E-Mail Security

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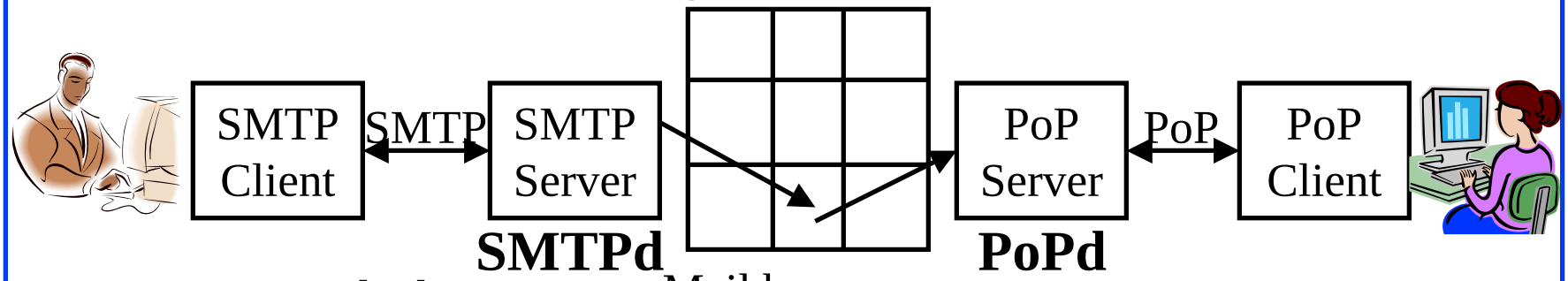
Audio/Video recordings of this lecture are available at:

http://www.cse.wustl.edu/~jain/cse571-07/

- Email Overview: SMTP, POP, IMAP, Radix-64, MIME
- Security Services: Privacy, authentication, Integrity, Non-Repudiation, Anonymity
- Secure Email Standards: S/MIME, PGP, DKIM, …
- Spam

Internet Email Overview

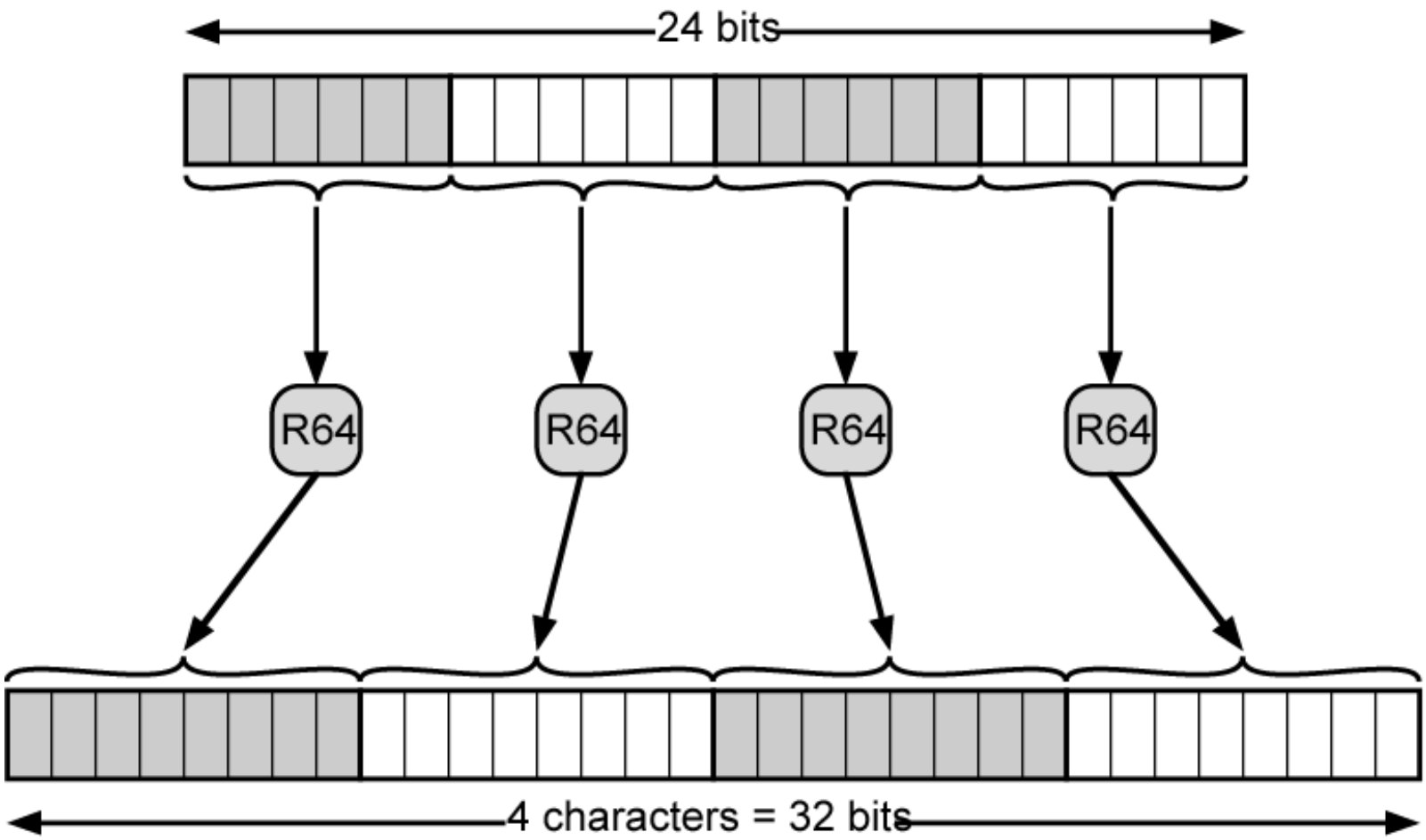
- Simple Mail Transfer Protocol (SMTP):
  Protocol to deposit email in another user's mailbox
  Was originally designed for 7-bit ASCII text messages
- Post Office Protocol (PoP):
  Protocol to retrieve email from your mailbox
  Authenticates the user
- Internet Mail Access Protocol (IMAP)
- Multimedia Internet Mail Encoding (MIME):
  To encode non-text messages



