CSC 774 Advanced Network Security

Dr. Peng Ning

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http://www.csc.ncsu.edu/faculty/ning

About Instructor

• Dr. Peng Ning, assistant professor of computer science
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  – Office: 250 Venture III, centennial campus
  – Office hours:
    • Mondays and Wednesdays, 3:00 pm – 4:00 pm
About TA

- Mithun Acharya
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- Office hours:
  - Tuesdays 9:30 am - 11:30 am
  - Ventures I, Suite 110, Room 102
    - please ring the bell

Course Objectives

- Understanding of fundamental issues, concepts, principles, and mechanisms in network security (beyond CSC 574).
  - Electronic payment systems
  - Broadcast authentication
  - Group key management
  - MANET and sensor network security
- Prepare for graduate research in network security
  - Advanced topics: MANET security, sensor network security
  - Will give a list of recently published papers
Prerequisites

- You must have taken
  - CSC 570
  - CSC 574
- Or convince the instructor that you have enough background knowledge

Text

- No required textbook
- Research papers listed on the course website
Course Mechanics

- WWW page:
  - For course materials, e.g., lecture slides, homework files, papers, tools, etc.
  - Will be updated frequently
- Message board at
  - http://courses.ncsu.edu/csc774/
  - For discussions, Q&As
  - TA will answer questions there regularly

Grading

- Assignments: 10%
- Midterm #1: 15%
- Midterm #2: 15%
- Final: 30%
- Research/survey paper: 20%
- In-class presentation: 10%
  - 15 minutes
  - On a technical paper assigned by the instructor.
Grading (Cont’d)

• 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%

• Audit students:
  – No in-class presentation;
  – Grade will be adjusted by grade = grade/0.9;
  – Need grade >=63% to pass.

Course Outline

• Topic 1: Course Introduction
  – Overview of the course contents
  – Review basic security concepts
Course Outline (Cont’d)

• Topic 2: Review of cryptography and traditional network security techniques
  – Secret key cryptosystems
  – Public key cryptosystems
  – One-way hash function
  – Merkle hash tree
  – Pseudo random generator and function
  – Key distribution and management

Course Outline (Cont’d)

• Topic 3: Electronic Payment Systems
  – Electronic billing systems
    • NetBill
  – Micropayments
    • PayWords and MicroMints
  – Fair Exchange Protocols
    • Optimistic fair exchange protocol
Course Outline (Cont’d)

• Topic 4: Broadcast Authentication
  – EMSS
    • Based on signature amortization
  – TESLA
    • Based on hash chain and delayed disclosure of symmetric keys
  – BiBa
    • Based on collision of hash functions

Course Outline (Cont’d)

• Topic 5: Group Key Management
  – Group key agreement
    • Group Diffie-Hellman (GDH) protocols
    • Tree-based GDH
  – Group key distribution
    • Iolus
    • Logical Key Hierarchy (LKH)
      – Or key graph
Course Outline (Cont’d)

• Topic 6: Security in Mobile Ad-Hoc Networks (MANET)
  – Secure MANET routing protocols
    • ARIADNE
    • Security mechanisms for routing protocols
  – Detect malicious/selfish nodes
    • WatchDog and PathRater

Course Outline (Cont’d)

• Topic 7: Security in Wireless Sensor Networks
  – Key pre-distribution
    • Random key pre-distribution scheme
    • q-composite scheme
    • Random pairwise keys scheme
    • Polynomial pool-based schemes
  – Secure and resilient data aggregation
    • SIA
  – Secure and resilient location discovery
    • Tolerate malicious data
    • Detect malicious nodes
Course Outline (Cont’d)

• Topic 8. Misc Topics
  – Client puzzle
    • Mitigate DoS attacks
  – Security for, and by, mobile devices

Course Outline (Cont’d)

• Advanced Topics:
  – MANET security
  – Sensor network security
• Every student is responsible for presenting one technical paper in class, and managing a discussion forum in the message board
  – Will be graded. Instructions and grading policy is posted on the course website
  – Content will be included in the final exam
  – Students are encouraged to write research papers related to these topics
What’s behind these Topics

• Efficient use of cryptography
  – Public key cryptography
  – Symmetric cryptography
    • One-way hash chains
    • Merkle hash trees
    • Cryptographic puzzles

• Non-crypto techniques

In-class Presentation

• 15 minutes
• Will be graded
  – See the grading sheet on course website
Research/Survey Paper

- Small team -- one to three students
- Proposal, work, and final write-up
- Both the proposal and the final submission will be graded
  - Proposal due: 10/05/05
  - Final submission due: 12/02/05
- Grading policy is posted on the course website
- The instructor will be available to discuss your topic during the office hours
- You should start thinking about your team and topic now

Check the website for details!
Review of Basic Security Concepts

Security Objectives

- Secrecy (Confidentiality)
- Integrity
- Availability (Denial of Service)
Security Objectives

- Secrecy — 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

Commercial Example

- Secrecy — 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
Military Example

- Secrecy — 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

[Diagram showing Organizational Policy and Automated Information System Policy]

Organizational Policy

Automated Information System Policy
Compusec + Comsec = Infosec

Security Mechanism

- Prevention — Access control
- Detection — Auditing and intrusion detection
- Tolerance — Practicality

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

- 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 Tradeoffs

Security  Functionality

COST

Ease of Use
## 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