Design and Analysis of Operating Systems CSCI 3753

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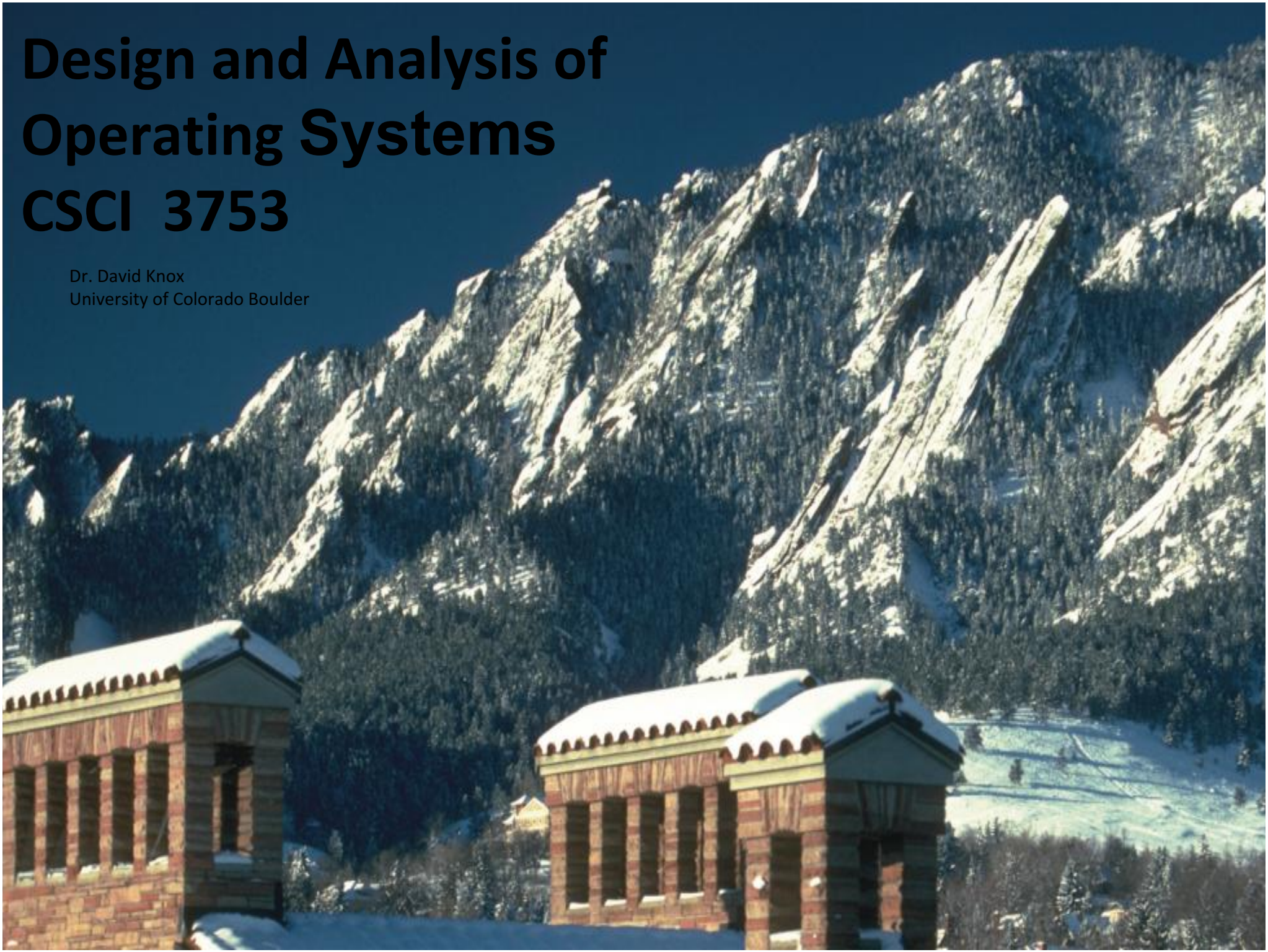

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Security in Operating Systems

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Security in Operating Systems

Authentication

Data Integrity

6 Main Areas of Security

1. ***Authorization*** **– managing access to resources**
2. ***Confidentiality*** **– only allow authorized viewing of data - encrypting files and communication**
3. ***Authentication*** **– proving you are who you say you are**
4. ***Data Integrity*** **– detecting tampering with digital data**
5. ***Non-repudiation*** **– proving an event happened**
6. ***Availability*** **– ensuring a service is available (despite denial of service attacks)**

Authentication

- **Prove you are who you say you are**
  - e.g. Logging into your laptop or smartphone
- **Password is a form of authentication**
  - Providing the correct password is seen as authenticating the user to the OS
- **New: biometric authentication on smartphones**
- **For text-based authentication:**
  - Attacker can try to guess your password, using common words, etc.
  - OS can block or slow down access after too many login attempts

Remote Authentication

- **Harder than logging into your own laptop/mobile phone**
- **Now must communicate login messages over the network**
  - Early *rlogin* sent password unencrypted!
  - An attacker can employ a *replay attack*: just replay the password to login as the intercepted user
- **Should encrypt the password!**
  - *But even an encrypted password can be replayed!*

