Vulnerabilities, exploits, and the secure design principles of Saltzer and Schroeder
What is a vulnerability?

- Management information stored in-band with regular information?
- Programming the weird machine?
- A failure to properly sanitize inputs?
Can be local or remote, sometimes something else

- Send malicious input over a network socket to take control of a remote machine
- Give malicious input to a privileged local process to get escalated privileges for yourself
- Confuse the logic of an accounting mechanism
- Break the separation between web sites in a browser to get access to someone's bank credentials
Other examples of logic bugs or more general vulnerabilities?

- Werewolves had a couple
- Amazon shopping cart (there was an IEEE Symposium on Security and Privacy paper about this, but I can't find it)
- Pouring salt water or putting tabs from construction sites in Coke machines
- Getting a code out of a locked locker
- Other examples you guys know of?
SQL command injection

```
SELECT * where username = '$u' and password = '$p'
```

$u = crandall
$p = abc123

```
SELECT * where username = 'crandall' and password = 'abc123'
```
SQL command injection

SELECT * where username = '$u' and password = '$p'

$u = bla' or '1' = '1' --
$p = idontknow

SELECT * where username = 'bla' or '1' = '1' --' and password = 'idontknow'
SQL command injection

SELECT * where username = '$u' and password = '$p'

$u = bla' or '1' = '1' --
$p = idontknow

SELECT * where username = 'bla' or '1' = '1' -- and password = 'idontknow'
Figure 4. Parse trees for WHERE clauses of generated queries. Substrings from user input are underlined.
Cross-site Scripting (XSS)

Send a message in the WebCT platform:

Hi Professor Crandall, I had a question about the homework. When is it due? p.s.
<script>alert("youve ben h@xored!")</script>
Werewolves command injection

```plaintext
system("echo $s > /path/to/pipe")

$s = hi; chmod 777 ~/server.py

echo hi; chmod 777 ~/server.py > /path/to/pipe
```
Werewolves not unanimous
Witch vote
Witch poisoned group12
These are group12s last words.
It is day. Everyone, ['group1', 'group10', 'group11', 'group2', 'group3', 'group4', 'group5', 'group6', 'group7', 'group8', 'group9'], open your eyes. You will have 30 seconds to discuss who the werewolves are.
Day-townspeople debate
group5-2
group2-stop messing with the logs; chmod 777 /home/moderator/server.py
group6-2
group1-yeh 2
group8-lol its always twelve
group4-2
group2-stop messing with the logs; chmod 777 /home/moderator/server.py
group4-2
group9-its 9
group11-u mean 12?
group2-iyits not me pls
group10-kappa
group1-poor 12
Buffer overflows

"excessive" → A

'e' 'x' 'c' 'e' 's' 's' 'i' 'v' 'e' 0
Format string vulnerabilities

`scanf("%s", string)`
`printf(string)`

`%500x%500x%12x\xbf\xff\xff\xff\x2c%n`
Memory corruption

- Buffer overflows on the stack and heap, format strings, double free()'s, etc.
- Easily the most well-studied vulnerability/exploit type
- Goal is often to execute code in memory
- See Shacham's ACM CCS 2007 paper for Return Oriented Programming
  - Even with just existing code in memory, you can build a Turing-complete machine
Race conditions

- Often called Time-of-Check-to-Time-of-Use (TOCTTOU)

```c
if (!access("/home/crandall/s", W_OK))
{
    F = open("/home/crandall/s", O_WRITE);
    ... /* Write to the file */
}
else
{
    perror("You don't have permission to write to that file!")
}
```
Werewolves race condition

touch moderatoronlylogfile.txt
chmod og-rw moderatoronlylogfile.txt
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Remember: Information only has meaning in that it is subject to interpretation. (Also, information is inherently physical.)
Saltzer and Schroeder's secure design principles

- Originally published in 1973
- Amazingly prescient
- There's a cool Star Wars version online, but not everyone has seen Star Wars...
Economy of Mechanism

• “Keep the design as simple and small as possible”
Fail-safe defaults

- “Base access decisions on permission rather than exclusion”
Complete mediation

• “Every access to every object must be checked for authority”
Open design

• “The design should not be secret.”
Separation of privilege

• “a protection mechanism that requires two keys to unlock it is more robust and flexible than one that allows access to the presenter of only a single key”
Least privilege

- “Every program and every user of the system should operate using the least set of privileges necessary to complete the job”
Least common mechanism

- “Minimize the amount of mechanism common to more than one user and depended on by all users”

Plagiarized from http://i.imgur.com/uWIXA.png
Psychological acceptability

• “It is essential that the human interface be designed for ease of use, so that users routinely and automatically apply the protection mechanisms correctly”
Resources

- Matt Bishop's *Computer Security: Art and Practice*
- http://langsec.org/
- phrack.org