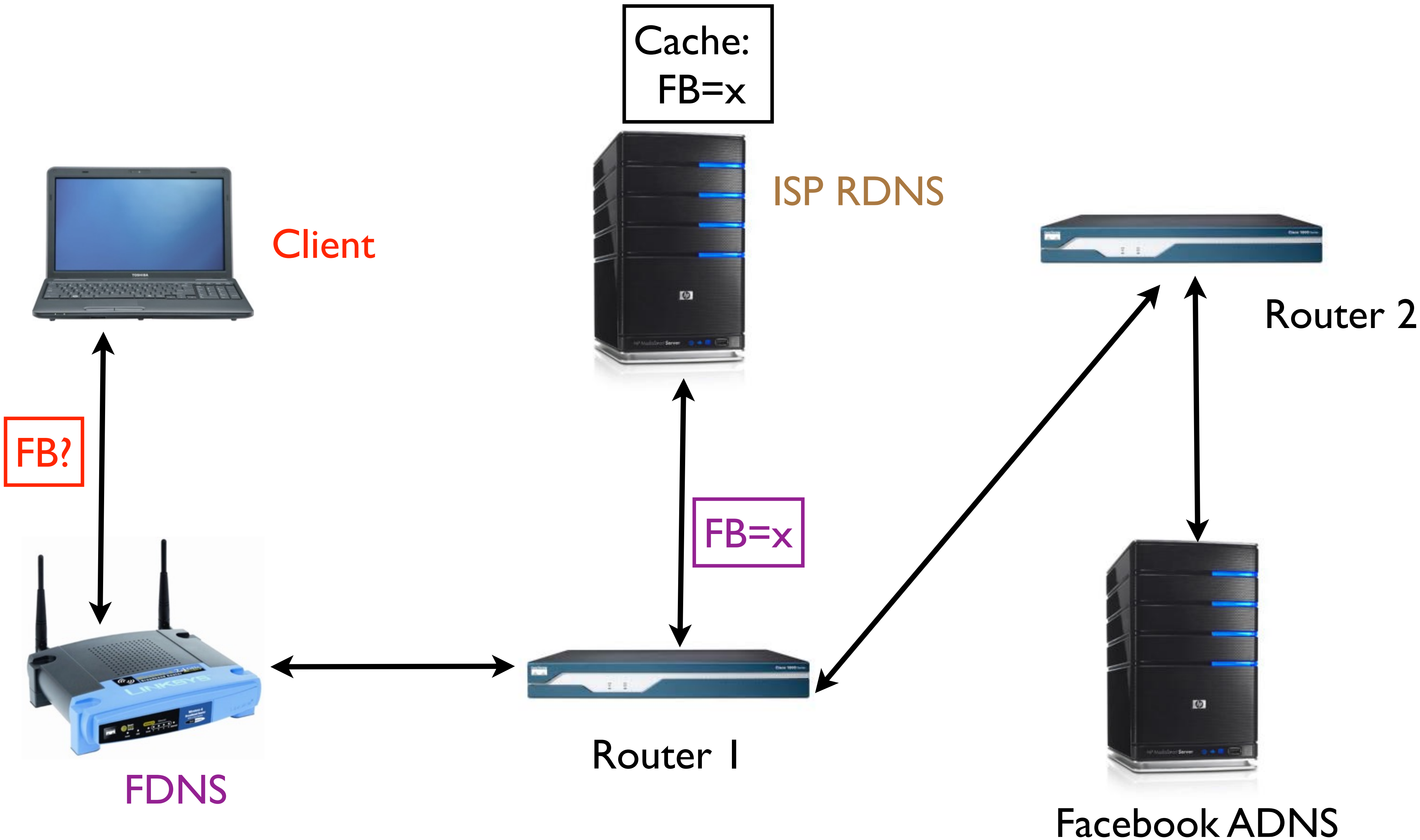

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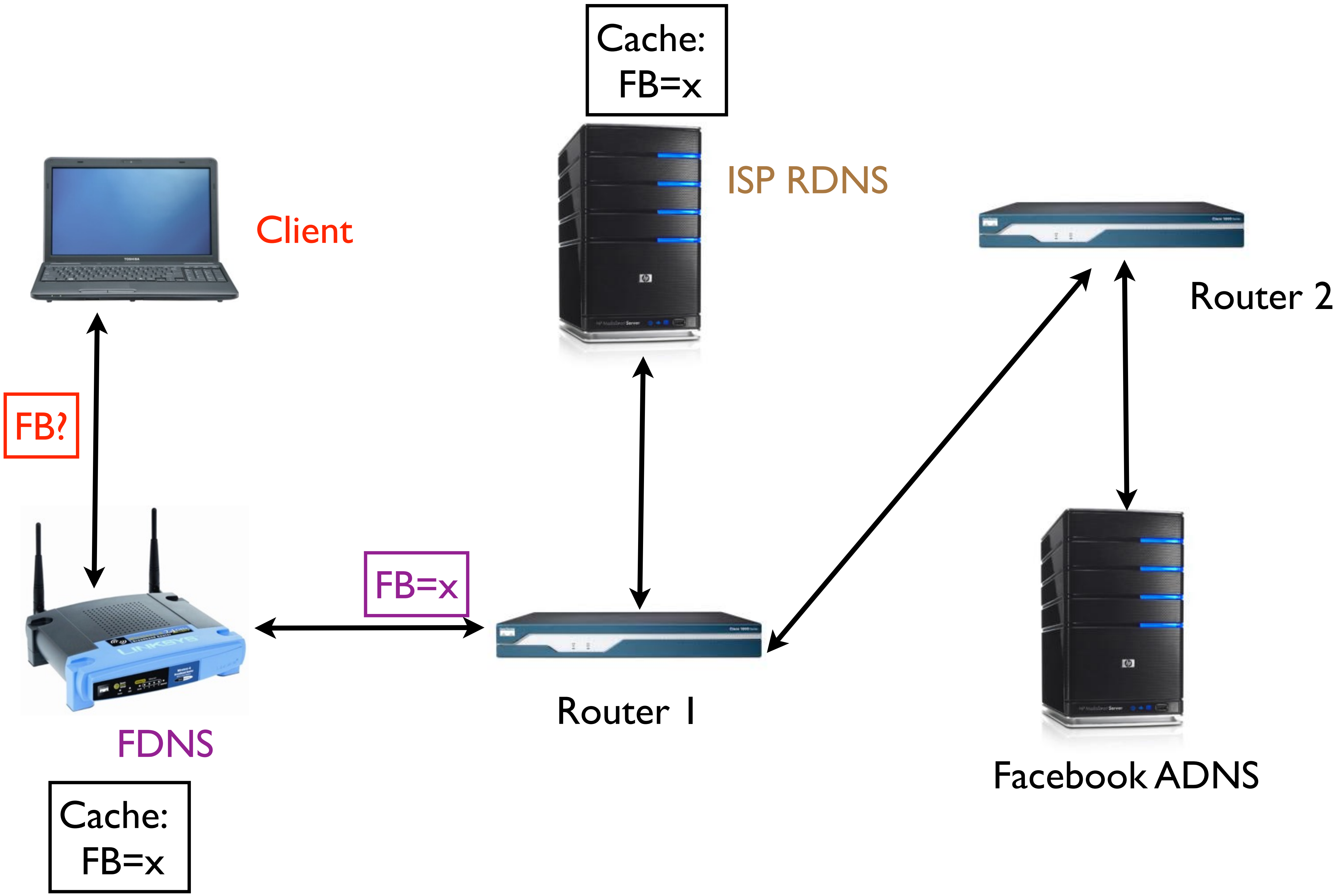

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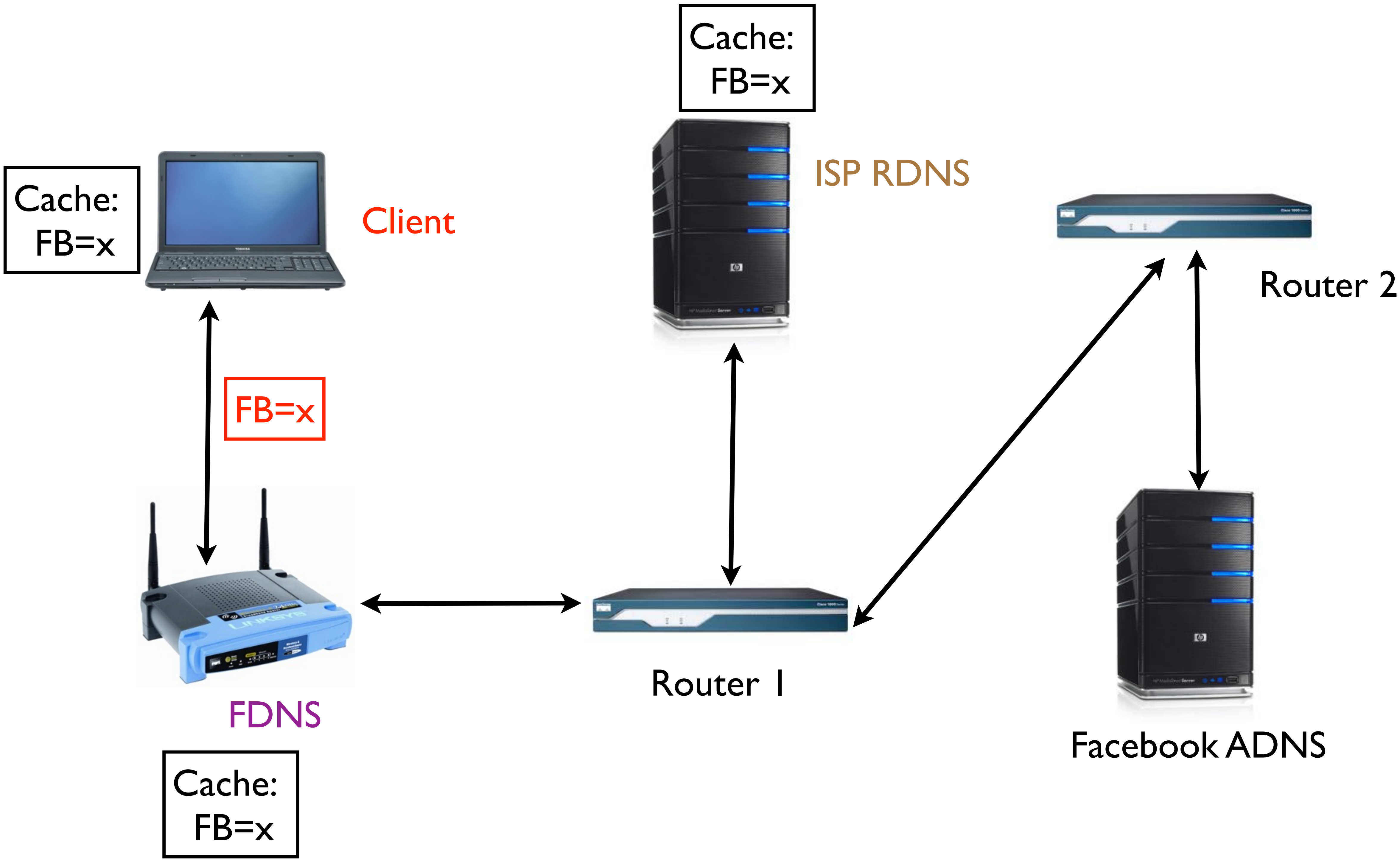

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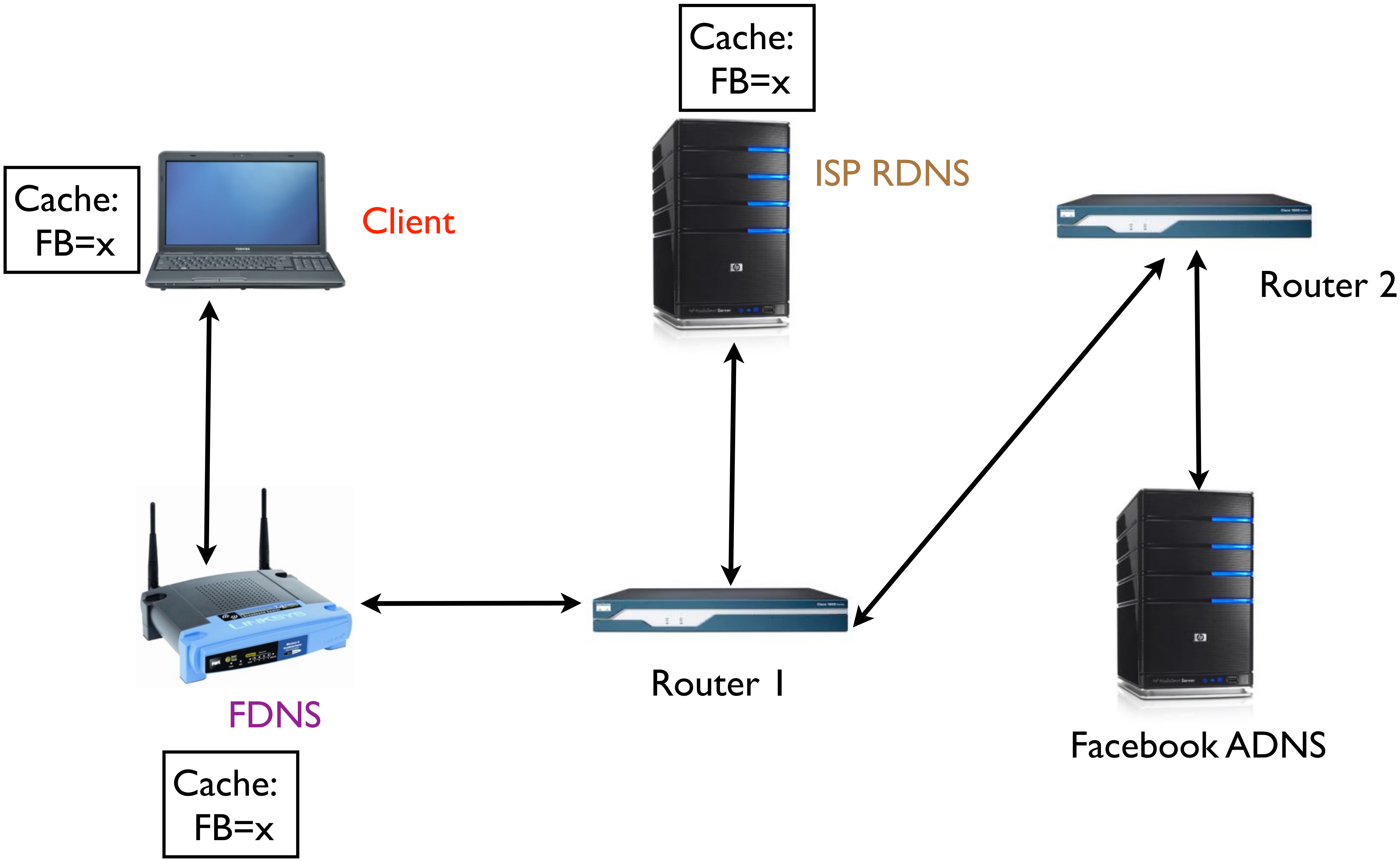

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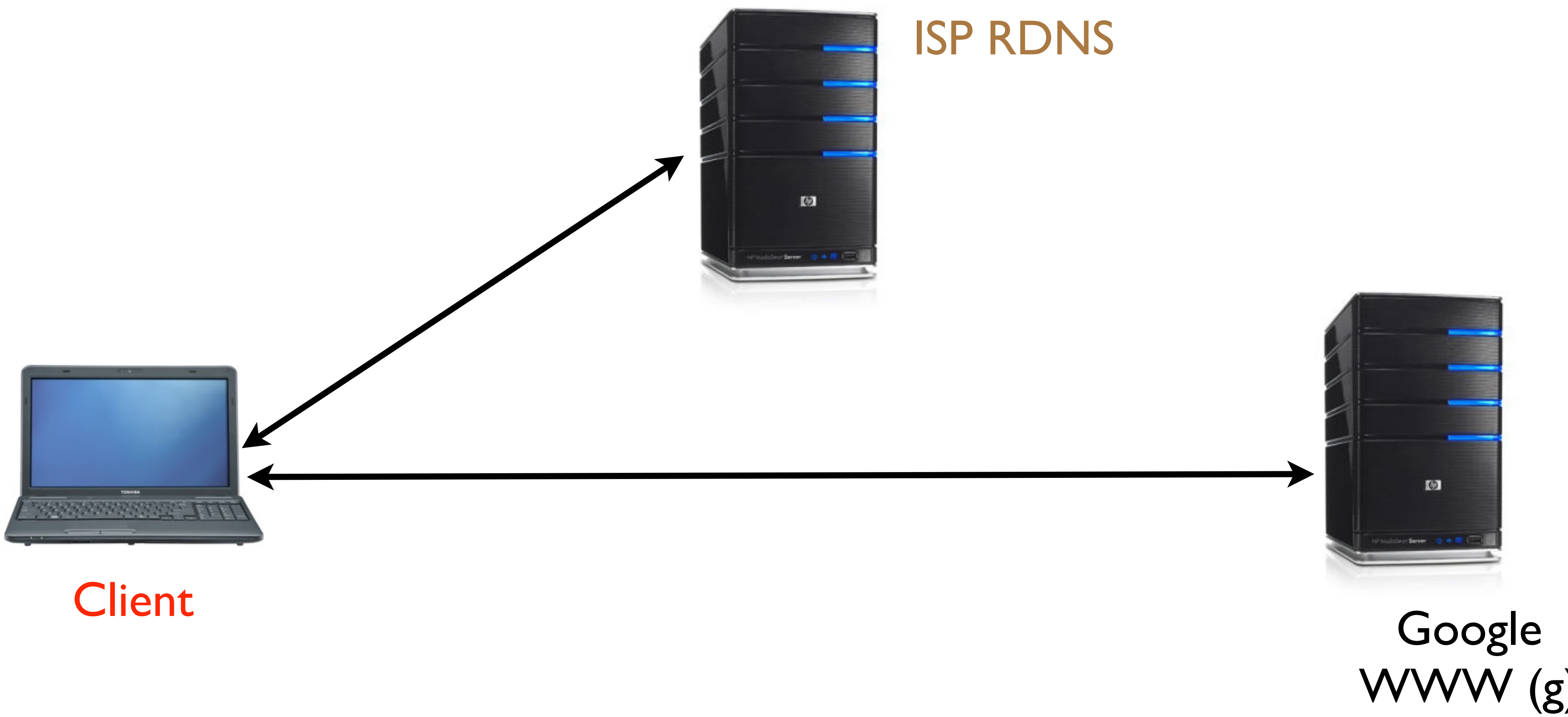
- Roughly 24% of open resolvers experience NXDOMAIN re-writing
  - across over 100 ISPs

Search Engine Hijacking



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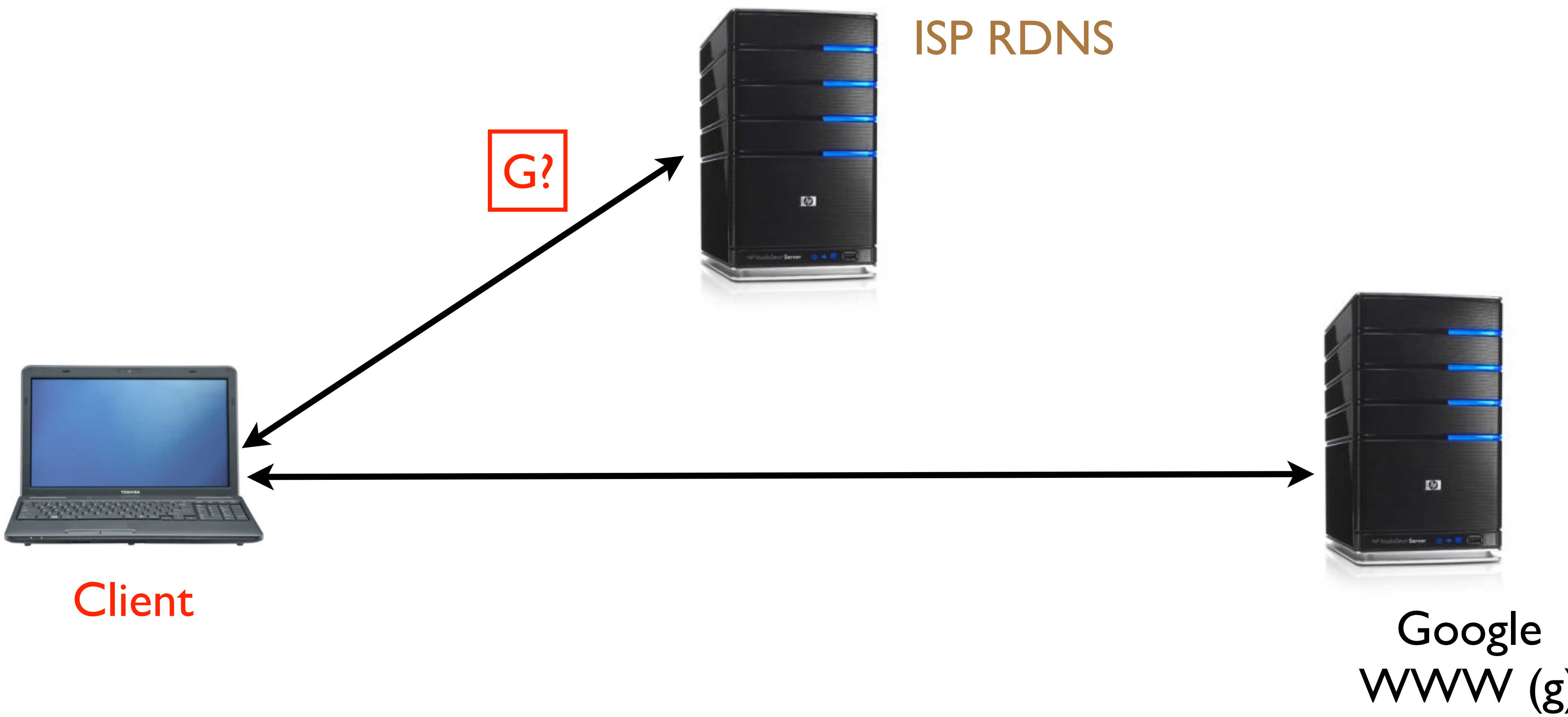

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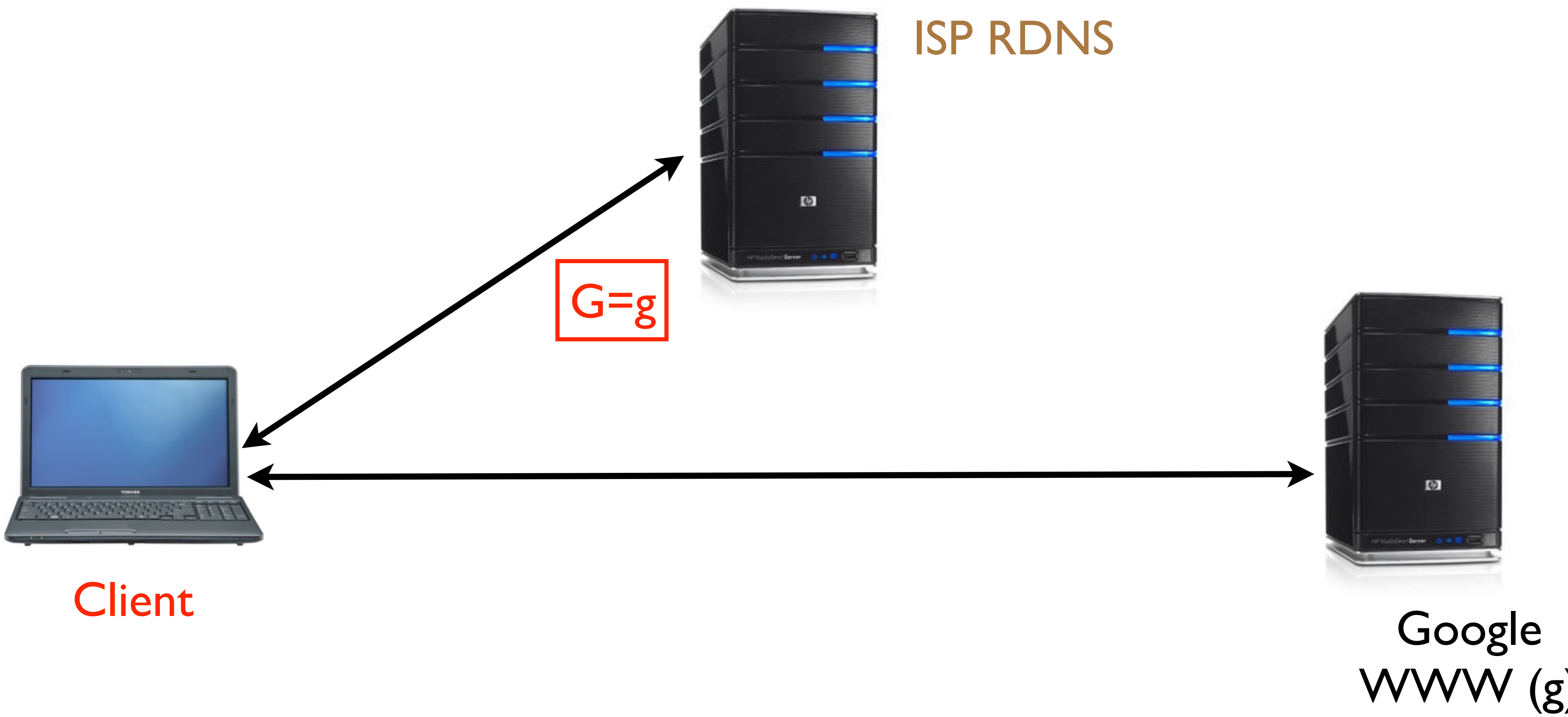

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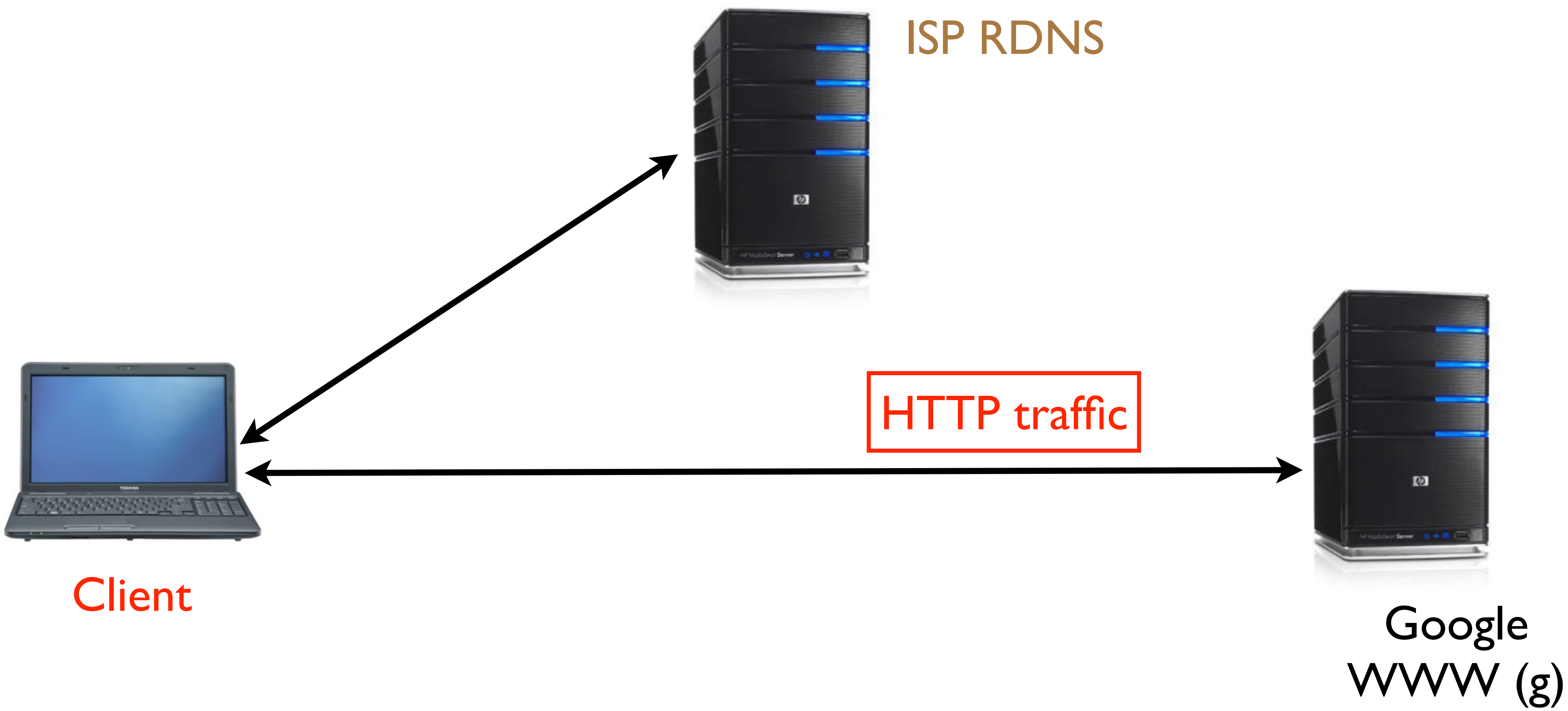

