USC CSci530
Computer Security Systems
Lecture notes Fall 2024

Dr. Clifford Neuman
University of Southern California
Information Sciences Institute

(preliminary slides part 1)

CSci530: Security Systems
Lecture 1 – August 30, 2024 – OHE122
The Security Problem

Dr. Clifford Neuman
University of Southern California
Information Sciences Institute

http://ccss.usc.edu/530

Administration

- Class home page

  http://ccss.usc.edu/530

  - Syllabus (top level web page)
  - Assigned Readings
  - Lecture notes
  - Assignments

Structure of lecture

- Classes from 9:00 AM – 11:50 AM
  - 10 minute break - halfway through
- Lab and Discussion Section
  - Friday's 4:30PM to 5:20PM
  - Discussion of Upcoming Lab or
  - Review for Mid-term or final and/or
  - 10 minute discussions by led by teams of 1-3 students on current events related to the discussion (Send 2 sentences proposing topic before Wednesday)

Administration

- Lab Component
  - 1 of the 4 units
  - Discussion of Upcoming Labs 4:30-5:20 Fridays
    - This is not when you perform the labs
    - Today's Lab instruction is introduction to the labs
  - You will perform the lab online during the following week

Administration

- Class e-mail: csci530@usc.edu (to all course staff preferred)
- Instructor
  - Dr. Clifford Neuman – bcn@isi.edu
    - Please be sure to include CSCI530 in the subject of the message
  - Office hours Monday 12:30PM to 2:00 PM
    - Via Zoom – link to be emailed to class
  - Contact info on class web page
- TA s
  - Christina Chaniotaki
    - Email: cchaniot at usc.edu
    - Office Hours T.B.D.
  - Dipsy Desai
    - Email: deepakde at usc.edu
    - Office Hours T.B.D.

Administration

- Grading Base Grade
  - Assignments: 10% (total across 2 or 3 assignments)
  - Exams: 25%, 25%
  - Research paper 30%
  - Lab exercise 10%
  - Class participation
    - Can boost grade by averaging in up to an additional 10%

Desire 2 Learn

- Using the DEN Desire to Learn Brightspace
  - Follow Link to Lectures and Discussion forum from ccss.usc.edu/530
  - Contact webclass@usc.edu if you have difficulty gaining access to the system.

Class Participation

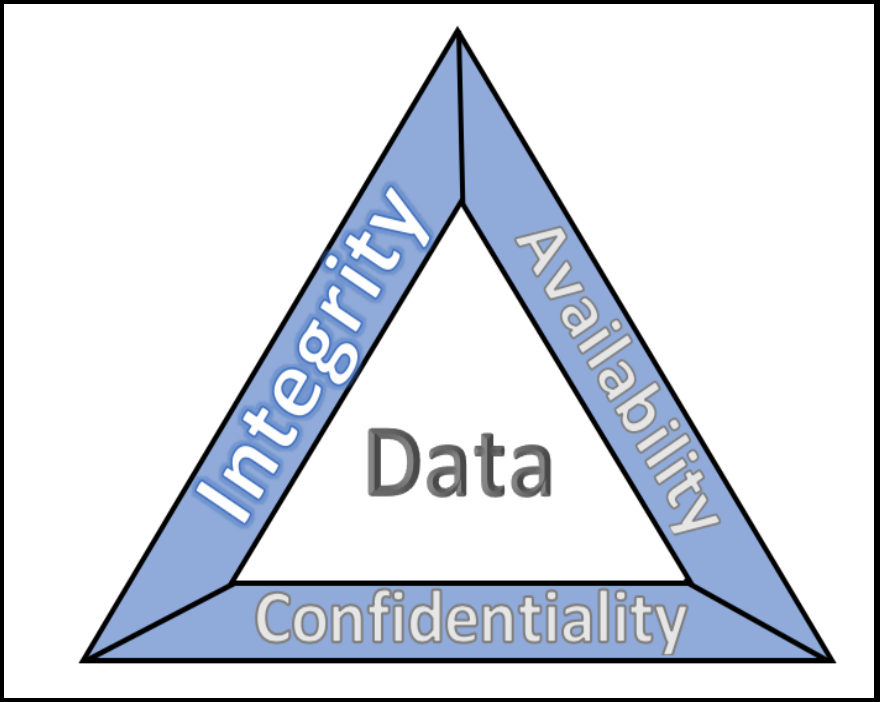
- Class participation is important.
  - Ask and answering questions in class.
  - Ask, answer, participate on-line
  - Presentation of current events
- Bonus for class participation
  - If I don't remember you from class, I look in the web discussion forum to check participation.
    - Did you ask good questions.
    - Did you provide good answers.
    - Did you make good points in discussions.

Academic Integrity

- I take Academic Integrity Seriously
  - Every year I have too many cases of cheating
  - Last year I assigned multiple F's for the class
  - On occasion, students have been dismissed from program
- What is and is not OK
  - I encourage you to work with others to learn the material
  - Do not to turn in the work of others
  - Do not give others your work to use as their own
  - Do not plagiarize from others (published or not)
  - Do not try to deceive the instructors
  - Discussion of generative AI (treat is as work by others)
- See section on web site and assignments
  - More guidelines on academic integrity
  - Links to university resources
  - Don't just assume you know what is acceptable.

The Three Aspects of Security

- Confidentiality
  - Keep data out of the wrong hand
- Integrity
  - Keep data from being modified
- Availability
  - Keep the system running and reachable



Policy v. Mechanism

- **Security policy defines what is and is not allowed**
  - **What confidentiality, integrity, and availability actually mean**
- **Security mechanism is a method or tool for enforcing security policy**
  - Prevention
  - Detection
  - Reaction
- **Among mechanisms are:**
  - **Mechanisms enforce policy.**
  - Mechanisms may solve intermediate problems.
    - Authentication, Audit
    - Containment

Trusted vs. Trustworthy

- We trust our computers
  - We depend upon them.
  - We are vulnerable to breaches of security.
- Our computer systems today are not worthy of trust.
  - We have buggy software
  - We configure the systems incorrectly
  - Our user interfaces are ambiguous regarding the parts of the system with which we communicate.
- Trust is for a purpose and an assumed environment

Terminology

Trusted – Parts of a system that we depend upon for the proper enforcement of policies, whether or not the code is free of vulnerabilities (almost all systems have vulnerabilities). - as compared with

Trustworthy – our belief that a system is free of vulnerabilities that could result in the violation the relevant security policies.

Accreditation – A statement by a third party that a system or software has been found to be trustworthy with respect to a particular set of policies and for a particular operational environment.

Important Considerations

- Risk analysis and Risk Management
  - Impact of loss of data.
  - Impact of disclosure.
  - Legislation may play a role.

- Human factors
  - The weakest link

In The Shoes of an Attacker

- Motivation
  - Bragging Rights
  - Revenge / to inflict damage
  - Terrorism and Extortion
  - Financial / Criminal enterprises
  - Nation State Objectives

- Risk to the attacker
  - Can play a defensive role
  - Including effective attribution

Kinds of Adversaries: Users of Published Attack Tools

- Attacker has specific tools
  - Casts the tool widely to see what can be caught.
  - Sometimes described as script-kiddies
    - Gets them into systems or with specific vulnerabilities
    - Gets them account access to susceptible employees
  - The gather what they find, exfiltrate or modify, and stop there
- Strong security posture is effective
  - Sound security practices
  - Systems up to date
  - Least privilege

Kinds of Adversaries: Opportunistic or Bottom Up Adversaries

- Looks for the weak link
  - Uses tools to scan for vulnerabilities
  - Once in, repeats the process
    - This time starting with elevated access because of the system or user ID already compromised.
- Your containment architecture is critical against such adversaries.
  - You need to be aware of the paths that might be followed to reach sensitive data.

Kinds of Adversaries: Goal Oriented Top Down Adversaries

- Learns about your organization and system
  - Goal is to compromise some component of your system or access specific data.
  - Learns precursor activities that must be achieved to meet that goal.
  - Often applies APT – Advanced Persistent Threat tactics
  - Will wait for threat vector to propagate
- Defenses require all of:
  - Strong security posture
  - Training of privileged employees
  - Containment Architecture
  - Strong defenses to subversion.

Economics of Malicious Code

- Controlled machines for sale
- "Protection" or "recovery" for sale
- Attack software for sale
- Stolen data for sale
- Intermediaries used to convert online balances to cash.
  - These are the pawns and the ones that are most easily caught

Terminology (around attacks)

Vulnerability – A weakness in a system, program, procedure, or configuration that could allow an adversary to violate the intended policies of a system.

Threat – Tools or knowledge (capabilities) that care capable of exploiting a vulnerability to violate the intended policies of a system.

Attack – An attempt to exploit a vulnerability to violate the intended policies of a system.

Compromise or intrusion – The successful actions that violate the intended polices of a system.

Incidents and Breaches

- **Penetration – A successful attack (intrusion) that exploits a vulnerability in the code base of a system or its configuration. The result will often be to install a subversion.**
- **Denial of Service – An attack that prevents authorized access to a resource, by destroying a target or overwhelming it with undesired requests.**
- **Subversion - An intentional change to the code base or configuration of a system that alters the proper enforcement of policy. This includes the installation of backdoors and other control channels in violation of the policy relevant to the system.**
- **Subversion vectors – the methods by which subversions are introduced into a system. Often the vectors take the form of malicious code.**

More Terminology

Secure – A system is secure if it correctly enforces a correctly stated policy for a system. A system can only be secure with respect to a particular set of policies and under a set of stated assumptions. There is no system that is absolutely secure.

Trusted Computing Base – That part of a system which if compromised affects the security of the entire system. One often unstated assumption made with respect to a secure system is that the TCB is correctly implemented and has not been compromised.

Attack Surface – The accumulation of all parts of a system that are exposed to an adversary against which the adversary can try to find and exploit a vulnerability that will render the system insecure (i.e. violate the security policies of the system).

Security and Society

- Does society set incentives for security.
  - OK for criminal aspects of security.
  - Not good in assessing responsibility for allowing attacks.
  - Privacy rules are a mess.
  - Incentives do not capture gray area
    - Spam and spyware
    - Tragedy of the commons

Why we aren't secure

- Buggy code
- Protocols design failures
- Weak crypto
- Social engineering
- Insider threats
- Poor configuration
- Incorrect policy specification
- Stolen keys or identities
- Denial of service

What do we want from security

- Confidentiality
  - Prevent unauthorized disclosure
- Integrity
  - Authenticity of document
  - That it hasn't changed
- Availability
  - That the system continues to operate
  - That the system and data is reachable and readable.
- Enforcement of policies
  - Privacy
  - Accountability and audit
  - Payment

The role of policy in security architecture

Policy – Defines what is allowed and how the system and security mechanisms should act.

Enforced By

Mechanism – Provides protection
interprets/evaluates
(firewalls, ID, access control, confidentiality, integrity)

Implemented as:

Software: which must be implemented correctly and according to sound software engineering principles.

Security Mechanisms

- Encryption
- Checksums
- Key management
- Authentication
- Authorization
- Accounting
- Firewalls
- Virtual Private Nets
- Intrusion detection
- Intrusion response
- Development tools
- Virus Scanners
- Policy managers
- Trusted hardware

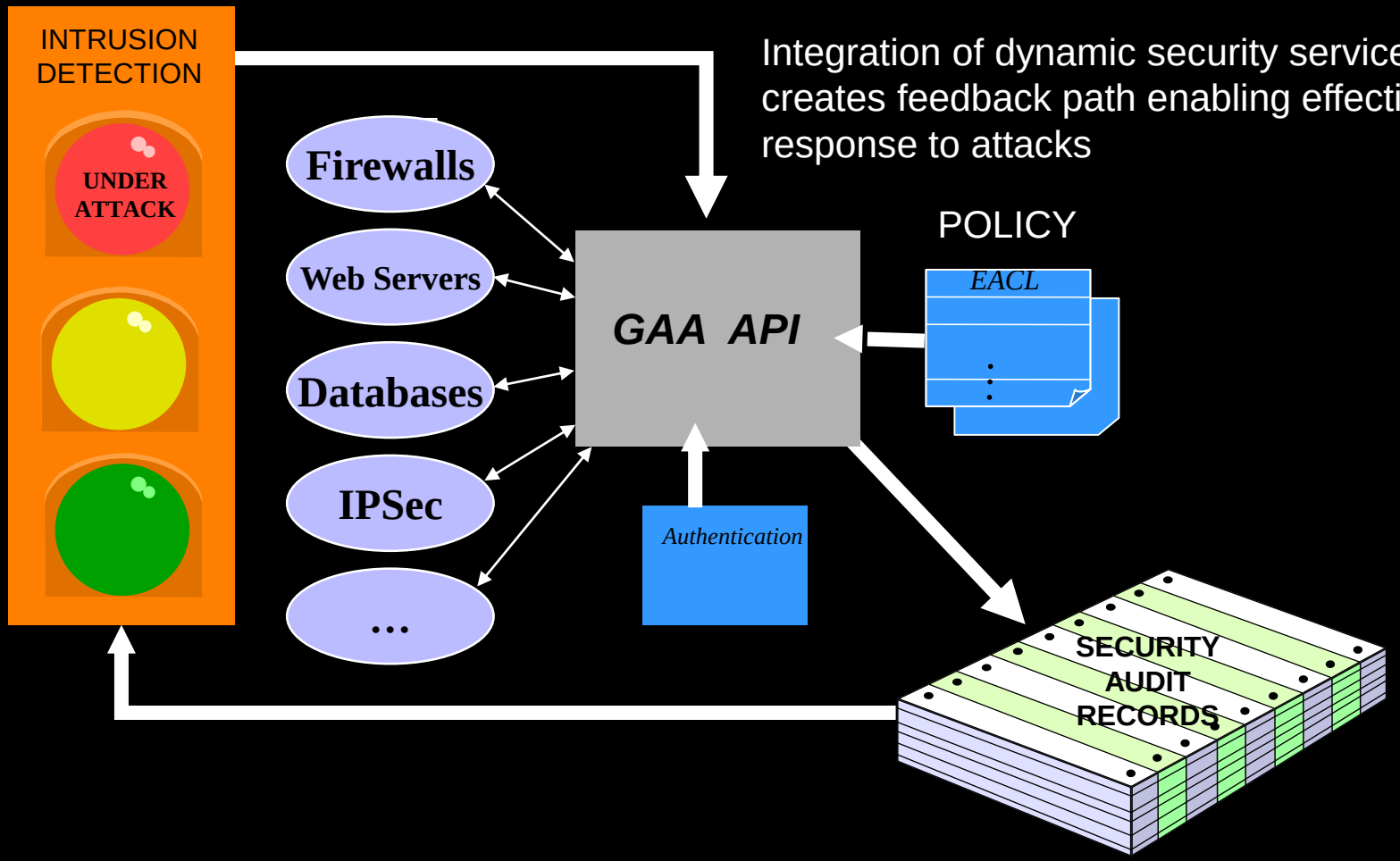
Today's security deployment

- Most deployment of security services today handles the easy stuff, implementing security at a single point in the network, or at a single layer in the protocol stack:
  - Firewalls, VPN's
  - IPSec
  - SSL
  - Virus scanners
  - Intrusion detection

A more difficult problem

- **Unfortunately, security isn't that easy. It must be better integrated with the application.**
  - **At the level at which it must ultimately be specified, security policies pertain to application level objects, and identify application level entities (users).**

Security Systems vs Systems Security



Integration of dynamic security services creates feedback path enabling effective response to attacks

Loosely Managed Systems

- Security is made even more difficult to implement since today's systems lack a central point of control.
  - Home machines unmanaged
  - Networks managed by different organizations.
  - A single function touches machines managed by different parties.
    - Clouds

Who is in Control

- The Intruder?
- The Government?
- Your employer?
- Those with whom you do business?
- Infrastrcture (cloud) providers?
- Ultimately, it must be you who takes control, but today's systems don't take that view.
  - You must balance conflicting interests and control.

