CSC 474 -- Network Security

Introduction

About Instructor

- Dr. Peng Ning, Associate Professor of Computer Science
  - http://www.csc.ncsu.edu/faculty/ning
  - pning@ncsu.edu
  - (919)513-4457
  - Office: Room 3258, Engineering Building II, centennial campus
  - Office hours: Tuesdays and Thursdays, 3:45pm – 4:45pm

About TA

- Junjie Ni
  - jni2@ncsu.edu
- Office hours:
  - Mondays and Wednesdays, 2:30pm to 3:30pm
  - Room 3224, EB II
Course Objectives

• Understanding of basic issues, concepts, principles, and mechanisms in network security.
  – Basic security concepts
  – Cryptography
  – Authentication
  – IPsec and Internet key management
  – SSL/TLS
  – Firewall
  – Email security
• Be able to determine appropriate mechanisms for protecting networked systems.

Course Styles

• Descriptive: what is out there.
• Critical: what is wrong with ...
• Both knowledge and skill oriented
• Interactive: discussion and questions encouraged.

Course Outline

• Basic Security Concepts
  – Confidentiality, integrity, availability
  – Security policies, security mechanisms, assurance
• Cryptography
  – Basic number theory
  – Secret key cryptosystems
  – Public key cryptosystems
  – Hash function
  – Key management
Course Outline (Cont’d)

• Identification and Authentication
  – Basic concepts of identification and authentication
  – Password authentication
  – Security handshake pitfalls

Course Outline (Cont’d)

• Network and Distributed Systems Security
  – Public Key Infrastructure (PKI)
  – Kerberos
  – IPsec
  – IPsec key management
  – SSL/TLS
  – Firewalls
  – Email security
  – Web security

Lab Exercises

• Tentative list
  – TCP/UDP Attacks
  – DNS Pharming Attack
  – Cross-site Scripting Attack
• Mechanism (TBD)
  – Virtual Computing Lab (VCL) or networking lab
• You are expected to explore issues beyond what’s included in lectures by yourselves
• By taking this course, you agree you will not misuse tools obtained in the labs
Prerequisites

- Programming experience in C/C++ or JAVA is required
- Knowledge in data communication and networking is highly desired

Textbook

- Required textbook

On-line Resources

- WWW page: [http://courses.ncsu.edu/csc474/lec/001](http://courses.ncsu.edu/csc474/lec/001)
  - For course materials, e.g., lecture slides, homework files, papers, tools, etc.
  - Will be updated frequently. So check frequently.
- Message board: [http://courses.ncsu.edu/csc474](http://courses.ncsu.edu/csc474)
  - For discussions, Q&As.
Grading

• CSC 474: Assignments 20%, midterm 30%, labs 20%, final 30%.
• The final grades are computed according to the following rules:
  - A+: >= 95%; A: >= 90% and < 95%; A-: >= 85% and < 90%;
  - B+: >= 80% and < 85%; B: >= 75% and < 80%;
  - B-: >= 70% and < 75%; C+: >= 66% and < 70%;
  - C: >= 63% and < 66%; C-: >= 60% and < 63%;
  - D+: >= 56% and < 60%; D: >= 53% and < 56%;
  - D-: >= 50% and < 53%;
  - F: < 50%.

Policies on incomplete grades and late assignments

• Homework and project deadlines will be hard.
• Late homework will be accepted with a 10% reduction in grade for each class period they are late by.
• Once a homework assignment is discussed in class, submissions will no longer be accepted.

Policies on Absences and Scheduling Makeup Work

• You may be excused from an exam only with a university approved condition, with proof. For example, if you cannot take an exam because of a sickness, we will need a doctor's note.
• Events such as going on a business trip or attending a brother's wedding are not an acceptable excuse for not taking an exam at its scheduled time and place.
• You will have one chance to take a makeup exam if your absence is excused. There will be no makeup for homework assignments.
Academic Integrity

- The university, college, and department policies against academic dishonesty will be strictly enforced.
- You may obtain copies of the NCSU Code of Student Conduct from the Office of Student Conduct, or from the following URL.

NC State Policy on Working with Students with Disabilities

- Reasonable accommodations will be made for students with verifiable disabilities.
  - Please schedule an appointment with the instructor.
- In order to take advantage of available accommodations, students must register with Disability Service for Students at 1900 Student Health Center, Campus Box 7509, 515-7653.
  - http://www.ncsu.edu/provost/offices/affirm_action/dss/
- For more information on NC State’s policy on working with students with disabilities, please see

Check the website for details!
Information Security Problems

• Public, private, and government networks have been penetrated by unauthorized users and rogue programs
• Increased volume of security breaches attributed Computer Emergency Response Team (CERT) reports a tremendous increase in cracking incidents
• Insider attacks

Information Security Concerns

• Distributed Denial of Service (DDOS) attacks
• Worm attacks (e.g., code red, SQL slammer)
• Web attacks (e.g., cross-site scripting, SQL injection)
• Monitoring and capture of network traffic
  – User IDs, passwords, and other information are often stolen on Internet
• Exploitation of software bugs
• Unauthorized access to resources
  – Disclosure, modification, and destruction of resources
• Compromised system used as hostile attack facility
• Masquerade as authorized user or end system
• Data driven attacks
  – Importation of malicious or infected code
• E-Mail forgery
Contributing Factors

