Q1 *DNS over TCP (SU20 Final Q6)* **(20 points)**

Standard DNS uses UDP to send all queries and responses. Consider a modified DNS that instead uses TCP for all queries and responses.

Q1.1 (3 points) Which of the following does DNS over TCP guarantee against a man-in-the-middle attacker? Select all that apply.

☐ (A) Confidentiality ☐ (C) Authenticity ☐ (E) ——

☐ (B) Integrity ☐ (D) None of the above ☐ (F) ——

Q1.2 (3 points) Compared to standard DNS, does DNS over TCP defend against more attacks, fewer attacks, or the same amount of attacks against an on-path attacker?

◯ (G) More attacks ◯ (I) Fewer attacks ◯ (K) ——

◯ (H) Same amount of attacks ◯ (J) —— ◯ (L) ——

Q1.3 (5 points) What fields does an off-path attacker ***not know*** and need to ***guess*** correctly to spoof a response in DNS over TCP? Assume source port randomization is enabled. Select all that apply.

☐ (A) TCP sequence numbers ☐ (C) Recursive resolver port ☐ (E) DNS NS records

☐ (B) Name server port ☐ (D) DNS A records ☐ (F) None of the above

Q1.4 (3 points) Is the Kaminsky attack possible on DNS over TCP? Assume source port randomization is disabled.

◯ (G) Yes, because the attacker only needs to guess the DNS Query ID

◯ (H) Yes, but we consider it infeasible for modern attackers

◯ (I) No, because the attacker cannot force the victim to generate a lot of DNS over TCP requests

◯ (J) No, because TCP has integrity guarantees

◯ (K) ——

◯ (L) ——

Q1.5 (3 points) Recall the DoS amplification attack using standard DNS packets. An off-path attacker spoofs many DNS queries with the victim's IP, and the victim is overwhelmed with DNS responses.

Does this attack still work on DNS over TCP?

◯ (A) Yes, the attack causes the victim to consume more bandwidth than the standard DNS attack

◯ (B) Yes, the attack causes the victim to consume less bandwidth than the standard DNS attack

◯ (C) No, because the DNS responses no longer provide enough amplification

◯ (D) No, because the attacker cannot force the server to send DNS responses to the victim

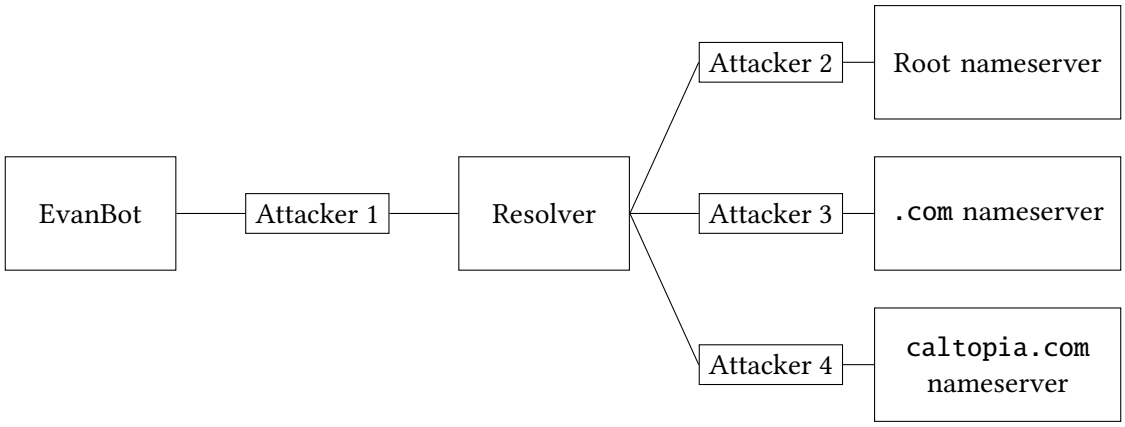
◯ (E) ——

◯ (F) ——

Q1.6 (3 points) What type of off-path DoS attack from lecture is DNS over TCP vulnerable to, but standard DNS not vulnerable to? Answer in five words or fewer.

Q2 *Caltopia DNS (SP21 Final Q8)* **(21 points)**

EvanBot is trying to determine the IP address of `caltopia.com` with DNS. However, some attackers on the network want to provide EvanBot with the wrong answer.



Assumptions:

- Each attacker is a man-in-the-middle (MITM) attacker between their two neighbors on the diagram above.
- No attackers can perform a Kaminsky attack.
- Standard DNS (not DNSSEC) is used unless otherwise stated.
- No private keys have been compromised unless otherwise stated.
- In each subpart, both EvanBot's cache and the local resolver's cache start empty.
- Each subpart is independent.