- End of Lecture 1
- Following slides are start of lecture 2

CSci530: Security Systems
Lecture 2 – September 6th, 2024
Cryptography

Dr. Clifford Neuman
University of Southern California
Information Sciences Institute

http://ccss.usc.edu/530

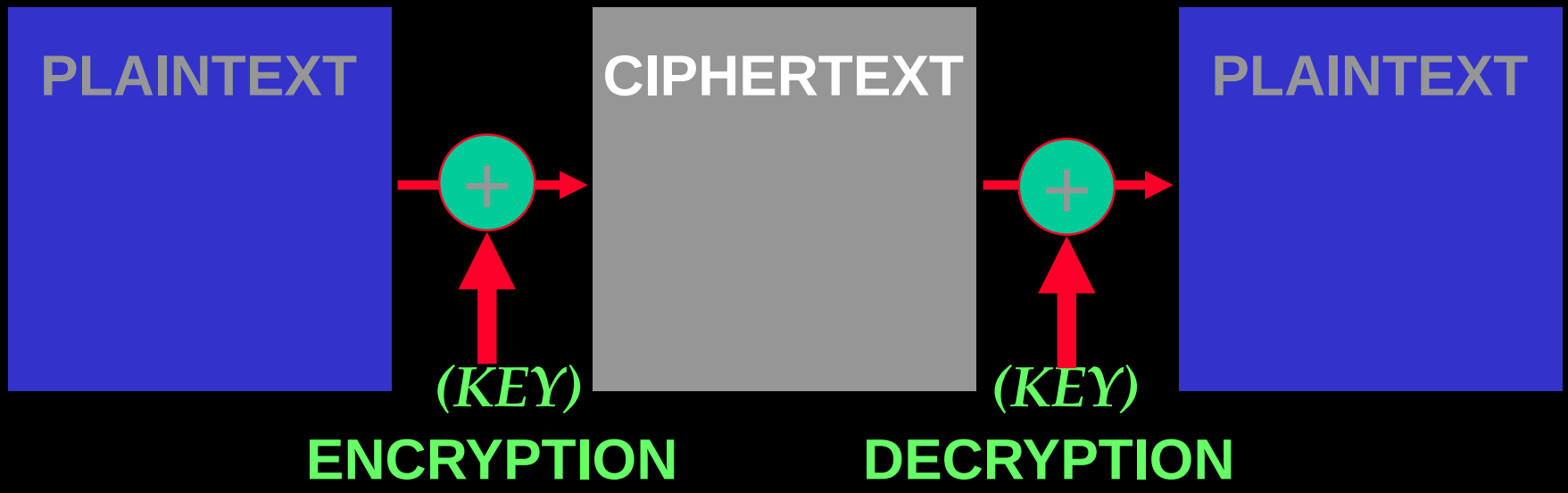
Cryptography and Security

- Cryptography underlies many fundamental security services
  - Confidentiality
  - Data integrity
  - Authentication
- It is a basic foundation of much of security.

A Brief History

- Steganography: “covered writing”
  - Demaratus and wax tablets
  - German microdots (WWII) .
  - Flaw: Discovery yields knowledge
    - Confidentiality through obscurity
- Cryptography: “secret writing”
  - TASOIINRNPSTO and TVCTUJUVUJPO

Encryption used to scramble data



The Basics of Cryptography

- Two basic types of cryptography
  - TASONO PINSTIR
    - Message broken up into units
    - Units permuted in a seemingly random but reversible manner
    - Difficult to make it easily reversible only by intended receiver
    - Exhibits same first-order statistics

The Basics of Cryptography

- Two basic types of cryptography
  - TRANSPOSITION (TASONOPINSTIR)
    - Message broken up into units
    - Units permuted in a seemingly random but reversible manner
    - Difficult to make it easily reversible only by intended receiver
    - Exhibits same first-order statistics

The Basics (continued)

- Two basic types of cryptography (cont)
  - TVCTUJUVUJPO
    - Message broken up into units
    - Units mapped into ciphertext
      - Ex: Caesar cipher
    - First-order statistics are isomorphic in simplest cases
    - Predominant form of encryption

The Basics (continued)

- Two basic types of cryptography (cont)
  - Substitution (TVCTUJUVUJPO)
    - Message broken up into units
    - Units mapped into ciphertext
      - Ex: Caesar cipher
    - First-order statistics are isomorphic in simplest cases
    - Predominant form of encryption

How Much Security?

- Mono-alphabetic substitution cipher
  - Permutation on message units—letters
    - 26! different permutations
    - Each permutation considered a *key*
  - Key space contains 26! = 4×10^{26} keys
    - Equals number of atoms in gallon H_2O
    - Equivalent to a 88-bit key

How Much Security?

- So why not use substitution ciphers?
  - Hard to remember 26-letter keys
    - But we can restrict ourselves to shorter keys
    - Ex: JULISCAERBDFGHKM, etc
  - Remember: first-order statistics are isomorphic
    - Vulnerable to simple cryptanalysis
    - Hard-to-read fonts for crypto?!

Crypto-analytic Attacks

- Classified as:
  - Cipher text only
    - Adversary sees only the ciphertext
  - Known plain text
    - May know some corresponding plaintext (e.g. Login:)
  - Chosen plaintext
    - Can ask to have text encrypted

Substitution Ciphers

- Two basic types
  - Symmetric-key (conventional)
    - Single key used for both encryption and decryption
    - Keys are typically short, because key space is densely filled
    - Ex: AES, DES, 3DES, RC4, Blowfish, IDEA, etc

Substitution Ciphers

- Two basic types (cont)
  - Public-key (asymmetric)
    - Two keys: one for encryption, one for decryption
    - Keys are typically long, because key space is sparsely filled
    - Ex: RSA, El Gamal, DSA, etc

One Time Pads

- For confidentiality, One Time Pad provably secure.
  - Generate truly random key stream size of data to be encrypted.
  - Encrypt: Xor plaintext with the keystream.
  - Decrypt: Xor again with keystream.
- Weak for integrity
  - 1 bit changed in cipher text causes corresponding bit to flip in plaintext.
- Key size makes key management difficult
  - If key reused, the cipher is broken.
  - If key pseudorandom, no longer provably secure
  - Beware of claims of small keys but as secure as one time pad – such claims are wrong.

Block vs. Stream: Block

- Block ciphers encrypt message in units called blocks
  - E.g. DES: 8-byte key (56 key bits), 8-byte block
  - AES (discussed later) is also a block cipher.
  - Larger blocks make simple cryptanalysis useless (at least for short messages)
    - Not enough samples for valid statistics
    - 8 byte blocks common
    - But can still tell if something is the same.

Key and Block Size

- Do larger keys make sense for an 8-byte block?
  - 3DES: Key is 112 or 168 bits, but block is still 8 bytes long (64 bits)
  - Key space is larger than block space
  - But how large is permutation space?

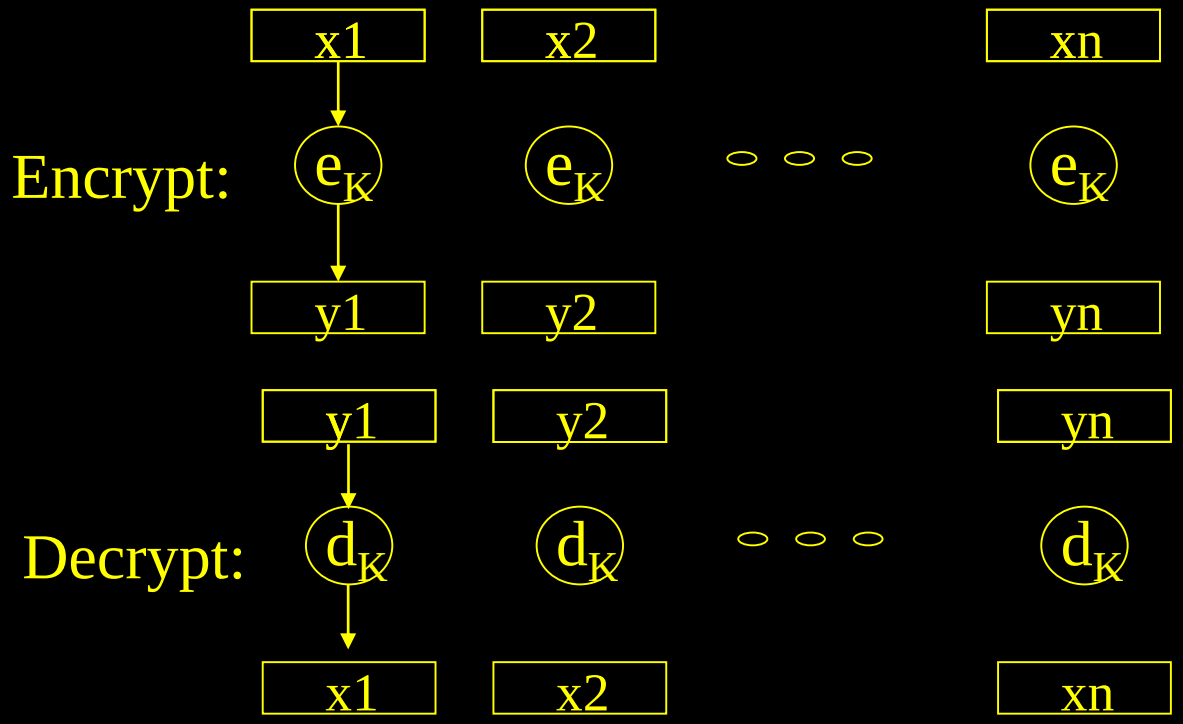
More on DES Internals

- More details on the internal operation of DES is covered in CSci531.
- But we cover Modes of Operation in this lecture since these modes are important to apply DES, and the same modes can be used for other block ciphers.

Block vs. Stream: Stream

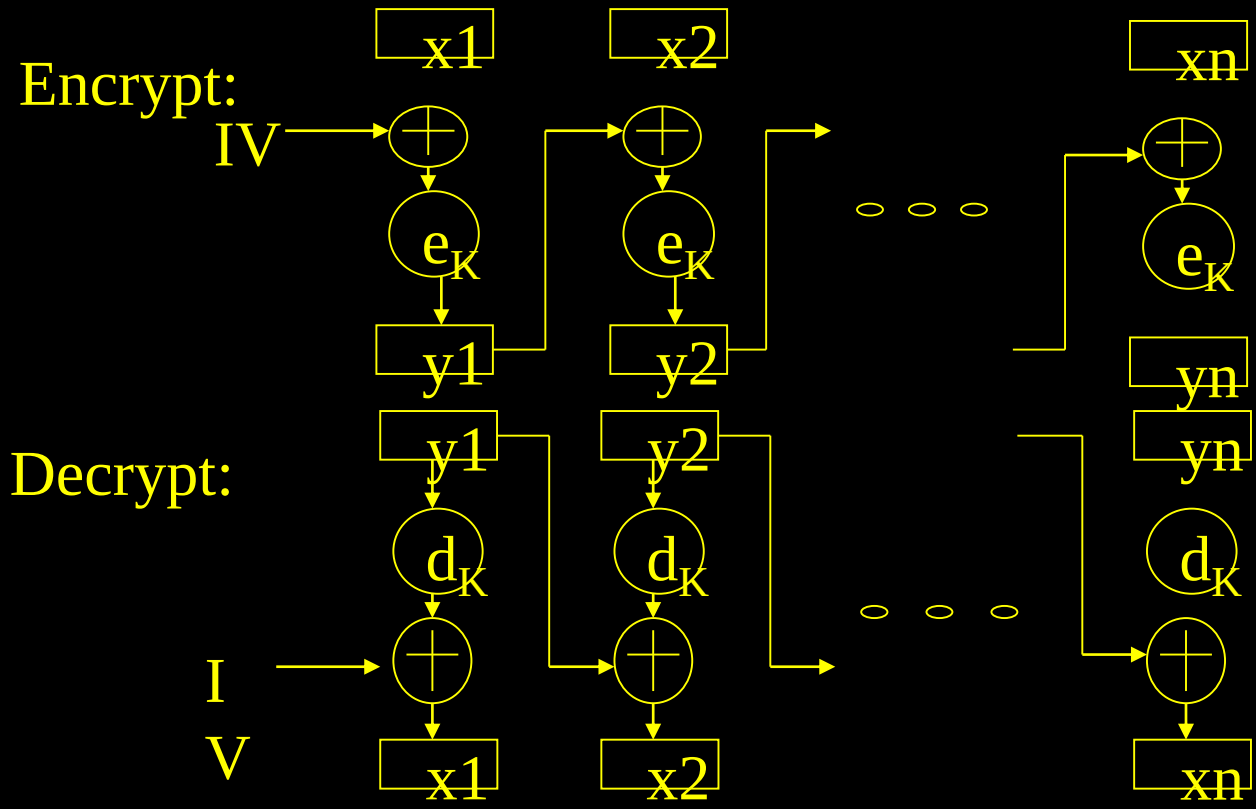
- Stream ciphers encrypt a bit, byte, or block at a time, but the transformation that is performed on a bit, byte, or block varies depending on position in the input stream and possibly the earlier blocks in the stream.
  - Identical plaintext block will yield a different cipher text block.
  - Makes cryptanalysis more difficult.
  - DES modes CBC, CFB, and OFB modes (discussed next) create stream ciphers from DES, which is a block cipher.
  - Similar modes available for AES.

