Protecting Privacy: The Evolution of DNS Security

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Agenda

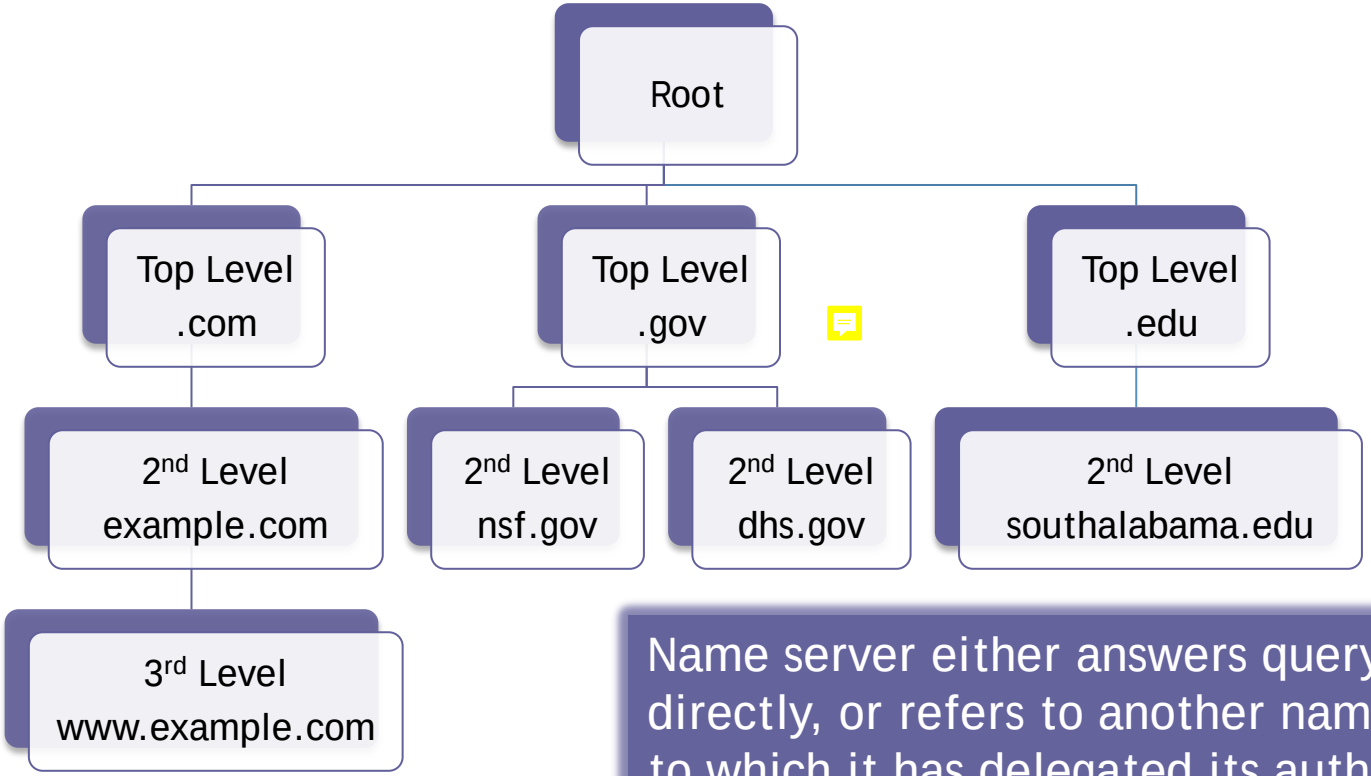

DNS Overview
Privacy Risks
Risk Mitigations
Recommendations

DNS Overview

Domain Name System (DNS) Overview

- Hierarchical, global name space for Internet names, e.g., www.example.com
- DNS records associate IP addresses, other data with domain names
- **Authoritative name servers** publish records, delegate to other name servers
- Clients typically query via a **recursive name server**

DNS Hierarchy - Example

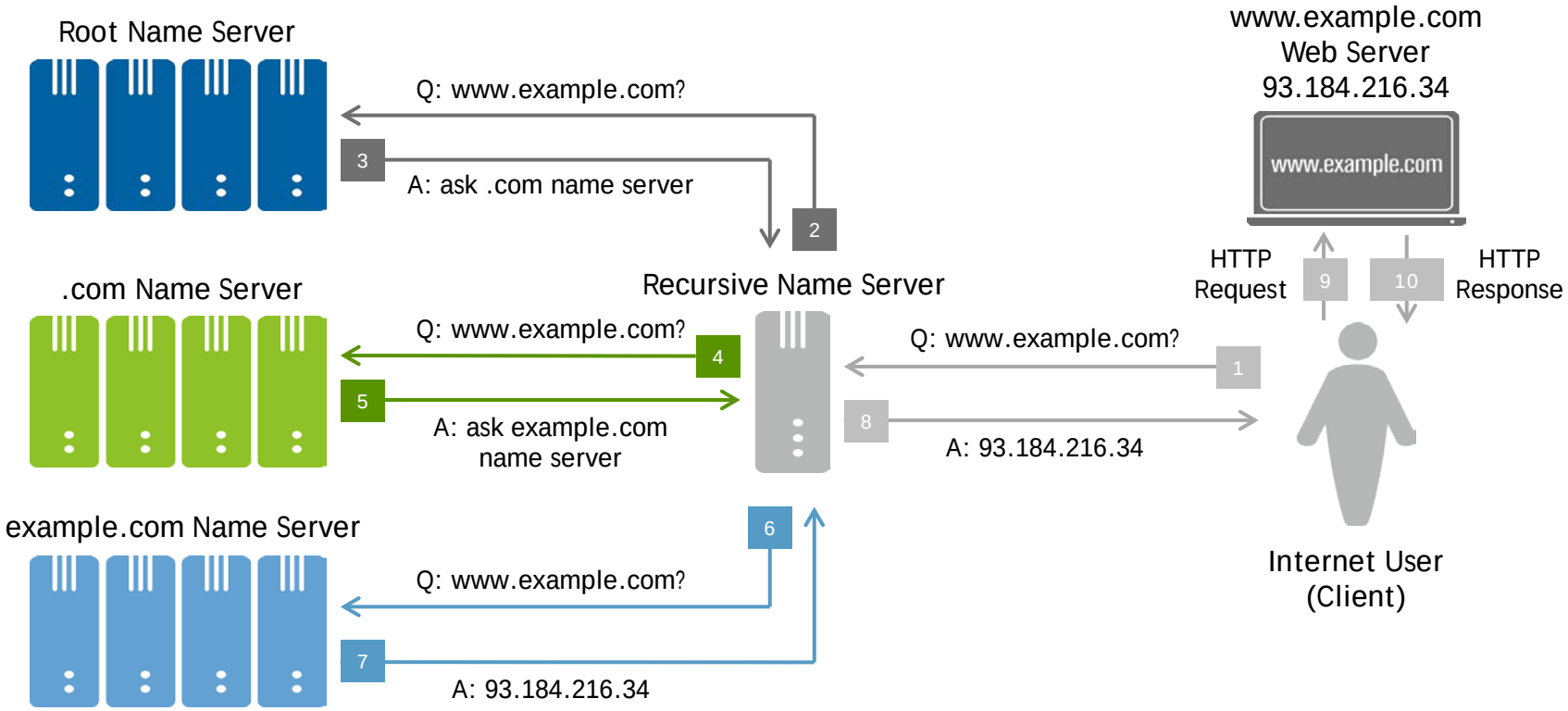


Name server either answers query directly, or refers to another name server to which it has delegated its authority

DNS Resolution

- **Resolution** is the process of answering a query by following the hierarchy of name servers
- To resolve www.example.com, query root server, then .com, then example.com
  - Each refers to next in hierarchy
- Recursive name server optimizes process by caching recent results

