CSC 4103 - Operating Systems
Spring 2008

LECTURE - XXI

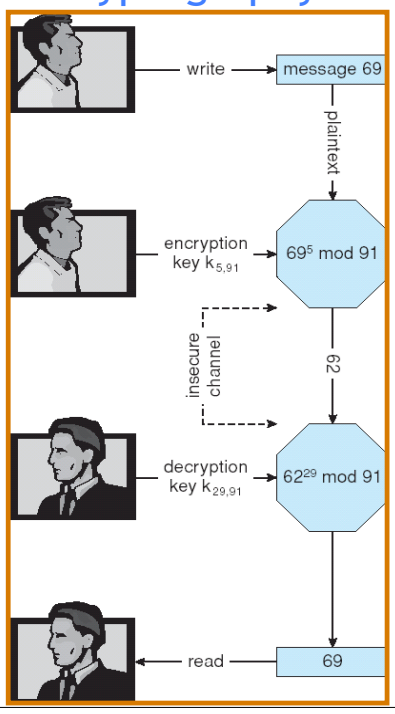
PROTECTION AND SECURITY - II

Tevfik Koşar

Louisiana State University

April 22nd, 2008

Encryption and Decryption using RSA Asymmetric Cryptography



Authentication

- Constraining set of potential senders of a message
  - Complementary to encryption
  - Also can prove message unmodified
- Algorithm components
  - A set K of keys
  - A set M of messages
  - A set A of authenticators
  - A function $S : K \rightarrow (M \rightarrow A)$
    - That is, for each $k \in K$, $S(k)$ is a function for generating authenticators from messages
    - Both S and $S(k)$ for any k should be efficiently computable functions
  - A function $V : K \rightarrow (M \times A \rightarrow \{\text{true, false}\})$. That is, for each $k \in K$, $V(k)$ is a function for verifying authenticators on messages
    - Both V and $V(k)$ for any k should be efficiently computable functions

Authentication (Cont.)

- For a message m, a computer can generate an authenticator $a \in A$ such that $V(k)(m, a) =$ `true` only if it possesses $S(k)$
- Thus, computer holding $S(k)$ can generate authenticators on messages so that any other computer possessing $V(k)$ can verify them
- Computer not holding $S(k)$ cannot generate authenticators on messages that can be verified using $V(k)$
- Since authenticators are generally exposed (for example, they are sent on the network with the messages themselves), it must not be feasible to derive $S(k)$ from the authenticators

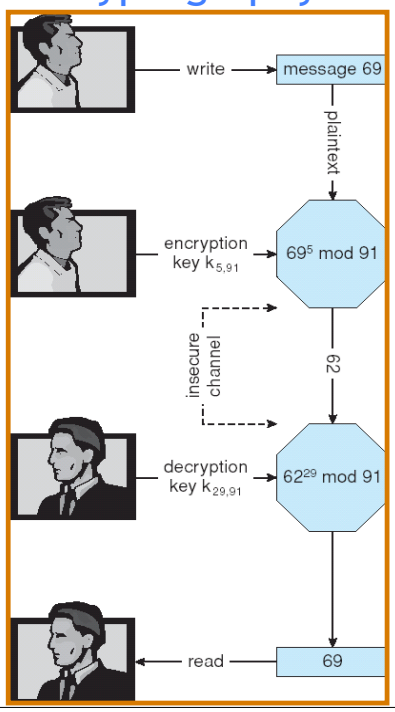
Constraining both Sender & Receiver

- generate an authenticator $a \in A$ such that $V(k)(m, a)$ = `true` only if it possesses $S(k)$
- Encrypt this authenticator with the public key of the targeted receiver
  - E(k)(m,a) = C

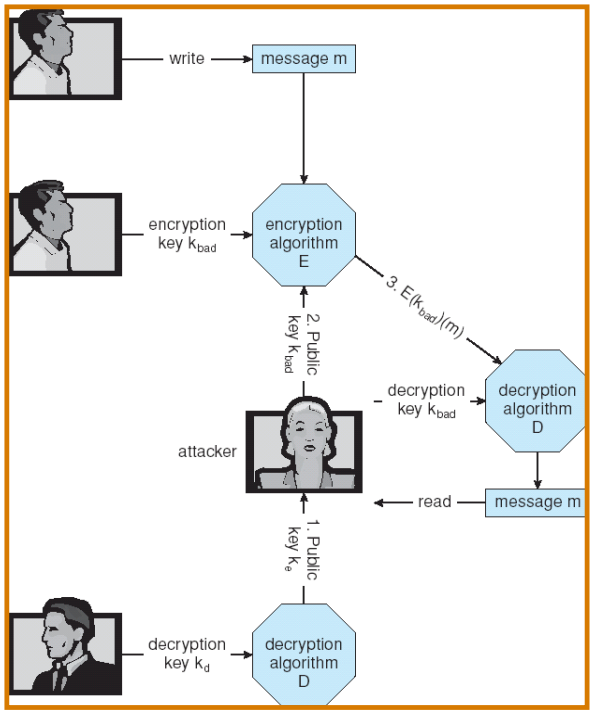
Key Distribution

- Delivery of symmetric key is huge challenge
  - Sometimes done **out-of-band,** via paper documents or conversation
- Asymmetric keys can proliferate – stored on **key ring**
  - Even asymmetric key distribution needs care – man-in-the-middle attack

