INF3510
Information Security

Lecture 8: User Authentication

University of Oslo

Spring 2015

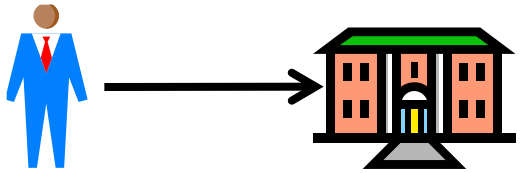
Outline

- Concepts related to authentication
  - Identity and authentication steps
- User Authentication
  - Knowledge-Based Authentication
    - Passwords
  - Ownership-Based Authentication
    - Tokens
  - Inherence-Based Authentication
    - Biometrics
- Authentication frameworks for e-Government

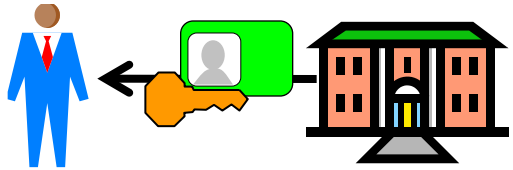
Steps of User Authentication

Config-uration phase

1. **Registration**
   - User visits ID-provider, with pre-authentication credents.

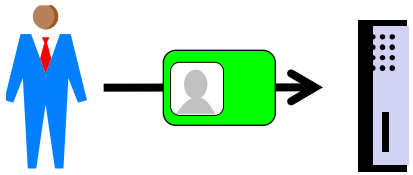


2. **Provisioning**
   - ID-provider registers unique name and issues credential

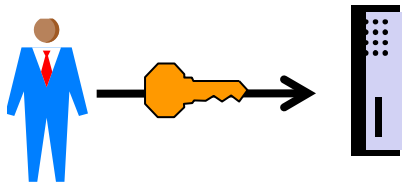


Operation phase

3. **Identification**
   - User presents the unique name to claim identity



4. **Verification of identity**
   - Proof of identity based on credentials

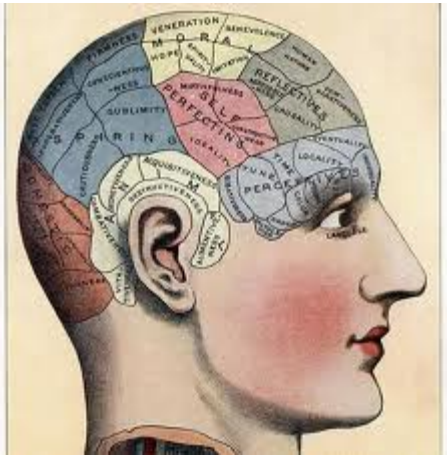


User authentication credentials

- A credential is the ‘thing’ used for authentication.
  - May also be referred to as a “token” or “authenticator”
  - e.g. reusable passwords, PIN, biometrics, smart cards, certificates, cryptographic keys, OTP hardware tokens.
- Credential categories:
  1. Knowledge-Based (Something you know): Passwords
  2. Ownership-Based (Something you have): Tokens
  3. Inherence-Based (Something you are/do): Biometrics
     - physiological biometric characteristics
     - behavioural biometric characteristics
- Combinations, called multi-factor authentication

Knowledge-Based Authentication

Something you know: Passwords



Authentication: Reusable passwords

- Passwords are a simple and most-often-used authenticator.
  - Something the user knows
- Problems:
  - Easy to share (intentionally or not)
  - Easy to forget
  - Often easy to guess
  - Can be written down (both god and bad)
    - If written down, then “what you know” is “where to find it”

RockYou Hack

- 32 million cleartext passwords stolen from RockYou database in 2009
- Posted on the Internet
- Contains accounts and passwords for websites
  - MySpace, Yahoo, Hotmail
- Analyzed by Imperva.com
  - 1% use 123456
  - 20% use password from set of 5000 different passwords

MOST POPULAR PASSWORDS

Nearly one million RockYou users chose these passwords to protect their accounts.

1.	**123456**	17.	**michael**
2.	**12345**	18.	**ashley**
3.	**123456789**	19.	**654321**
4.	**password**	20.	**qwerty**
5.	**iloveyou**	21.	**iloveu**
6.	**princess**	22.	**michelle**
7.	**rockyou**	23.	**111111**
8.	**1234567**	24.	**0**
9.	**12345678**	25.	**tigger**
10.	**abc123**	26.	**password1**
11.	**nicole**	27.	**sunshine**
12.	**daniel**	28.	**chocolate**
13.	**babygirl**	29.	**anthony**
14.	**monkey**	30.	**angel**
15.	**jessica**	31.	**FRIENDS**
16.	**lovely**	32.	**soccer**

Source: Imperva

Secure password strategies

- Passwords length $\geq$ 13 characters
- Use $\geq$ 3 categories of characters
  - L-case, U-case, numbers, special characters
- Do not use ordinary words (names, dictionary wds.)
- Change typically every 3 – 13 months
- Reuse only between low-sensitivity accounts
- Store passwords securely
  - On paper
  - In cleartext on offline digital device
  - Encrypted on online digital device

Strategies for strong passwords

- User education and policies
  - Not necessarily with strict enforcement
- Proactive password checking
  - User selects a potential password which is tested
  - Weak passwords are not accepted
- Reactive password checking
  - SysAdmin periodically runs password cracking tool (also used by attackers) to detect weak passwords that must be replaced.
- Computer-generated passwords
  - Random passwords are strong but difficult to remember
  - FIPS PUB 181 http://www.itl.nist.gov/fipspubs/fip181.htm specifies automated pronounceable password generator

Password Caching

- Problem: the password is stored on medium
  - Buffers, caches, web pages
  - Outside user's control
- If you leave the browser open on a public machine, the next user can obtain information about you.

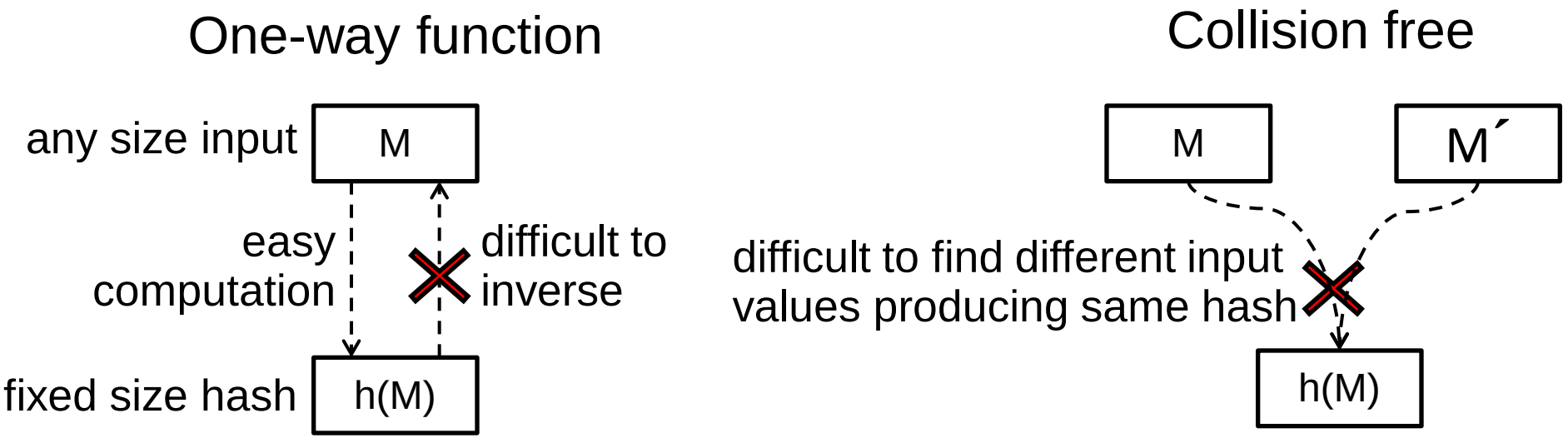
Password storage in OS

- /etc/shadow is the file where modern Linux/Unix stores it passwords
  - Earlier version stored it in /etc/passwd
  - Need root access to modify it
- \windows\system32\config\sam it the file Windows systems normally stores it passwords
  - Undocumented binary format