DNS Resolution - Example



DNS Privacy Risks

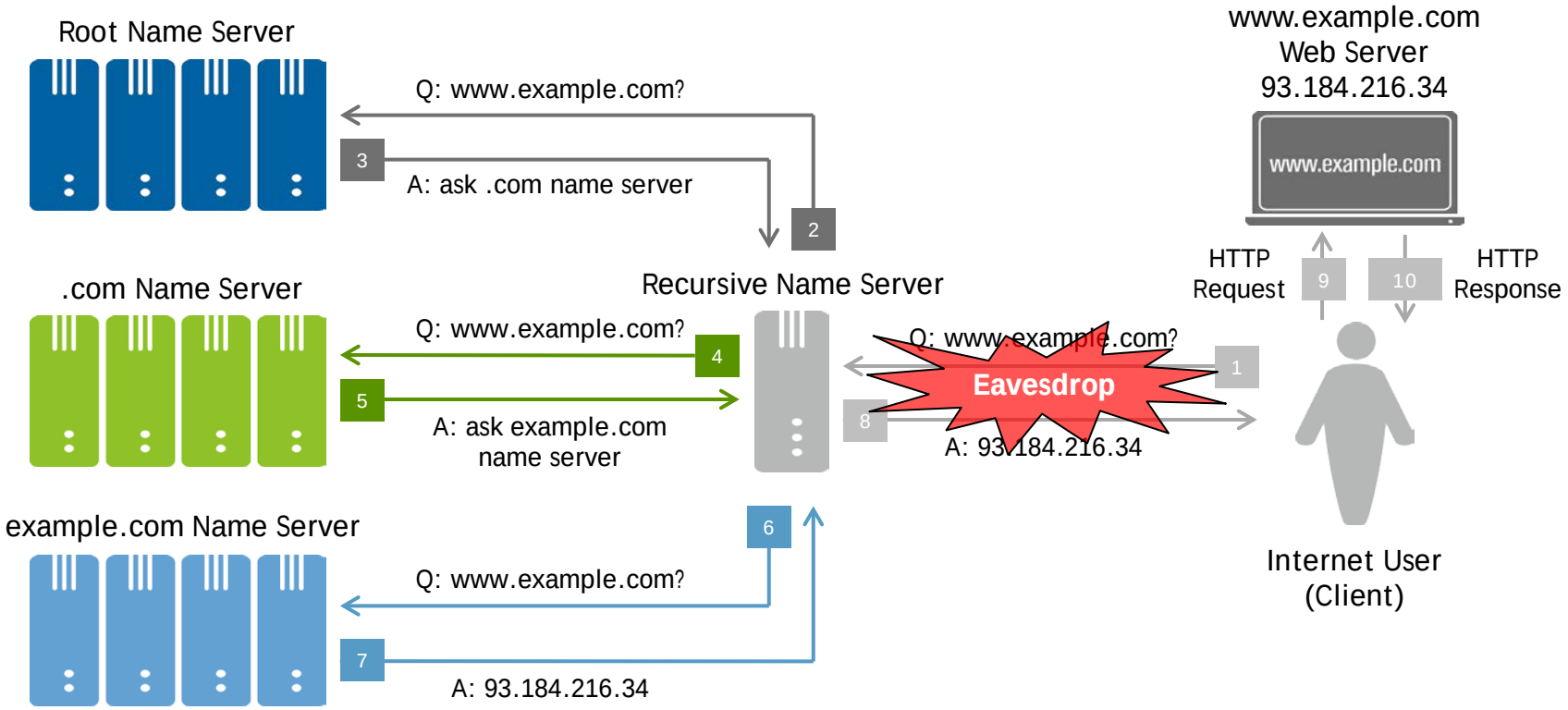
- DNS data may be at risk of disclosure:
  - Between client and recursive
  - At recursive name server
  - Between recursive and authoritative
  - At authoritative name server
- Data may also be at risk of modification: privacy risk if client misdirected
- Important to consider such risks as part of overall privacy strategy

Privacy Risks

Risk 1: Between Client and Recursive

- Client effectively reveals browsing history via DNS traffic to recursive name server
- Adversary must be “on path” to see it, but it’s all in one place
- Risk increases when recursive name server deployed outside organization
- How to protect against eavesdropping?

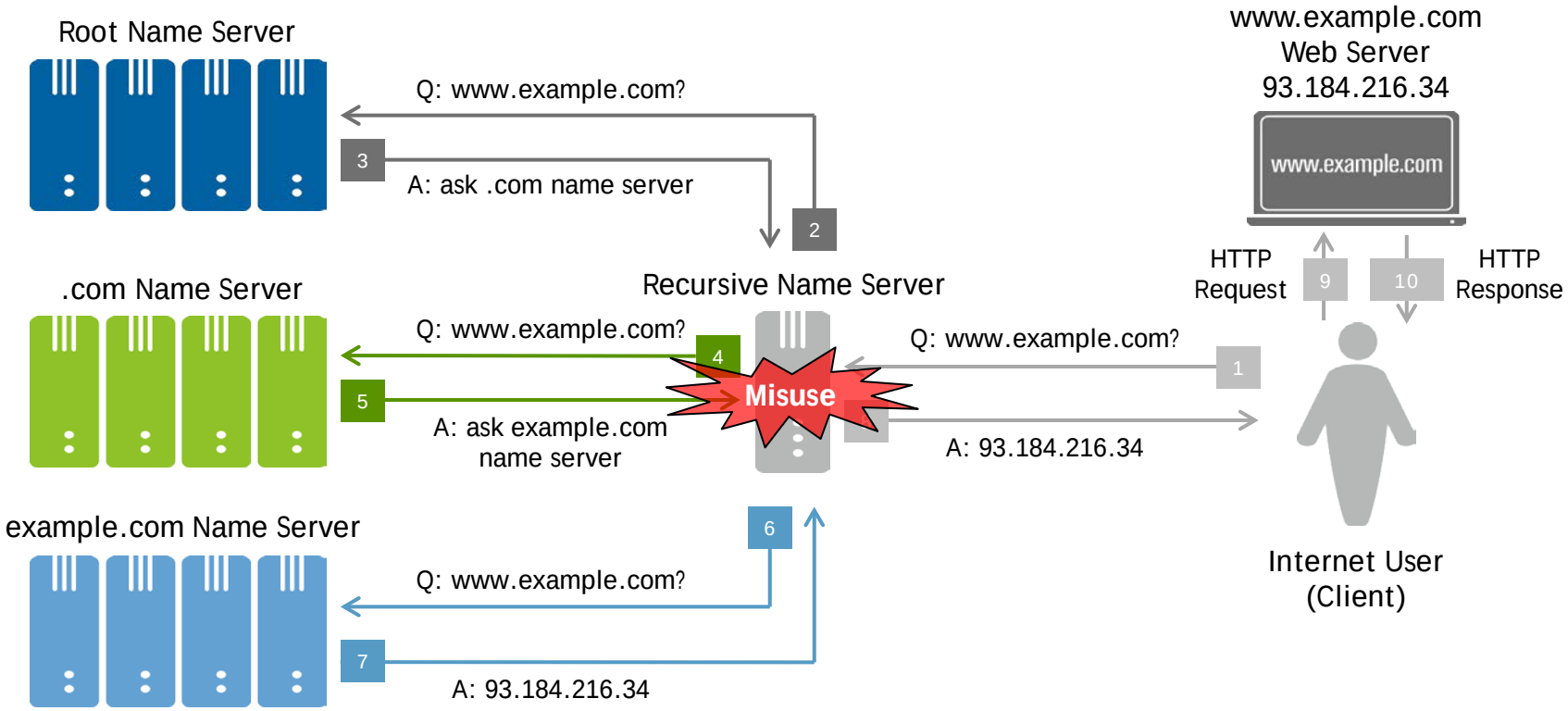
Risk 1: Between Client and Recursive



Risk 2: At Recursive Name Server

- Recursive name server learns client's browsing history through its DNS traffic
- Adversary may try to compromise server to get this data
- Server itself may be "adversary," misusing data …
- How to protect against compromise, misuse?