DES Modes of Operation – Electronic Code Book (ECB)



- **Each block encrypted in isolation**
- **Vulnerable to block replay**

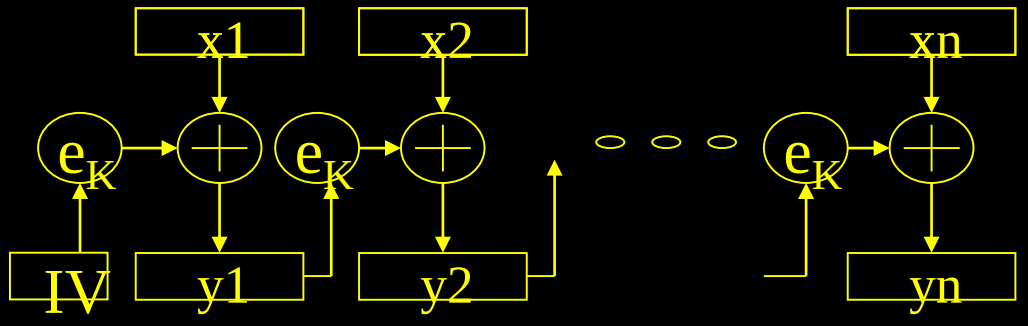
DES Modes of Operation – Cipher Block Chaining (CBC)



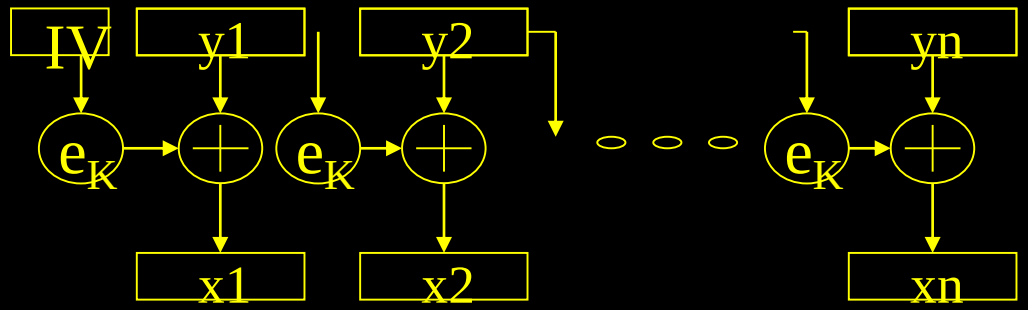
- **Each plaintext block XOR'd with previous ciphertext**
- **Easily incorporated into decryption**
- **What if prefix is always the same? IV!**

DES Modes of Operation – Cipher Feedback Mode (CFB)

Encrypt:

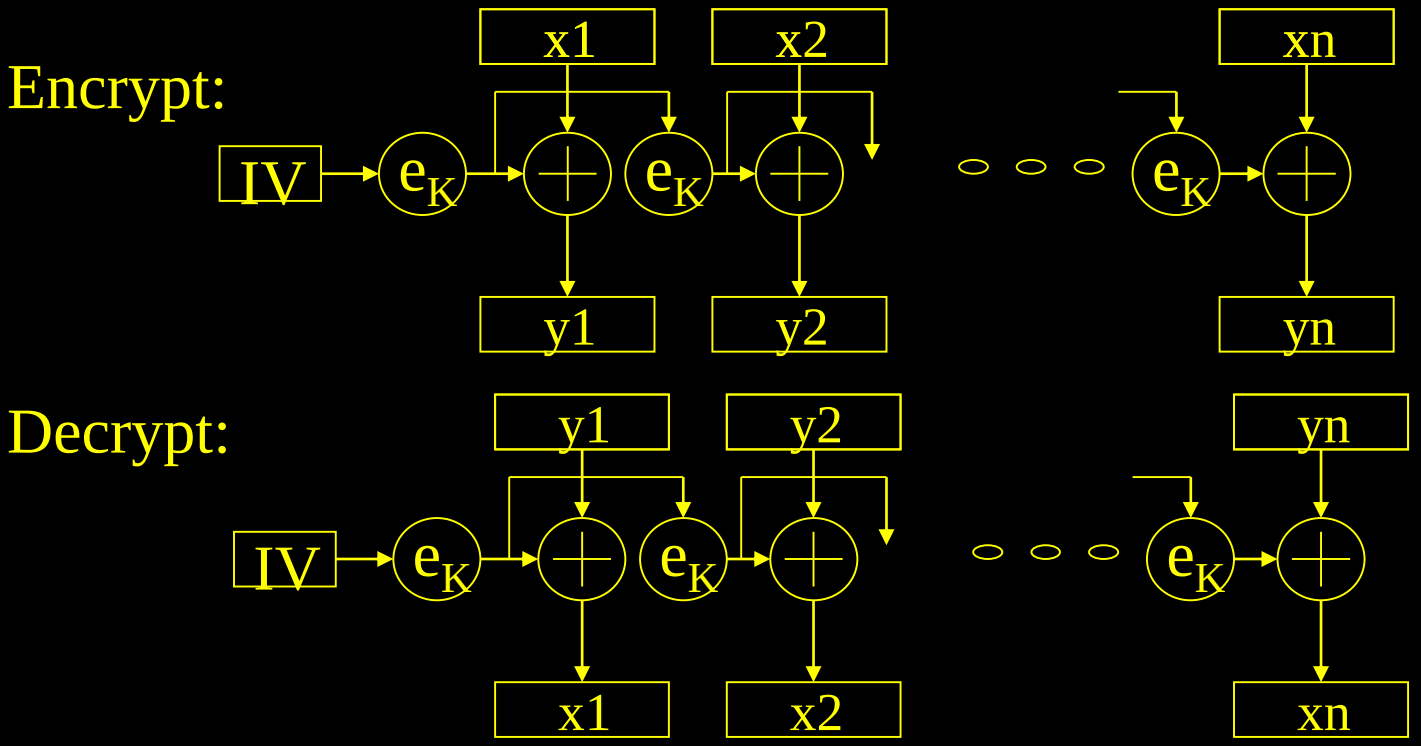


Decrypt:



- **For encrypting character-at-a-time (or less)**
- **Chains as in CBC**
- **Also needs an IV – Must be Unique – Why?**

DES Modes of Operation – Output Feedback Mode (OFB)



– Like CFB, but neither ciphertext nor plaintext is fed back to the input of the block encryption.

Variants and Applications

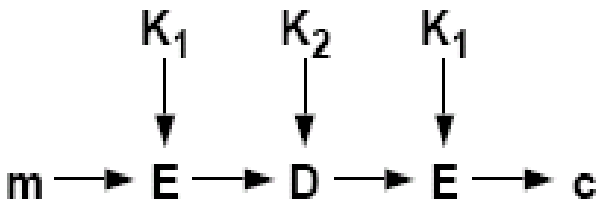
- 3DES: Encrypt using DES 3x
  - Two and three-key types
  - Inner and outer-CBC modes
- Crypt: Unix hash function for passwords
  - Uses variable expansion permutations
- DES with key-dependent S-boxes
  - Harder to analyze

3DES Using Two Keys

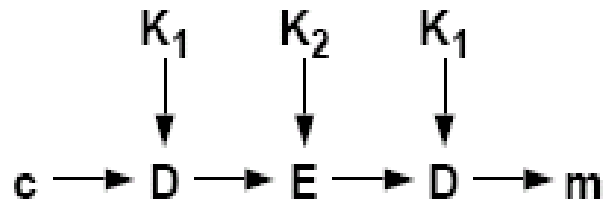
3DES: Encrypt using DES 3x

- two and three-key types

encryption:

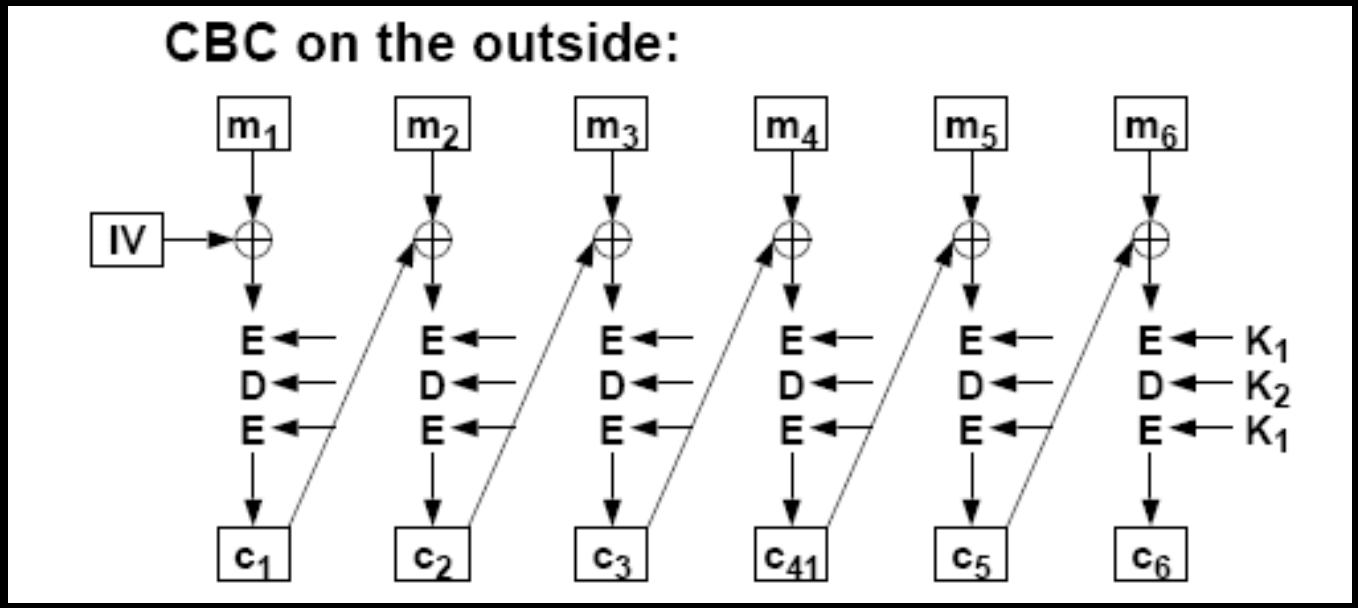


decryption:



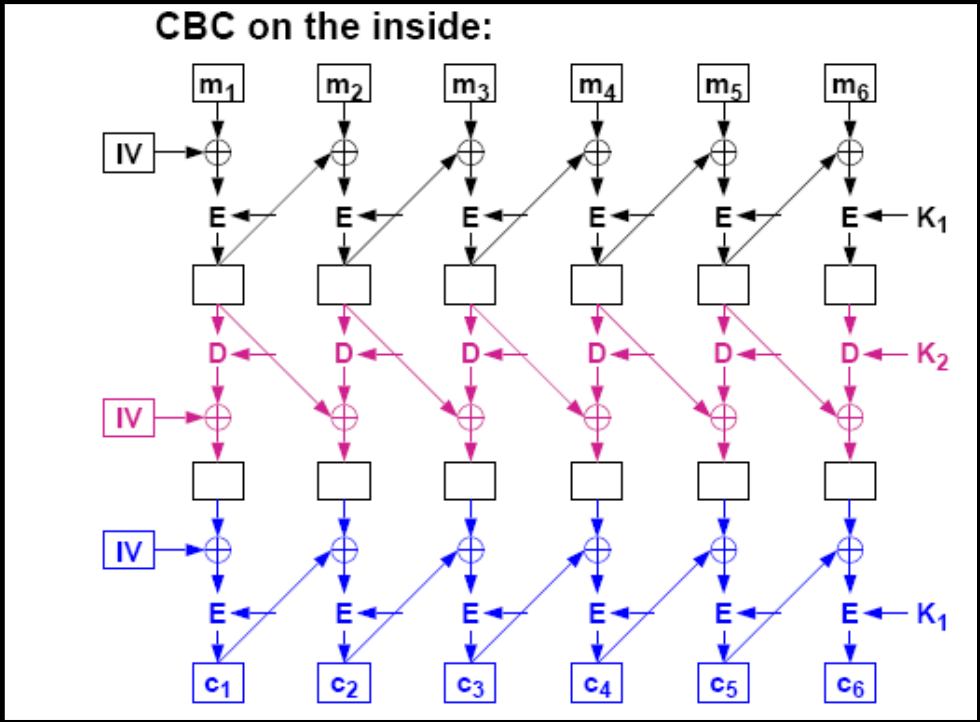
- Can use K1,K2,K3, or K1,K2,K1, or K1,K1,K1
- Figure courtesy William Cheng

3DES Outer CBC



- Figure courtesy William Cheng

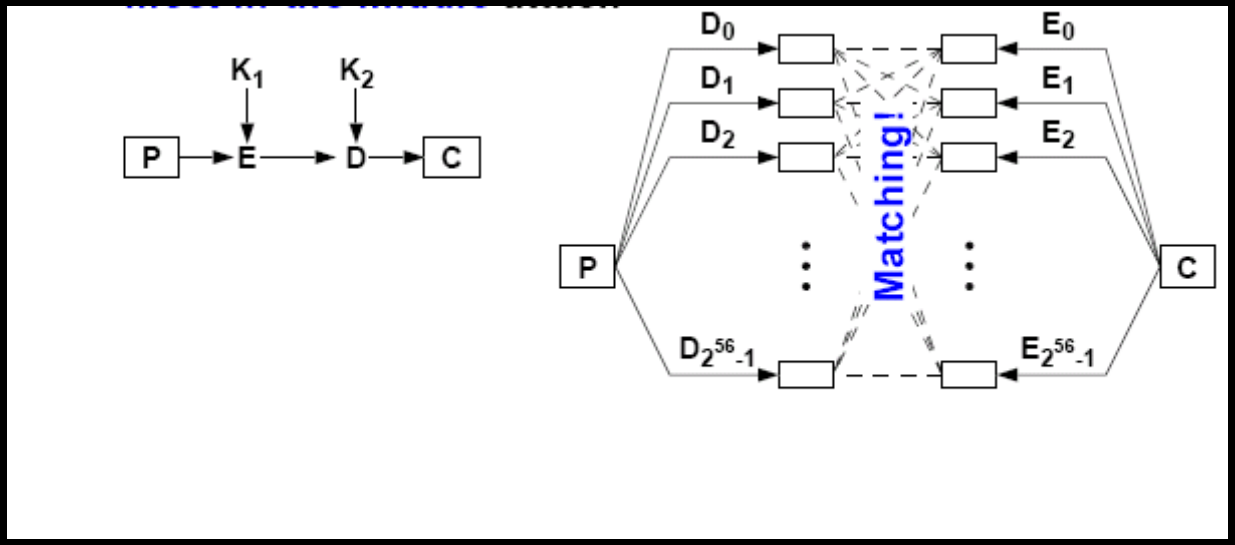
3DES Inner CBC



- Inner is more efficient, but less secure
  - More efficient due to ability to pipeline implementation
  - Weaker for many kinds of attacks

- Figure courtesy William Cheng

Why not Two Round



- Meet in middle attack makes it not much better than single DES.