Prevent exposure of password file

- The computer verifies user passwords against stored values in the password file
- Password file must be available to OS
  - This file need protection from users and applications
  - Avoid offline dictionary attacks
- Protection measures
  - Access control (only accessible by OS kernel)
  - Hashing or Encryption
- In case a password file gets stolen, then hashing/encryption can provide protection.

Hash functions



- *A hash function is easy to compute but hard to invert.*

- Passwords can be stored as hash values.
- Authentication function first computes hash of received password, then compares against stored hash value

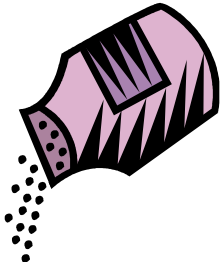
Cracking passwords

- Bruce Force
  - Trying all possible combinations
- Intelligent search
  - User name
  - Name of friends/relatives
  - Phone number
  - Birth dates
  - Dictionary attack
    - Try all words from an dictionary
    - Precomputed hashes: Rainbow tables

Hash table and rainbow table attacks

- Attackers can compute and store hash values for all possible passwords up to a certain size
- A list of password hashes is a **hash table**
- A compressed hash table is a **rainbow table**
- Comparing and finding matches between hashed passwords and hash/rainbow table is used to determine cleartext passwords.

Password salting: Defence against password cracking



- Prepend or append random data (salt) to a user's password before hashing
  - In Unix: a randomly chosen integer from 0 to 4095.
  - Different salt for each user
  - Produces different hashes for equal passwords
  - Prevents that users with identical passwords get the same password hash value
  - Increases the amount of work required for hash table attacks and rainbow table attacks

Methods of storing passwords on server

- Cleartext password (low security)
  - Password: 123456,
  - Stored on server: 123456

- Hashed password (moderately security)
  - Password: 123456
  - Stored on server: e.g. SHA1-hash of password: 7c4a8d09ca3762af61e59520943dc26494f8941b

- Salted password (good security)
  - Password: 123456
  - Stored on server: Salt + Salted hash

    e.g. “salt”: f8b97abc30b72e54

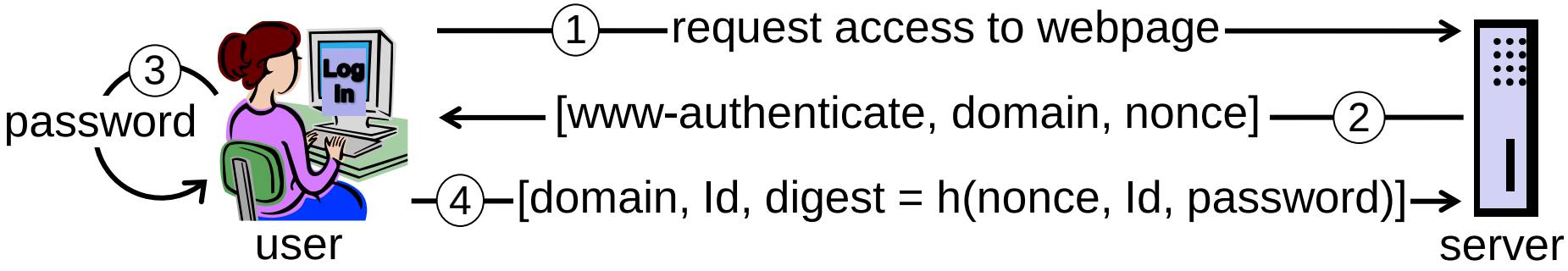
    eg. SHA1-hash of password + salt 1736f11fae29189749a8a54f45e25fb693c3959d

Problems with using passwords in the clear

- A password sent “in clear” can be captured during transmission, so an attacker may reuse it.
- An attacker setting up a fake server can get the password from the user
  - E.g. phishing attack.
- Solutions to these problems include:
  - Encrypted communication channel
  - One-time passwords (token-based authentication)
  - Challenge-response protocols

HTTP Digest Authentication
A simple challenge-response protocol

- A simple challenge response protocol specified in RFC 2069
- Server sends:
  - WWW-Authenticate = Digest
  - realm="service domain"
  - nonce="some random number"
- User types Id and password in browser window
- Browser produces a password digest from nonce, Id and password using a 1-way hash function (SHA-1….)
- Browser sends Id and digest to server that validates digest