Encryption and Decryption using RSA Asymmetric Cryptography



Man-in-the-middle Attack on Asymmetric Cryptography



Digital Certificates

- Proof of who or what owns a public key
- Public key digitally signed a trusted party
- Trusted party receives proof of identification from entity and certifies that public key belongs to entity
- Certificate authority are trusted party – their public keys included with web browser distributions
  - They vouch for other authorities via digitally signing their keys, and so on
  - i.e. VeriSign, Comodo etc.

Encryption Example - SSL

- Insertion of cryptography at one layer of the ISO network model (the transport layer)
- SSL – Secure Socket Layer (also called TLS)
- Cryptographic protocol that limits two computers to only exchange messages with each other
  - Very complicated, with many variations
- Used between web servers and browsers for secure communication (credit card numbers)
- The server is verified with a **certificate** assuring client is talking to correct server
- Asymmetric cryptography used to establish a secure **session key** (symmetric encryption) for bulk of communication during session
- Communication between each computer then uses symmetric key cryptography

User Authentication

- Crucial to identify user correctly, as protection systems depend on user ID
- User identity most often established through *passwords*, can be considered a special case of either keys or capabilities
  - Also can include something user has and /or a user attribute
- A password can be associated with each resource (eg. File)
- Different passwords may be associated with different access rights
  - Eg. Reading, updating, and deleting files
- Passwords must be kept secret
  - Frequent change of passwords
  - Use of “non-guessable” passwords
  - Log all invalid access attempts
- Passwords may also either be encrypted or allowed to be used only once

Password Vulnerabilities

- Password length
  - A four digit password would take less than 5 seconds to crack
- Password combination
  - Should use combination of digits, upper and lower case letters, and other characters
- Never write your password somewhere, memorize it
- Periodically change your password
- Do not use the following in your password:
  - Name, lastname
  - Username
  - Date of birth, zipcode, other personal info
- Do not share your accounts with others

Encrypted Passwords

- How to keep a password secure within the computer?
- UNIX-type systems keep the password lists encrypted
  - Impossible to invert
  - Simple to compute

  ==> one-way encryption
- Comparison is performed between encoded passwords
- Another level of protection:
  - Encrypted password file is only readable to root

Biometrics

- Instead of passwords, use biometric measures
  - Palm-readers
  - Finger-print-readers
  - Iris scanners
  - Voice recognition

- Multi-factor authentication
  - Use a combination of different authentication mechanisms

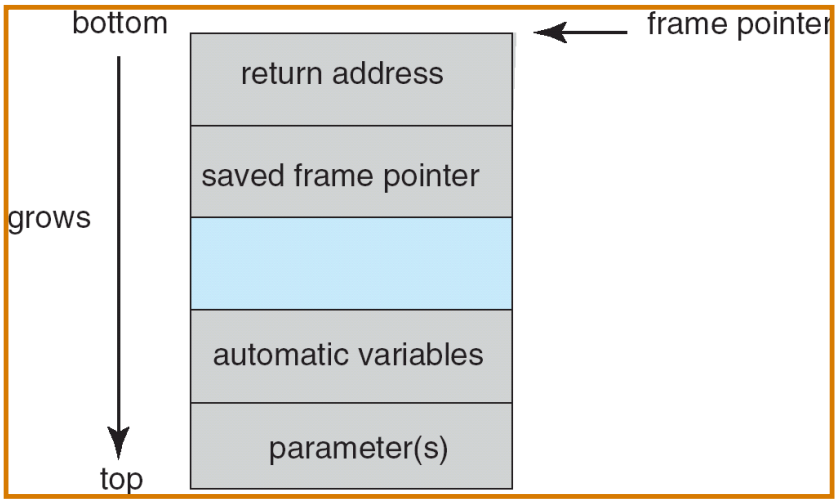
Program Threats

- Trojan Horse
  - Code segment that misuses its environment
  - Exploits mechanisms for allowing programs written by users to be executed by other users
  - **Spyware, pop-up browser windows, covert channels**
- Trap Door
  - Specific user identifier or password that circumvents normal security procedures
  - Could be included in a compiler
- Logic Bomb
  - Program that initiates a security incident under certain circumstances
- Stack and Buffer Overflow
  - Exploits a bug in a program (overflow either the stack or memory buffers)

C Program with Buffer-overflow Condition

```
#include <stdio.h>
#define BUFFER SIZE 256
int main(int argc, char *argv[])
{
  char buffer[BUFFER SIZE];
  if (argc < 2)
      return -1;
  else {
      strcpy(buffer,argv[1]);
      return 0;
  }
}
```

