590.7 Network Security Lecture 2: Goals and Challenges of Security Engineering

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Roadmap

- What is security?
- Examples of secure systems
- Security properties
- Challenges

What is security?

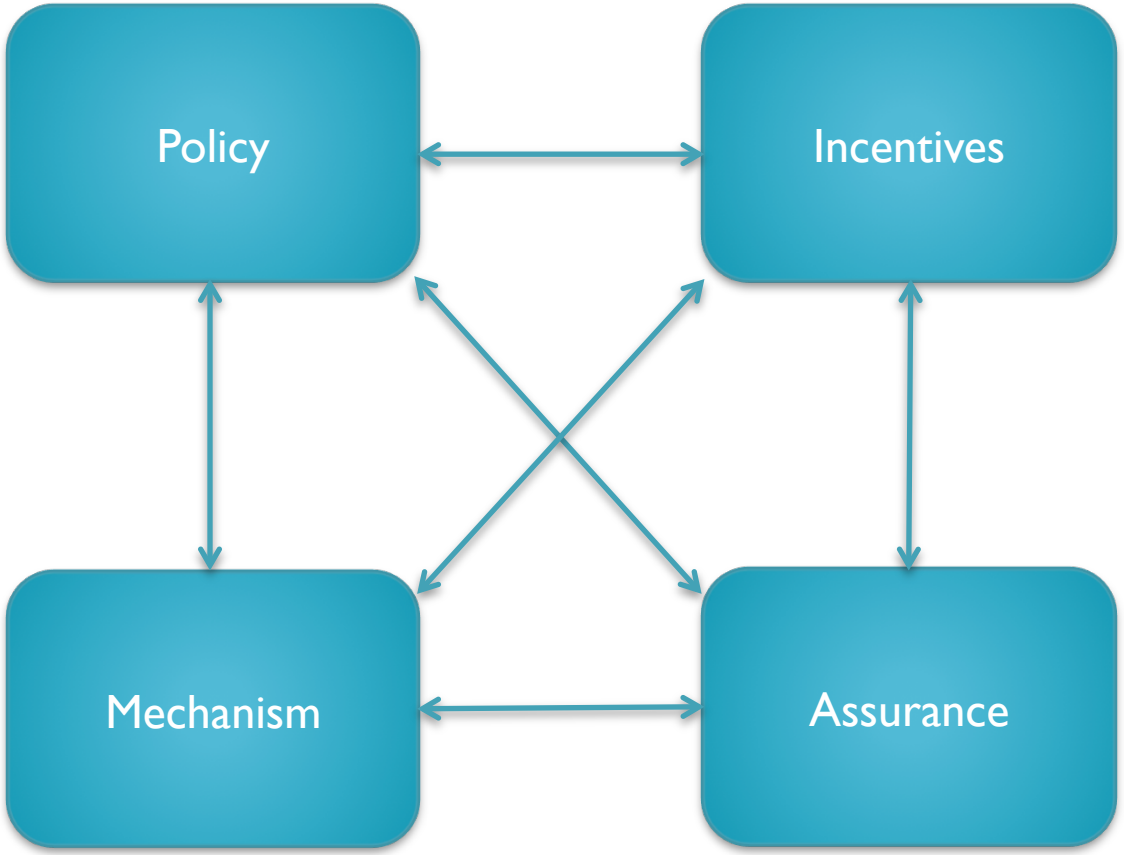
- System correctness
  - If user supplies expected input, system generates desired output
- Security
  - If attacker supplies unexpected input, system does not fail in certain ways

What is security?

- System correctness
  - Good input ⇒ Good output
- Security
  - Bad input ⇏ Bad output

How to analyze a security system

1. Policy
   - What you are supposed to achieve
2. Mechanism
   - The techniques to meet the policy requirements
   - Ex: ciphers, access controls
3. Assurance (security guarantees)
   - The amount of reliance one can place on each mechanism
4. Incentives
   - Motive that good guys do their jobs right and bad guys defeat your policy


