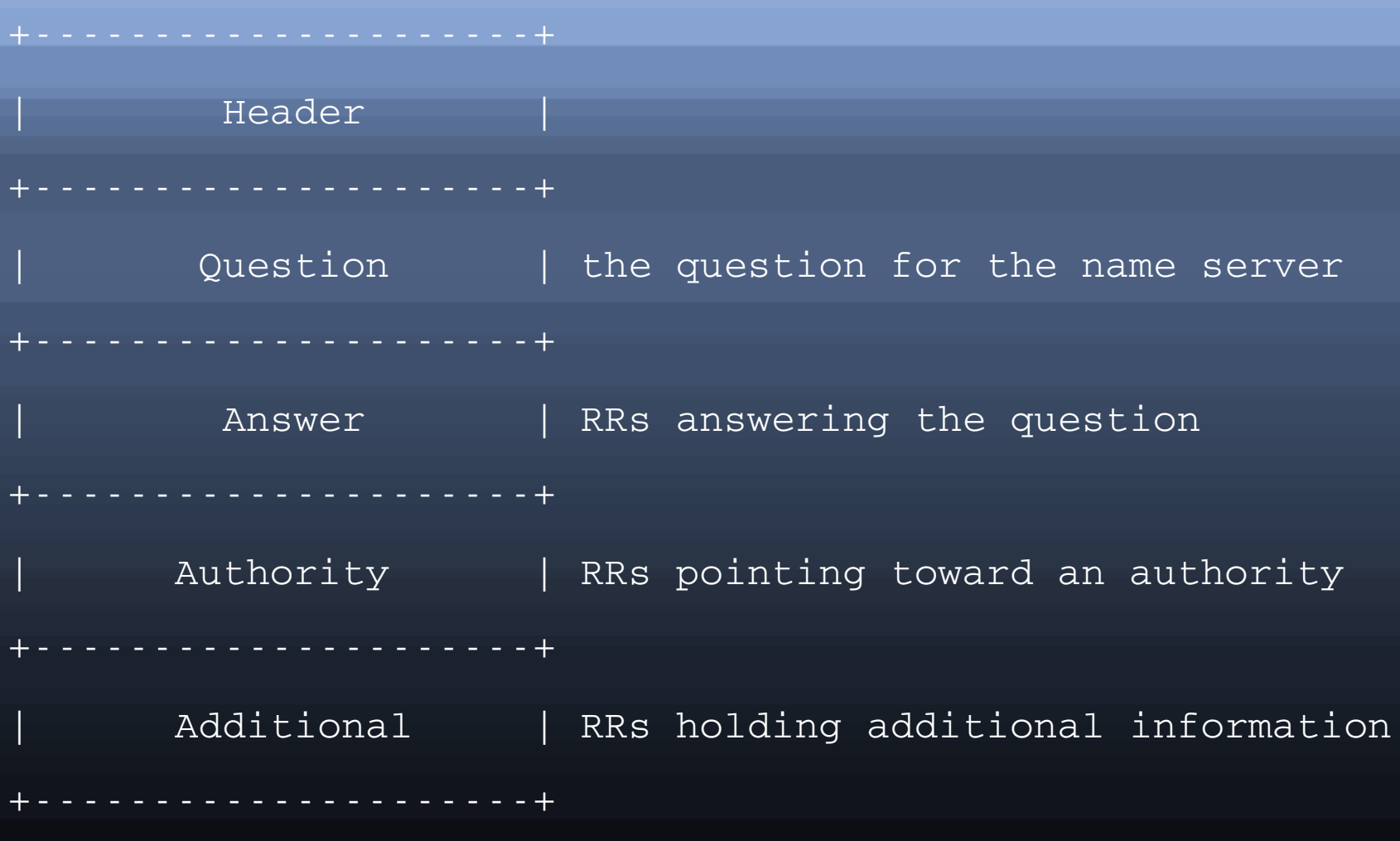
ICS 451: Today's plan

- Domain Name System:
  - DNS Protocol
- dig
- DNSSEC overview

DNS Protocol

- DNS has requests and replies (*queries* and *answers*)
- Each query is for a Resource Record (RR)
  - each answer is a RR
- Each message has a header followed by one or more RRs
- The message can be sent over UDP
  - or, with a length header, over TCP
- RFC 1035, and many more