- Figure courtesy William Cheng

Certification of DES

- Had to be recertified every ~5 years
  - 1983: Recertified routinely
  - 1987: Recertified after NSA tried to promote secret replacement algorithms
    - Withdrawal would mean lack of protection
    - Lots of systems then using DES
  - 1993: Recertified after continued lack of alternative

Enter AES

- 1998: NIST finally refuses to recertify DES
  - 1997: Call for candidates for Advanced Encryption Standard (AES)
  - Fifteen candidates whittled down to five
  - Criteria: Security, but also efficiency
    - Compare Rijndael with Serpent
    - 9/11/13 rounds vs 32 (breakable at 7)
  - 2000: Rijndael selected as AES

Structure of Rijndael

- Unlike DES, operates on whole bytes for efficiency of software implementations
- Key sizes: 128/192/256 bits
- Variable rounds: 9/11/13 rounds
- More details on structure in the applied cryptography class.

Security of Rijndael

- Key size is enough
- Immune to linear or differential analysis
- But Rijndael is a very structured cipher
- Attack on Rijndael's algebraic structure
  - Breaking can be modeled as equations

Impact of Attacks on Rijndael

- Currently of theoretical interest only
  - Reduces complexity of attack to about 2^{100}
  - Also applicable to Serpent
- Still, uncomfortably close to feasibility
  - DES is already insecure against brute force
  - Schneier (somewhat arbitrarily) sets limit at 2^{80}
- Certainly usable pending further results

Public Key Cryptography

- aka asymmetric cryptography
- Based on some NP-complete problem
  - Unique factorization
  - Discrete logarithms
    - For any b, n, y: Find x such that $b^x \bmod n = y$
- Modular arithmetic produces folding

A Short Note on Primes

- Why are public keys (and private keys) so large?
- What is the probability that some large number p is prime?
  - About 1 in 1/ln(p)
  - When p ~ 2^{512}, equals about 1 in 355
    - About 1 in 355^2 numbers ~ 2^{1024} is product of two primes (and therefore valid RSA modulo)

RSA

- Rivest, Shamir, Adleman
- Generate two primes: p, q
  - Let n = pq
  - Choose e, a small number, relatively prime to (p-1)(q-1)
  - Choose d such that ed = 1 mod (p-1)(q-1)
- Then, $c = m^e \bmod n$ and $m = c^d \bmod n$

An Example

- Let p = 5, q = 11, e = 3
  - Then n = 55
  - d = 27, since (3)(27) mod 40 = 1
- If m = 7, then c = 7^3 mod 55 = 343 mod 55 = 13
- Then m should = 13^{27} mod 55

An Example

- Computing 13^{27} mod 55
  - 13^1 mod 55 = 13, 13^2 mod 55 = 4, 13^4 mod 55 = 16, 13^8 mod 55 = 36, 13^{16} mod 55 = 31
  - 13^{27} mod 55 = (13)(4)(36)(31) mod 55 = (1872 mod 55)(31) mod 55 = 62 mod 55 = 7 (check)

Other Public Cryptosystems

- ElGamal (signature, encryption)
  - Choose a prime p, a generator < p
  - Choose a random number x < p
  - Public key is g, p, and $y = g^x \bmod p$
  - Private key is x; to obtain from public key requires extracting discrete log
  - Mostly used for signatures

Other Public Cryptosystems

- Elliptic curve cryptosystems
  - $y^2 = x^3 + ax^2 + bx + c$
  - Continuous elliptic curves used in FLT proof
  - Discrete elliptic curves used to implement existing public-key systems
    - Allow for shorter keys and greater efficiency

Importance of ECC

- There has been rapid progress in cryptanalysis of RSA and Diffie-Hellman public key systems.

  http://www.technewsdaily.com/18662-internet-security-cryptopalypse.html

- ECC is based on different mathematics, which has been shown to be NP complete.

Hash Functions

- Given m, compute H(m)
- Should be…
  - Efficient: H() easy to compute
  - One-way: Given H(m), hard to find m' such that H(m') = H(m)
  - Collision-resistant: Hard to find m and m' such that H(m') = H(m)

Digital Signatures

- Provides data integrity
  - Can it be done with symmetric systems?
    - Verification requires shared key
    - Doesn't provide non-repudiation
- Need proof of provenance
  - Hash the data, encrypt with *private* key
  - Verification uses public key to decrypt hash
  - Provides "non-repudiation"
    - But what does non-repudiation really mean?

Digital Signatures

- RSA can be used
- DSA: Digital Signature Algorithm
  - Variant of ElGamal signature
  - Adopted as part of DSS by NIST in 1994
  - Slower than RSA (but likely unimportant)
  - NSA had a hand in its design (?!)
  - Key size ranges from 512 to 1024 bits
  - Royalty-free

Cryptography in Use

- Provides foundation for security services
  - Provides confidentiality
  - Validates integrity
  - Provides data origin authentication
  - If we know the key
- Where does the key come from
  - Straightforward plan
    - One side generates key
    - Transmits key to other side
    - But how?

CSci530: Security Systems

Lecture 3 – September 13, 2024

Key Management

Dr. Clifford Neuman
University of Southern California
Information Sciences Institute

http://ccss.usc.edu/530

Key Management

- Key management is where much security weakness lies
  - Choosing keys
  - Storing keys
  - Communicating keys

What to do with keys

- Practical issues
  - How to carry them
    - Passwords vs. disks vs. smartcards
  - Where do they stay, where do they go
  - How many do you have
  - How do you get them to begin with.

Relevant News: It is Easier to do it wrong

Internet of Sins: Million more devices sharing known private keys for HTTPS, SSH admin – The Register September 7, 2016.

Millions of internet-facing devices – from home broadband routers to industrial equipment – are still sharing well-known private keys for encrypting their communications.

This is according to research from SEC Consult, which said in a follow-up to its 2015 study on security in embedded systems that the practice of reusing widely known secrets is continuing unabated.

Devices and gadgets are still sharing private keys for their builtin HTTPS and SSH servers, basically. It is not difficult to extract these keys from the gizmos and use them to eavesdrop on encrypted connections and interfere with the equipment: imagine intercepting a connection to a web-based control panel, decrypting it, and altering the configuration settings on the fly. And because so many models and products are using the same keys, it's possible to attack thousands of boxes at once.

Bootstrapping Security

- Exchange the key in person
  - Can exchange key before it is needed.
  - Could be a password.
- Hide the key in something else
  - Steganography, fairly weak
- Armored courier
  - If all else fails
- Send key over the net encrypted
  - But, using what key (bootstrap)

Diffie-Hellman Key Exchange (1)

- Choose large prime n, and generator g
  - For any b in (1, n-1), there exists an a such that $g^a = b$. This means that every number mod p can be written as a power of g (mod p).
    - To find such a g, pick the p such that p = 2q + 1 where q is also prime.
    - For such choices of p, half the numbers will be generators, and you can test if a candidate g is a generator by testing whether g^q (mod n) is equal to n-1.

Diffie-Hellman Key Exchange (2)

- Alice, Bob select secret values x, y
- Alice sends $X = g^x \bmod n$
- Bob sends $Y = g^y \bmod n$
- Both compute $g^{xy} \bmod n$, a shared secret
  - Can be used as keying material

Key Exchange (phrased differently)

- Diffie-Hellman key exchange
  - Choose large prime n, and generator g
    - For any b in (1, n-1), there exists an a such that $g^a = b$
  - Alice, Bob select secret values x, y, resp
  - Alice sends $X = g^x \bmod n$
  - Bob sends $Y = g^y \bmod n$
  - Both compute $g^{xy} \bmod n$, a shared secret
    - Can be used as keying material

Man in the middle of DH

- DH provides key exchange, but not authentication
  - You don't really know you have a secure channel
- Man in the middle
  - You exchange a key with eavesdropper, who exchanges key with the person you think you are talking to.
  - Eavesdropper relays all messages, but observes or changes them in transit.
- Solutions:
  - Published public values
  - Authenticated DH (Sign or encrypt DH value)
  - Encrypt the DH exchange
  - Subsequently send hash of DH value, with secret

Two Cases so Far

- Can exchange a key with anyone, but you don't know who you are talking with.
- Can exchange keys with known parties in advance, but are limited to communication with just those parties.

Peer-to-Peer Key Distribution

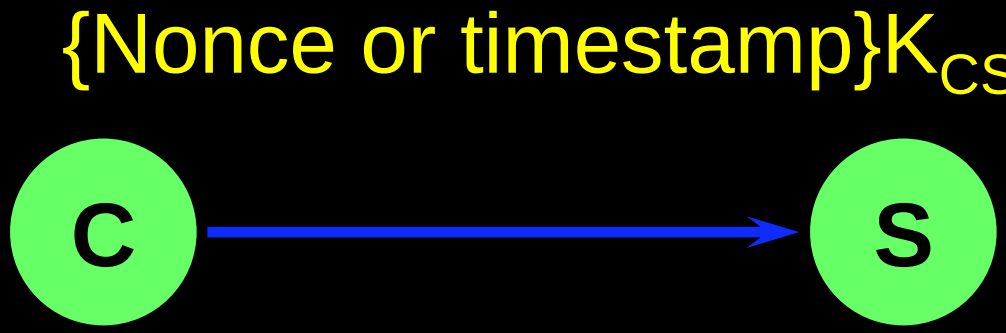
- Technically easy
  - Distribute keys in person
- But it doesn't scale
  - Hundreds of servers…
  - Times thousands of users…
  - Yields ~ million keys

Incremental Key Distribution

- Build toward Needham-Schroeder and Kerberos mechanisms
- Key-distribution tied to authentication.
  - If you know who you share a key with, authentication is easy.
  - You want to know who has the key, not just that anyone has it.

But first a look forward – Encryption Based Authentication

- Proving knowledge of encryption key
  - Nonce = Non repeating value



But where does K_{cs} come from?

That is the subject of Key Distribution/Management

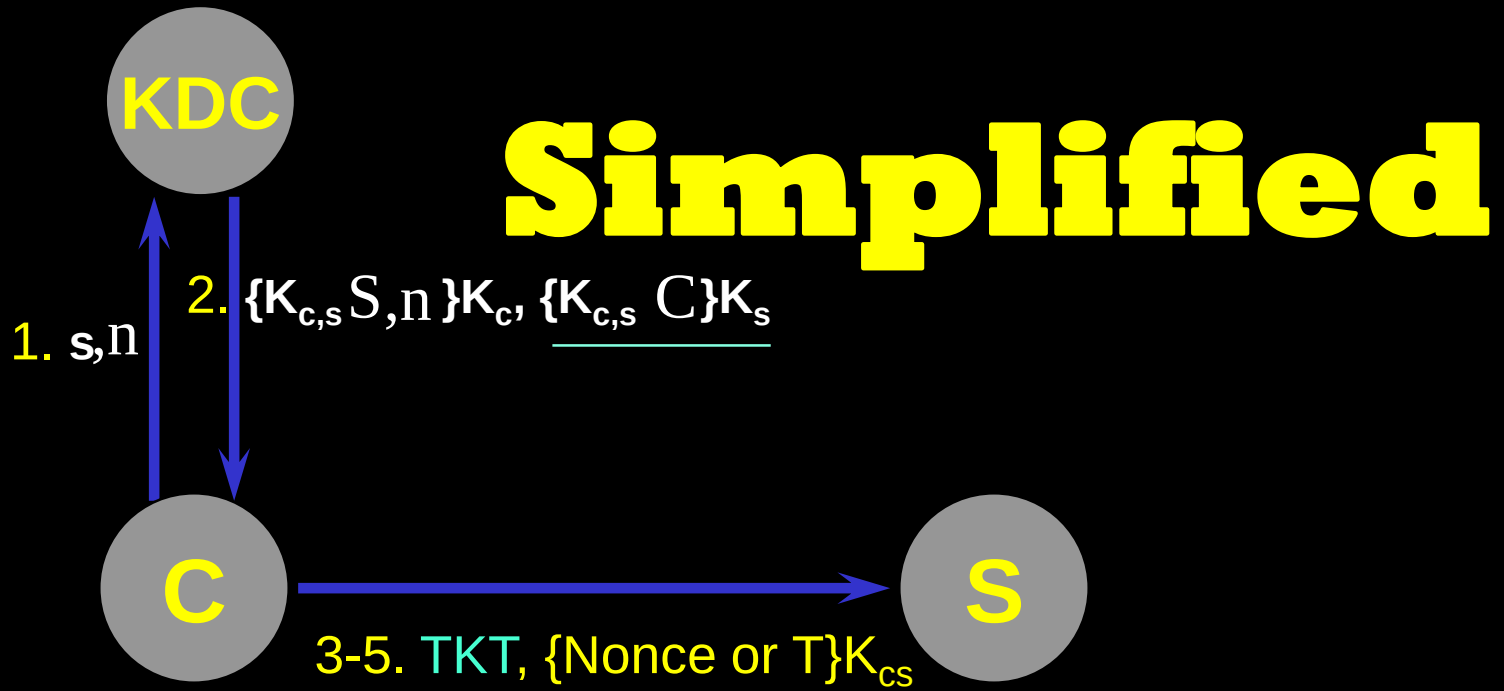
KDC Based Key Distribution

As used in both Needham Schroeder and Kerberos we will use Kerberos terminology

- User sends request to KDC: {s}
- KDC generates a random key: $K_{c,s}$
  - Encrypted twice: $\{K_{c,s...}\}K_c$, $\{K_{c,s...}\}K_s$
  - $\{K_{c,s...}\}K_s$ called ticket
  - Ticket plus $K_{c,s}$ called credentials
  - Ticket is opaque and forwarded with application request
- No keys ever traverse net in the clear

Kerberos or Needham Schroeder

- Third-party authentication service
  - Distributes session keys for authentication, confidentiality, and integrity



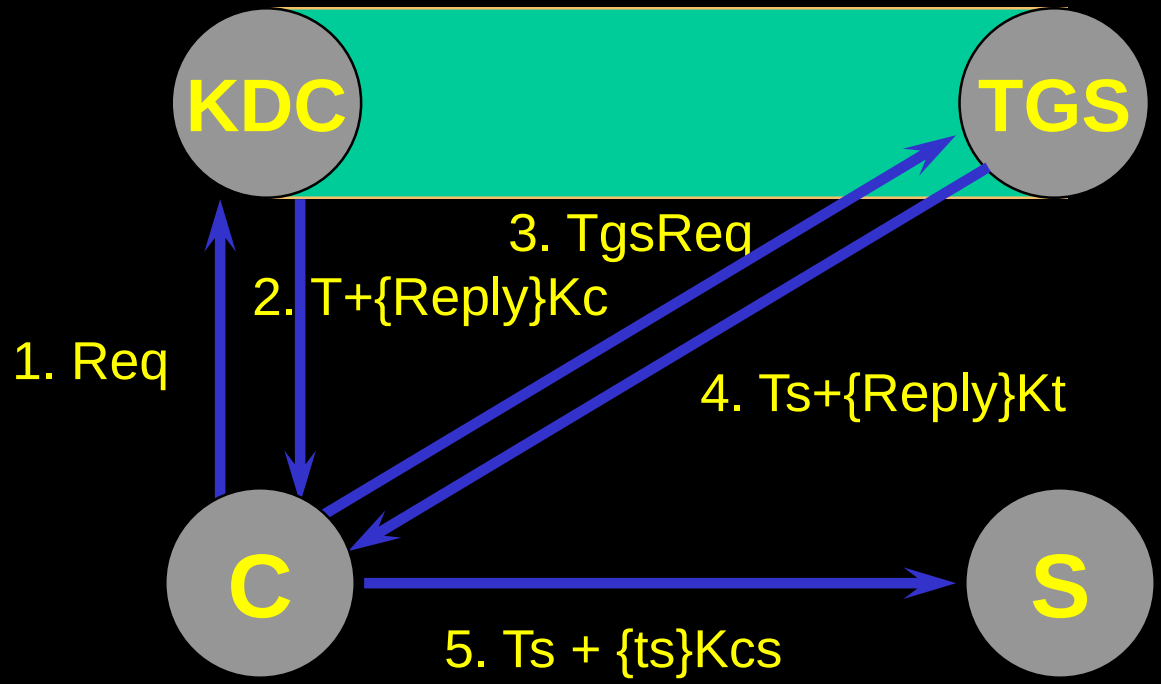
Reduce User Key Exposure

- Introduce Ticket Granting Server (TGS)
  - Daily ticket plus session keys
- TGS+AS = KDC
  - This is modified Needham-Schroeder
  - Basis for Kerberos
- Pre-authentication
- Note: not a full solution
  - Makes it slightly harder for adversary.