SMTP

- Defined in RFC 2821 and RFC 2822
- Clients connect to port 25 of SMTP server
- It is a push protocol and does not allow to pull
- Extended SMTP (ESMTP) is defined in RFC 2821
- ESMTP uses EHLO in stead of HELO
- ESMTP allows finding the maximum message size
- SMTP-AUTH is an authentication extension to SMTP (RFC 4954)
- Allows only authorized users to send email

Radix-64 Encoding



MIME Example

--unique-boundary-1
Content-Type: multipart/parallel;
boundary=unique-boundary-2

--unique-boundary-2
Content-Type: audio/basic
Content-Transfer-Encoding: base64

... base64-encoded 8000 Hz single-channel
u-law-format audio data goes here....

--unique-boundary-2
Content-Type: image/gif
Content-Transfer-Encoding: Base64
... base64-encoded image data goes here....

Security Services for E-Mail

- Privacy: of content
- Authentication: of Sender
- Integrity: of Content
- Non-repudiation: Sender cannot deny
- Proof of Submission: Proof of sending
  (Certified mail) – MTA can sign a message digest
- Proof of Delivery: to recipient
  (return receipt + Content non-repudiation)
- Message flow confidentiality
- Anonymity

Security Services for E-Mail (Cont)

- Containment: Keeping messages in a security zone
- Audit: event log
- Accounting: Accounting log
- Self Destruct: Receiving mail program will destroy the message
- Message Sequence Integrity: in-order delivery

Establishing Keys

- 1-to-1
- Public Keys:
  - Need public key to send an encrypted message
  - Can sign a message and send a certificate
- Secret Keys:
  - Via KDC

Privacy

- Employee vs. Employer
- End-to-End Privacy
- Use public key to encrypt a secret key
- Same encrypted message can be sent to multiple recipients
- Distribution lists require trusting the exploder