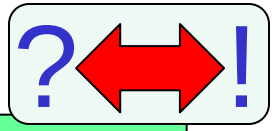


Ownership-Based Authentication

Something you have: Tokens

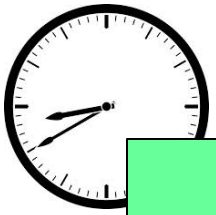
Taxonomy of Authentication Tokens

Authentication Tokens



Synchronised Tokens

Challenge-Response Tokens



Clock-Based Tokens

Counter-Based Tokens

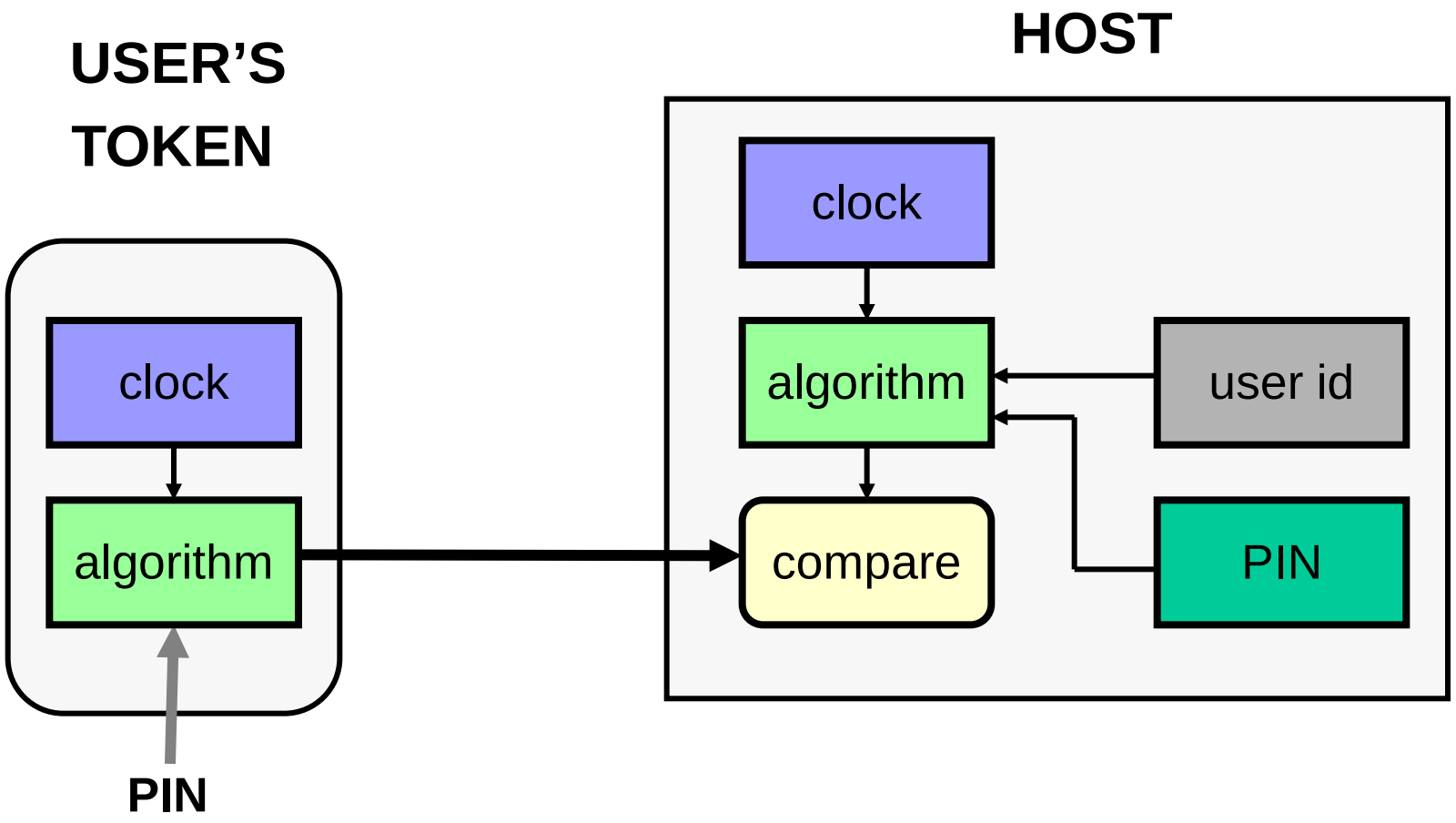
Synchronised OTP (One-Time-Password) Generator

- Using a password only once significantly strengthens the strength of user authentication.
- Synchronized password generators produce the same sequence of random passwords both in the token and at the host system.
  - OTP is ‘something you have’ because generated by token
- There are two general methods:
  - Clock-based tokens
  - Counter-based tokens

Clock-based OTP Tokens: Operation

- Token displays time-dependent code on display
  - User copies code from token to terminal to log in
- Possession of the token is necessary to know the correct value for the current time
- Each code computed for specific time window
- Codes from adjacent time windows are accepted
- Clocks must be synchronised
- Example: BankID and SecurID

Clock-based OTP Tokens: Operation



Clock-based OTP Tokens: RSA SecurID tokens and BankID tokens

RSA SecurID SD600

RSA SecurID SID700

BankID OTP calculator with PIN

RSA SecurID SD200

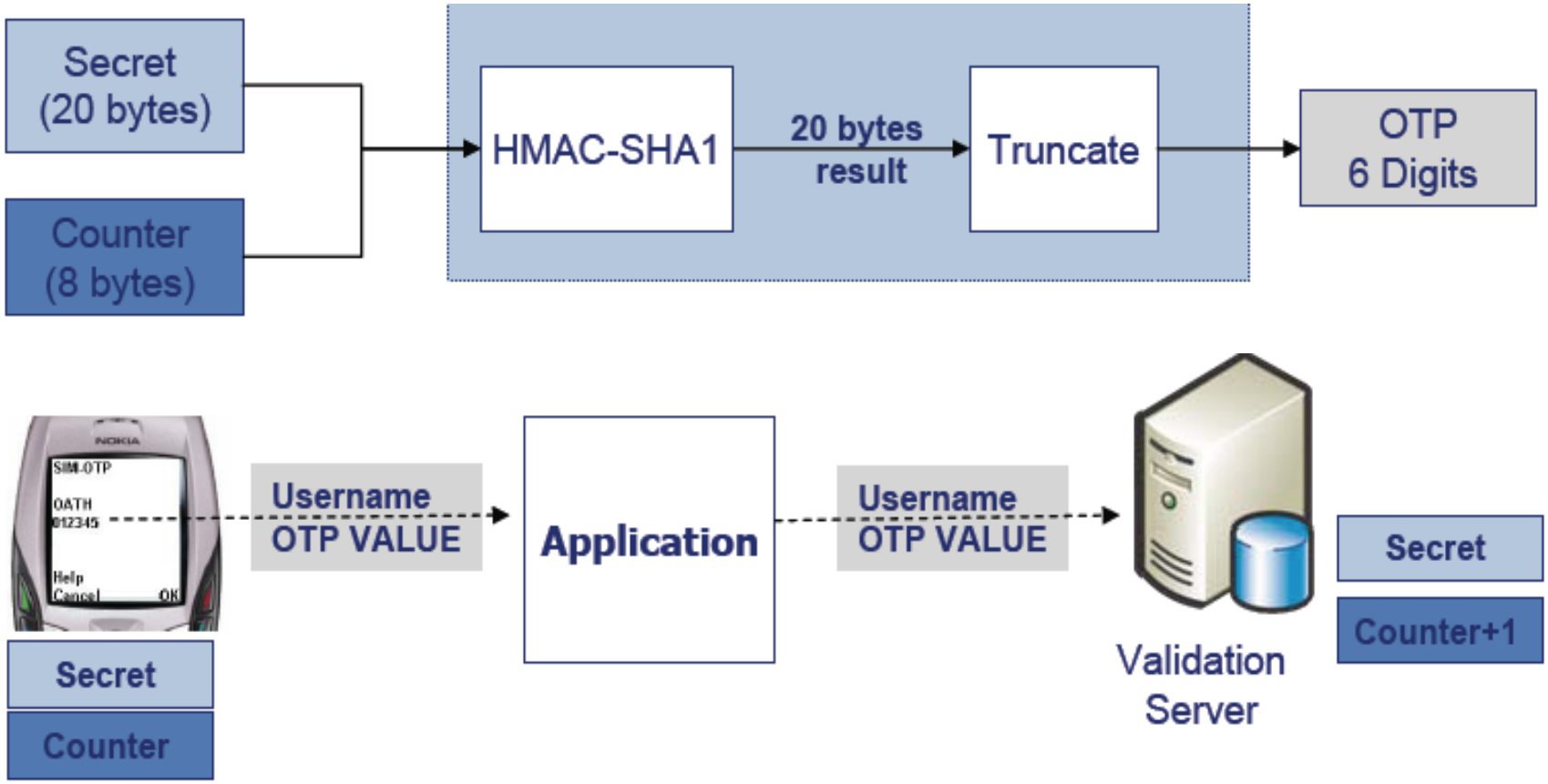
BlackBerry with RSA SecurID software token

BankID OTP calculator without PIN

Counter-based OTP Tokens: Overview

- Counter-based tokens generate a ‘password’ result value as a function of an internal counter and other internal data, without external inputs.
- HOTP is a HMAC-Based One-Time Password Algorithm described in RFC 4226 (Dec 2005)
  http://www.rfc-archive.org/getrfc.php?rfc=4226
  - Tokens that do not support any numeric input
  - The value displayed on the token is designed to be easily read and entered by the user.