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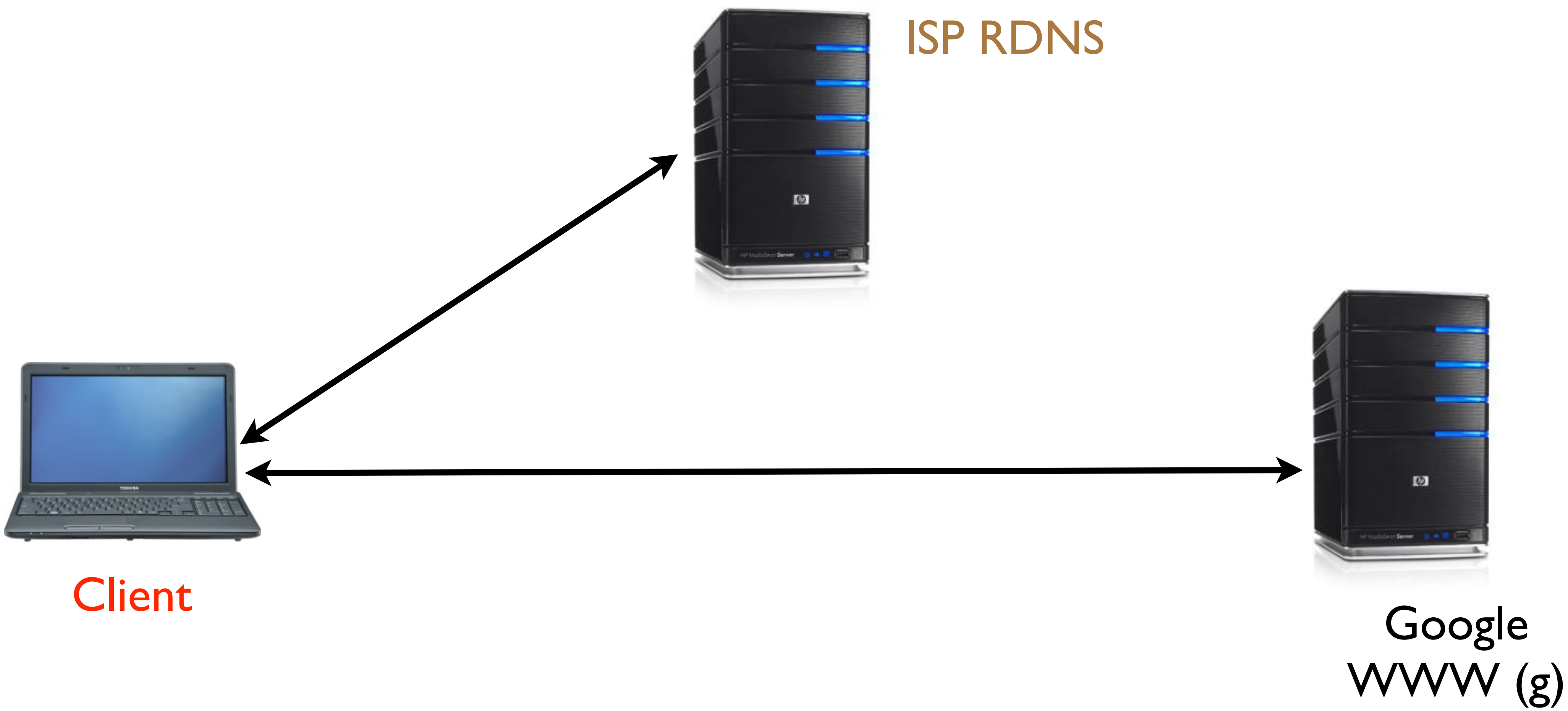

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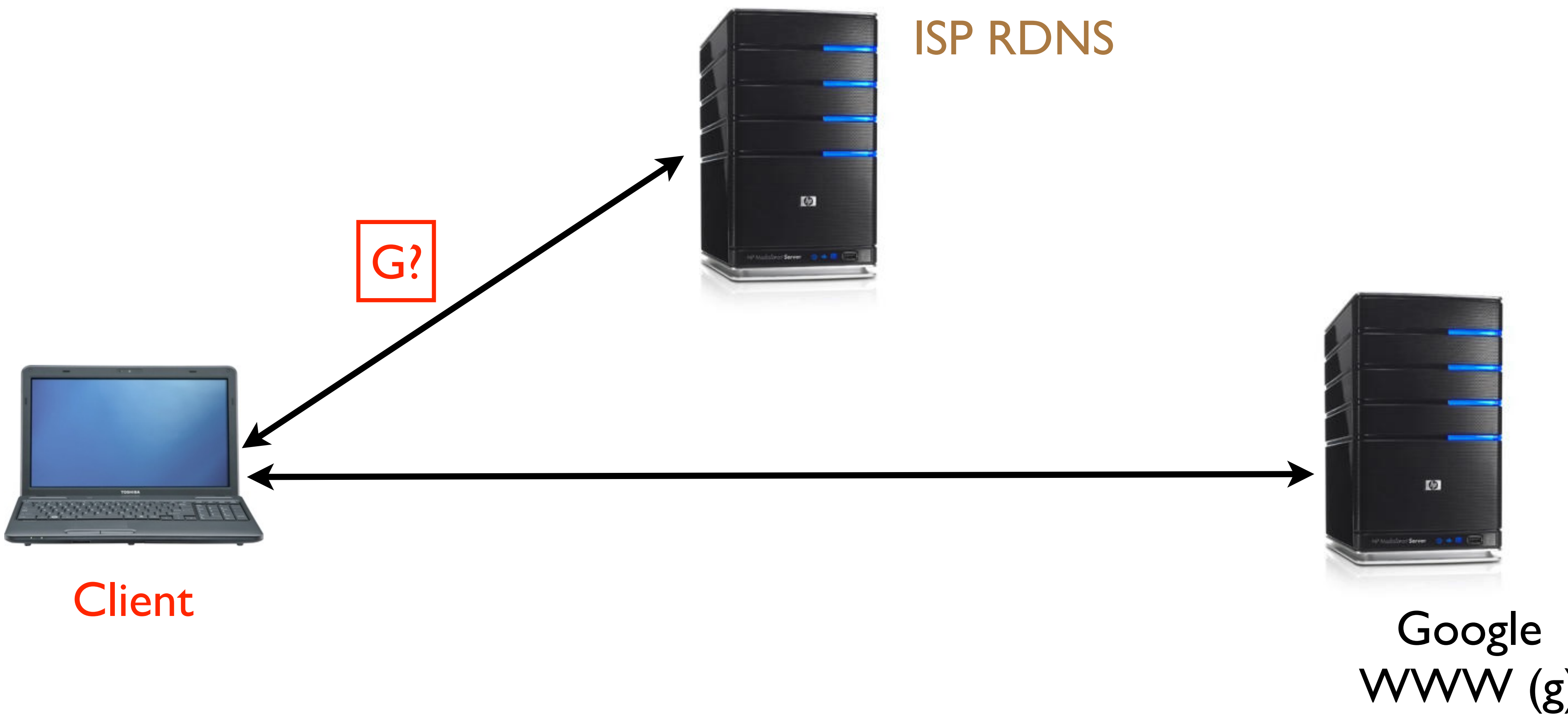

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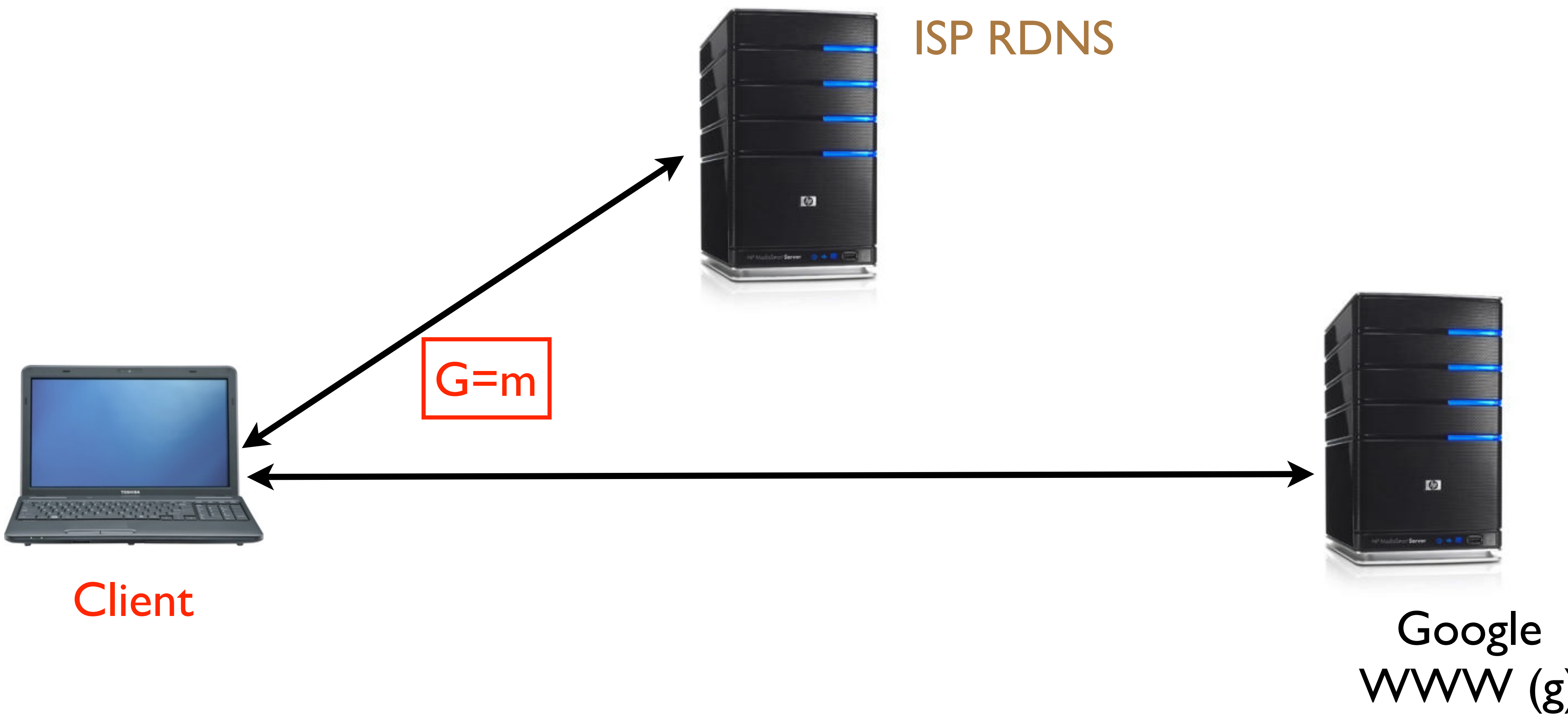

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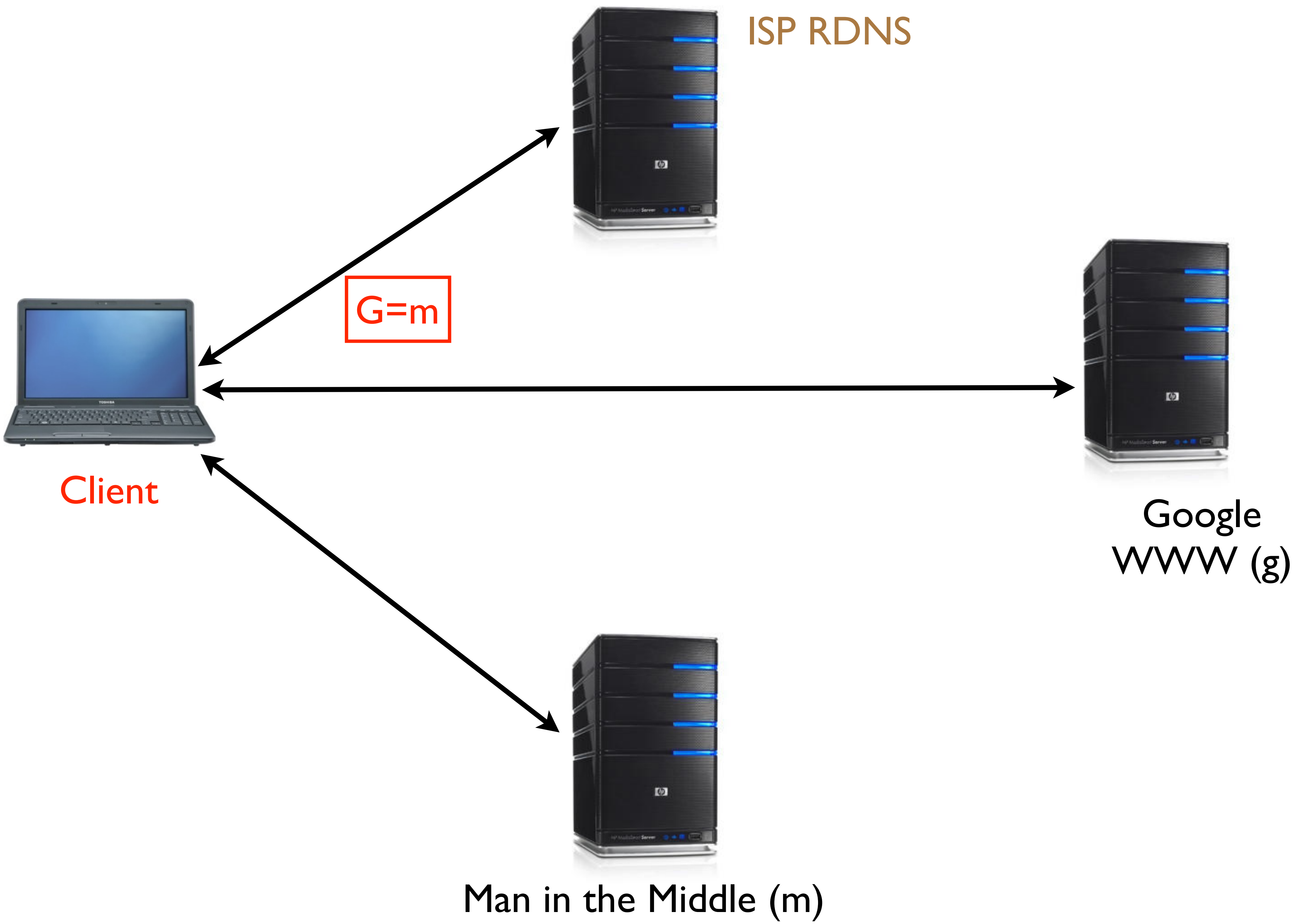

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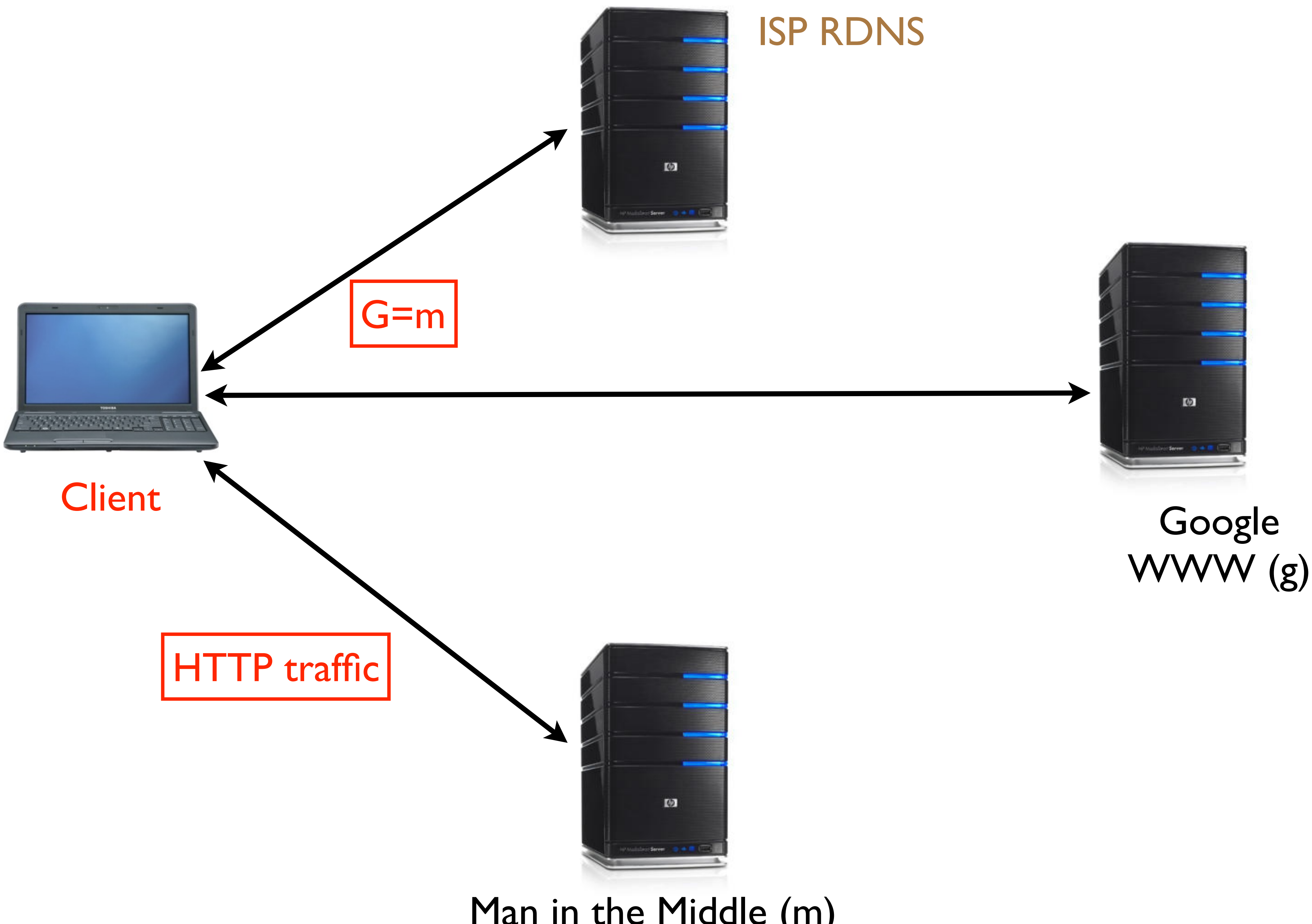

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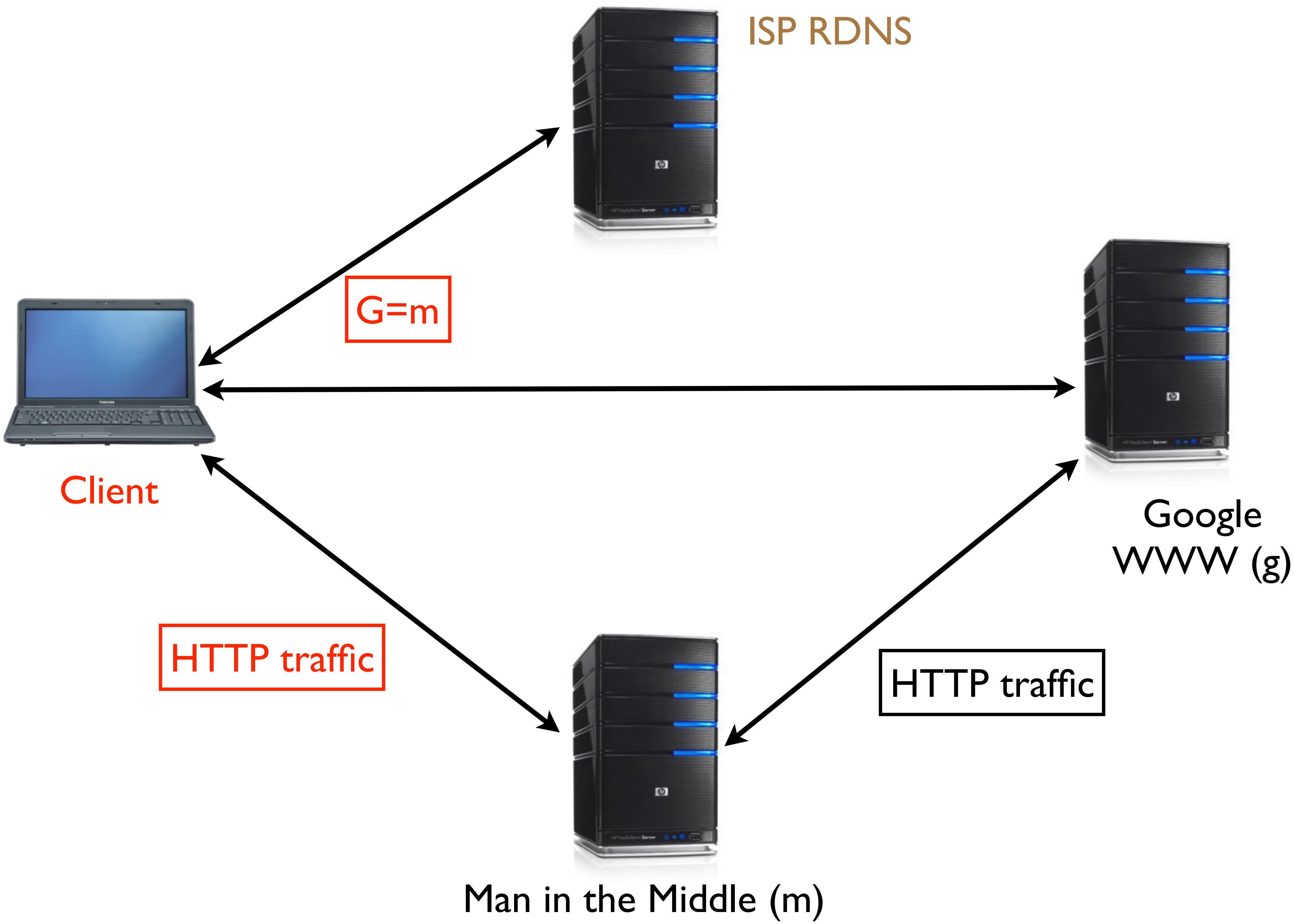

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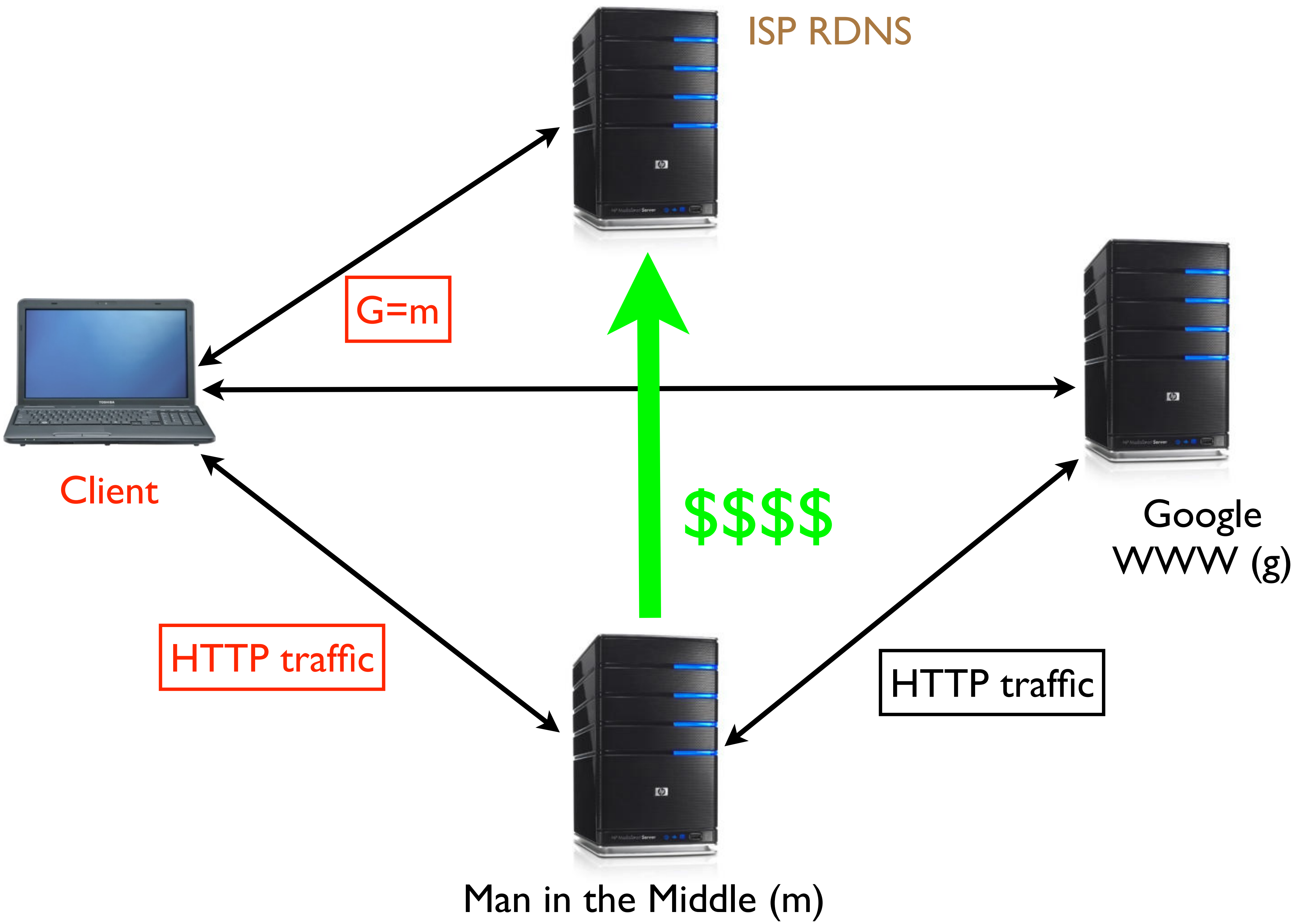

Search Engine Hijacking

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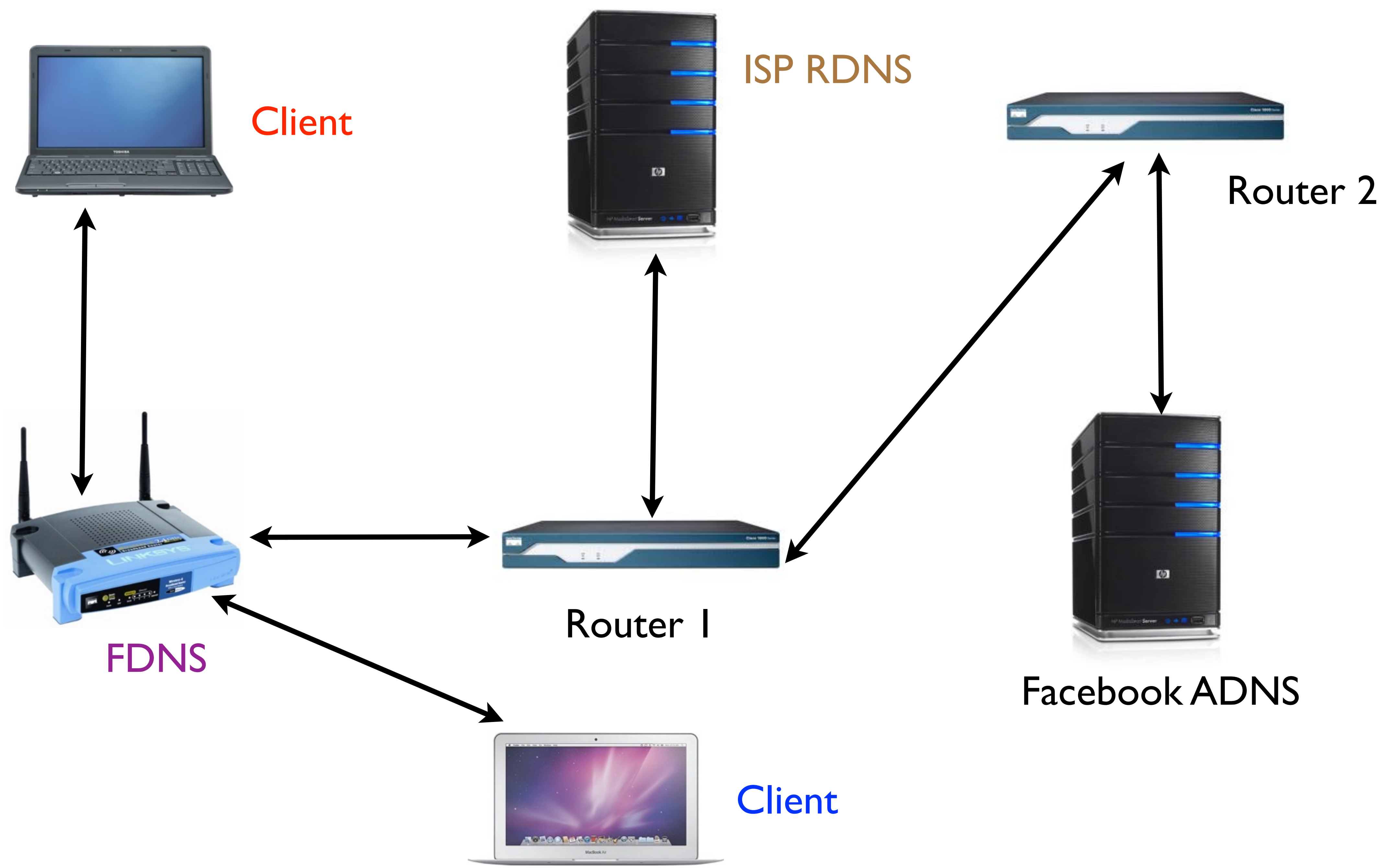
- Paxfire boxes once prevalent
  - no longer widespread
  - we detect small bits in 18 regional ISPs

- In general, our measurements do not show much of this form of attack

What Can Go Wrong? (3)



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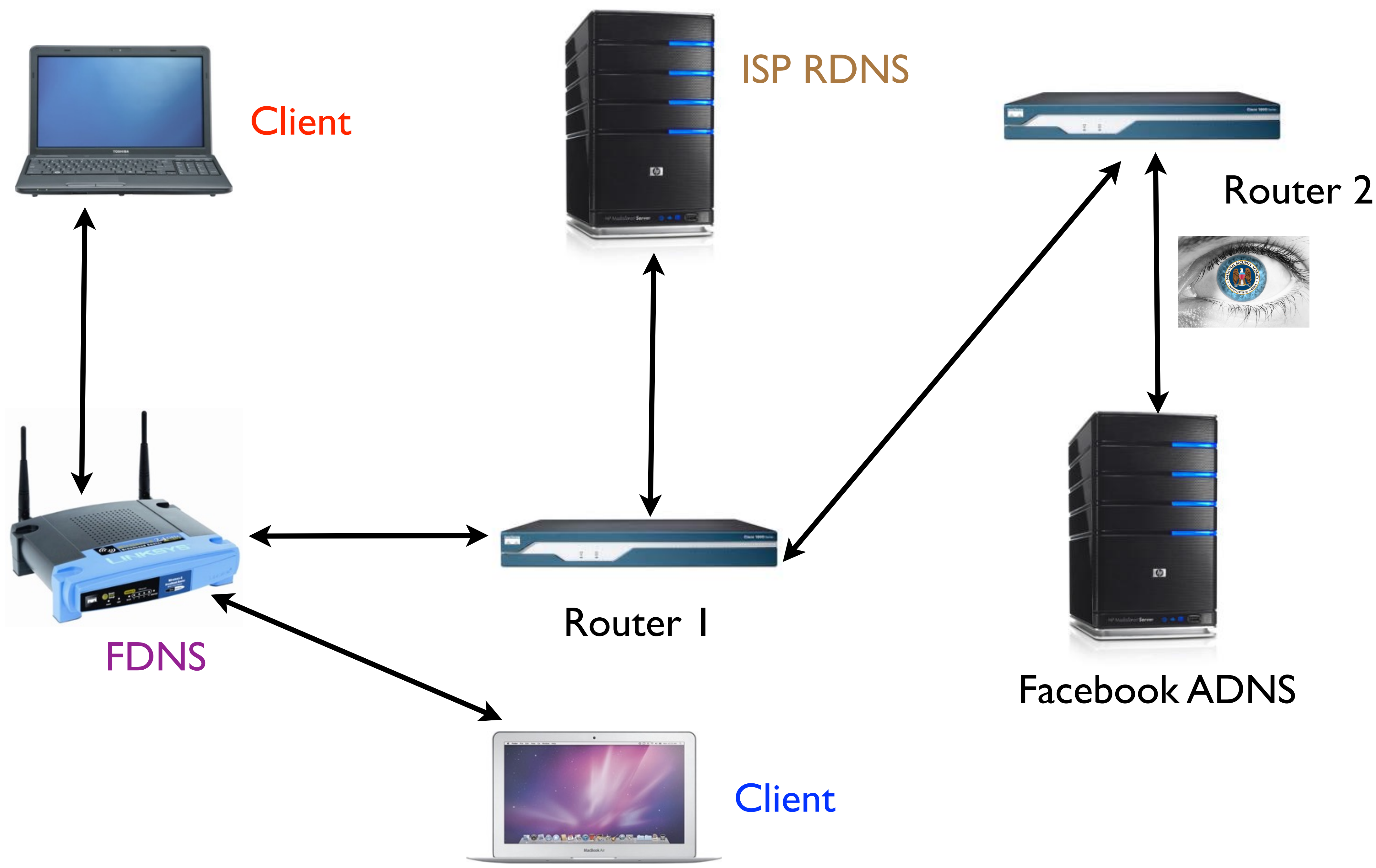