Source Authentication

- Sign a hash of the message with private key
  (Good for distribution lists also)
- Secret Key:
  - MAC=CBC residue with secret key
  - Message digest of the secret key
  - Message digest is encrypted with the secret key
    (Same digest for multiple recipients)
  - Can share a secret key with mail exploder

Message Integrity

- Generally goes with source authentication
  Integrity with source anonymity is meaningless
- You can use a shared secret
- Anyone can change the message encrypted or protected with public key

Non-Repudiation

- Public Key:
  - Non-Repudiation: sender signs the message with private key
  - Plausible Deniability: Sender computes a MAC using a random key S and sends $[[S]_{\text{Bob Public}}]_{\text{Alice Private}}$
- Secret Key:
  - Non-Repudiation: Notary N. N and receipient share a secret
  - N computes a seal = digest of the message and alice's name using a secret key
  - N shares a secret key with recepient and sends A MAC of the message, seal, and Alice.
  - A judge could ask N to verify if the seal is valid.

Proof of Delivery

- Delivering MTA or recipient can sign a message digest
- Impossible to prove that recipient got the message.
  - If recipient signs it before getting the last part of the message, it may not get complete message but has signed.
  - If recipient signs after getting the last part of the message, it may not sign but has the message.

Verifying Posting Date

- Preventing Backdating: Notary signs and dates the message
- Preventing Postdating: Notary signs and dates the message along with a fact not known before the date, e.g., newspaper headline, lottery number, ...

Digital Postmarks

- Post office can date stamp your document (Service available in USA and other countries also)
- Client software signs a document and sends it to DPM service
- DPM authenticates the signature, generates a timestamp and signs the resulting package (hash of message, signature, time)
- The DPM receipt is sent to the client software and also stored in a non-repudiation database with the message and signature
- The client software wraps the original document and DPM receipt
- Anyone can verify the signature and time
- Original document can be requested from DPM service database
- www.usps.com/electronicpostmark/

Anonymity

- penet.fi allowed two-way communication. Assigned code name to sender.
- If someone replies they are also assigned a code name
  - Assigned code name to the source exploder of the replies.
- Message Flow Confidentiality
  - Can send random messages through third party
  - Can use several intermediaries

Anonymous Remailers

- Pseudonymous Remailers: Give a pseudonym to the sender and send.
- Keep a log of pseudonym and actual address => Can be disclosed
- Cypherpunk Remailers: Removes the senders address (no return address) => No log
- Mixmaster Remailers: Anonymous remailer that sends messages in fixed size packets and reorders them to prevent tracing
- Mixminion Remailers: Strongest anonymity. Handle replies, forward anonymity, replay prevention, key rotation, exit policies, integrated directory servers, dummy traffic

Secure Email Standards

- Privacy Enhanced Mail (PEM) - Not deployed
- S/MIME - Uses PEM principles
- PGP
- STARTTLS (SMTP over TLS – RFC 2487)
- SMTP-AUTH (SMTP with password authentication)
- DKIM

S/MIME

- Secure MIME
- Originally developed by RSA Data Security Inc.
- Later control passed on to IETF
- Can use any certificate
- Bob first sends a signed message with a certificate
- Alice can then send an encrypted message to Bob
- PEM and S/MIME use X.500 names
- S/MIME requires Email as "Alternate Name" in the X.509 certificate
- Also, a new component E was added to the X.500 name

S/MIME Example

----------boundarymarker

Content-Type: application/pkcs7-signature;
name="smime.p7s"

Content-Transfer-Encoding: base64

Content-Disposition: attachment; filename="smime.p7s"

Content-Description: S/MIME Cryptographic Signature

ABDECDIPAQaAIHGNPAISJPDSFPSDNADNPA

----------boundarymarker

Pretty Good Privacy (PGP)

- Used RSA and IDEA (RSA patent in US until 2000)
- V2.6.2 became legal for use within US and can be downloaded from MIT
- A patent-free version using public algorithm has also been developed
- Code published as an OCRable book
- Open PGP and GNU Privacy Guard
- Uses certificates issued by almost anyone
- Certificates can be registered on public sites, e.g., MIT
- hushmail.com is an example of pgp mail service

DomainKeys Identified Mail (DKIM)