Policy
Incentives
Mechanism
Assurance

Ex: analyzing the 911 attack

- A failure of policy not mechanism

- Policy changed later
- Assurance is poor

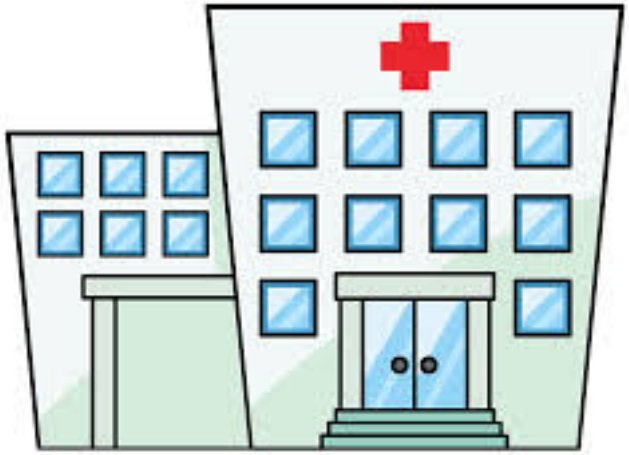
Examples of security systems

- Home
- Hospital
- Bank

Home

- Home banking
- Remote car keys
- Mobile phones
- Wireless routers

Hospital



- Keeping patient records private
- Anonymizing patient records
- Web-based access to patient records

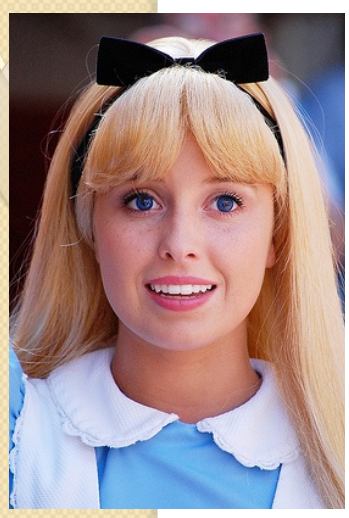
Bank

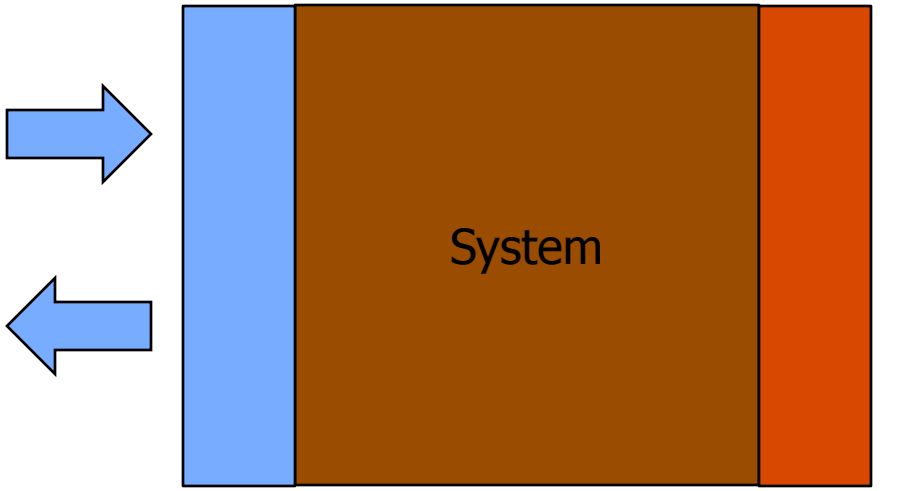
- Bookkeeping a customer's transactions
- ATM
- Bank websites
- Messaging systems
- Bank offices

Security Properties

- Confidentiality
  - Information about system or its users cannot be learned by an attacker
- Integrity
  - Protected information not modified by attackers
- Availability
  - Actions by an attacker do not prevent users from having access to use of the system

General picture



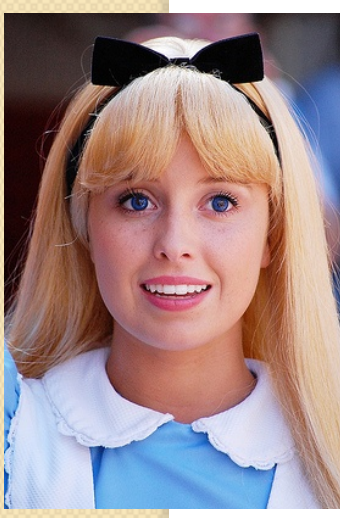


Alice

Attacker

- Security is about
  - Honest user (e.g., Alice, Bob, …)
  - Dishonest Attacker
  - How the Attacker
    - Disrupts honest user’ s use of the system (Integrity, Availability)
    - Learns information intended for Alice only (Confidentiality)