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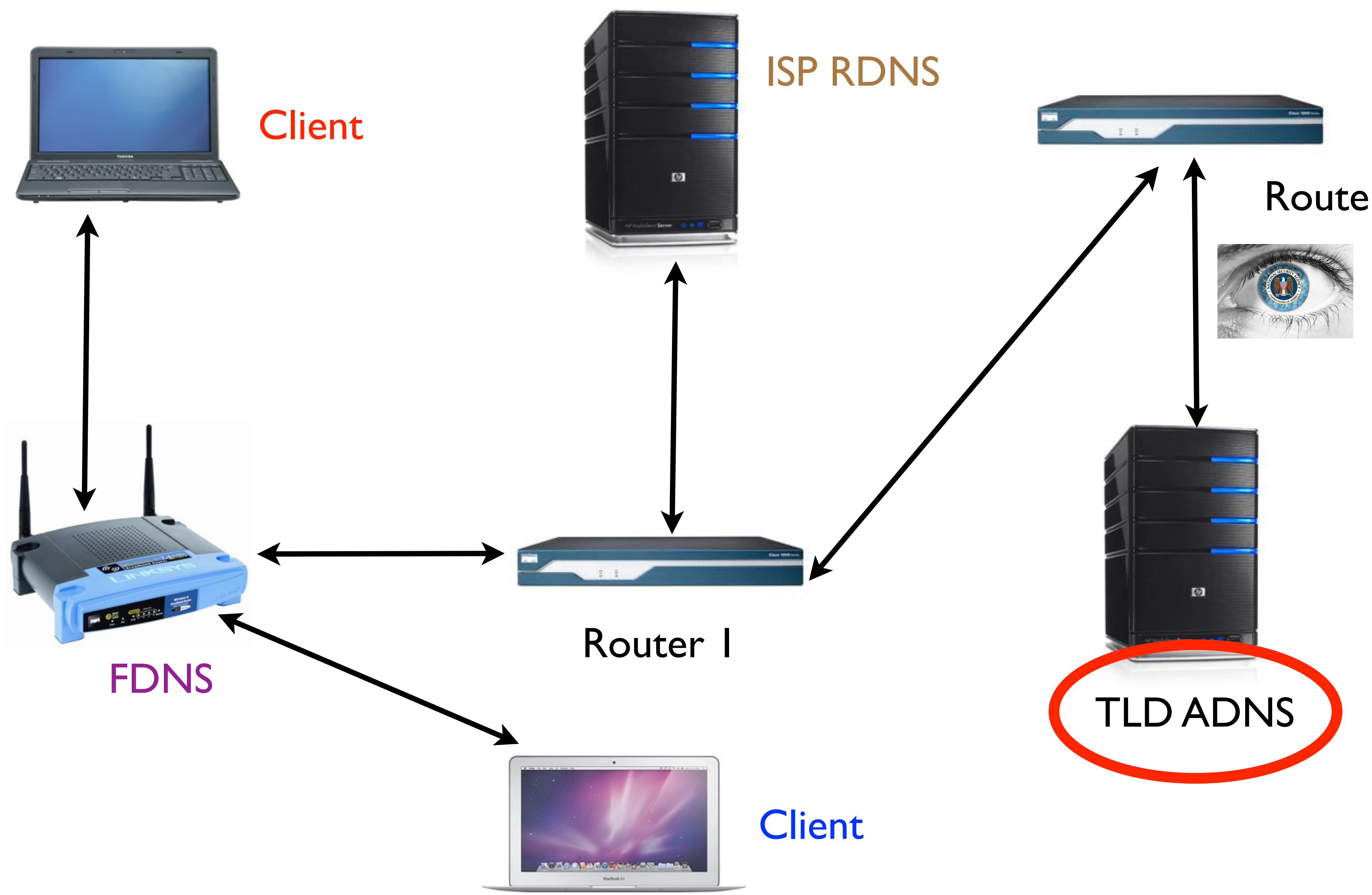

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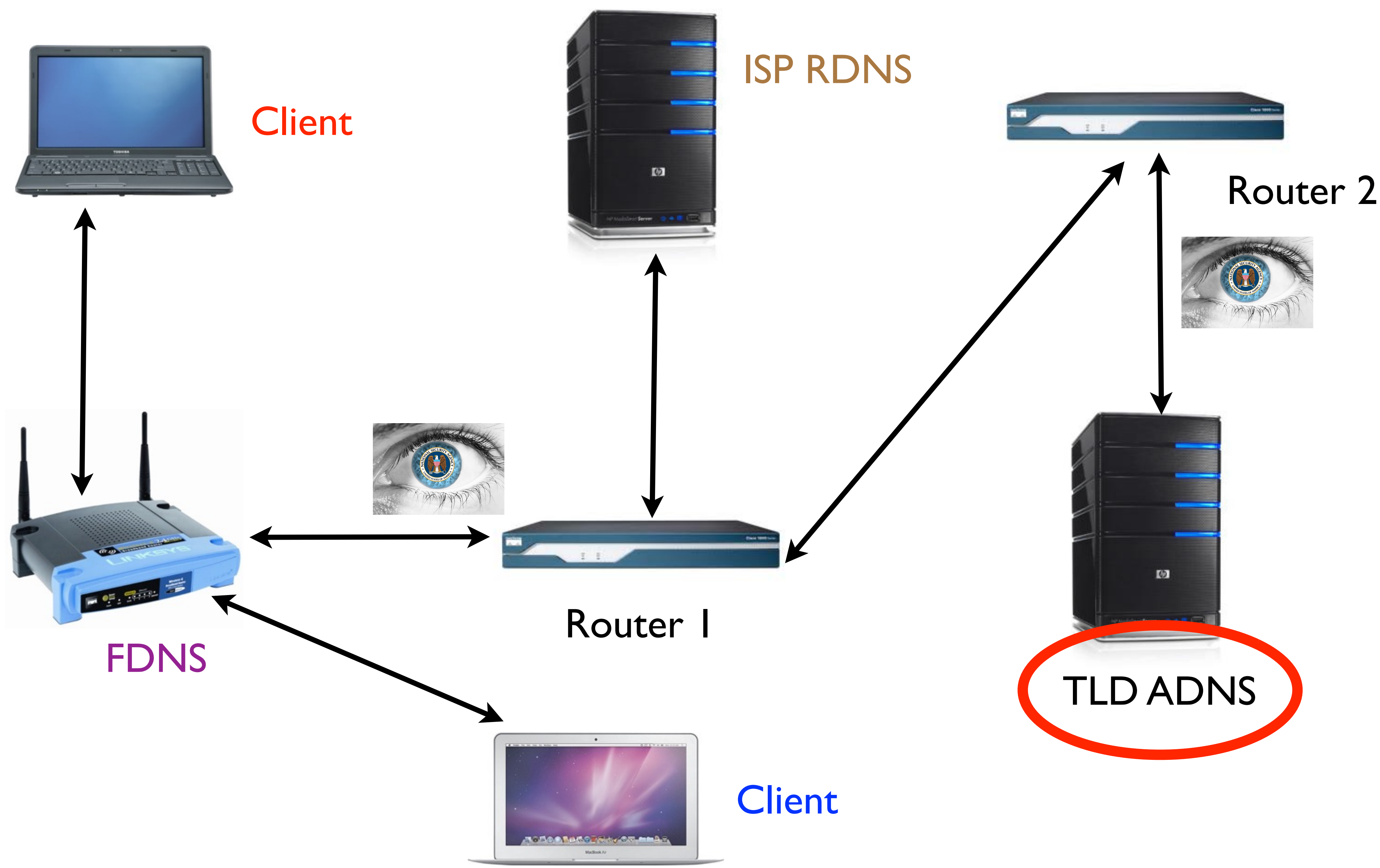

What Can Go Wrong? (3)

An Observation ...

- Thus far the attacks involve legitimate components being fraudulent or simple passive observation

- But, DNS is a simple, clear text protocol ...
- ... as are UDP and IP underneath

- So, crafting technically acceptable portions of the transaction is possible ...
- ... but, how difficult is it?

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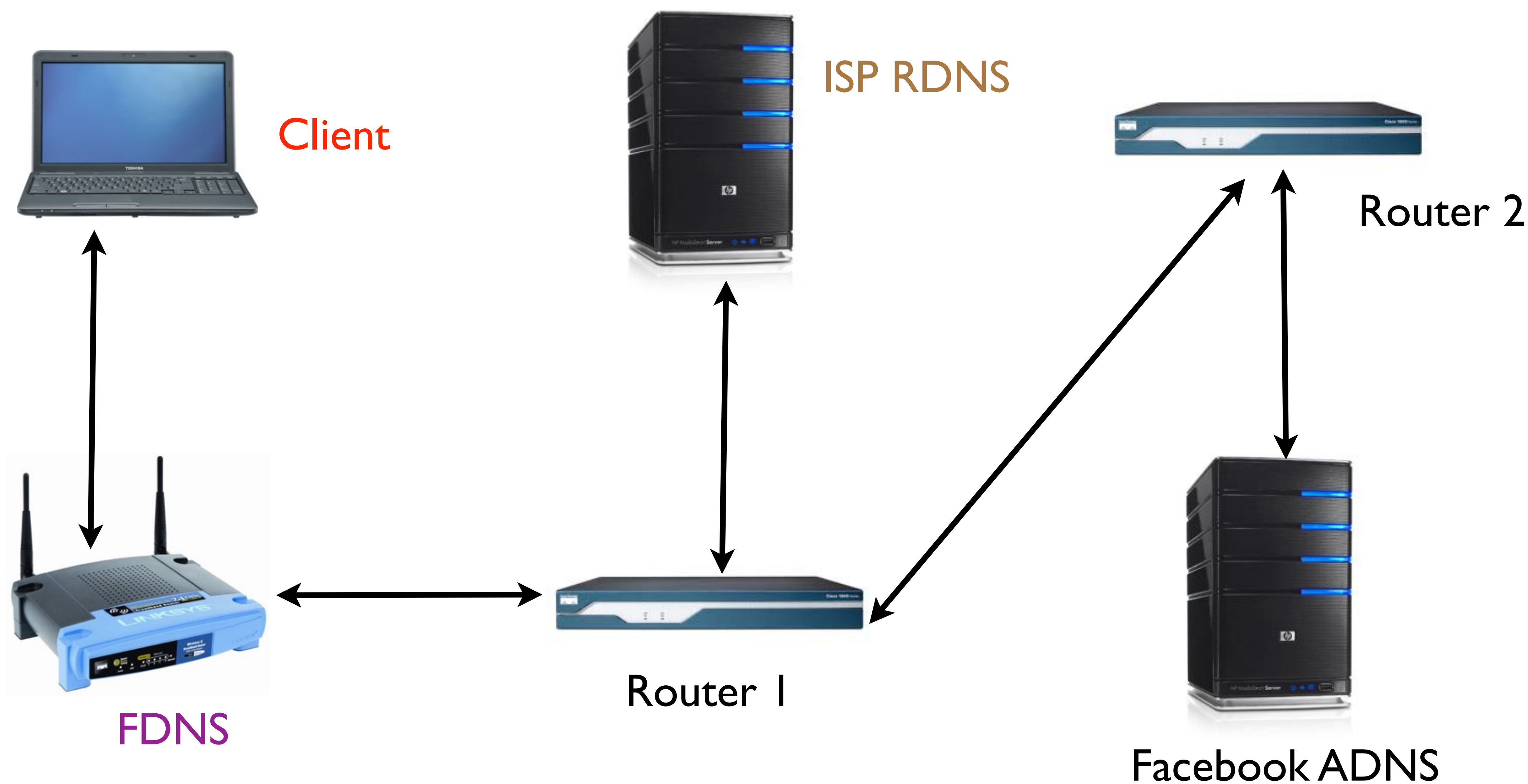
- If we know all of these we can create components of the transactions that are ...
  .... *technically acceptable*
  .... *but, contain fraudulent content*

What Can Go Wrong? (3.5)



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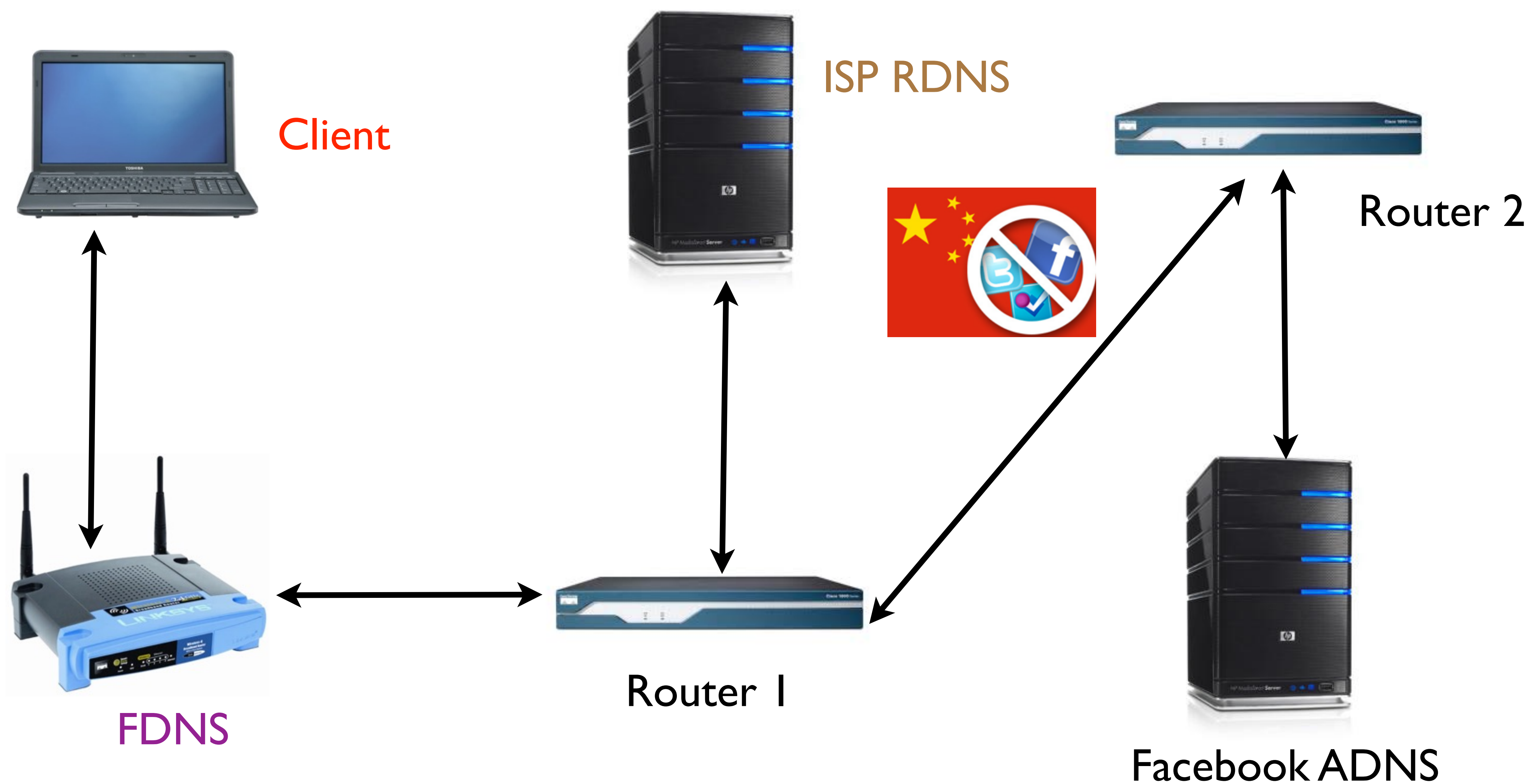

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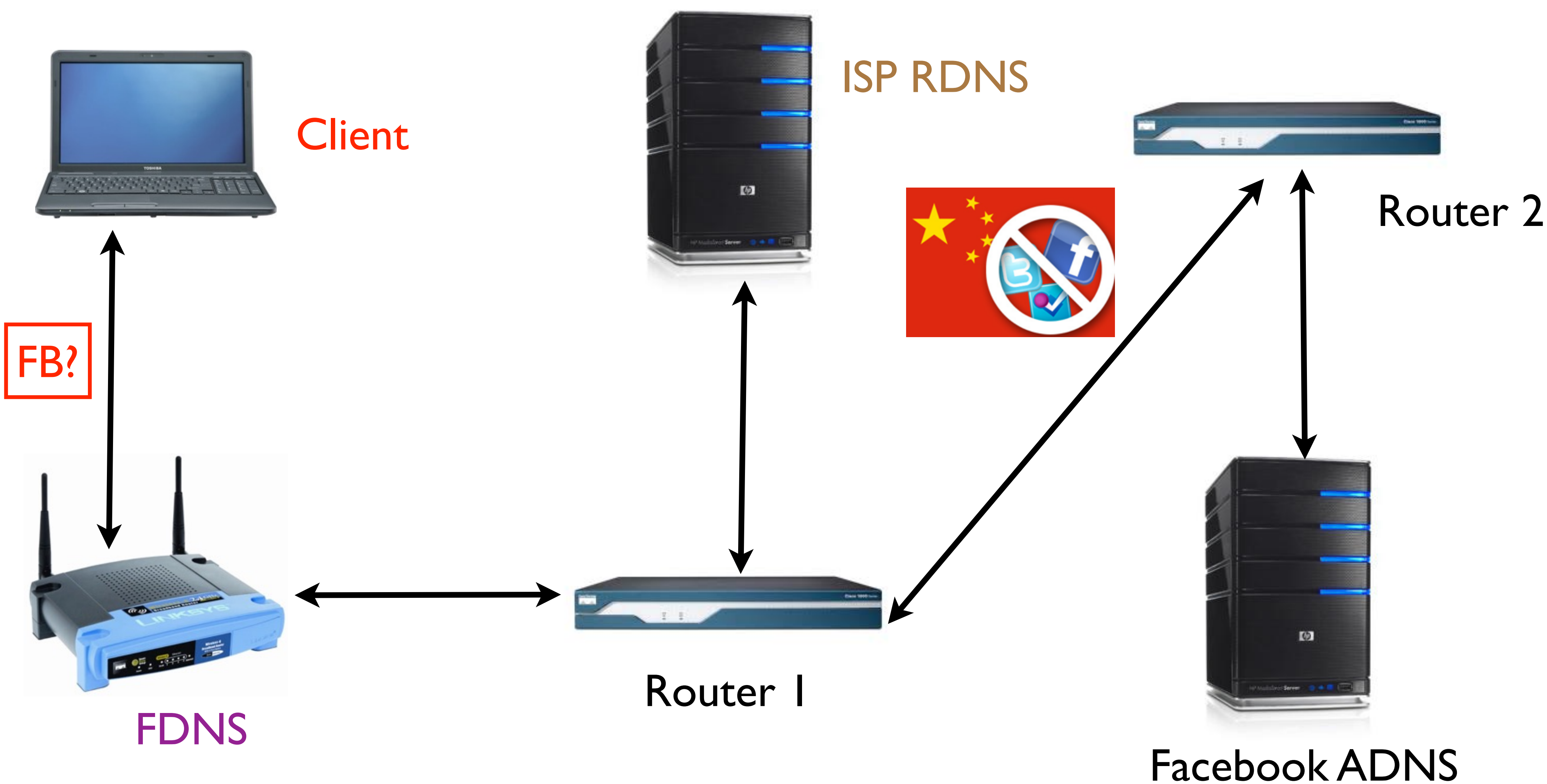

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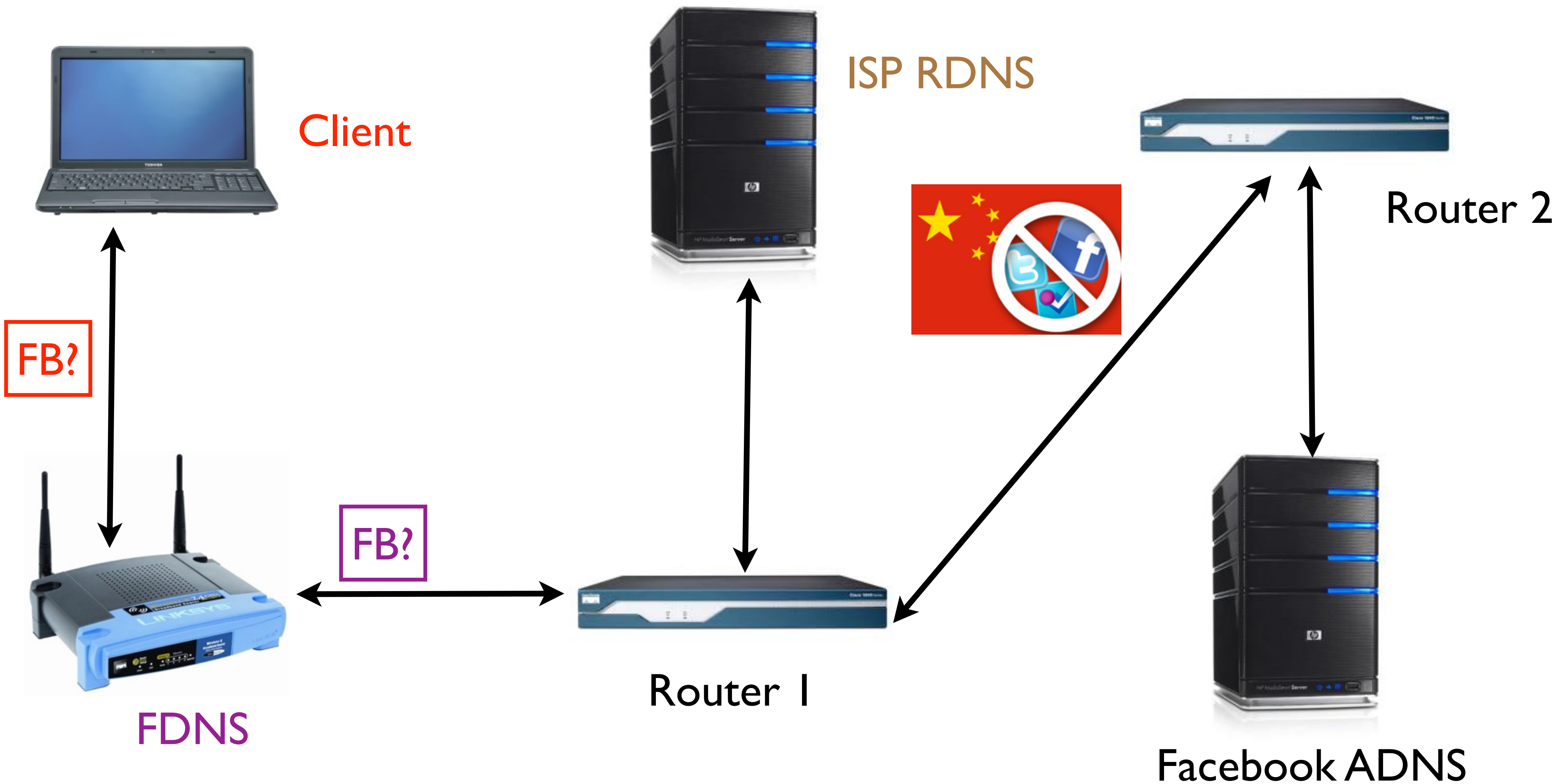

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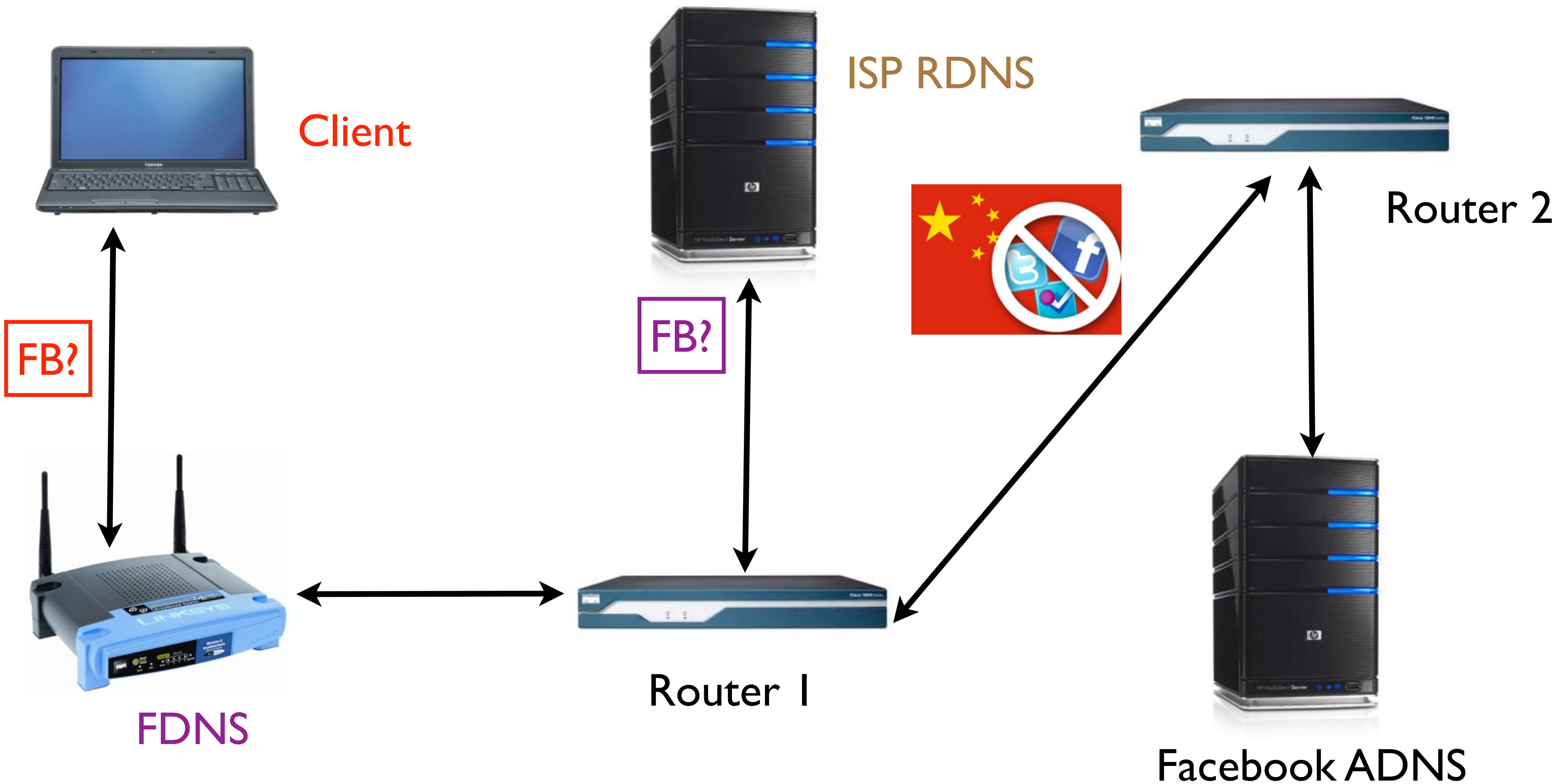

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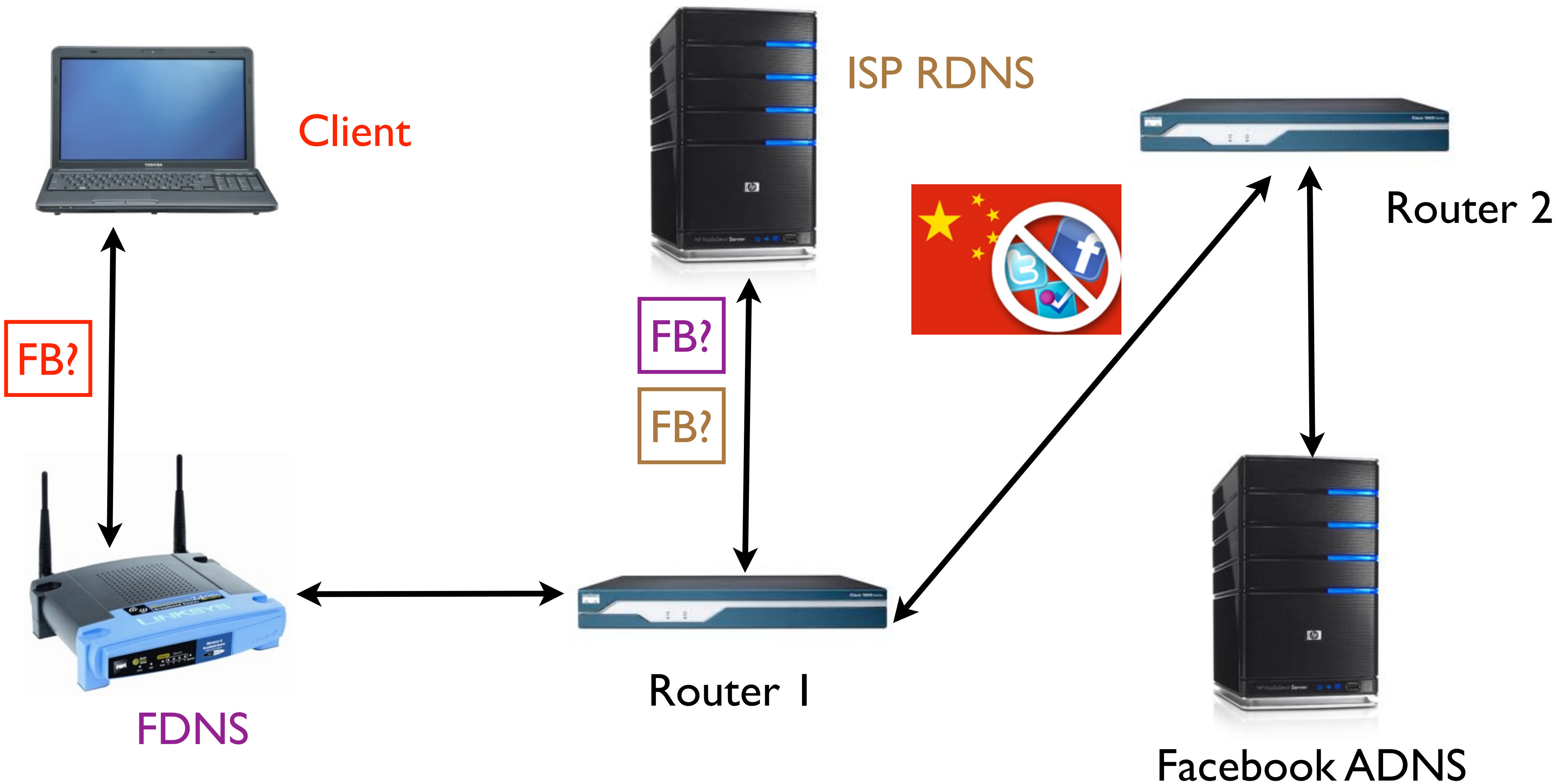