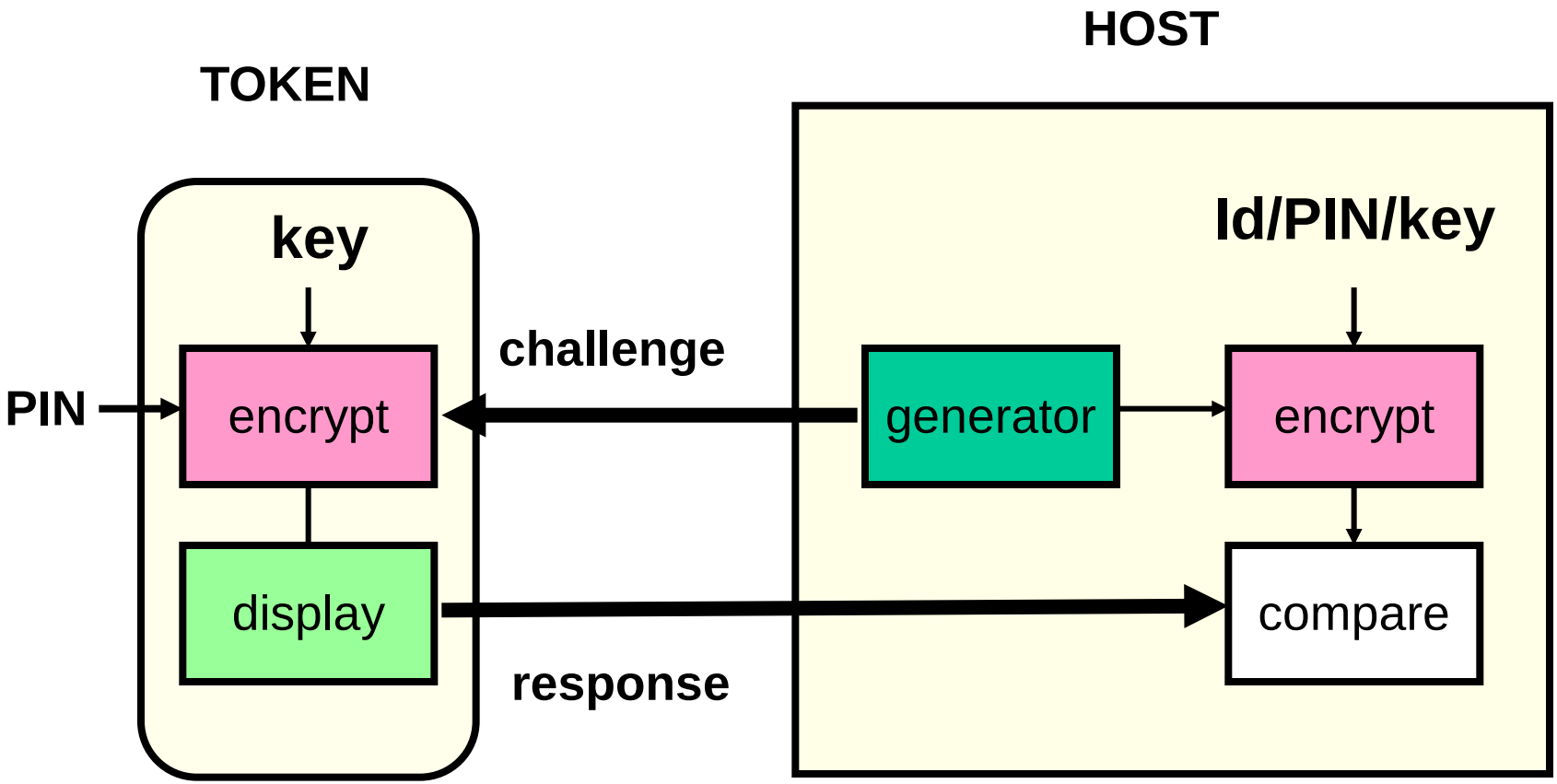
Counter-based OTP Tokens: HOTP



Token-based User Authentication: Challenge Response Systems

- A challenge is sent in response to access request
  - A legitimate user can respond to the challenge by performing a task which requires use of information only available to the user (and possibly the host)
- User sends the response to the host
  - Access is approved if response is as expected by host.
- Advantage: Since the challenge will be different each time, the response will be too – the dialogue can not be captured and used at a later time
- Could use symmetric or asymmetric crypto

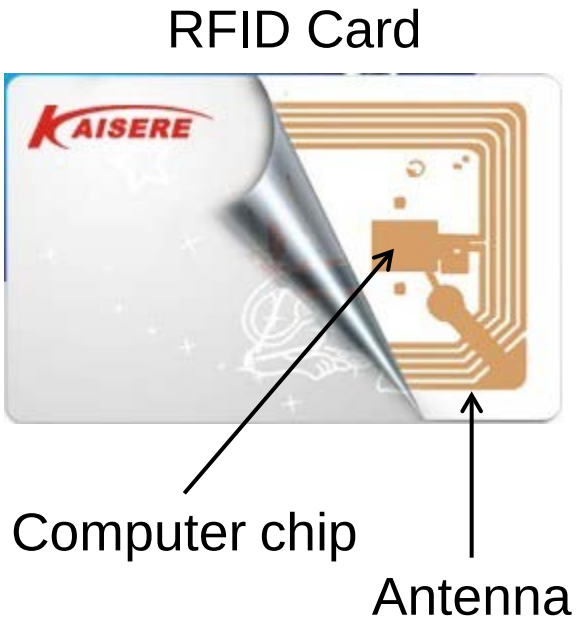
Token-based User authentication
Challenge Response Systems



Symmetric algorithm case

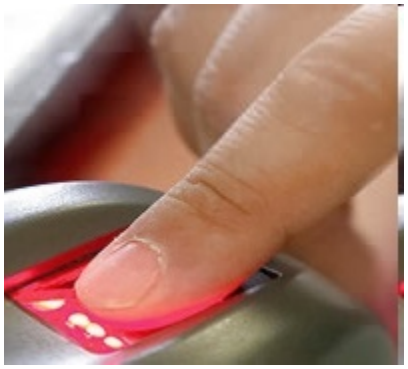
Contactless Cards: Overview

- Contactless cards, also called RFID (Radio Frequency Id) cards, consists of a chip and an antenna.
  - No need to be in physical contact with the reader.
  - Uses radio signals to communicate
  - Powered by magnetic field from reader
  - When not within the range of a reader it is not powered and remains inactive.
  - Battery powered RFID tags also exist
- Suitable for use in hot, dirty, damp, cold, foggy environments



Inherence-Based Authentication

Biometrics



Something you are

Something you do

Biometrics: Overview

- What is it?
  - Automated methods of verifying or recognizing a person based upon a physiological characteristics.
- Biometric modalities, examples:
  - fingerprint
  - facial recognition
  - eye retina/iris scanning
  - hand geometry
  - written signature
  - voice print
  - keystroke dynamics

Biometrics: Requirements

- **Universality**:
  Each person should have the characteristic;
- **Distinctiveness**:
  Any two persons should be sufficiently different in terms of the characteristic;
- **Permanence**:
  The characteristic should be sufficiently invariant (with respect to the matching criterion) over a period of time;
- **Collectability**:
  The characteristic should be measurable quantitatively.