Network security



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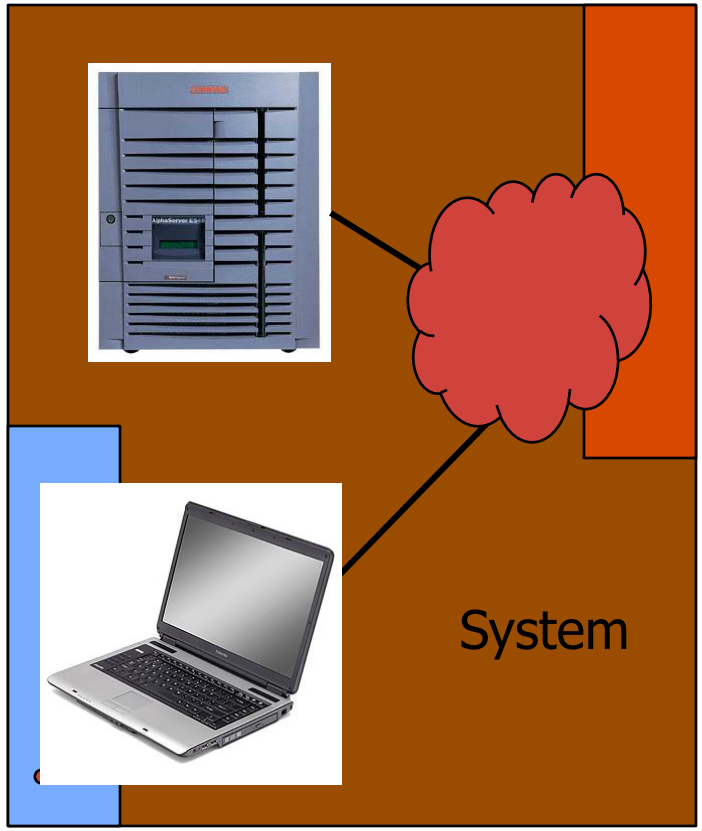
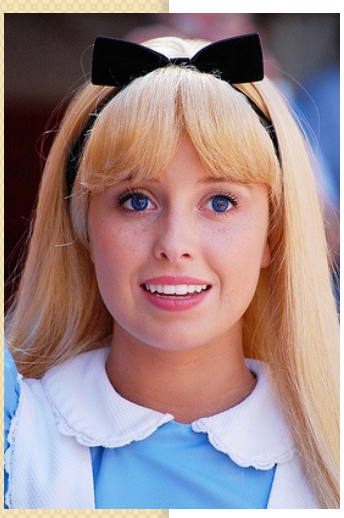


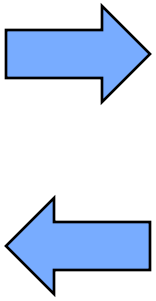
Network Attacker

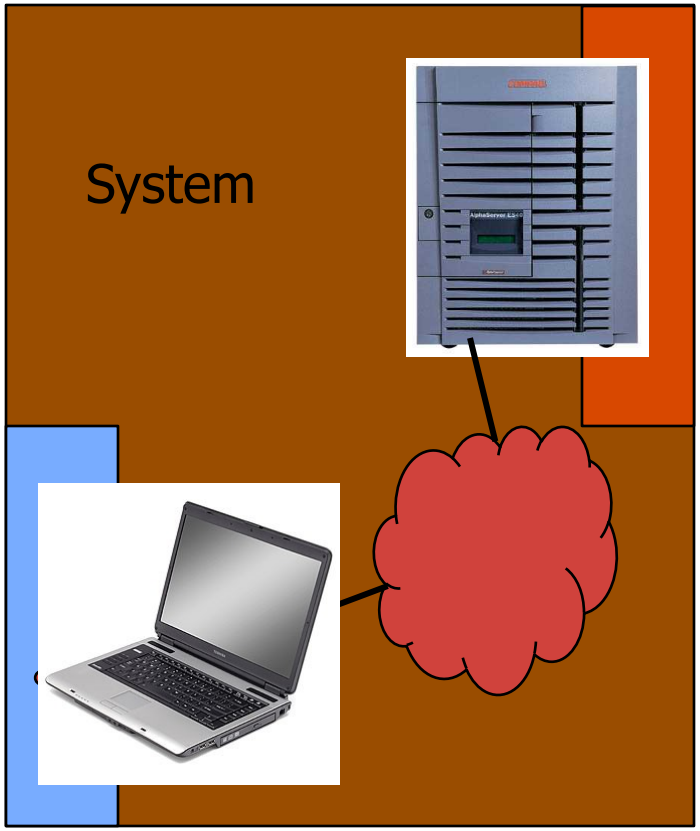
Intercepts and controls network communication