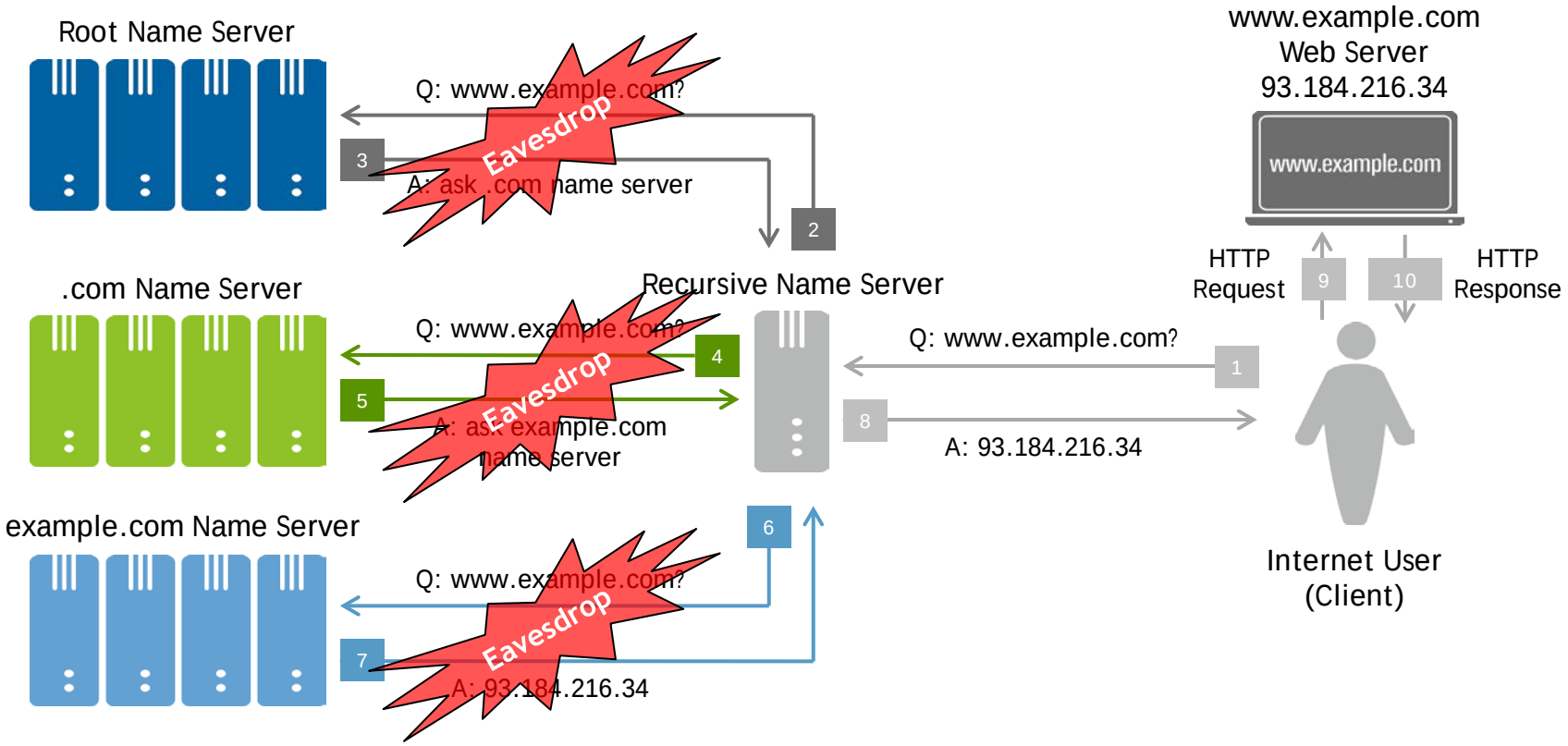
Risk 2: At Recursive Name Server



Risk 3: Between Recursive and Authoritative

- Recursive name server reveals samples of community's browsing history via DNS traffic to authoritative name servers
- Adversary again must be "on path" to see traffic, but all in one place
- Authoritative name servers by definition deployed outside organization
- How to protect against eavesdropping?

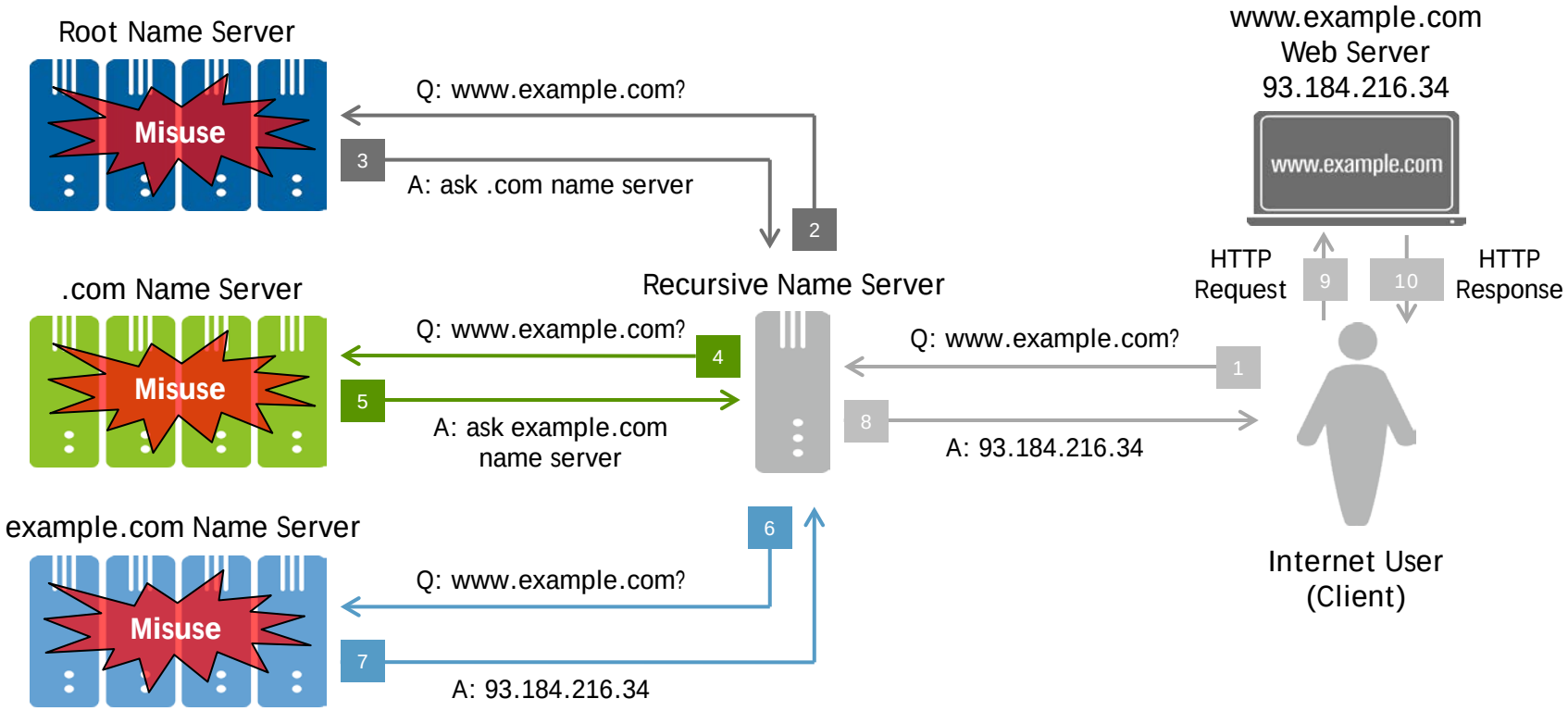
Risk 3: Between Recursive and Authoritative



Risk 4: At Authoritative Name Server

- Authoritative name server learns samples of recursive's community's browsing history
- Adversary may again try to compromise server to get this data
- Server itself may again be "adversary"
- How to protect against compromise, misuse?

