Opening and Closing Problems in Security Protocols Research

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Baseball analogy

- Baseball pitchers
  - starters
  - middle relievers
  - closers
- A line of research is like a baseball game with starters, middle relievers, and closers
- But unlike baseball games,
  - lines of research in an area are related and form a tree
  - a middle reliever can become a closer or starter during a "game"

Authentication protocols for computer networks

- Starter: Needham and Schroeder protocols (1978)
  - public key crypto (Diffie and Hellman, 1976)
  - authentication and secrecy concerns

- Two lines of ensuing research
  - verification of security protocols
  - design and implementation of authentication services

Verification of security protocols

- Starter: Dolev and Yao (1981)
  - secrecy concerns only
- Starter: BAN logic (1989)
  - authentication concerns

    e.g., after authentication, two principals believe that they are communicating with each other and not with intruders
- More on BAN logic
  - high level of abstraction
  - protocol idealization—potentially large semantic gap
  - secrecy concerns not addressed

Verification—middle relievers

… (numerous)

- Woo-Lam protocol model (1993)
  - state transition semantics
  - formalize authentication as well as secrecy properties

    correspondence assertion: X $\hookrightarrow$ Y

    if event X occurs, then event Y must have occurred in the past

- CMU model checker for security protocols (1997)

…

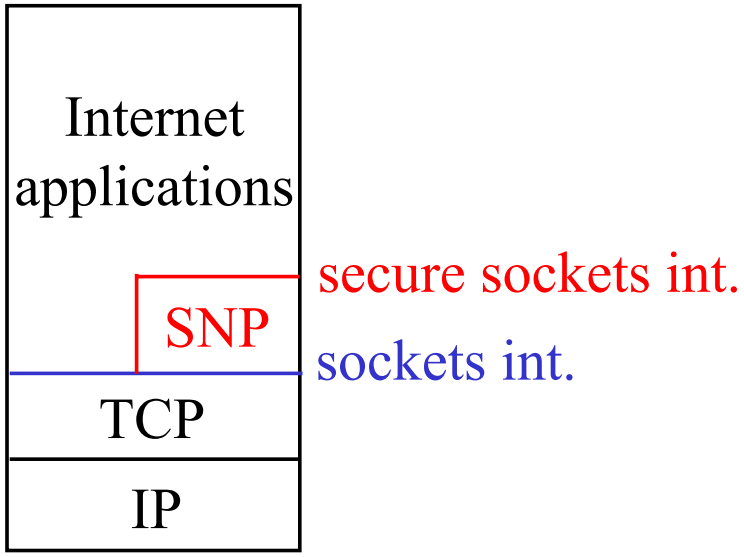
(game in progress)

Authentication service for client-server Internet applications

- Starter: Kerberos (MIT, 1988)
  - also a closer: used in ftp, rcp, rlogin, ssh, …
- Middle relievers:
  - SPX (DEC, 1991)
  - KryptoKnight (IBM, 1992)
  - GSS-API (1993)

  …
- Disadvantage:
  - each system has its own user interface
  - applications need to work with "low-level" security concepts
- "Kerberizing an application is the most difficult part of installing Kerberos."

The accidental closer



SNP (1993), the first secure sockets layer

- demonstrated to NSA, 1993
- USENIX conference, June 1994

- Idea: clean separation of concerns—application programmer does not need to deal with security operations
- Goal: "toward secure network programming for the masses"

Secure Network Programming

- Easy to use and to retrofit
  - secure sockets interface very similar to sockets interface
  - only minor, mostly syntactic, modifications are needed to convert an application's socket program into a secure network program

- For most socket calls,

  connect() → snp_connect()

  accept() → snp_accept()

  write() → snp_write()

  read() → snp_read()

  shutdown() → snp_shutdown()

  …

- Only new call necessary is snp_attach()

  for application to provide credentials to support its claim of identity

Historical context

- November 1992, only 26 reasonably reliable www servers exist
- October 1993, over 200 www servers in the world
- February 1993, first Alpha release of Mosaic for X browser
- April 1994, Netscape founded
- October 1994, Beta release of Netscape browser
- E-commerce (circa 1995)

What are some new concerns?

- By mid 1990s, protocol design to address client-server authentication and secrecy concerns understood
- Our new concerns: efficiency, latency, and scalability of security protocols to keep up with Internet's growth
  - multicast to large groups
  - real-time packet flows (multimedia)
  - high-speed transmissions

Problems we opened

- Secure group communications
  - Scalable key server using Key Tree approach (WGL 1998)
  - Scalable and reliable transport protocol for group rekeying
    - IP multicast or broadcast (ZLLY 2001)
    - Application-layer multicast (ZLL 2005)
- Efficient digital signature schemes for packet flows and multicasts (WL 1998)
  - Signed packets are individually verifiable

Conclusions

- Moral of the "accidental closer" story
  - In designing a protocol, think about its users. Make the protocol as easy to use as possible.
- Middle relief work
  - It pays the bills
  - It keeps us busy and thinking until the next big opportunity
  - Unlike baseball, our role is not determined by a manager. *A middle reliever can become a starter or closer during a game.*