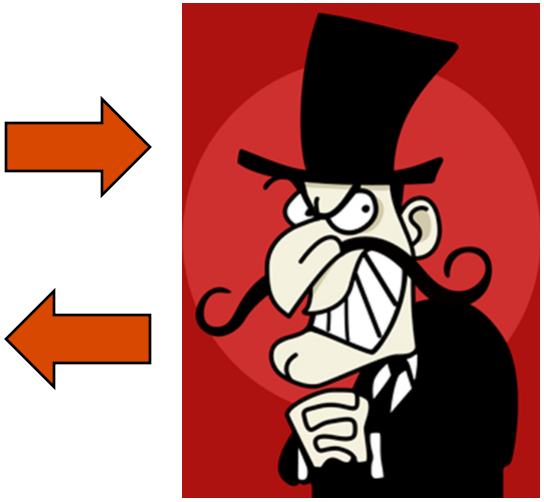
Web security



Alice



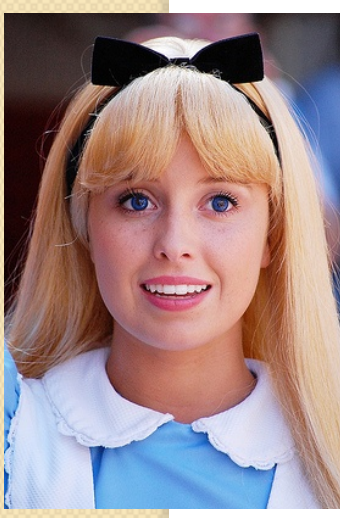




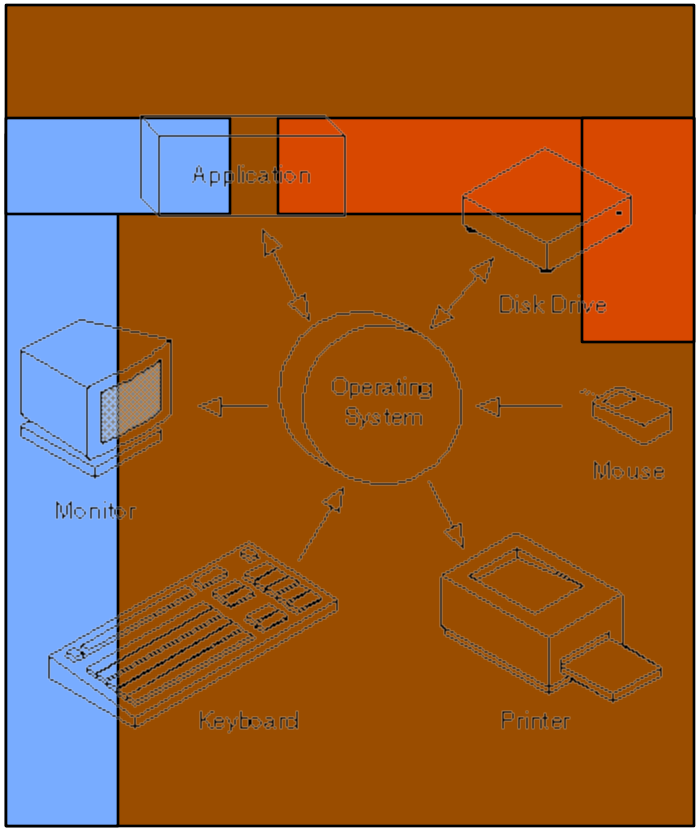
Web Attacker

Sets up malicious site visited by victim; no control of network

Operating system security

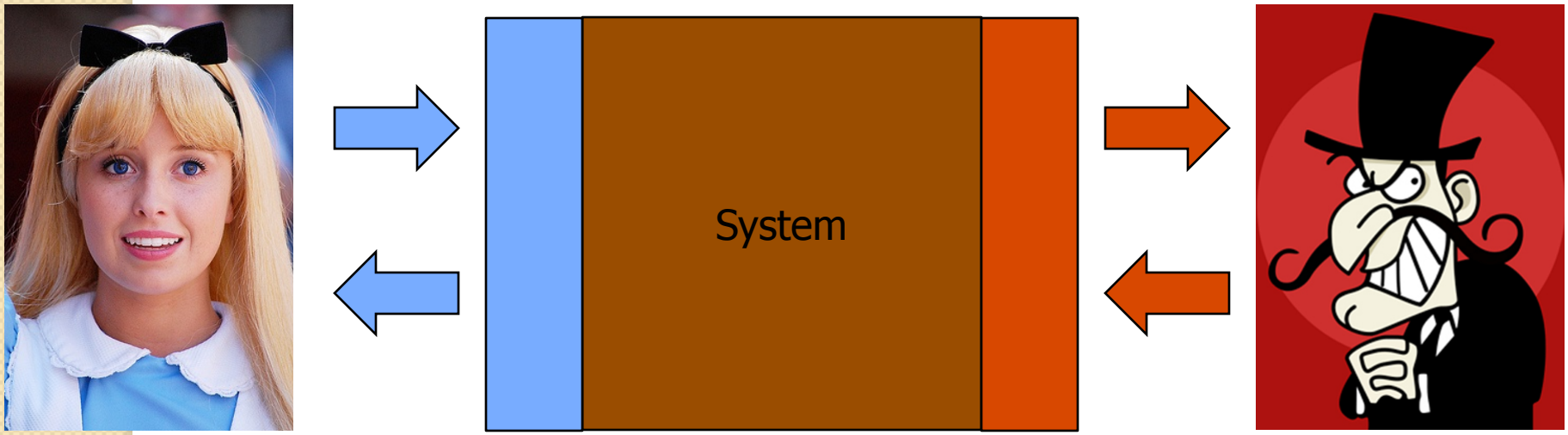