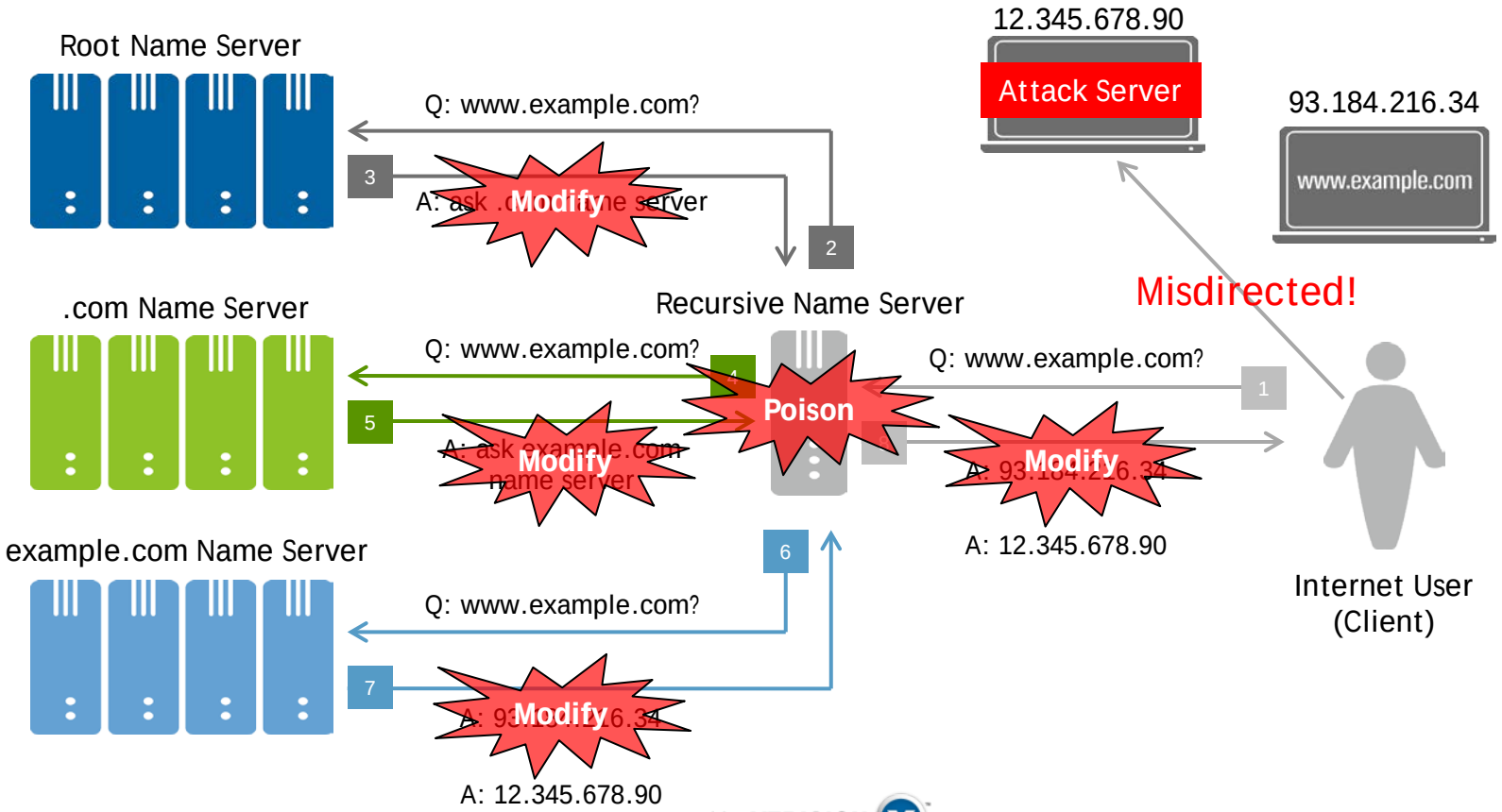
Risk 4: At Authoritative Name Server



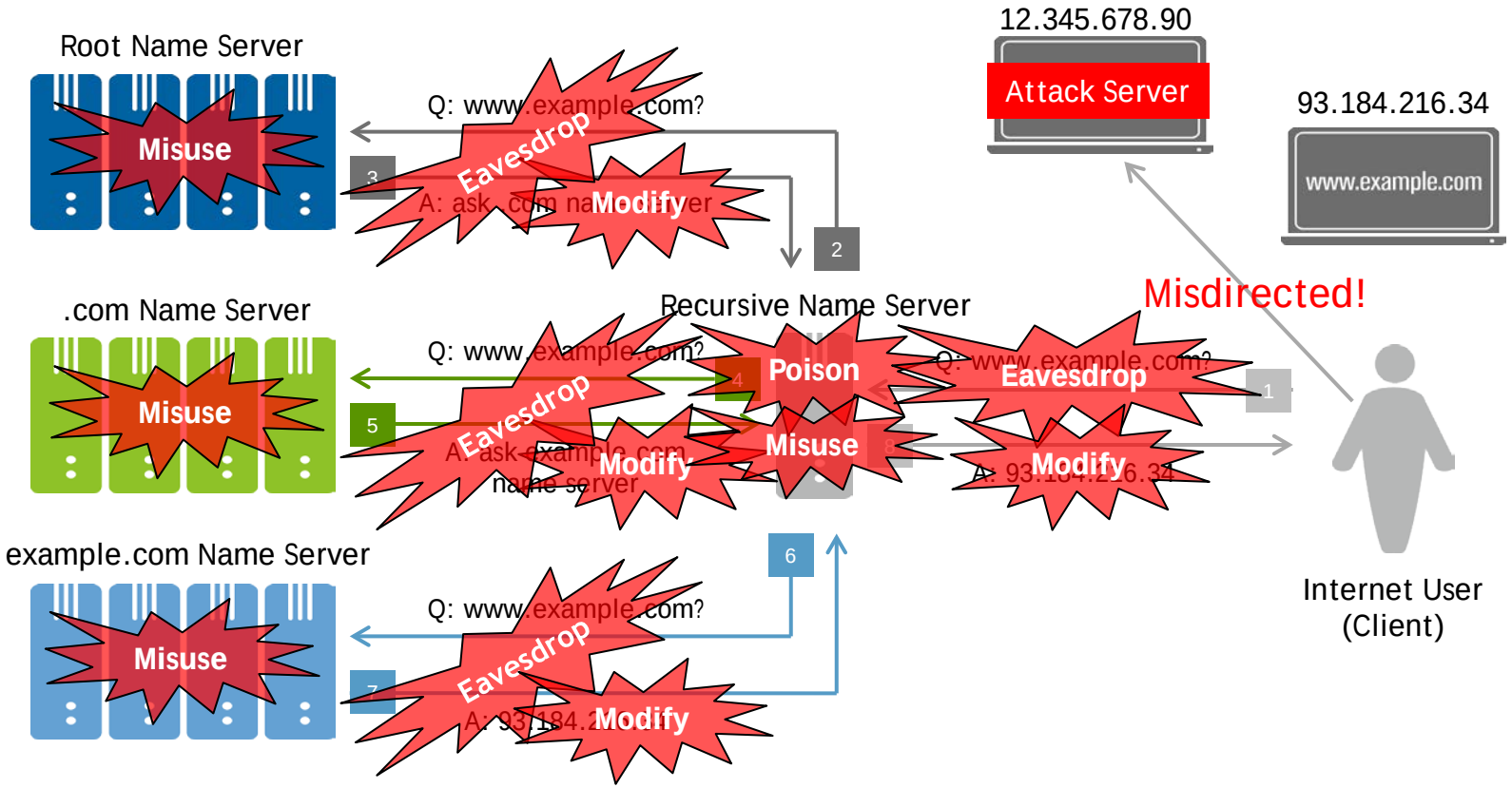
Risk 5: Modification

- In addition to risks related to disclosure of DNS traffic, clients' privacy may also be at risk if DNS responses are modified
- By modifying a DNS response, an adversary can misdirect a client to an incorrect server, facilitating an attack