Remote Authentication

- **Solution: change/perturb the encrypted message containing the password on each login**
  - Approach 1: Add a different # to the message containing the password on each login attempt
    - e.g. a timestamp
    - Then encrypt the perturbed message
  - Approach 2: change the encryption key each login
- **For both approaches, the login message will look different on every login**
  - Hence, an attacker cannot replay an old encrypted message

SSH and SSL/TLS

- **SSH (Secure Shell) provides secure remote login**
  - is used to securely encrypt your password login and terminal traffic during a shell session (can be used to tunnel other data too)
- **SSL/TLS (Secure Sockets Layer/Transport Layer Security) is used to securely encrypt http Web traffic**
  - Any URL beginning with https:// is encrypted using SSL/TLS, e.g. for financial and product-ordering Web sites like Amazon

SSH

User/Client

Server

Server's Keys: K_{PUBLIC}, $K_{PRIVATE}$

Login?

K_{PUBLIC}

Ask user if they will accept K_{PUBLIC}. If so, choose symmetric session key K[1]

$E(K_{PUBLIC},K)$[2]

Decrypt session key K with $K_{PRIVATE}$:

$K = D(K_{PRIVATE},E(K_{PUBLIC},K))$

Encrypt password and messages

E(K,message)

Decrypt message with session key K

[1]In SSH-2, user and server negotiate a session key, e.g. using Diffie-Hellman, rather than the user just choosing a session key

[2]Note E(k,d) means some data d is encrypted by key k

SSH

- **Observation #1: SSH is a *hybrid* public key + symmetric key scheme. Why?**
  - Public key (RSA) cryptography is computationally expensive because of exponentiation at both encryptor and decryptor
  - In comparison, symmetric key cryptography is much faster
  - But symmetric key crypto suffers from the key distribution problem
  - So combine them: use public key to distribute the symmetric key!

SSH

- **Observation #1: SSH is a *hybrid* public key + symmetric key scheme. Why? (continued)**
  - Public key only encrypts the symmetric key, which is a small amount of data, so computational expense is minimized
  - Afterwards, all future data messages are encrypted using fast symmetric key cryptography
  - Get the best of both worlds:
    - solve the key distribution problem and
    - get fast encryption/decryption

SSH

- **Observation #2: The symmetric key changes on each login.**
  - This prevents a replay attack
- **Observation #3: The initial public key is not certified! SSH is subject to an MIM attack!**
  - When you SSH for the first time into a new server, it will prompt you to ask if you trust the advertised public key. This is called “trust on first use” (TOFU).
  - If you say yes, SSH caches the public key and proceeds. Hope no MIM on first access.

SSH

- There is a provision for certificates in SSH-2 (OpenSSH has a patch), but it is not widely used yet.
- Servers probably don't provide such certificates because of the effort to obtain certification from a trusted 3rd party

SSL/TLS

- **Secure Sockets Layer (SSL), renamed to Transport Layer Security (TLS), is the basis of the secure Web protocol *https***
- **Similar to SSH, except uses certified public keys:**
  1. Requestee's *certified* public key is initially passed to requestor, who verifies certificate
  2. SSL requestor negotiates a symmetric session key K with requestee
     - Negotiation is protected by encrypting it with certified public key
  3. All subsequent messages (e.g. secure Web page contents) are encrypted with symmetric key K

SSL/TLS

User/Client

Server

Server's Keys: Certificate(K_{PUBLIC}), $K_{PRIVATE}$

Login?

certificate(K_{PUBLIC})

Verify K_{PUBLIC} with certificate. If OK, generate random premaster secret.
K = f(premaster secret)

E(K_{PUBLIC},premaster secret)

Decrypt premaster secret with $K_{PRIVATE}$:
session key K = f(premaster secret)

Send messages

E(K,message)

Decrypt message with session key K

SSL/TLS

- **Key difference from SSH**
  - SSL/TLS uses certified public key

- **SSL/TLS's approach solves:**
  - confidentiality: login & data are encrypted
  - key distribution: public keys are used to distribute symmetric keys
  - speed: most data is encrypted with fast symmetric keys
  - replay attack: the encrypted login password looks different every time because the symmetric key changes every session
  - man-in-the-middle attack: because the initial public key is certified (improvement over SSH)

Other Authentication Approaches

- **Challenge-response protocol:**
  - X and Y share a secret symmetric key. X wants to authenticate a node N that says it is Y.
  - X sends a challenge to N, i.e. a random number used only once (nonce)
  - N sends to X nonce encrypted w/ N's symmetric key
  - X decrypts N's message with X's sym key. If decrypted # matches nonce, X knows responder N is Y.
- **S/KEY has 1-time password vs replay attacks**
  - a list of one-time passwords is generated a priori and then consulted during login at both ends
  - list could be generated using a one-way function

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Data Integrity

- **Refers to the overall completeness, accuracy and consistency of the data**

- **Physical integrity**
  - challenges of correctly storing and retrieving the data
  - hardware faults

- **Logical integrity**
  - software bugs (corrupting data)
  - human errors

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