Network Security

Dr. Yeonjoon Lee

Instructor and AI

- **Instructor: Professor Yeonjoon Lee**
  - Office: 제 3 공학관, 504호
  - Email: yeonjoonlee@hanyang.ac.kr
  - Office hour: Right after class or by appointment

- Class meeting time and location:
  - 수업: Monday 15:00 PM – 17:00 PM (제 1공학관, 305 강의실)
  - 실습: Tuesday 15:00 PM – 17:00 PM (제 4공학관, PC1 실)

- **AIs:**
  - 이석원 (sevenshards00@gmail.com)
  - Office hour: Will be announced later

- Slides: https://github.com/luc2yj/HY-CSE4047

Tell me what you want from the class

- Your name
- Your cognate, program
- What do you expect from the class?
  - Credits only?
  - Know something about security
  - Some hands-on experiences
    - To which extent?
- What's your capability?
  - Programming (especially C)?
  - Operating systems?
  - Networking?

Course Objectives

- Introduction to information security
    - Give you a general survey of security and privacy technologies
    - Help you understand the basic concepts, ideas
    - Prepare you for taking more advanced security courses

- Try to offer some “experience” of security technologies
    - Get some hands-on experience on threats and defense
    - Capture the trend of some security threats
    - Learn how to do security-related research

Prerequisites

- You will be able to fully enjoy the fun of the course if you have the following skills:
  - Programming, especially C
  - Operating systems
  - Networking

Why should I take this course?

- For job interview
- Learn the basics about protection of your computers
- For taking more advanced security courses

Textbook

- *Computer Security: Principles and Practice (3rd or 4th Edition)*, by William Stallings and Lawrie Brown
  - There is online version for 3rd Edition
- *The Security Development Lifecycle*, Michael Howard and Steve Lipner
- Additional materials on slides
- Articles from the web (your reading project)

Grading

- Class attendance (10%)

- Weekly lab assignments (25%)

- Reading projects (25%)
  - Project proposal (20%)
  - Project report (80%)
  - Presentation (TBD)

- Final (40%)

Policies for Class Attendance

- Points that are subtracted from the total points for the semester associated for non-attendance will commence ONLY after 2 unexplained absences.

- Besides these two classes, you can ask for medical leave if you can provide proper evidence (see the course website).

- Otherwise, you will lose 3 points whenever you miss one class.

Policies for Class Participation

- You are expected to actively engage in class
- Lectures are intended to be interactive, involving discussion
- Ask questions, participate in discussion, don’t look at your laptop

Reading projects

- Review and analyze existing security technologies
  - One or Two students (with different expectations, see course website)
  - Bonus could be given to the project involving implementation and evaluation

- Suggested topics will be posted on the web, but you are encouraged to come up with your own topics

Ethics and Cheating

- **Ethics**

  DO NOT TRY HACKING EXPERIMENTS ON PUBLIC NETWORKS!!!

- **Cheating Policy**

  학교 규정에 따라 처리

Caution!!!

- Lesson: DO NOT TRY HACKING EXPERIMENTS ON PUBLIC NETWORKS!!!

Tentative Arrangement

- Basic concepts: 2 weeks
- Authentication and access control: 2 weeks
- Database and Web security: 2.5 weeks
- Malware: 1 week
- Buffer overflow and defense: 2.5 weeks
- Security development lifecycle: 1.5 weeks
- Final talk: To be discussed

Tentative Arrangement (cont'd)

- Quizzes and labs start from Week 2

- Reading assignments will be posted online

- Reading Project
  - Proposal: 2019/10/7
  - Final report: Will announce later (2019/11/17)
  - Final presentations: To be discussed

Reading Project Topic Examples

- Android Security
  - Detection approaches
  - Vulnerabilities
  - Type of malware
- IoT Security
  - Study on platforms (e.g., smartthings)
  - Study on the type of threats
- Cloud Security
- Threats on Autonomous Vehicles
- Cybercrime (e.g., Dark web, Crowdturfing)

If you want to build something..

- Let me know!

- NLP related things
- GUI automation
- Reverse Engineering
- Static or Dynamic analysis

Questions?

Basic concepts

Dr. Yeonjoon Lee

What is security?

- Protect information assets from intentional human misuses

- Information assets: valuable computing resources
  - Hardware: CPU, disk, network adapter card, etc.
  - Software: Operating System, utilities, applications, etc.
  - Data: files, database, password, etc.
  - Communication facilities and networks: link, bridge, router, etc.

Security concerns

- Information assets could be easily abused
  - Break into your systems to steal confidential data
  - Destroy your valuable files
  - Spy your communication
  - Squander your resources …
- Principle of easiest penetration (Maginot **Line**):
  - An intruder must be expected to use any available means of penetration, not necessarily from the most obvious one or the one against the most solid defense

Vulnerability, Threat, Risk and Attack (RFC4949)