Kerberos

Third-party authentication service

- **Distributes session keys for authentication, confidentiality, and integrity**



Key Distribution linked to Authentication

- Its all about knowing who has the keys.
- Authentication is really a topic for next lecture, but the tight linkage with key management is the reason that we covered the Kerberos authentication system in the past few slides.

Public Key Distribution

- Public key can be public!
  - How does either side know who and what the key is for? Private agreement? (Not scalable.)
- Does this solve key distribution problem?
  - No – while confidentiality is not required, integrity is.
- Still need trusted third party

Key Management

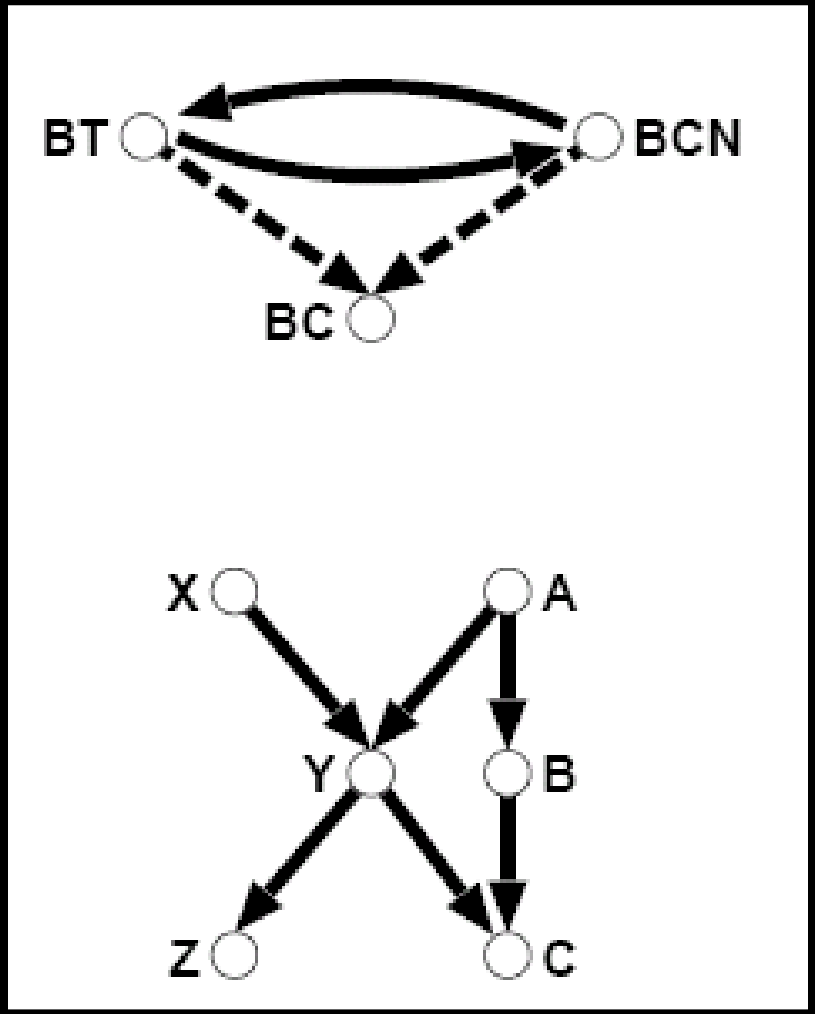
- Key management is where much security weakness lies
  - Choosing keys
  - Storing keys
  - Communicating keys

Certification Infrastructures

- Public keys represented by certificates
- Certificates signed by other certificates
  - User delegates trust to trusted certificates
  - Certificate chains transfer trust up several links

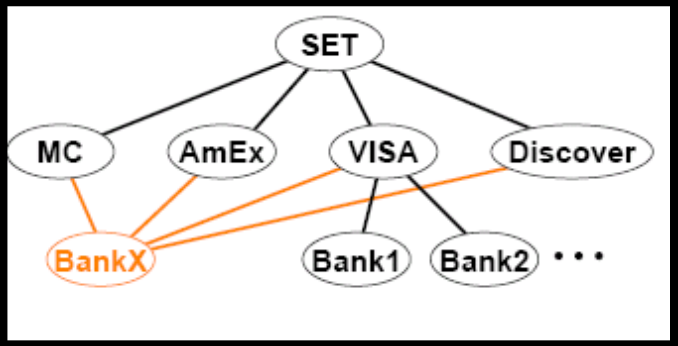
Examples

- PGP
  - "Web of Trust"
  - Can model as connected digraph of signers
- X.500
  - Hierarchical model: tree (or DAG?)
  - (But X.509 certificates use ASN.1!)



Examples

- SSH
  - User keys out of band exchange.
  - Weak assurance of server keys.
    - Was the same host you spoke with last time.
  - Discussion of benefits
- SET
  - Hierarchical
  - Multiple roots
  - Key splitting



Key Distribution

- Conventional cryptography
  - Single key shared by both parties
- Public Key cryptography
  - Public key published to the world
  - Private key known only by owner
- Third party certifies or distributes keys
  - Certification infrastructure
  - Authentication

Recovery from exposed keys

- Revocation lists (CRL's)
  - Long lists
  - Hard to propogate
- Lifetime / Expiration
  - Short life allows assurance of validitiy at time of issue.
- Realtime validation
  - Online Certificate Status Protocol (OCSP)
- What about existing messages?

Practical use of keys

- Email (PEM or S/MIME or PGP)
  - Hashes and message keys to be distributed and signed.
- Conferencing
  - Group key management (discussed later)
- Authentication (next lecture)
- SSL
  - And other “real time” protocols
  - Key establishment

Key Management Overview

- Key size vs. data size
  - Affects security and usability
- Reuse of keys
  - Multiple users, multiple messages
- Initial exchange
  - The bootstrap/registration problem
  - Confidentiality vs. authentication

Key Management Review

- KDC's
  - Generate and distribute keys
  - Bind names to shared keys

Key Management Overview

- Who needs strong secrets anyway
  - Users?
  - Servers?
  - The Security System?
  - Software?
  - End Systems?
- Secret vs. Public

Group Key Management

- Group key vs. Individual key
  - Identifies member of groups vs. which member of group
  - PK slower but allows multiple verification of individuals

Group Key Management Issues

- Revoking access
  - Change messages, keys, redistribute
- Joining and leaving groups
  - Does one see old message on join
  - How to revoke access
- Performance issues
  - Hierarchy to reduce number of envelopes for very large systems
  - Hot research topic

Group Key Management Approaches

- Centralized
  - Single entity issues keys
  - Optimization to reduce traffic for large groups
  - May utilize application specific knowledges
- Decentralized
  - Employs sub managers
- Distributed
  - Members do key generation
  - May involve group contributions

Look Forward
Security Architectures

- DSSA
  - Delegation is the important issue
    - Workstation can act as user
    - Software can act as workstation
      - if given key
    - Software can act as developer
      - if checksum validated
  - Complete chain needed to assume authority
  - Roles provide limits on authority – new sub-principal

CSci530: Security Systems

Lectures 4&5 September 20 and 27, 2024

Authentication

Dr. Clifford Neuman
University of Southern California
Information Sciences Institute

Identification vs. Authentication

- **Identification**
  - Associating an identity with an individual, process, or request
- **Authentication**
  - Verifying a claimed identity

Basis for Authentication

- Ideally
  - Who you are
- Practically
  - Something you know
  - Something you have
  - Something about you
    - (Sometimes mistakenly called things you are)

Something you know

Password or Algorithm

- e.g. encryption key derived from password

Issues

- Someone else may learn it
  - Find it, sniff it, trick you into providing it
- Other party must know how to check
- You must remember it
- How stored and checked by verifier

Examples of Password Systems

- Verifier knows password
- Encrypted Password
  - One way encryption
- Third Party Validation

Attacks on Passwords

- Brute force
- Dictionary
- Pre-computed Dictionary
- Guessing
- Finding elsewhere

General Problems with Password

- Space from which passwords Chosen
  - Too many passwords
    - And what it leads to
  - Too few passwords
    - i.e. password re-use
- That you need to present the password to use it
  - Compromise of verifier affects password.

What makes for a good password

How some systems define good passwords:

- MickeyMinniePlutoHueyLouieDewey
- DonaldGoofyWashington

Other attacks on passwords

- Social Engineering attacks
  - Including Phishing

Recent News

- Phishing is now (and has been) an automated process.
- Discussion:
  - Why we need to move away from passwords.
- What are the effective alternatives.

Something you Have

- Cards
  - Mag stripe (= password)
  - Smart card, USB key
  - Time varying password
- Issues
  - How to validate
  - How to read (i.e. infrastructure)

Case Study – RSA SecureID

Claimed - Something You Have

- Reduced to something they know

How it works:

- Seed
- Synchronization

Compromises:

- RSA Break-in
- Or man in the middle

Something about you

- Biometrics
  - Measures some physical attribute
    - Iris scan
    - Fingerprint
    - Picture
    - Voice
- Issues
  - How to prevent spoofing
    - Suited when biometric device is trusted, not suited otherwise

Other forms of authentication

IP Address

Caller ID (or call back)

Now “phone factor” (probably tm)

Past transaction information

(second example of something you know)

“Enrollment”

How to initially exchange the secret.

- In person enrollment
- Information known in advance
- Third party verification
- Mail or email verification

Multi-factor authentication

Require at least two of the classes above.

- e.g. Smart card plus PIN
- RSA SecurID plus password (AOL)
- Biometric and password

Issues

- Better than one factor
- Be careful about how the second factor is validated. E.g. on card, or on remote system.

CSci530: Security Systems

Lectures 5 – September 27, 2024

Authentication

Dr. Clifford Neuman
University of Southern California
Information Sciences Institute

Single Sign On

"Users should log in once

And have access to everything"

Many systems store password lists

Which are easily stolen

Better is encryption based credentials

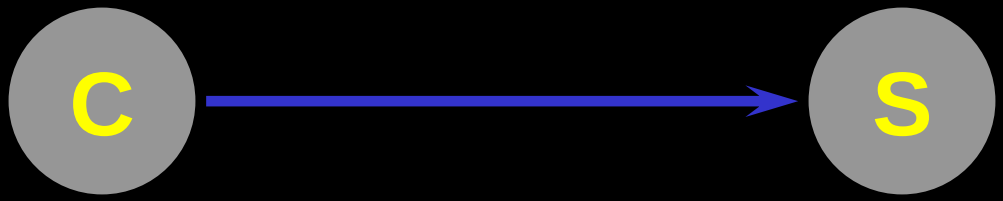
Usable with multiple verifiers

Interoperability is complicating factor.

Encryption Based Authentication

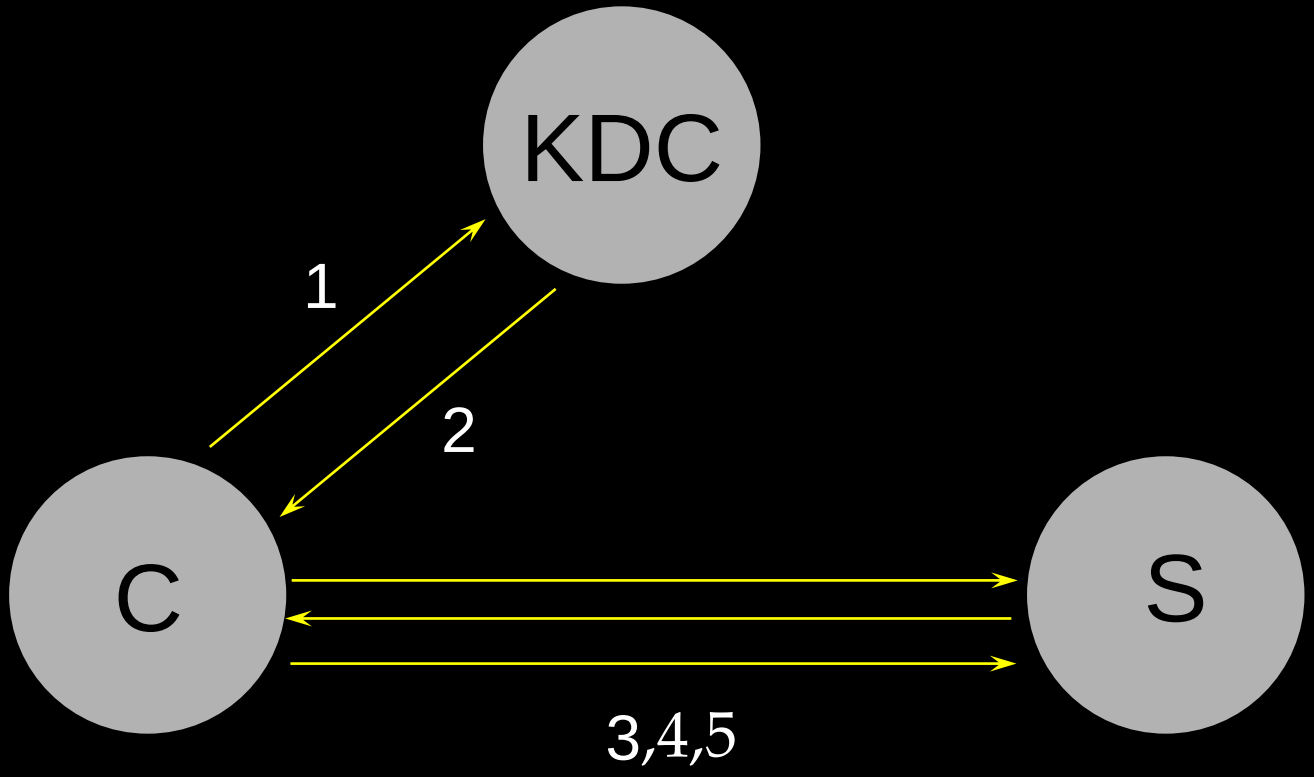
- Proving knowledge of encryption key
  - Nonce = Non repeating value