Risk 5: Modification



Summary of Risks



Risk Mitigations

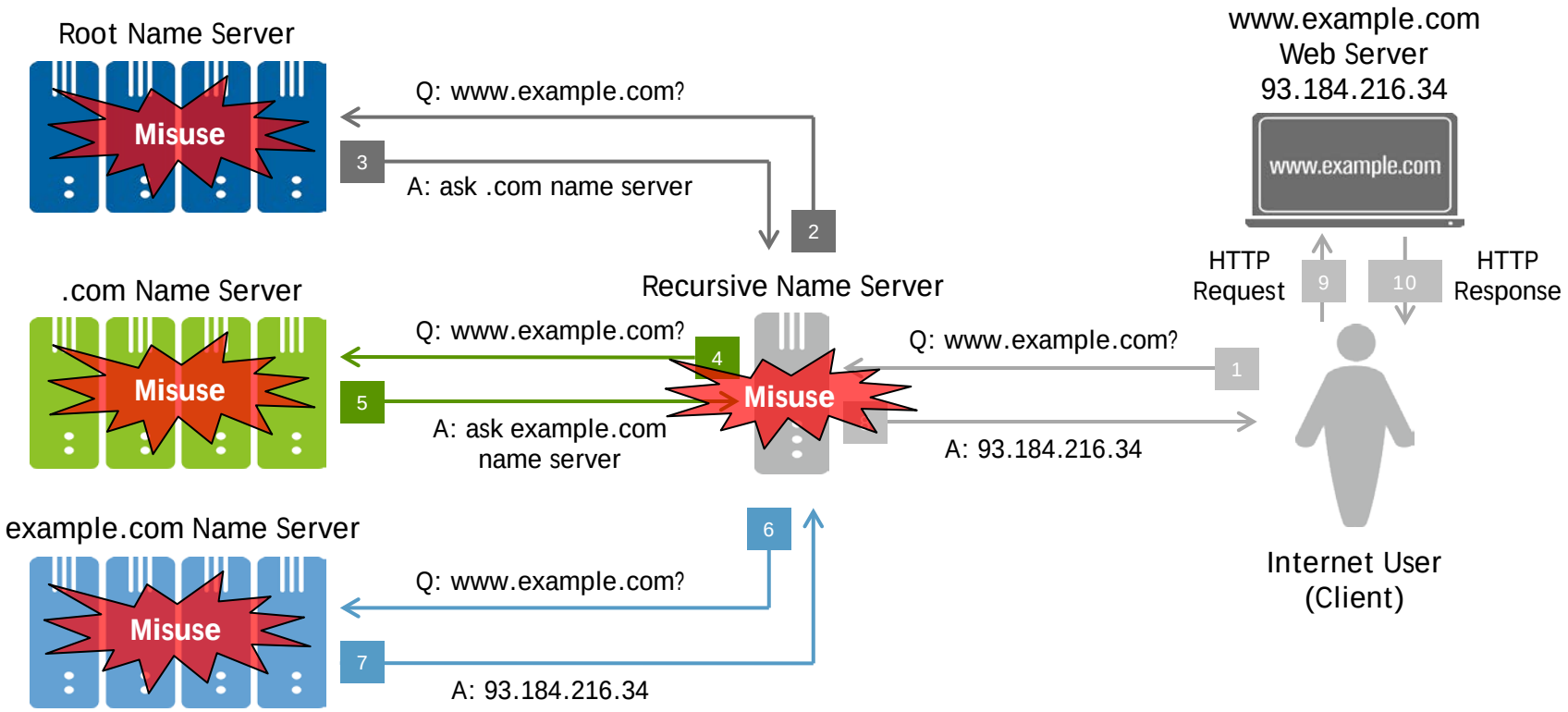
Mitigating DNS Privacy Risks

- Data handling policies can help mitigate the risks
- Technical enhancements to DNS have also been introduced in recent years to mitigate these risks:
  - DNS-over-TLS
  - qname-Minimization
  - DANE and DNSSEC

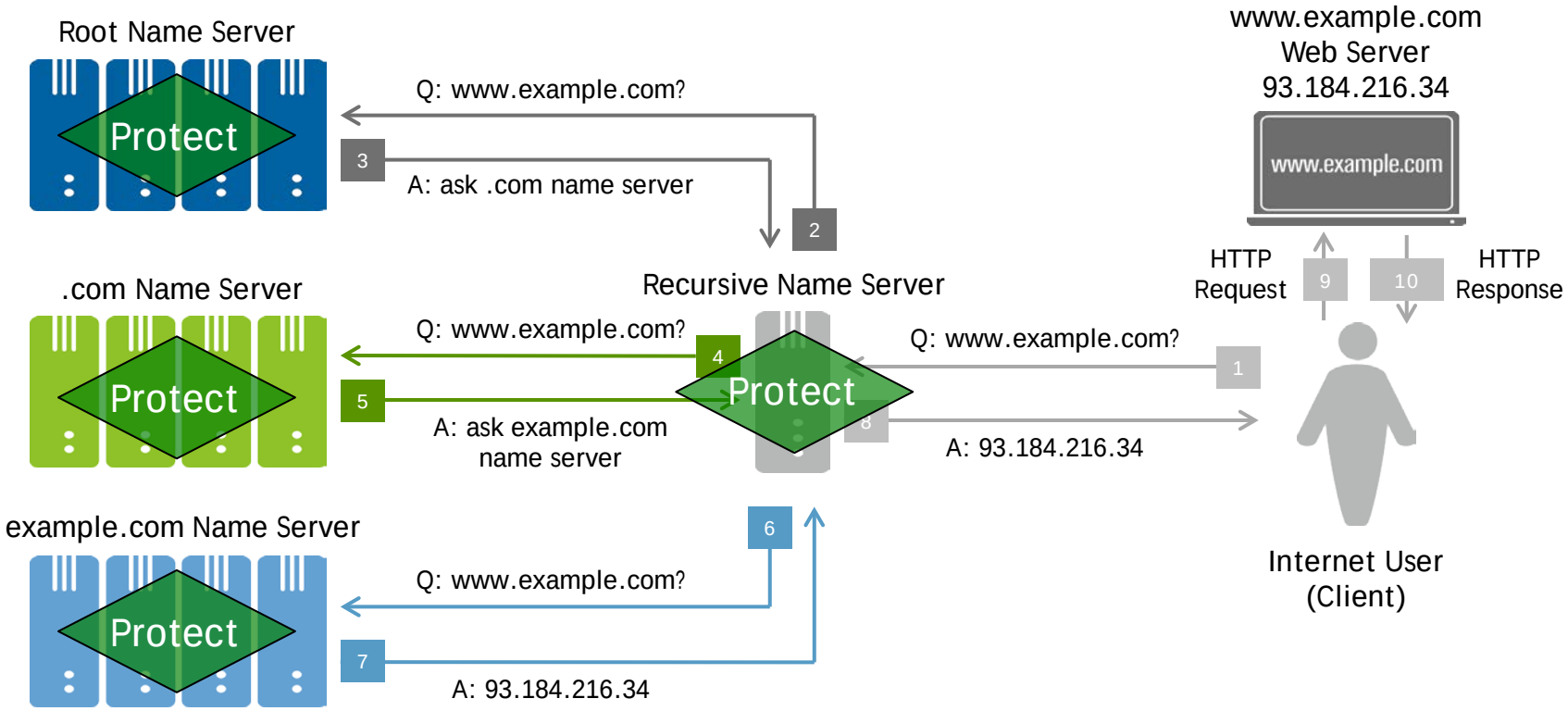
Mitigation 1: Data Handling

- Data handling policies, technologies and audits can mitigate risk of compromise, misuse of data at recursive, authoritative servers
- Root, top-level domain servers generally operate under established agreements
- Other authoritative name servers, recursive name servers may not