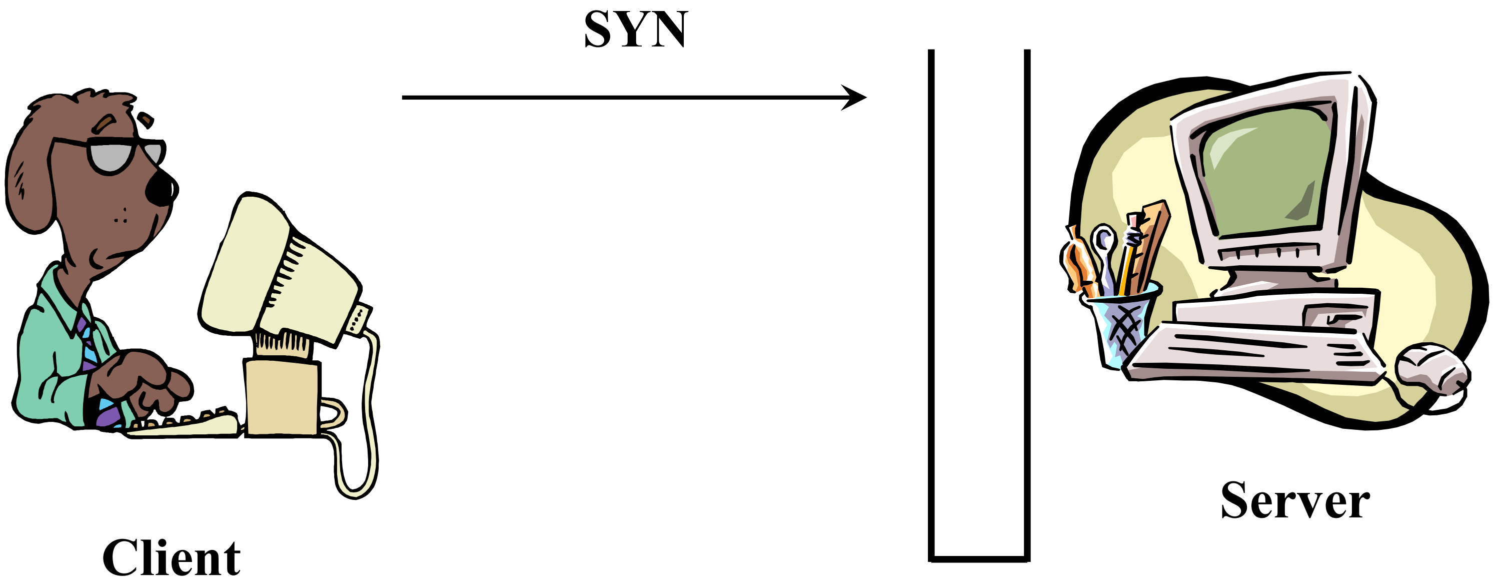
- Vulnerability: weakness in the security system
  - Corruption, leakage and unavailability
  - e.g., software bugs, defense holes…

- Threat: a set of circumstances that has the potential to cause exploit of vulnerabilities and damages to information assets

- Risk: Loss as the probability that threat causes harm

- Attack: an assault (evading protection, violation of policy) on system that derives from a threat