{Nonce or timestamp}K_{cs}



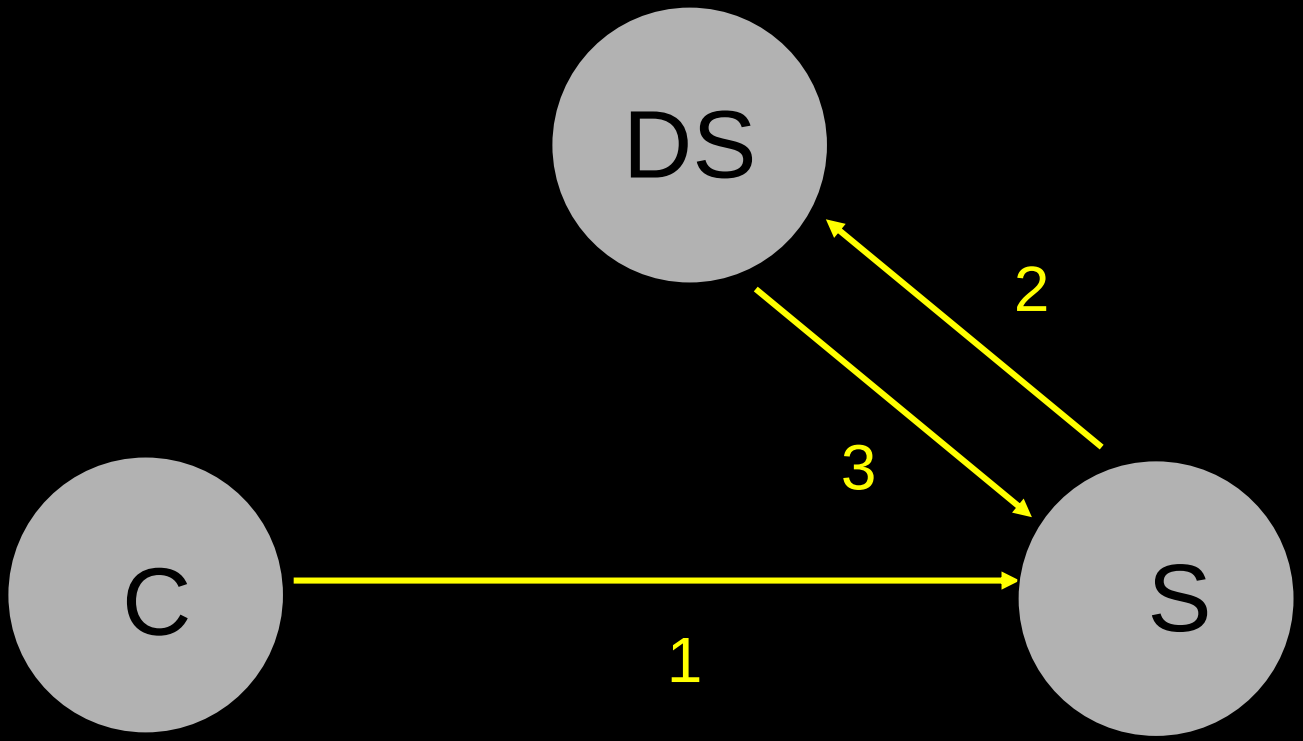
Authentication w/ Conventional Crypto

- Kerberos or Needham Schroeder



Authentication w/ PK Crypto

- Based on public key certificates



Public Key Cryptography (revisited)

- Key Distribution
  - Confidentiality not needed for public key
  - Solves n^2 problem
- Performance
  - Slower than conventional cryptography
  - Implementations use for key distribution, then use conventional crypto for data encryption
- Trusted third party still needed
  - To certify public key
  - To manage revocation
  - In some cases, third party may be off-line

Certificate-Based Authentication

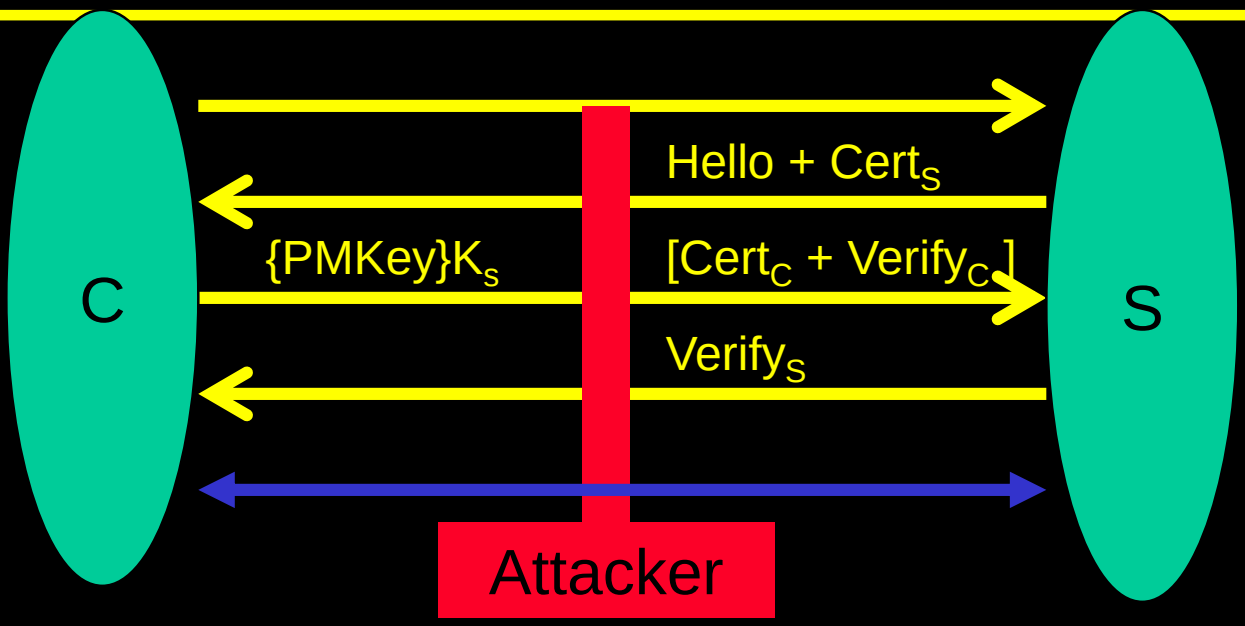
- Certification authorities issue signed certificates
  - Banks, companies, & organizations like Verisign act as CA's
  - Certificates bind a public key to the name of a user
  - Public key of CA certified by higher-level CA's
  - Root CA public keys configured in browsers & other software
  - Certificates provide key distribution

Certificate-Based Authentication (2)

Authentication steps

- Verifier provides nonce, or a timestamp is used instead.
- Principal selects session key and sends it to verifier with nonce, encrypted with principal's private key and verifier's public key, and possibly with principal's certificate
- Verifier checks signature on nonce, and validates certificate.

Secure Sockets Layer (and TLS)



Encryption support provided between
Browser and web server - below HTTP layer
Client checks server certificate
Works as long as client starts with the correct URL
Key distribution supported through cert steps
Authentication provided by verify steps

Trust models for certification

- X.509 Hierarchical
  - Single root (original plan)
  - Multi-root (better accepted)
  - SET has banks as CA's and common SET root
- PGP Model
  - "Friends and Family approach" - S. Kent
- Other representations for certifications
- No certificates at all
  - Out of band key distribution
  - SSH

Federated Identity
Passport v Liberty Alliance

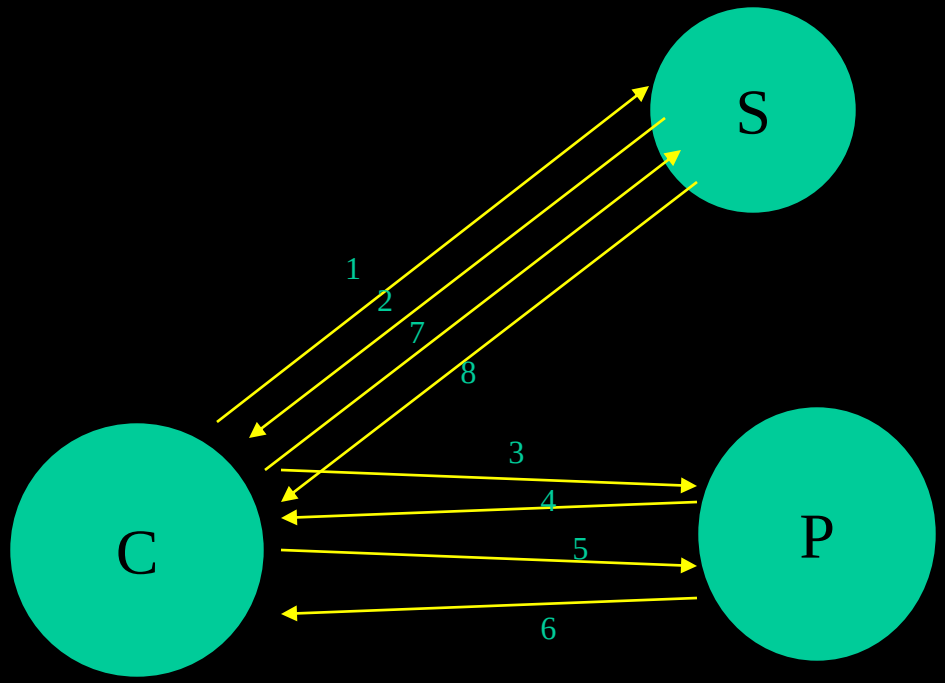
- Two versions of Passport
  - Current deployed version has lots of weaknesses and is centralized
  - Version under development is "federated" and based on Kerberos

Liberty Alliance

  - Loosely federated with framework to describe authentication provided by others.

Passport v1

- Goal is single sign on
- Implemented via redirections



Assigned reading: http://avirubin.com/passport.html

Federated Passport

- Announced September 2001
- Multiple registrars
  - E.g. ISPs register own users
- Kerberos credentials
  - Embedded authorization data to pass other info to merchants.
- Federated Passport is predominantly vaporware today, but .net authentication may be where their federated model went.

Liberty Alliance

- Answer to MS federated Passport
- Design criteria was most of the issues addressed by Federated Passport, i.e. no central authority.
- Got off to slow start, but to date has produced more than passport has.
- Use SAML (Security Association Markup Language) to describe trust across authorities, and what assertions means from particular authorities.
- These are hard problems, and comes to the core of what has kept PKI from being as dominant as orginally envisioned.
- Phased approach: Single sign on, Web service, Federated Services Infrastrcture.

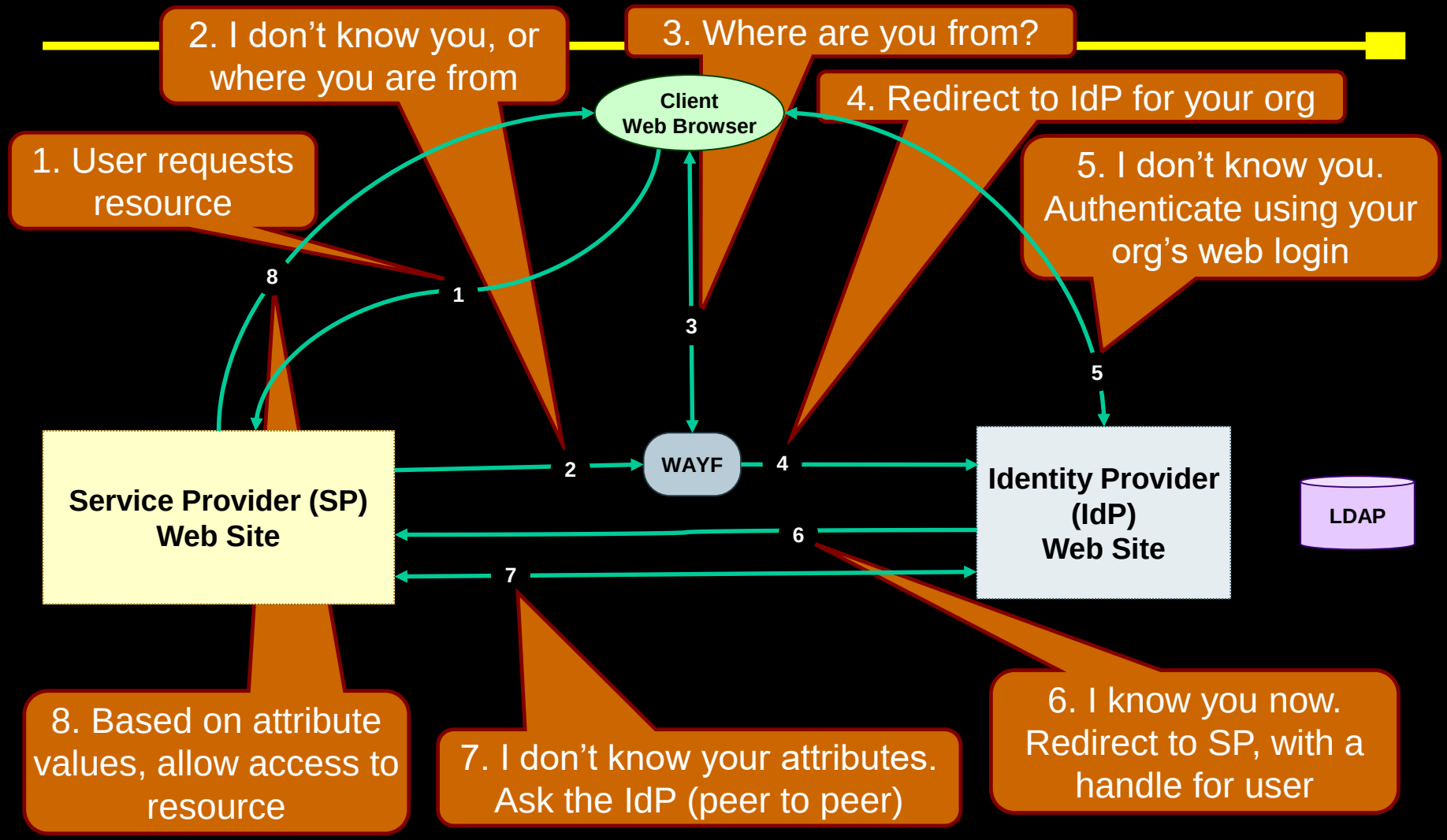
Federated Identity - Shibboleth

- Internet 2 Project
  - Federated Administration
  - Attribute Based Access Control
  - Active Management of Privacy
  - Based on Open SAML
  - Framework for Federation

Shibboleth - Architecture

- Service Provider
  - Browser goes to Resource Manager who users WAYF, and users Attribute Requester, and decides whether to grant access.
- Where are you from service
  - Redirects to correct servers
- Federation

The Shibboleth Protocol



Source: Kathryn Huxtable khuxtable@ku.edu 10 June 2005

Generic Security Services API
Moving up the Stack

- Standard interface for choosing among authentication methods
  - Once an application uses GSS-API, it can be changed to use a different authentication method easily.
  - Calls
    - Acquire and release cred
    - Manage security context
      - Init, accept, and process tokens
    - Wrap and unwrap

Authentication in Applications

- Unix login
- Telnet
- RSH
- SSH
- HTTP (Web browsing)
- FTP
- Windows login
- SMTP (Email)
- NFS
- Network Access

Unix Login

- One way encryption of password
  - Salted as defense against pre-computed dictionary attacks
  - To validate, encrypt and compare with stored encrypted password
  - May use shadow password file

Telnet

- A remote login application
  - Normally just an unencrypted channel over which plaintext password sent.
  - Supports encryption option and authentication options using protocols like Kerberos.