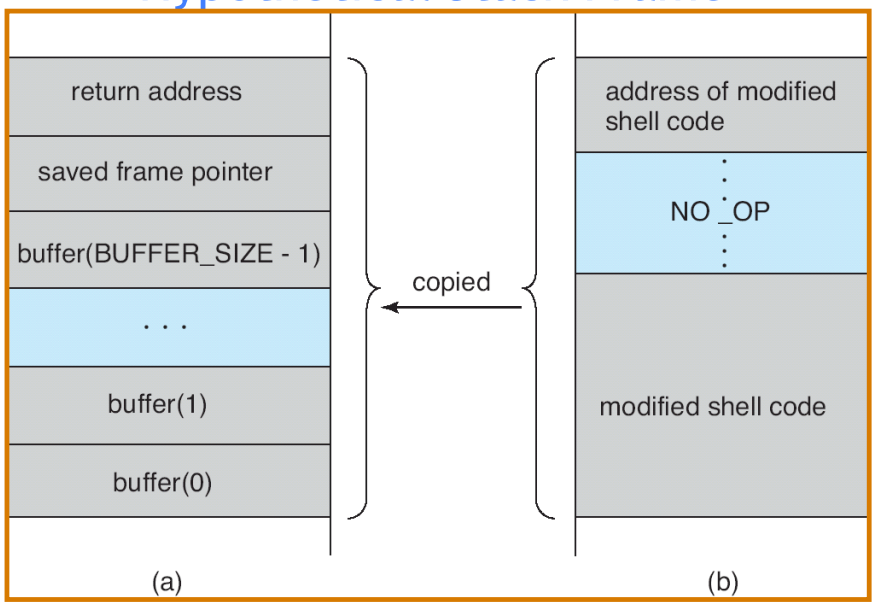
Layout of Typical Stack Frame



Modified Shell Code

```
#include <stdio.h>
int main(int argc, char *argv[])
{
  execvp(``\bin\sh'',``\bin\sh'', NULL);
  return 0;
}
```

Hypothetical Stack Frame



Program Threats (Cont.)

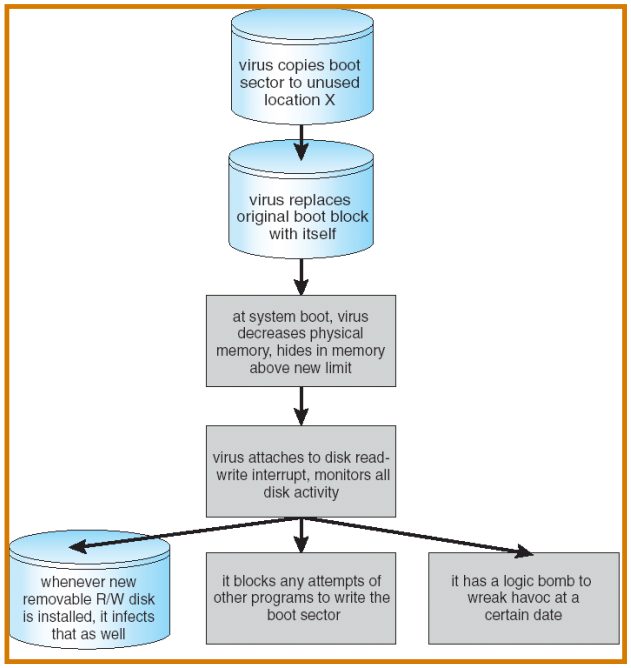
- Viruses
  - Code fragment embedded in legitimate program
  - Very specific to CPU architecture, operating system, applications
  - Usually borne via email or as a macro
    - Visual Basic Macro to reformat hard drive

```
Sub AutoOpen()
Dim oFS
  Set oFS = CreateObject(''Scripting.FileSystemObject'')
  vs = Shell(''c:command.com /k format         c:'',vbHide)
End Sub
```

Program Threats (Cont.)

- **Virus dropper** inserts virus onto the system
- Many categories of viruses, literally many thousands of viruses:
  - File (appends itself to a file, changes start pointer, returns to original code)
  - Boot (writes to the boot sector, gets exec before OS)
  - Macro (runs as soon as document containing macro is opened)
  - Source code (modifies existing source codes to spread)
  - Polymorphic (changes each time to prevent detection)
  - Encrypted (first decrypts, then executes)
  - Stealth (modify parts of the system to prevent detection, eg read system call)
  - Tunneling (installs itself as interrupt handler or device driver)
  - Multipartite (can infect multiple pars of the system, eg. Memory, bootsector, files)
  - Armored (hidden and compressed virus files)
  - Browser virus, keystroke logger ..etc

A Boot-sector Computer Virus



System and Network Threats

- Worms – use **spawn** mechanism; standalone program
- Internet worm *(Robert Morris, 1998, Cornell)*
  - Exploited UNIX networking features (remote access) and bugs in *finger* and *sendmail* programs
  - **Grappling hook** program uploaded main worm program
- Port scanning
  - Automated attempt to connect to a range of ports on one or a range of IP addresses
- Denial of Service
  - Overload the targeted computer preventing it from doing any useful work
  - Distributed denial-of-service (**DDOS**) come from multiple sites at once

The Morris Internet Worm