Example: TCP three-way handshaking

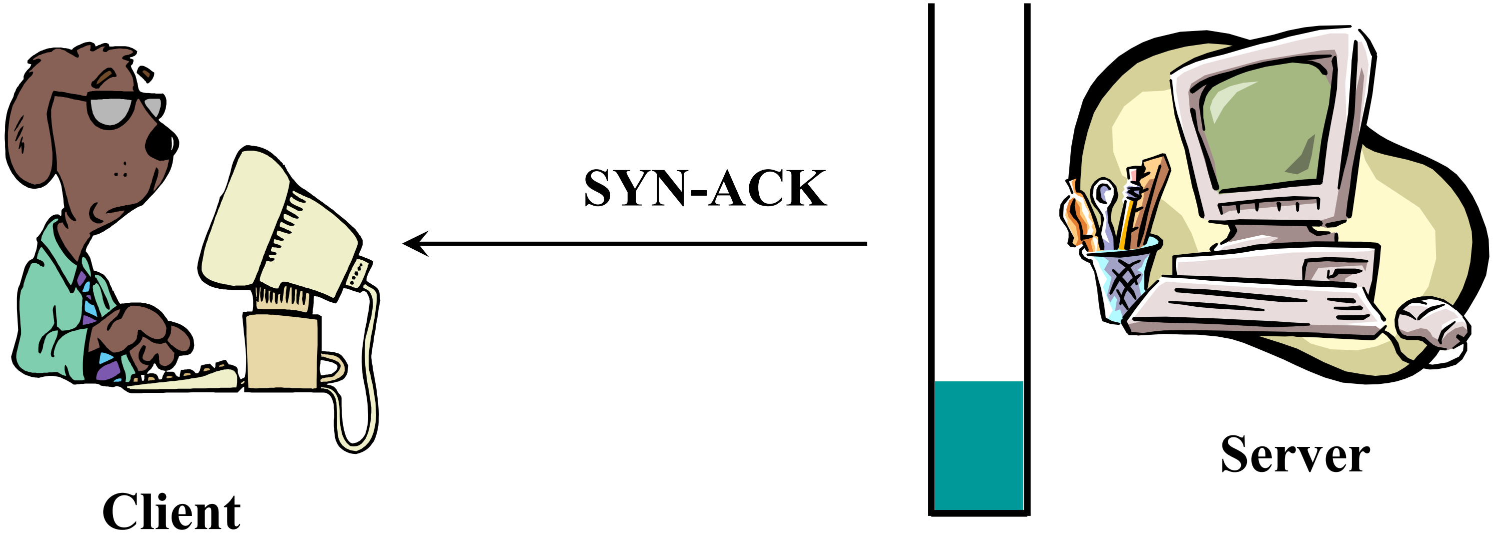


SYN

Client

Server

Example: TCP three-way handshaking

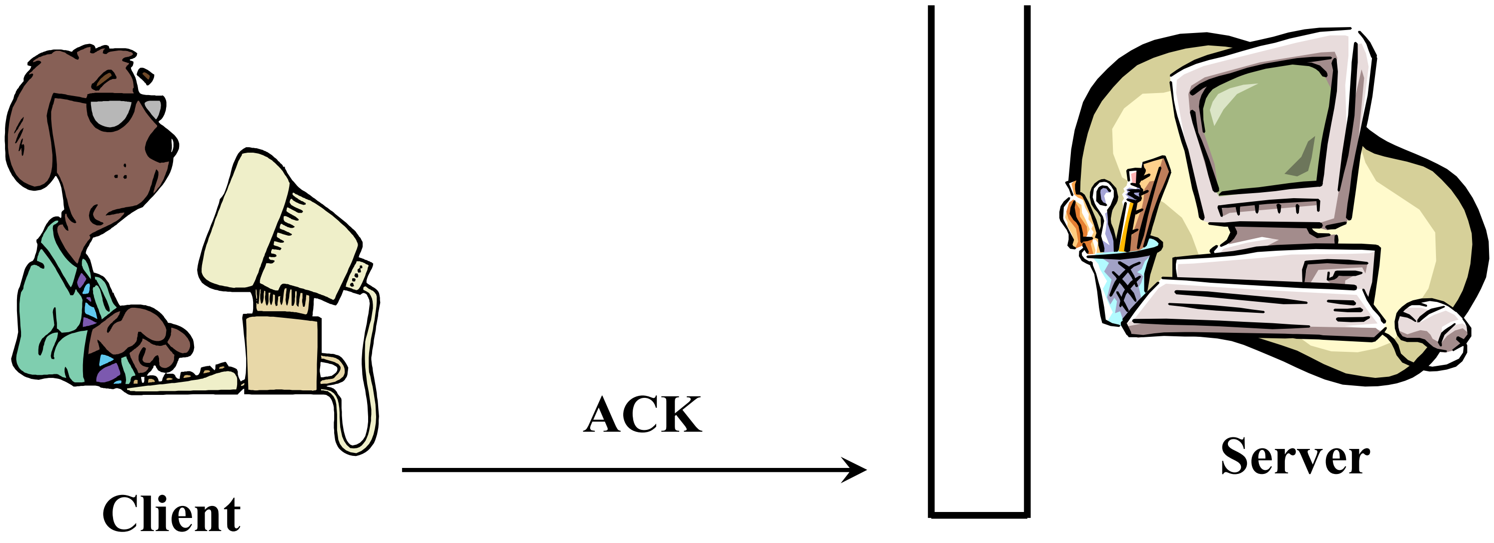


SYN-ACK

Client

Server

Example: TCP three-way handshaking

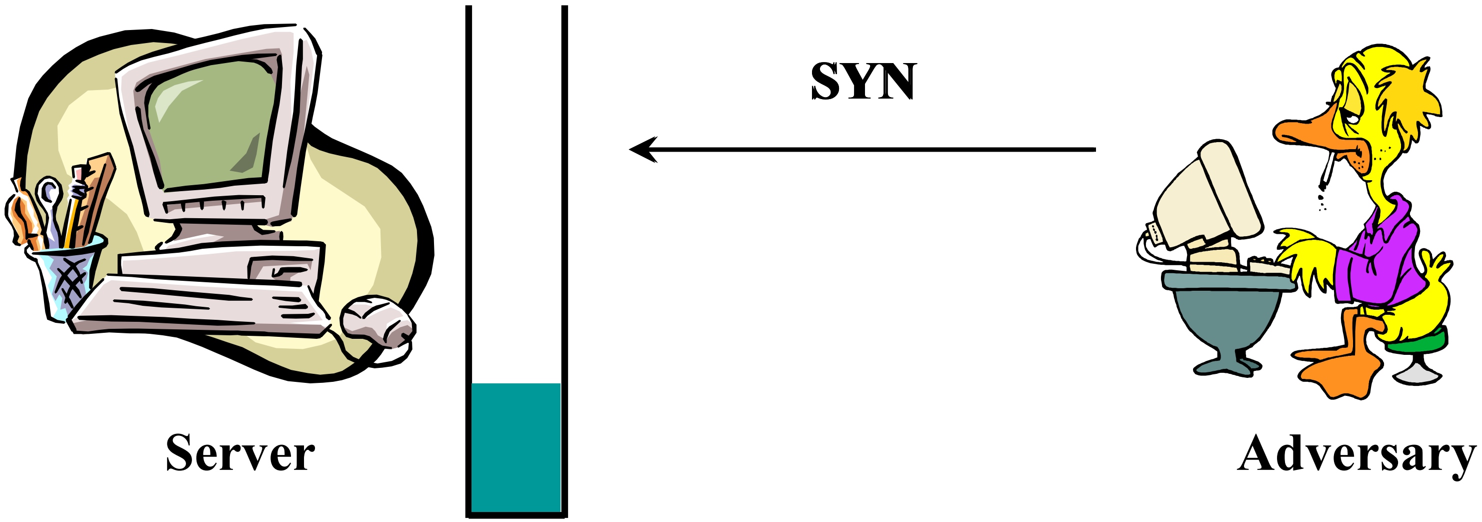


ACK

Client

Server

Syn-flooding!



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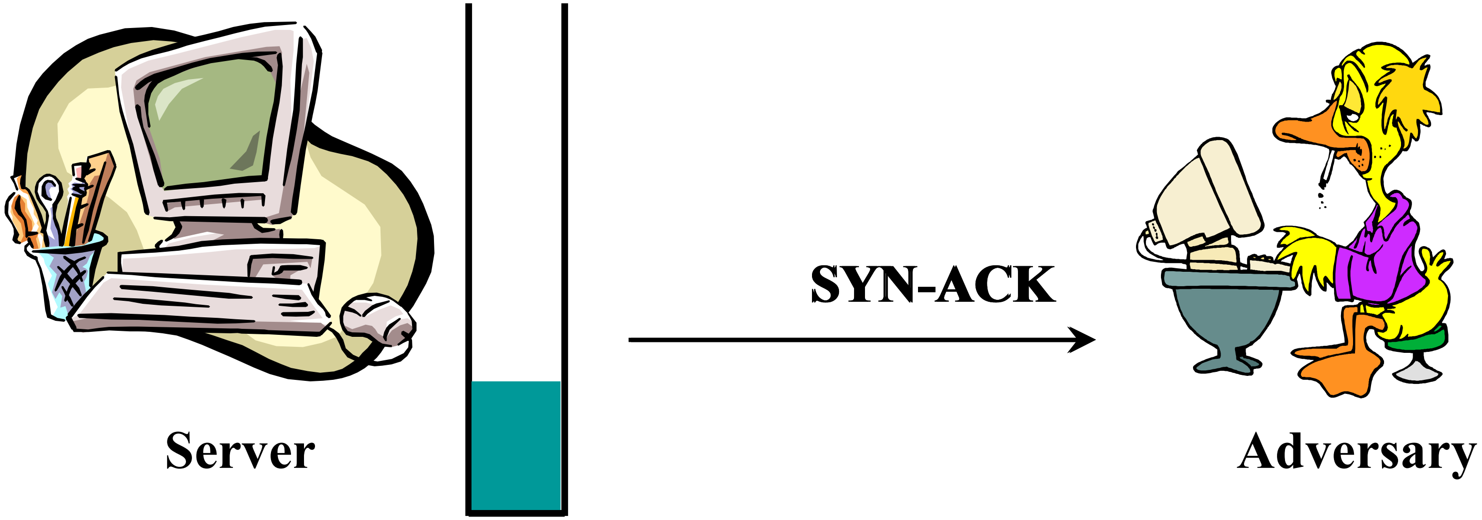