Risks 2 & 4: Misuse



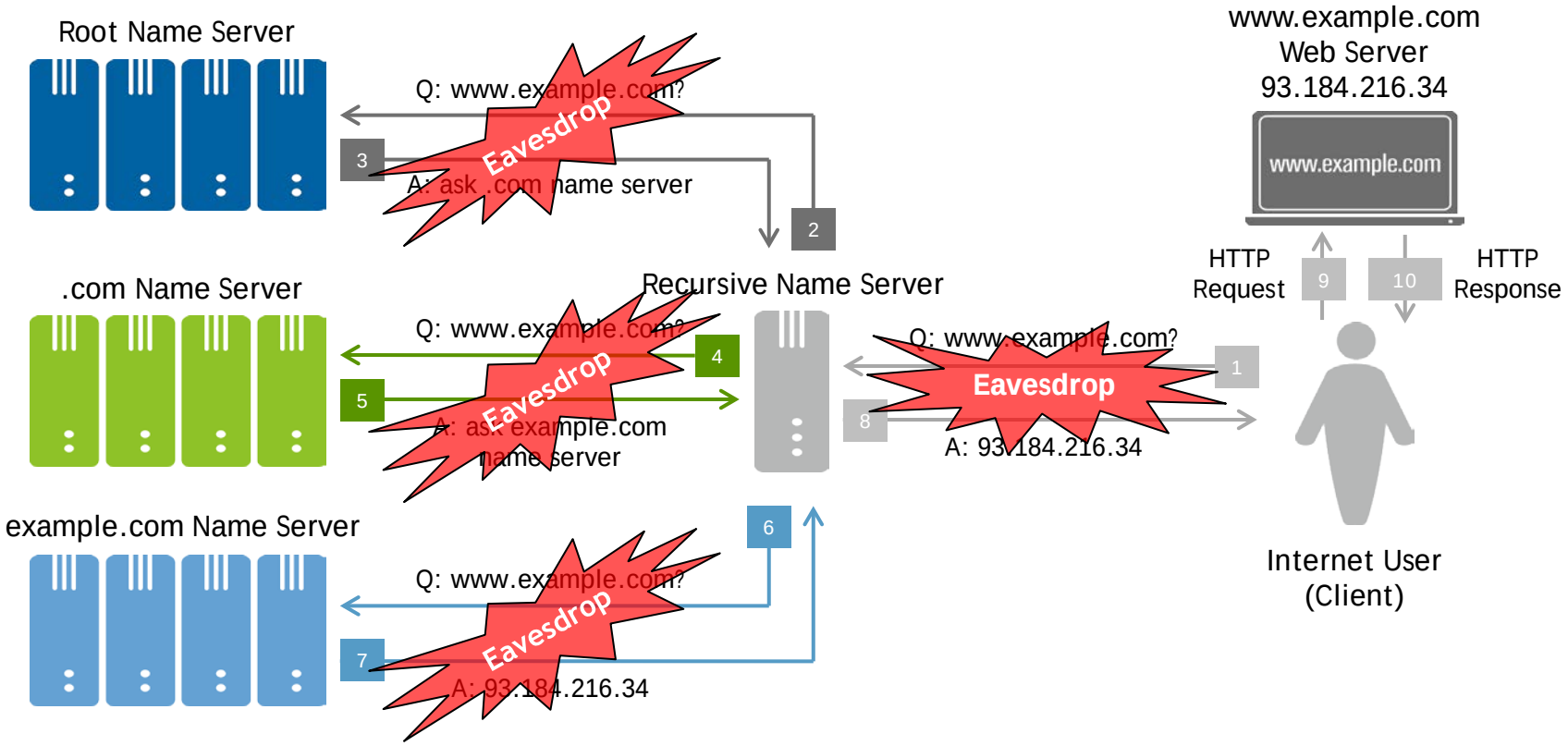
Mitigation 1: Data Handling



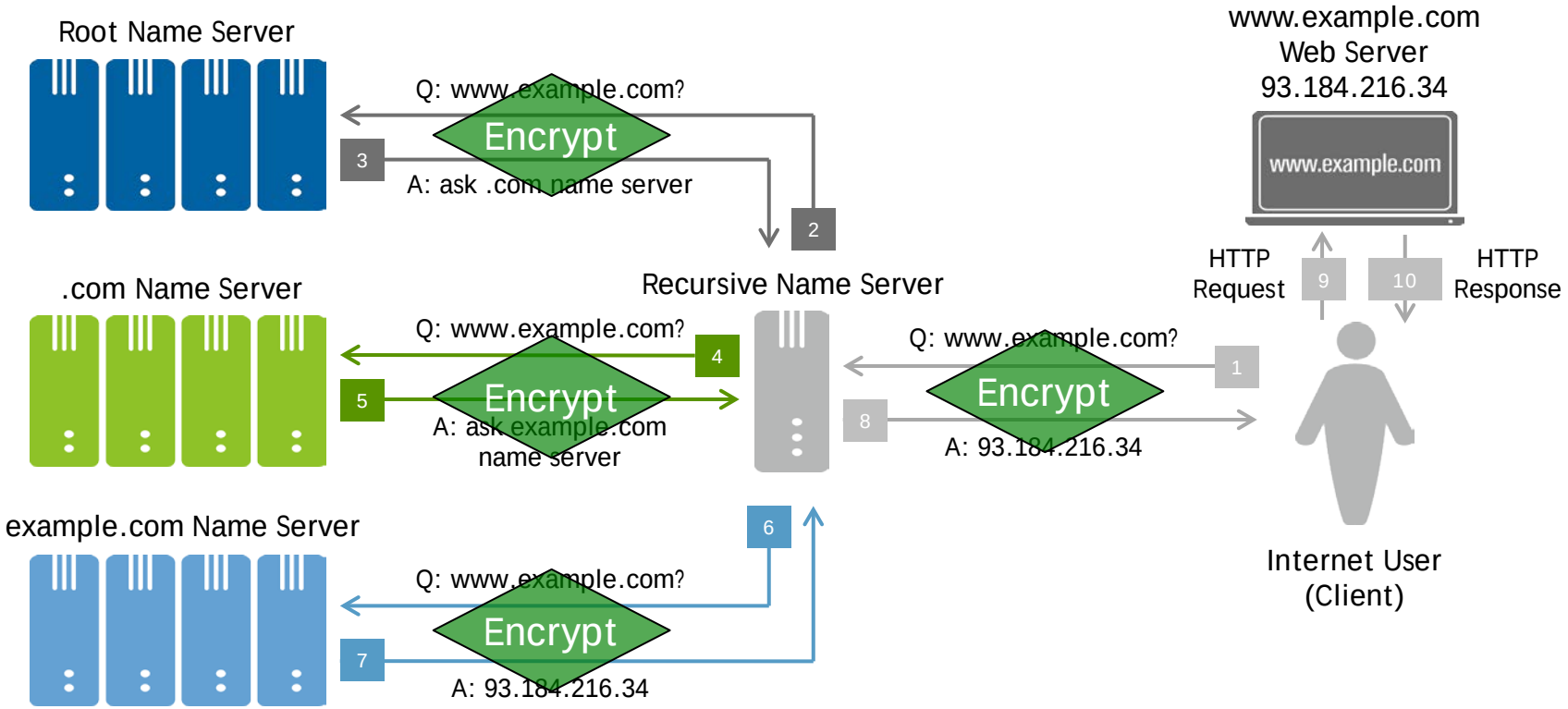
Mitigation 2: DNS-Over-TLS

- Like other Internet protocols, DNS can be made more secure and information disclosure can be reduced by running over Transport Layer Security (TLS)
- IETF DPRIVE working group currently developing DNS-over-TLS specification
- Mitigates eavesdropping (risks 1 & 3)
  - Also mitigates modification in transit

