IT441: Network Servers & Infrastructure

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13:30 - 16:15

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Last Time

- TCP
- boot-time issues
- IP address: how allocated to host
- DNS
This Time

- DNS, DNS records, messages
- email service: SMTP, POP, IMAP
  - transfer encodings

Resolving Names

after Peterson & Davie ©2003 Elsevier Science (USA)
Resolving Names

- some nameserver is the **authoritative** nameserver for the domain in question
  - provides authoritative answer: either address or indication that the sought name doesn’t exist
- UNIX provides command-line resolvers
- e.g., `dig osfl.gmu.edu` replies with:
  ```
  ;; ANSWER SECTION:
  osfl.gmu.edu. 30139 IN A 129.174.1.13
  ;; AUTHORITY SECTION:
  gmu.edu. 85749 IN NS portal.gmu.edu.
  gmu.edu. 85749 IN NS sargon.gmu.edu.
  ```

Resolving Names

- UNIX provides resolver for use by programs as set of library functions:
  - `struct hostent *gethostbyname()`
  - `struct hostent *gethostbyaddr()`

```c
struct hostent
{
    char *h_name;           /* Official name of host. */
    char **h_aliases;       /* Alias list. */
    int  h_addrtype;        /* Host address type. */
    int  h_length;          /* Length of address. */
    char **h_addr_list;     /* List of addresses from name server. */
};
```
Sample DNS Record

- db in nameserver is a text file containing **resource records**
  - syntax: `<domain_name><ttl><class><type><value>
- example entry: (from Tanenbaum⁴, fig. 7-3)
  - flits.cs.vu.nl 86400 IN HINFO Sun Unix
  - flits.cs.vu.nl 86400 IN A 192.31.231.165
  - flits.cs.vu.nl 86400 IN MX 1 flits.cs.vu.nl
  - flits.cs.vu.nl 86400 IN MX 2 zephyr.cs.vu.nl
  - www.cs.vu.nl 86400 IN CNAME star.cs.vu.nl
  - ftp.cs.vu.nl 86400 IN CNAME zephyr.cs.vu.nl

Sample Resource Record

- flits.cs.vu.nl 86400 IN HINFO Sun Unix
- flits.cs.vu.nl 86400 IN A 192.31.231.165
- flits.cs.vu.nl 86400 IN MX 1 flits.cs.vu.nl
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- www.cs.vu.nl 86400 IN CNAME star.cs.vu.nl
- ftp.cs.vu.nl 86400 IN CNAME zephyr.cs.vu.nl
DNS Messages

Identification [16]: value assigned by client, returned by server, to let client match requests with answers

OP Code [4]: 0 ⇒ normal query
TC[1]: 0 if not, 1 if is truncated answer (was > 512 bytes)
QR [1]: 0 if query, 1 if response
AA[1]: 0 if not, 1 if is authoritative answer
RA[1]: 0 if not, 1 if is recursion available
RD[1]: 0 if not, 1 if recursion desired
Return Code[4]: 0 if no error, 3 if name error
DNS Messages

- sent via UDP
A Familiar Content Service

- electronic mail service

MTA to MTA

- mail transfer agent (MTA) moves messages to their destination
  - from a queue to some (recipient) MTA
  - to a user agent from some (sender) MTA
- MTAs speak simple mail transfer protocol (SMTP) to each other
  - originally in RFC821
  - currently RFC2821
- SMTP is a TCP service
  - runs on port 25
**MTA's view: sending mail**

220 something.org Sendmail 8.12 ready
HELO mynode.subdomain.com
250 OK
MAIL From: <scarter@mynode.subdomain.com>
250 <scarter@mynode.subdomain.com> OK
RCPT To: <joneil@nodex.sgc.mil>
250 <joneil@nodex.sgc.mil> OK
DATA
354 Enter mail, end with \r\n.\r\nmail message inserted here
.
250 OK mail accepted
QUIT
221 something.org closing connection

---

**Server Response Codes**

- first defined for SMTP in RFC822
- now widely used in other services
- based on 3-digit xyz values:

<table>
<thead>
<tr>
<th>1yz</th>
<th>positive preliminary reply</th>
</tr>
</thead>
<tbody>
<tr>
<td>2yz</td>
<td>positive completion reply</td>
</tr>
<tr>
<td>3yz</td>
<td>positive intermediate reply</td>
</tr>
<tr>
<td>4yz</td>
<td>transient negative completion reply</td>
</tr>
<tr>
<td>5yz</td>
<td>permanent completion reply</td>
</tr>
</tbody>
</table>
Server Response Codes

| x0z | syntax       |
| x1z | informational|
| x2z | connections  |
| x3z | unspecified  |
| x4z | unspecified  |
| x5z | Mail system  |

- and $z$ is context-specific code providing more detail

Server Commands

1. HELO, EHLO:
   - identify the SMTP client to the SMTP server
   - client sends its fully-qualified domain name
   - HELO used by older clients
   - all servers support HELO
   - newer ones support extended services, hence EHLO
Server Commands