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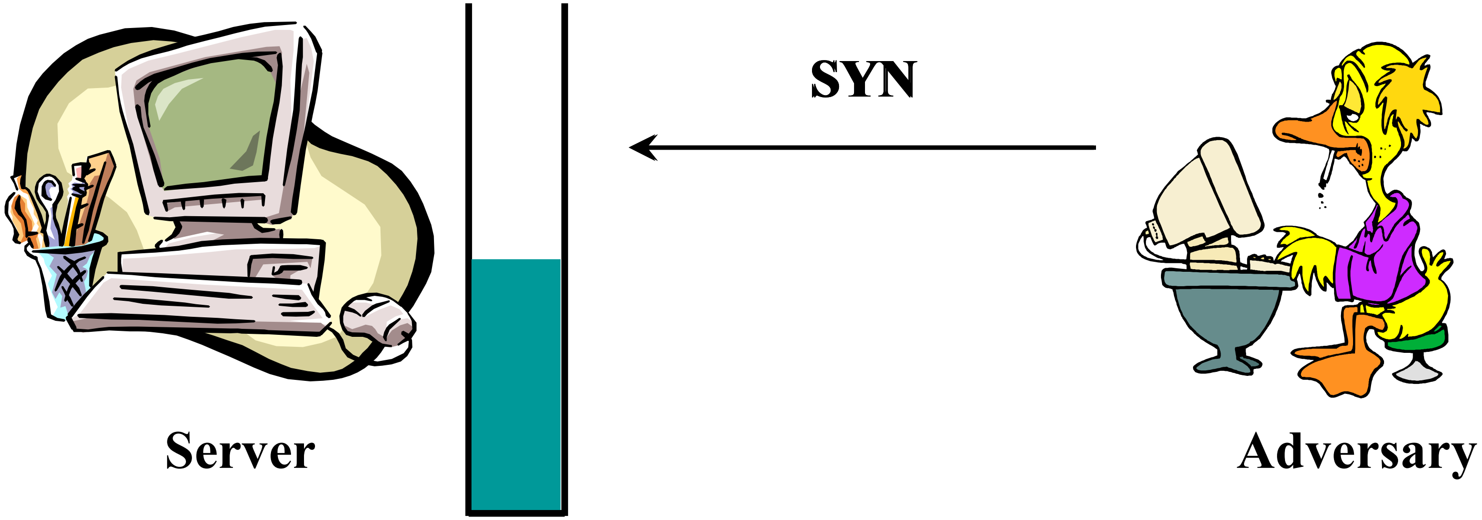
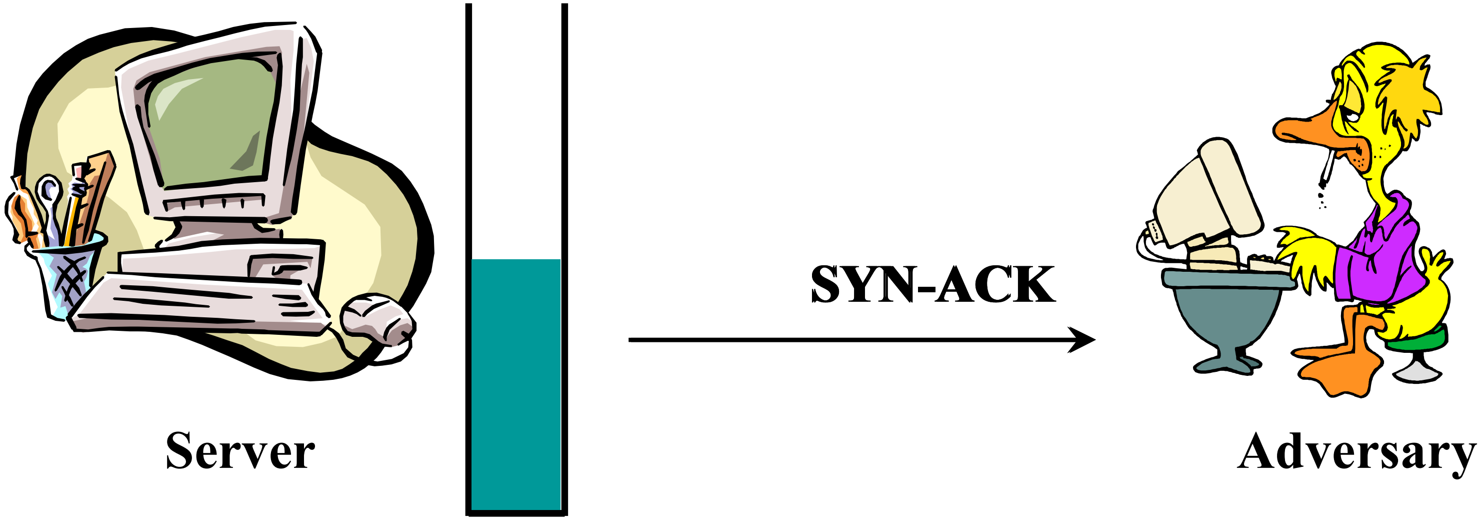


SYN

Server

Adversary

Syn-flooding!