Risks 1 & 3: Eavesdropping



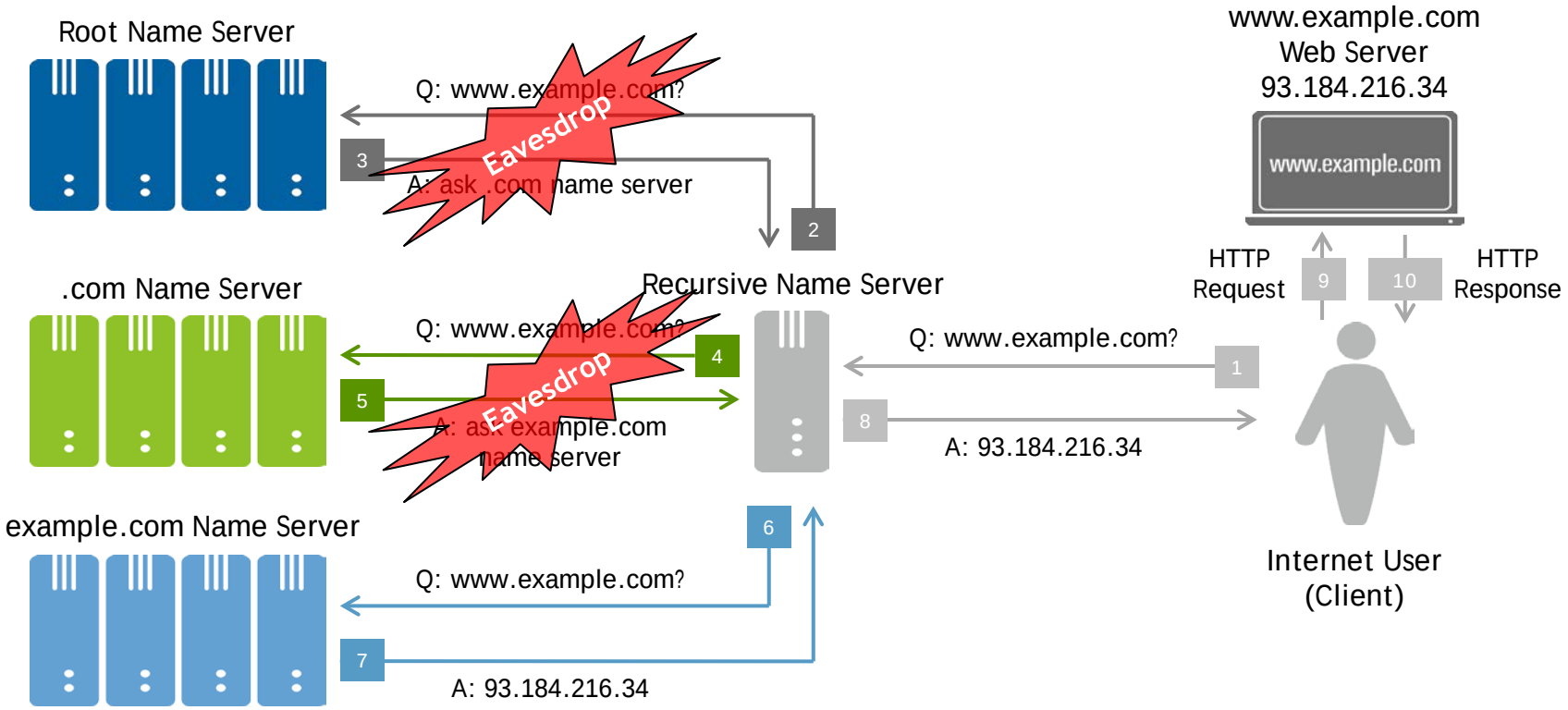
Mitigation 2: DNS-over-TLS



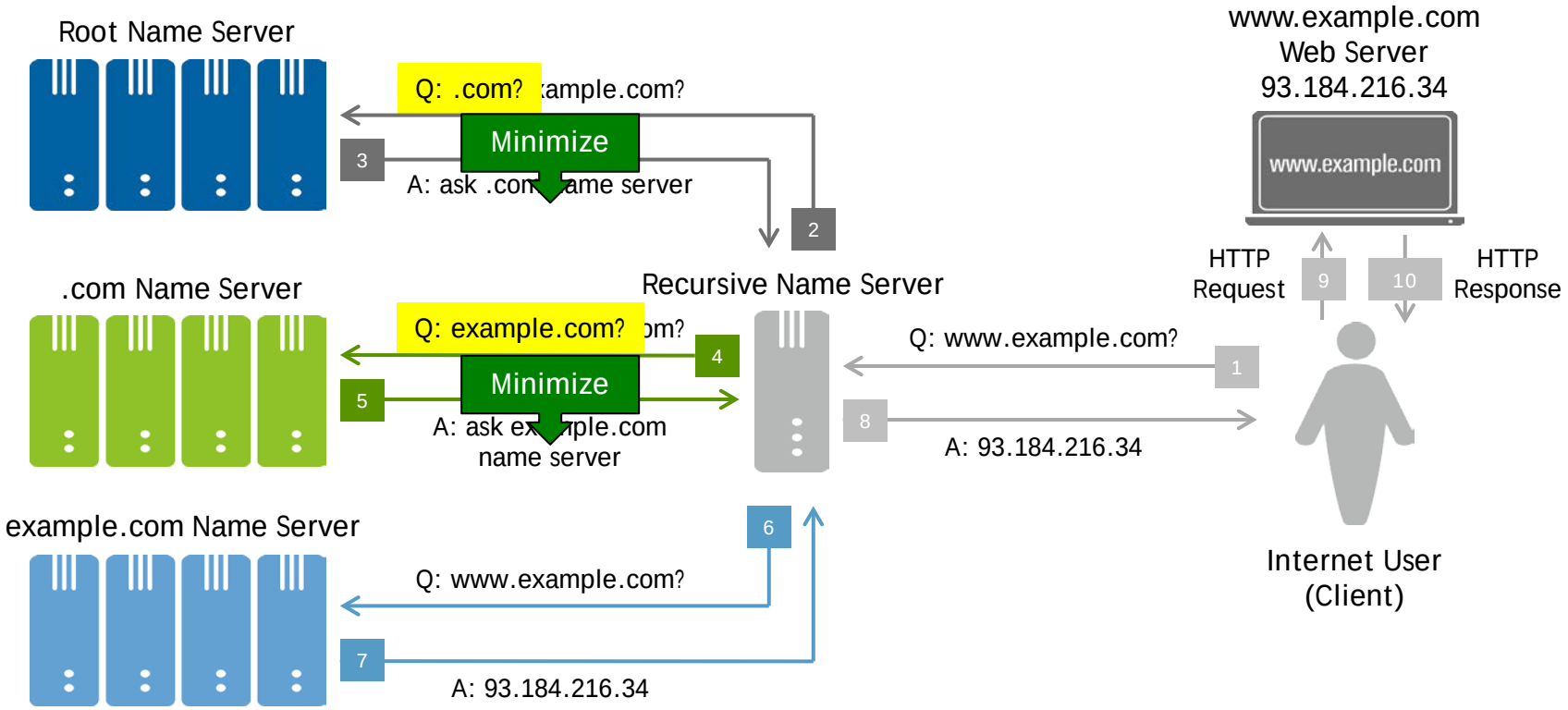
Mitigation 3: qname-Minimization

- DNS information disclosure can be reduced by asking authoritative only enough for referral to next server – not full query name (“qname”) each time
- IETF DNSOP working group currently developing qname-minimization spec
- Partially mitigates eavesdropping (risk 3) w/o encryption or changing authoritative