1. HELO, EHLO:
2. MAIL
   - start mail transaction where mail is sent to server
3. RCPT
   - identifies a single recipient of the mail message
   - use multiple instances of RCPT for multiple recipients
Server Commands

1. HELO, EHLO:
2. MAIL
3. RCPT
4. DATA
   - server replies with 354 line then copies everything sent to it by client up to the ‘.’ line
   - data should consist only of 7–bit ASCII characters
     - and avoid ctrl chars other than SP, HT, CR, and LF

5. RSET
   - aborts current mail operation in progress
   - any data received as part of this operation is deleted from server
   - has no effect if appears immediately after EHLO
Server Commands

1. HELO, EHLO:
2. MAIL
3. RCPT
4. DATA
5. RSET
6. VRFY
   - asks receiver to confirm that argument identifies a user or mailbox

7. EXPN
   - asks receiver to confirm that argument identifies a mailing list and, if so, return list membership
Server Commands

1. HELO, EHLO:
2. MAIL
3. RCPT
4. DATA
5. RSET
6. VRFY
7. EXPN
8. HELP
   - causes server to send helpful information to client

9. NOOP
   - has no effect on server other than to cause it to respond with OK
Server Commands

1. HELO, EHLO:
2. MAIL
3. RCPT
4. DATA
5. RSET
6. VRFY
7. EXPN
8. HELP
9. NOOP
10. QUIT

server must send OK and close connection

email messages

- simple structure —
  - envelope: used by MTAs for delivery
    - consists of the 2 SMTP commands MAIL and RCPT
  - header: contains non-message information like addressee, sender, date, etc.
    - has a standard syntax
  - body: contains actual content of message
    - can be ‘anything’
Mail Headers

- used by user agents
- simple syntax: attribute:value
  - attributes may contain ASCII chars with codes 0x21 to 0xFE except 0x3A
  - values may contain any ASCII chars except CR and LF
  - e.g., "From: user@somplace.com"
  - some start with X- are user-defined
  - e.g., X-Charset, X-Mailer
Mail Headers

- **To:** address-list
  - contains the address(es) of the primary recipient(s) of the message
- **CC:** address-list
  - contains the addresses of others who are to receive the message
- **BCC:** address-list
  - contains addresses of recipients of the message whose addresses are not to be revealed to other recipients of the message

Mail Headers

- **Message-ID:** <ident>
  - not intended to be human-readable
  - e.g., <200403262028.12zK5Z2C0018562@netlab.gmu.edu>
  - provides unique identifier referring to particular version of particular message; uniqueness guaranteed by host generating it
- **In-Reply-To:** <ident>
  - lists message-id of current msg (to which it is a reply)
- **References:** <ident>
  - provides id's appearing in current msg's references field
Mail Headers

- informational fields, human readable:
  - Subject:
  - Comments:
  - Keywords:

Mail Headers

- user defined fields:
  - X-Charset: identify character set used to represent message
  - X-Mailer: user agent used to send message
  - X-Sender: duplicate of From:
email messages

- originally were only text
  - using 7-bit ASCII
- protocols designed around text-only original version
  - still support 7-bit ASCII
  - some may support 8-bit character data (see RFC1652)
  - described in RFC822 (still often cited)
  - current version is RFC2822
- lines must be ≤ 1000 bytes long
- but now want more than just text...

Different Content Types

- need mechanism to support:
  - different kinds of content to appear in a msg
  - multiple different kinds of content within one msg
Different Content Types

- need mechanism to support:
  - different kinds of content to appear in a msg
  - multiple different kinds of content within one msg
- use Multipurpose Internet Mail Extensions (MIME) RFC1521 (now: RFCs: 2045–2049)
  - provides way to encode binary data using only printable ASCII characters
  - inflates size of data

MIME

- used in email, adds lines to headers:
- for standard text messages:
  - MIME-Version: 1.0
  - Content-type: text/plain;
    charset=US-ASCII
- text of message follows
- message ends at end-of-text
**MIME**

- used in email, adds lines to headers:
- for multi-part messages:
  
  ```
  Content-Type: multipart/mixed;
  boundary="-----------------------------090405080304070600000708"
  -----------------------------090405080304070600000708
  Content-Type: text/plain; charset=ISO-8859-1;
  Format-Flowed
  Content-Transfer-Encoding: 7bit
  
  first part of message (text)
  
  -----------------------------090405080304070600000708
  Content-Type: image/jpeg;
  name="IMG_0980.jpg"
  Content-Transfer-Encoding: base64
  Content-Disposition: inline;
  filename="IMG_0980.jpg"
  
  second part of message (jpeg image)
  
  -----------------------------090405080304070600000708--
  ```

**Non-ASCII in Header**

- headers may also contain non-ASCII chars
- introduced using syntax:

```
=? charset ? encoding ? encoded-text ?=
```

  - start delimiter
  - identify character set:
    - e.g., ISO-8859-1
  - encoding scheme:
    - Q for quoted printable
    - B for base-64
  - end delimiter
Transfer Encodings

ways to represent non-ASCII data as ASCII:

2. quoted-printable:
   - ASCII chars with codes 0x21 to 0x7E (except
     0x3D) appears “as is”
   - all line breaks expressly appear as \r\n
   space appears as “_” unless at end of line “=20”
   - lines longer than 76 bytes have inserted line
     breaks
   - everything else represented as sequence =xx
     - e.g., ‘é’ appears as “=E9”

Quoted Printable Example

From: =?ISO-8859-1?q?Patrik_Faltstrom?= <paf@nada.kth.se>
translates into:

Patrik Faltstrom

eample taken from RFC1522
Transfer Encodings

ways to represent non-ASCII data as ASCII:

2. base64 encoding
   - replace every 6 bits of binary data with a single ASCII character from special charset table
   - table contains:
     - A..Z
     - a..z
     - 0..9
     - + / =
   - send string so generated

Base-64 Example

To: =?ISO 8859-1?Q?Keld_J=AErn_Simonsen?= <keld@dkuug.dk>
Subject: =?ISO-8859-1?Q?SwYGew91IGNhbihByZwFkIHRoXMgeW8=?= 
=?ISO-8859-2?B?dS1bmR1cnNOYw5kIHRoZSBleGFtcGxlLg==?= 

which a user agent renders as:

From: Keith Moore <moore@cs.utk.edu>
To: Keld Jørn Simonsen <keld@dkuug.dk>
CC: André Picard <PIRARD@vml.ulg.ac.be>
Subject: If you can read this you understand the example.
Address Services

- what's in a name?
  - user@somenode.subdomain.domain
- where does “user” get its email?
- what about
  - user@someothernode.subdomain.domain

Address Services

- many organizations now use email gateway
  - node dedicated to receiving, forwarding, sending email
- lets users have email addresses like
  - username@domain
- gateway receives all inbound email
  - either forwards to particular node, or,
  - keeps local and user's user-agent retrieves the email therefrom
Address Services

- gateway receives all inbound email
  - either forwards to particular node
- gateway needs list of entries associating
  - username@domain with username@node.subdomain.com
- must this association be 1:1?

Address Services

- must this association be 1:1?
- no: can have one name: many names
  - so email gateway can match a listname with ≥ 1 mailboxes and must generate individual copies of the message to each
  - such a gateway is hence known as a mail-exploder
  - see Comer fig. 32.5 for example
  - users must have their email address added to list in order to receive mailings
Address Services

- adding name to list can be automated procedure:
  - usually simply send email message to list
  - follow syntax rules specified by list, e.g., send subject line as “add me”
  - no body to msg (not being read by human)
- list manager on email gateway watches for these special msgs
  - performs add when discovers one to do
  - analogously for removal

Getting Your Mail

- today, email usually is delivered to some server whence you must retrieve it
  - rather than being delivered to ‘your’ local machine
  - i.e., your email user agent may be local, but the actual mailbox isn’t
- how to retrieve?
Post Office Protocol (POP)

- currently POP-3 as described in RFC1939
- POP is client–server pair
  - server runs on system where email physically is collected
  - client runs on system where user agent runs
- so mail server runs
  - software to collect email directed to it, including exploding function
  - software to support access to collected email via POP

- so mail client runs
  - software to send email (via SMTP)
  - software to receive email (via POP)
- POP client interacts with server to,
  - copy accumulated email from mail server to user client
  - delete copied messages from email server, or leave intact
- service runs on port 110
Post Office Protocol (POP)

- example client server interaction in POP3:
  
  connect to port 110 on server...
  
  +OK POP3 server ready
  USER fred
  +OK
  PASS derf
  +OK user logged on
  LIST
  +OK 2 messages (320 octets)
  1 120
  2 200
  .

- example client server interaction in POP3, cont’d:
  RETR 1
  +OK 120 octets
  <the POP3 server sends the entire message here>
  .
  DELE 1
  +OK message 1 deleted
  DELE 1
  -ERR message 1 already deleted
  QUIT
  +OK POP3 server signing off
POP3

- available commands in the POP3 protocol include:

  APOP       PASS       STAT
  DELE       QUIT       TOP
  LIST       RETR       UIDL
  NOOP       RSET       USE

Another Mail Fetching Protocol

- instead of POP, a user agent may use Internet Mail Access Protocol (IMAP) RFC3501
- particular advantage: allows management of messages on a server
  - e.g., can organize messages into folders
- also provides ability to retrieve only parts of a message
  - e.g., subject lines
  - e.g., specific part of MIME multipart message
Servers

- provide a service
- provide content
  - static
  - dynamic
    - generated on-demand
  - “streamed”
    - on-going flow of data
    - often real-time sensitive
    - may be pre-computed (e.g., mp3)
  - real-time, not pre-computable (e.g., telephony)

Internet Telephony

- real-time
- full duplex
- cannot be pre-computed, pre-compressed
- provide usual telephony services
  - call forwarding
  - call waiting
  - caller ID
  - PBX services
- interoperability with existing PSTN
Telephones

- what is a telephone?
- any combination of hardware and software that performs these functions can be a telephone