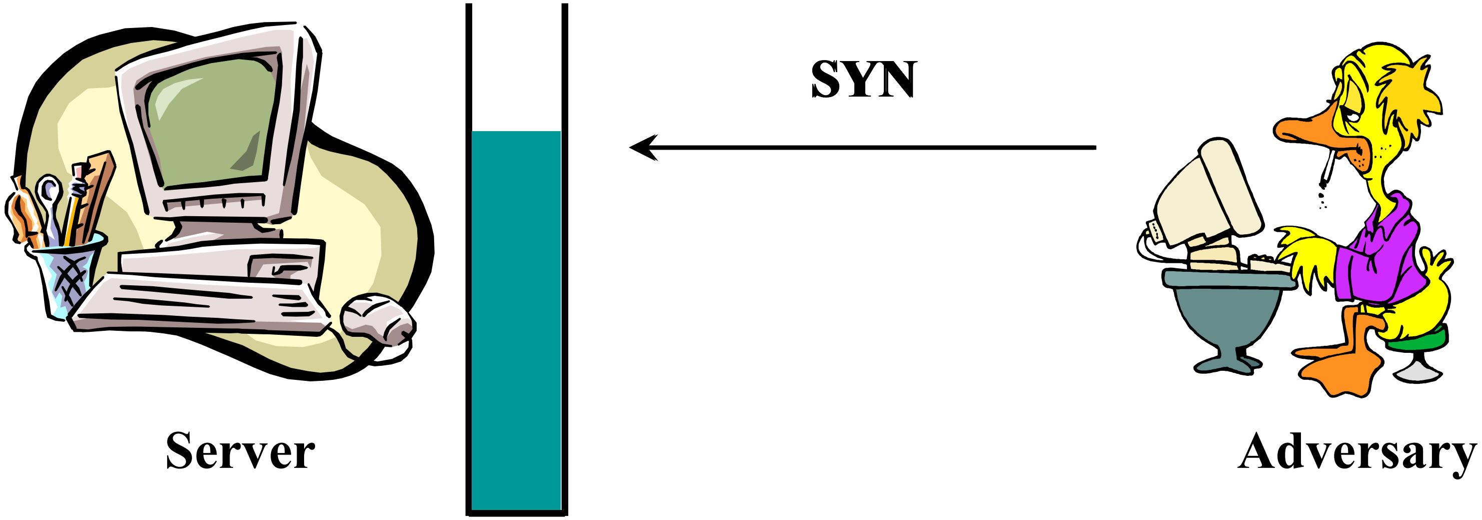


Server

SYN-ACK

Adversary

Syn-flooding!



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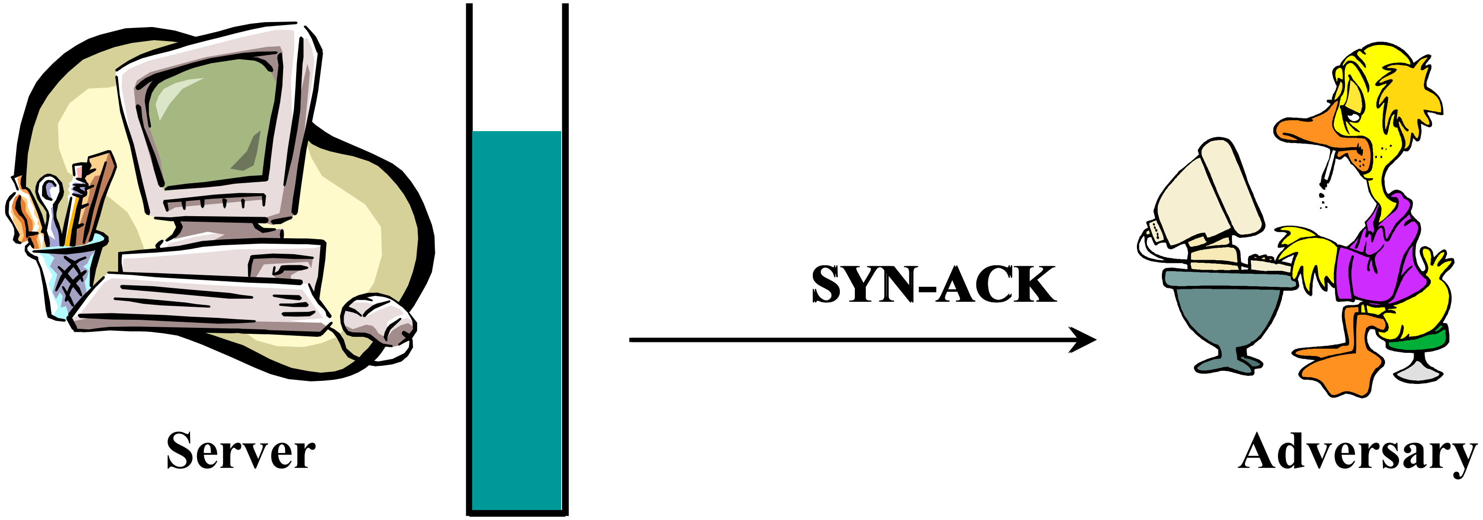

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SYN-ACK

Adversary

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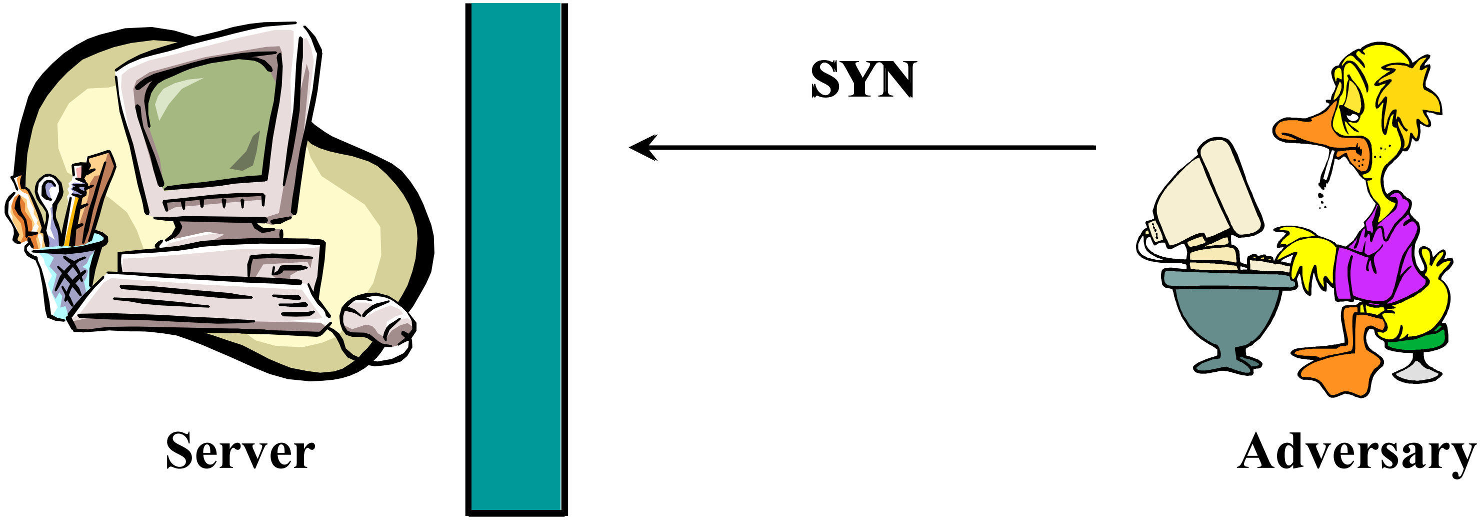