DNS Message Structure



- from RFC 1035

DNS Header


ID
QR
Opcode
AA
TC
RD
RA
Z
RCODE
QDCOUNT
ANCOUNT
NSCOUNT
ARCOUNT

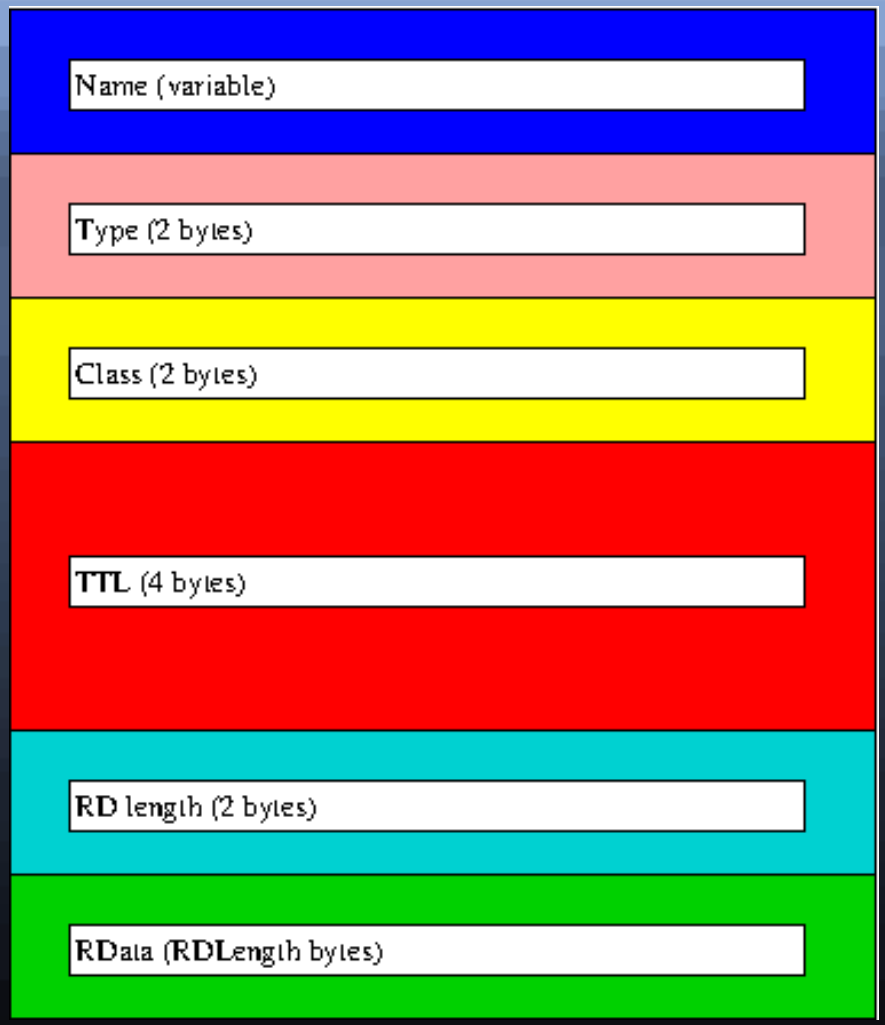
DNS Header Fields

- ID is used to match replies to requests
  - essentially random
- Opcode: 0 for query, 1 for inverse query
- Rcode (Response Code): 0 no error
- QD/AN/NS/AR count: number of questions/answers/name servers (authorities)/additional RRs