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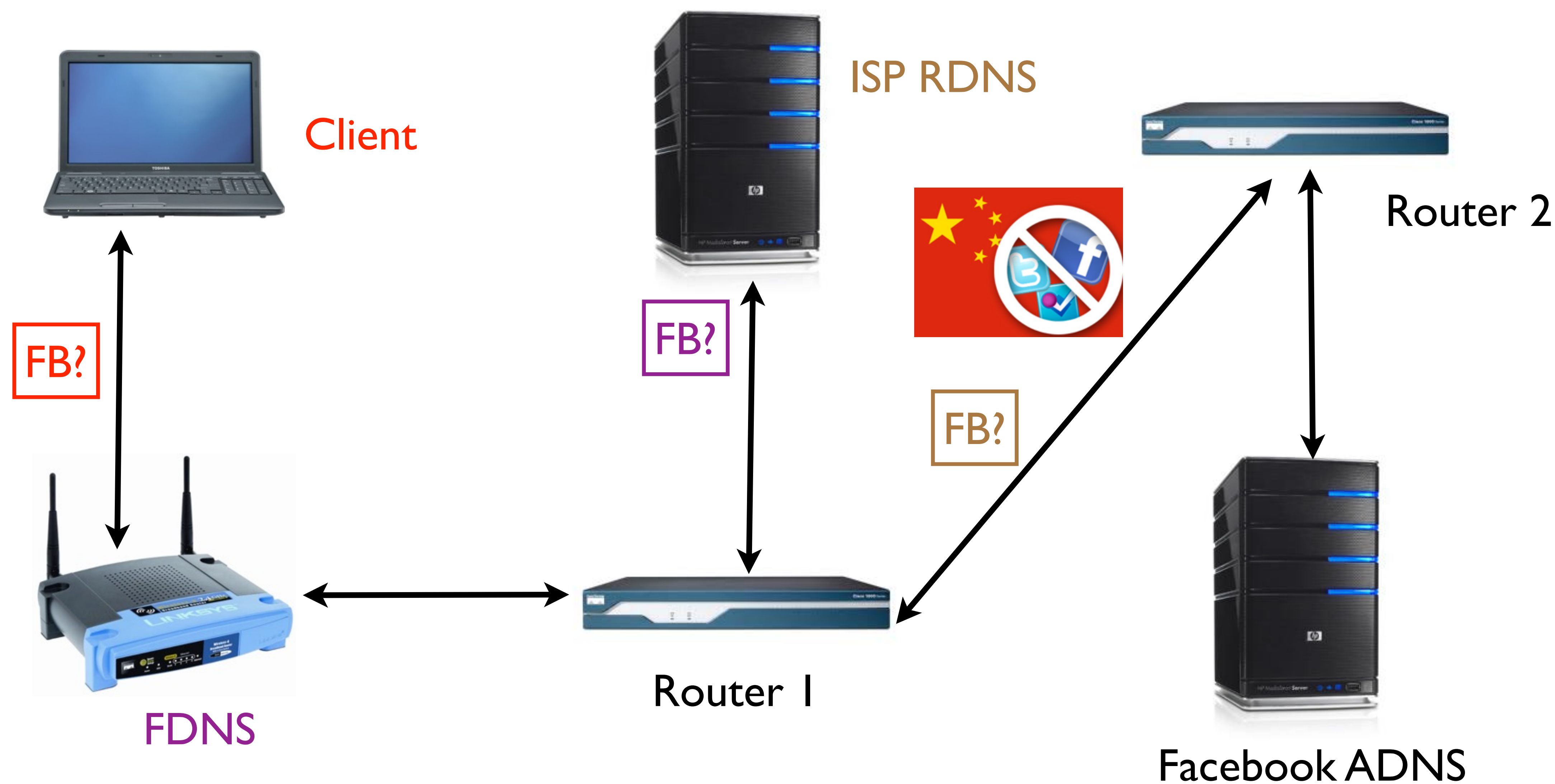

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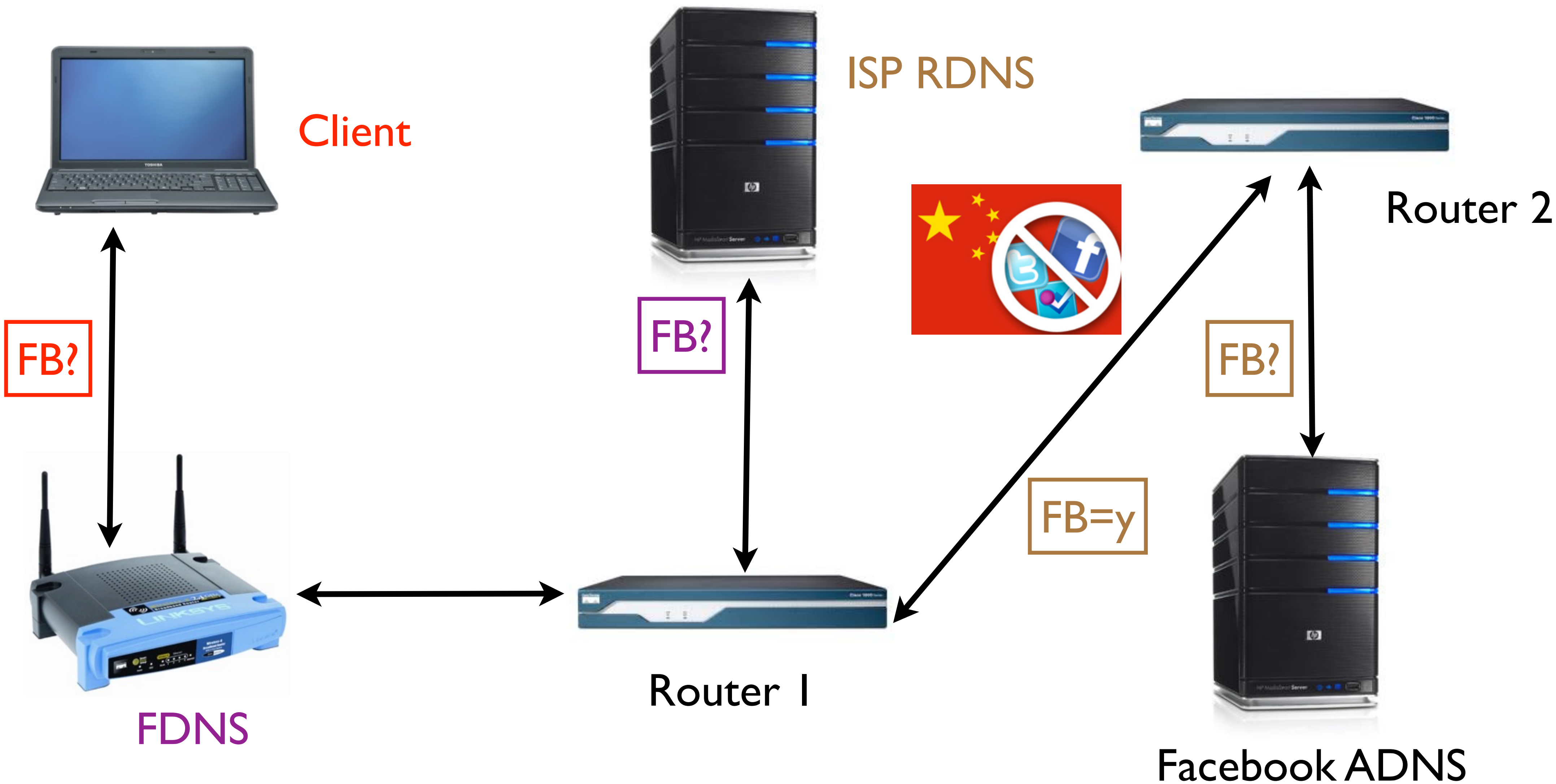

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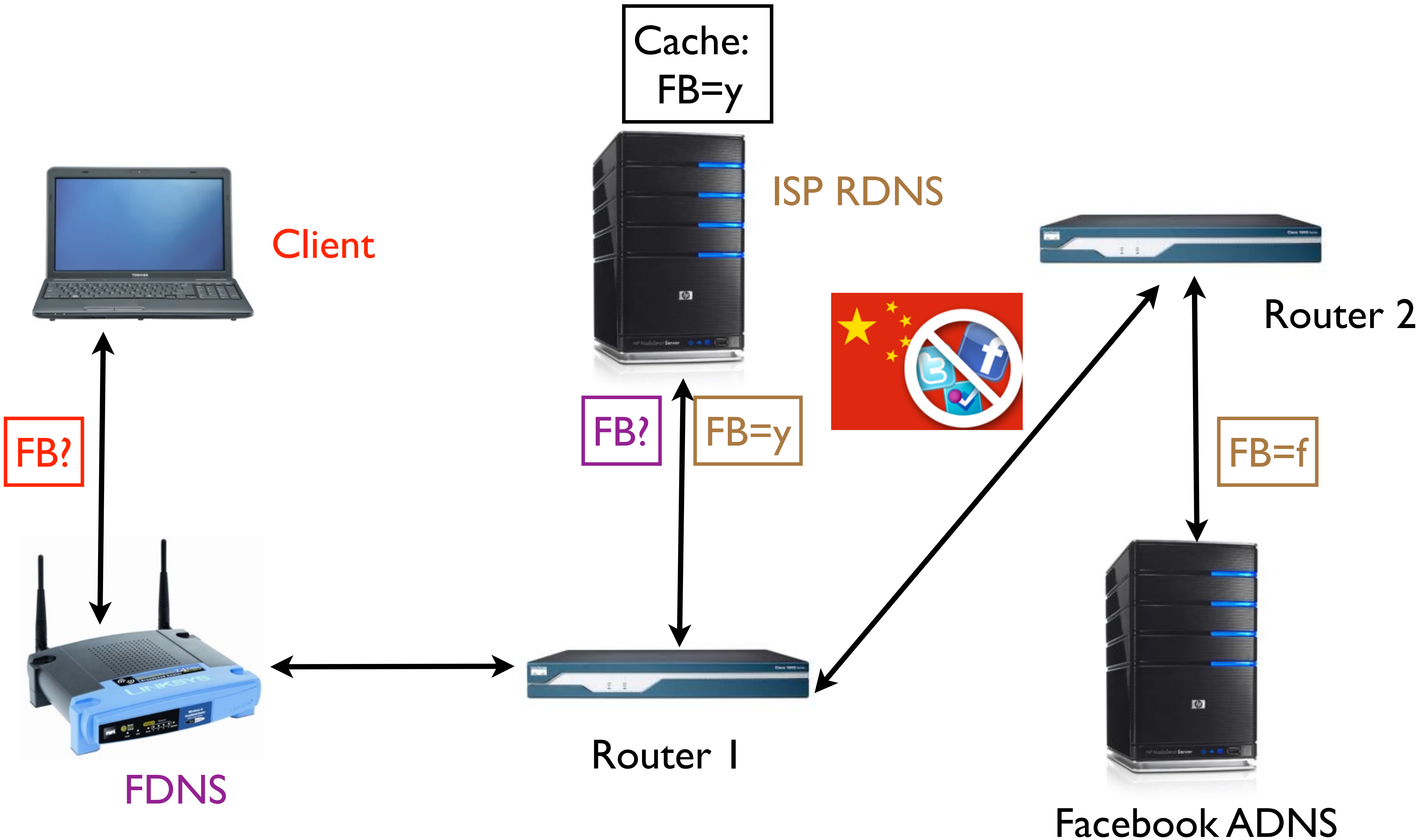

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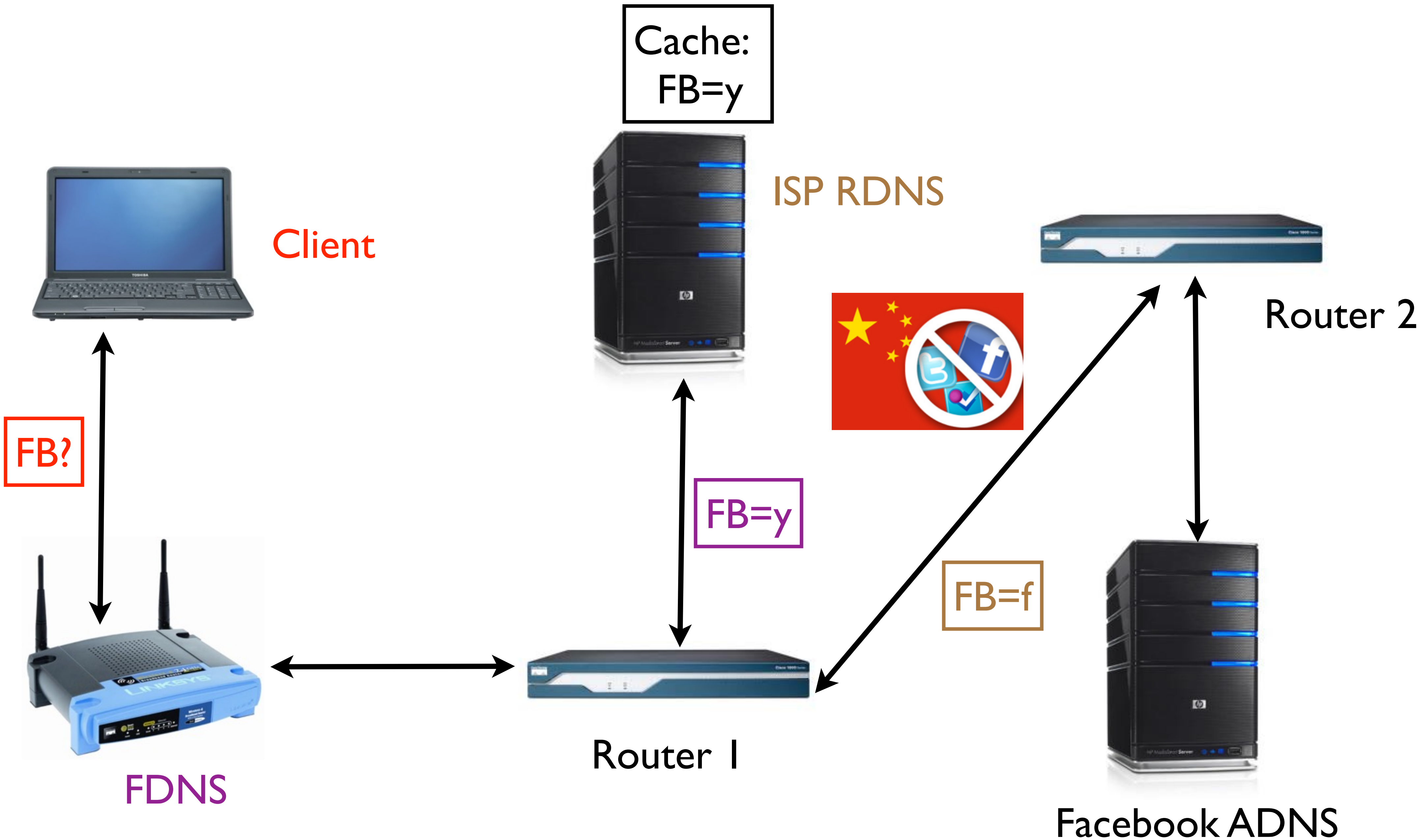

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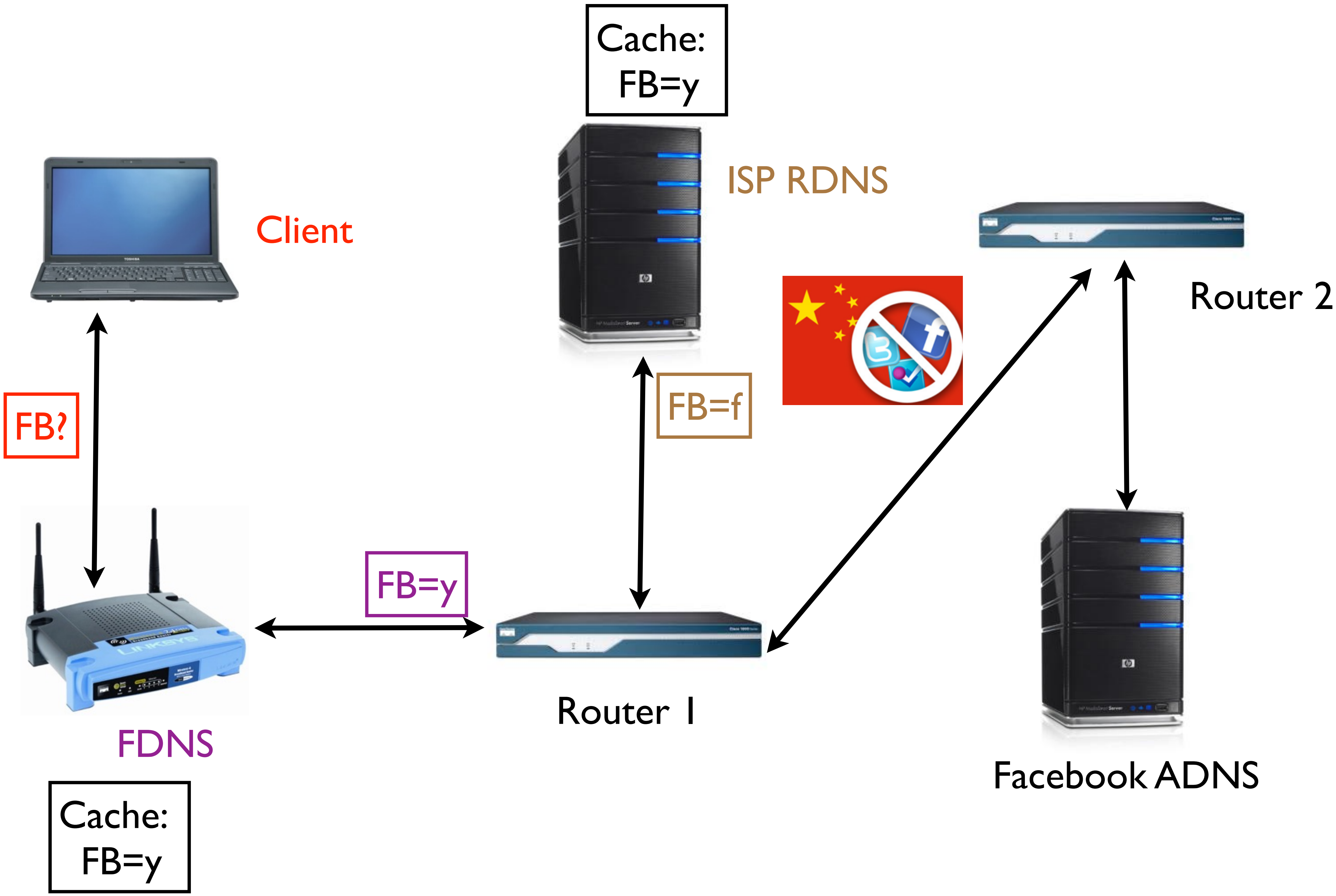

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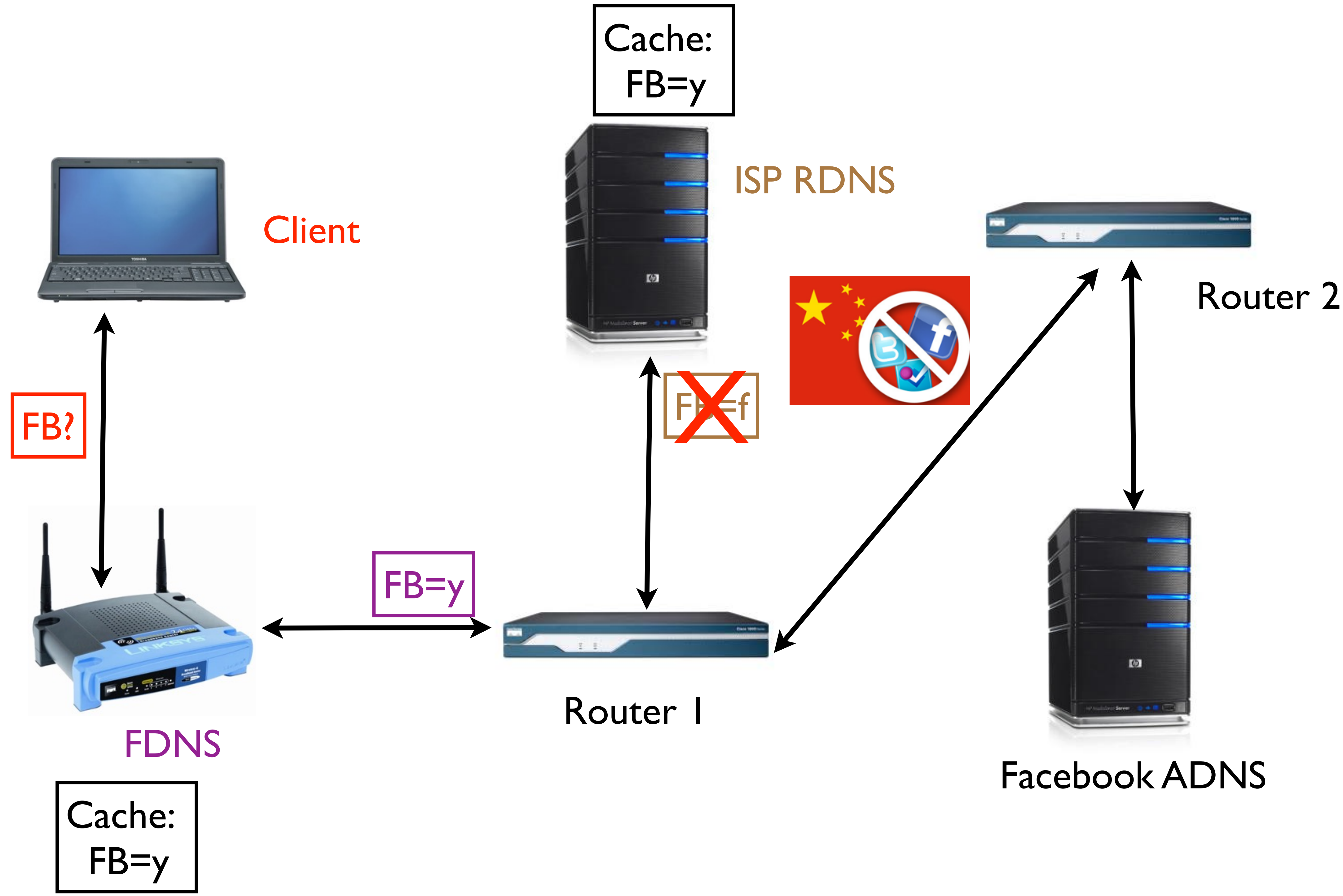

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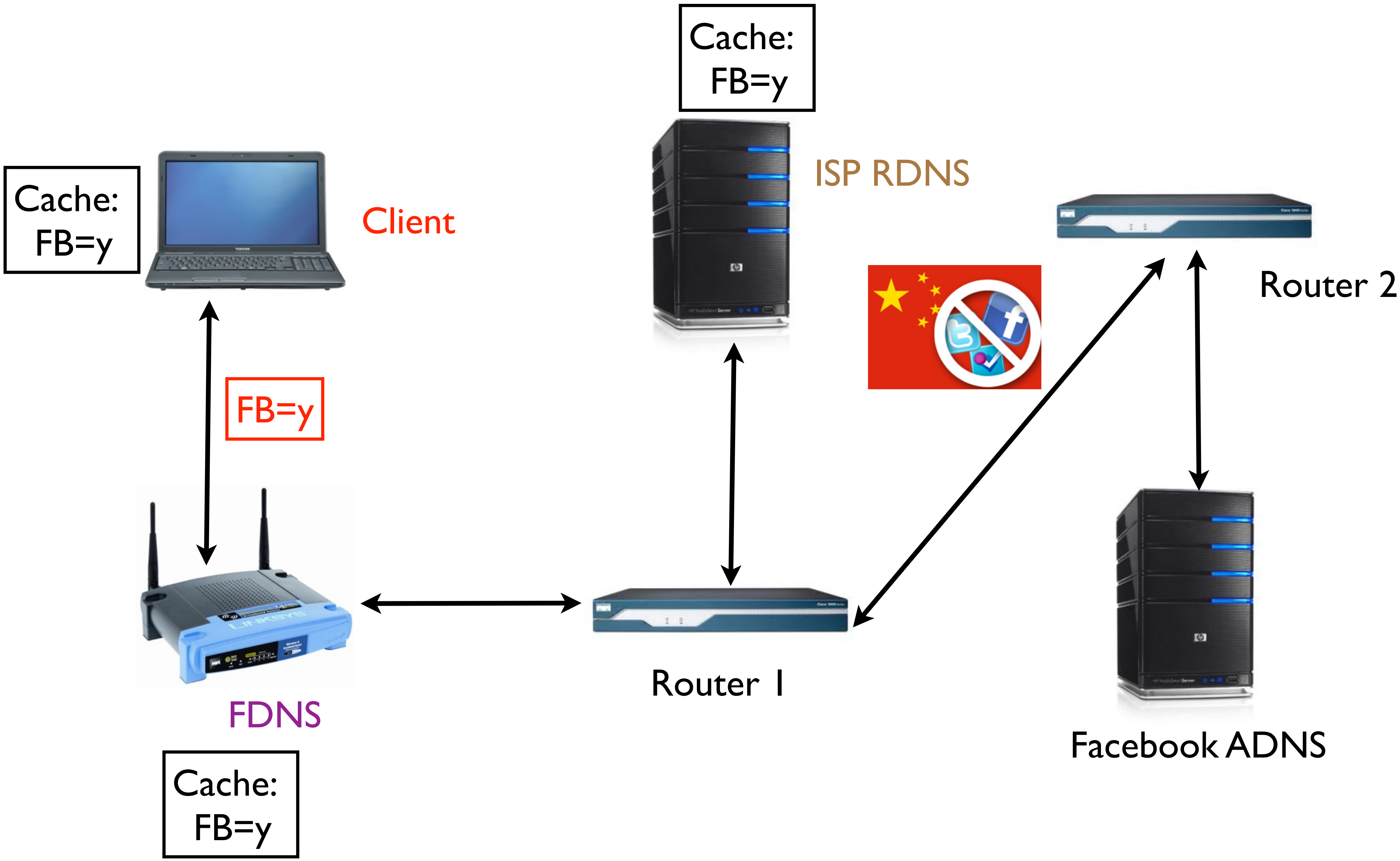

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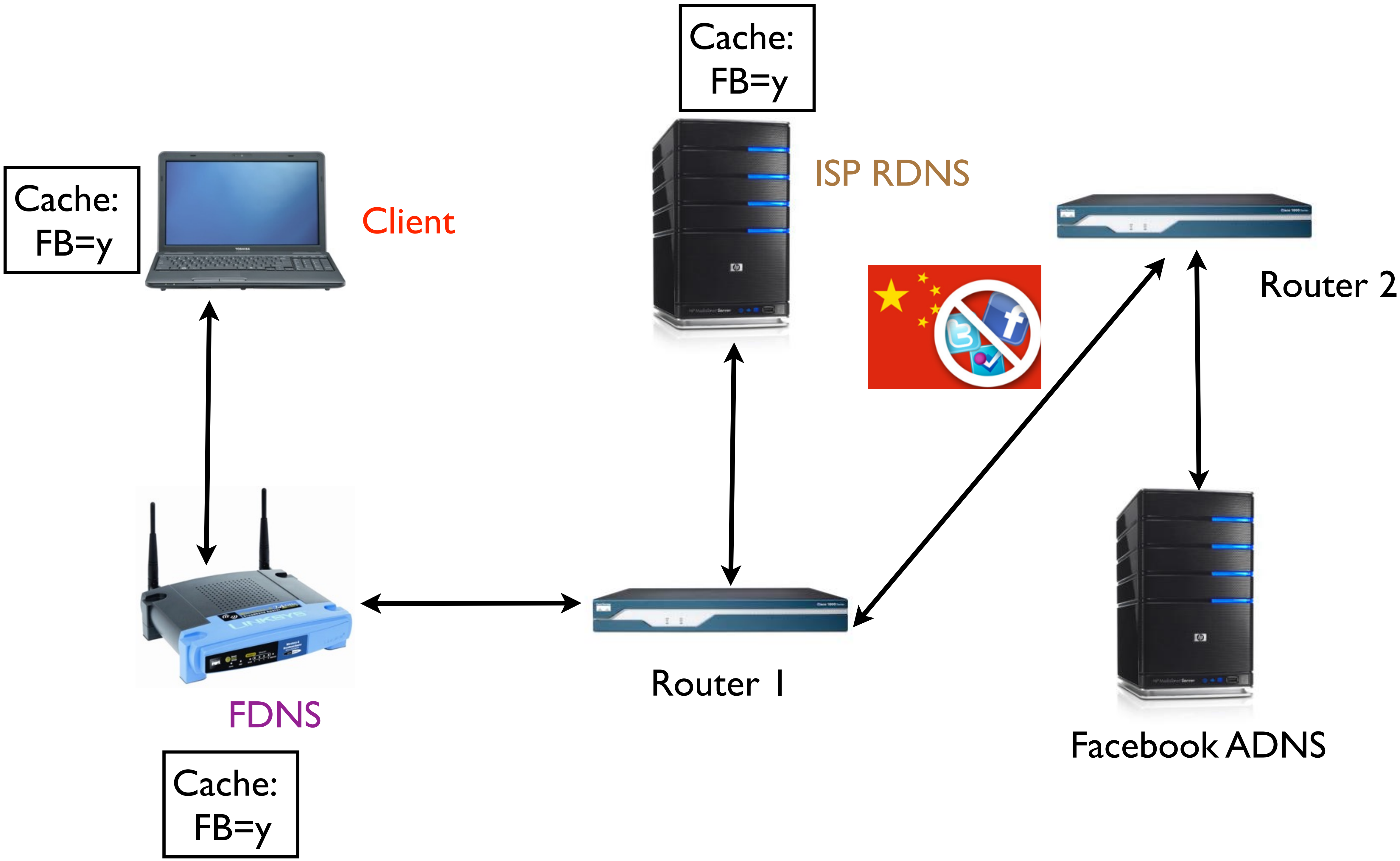

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- If we observe a request, we can create a fraudulent response
- But, what if we don't observe the request?
  - Forging a response is not as hard as one might imagine!