Biometrics: Practical considerations

- Accuracy:
  - The correctness of a biometric system, expressed as ERR (Equal Error Rate), where a low ERR is desirable.
- Performance:
  - the achievable speed of analysis,
  - the resources required to achieve the desired speed,
- Acceptability:
  - the extent to which people are willing to accept the use of a particular biometric identifier (characteristic)
- Circumvention resistance:
  - The difficulty of fooling the biometric system
- Safety:
  - Whether the biometric system is safe to use

Biometrics Safety

- Biometric authentication can be safety risk
  - Attackers might want to “steal” body parts
  - Subjects can be put under duress to produce biometric authenticator
- Necessary to consider the physical environment where biometric authentication takes place.

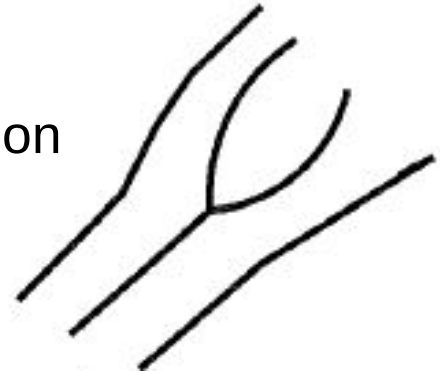
Car thieves chopped off part of the driver’s left index finger to start S-Class Mercedes Benz equipped with fingerprint key. Malaysia, March 2005
(NST picture by Mohd Said Samad)

Biometrics: Modes of operation

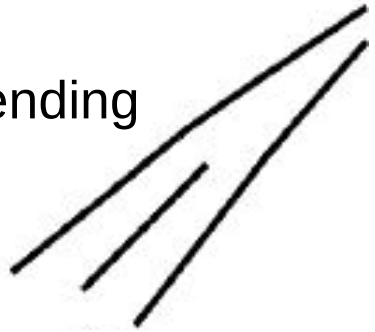
- Enrolment:
  - analog capture of the user's biometric attribute.
  - processing of this captured data to develop a template of the user's attribute which is stored for later use.
- Identification (1:N, one-to-many)
  - capture of a new biometric sample.
  - search the database of stored templates for a match based solely on the biometric.
- Verification of claimed identity (1:1, one-to-one):
  - capture of a new biometric sample.
  - comparison of the new sample with that of the user's stored template.

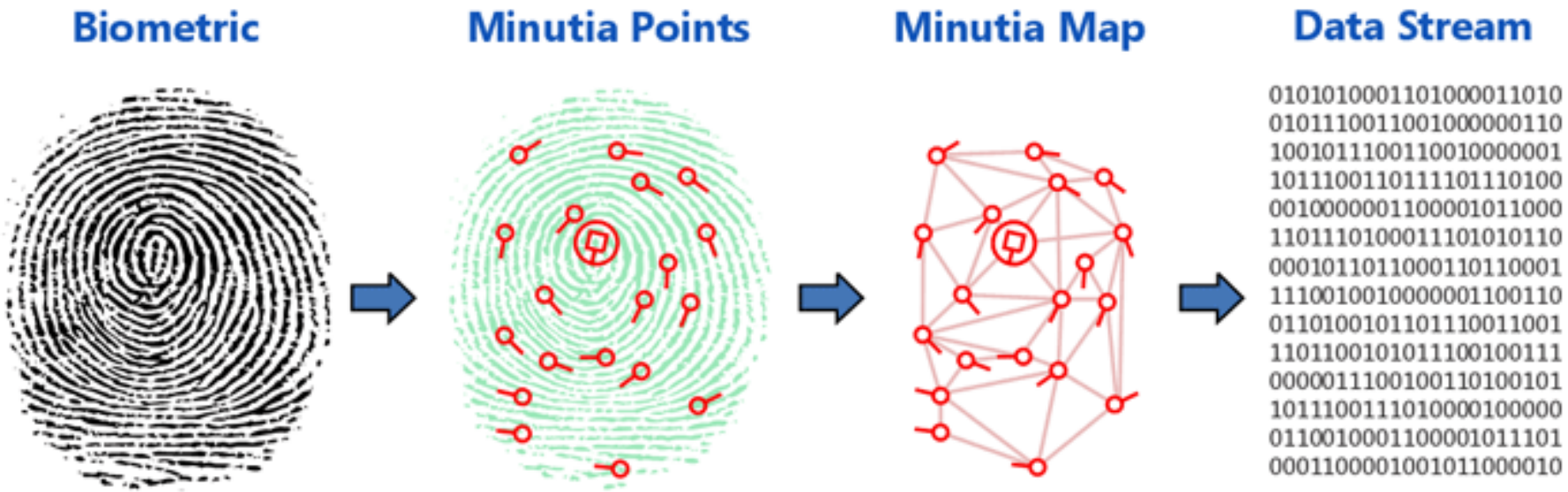
Extracting biometric features
Example fingerprints: Extracting minutia