DNS Header Bits

- QR: 0 for query, 1 for response
- AA: this answer sent by an authoritative server
  - not authenticated, i.e. not secure
- TC: message was truncated
- RD: Recursion Desired
  - set in query, copied to response
- RA: Recursion Available
  - set in response if server provides recursion

Resource Record Structure



RR Fields

- Name is the domain name
- TTL is the time in second this record may be cached
- RDLength is the length of the RData field
- RData is the actual data, e.g. IP address
  - questions have no TTL, RDLength, or RData

Types and Classes

- Types:
  - A (IPv4 address), AAAA (IPv6)
  - MX (mail server)
  - NS (name server)
  - CNAME (canonical name for an alias)
  - PTR (reverse lookup pointer)
- Only 1 Class: IN (1), the Internet
  - other classes are obsolete

A DNS Lookup

- Query carries a Query Name, followed by a Type and a Class
  - e.g. www.hawaii.edu, A, IN
  - typically 1 query, and no other records
- Response has:
  - answers: CNAME web00.its.hawaii.edu

    web00.its.hawaii.edu A 128.171.224.100
  - authority: hawaii.edu NS dns1.hawaii.edu
  - additional: dns1.hawaii.edu A 128.171.213.116

Encoding Names

- Domain Names are encoded as sequences of labels, each label up to 63 bytes long
- Each label is 1 byte of length, then the name
  - The root is a single byte of 0
- Optimization: a label can be replaced by a 14-bit pointer preceded by two 1 bits
  - the remaining 14 bits are an index into the message
  - that is the beginning of another label

Encoding Names – example

- web00.its.hawaii.edu appears as:
  - **5**web00**3**its**6**hawaii**3**edu**0**
- if the index of the **5** in the message is 45, and the **6** is at index 55 in the message
- dns1.hawaii.edu can be encoded as
  - **4**dns1**xC0 x37** (55 is x37)
- any further web00.its.hawaii.edu can be
  - **xC0 x2D** (45 is x2D)
- www.hawaii.edu is **3**www**xC0 x37**

Request and Reply IDs

- The requester generates a different ID for each request
- The server copies the ID field into the reply
- The requester ignores replies with different Ids

- Security issue:
  - if I can guess what you are going to query
  - and I can guess your ID
  - I can send you a spoofed reply

dig

- Domain Information Groper?
- Unix tool for DNS lookups
- Sends a query, prints the response

- many options!

dig example

```
$ dig @128.171.3.13 www.hawaii.edu a
;; QUESTION SECTION:
;www.hawaii.edu.          IN A
;; ANSWER SECTION:
www.hawaii.edu.   IN   CNAME web00.its.hawaii.edu.
web00.its.hawaii.edu.    IN A  128.171.224.100
;; AUTHORITY SECTION:
hawaii.edu.          1571  IN NS dns4.hawaii.edu.
;; ADDITIONAL SECTION:
dns4.hawaii.edu.1457  IN A  130.253.102.7
dns4.hawaii.edu.1457  IN AAAA  2001:468:508:2::7
```

DNSSEC motivation

- If I send a query and I get a response, how can I trust the response?
  - anyone who can intercept the query can send me an arbitrary response
  - e.g. an ISP that wants to redirect me
  - even without intercepting the query, an attacker may guess the query and the ID
- DNS is not secure: the response may give me an incorrect IP number

DNSSEC strategy

- client/resolver must know the **root key**
- the root key is used to sign a TLD key
- the TLD key is used to sign the lower key
- … and so on
- client getting a record follows the chain back to the root key
- this confirms that the RR we received has been signed by someone known to the level above it
  - going back to the DNS root

DNSSEC weaknesses

- DNSSEC is not yet in widespread use
  - so an unauthenticated answer may be legit
- client/resolver must know the **root key**
- DNSSEC reveals zone data
  - which many admins prefer to keep secret
- DNSSEC provides authentication, but not confidentiality
- DNS is much more lightweight than DNSSEC