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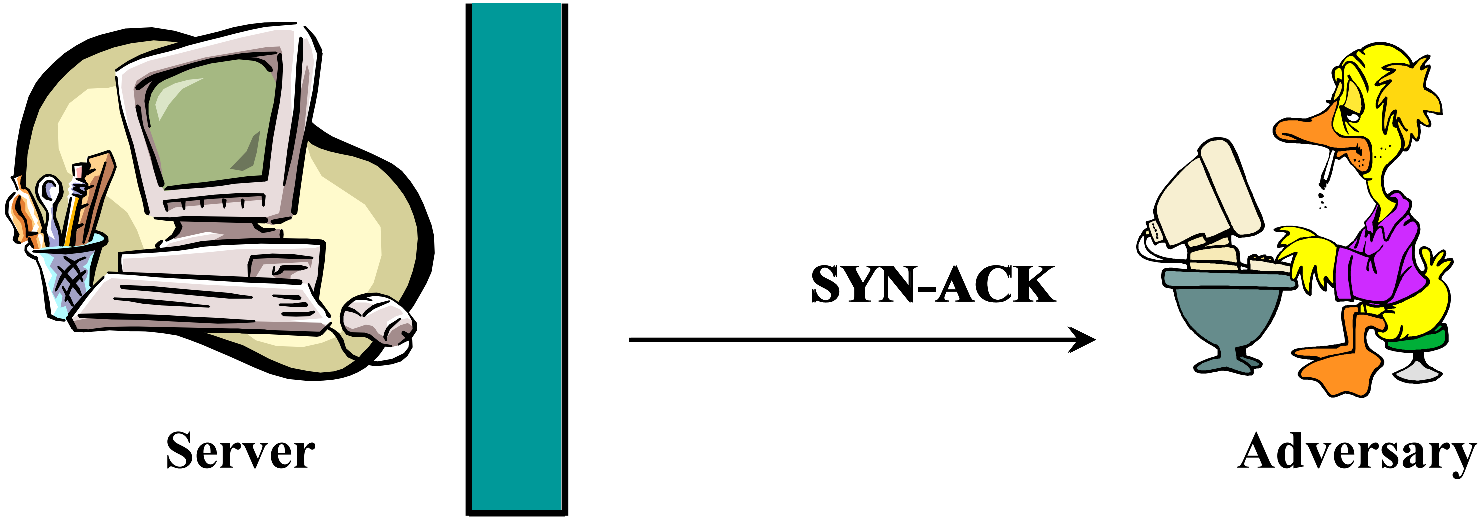


Syn-flooding!

Attack Surfaces

- Reachable and exploitable vulnerabilities

- General categories:
  - Network surface: e.g., open ports, services on the inside of a firewall
  - Software surface: e.g., code processing incoming data
  - Human surface: gullible employee access to sensitive data

Threats

- Unauthorized disclosure
  - Exposure, Interception, Inference, Intrusion
- Deception (false data accepted as true)
  - Masquerade, falsification, repudiation
- Disruption (aiming at availability or integrity)
  - Incapacitation (physically disable system), corruption (system modification), obstruction (interfere with communicaton)
- Usurpation (unauthorized system control)
  - Misappropriation (theft of service), misuse (unauthorized system access)

Threat Examples

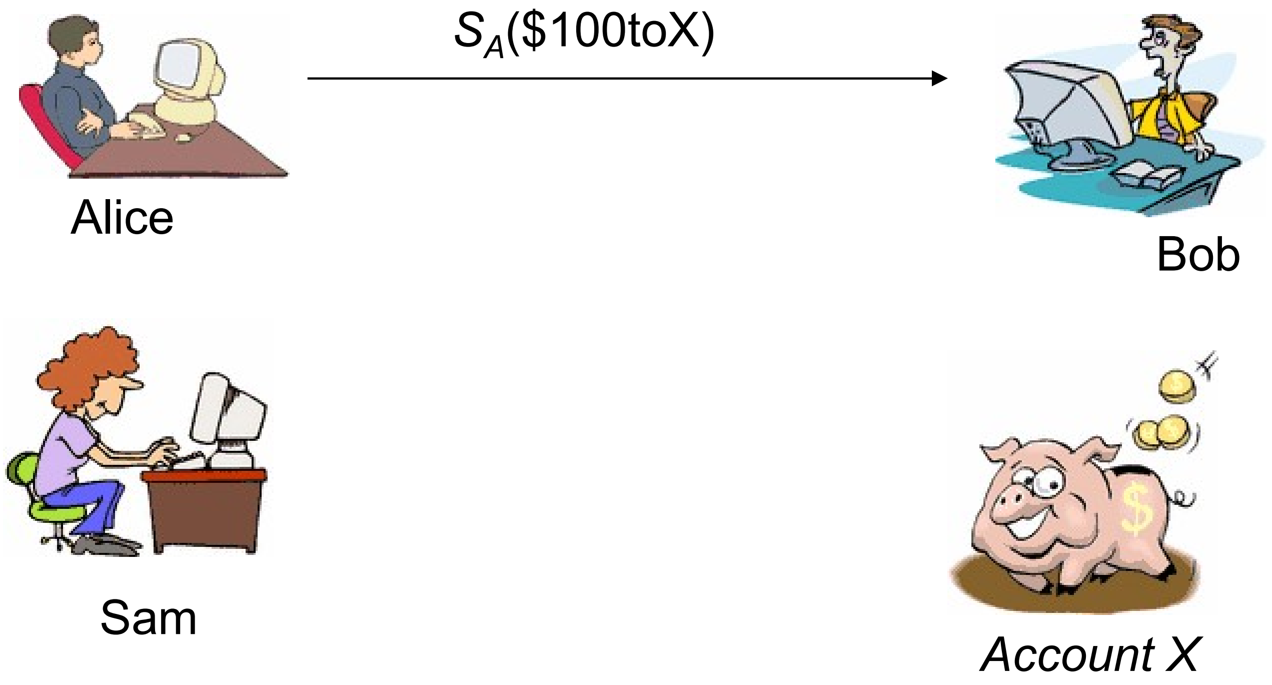
- Interception
  - Unauthorized access to assets
  - e.g., someone gets to know my salary
- Obstruction
  - Make assets unavailable
  - e.g., someone prevents me from getting my pay checks
- Fabrication
  - Tamper with assets or even create counterfeit objects
  - e.g., someone changes the amount on my pay check to 100,000,000 won!