Bifurcation

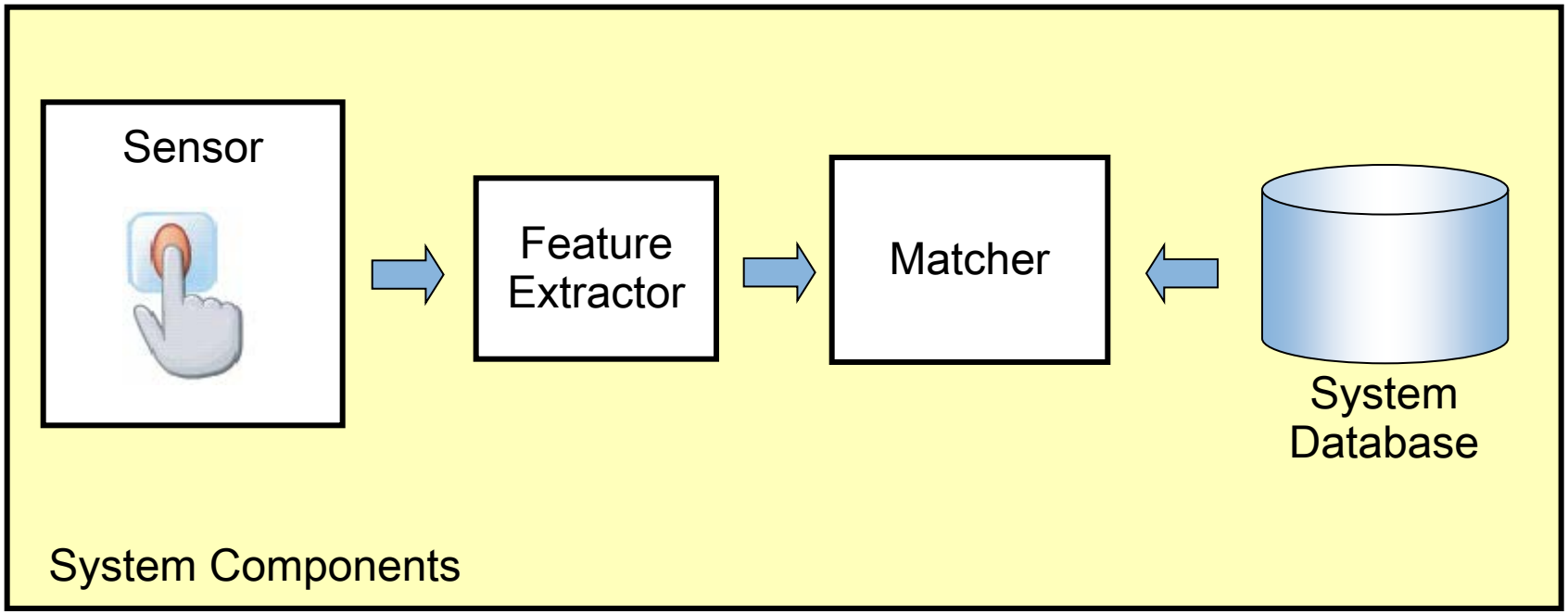


Ridge ending

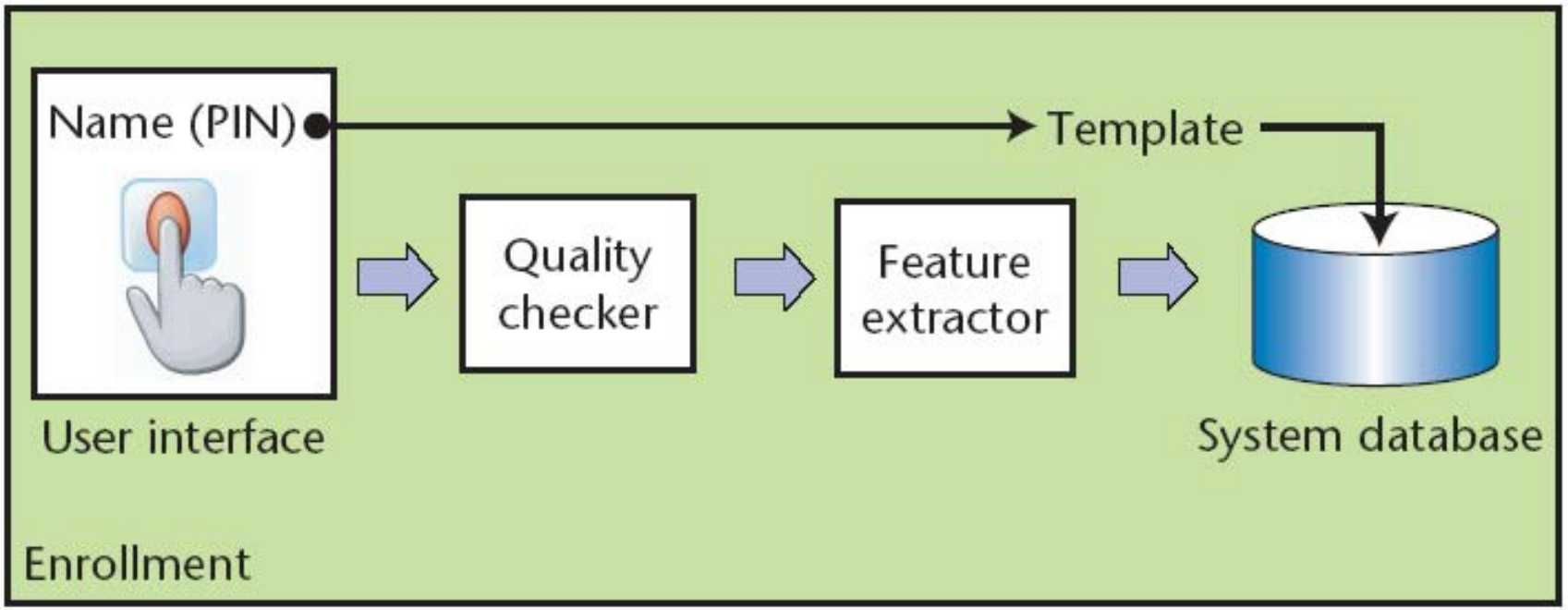




Biometrics:
System components

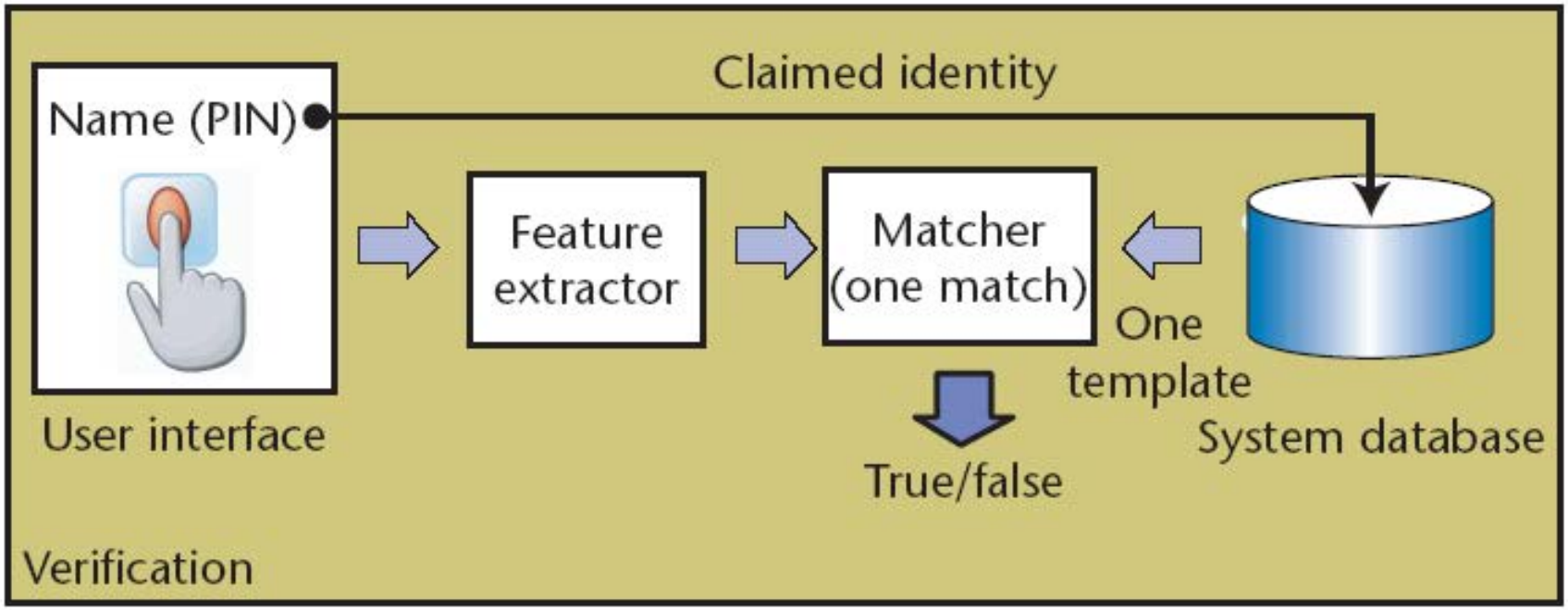


Biometrics: Enrolment



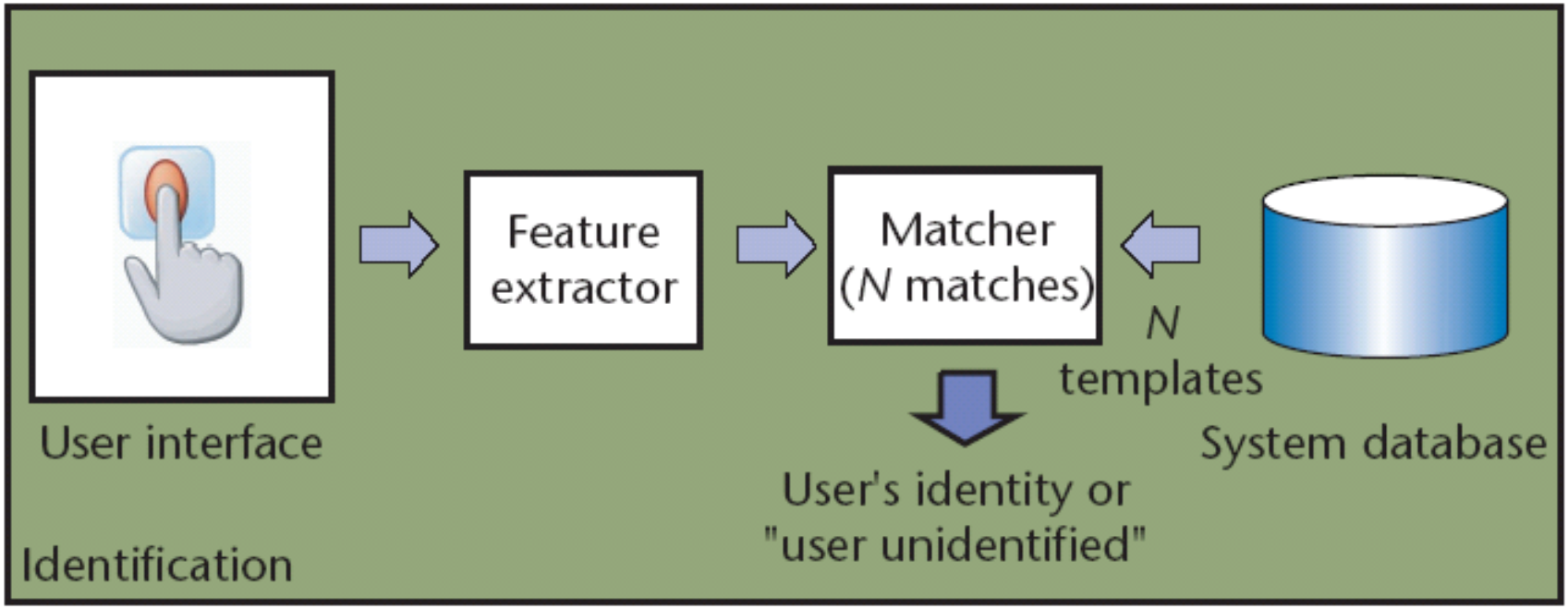
Biometric Recognition: Security and Privacy Concerns

Biometrics: Verification



Biometric Recognition: Security and Privacy Concerns

Biometrics: Identification



Biometric Recognition: Security and Privacy Concerns

Evaluating Biometrics:

- Features from captured sample are compared against those of the stored template sample
- Score *s* is derived from the comparison.
  - Better match leads to higher score.