Risks 1 & 3: Eavesdropping



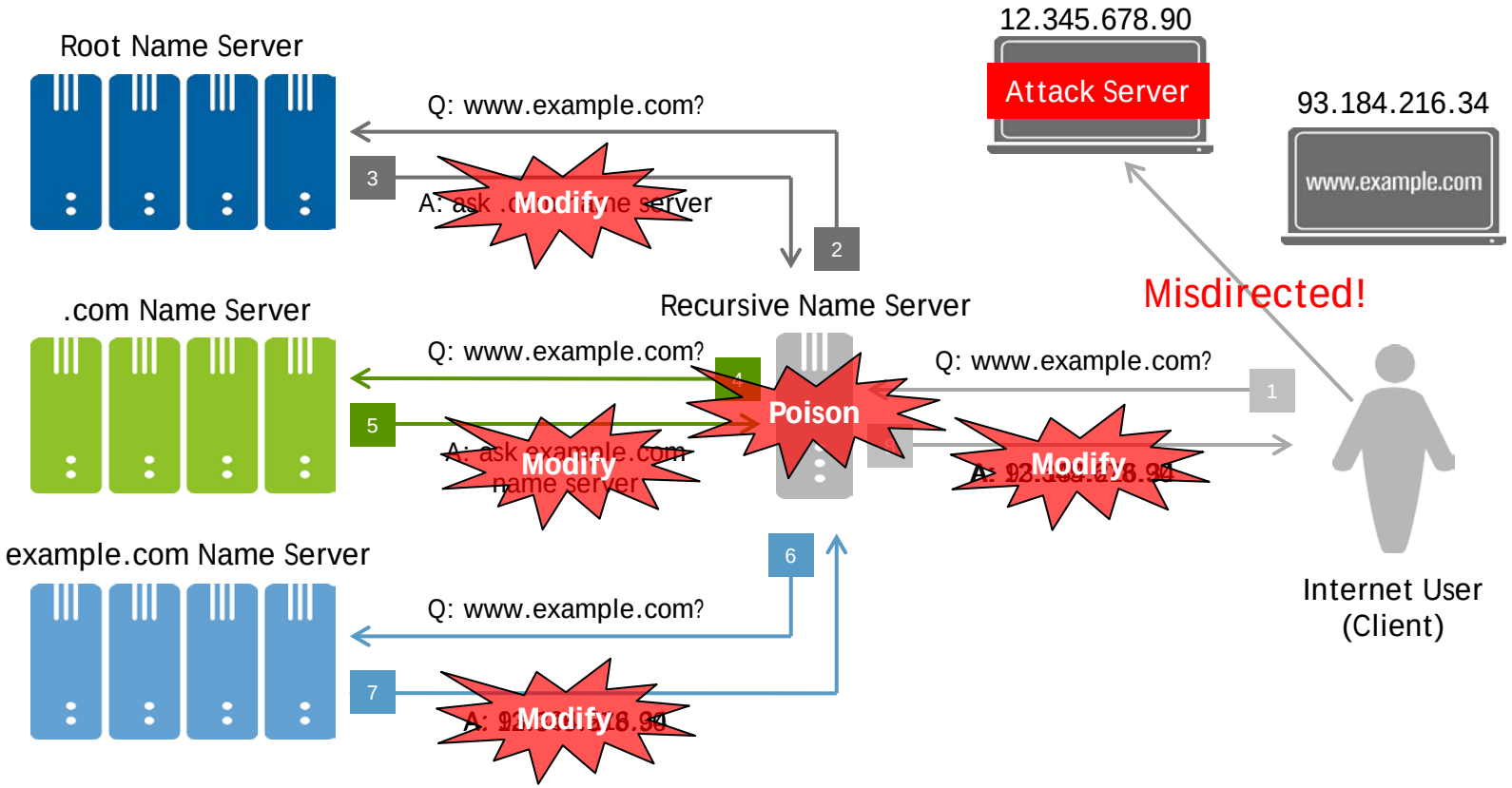
Mitigation 3: qname-Minimization



Mitigation 4: DNSSEC and DANE

- DNS Security Extensions (DNSSEC) mitigates modification risk by adding digital signatures to DNS records
- Recursive, client can validate that records are unmodified
- DNS-Based Authentication of Named Entities (DANE) extends validation to include web server keys and certificates

Risk 5: Modification



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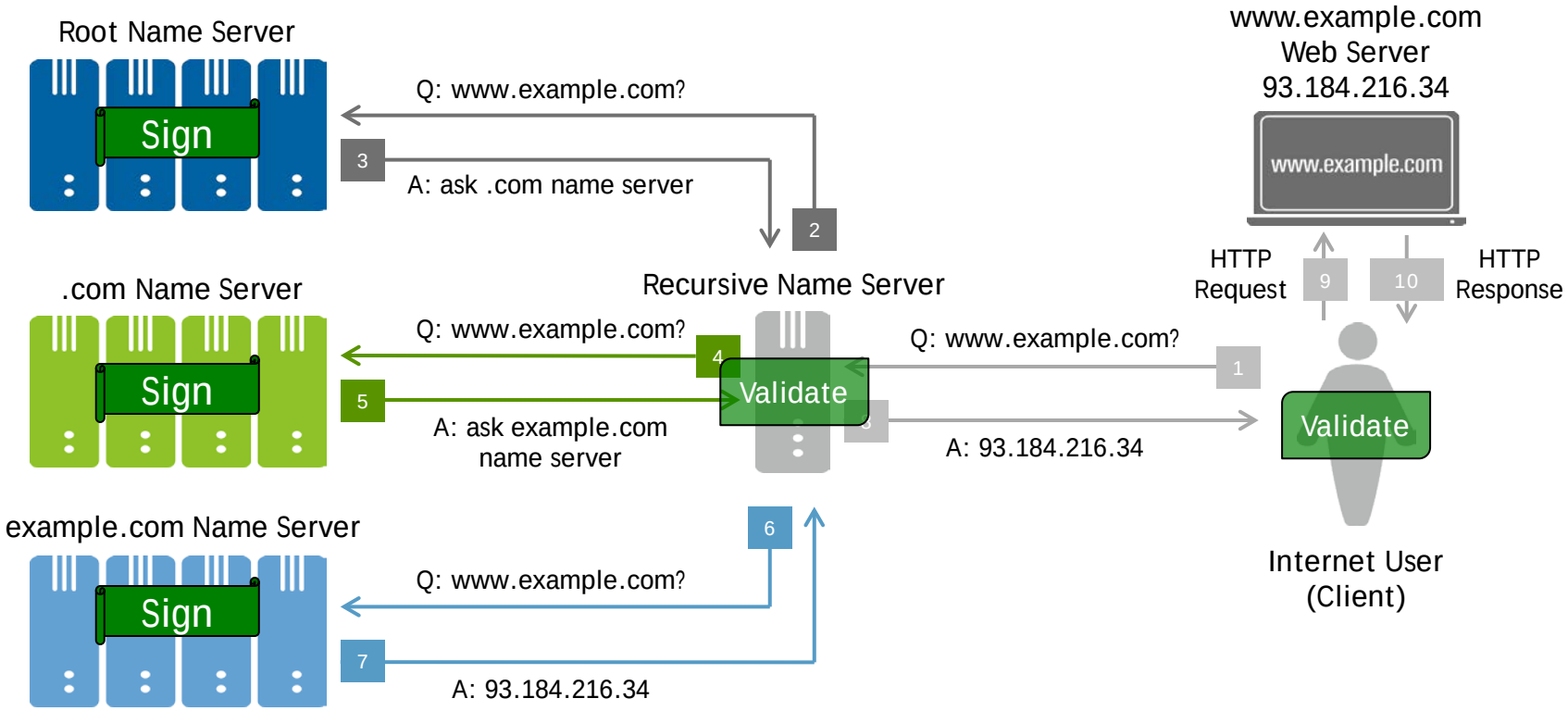

Summary: Risk Mitigation Matrix

		Risk				
		Disclosure or Misuse				Modification
		Client to Recursive	At Recursive	Recursive to Authoritative	At Authoritative	
Mitigation	Data Handling		**Protect**		**Protect**	**+**
	DNS-over-TLS	**Encrypt**		**Encrypt**		**+**
	qname-minimization			**Minimize**	**Minimize**	
	DNSSEC and DANE					**Sign Validate**

Recommendations

Recommendations for Privacy Professionals

- If DNS is part of the system you're protecting ...

- Ask if these risks apply
- Ask if existing mitigations are sufficient
- Consider how these mitigations can help
- Ask your DNS provider about its privacy practices

For More Information

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Q & A

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