- Lack of awareness of threats and risks of information systems
  - Security measures are often not considered until an enterprise has been penetrated by malicious users
  - The situation is getting better, but …
- Reluctance to invest in security mechanisms
  - The situation is improving,
  - But there exists legacy software
- Wide-open network policies
  - Many Internet sites allow wide-open Internet access

Contributing Factors (Cont’d)

- Lack of security in TCP/IP protocol suite
  - Most TCP/IP protocols not built with security in mind
  - Work is actively progressing within the Internet Engineering Task Force (IETF)
- Complexity of security management and administration
  - Security is not just encryption and authentication
- Software vulnerabilities
  - Example: buffer overflow vulnerabilities
  - We need techniques and tools to better software security
- Cracker skills keep improving
  - Cracker A: It’s a business…

Security Objectives

Confidentiality (Secrecy)

Integrity

Availability (Denial of Service)
Security Objectives (CIA)

- **Confidentiality** — Prevent/detect/deter improper disclosure of information
- **Integrity** — Prevent/detect/deter improper modification of information
- **Availability** — Prevent/detect/deter improper denial of access to services provided by the system

- These objectives have different specific interpretations in different contexts

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Commercial Example

- **Confidentiality** — An employee should not come to know the salary of his manager
- **Integrity** — An employee should not be able to modify the employee's own salary
- **Availability** — Paychecks should be printed on time as stipulated by law

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Military Example

- **Confidentiality** — The target coordinates of a missile should not be improperly disclosed
- **Integrity** — The target coordinates of a missile should not be improperly modified
- **Availability** — When the proper command is issued the missile should fire
A Fourth Objective

- Securing computing resources — Prevent/detect/deter improper use of computing resources including
  - Hardware Resources
  - Software resources
  - Data resources
  - Network resources

Achieving Security

- Security policy — What?
- Security mechanism — How?
- Security assurance — How well?

Security Policy

Organizational Policy

Automated Information System Policy
Compusec + Comsec = Infosec

Security Mechanisms

- In general three types
  - Prevention
    - Example: Access control
  - Detection
    - Example: Auditing and intrusion detection
  - Tolerance
    - Example: Byzantine agreement

Good prevention and detection both require good authentication as a foundation

Security Mechanism

- Security mechanisms implement functions that help prevent, detect, and respond to security attacks
- Prevention is more fundamental
  - Detection seeks to prevent by threat of punitive action
  - Detection requires that the audit trail be protected from alteration
- Sometime detection is the only option, e.g.,
  - Accountability in proper use of authorized privileges
  - Modification of messages in a network
- Security functions are typically made available to users as a set of security services through APIs or integrated interfaces
- Cryptography underlies (almost) all security mechanisms
Security Services

- Security functions are typically made available to users as a set of security services through APIs or integrated interfaces.

- **Confidentiality**: protection of any information from being exposed to unintended entities.
  - Information content.
  - Parties involved.
  - Where they are, how they communicate, how often, etc.

- **Authentication**: assurance that an entity of concern or the origin of a communication is authentic - it’s what it claims to be or from.

- **Integrity**: assurance that the information has not been tampered with.

Security Services - Cont’d

- **Non-repudiation**: offer of evidence that a party is indeed the sender or a receiver of certain information.

- **Access control**: facilities to determine and enforce who is allowed access to what resources, hosts, software, network connections.

- **Monitor & response**: facilities for monitoring security attacks, generating indications, surviving (tolerating) and recovering from attacks.

Security Services - Cont’d

- **Security management**: facilities for coordinating users’ service requirements and mechanism implementations throughout the enterprise network and across the internet.
  - Trust model.
  - Trust communication protocol.
  - Trust management infrastructure.
Security Assurance

- How well your security mechanisms guarantee your security policy
- Everyone wants high assurance
- High assurance implies high cost
  - May not be possible
- Trade-off is needed

Security by Obscurity

- Security by obscurity says that if we hide the inner workings of a system it will be secure
- It is a bad idea
- Less and less applicable in the emerging world of vendor-independent open standards
- Less and less applicable in a world of widespread computer knowledge and expertise

Security by Legislation

- Security by legislation says that if we instruct our users on how to behave we can secure our systems
- It is a bad idea
- For example
  - Users should not share passwords
  - Users should not write down passwords
  - Users should not type in their password when someone is looking over their shoulder
- User awareness and cooperation is important, but cannot be the principal focus for achieving security
Security Tradeoffs

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<thead>
<tr>
<th>Security</th>
<th>Functionality</th>
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<tbody>
<tr>
<td>COST</td>
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<td>Ease of Use</td>
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Threat-Vulnerability-Risk

- **Threats** — Possible attacks on the system
- **Vulnerabilities** — Weaknesses that may be exploited to cause loss or harm
- **Risk** — A measure of the possibility of security breaches and severity of the ensuing damage

- Requires assessment of threats and vulnerabilities

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Threat Model and Attack Model

- Threat model and attack model need to be clarified before any security mechanism is developed

- Threat model
  - Assumptions about potential attackers
  - Describes the attacker’s capabilities

- Attack model
  - Assumptions about the attacks
  - Describe how attacks are launched
Risk Management

- Risk analysis
  - Mathematical formulae and computer models can be developed, but the underlying parameters are difficult to estimate.
- Risk reduction
- Risk acceptance
  - Certification
    - Technical evaluation of a system's security features with respect to how well they meet a set of specified security requirements
  - Accreditation
    - The management action of approving an automated system, perhaps with prescribed administrative safeguards, for use in a particular environment