- The system decision is tuned by threshold *T*:
  - System gives a match (same person) when the sample comparison generates a score *s* where $s \geq T$
  - System gives non-match (different person) when the sample comparison generates a score *s* where $s < T$

Matching algorithm characteristics

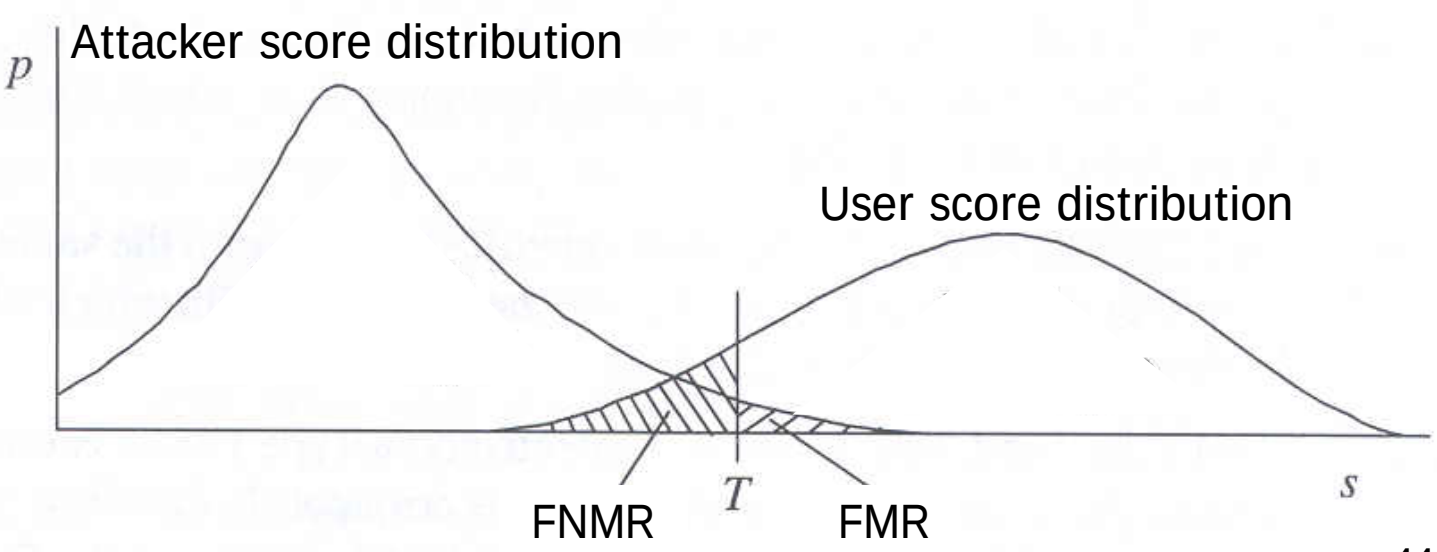
- True positive
  - User sample matches → User is accepted
- True negative
  - Attacker sample does not match → Attacker is rejected
- False positives
  - Attacker sample matches → Attacker is accepted
- False negatives
  - User sample does not match → User is rejected
- Computing FMR and FNMR