- RFC 4871
- Sending MTA inserts a signature on behalf of the sender
- Verifying (Receiving) MTA verifies the signature based on public key of the sender

Spam Statistics

- 30 Billion spams per day (June 2005) to 90 billion spams per day (feb 2007)
- 80 to 85% of mail is spam
- Most spam originates from USA (19.6%) but 73.58% of spamvertisers are in China.
- Addresses are harvested from web pages, usenet groups, corporate directories
- Spam is sent using botnets, open relays, and open proxies
- Many DNS blackhole list sites were closed down due to DDoS attacks

CAN-SPAM Act of 2003

- Spamming is a misdemeanor
- You can send unsolicited commercial email iff

1. Unsubscribe compliance
   - Unsubscribe mechanism
   - Opt-out honored within 10 days
   - Opt-out lists used only for compliance
2. Content compliance
   - Accurate from, subject, advertisers address
   - Identify Adult content
3. Sending behavior Compliance
   - Not sent through an open relay
   - Not sent to harvested address
   - Cannot contain false header

Anti-SPAM:End-User Techniques

- Address munging: jain at wustl dot edu
- Avoid responding to spam
- Use contact forms
- Disable HTML in e-mail: Web bugs (1x1 transparent gifs) can identified who read the mail
- Disposable e-mail addresses
- Reporting spam: spam@uce.gov
- Responding to spam: Overload the advertiser

Anti-SPAM:Administrator Techniques

- Authentication and Reputation
- Challenge/Response Systems
- Checksum-based filtering: Matching checksum => Spam, hash busters
- Country-based filtering
- DNS Black Lists
- Enforcing RFC standards
- HELO/EHLO checking: HELO 127.0.0.1 or HELO localhost
- Greylisting: Error code 4xx => Retry later
- Fake MX Records: Multiple MX records, spammers do not retry
- Greeting delay: Spammers do not wait

Administrator Techniques (Cont)

- Hybrid filtering: Pattern matching and scoring
- Rule-based filtering: more general filtering and scoring
- Statistical content filtering: Learning from user submitted spam/ham
- Reverse DNS checks: Email address domain=IP address domain?
- Sender-supported whitelists and tags: Certified not be spammer
- SMTP callback verification: Check return address

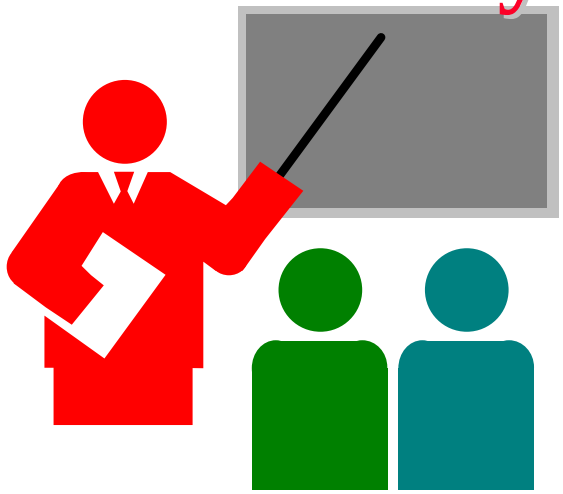
Anti-SPAM: Sender ISP Techniques

- Background checks on new users and customers
- Confirmed opt-in for mailing list: Removes false submission
- Egress spam filtering: Check customer's email addresses
- Limit e-mail backscatter: bouncing messages
- Port 25 blocking
- Port 25 interception: Rate limit and egress spam filter
- Rate limiting
- Monitor Spam reports
- Strong Acceptable Use Policy

Anti-SPAM:Law Enforcement

- Honeypots
- Spamtraps

Summary



- UA, MTA, SMTP, PoP, IMAP, Radix-64, MIME
- Encryption is done using secret keys, which are sent using public key encryption
- S/MIME and PGP both use certificates
- Spam identification/reduction requires recipient, adminstrators, ISPs, and government actions

Homework 16

- Read chapter 20 complete, and relevant sections of 21, 22 of the textbook
- Try answering Exercise 20.4 and 20.7