Clarification during exam: Assume that bailiwick checking is in use for this entire question.

In each subpart, EvanBot performs a DNS query for the address of `caltopia.com`.

Q2.1 (4 points) In this subpart only, assume the attackers only passively observe messages.

Which of the attackers would observe an `A` record with the IP address of `caltopia.com` as a result of EvanBot's query? Select all that apply.

☐ (A) Attacker 1 ☐ (C) Attacker 3 ☐ (E) None of the above

☐ (B) Attacker 2 ☐ (D) Attacker 4 ☐ (F) ——

Q2.2 (3 points) Which of the attackers can poison the local resolver's cached record for `cs161.org` by injecting a record into the additional section of the DNS response? Select all that apply.

Note: Attacker 1 has intentionally been left out as an answer choice.

☐ (G) Attacker 2 ☐ (I) Attacker 4 ☐ (K) ——

☐ (H) Attacker 3 ☐ (J) None of the above ☐ (L) ——

Q2.3 (4 points) Assume that the resolver and the name servers all validate DNSSEC, but EvanBot does not validate DNSSEC. Which of the attackers can poison EvanBot's cached record for `caltopia.com` by modifying the DNS response? Select all that apply.

☐ (A) Attacker 1 ☐ (C) Attacker 3 ☐ (E) None of the above

☐ (B) Attacker 2 ☐ (D) Attacker 4 ☐ (F) ——

Q2.4 (5 points) In this subpart only, assume the attackers only passively observe messages.

Assume that everyone validates DNSSEC. Which of the following records would Attacker 3 observe as a result of EvanBot's query? Select all that apply.

☐ (G) `DS` record with hash of the `.com` name server's public KSK

☐ (H) `DS` record with hash of the `caltopia.com` name server's public KSK

☐ (I) `A` record with the IP address of `caltopia.com`

☐ (J) `A` record with the IP address of the `caltopia.com` name server

☐ (K) `DNSKEY` record with the `.com` name server's public KSK

☐ (L) None of the above

Q2.5 (3 points) Assume that everyone validates DNSSEC, and the `caltopia.com` name server's private KSK has been compromised (i.e. all attackers know the `caltopia.com` name server's private KSK). No other private keys have been compromised.

Can EvanBot trust that they received the correct IP address of `caltopia.com`?

◯ (A) Yes, because the ZSK that signs the `A` record has not been compromised

◯ (B) Yes, because the trust anchor (the root's KSK) has not been compromised

◯ (C) No, because the compromised KSK can be used to sign a malicious `A` record

◯ (D) No, because the compromised KSK can be used to sign a fake ZSK that is used to sign a malicious `A` record

◯ (E) ——

◯ (F) ——

Q2.6 (2 points) True or False: DNSSEC prevents Attacker 4 from learning the IP address of `caltopia.com`.

◯ (G) True ◯ (H) False ◯ (I) —— ◯ (J) —— ◯ (K) —— ◯ (L) ——

Q3 *Peter Parker in CS161: Training Wheels Protocol* **(7 points)**

There is an off-path attacker trying to poison Peter's DNS cache. This attacker wishes to trick Peter's recursive resolver into caching their IP address as the address of `cs161.org`. Assume Peter does not use DNSSEC and that Bailiwick checking is implemented.

Q3.1 (2 points) Select all true statements:

- ☐ The attacker must send a DNS response before the real nameserver responds to poison the cache
- ☐ The attacker must break symmetric key encryption to poison the cache
- ☐ The attacker must break asymmetric key encryption to poison the cache
- ☐ The attacker would not be able to poison the recursive resolver's cache if Peter's recursive resolver and all nameservers used DNSSEC
- ☐ None of the above

Q3.2 (2½ points) Which of the following domains, when visited by Peter using his browser, would give the attacker a non-negligible chance to poison the cache for `cs161.org`? Select all that apply.

- ☐ `https://cs161.org`
- ☐ `http://cs161.org`
- ☐ `http://nonexistentdomain.cs161.org`
- ☐ `http://www.google.com`
- ☐ `http://nonexistentdomain.google.com`
- ☐ None of the above

Q3.3 ($2\frac{1}{2}$ points) Now assume that Peter is a frequent visitor of `cs161.org` and `google.com` and that his recursive resolver has already cached those two domains. Which of the domains below may still give the attacker a non-negligible chance to poison the cache when Peter visits that domain? Select all that apply.

- ☐ `https://cs161.org`
- ☐ `http://cs161.org`
- ☐ `http://nonexistentdomain.cs161.org`
- ☐ `http://www.google.com`
- ☐ `http://nonexistentdomain.google.com`
- ☐ None of the above