Alice



OS Attacker

Controls malicious files and applications



Alice

Attacker

Confidentiality: Attacker does not learn Alice's secrets

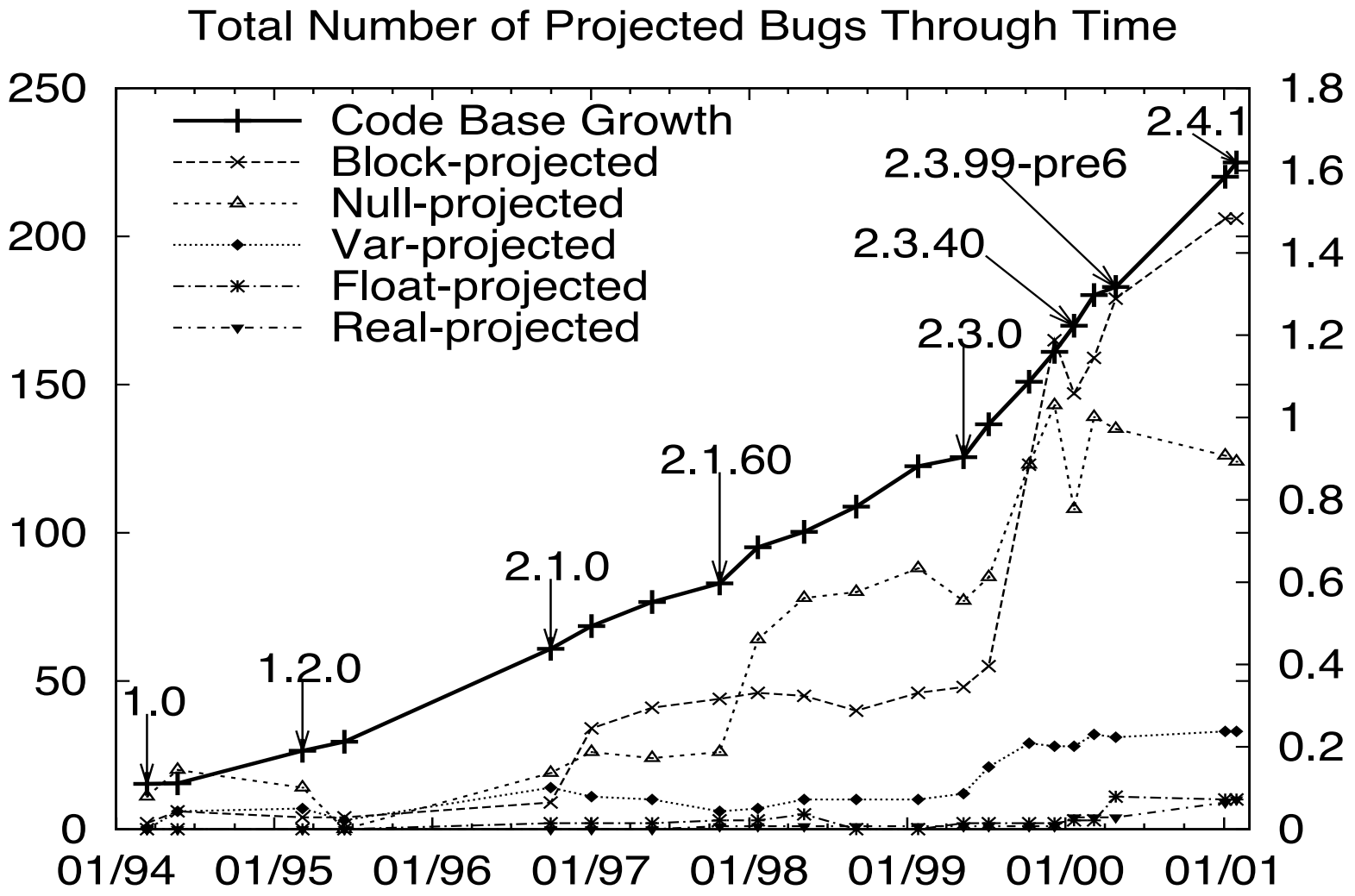
Integrity: Attacker does not undetectably corrupt system's function for Alice

