Announcements

- Project #4 is due on Thursday
- Project #5 is on the web
Monitoring

- **Record (log) significant events**
  - attempts to login to the system
  - changes to selected files or directories

- **Possible to compromise the log**
  - the user or software breaking in could delete all or part of the logs
  - could record logs to non-erasable storage
    - have a line printer attached to the machine
    - use WORM drives
  - send data to a secure remote host
Encryption: protecting info from being read

- **Given a message** $m$
  - use a key $k$, and function $E_k$ to compute $E_k(m)$
  - store or send only $E_k(m)$
  - use a second second key $k'$ and function $D_{k'}$ such that
    - $D_{k'}(E_k(m)) = m$
    - $E_k$ and $D_{k'}$ need not be kept a secret

- **If** $k=k'$ **it’s called private key encryption**
  - need to keep $k$ secret
  - example DES

- **If** $k \neq k'$, **it’s called public key encryption**
  - need only keep one of them secret
  - if $k'$ is secret, anyone can send a private message
  - if $k$ is secret, it is possible to “sign” a message
  - still need a way to authenticate $k$ or $k'$ for a user
  - example RSA
Transposition Cipher

- **To Break:**
  - each letter is itself, so normal distribution of letters is seen
  - guess number of columns (verify with known plaintext)
  - order columns using trigram frequency
- **Block of text is used to break up digrams**

Read Vertically

<table>
<thead>
<tr>
<th>M</th>
<th>E</th>
<th>G</th>
<th>A</th>
<th>B</th>
<th>U</th>
<th>C</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>4</td>
<td>5</td>
<td>1</td>
<td>2</td>
<td>8</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>please transfer onemillion dollars to my swiss bank account six two two</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start Here</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Plaintext
- please transfer onemillion dollars to my swiss bank account six two two

Ciphertext
- A F L L S K S O S E L A W A I A T O O S S T C L N M O M A
- E S I L Y N T W R N N T S O W D P A E D O B U O E R I C X

From: *Computer Networks*, 3rd Ed. by Andrew S. Tanenbaum, (c)1996 Prentice Hall.
DES

- Block cipher: uses 56 bit keys, 64 bits of data
- Uses 16 stages of substitution
- Variations
  - cipher block chaining: xor output of block n with into block n+1
  - cipher feedback mode: use 64bit shift register
    - can produce one byte at a time

From: *Computer Networks*, 3rd Ed. by Andrew S. Tanenbaum, (c)1996 Prentice Hall.
One Time Pad

- Key Idea: randomness in key
- Create a random string as long as the message
  - each party has the pad
  - xor each bit of the message with the a bit of the key
- Almost impossible to break
- Some practical problems
  - need to ensure key is not captured
  - a one bit drop will corrupt the rest of the message
Sending Data

- **Data is split into packets**
  - limited size units of sending information
  - can be
    - fixed sized (ATM)
    - variable size (Ethernet)

- **Need to provide a destination for the packet**
  - need to identify two levels of information
    - machine to send data to
    - comm abstraction (e.g. process) to get data
  - address may be:
    - a globally unique destination
      - for example every host has a unique id
    - may unique between hops
      - unique id between two switches
Ethernet

- 10 Mbps (to 100 Mbps)
- millisecond latency
- limited to several kilometers in distance
- variable sized units of transmission
- bus based protocol
  - requests to use the network can collide
- addresses are 48 bits
  - unique to each interface
Hub based Ethernet

- Logically it is still a bus
- Physically, it is a star configuration
  - the hub is at the center of the network
- Hubs provide:
  - better control of hosts
    - possible to restrict traffic to only the desired target
    - can shutdown a host’s connection at the hub if its Ethernet device is misbehaving
  - easier wiring
    - can use normal telephone wire to connect links (called 10 base-T)
- 100 Megabit Ethernet
  - is only available with Hubs
  - requires different hubs than 10base-T
Ethernet Collisions

- If one host is sending, other hosts must wait
  - called Carrier Sense with Multiple Access (CSMA)
- Possible for two hosts to try to send at once
  - each host can detect this event (cd- Collision Detection)
  - both hosts must re-send information
    - if they both try immediately, will collide again
    - instead each waits a random interval then tries again
- Only provides statistical guarantee of transmission
  - however, the probability of success if higher than the probability of hardware failures and other events
ATM (Asynchronous Transfer Mode)

- 155Mbps and up
- fixed sized unit of transmission called a cell
  - cells are 48 bytes plus 5 bytes header
- switch based protocol
- for both local area and wide area networking
- addresses are VCI
  - virtual circuit ids
TCP/IP Protocol

- **Name for a family of Network and Transport layers**
  - can run over many link layers:
    - Arpanet, Ethernet, Token Ring, SLIP/PPP, T1/T3, etc.

- **IP - Internet Protocol**
  - network level packet oriented protocol
  - 32 bit host addresses (dotted quad 128.8.128.84)
  - 8 bit protocol field (e.g. TCP, UDP, ICMP)

- **TCP - Transmission Control Protocol**
  - transport protocol
  - end-to-end reliable byte streams
  - provides ports for application specific end-points

- **UDP - user datagram protocol**
  - transport protocol
  - unreliable packet service
  - provides ports for application specific end-points
TCP/IP History

- Arpanet was the origin of today’s Internet
  - started in 1969 to connect universities and DoD sites
  - early example of packet switched network
  - original links were 64kbps and 9.6kbps

- Current TCP protocol
  - started in use Jan 1, 1983
  - This was a flag day
    - all systems had to change to the new protocol at once
    - with the modern Internet this would be hard to do