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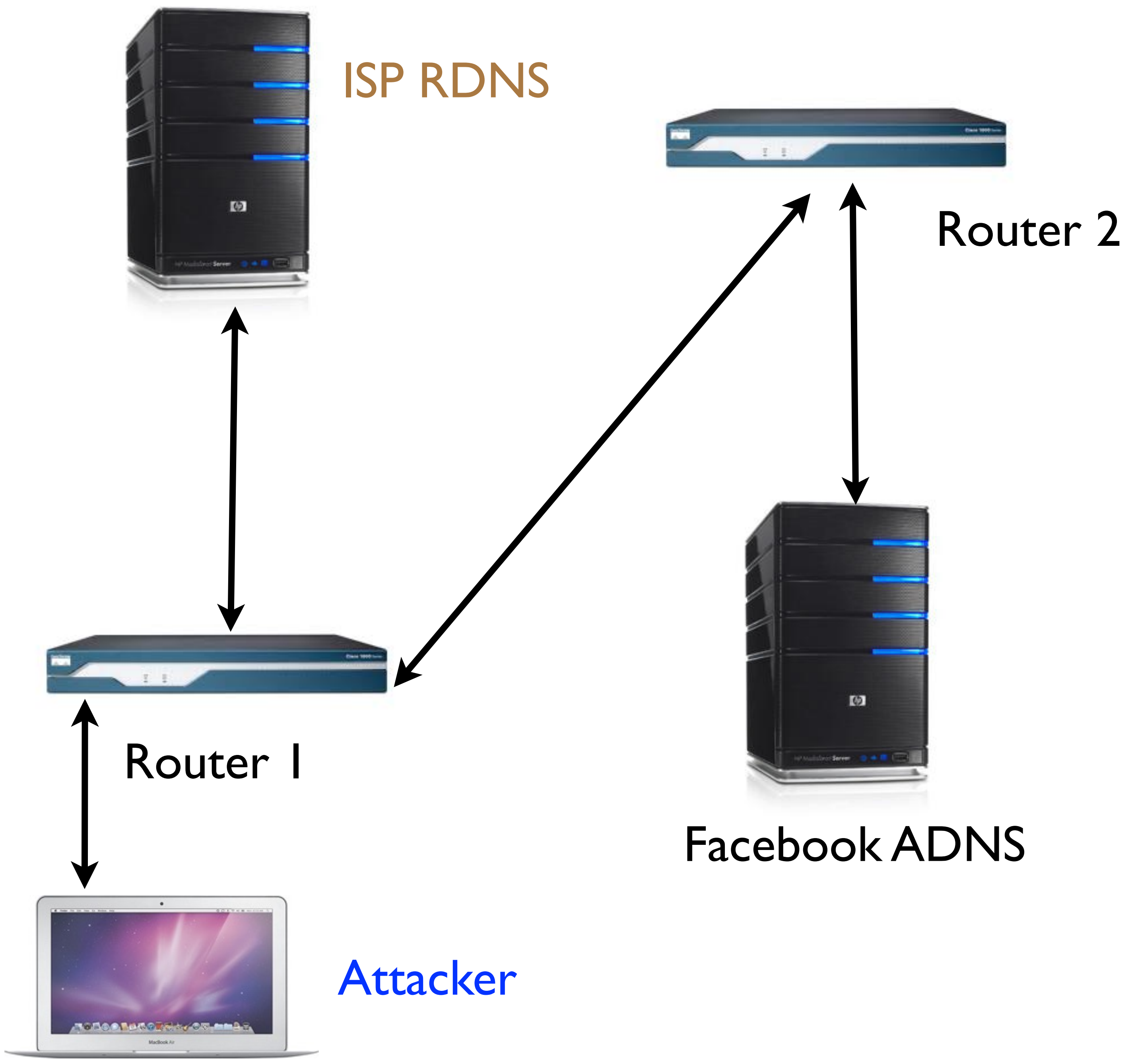

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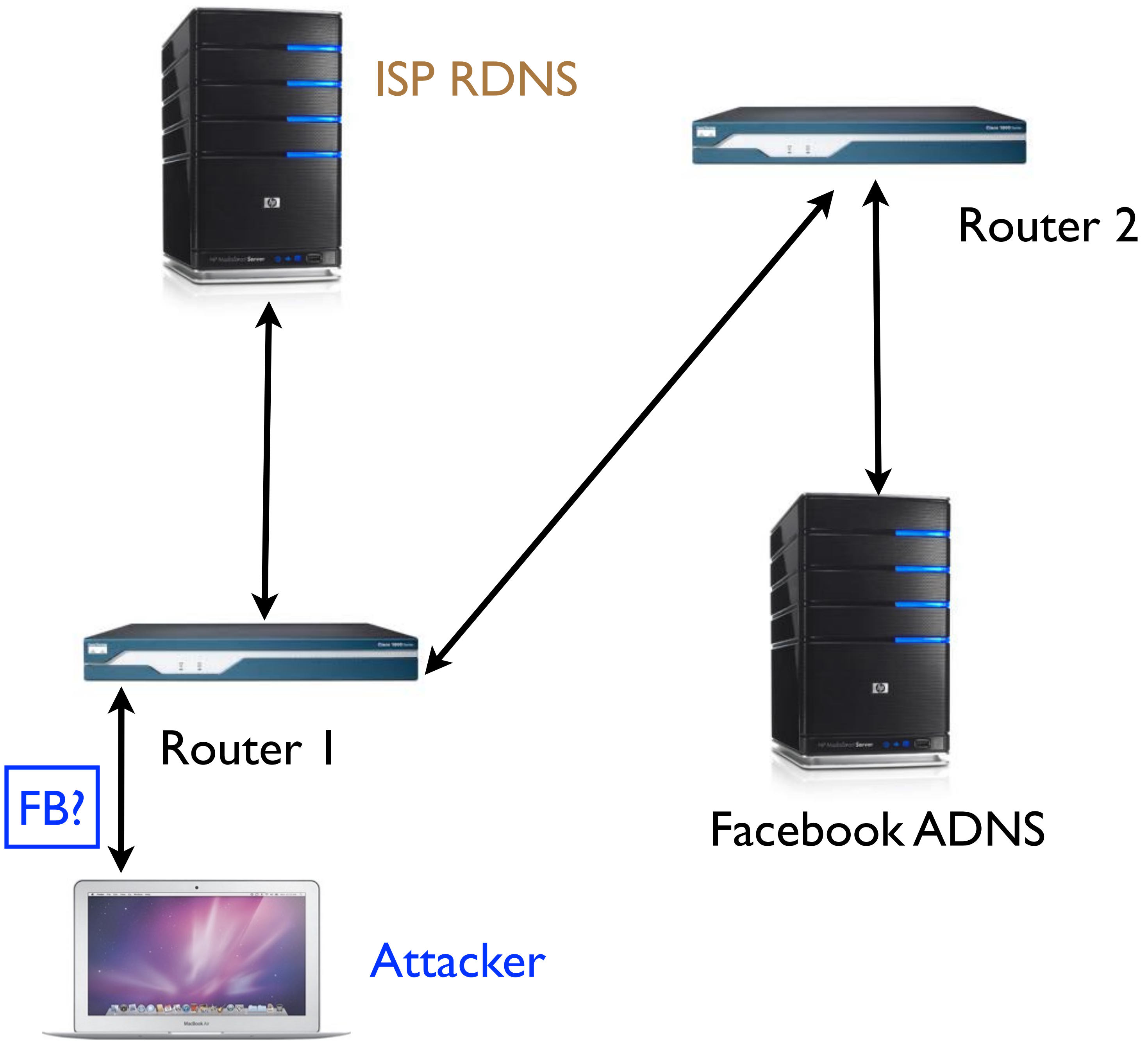
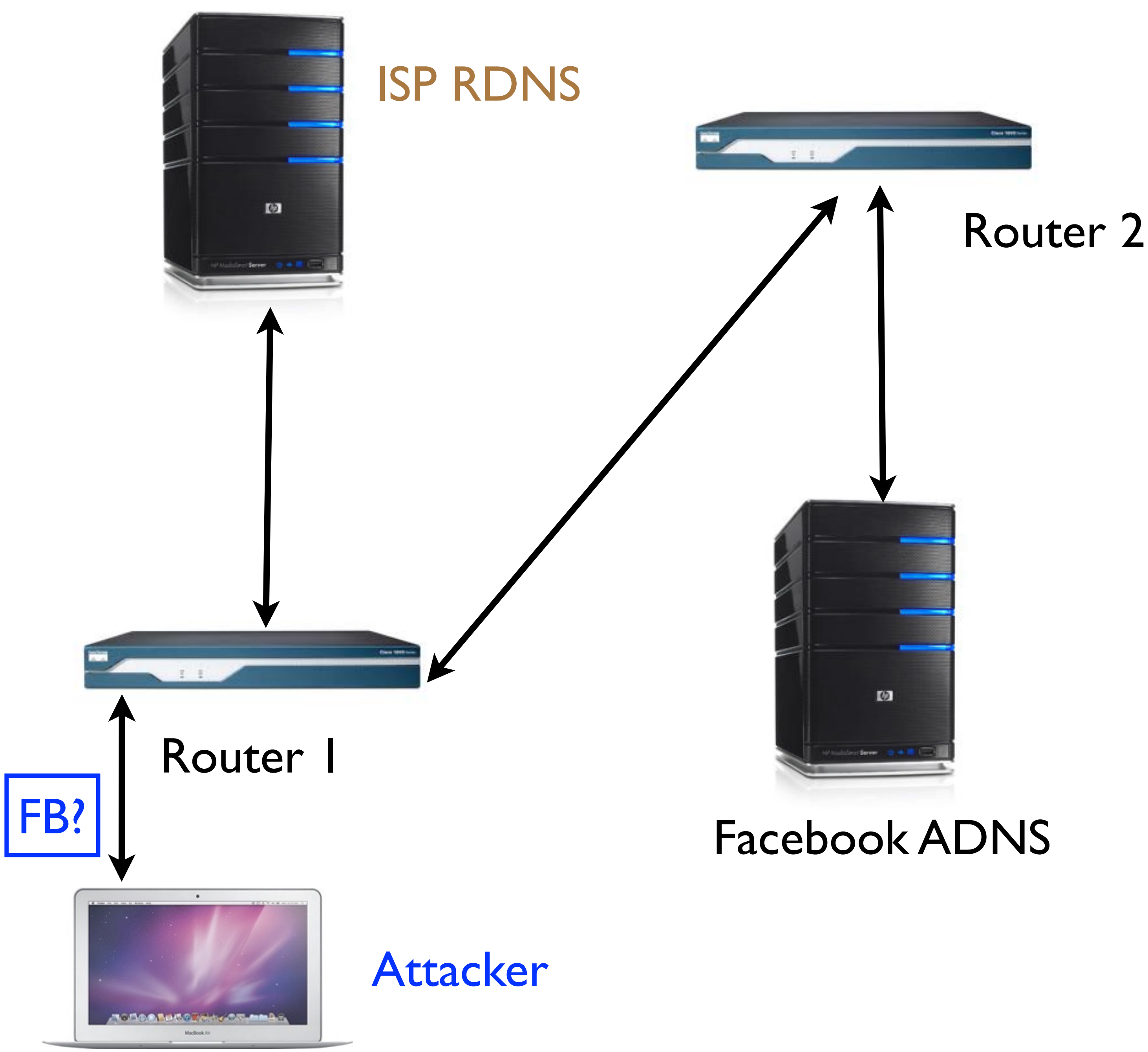


What Can Go Wrong? (4)

local IP: Client IP
remote IP: RDNS
local port: X
remote port: 53
txID:Y
query: www.facebook.com



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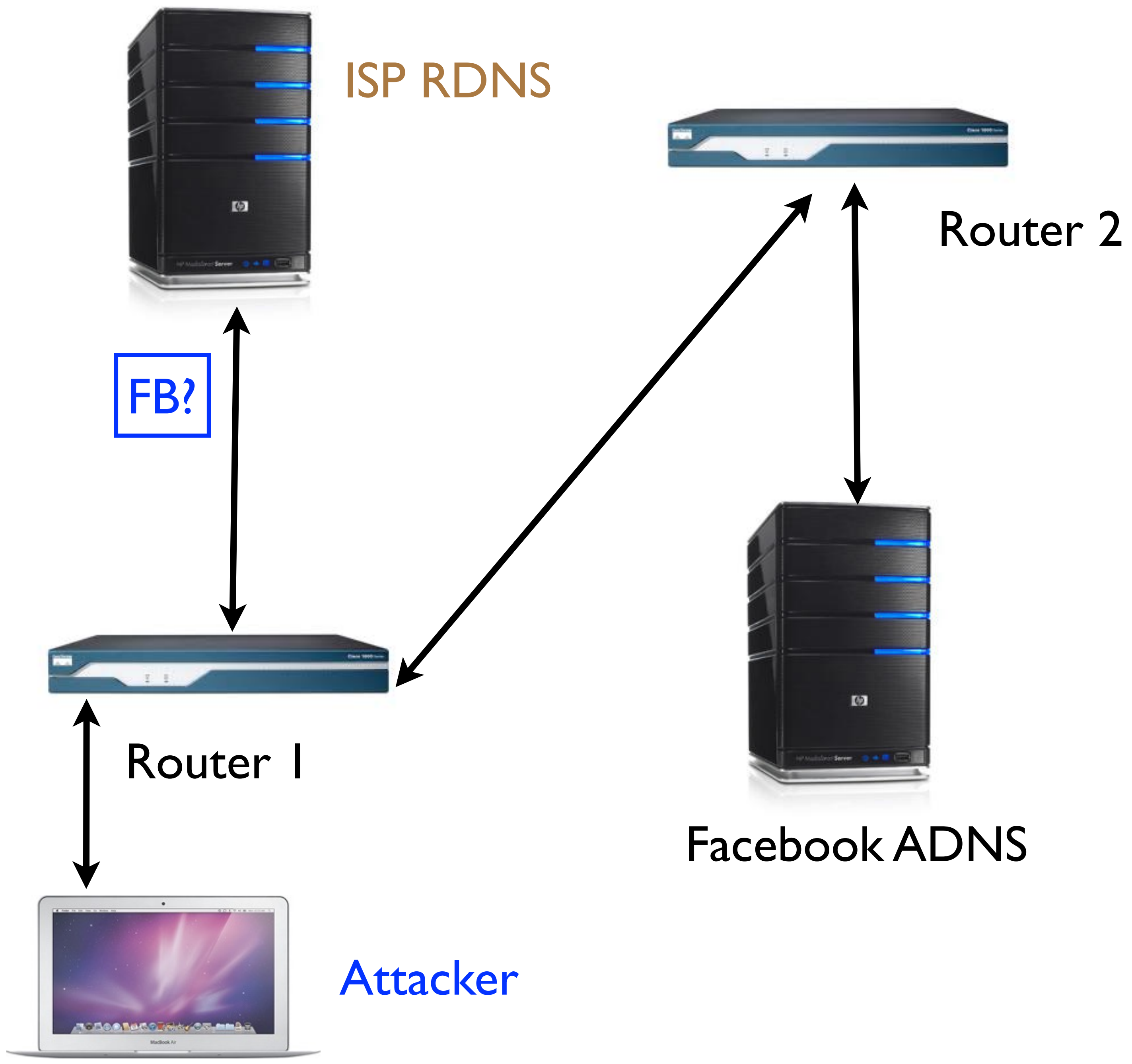

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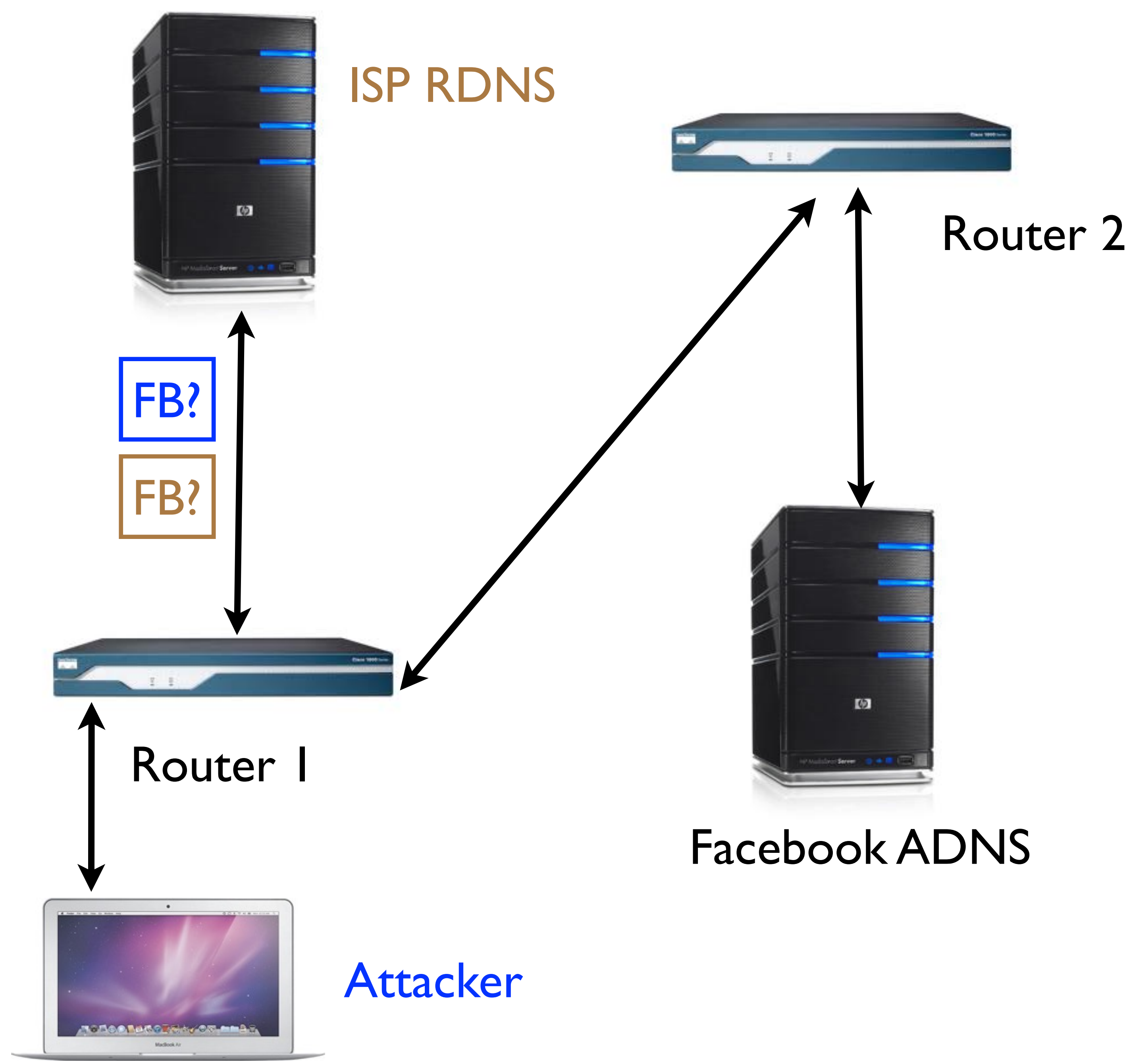

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txID: ???
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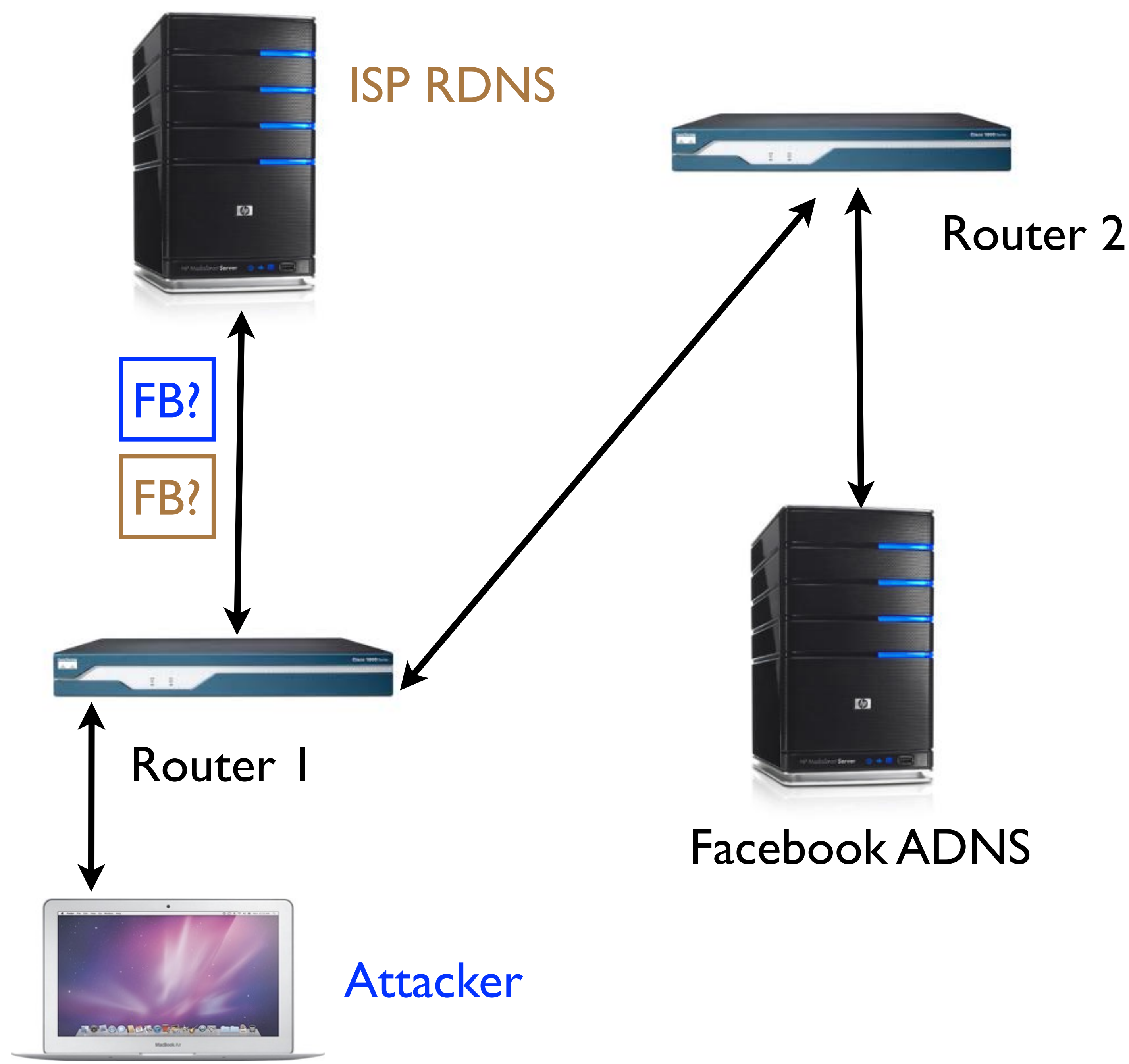

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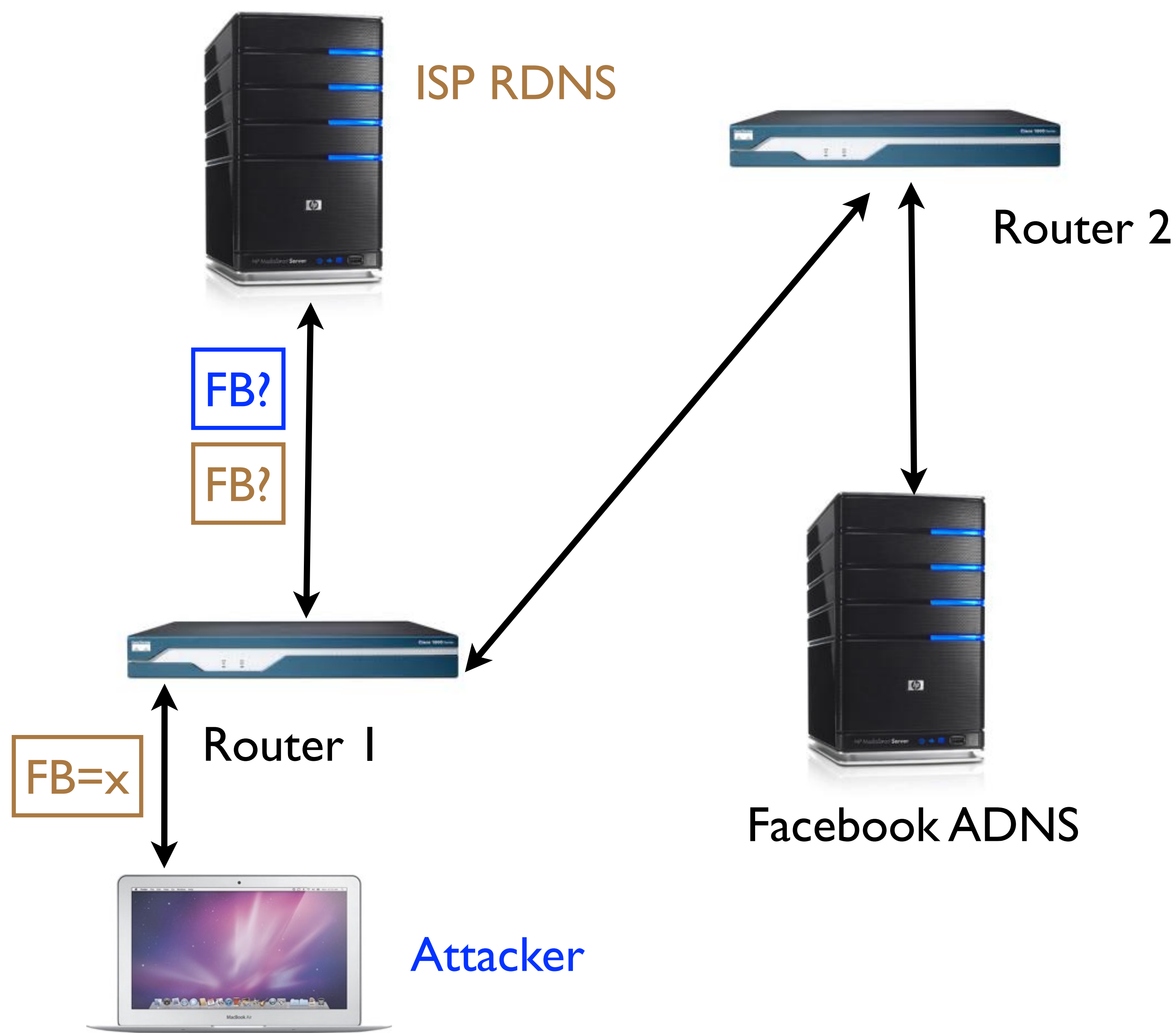

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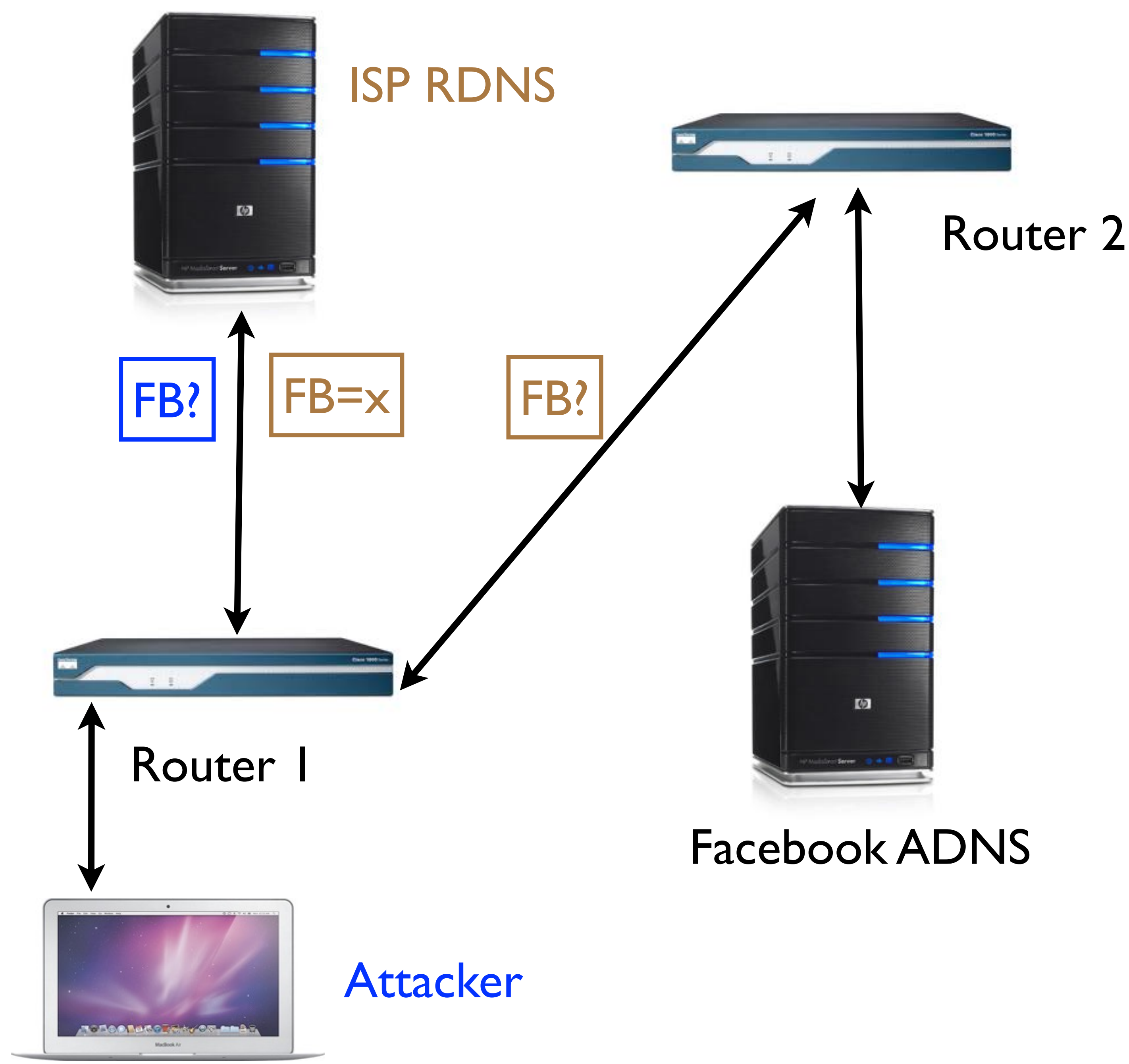