RSH (Remote Shell/Remote Login)

- Usually IP address and asserted account name.
  - Privileged port means accept asserted identity.
  - If not trusted, request unix password in clear.
- Kerberos based options available
  - Kerberos based authentication and optional encryption

Secure Shell (SSH)

- Encrypted channel with Unix login
  - Establish encrypted channel, using public key presented by server
  - Send password of user over channel
  - Unix login to validate password.
- Public key stored on target machine
  - User generate Public Private key pair, and uploads the public key to directory on target host.
  - Target host validates that corresponding private key is known.

Web Browsing (HTTP)

- Connect in the clear, Unix Password
- Connect through SSL, Unix password
- Digest authentication (RFC 2617)
  - Server sends nonce
  - Response is MD5 checksum of
    - Username, password, nonce URI
- User certificate, strong authentication

File Transfer Protocol

- Password based authentication or
- GSS-API based authentication
  - Including use of Kerberos
  - Authentication occurs and then stream is encrypted

Windows Network Login

- In Win2K and later uses Kerberos
- In Win NT
  - Challenge response
  - Server generates 8 byte nonce
  - Prompts for password and hashes it
  - Uses hash to DES encrypt nonce 3 times

Email

- SMTP – To send mail
  - Usually network address based
  - Can use password
  - Can be SSL protected
  - SMTP after POP

Email

- Post Office Protocol
  - Plaintext Password
  - Can be SSL protected
  - Eudora supports Kerberos authent
- IMAP
  - Password authentication
  - Can also support Kerberos

Email – Message Authentication

- PGP and S/MIME
  - Digital Signature on messages
    - Message encrypted in session key
      - Optional
    - Hash of message encrypted in private key
    - Validation using sender's public key

Email – Message Authentication

SPF and SenderID

- Authenticate domain of sender
- SPF record for domain in DNS
  - Specifies what hosts (i.e. mail server host) can send mail originating from that address.
  - Receivers may validate authorized sender based on record
  - Can falsely reject for forwarded messages

Email – Message Authentication

Domain Keys

- Public key associated with domain in DNS
- Originators MTA attaches signature
  - Authenticates senders domain
  - Not individual sender
  - Signature covers specific header fields and possibly part of message.
- Messages may be forwarded

File System Authentication

- Sun's Network File System
  - Typically address based
  - Athena Kerberized version
    - Maps authenticated UID's to addresses
  - NFS bult on ONC RPC
    - ONC RPC has stronger Kerberos/GSSAPI support

File System Authentication

- Andrew File System
  - Based on Andrew RPC
  - Uses Kerberos authentication
- OSF's DCE File System (DFS)
  - Based on DCE RPC
  - Uses Kerberos authenciation

Network Access Servers

- Radius
  - Problem: Not connected to network until connection established
  - Need for indirect authentication
    - Network access server must validate login with radius server.
    - Password sent to radius server encrypted using key between agent and radius server

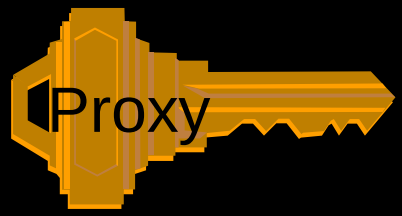
Delegated Authentication

- Usually an authorization problem
- How to allow an intermediary to perform operations on your behalf.
  - Pass credentials needed to authenticate yourself
  - Apply restrictions on what they may be used for.

Proxies

- A proxy allows a second principal to operate with the rights and privileges of the principal that issued the proxy
  - Existing authentication credentials
  - Too much privilege and too easily propagated
- Restricted Proxies
  - By placing conditions on the use of proxies, they form the basis of a flexible authorization mechanism

Restricted Proxies



- Two Kinds of proxies
  - Proxy key needed to exercise bearer proxy
  - Restrictions limit use of a delegate proxy
- Restrictions limit authorized operations
  - Individual objects
  - Additional conditions

- End of Lecture Authentication
- Following slides are start of lecture on Access Control and Policy

CSci530: Computer Security Systems
Lecture 6 – 4 October 2024
Authorization and Policy

Dr. Clifford Neuman
University of Southern California
Information Sciences Institute

Announcements

- Mid-term exam Friday October 6th
  - 100 minutes
    - Logistics: Start of Lecture Period
  - Review during this week's Afternoon Lab Instruction
    - Past exams posted on web site

Authorization

- Final goal of security
  - Determine whether to allow an operation.
- Depends upon
  - Policy
  - Possibly authentication
  - Other characteristics

The role of policy in security architecture

Policy – Defines what is allowed and how the system and security mechanisms should act.

Enforced By

Mechanism – Provides protection interprets/evaluates (firewalls, ID, access control, confidentiality, integrity)

Implemented as:

Software: which must be implemented correctly and according to sound software engineering principles.

Two Kinds of Policy

- Specific criteria evaluated by a system (reference monitor) to decide whether an action is permitted.
  - This will be the definition we use in most of this lecture.
- But also, statements and requirements imposed on the operation of a system, such as required security characteristics, etc.
  - Organization Policy
  - Public Policy

Policy: The Access Matrix

- Policy represented by an Access Matrix
  - Also called Access Control Matrix
  - One row per object
  - One column per subject
  - Tabulates permissions
  - But implemented by:
    - Row – Access Control List
    - Column – Capability List

Instantiations of ACMs

- Capabilities
  - For each principal, list objects and actions permitted for that principal
  - Corresponds to columns of ACM
  - Example: Kerberos restricted proxies
- The Unix file system is an example of…?

Problems

- Permissions may need to be determined dynamically
  - Time
  - System load
  - Relationship with other objects
  - Security status of host

Problems

- Distributed nature of systems may aggravate this
  - ACLs need to be replicated or centralized
  - Capabilities don't, but they're harder to revoke
- Approaches
  - GAA

Policy models: Bell-LaPadula

- Discretionary Policy
  - Based on Access Matrix
- Mandatory Policy
  - Top Secret, Secret, Confidential, Unclassified
  - * Property: S can write O if and only if Level S <= Level O
    - Write UP, Read DOWN
  - Categories treated as levels
    - Form a matrix

(more models later in the course)

Other Policy Models

- Mandatory Acces Control
  - Bell-Lepadula is an example
- Discretionary Access Control
  - Many examples
- Role Based Access Control
- Integrity Policies
  - Biba Model – Like BellLepadula but inverted
  - Clark Wilson
    - Constrained Data, IVP and TPs

Role Based Access Control

- Similar to groups in ACLs, but more general.
- Multiple phases
  - Administration
  - Session management
  - Access Control
- Roles of a user can change
  - Restrictions may limit holding multiple roles simultaneously or within a session, or over longer periods.
  - Supports separation of roles
- Maps to Organization Structure

Integrity Policies

- Biba Model – Like BellLepadula but inverted
- Clark Wilson
  - Constrained Data, IVP and TPs

Authorization Examples

- Access Matrix
- Access Control Lists
  - .htaccess (web servers)
  - Unix file access (in a limited sense)
    - On login lookup groups
  - SSH Authorized Keys
- Capabilities
  - Unix file descriptors
  - Proxies mix ACLs and capabilities

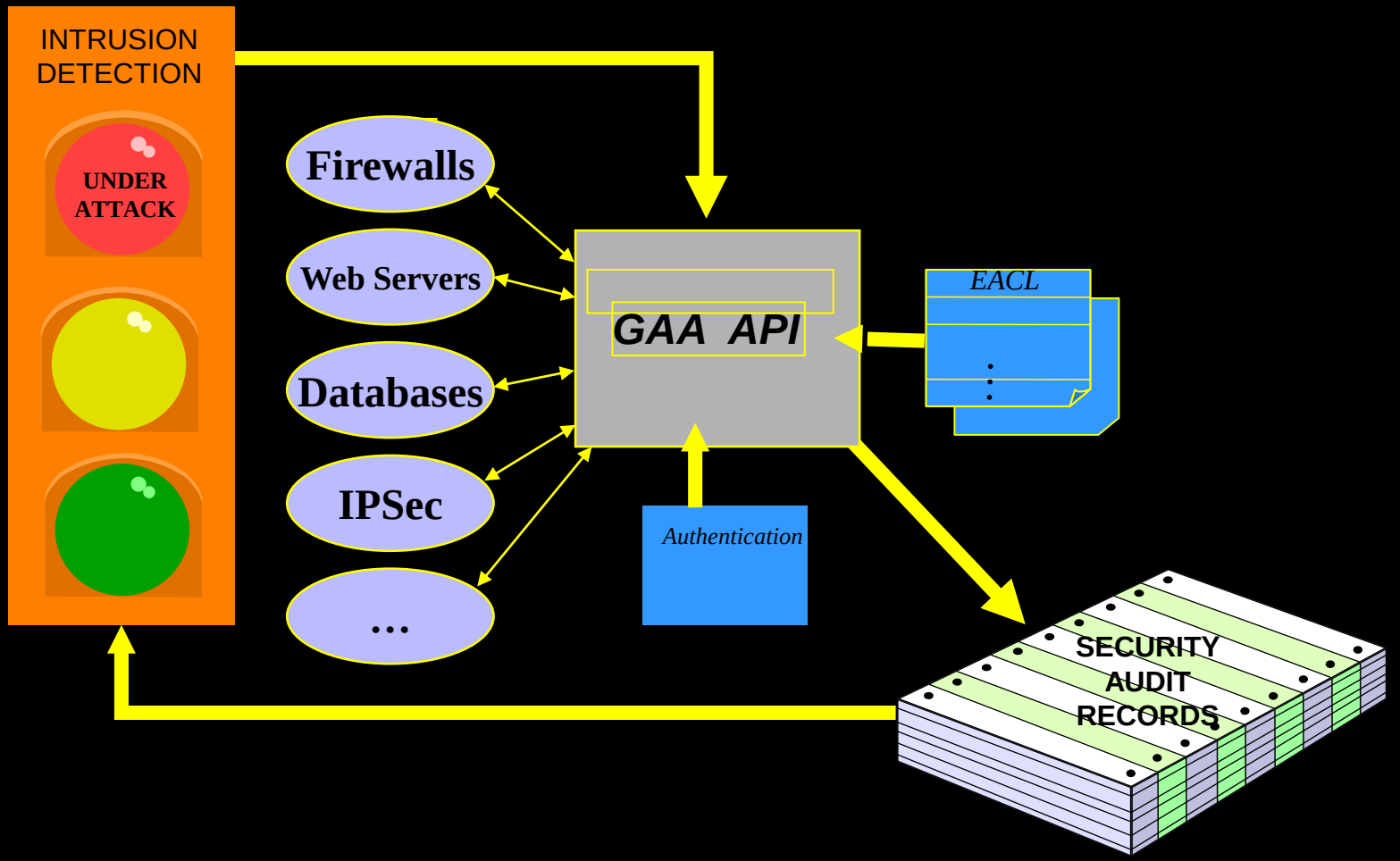
Security is more than mix of point solutions

- **Today's security tools work with no coordinated policy**
  - **Firewalls and Virtual Private Networks**
  - **Authentication and Public Key Infrastructure**
  - **Intrusion Detection and limited response**
- **We need better coordination**
  - **Intrusion response affected at firewalls, VPN's and Applications**
  - **Not just who can access what, but policy says what kind of encryption to use, when to notify ID systems.**
- **Tools should implement coordinated policies**
  - **Policies originate from multiple sources**
  - **Policies should adapt to dynamic threat conditions**
  - **Policies should adapt to dynamic policy changes triggered by activities like September 11th response.**

GAA-API: Integration through Authorization

- **Focus integration efforts on authorization and the management of policies used in the authorization decision.**
  - **Not really new - this is a reference monitor.**
  - **Applications shouldn't care about authentication or identity.**
    - **Separate policy from mechanism**
  - **Authorization may be easier to integrate with applications.**
  - **Hide the calls to individual security services**
    - **E.g. key management, authentication, encryption, audit**