Availability: Attacker does not keep system from being useful to Alice

Challenges

- Buggy code
- Inexperienced users
- Poorly designed protocols
- Insider attacks
  - What can you trust?

Buggy code


Total Number of Projected Bugs Through Time
Code Base Growth
Block-projected
Null-projected
Var-projected
Float-projected
Real-projected
1.0
1.2.0
2.1.0
2.1.60
2.3.0
2.3.40
2.3.99-pre6
2.4.1
250
200
150
100
50
0
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
01/94
01/95
01/96
01/97
01/98
01/99
01/00
01/01

Market place for vulnerabilities

Option 1: bug bounty programs

- Google Vulnerability Reward Program: 3K $
- Mozilla Bug Bounty program: 500$
- Pwn2Own competition: 15K $

Option 2:

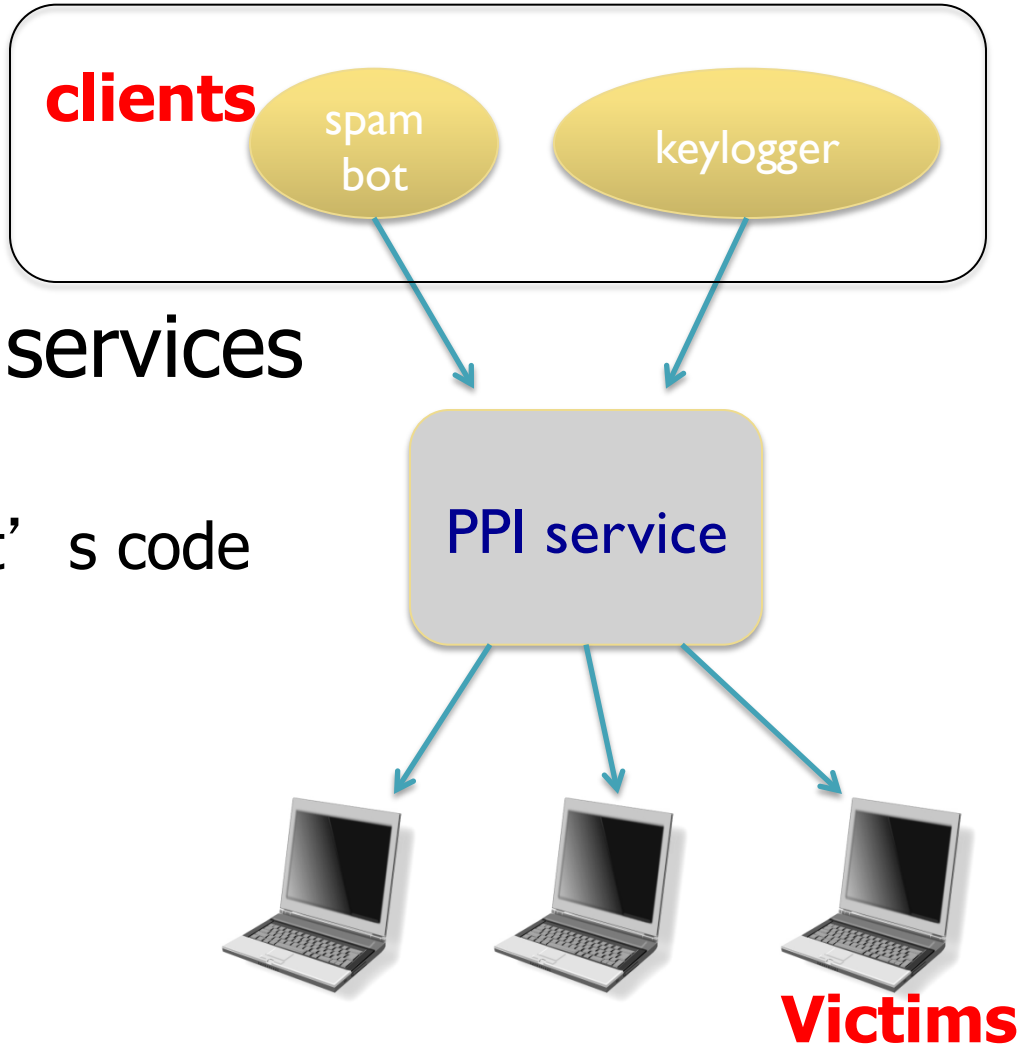
- Zero Day Initiatives, iDefense: 2K – 25K $