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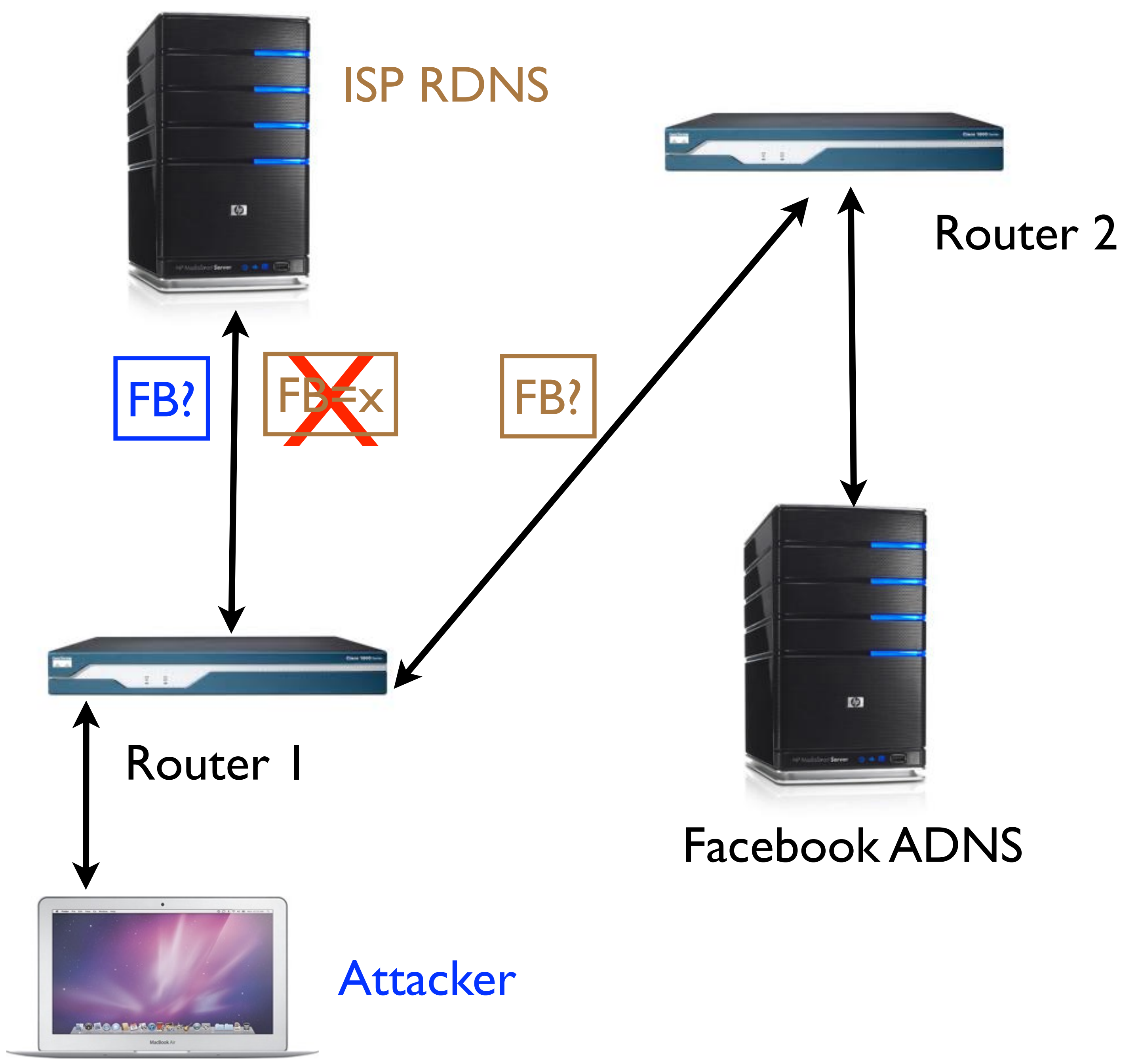

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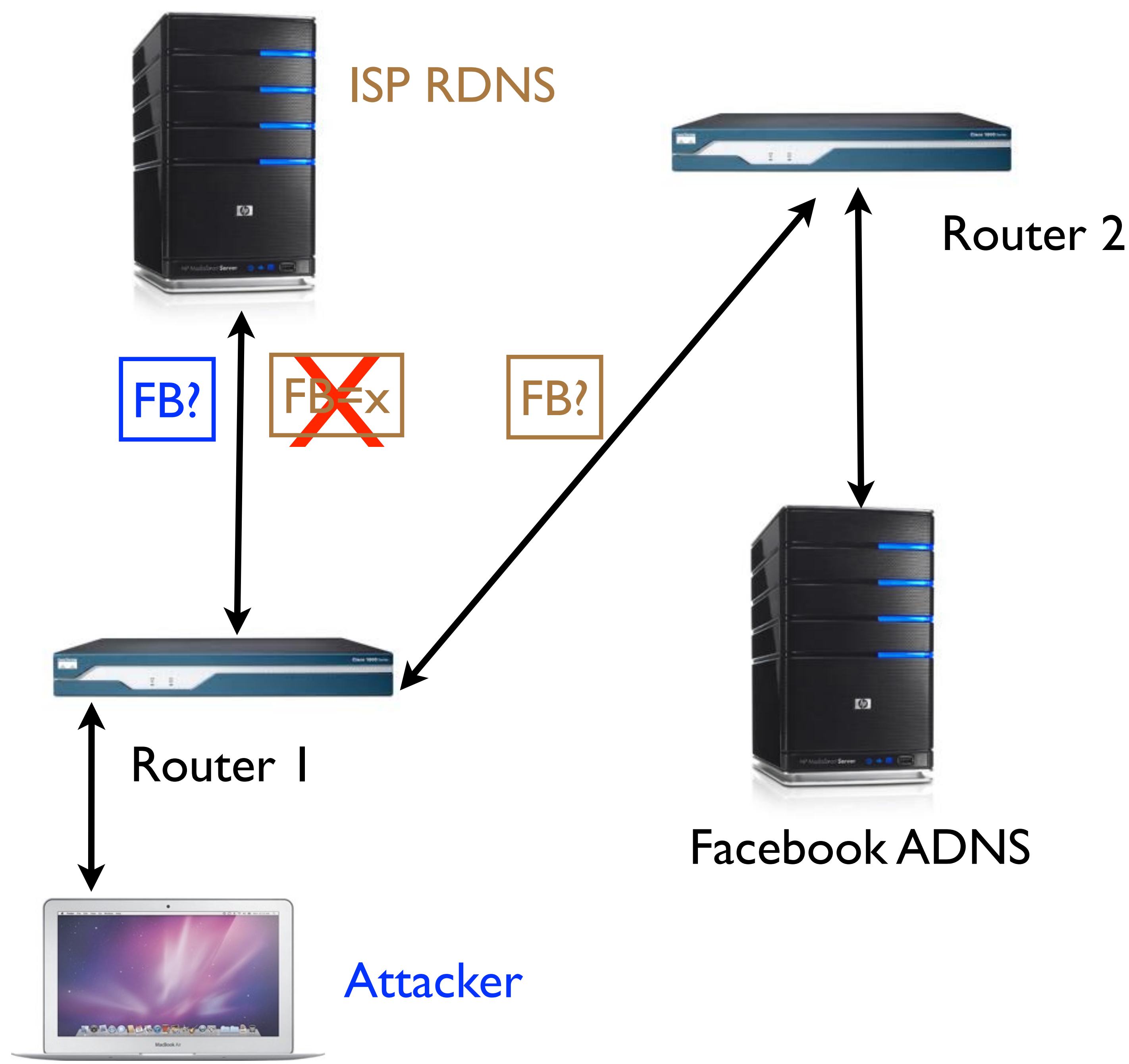
query: www.facebook.com

local IP: RDNS
remote IP: FB ADNS
local port: ???
remote port: 53
txID: ???
query: www.facebook.com



Kaminsky Attack

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- 15 guesses, P(success) = 0.000000003

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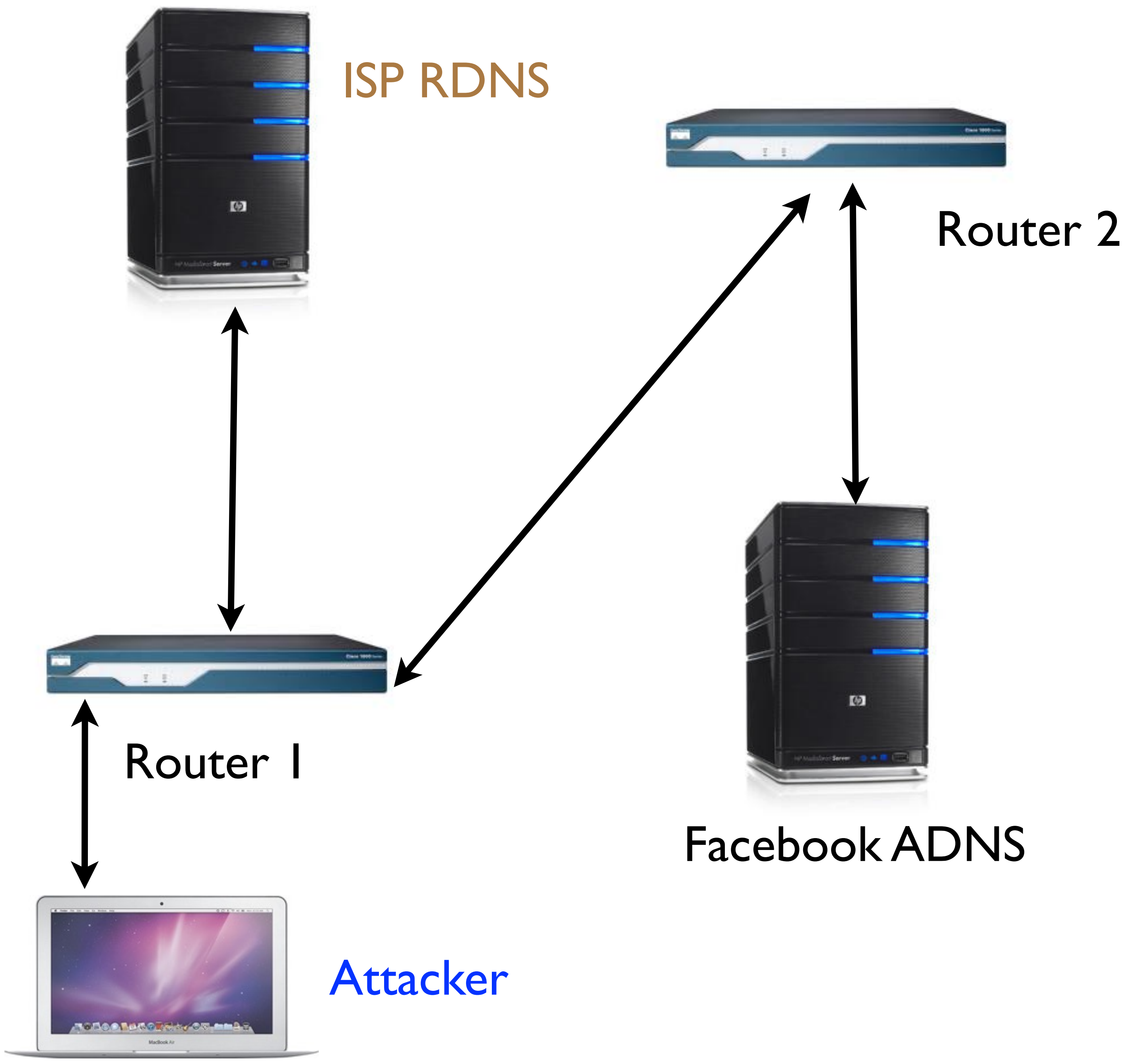
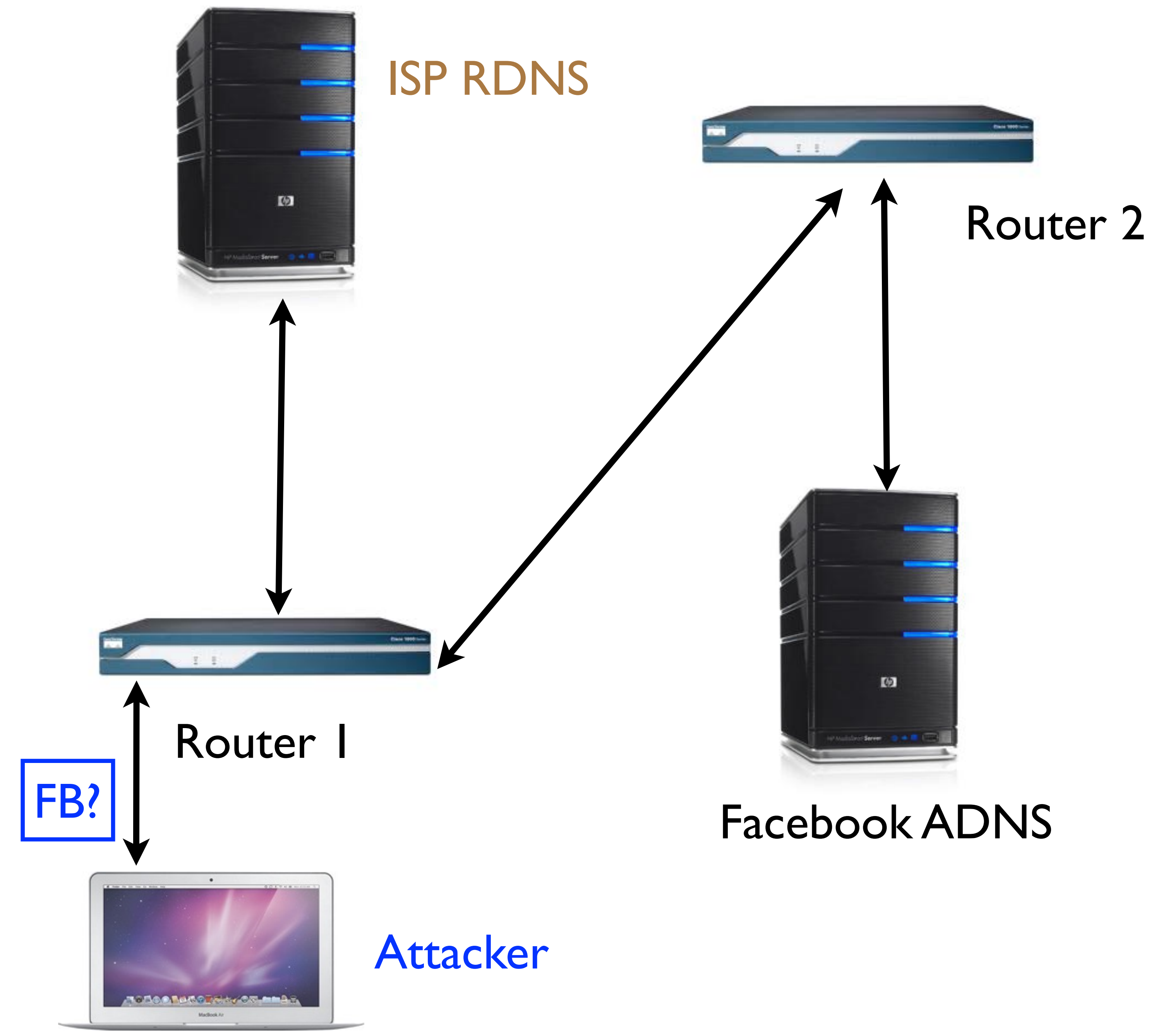
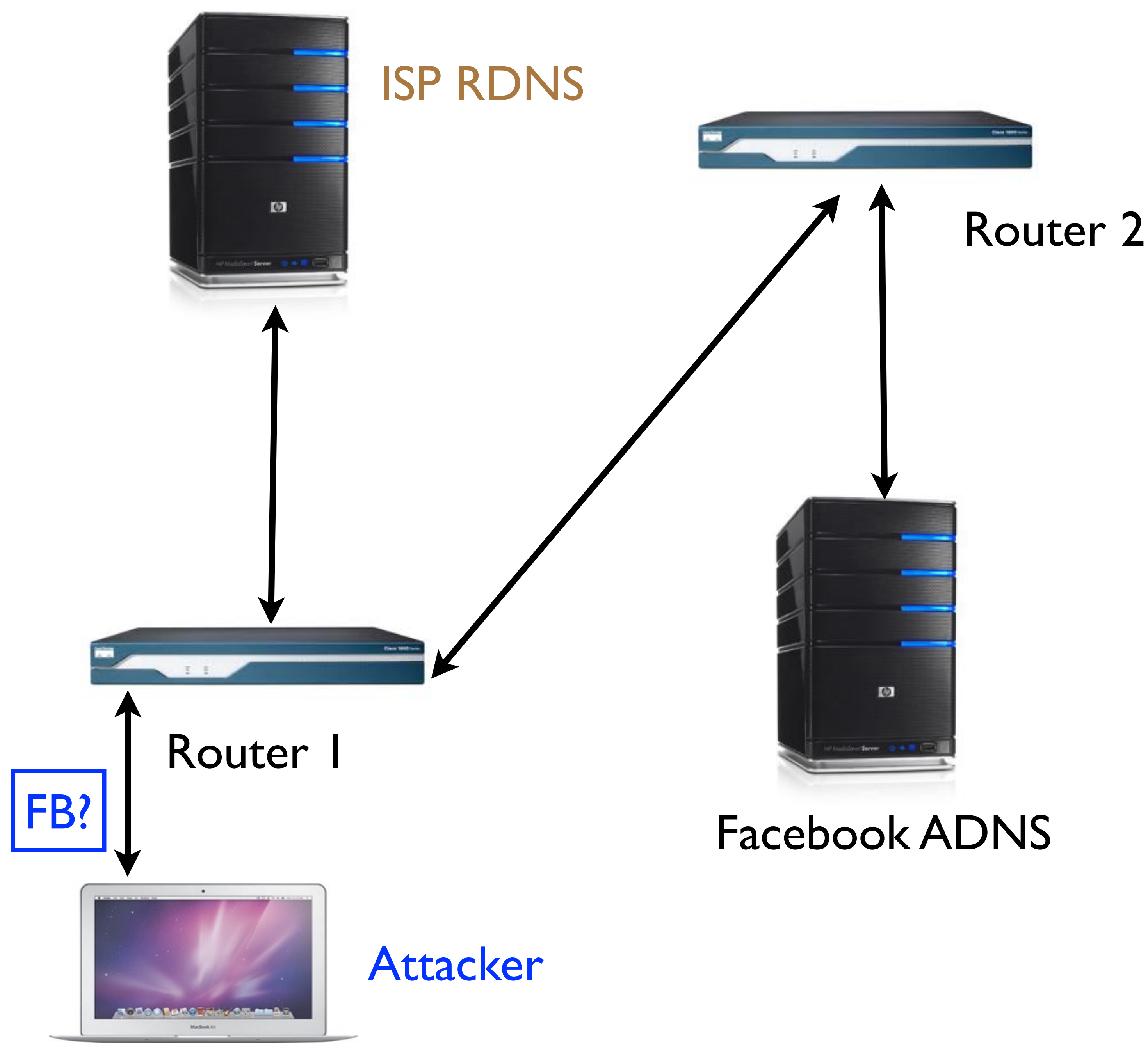


Kaminsky Attack



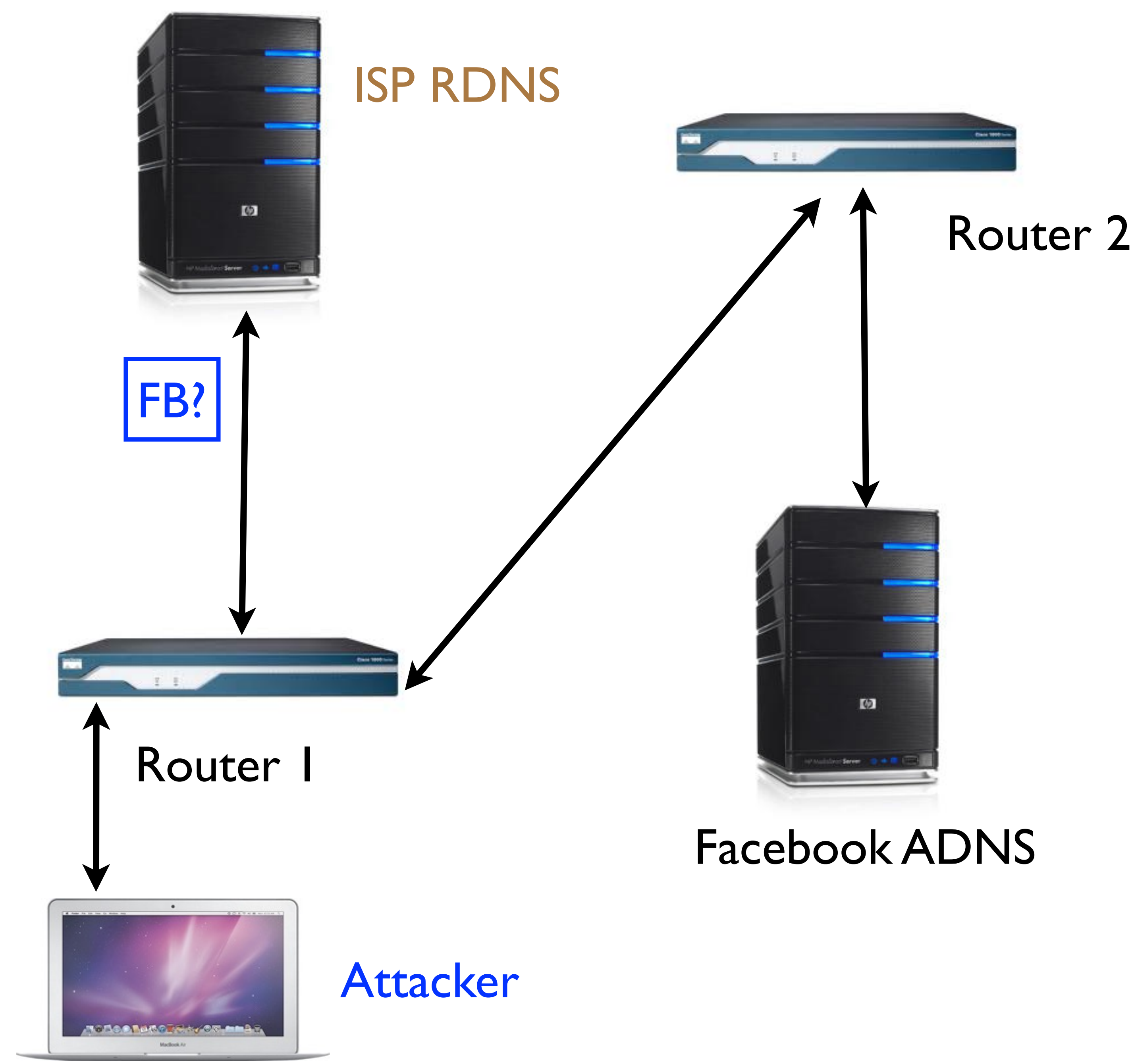
Kaminsky Attack

local IP: Client IP
remote IP: RDNS
local Port: X
remote Port: 53
txID:Y
query: 1.facebook.com



Kaminsky Attack

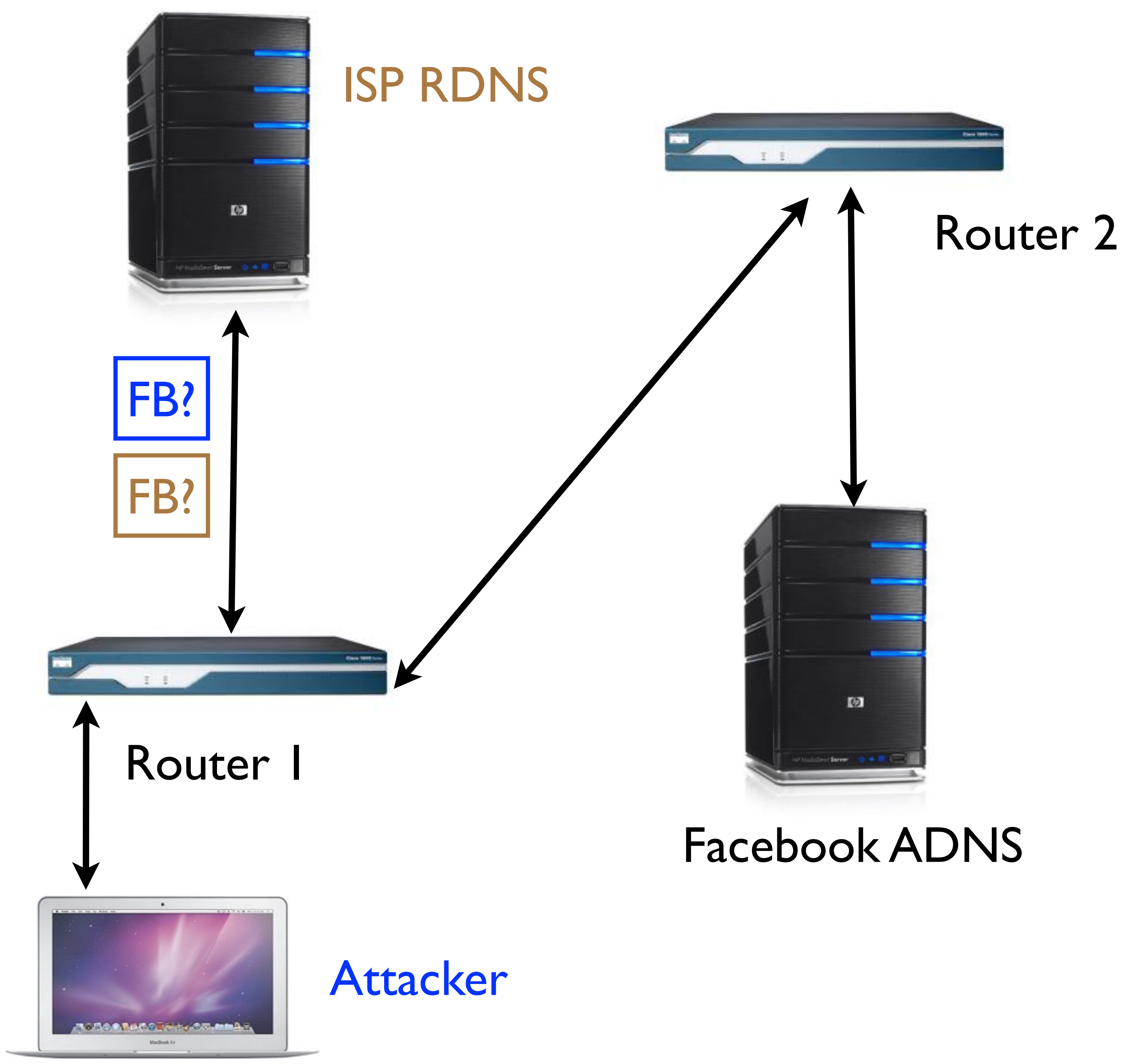
local IP: Client IP
remote IP: RDNS
local Port: X
remote Port: 53
txID:Y
query: 1.facebook.com



Kaminsky Attack

local IP: Client IP
remote IP: RDNS
local Port: X
remote Port: 53
txID:Y
query: 1.facebook.com

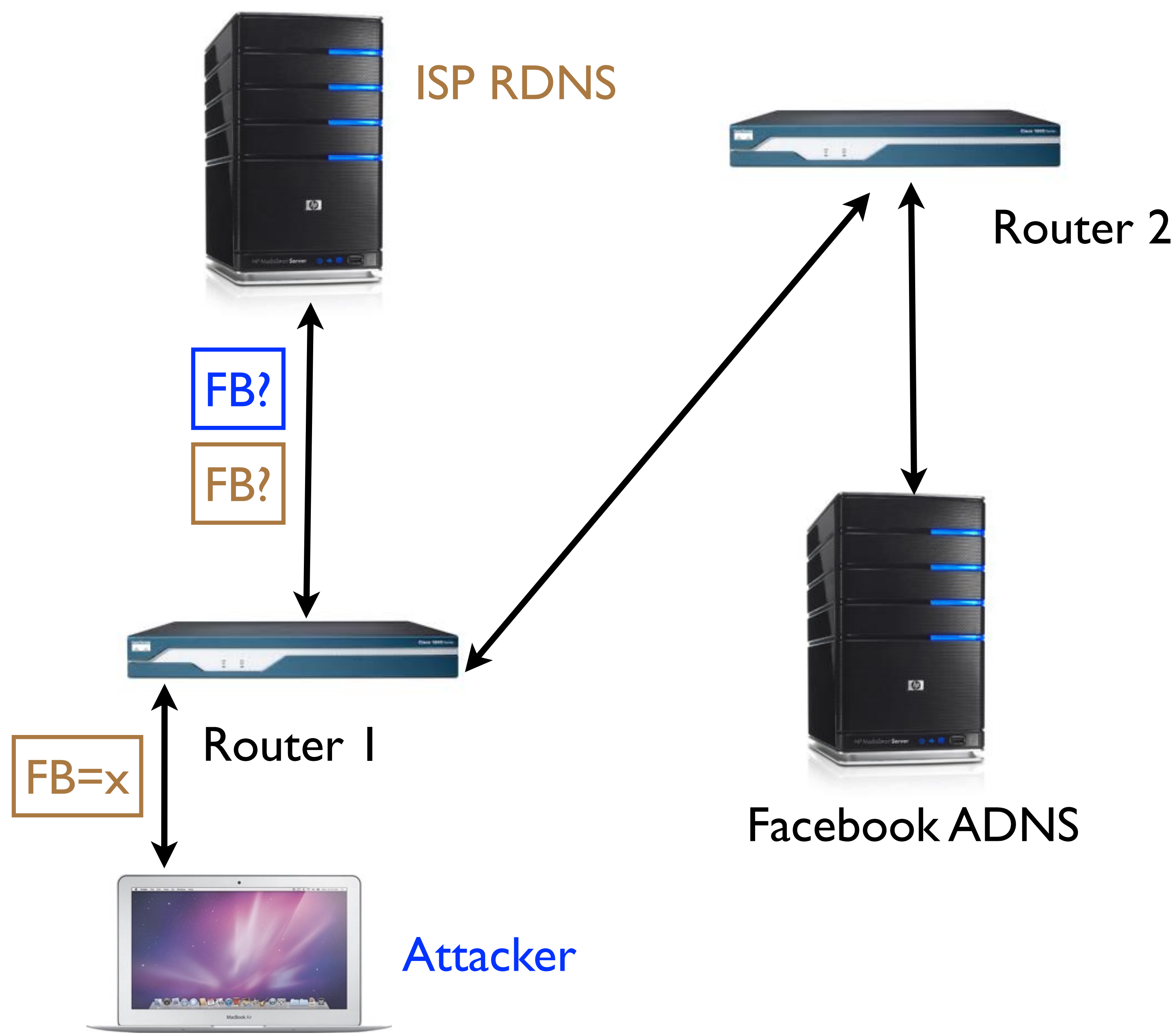
srcIP: RDNS
dstIP: Facebook ADNS
srcPort: ???
dstPort: 53
txID: ???
query: 1.facebook.com



Kaminsky Attack

local IP: Client IP
remote IP: RDNS
local Port: X
remote Port: 53
txID:Y
query: 1.facebook.com