Attacks

- From the way attack is carried out
  - Active attack: affect a target system’s operation
  - Passive attack: learn information without affecting system

- From the origin of the attack
  - Insider attack: authorized users do bad things
  - Outsider attack: unauthorized parties gain access

Active Attack Example: Replay



$S_A(\$100toX)$

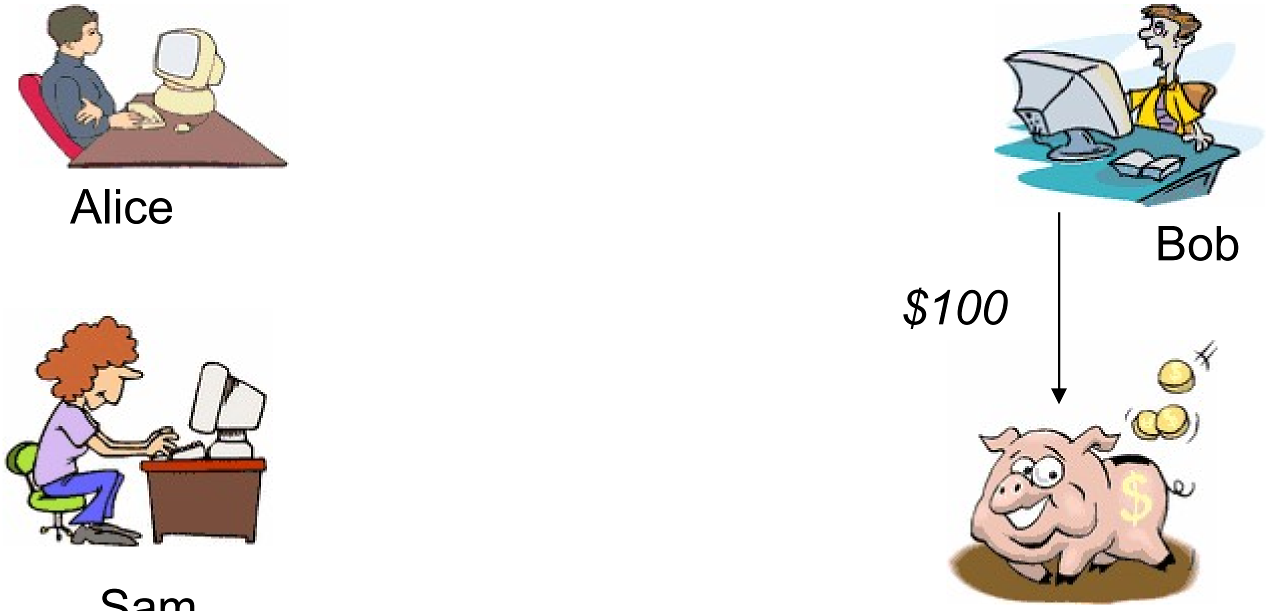
Alice

Bob

Sam

Account X

Active Attack Example: Replay



Alice

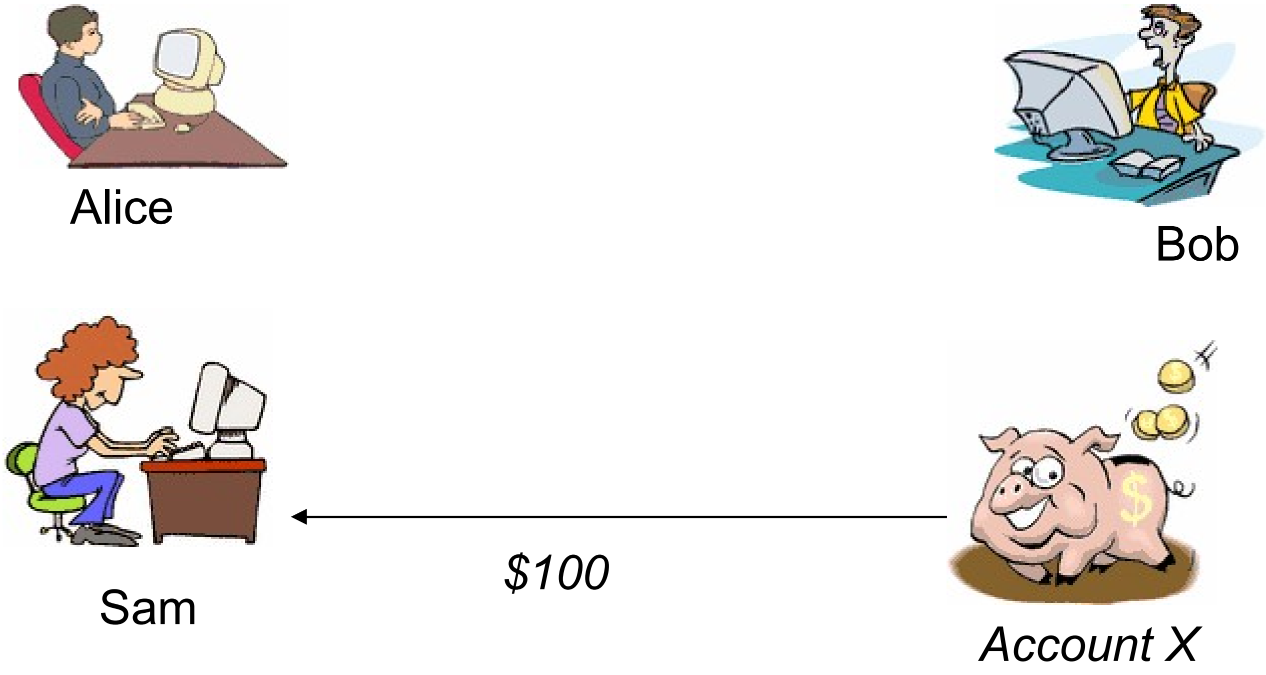
Sam

Bob

$100

Account X

Active Attack Example: Replay



Alice

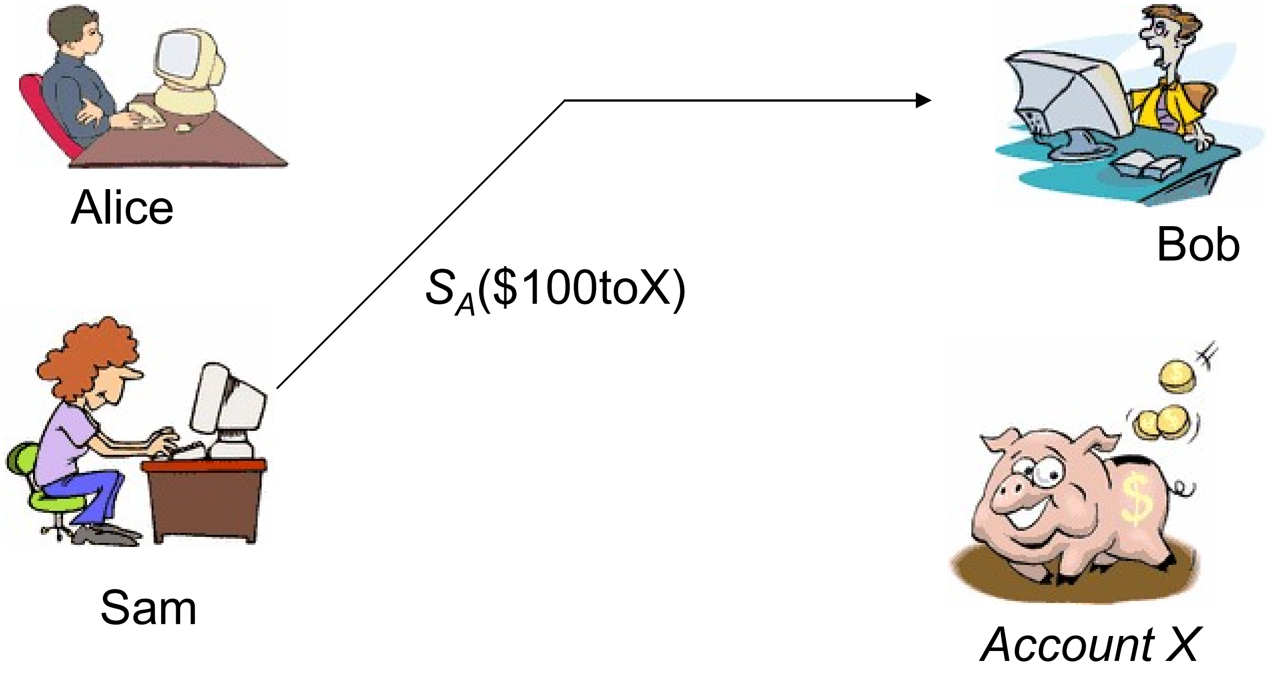
Bob

Sam

$100

Account X

Active Attack Example: Replay



Alice

Bob

S_A($100toX)

Sam

Account X

Active Attack Example: Replay

Alice

Sam

Bob

$100

Account X

Active Attack Example: Replay

Alice

Bob

Sam

$100

Account X

Passive Attack Example: Inference

- Side-channel leaks in encrypted wireless communication

http://www.youtube.com/watch?v=3sGH9KpYOJk

- Side-channel leaks in online health information systems

http://www.youtube.com/watch?v=AkIb4_ibB64

Security Goals: CIA Triad

- Confidentiality: information is protected from unintended disclosure
  - Data: information is not disclosed to unauthorized parties
  - Privacy: control of one's own information disclosure

- Integrity: system and data are maintained in a correct and consistent condition
  - Data: information and code only changed by authorized parties
  - System: system operates without unauthorized inference

- Availability: systems and data are usable when needed

Security Goals (cont'd)

- A secure system needs to balance confidentiality, integrity and availability
- These goals may overlap or be exclusive, dependent on the situations
  - E.g. Dividing data into *n* shares increases confidentiality but reduces the availability

Additional Security Goals

- Authenticity
  - Property of being verified and trusted
  - E.g., authentication

- Accountability
  - Action uniquely traced back to the responsible party
  - E.g., nonrepudiation, deterrence, fault isolation, intrusion detection prevention, etc.

How to achieve security goals?

- Security controls: including policy and mechanism