Market place for vulnerabilities

- **Option 3**: black market

Vulnerability/Exploit	Value	Source
"Some exploits"	$200,000 - $250,000	A government official referring to what "some people" pay [9]
a "real good" exploit	over $100,000	Official from SNOsoft research team [10]
Vista exploit	$50,000	Raimund Genes, Trend Micro [8]
"Weaponized exploit"	$20,000-$30,000	David Maynor, SecureWorks [11]

Marketplace for owned machines



Pay-per-install (PPI) services

- Own victim's machine
- Download and install client's code
- Charge client

Cost:

US 100-180$ / 1000 machines

Asia 7-8$ / 1000 machines

Source: Cabalerro et al. (www.icir.org/vern/papers/ppi-usesec11.pdf)

Why own machines?
Steal IP addresses

Use the infected machine's IP address for:

- **Spam** (e.g. the storm botnet)

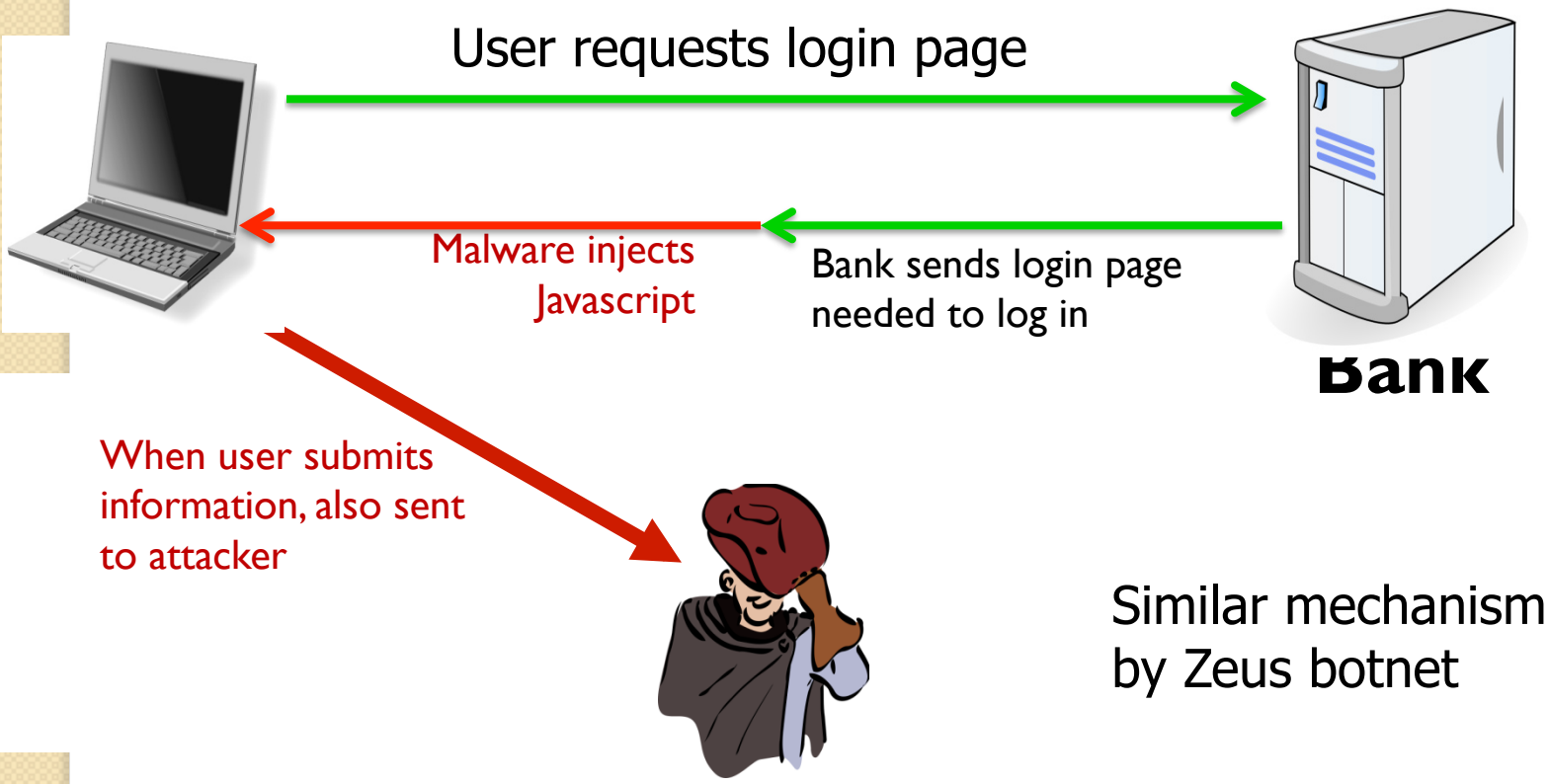
  Spamalytics: 1:12M pharma spams leads to purchase
  1:260K greeting card spams leads to infection