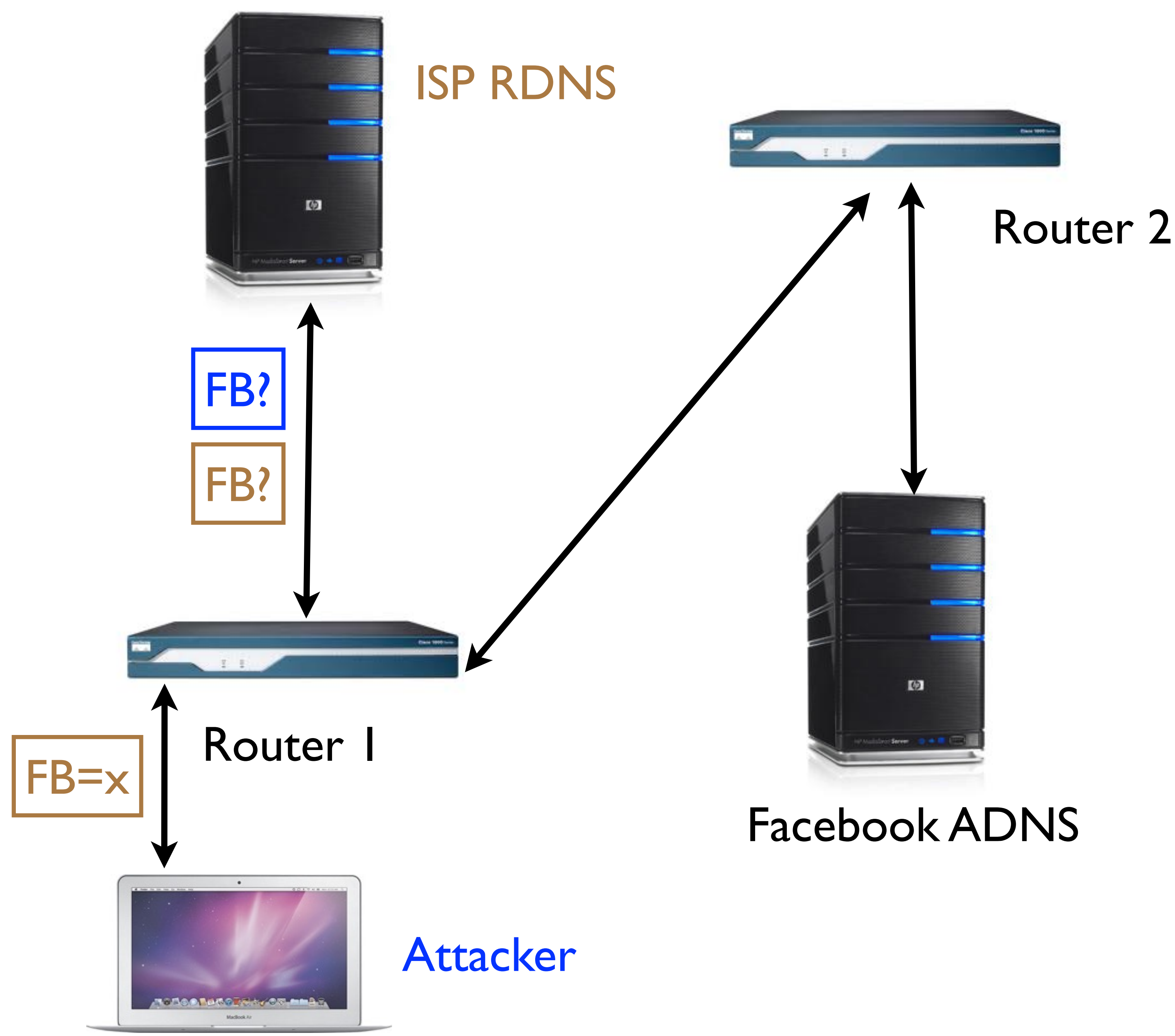
local IP: RDNS
remote IP: FB ADNS
local Port: 1 (guess)
remote Port: 53
txID: 1 (guess)
query: 1.facebook.com



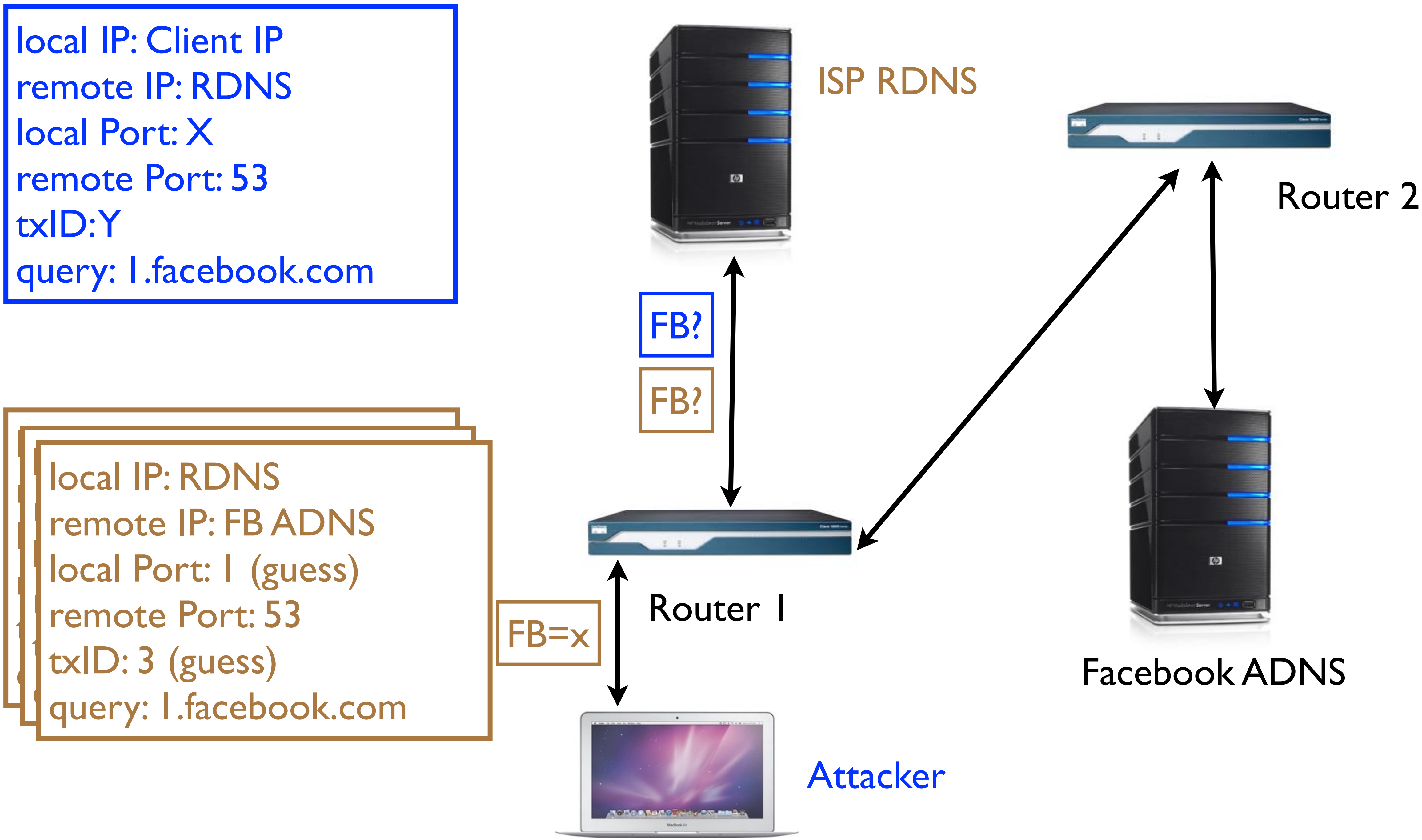
Kaminsky Attack

local IP: Client IP
remote IP: RDNS
local Port: X
remote Port: 53
txID:Y
query: 1.facebook.com

local IP: RDNS
remote IP: FB ADNS
local Port: 1 (guess)
remote Port: 53
txID: 2 (guess)
query: 1.facebook.com



Kaminsky Attack



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- In each answer we include an "additional record" for "www.facebook.com"
  - brute force a valid response for an unused name
  - .... and "www.facebook.com" is cached too!
- So, we get as many tries as we need!

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- Or, about 4 hours at 1Gb/sec
- But, in reality it took 10min to mount the attack

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- In the limit, nothing
- We can make the attack more difficult by using all of the entropy *currently available*
  - i.e., entire port and transaction ID space
- We can make the attack more difficult by finding new sources of entropy
  - e.g., 0x20 encoding

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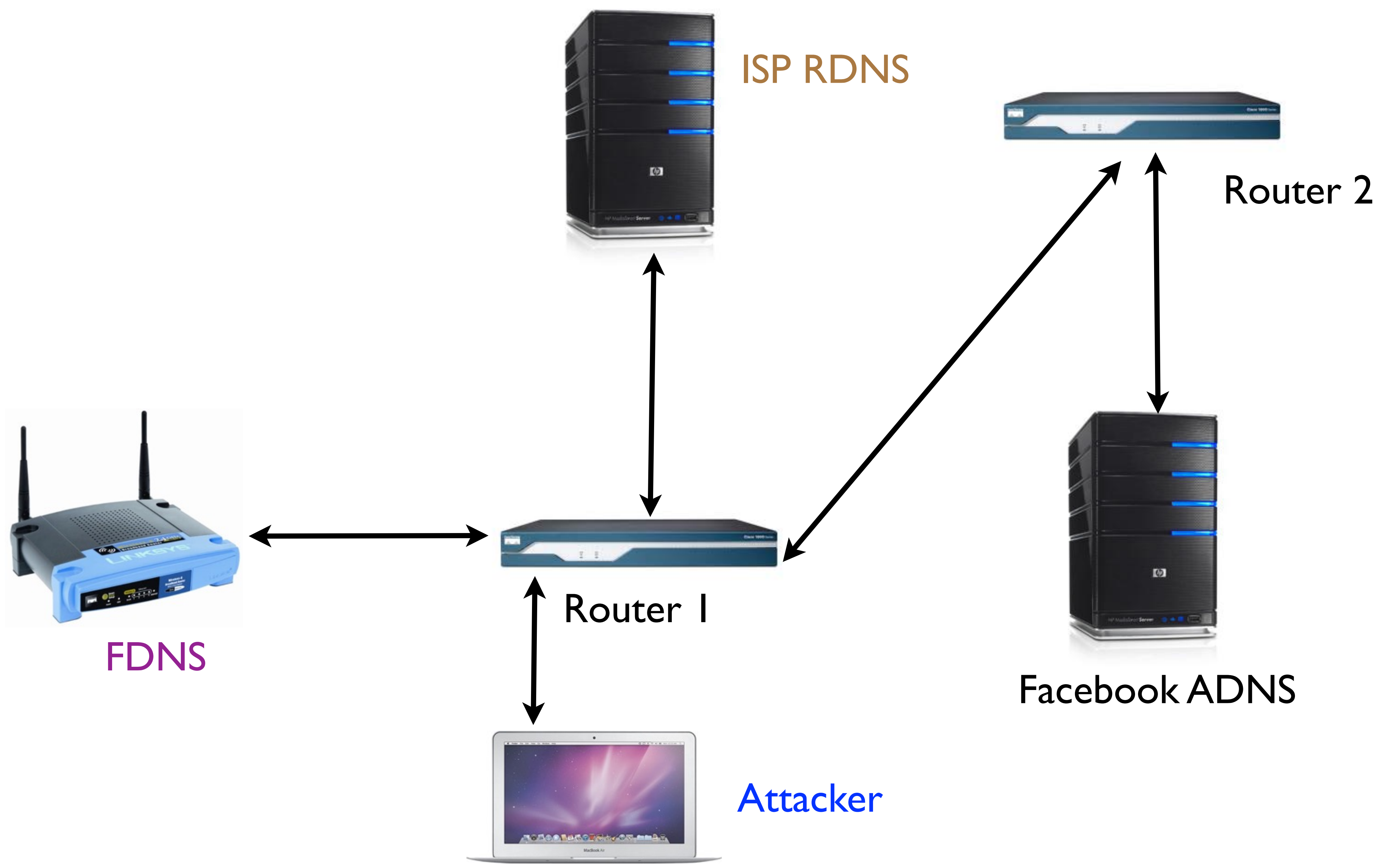
- 84% of RDNS vary the ephemeral port
- 16% of RDNS *use a static ephemeral port!*
  - across 37% of the ASes
- 0.3% of RDNS use 0x20 encoding (lower bound ...)

What Can Go Wrong? (5)



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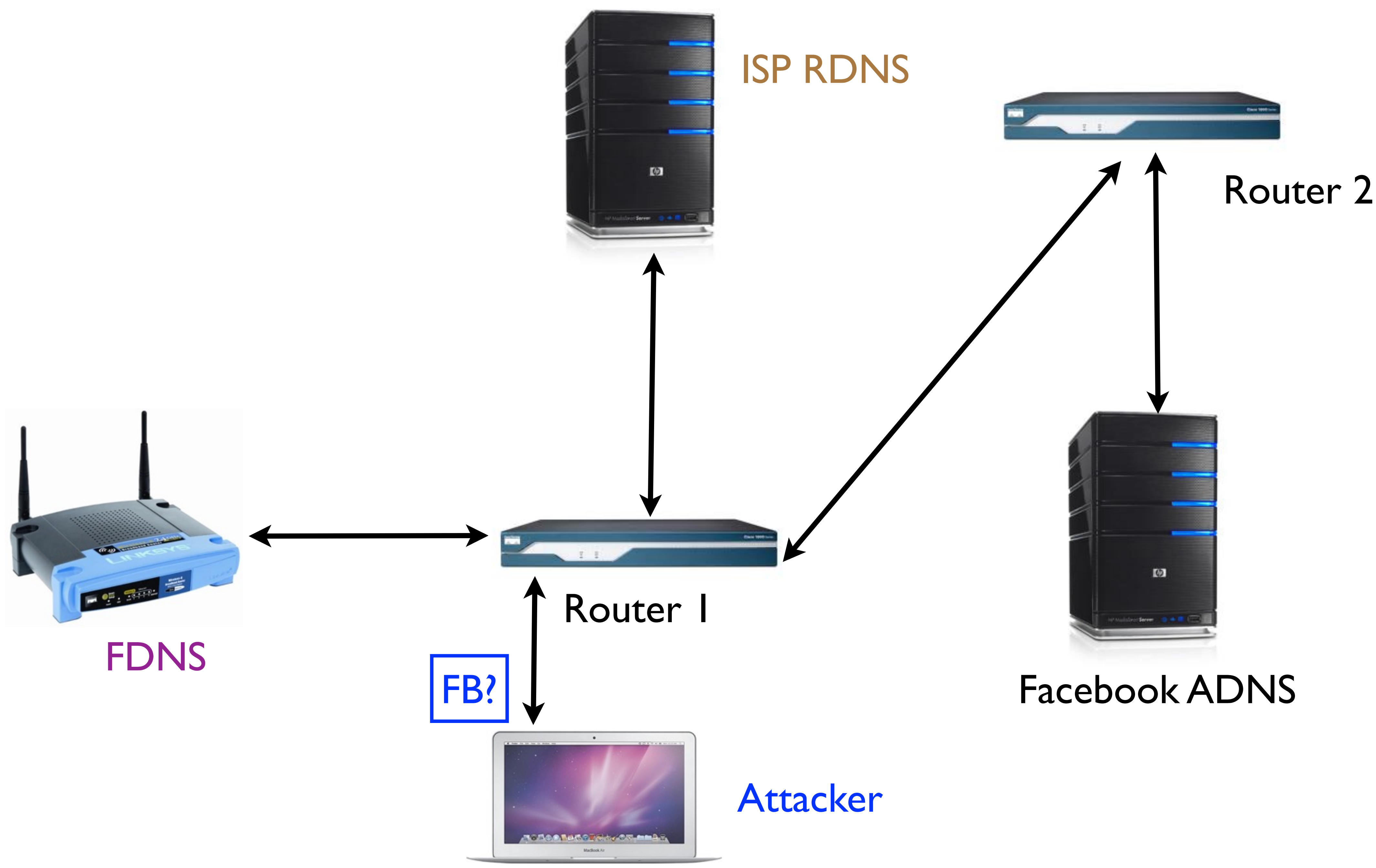

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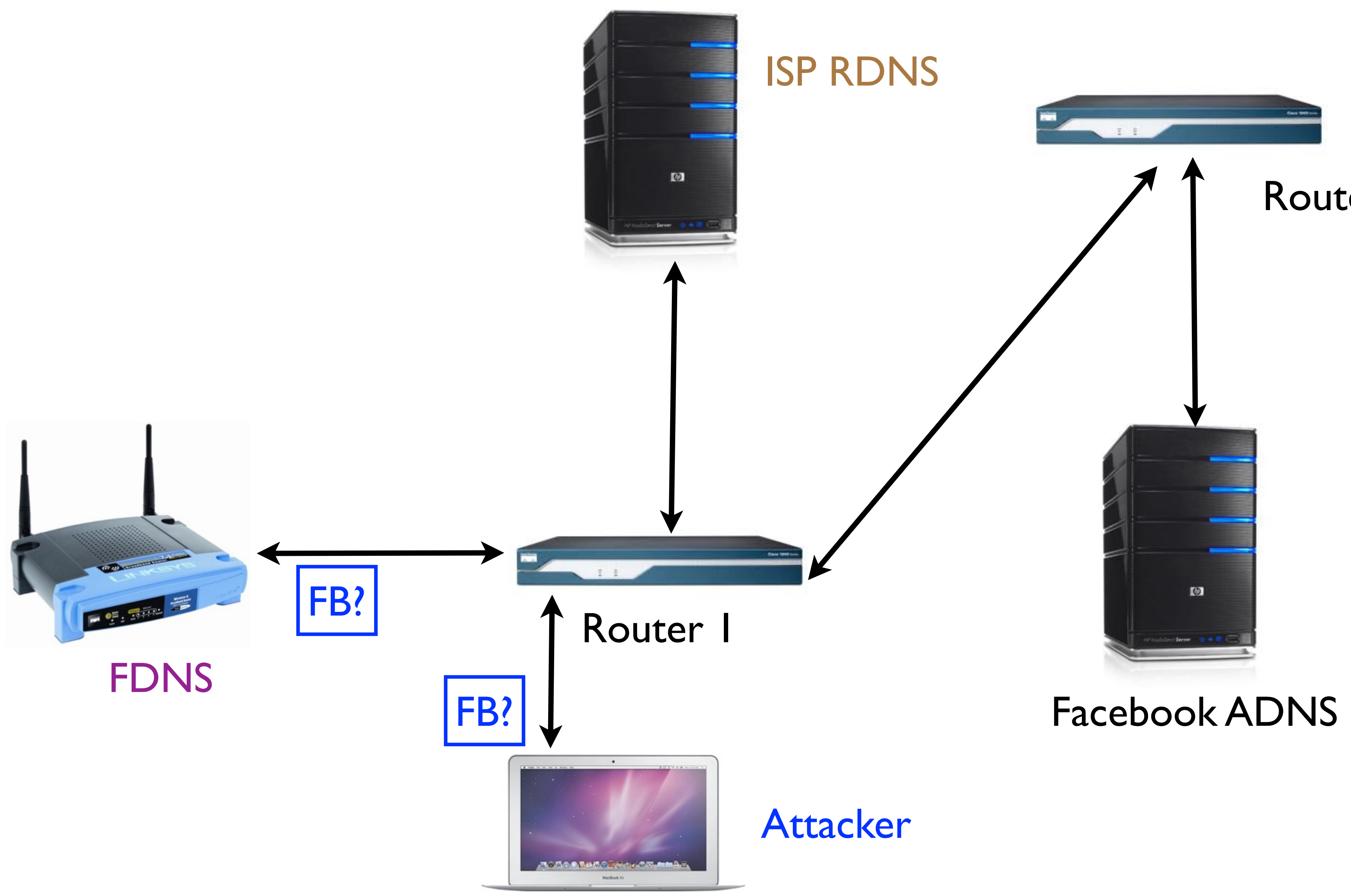

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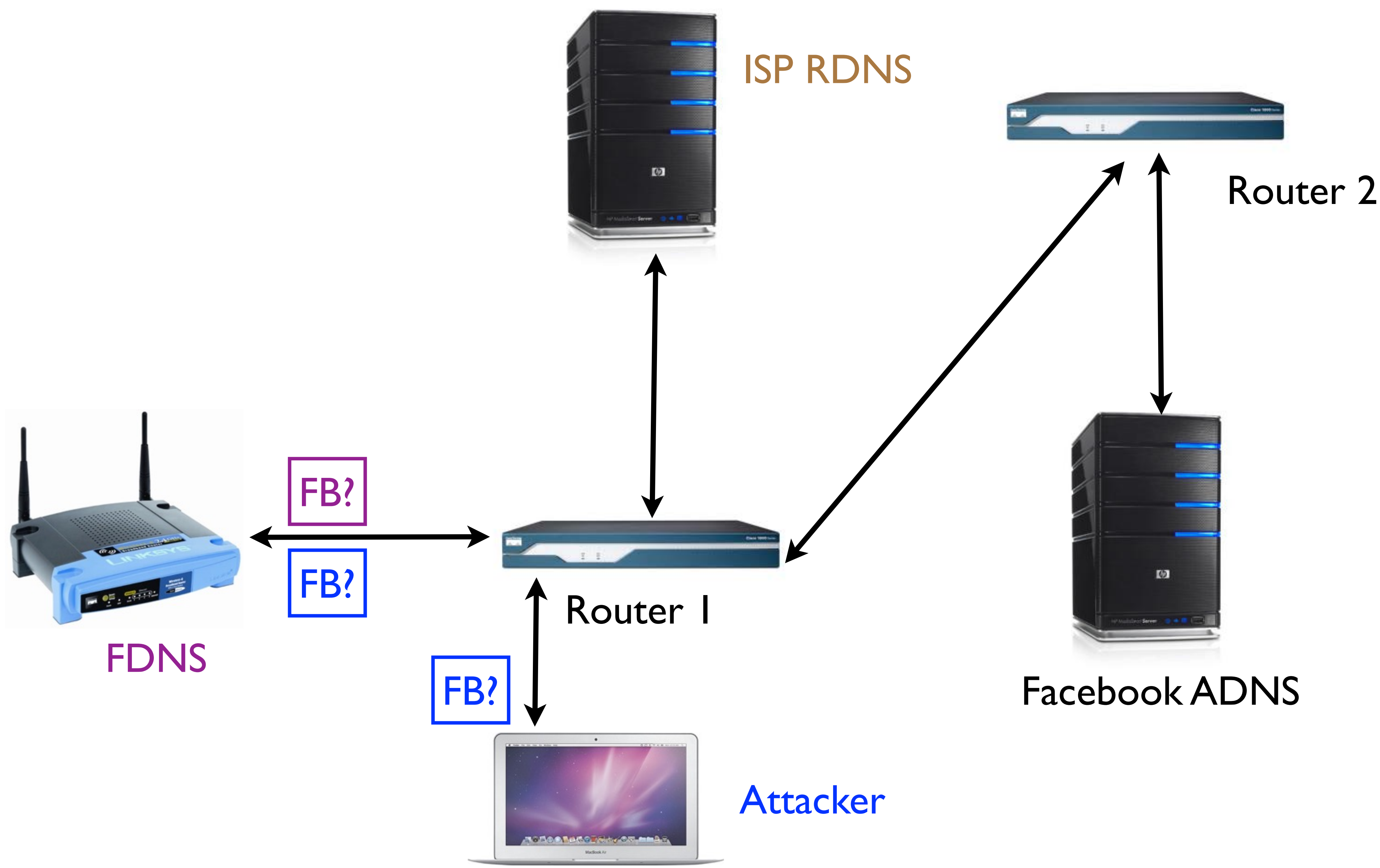

What Can Go Wrong? (5)

local IP: FDNS
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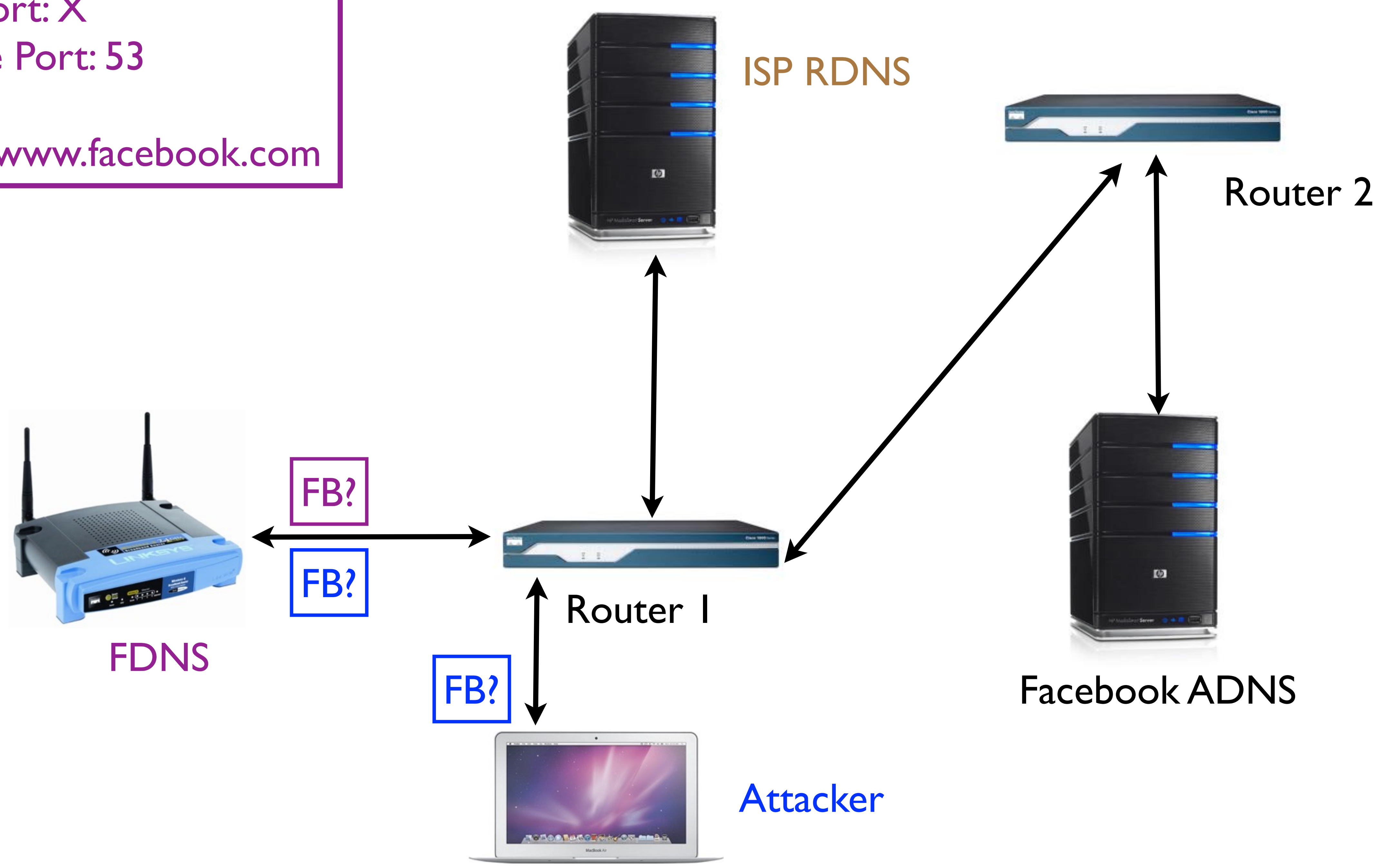
remote Port: 53
txID:Y
query: www.facebook.com



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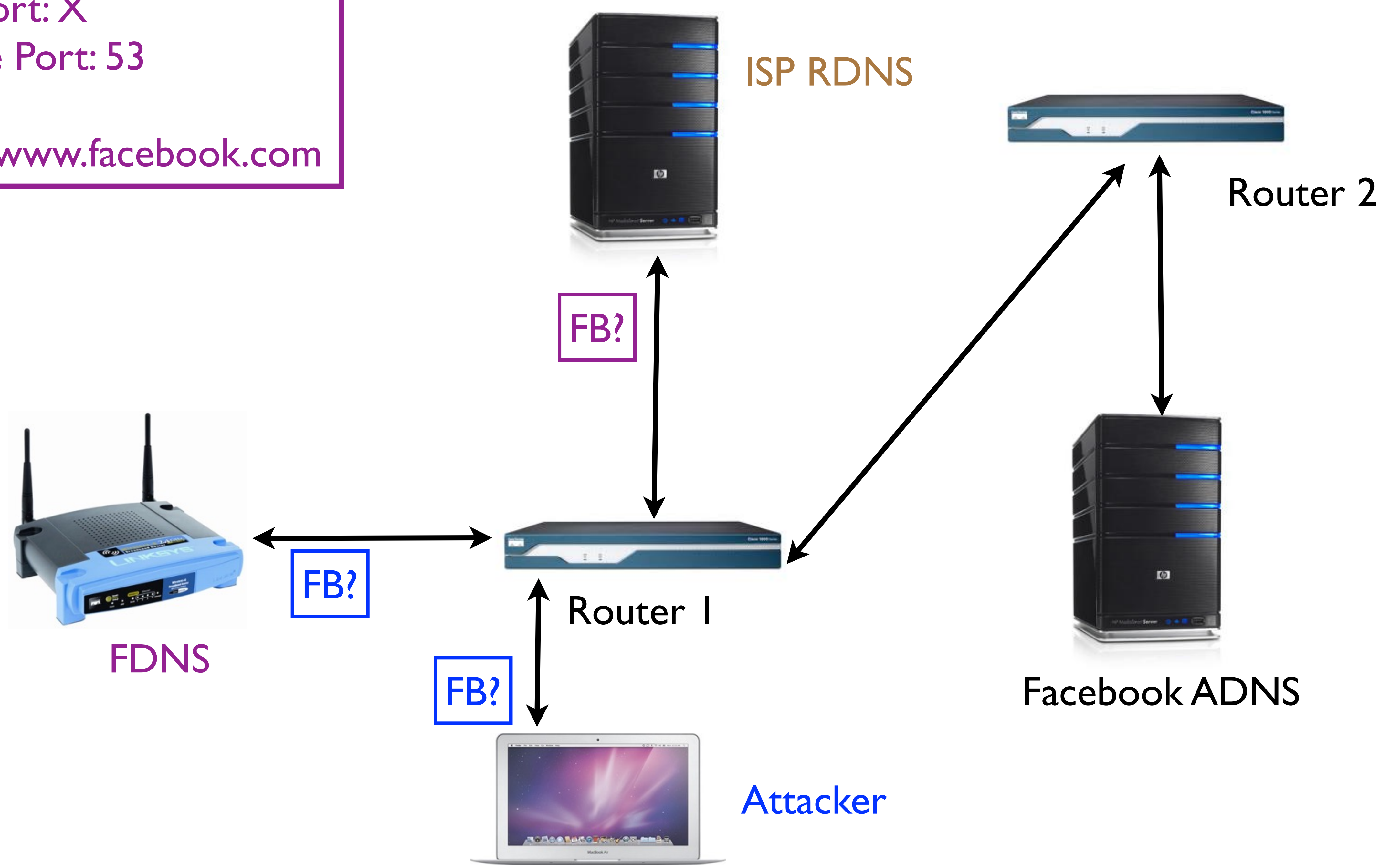