Authorization and Integrated Security Services

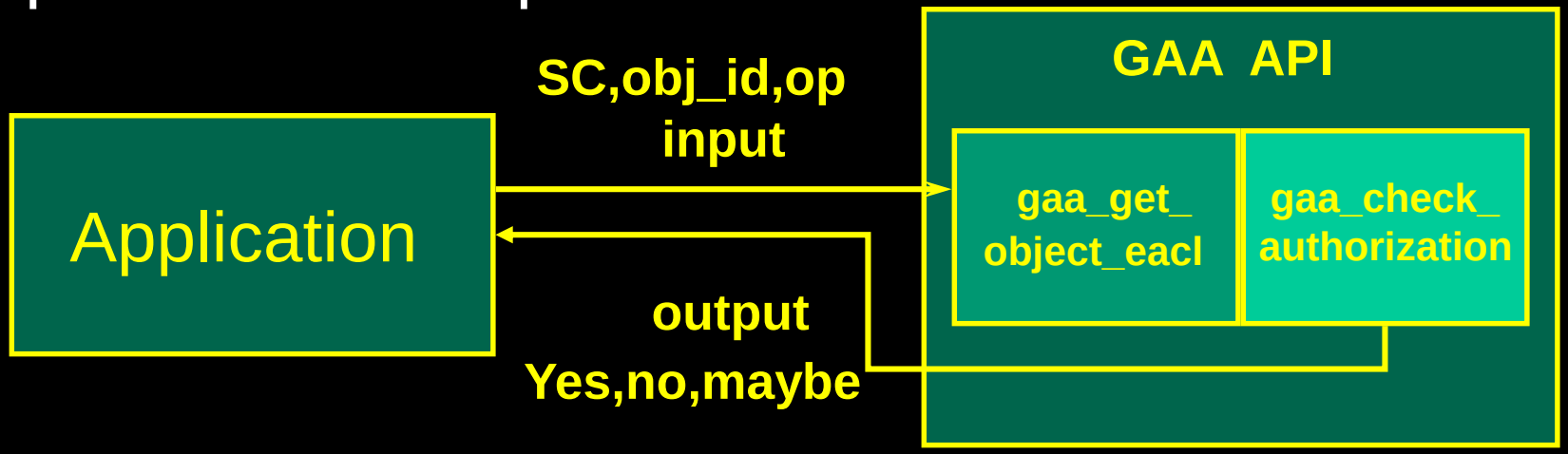


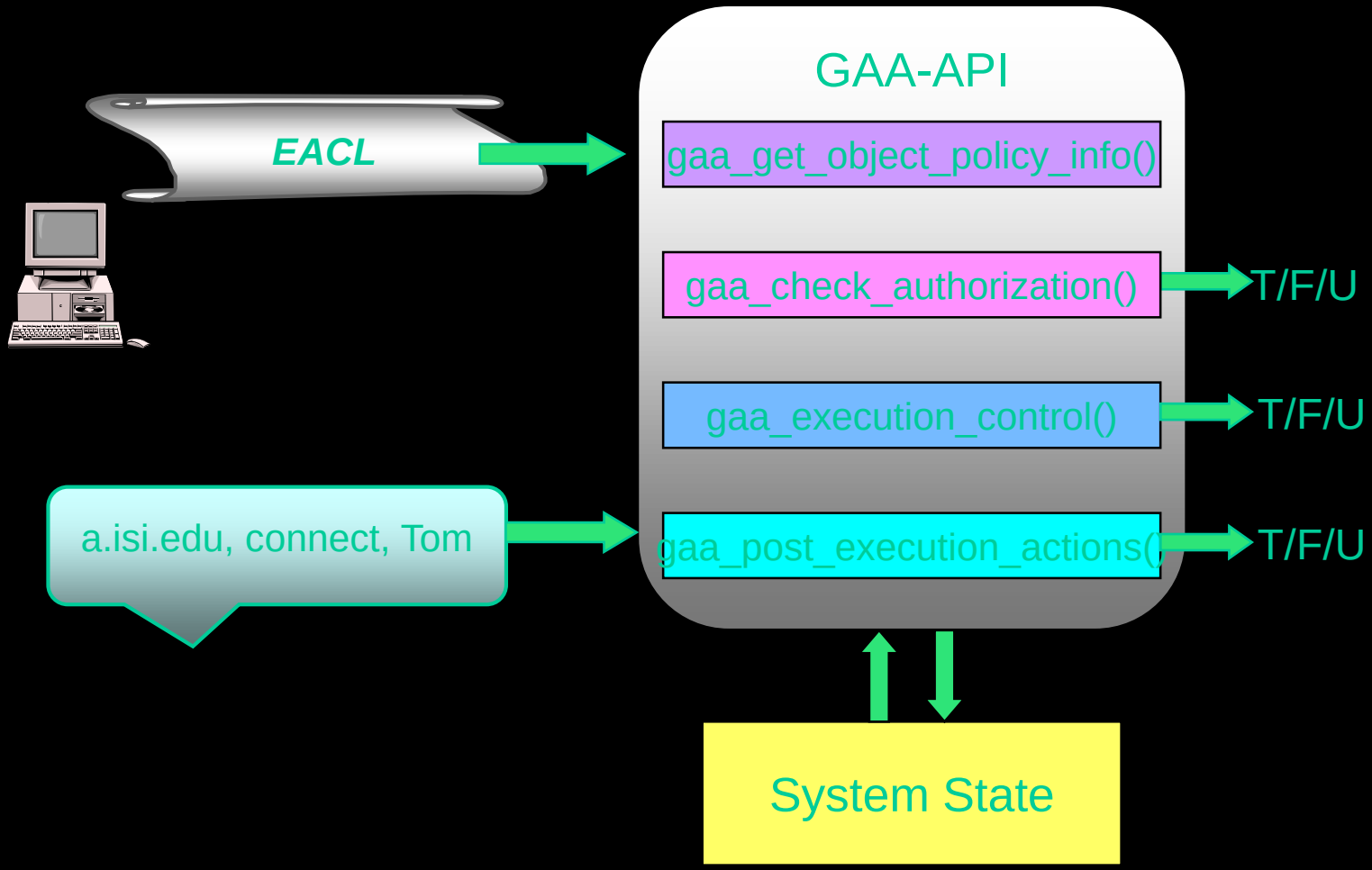
Generic Authorization and Access-control API

Allows applications to use the security infrastructure to implement security policies.

gaa_get_object_policy_info **function called before other GAA API routines which require a handle to object EACL to identify EACLs on which to operate. Can interpret existing policy databases.**

gaa_check_authorization **function tells application whether requested operation is authorized, or if additional application specific checks are required**





GAA-API Policies originate from multiple sources

- Discretionary policies associated with objects
  - Read from existing applications or EACLs
- Local system policies merged with object policies
  - Broadening or narrowing allowed access
- Policies imported from policy/state issuers
  - ID system issues state credentials, These credentials may embed policy as well.
- Policies embedded in credentials
  - These policies attach to user/process credentials and apply to access by only specific processes.
- Policies evaluated remotely
  - Credential issuers (e.g. authentication and authorization servers) evaluate policies to decide which credentials to issue.

Communicating threat conditions

- **Threat Conditions and New Policies carried in signed certificates**
  - **Added info in authentication credentials**
  - **Threat condition credential signed by ID system**
- **Base conditions require presentation or availability of credential**
  - **Matching the condition brings in additional policy elements.**

Integrating security services

- **The API calls must be made by applications.**
  - **This is a major undertaking, but one which must be done no matter how one chooses to do authorization.**
- **These calls are at the control points in the app**
  - **They occur at auditable events, and this is where records should be generated for ID systems**
  - **They occur at the places where one needs to consider dynamic network threat conditions.**
  - **Adaptive policies use such information from ID systems.**
  - **They occur at the right point for billable events.**

Advances Needed in Policy

- **Ability to merge & apply policies from many sources**
  - **Legislated policies**
  - **Organizational policies**
  - **Agreed upon constraints**
- **Integration of Policy Evaluation with Applications**
  - **So that policies can be uniformly enforced**
- **Support for Adaptive Policies is Critical**
  - **Allows response to attack or suspicion**
- **Policies must manage use of security services**
  - **What to encrypt, when to sign, what to audit.**
  - **Hide these details from the application developer.**

GAA - Applications and other integration

- Web servers - apache
- Grid services - globus
- Network control – IPsec and firewalls
- Remote login applications – ssh
- Trust management
  - Can call BYU code to negotiate credentials
  - Will eventually guide the negotiation steps

What dynamic policies enable

- **Dynamic policy evaluation enables response to attacks:**
  - **Lockdown system if attack is detected**
  - **Establish quarantines by changing policy to establish isolated virtual networks dynamically.**
  - **Allow increased access between coalition members as new coalitions are formed or membership changes to respond to unexpected events.**

Policies

- **HIPAA, other legislation**
- **Privacy statements**
- **Discretionary policies**
- **Mandatory policies (e.g. classification)**
- **Business policies**

Mechanisms

- Access Matrix
  - Access Control List
  - Capability list
- Unix file system
- Andrew file system
- SSH authorized key files
- Restricted proxies, extended certificates
- Group membership
- Payment

Summary

- **Policies naturally originate in multiple places.**
- **Deployment of secure systems requires coordination of policy across countermeasures.**
- **Effective response requires support for dynamic policy evaluation.**
- **Such policies can coordinated the collection of data used as input for subsequent attack analysis.**

Review for Mid-term

- Cryptography
  - Basic building blocks
  - Conventional
    - DES, AES, others
  - Public key
    - RSA
  - Hash Functions
  - Modes of operation
    - Stream vs. Block

Review for Mid-term

- Key Management
  - Pairwise key management
  - Key storage
  - Key generation
  - Group key management
  - Public key management
  - Certification

Review for Mid-term

- Authentication: Know, Have, About you
  - Unix passwords
  - Kerberos and NS
  - Public Key
  - Single Sign On
  - Applications and how they do it
  - Weaknesses

Review for Mid-term

- Authorization and Policy:
  - Access Matrix
    - ACL
    - Capability
  - Bell Lapadula
  - Dynamic Policy Management
  - Delegation
  - Importance of getting policy right

F17 Mid-Term Q1: Crypto/Key Management

Matching:

1. AES in Cipher Block Chaining Mode
2. One Time Pad
3. RSA
4. AES in Output Feedback Mode
5. Diffie-Hellman Key Exchange
6. Public Key Infrastructure (use of a Certification Authority)
7. Key Management in Kerberos

a) Involves a Trusted Third Party
b) Involves public keys or public key cryptography (asymmetric)
c) Involves conventional keys or conventional cryptography (symmetric)
d) Strong protection of confidentiality
e) Strong protection of Integrity
f) Requires Initialization Vector

F17 Mid-Term Q2: Short Answer

a. What are the main differences between the Bell-LaPadula model for authorization as compared with the Biba Model. (10 points)

b. Provide two examples for each and discuss two advantages or disadvantages each, for each of authentication based on i) something you know; ii) something you have; and iii) something about you. (for each of these I, ii, and iii, your answer should include the two examples, and then two sentences - those sentences describing and advantage or disadvantage of the approach). (20 points)

c. Provide two examples of information flow policies and explain how they are useful to prevent information disclosure and system compromise. (note that you may need to rely on the discussion in lecture, rather than simply searching for the term in the lecture notes) (10 points)

F17 Mid-Term Q3: Equifax

You have been hired as a consultant to advise on the response to the Equifax data breach. Your new employer understands that you have not taken the section of this class on malicious code, so you are only being asked to advise on technology solutions related to cryptography, identity management, and or policy. You will be asked how changes to the way these services are used in the credit reporting industry can help to mitigate the impact of the Equifax breach, or how these technologies might prevent similar breaches from occurring in the future.

A. Authentication Technologies – Problems with our current approach - What is wrong with the existing form of authentication of individuals applying for credit, and why is this a significant problem following the recent Equifax data beach. In answering this question focus on the initial authentication that is performed during "enrollment" (i.e. opening a new account), rather than the authentication performed after an account has been opened. (10 points)

B. Authentication Technologies – Improving the Situation - Thinking along the lines of federated identity (this is a hint of one possible approach), or along other lines if you choose to do so, suggest alternative ways to "enroll" users for new accounts (e.g. when applying for a new card). Discuss the advantage of your approach as compared with existing techniques. Discuss the limitation of your approach: what does it depend upon for security? Are there cases that it cannot be applied for certain users? How might a criminal attempt to get around the protections provided? What else might you do to mitigate some of these failures? (15 points)

C. Preventing these kinds of breaches in the future – Improving data access policy - It is believed that the attack exploited a known vulnerability in a software package that was used on a web server managed by Equifax. This specific attack could have been prevented if the appropriate patches had been applied, but there are many vulnerabilities that do exist for which the attacks are unknown (sometimes called a zero-day attack) and for which patches are not yet available. To address security comprehensively, we must design our system so that a vulnerable software module does not have significant access to all of the information in an enterprise such as Equifax. Part of that design involves applying policies for access to data (confidentiality and Integrity) that will limit the impact of these inevitable vulnerabilities. Discuss some of the kinds of policies that might be applied in the Equifax system that could reduce the impact of the breach that affected the vulnerable web server. (15 points)

F21 Mid-Term Q1: Identity&Key Management

Identity and Key Management

In the systems and mechanisms in the table below indicate which entities are authenticated (Yes/No), one or two words describing the information held by the entity which is the basis for authentication, what third party (if any) is involved, and the keys held by the entities at the end of the exchange that can be used to protect subsequent communication (i.e. the session). I have completed the first entry for you as an example of what I am looking for. (30 pts)

Mechanism	Client Auth	Server Auth	Information Held Client	Information Held Server	Third Party	Keys held at end	
Needham and Schroeder	Yes	Yes	Ko	Ks	KDC	Session Key	
Kerberos							
Diffie Hellman							
SSL or TLS (server cert only)							
SSH							
PGP or GPG							

F22 Mid-Term Q2

a. (5 points) When considering common mandatory access control policies, what is the main difference between the rules applies in confidentiality policies like Bell-Lapadula, as compared with integrity policies like Biba?

b. (5 points) Explain the advantages of using Cipher Block Chaining instead of Block Cipher mode (ECB) when encrypting communication streams. Specifically, give one example of an attack that would be easy to accomplish when using ECB that is made more difficult through Cipher Block Chaining.

c. (5 points) Why is it more secure to use a dedicated device such as a smart card or USB Key like UbiKey for Key Management in contrast to storing keys on your hard disk or Thumbdrive, and performing encryption operations on your computer, smartphone, or other general-purpose processor?

F22 Mid-Term Q2-2

d. (10 points) Explain how authorization occurs for file access in Linux. Be sure to distinguish the authorization that occurs for read and write calls from the authorization that occurs on file open? In what ways is this file access capability based and in what ways is it based on access control lists.

e. (5 points) Why is it important that we use Cryptographic Hash functions that are resistant to collisions? Specifically, provide an example of an attack that could be performed if an adversary were able to find two pieces of plaintext that yield that same hash value?

f. (5 points) In a couple of sentences explain how a brute force attack on a cryptographic system works, and tell me why the size of the keyspace for the system might be a useful indicator of the difficulty of such an attack.

F22 Mid-Term Q3 TrojanCheck

The steps required to obtain your daily pass and to get on to campus involve processes that we have discussed in the first half of the semester: Authentication, authorization, and verification of data. I will ask you some questions about different parts of this process.

3a) Authorization Models (10 points)

When we discussed the access matrix as one way to represent policy for computer systems, I presented the use of physical keys or access cards to gain to a building as an analogy to capabilities or access control lists. Please explain which of these approaches (capabilities or access control lists) is the better description for the authorization method implemented by Trojan Check.

F22 Mid-Term Q3 TrojanCheck

3b) Attack Methods (10 points)

In our discussion of authentication protocols, we discussed certain steps an adversary might use to impersonate the sender of a message if they do not have access to an encryption key. We also discussed the additions to such protocols to prevent an adversary from using this technique.

While Trojan Check is more of an authorization method, rather than authentication, it is still vulnerable to this kind of attack. Specifically, this attack is one of the methods used to bypass Trojan Check as described in the article: taking a photo or screenshot of someone else daily pass and using it to enter through the gate.

Name the type of attack as we described it in class (in the context of network protocols). What are the steps or additions that would be needed to the TrojanCheck Day Pass QR code to prevent this type of attack?

3c) Authentication (15 points)

Where does "authentication" occur or enter into the Trojan check system. Keep in mind that authentication can be performed in the context of identity management, but it can also occur in the context of "data origin" authentication. The latter component is similar to a digital signature. Hint: So, in this question I am really asking where authentication SHOULD occur within the system, and there are probably several places where it should occur.