- **Denial of Service:**
  - Services: 1 hour (20$), 24 hours (100$)
- **Click fraud** (e.g. Clickbot.a)

Why own machines: Steal user credentials

keylog for banking passwords, web passwords, gaming pwds

Example: SilentBanker (2007)



Similar mechanism used by Zeus botnet

Challenges

- Buggy code
- Gullible users
- Poorly designed protocols
- Insider attacks
  - What can you trust?

Inexperienced users

- Phishing attacks
  - “I am stuck in London… lost my wallet…”
- Poor choice of Passwords
- Unchanged default username/password

Poorly designed protocols

- telnet
  - Send plain passwords over the network
- TCP
  - Fixed initial syn numbers
- BGP
  - Unauthenticated messages

Insider attacks

- Hidden trap door in Linux (nov 2003)
  - Allows attacker to take over a computer
  - Practically undetectable change (uncovered via CVS logs)

What can you trust?

- What code can we trust?
  - Consider "login" or "su" in Unix
  - Is RedHat binary reliable?
  - Does it send your passwd to someone?
- Can't trust binary so check source, recompile
  - Read source code or write your own
  - Does this solve problem?

Compiler backdoor

- This is the basis of Thompson's attack
  - Compiler looks for source code that looks like login program
  - If found, insert login backdoor (allow special user to log in)
- How do we solve this?
  - Inspect the compiler source

C compiler is written in C

- Change compiler source S

```
compiler(S) {
  if (match(S, "login-pattern")) {
        compile (login-backdoor)
        return
  }
  if (match(S, "compiler-pattern")) {
        compile (compiler-backdoor)
        return
  }
  .... /* compile as usual */
}
```

Avoid detection

- Compile this compiler and delete backdoor tests from source
  - Someone can compile standard compiler source to get new compiler, then compile login, and get login with backdoor
- Simplest approach will only work once
  - Compiling the compiler twice might lose the backdoor
  - But can making code for compiler backdoor output itself
    - (Can you write a program that prints itself? Recursion thm)
- Read Thompson's article
  - Short, but requires thought

Self-reproducing code example

```
Code that prints itself
public class Quine
{
  public static void main( String[] args )
  {
    char q = 34;      // Quotation mark character
    String[] l = {    // Array of source code
    "public class Quine",
    "{",
    "  public static void main( String[] args )",
    "  {",
    "    char q = 34;      // Quotation mark character",
    "    String[] l = {    // Array of source code",
    "    ",
    "    };",
    "    for( int i = 0; i < 6; i++ )           // Print opening code",
    "        System.out.println( l[i] );",
    "    for( int i = 0; i < l.length; i++ )    // Print string array",
    "        System.out.println( l[6] + q + l[i] + q + ',' );",
    "    for( int i = 7; i < l.length; i++ )    // Print this code",
    "        System.out.println( l[i] );",
    "  }",
    "}",
    };
    for( int i = 0; i < 6; i++ )           // Print opening code
      System.out.println( l[i] );
    for( int i = 0; i < l.length; i++ )    // Print string array
      System.out.println( l[6] + q + l[i] + q + ',' );
    for( int i = 7; i < l.length; i++ )    // Print this code
      System.out.println( l[i] );
  }
}
```