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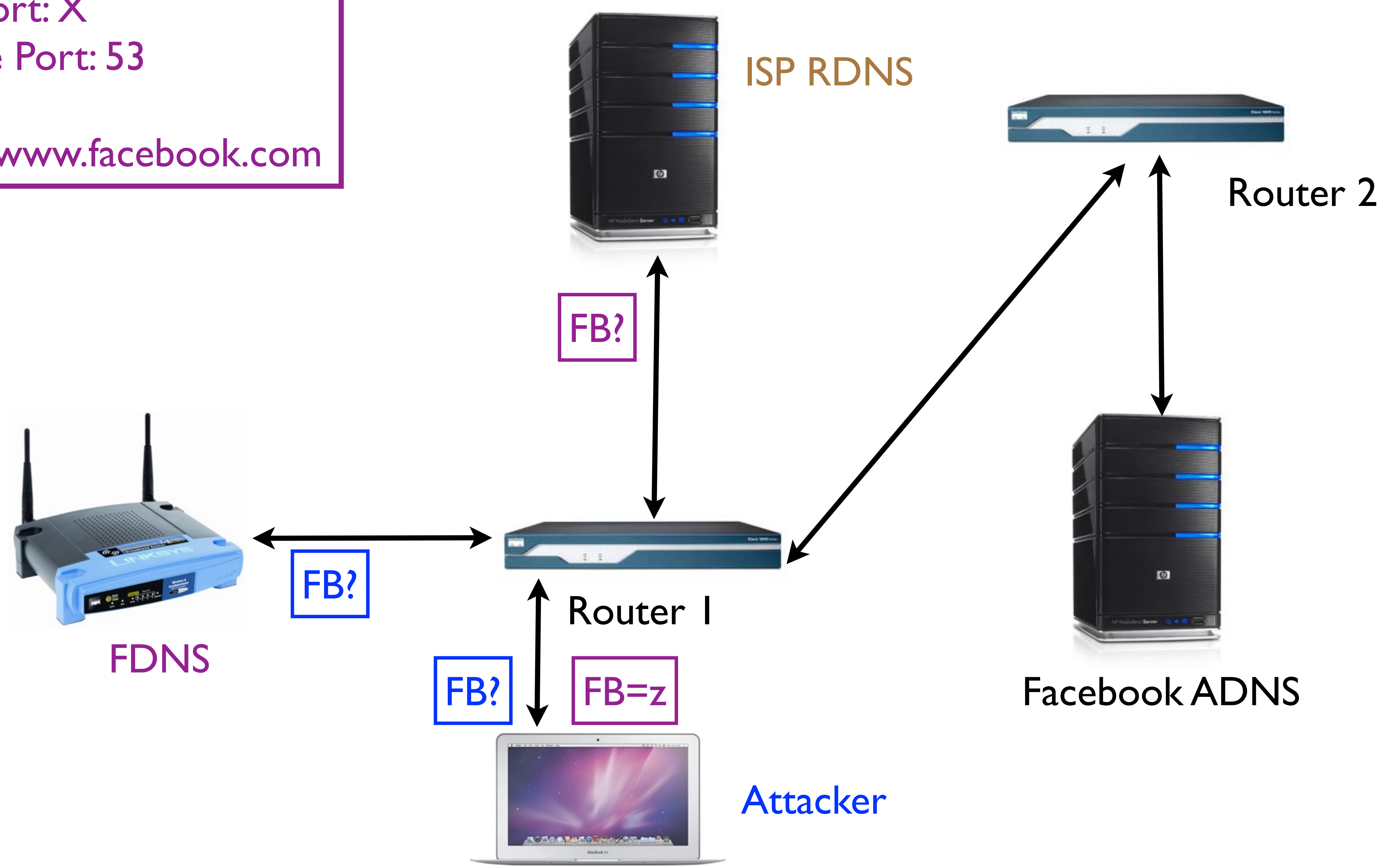

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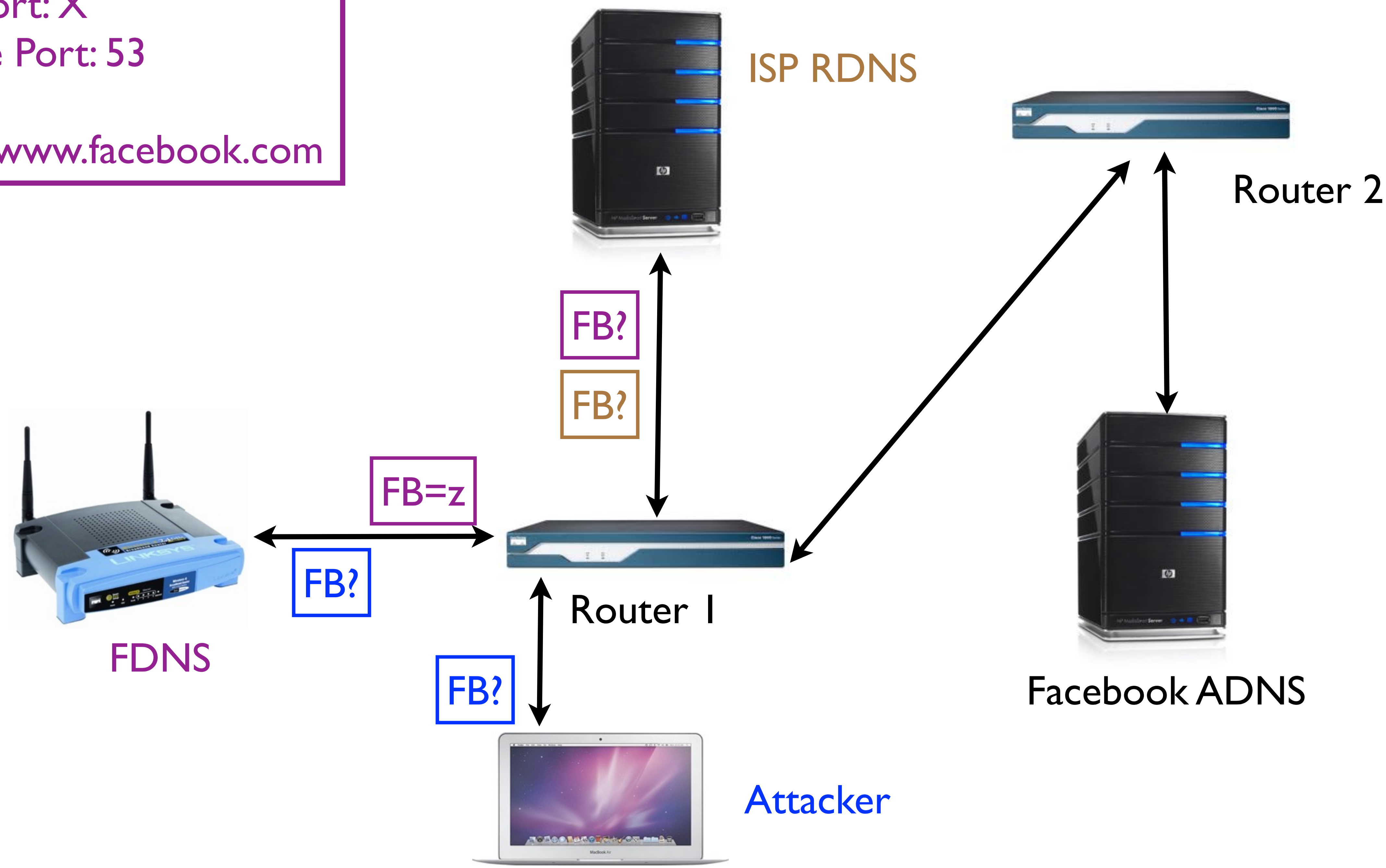
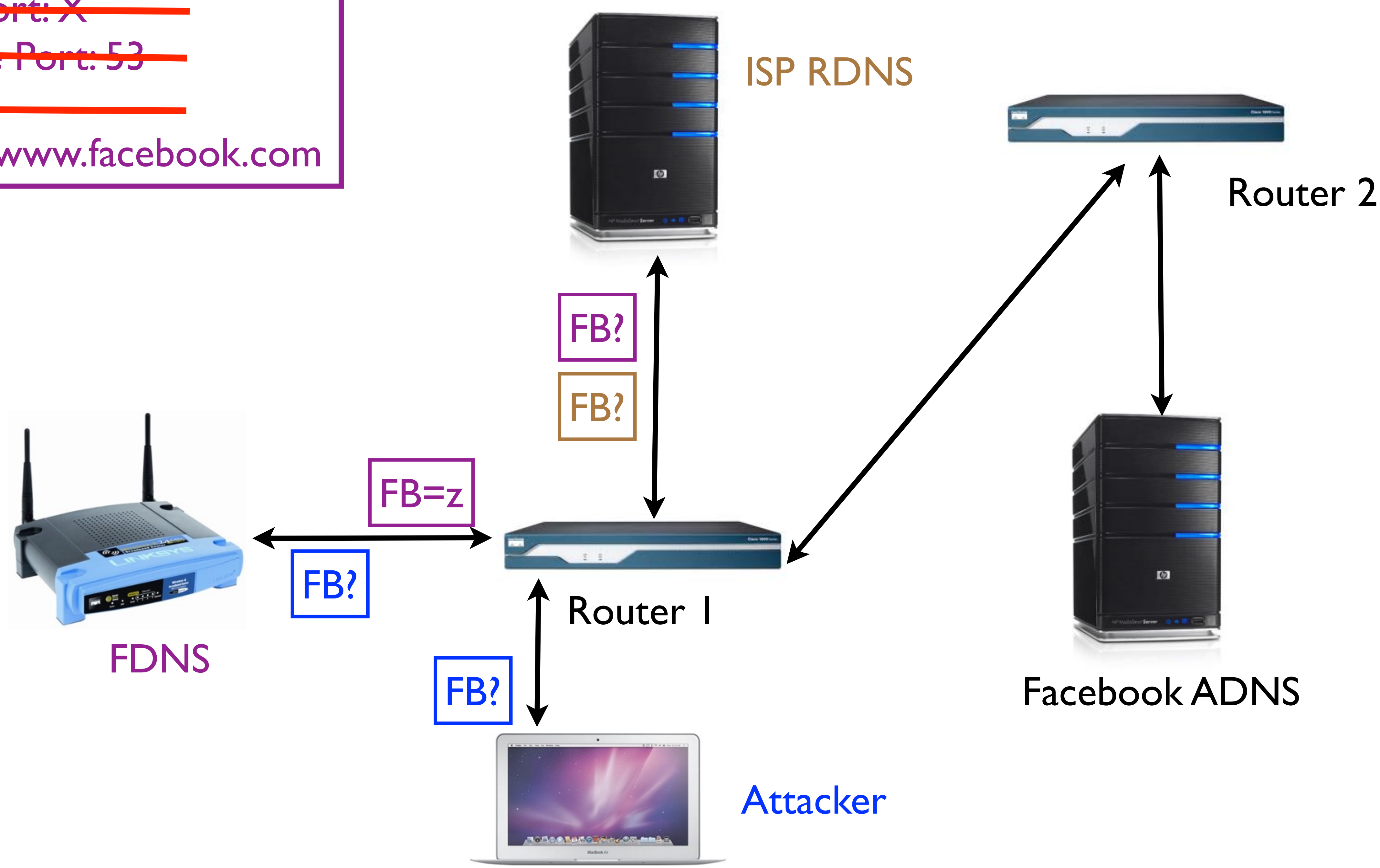


What Can Go Wrong? (5)

local IP: FDNS
~~remote IP: RDNS~~
~~local Port: X~~
~~remote Port: 53~~
~~txID:Y~~
query: www.facebook.com



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local IP: FDNS
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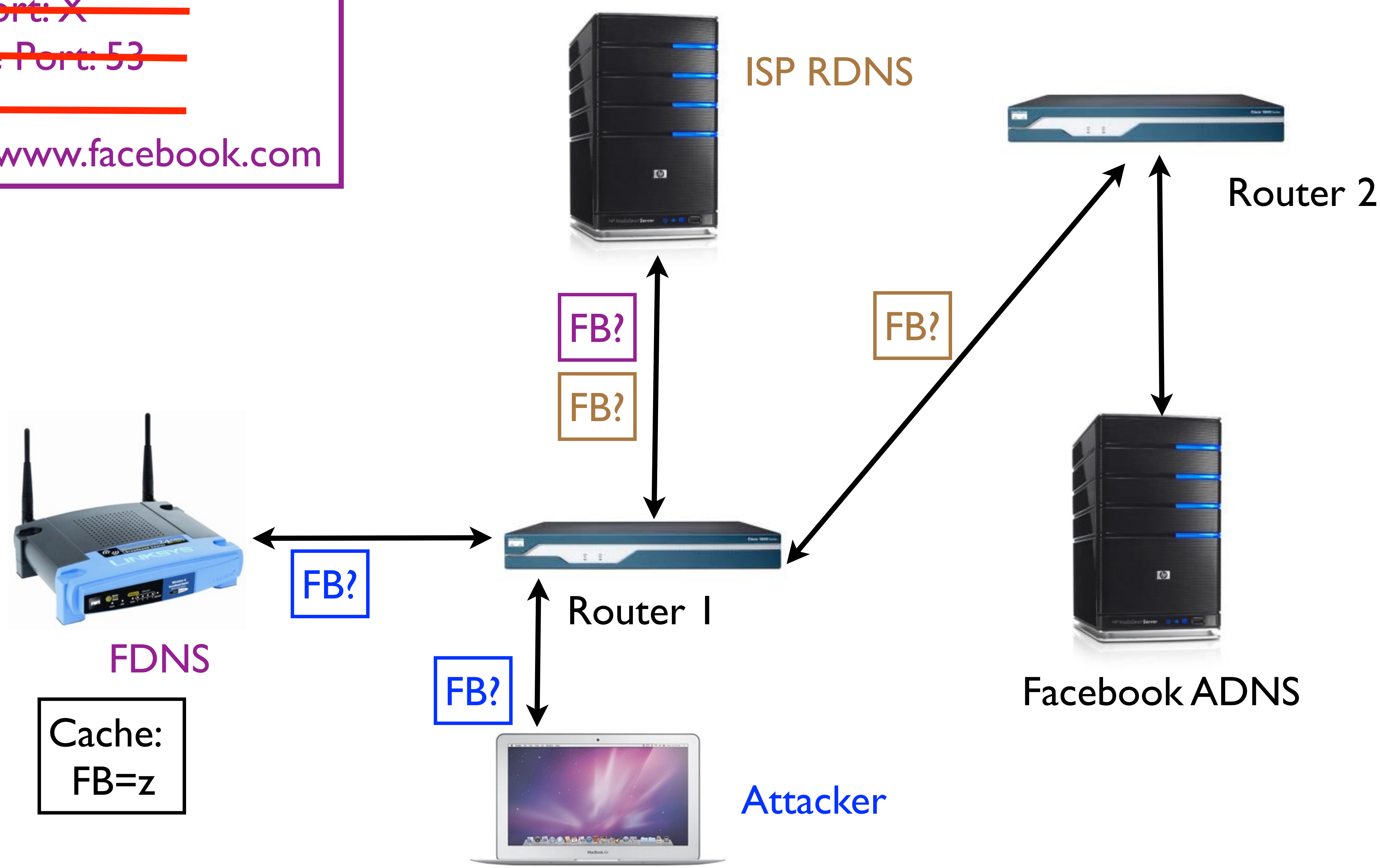
~~remote Port: 53~~
~~txID:Y~~
query: www.facebook.com



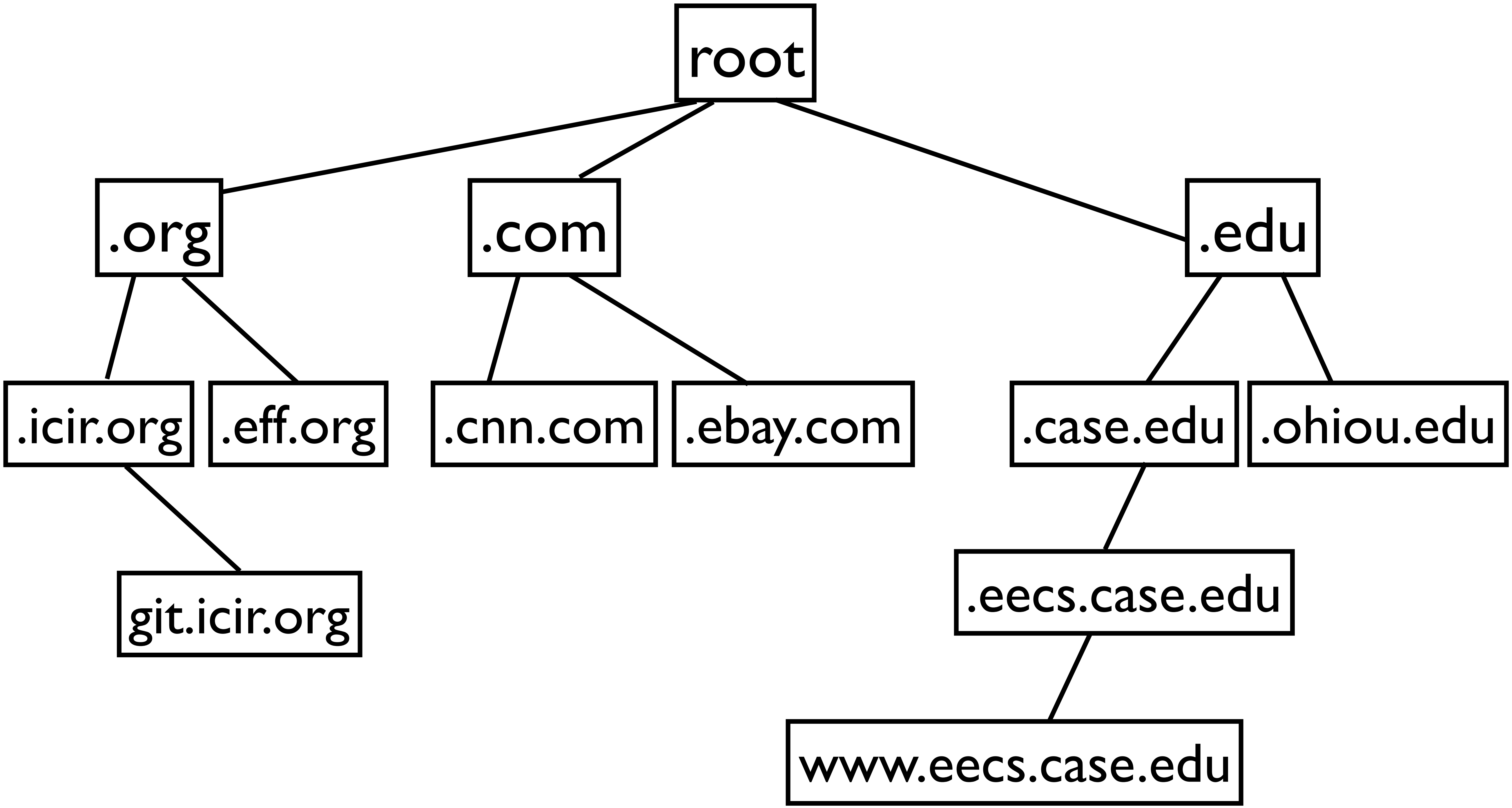
Preplay Attack

- We find 7--9% of open resolvers to be vulnerable to the preplay attack
  - i.e., about 2 million open resolvers

What Can Go Wrong? (6)

- Roots are the most crucial part of the DNS hierarchy
- And, have a *small footprint*
  - 13 logical servers
- Hence, an attacker that can usurp control of the roots or can manipulate traffic to/from the roots can have a tremendous impact

DNS Root Manipulation



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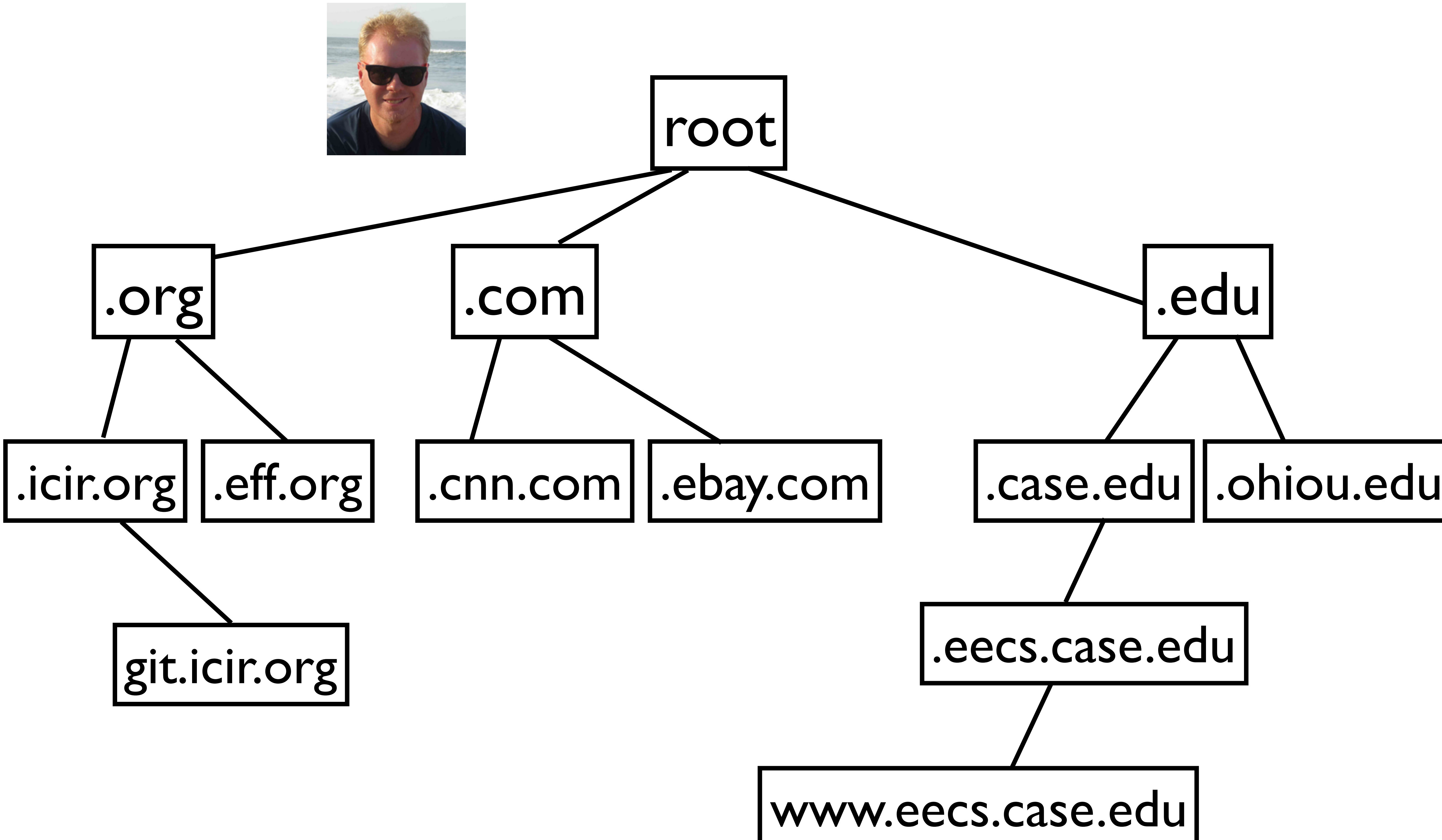
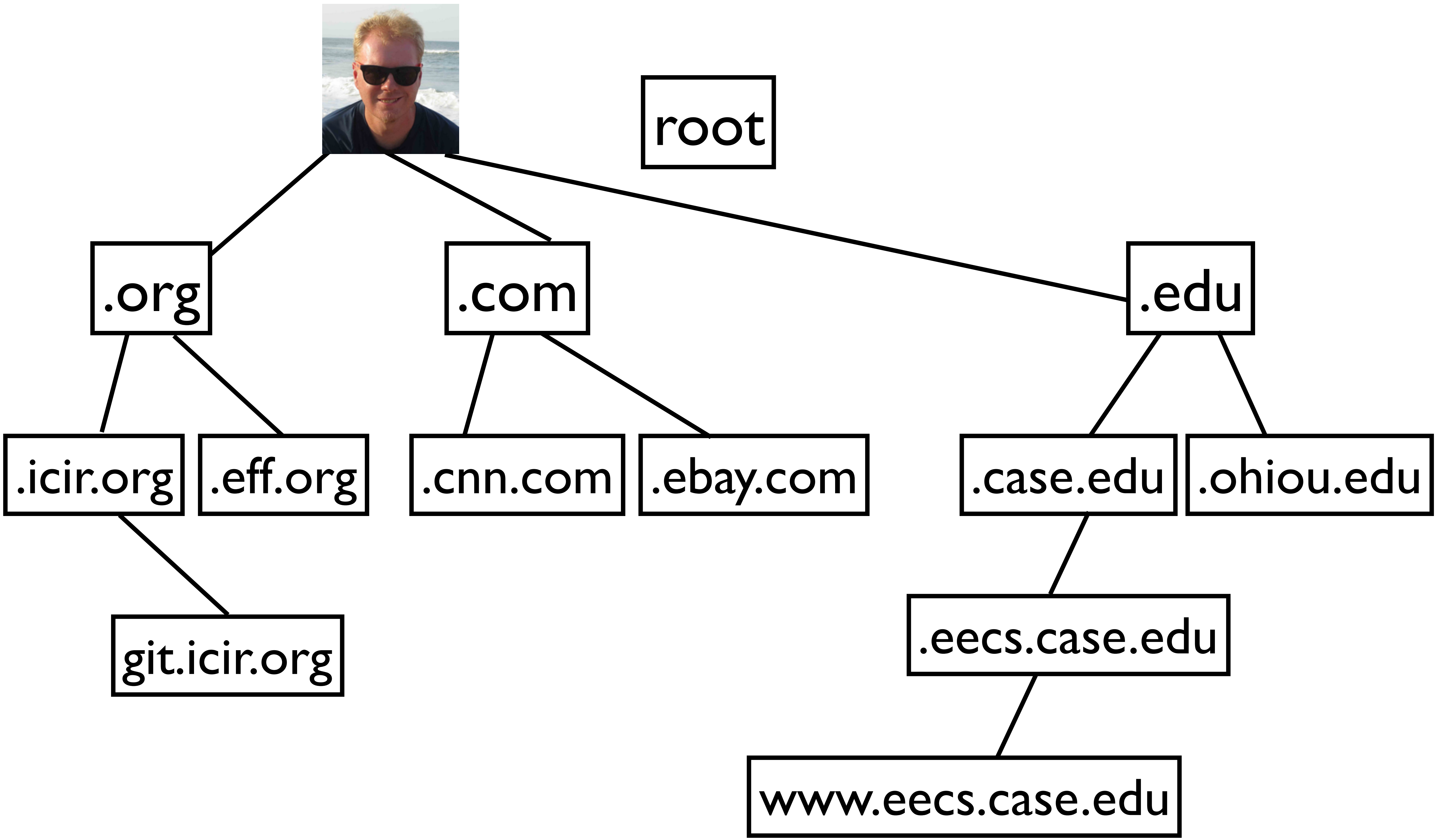


DNS Root Manipulation



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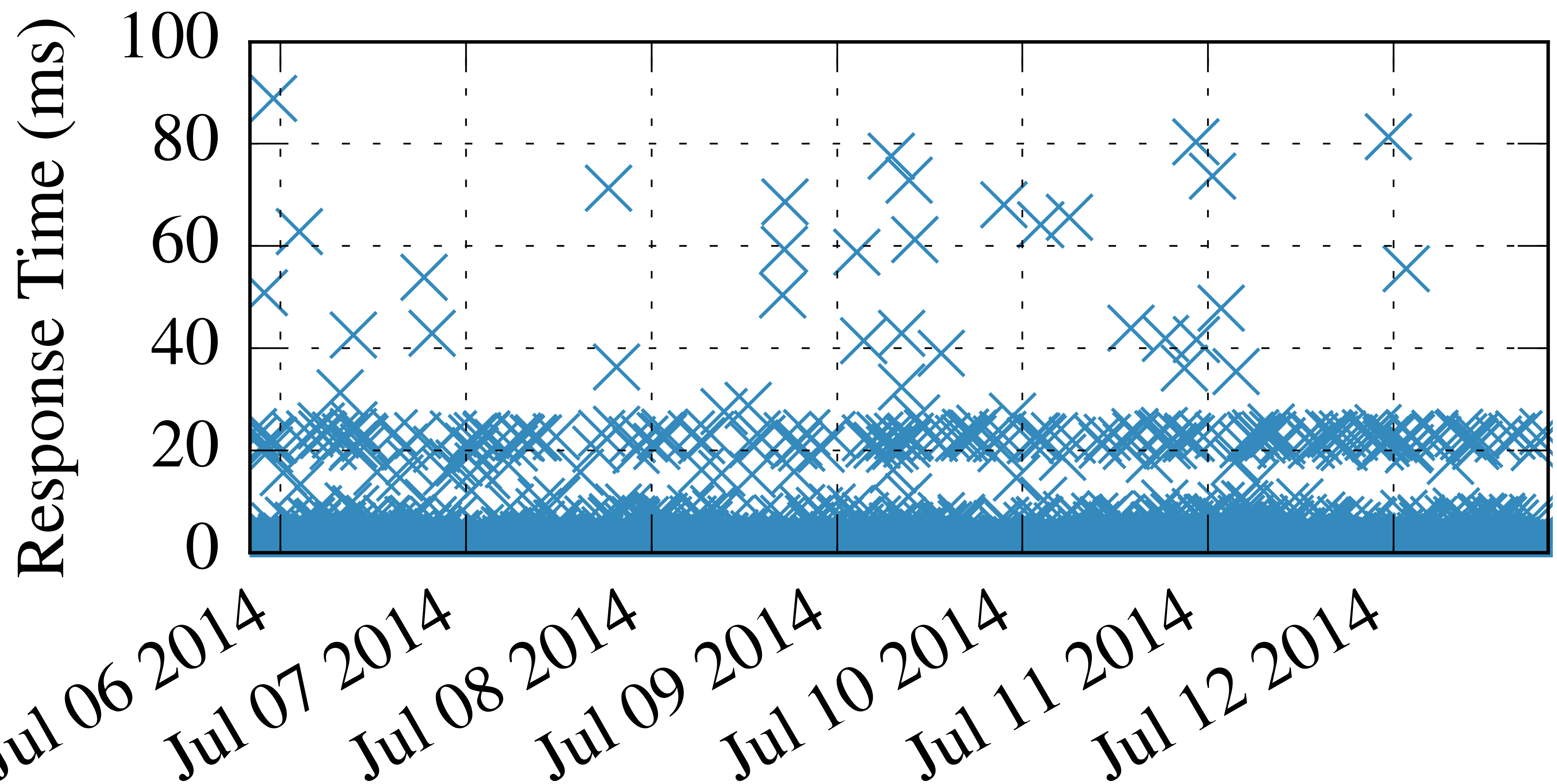

- Impossibly low RTTs from China to B root (in Los Angeles)