- Security Policy
  - A formal statement of rules and practices
  - Specify how information assets are protected

- Security Mechanism
  - Method, tool or procedure for enforcing the security policy

Security mechanisms

- Cryptographic primitives
  - Encryption helps achieve confidentiality
  - Digital signature helps achieve integrity
  - Client puzzle may helps achieve availability
- Security protocols
  - Authentication
  - Access control

Security mechanisms (cont'd)

- Security systems
  - Software security
  - Network security
  - Privacy preserving system
- Incentive engineering
  - Consider human factors

How to choose security control?

- There is no free lunch:
  - Security control introduces costs
  - e.g., performance or payments
- Risk: the chance of attacks
- Tradeoff
  - Assess the loss of an attack
  - Assess the risk
  - Assess the value of assets
  - Assess effectiveness of a security control

HEY, TOM, I JUST REALIZED THAT I DON'T NEED TO OUTRUN THE BEAR; I ONLY NEED TO OUTRUN YOU.

Pitfalls

- Identify incorrect threats
- Incorrect mapping of:
  - Threats → policy
  - Policy → mechanisms
- Changing environment invalidates assumptions!

Trust

- A *trusted* system is one whose failure can break the security policy
- A *trustworthy* system is one that won't fail

Assurance

- According to NIST Computer Security Handbook:

Assurance is degree of confidence that security measures work as intended to protect the system and information it processes

- Does security system design meet requirements?
- Does security system implementation meet specifications?

Fundamental Security Design Principles

- Economy of mechanism
- Fail-safe defaults
- Complete mediation
- Open design
- Separation of privilege
- Least privilege
- Least common mechanism
- Psychological acceptability
- Isolation/Encapsulation/Modularity/Layering
- Least astonishment

Proposal

- Proposal Deadline: 10/7 11:59pm
- Proposal Format
  - Single column
  - Single spacing
  - Font type: 바탕체
  - Font size: 10
  - Layout: 좌/우/위/아래 모두 20mm
  - Page limit: 2 pages
- Final Report Deadline: 11/24 11:59pm.
- Final Report template will be uploaded by 10/11.