  FMR = (# matching attacker samples) / (total # attacker samples)

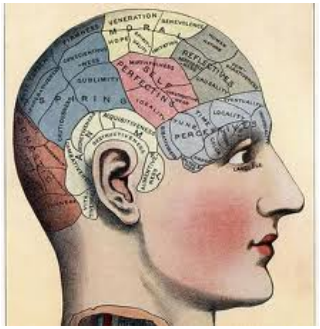
  FNMR = (# non-matching user samples) / (total # user samples)
- *T* determines tradeoff between FMR and FNMR

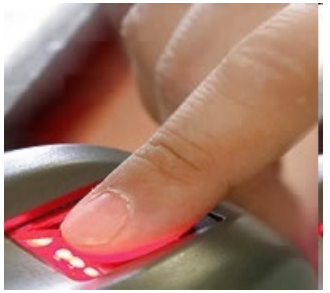
Evaluating Biometrics: System Errors

- Comparing biometric samples produces score *s*
- Acceptance threshold *T* determines FMR and FNMR
  - If *T* is set low to make the system more tolerant to input variations and noise, then FMR increases.
  - On the other hand, if *T* is set high to make the system more secure, then FNMR increases accordingly.
- EER (Equal Error Rate) is when FMR = FNMR.
- Low EER is good.



Authentication: Multi-factor

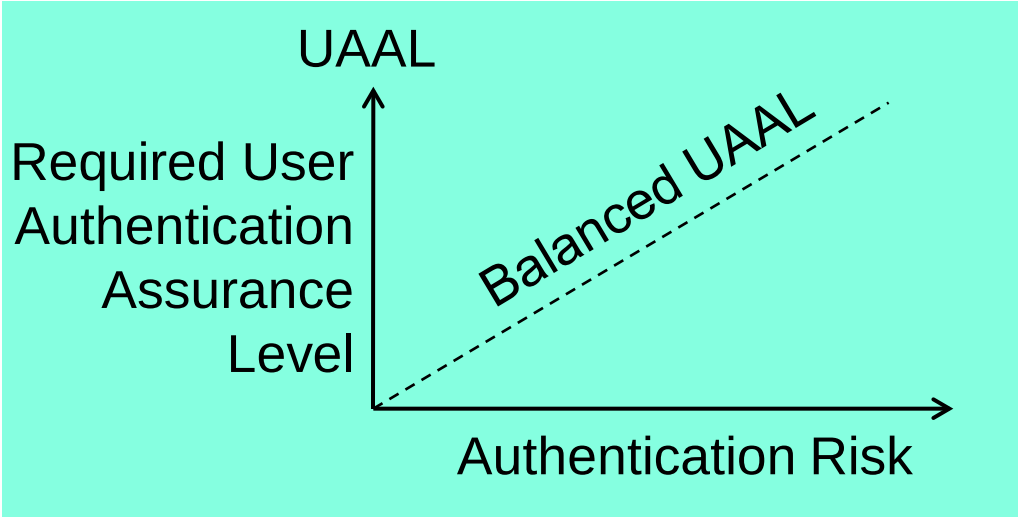




- Multi-factor authentication aims to combine two or more authentication techniques in order to provide stronger authentication assurance.
- Two-factor authentication is typically based on something a user knows (factor one) plus something the user has (factor two).
  - Usually this involves combining the use of a password and a token
  - Example: BankID OTP token with PIN + static password

Authentication Assurance

- Authentication assurance = robustness of authentication
- Resources have different sensitivity levels
  - High sensitivity gives high risk in case of authentication failure
- Authentication has a cost
  - Unnecessary authentication assurance is a waste of money
- Authentication assurance should balance resource sensitivity



e-Authentication Frameworks for e-Gov.

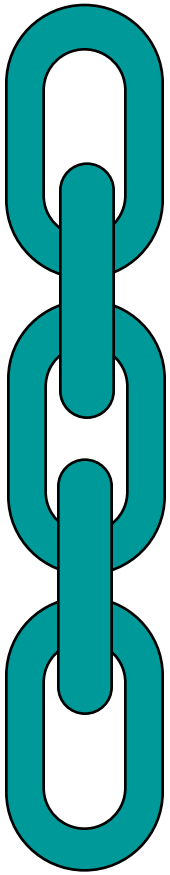
- Trust in identity is a requirement for e-Government
- Authentication assurance produces identity trust.
- Authentication depends on technology, policy, standards, practice, awareness and regulation.
- Consistent frameworks allow cross-national and cross-organisational schemes that enable convenience, efficiency and cost savings.

Alignment of e-Authentication Frameworks

Authentication Framework	***User Authentication Assurance Levels***				
OMB / NIST USA 2004 / 2011	Little or no assurance (1)		Some (2)	High (3)	Very High (4)
RAU / FAD Norway 2008	Little or no assurance (1)		Low (2)	Moderate (3)	High (4)
STORK QAA EU 2009	No or minimal (1)		Low (2)	Substantial (3)	High (4)
NeAF Australia 2009	None (0)	Minimal (1)	Low (2)	Moderate (3)	High (4)
e-Pramaan India 2012	None (0)	Minimal (1)	Minor (2)	Significant (3)	Substantial (4)
ISO 29115 ISO/IEC 2013	Low (Little or no) (1)		Medium (2)	High (3)	Very High (4)

UAAL: User Authentication Assurance Level

- UAAL is determined by the weakest of three links:



User Identity Registration Assurance (UIRA) requirements

Requirements for correct registration:
- Pre-authentication credentials, e.g.
  - birth certificate
  - biometrics

User Credential Management Assurance (UCMA) requirements

Requirements for secure handling of credentials:
- Creation
- Distribution
- Storage

User Authentication Method Strength (UAMS) requirements

Requirements for mechanism strength:
- Password length and quality
- Cryptographic algorithm strength
- Tamper resistance of token
- Multiple-factor methods

UAAL: User Authentication Assurance Levels

No Assurance	Minimal Assurance	Low Assurance	Moderate Assurance	High Assurance
Level 0	Level 1	Level 2	Level 3	Level 4
No registration of identity required	Minimal confidence in the identity assertion	Low confidence in the identity assertion	Moderate confidence in the identity assertion	High confidence in the identity assertion

Example taken from Australian NeAF 2009

Risk Analysis for Authentication

Determining the appropriate UAAL for an application

Likelihood	Impact of e-Authentication failure				
	Insignificant	**Minor**	**Moderate**	**Major**	**Severe**
Almost Certain	None (0)	Low (2)	Moderate (3)	High (4)	High (4)
Likely	None (0)	Low (2)	Moderate (3)	High (4)	High (4)
Possible	None (0)	Minimal (1)	Low (2)	Moderate (3)	High (4)
Unlikely	None (0)	Minimal (1)	Low (2)	Moderate (3)	Moderate (3)
Rare	None (0)	Minimal (1)	Low (2)	Moderate (3)	Moderate (3)

Example: NeAF Australia

RAU Norway
Rammeverk for Autentisering og Uavviselighet (Framework for Authentication and Non-Repudiation)

FANR Level 1: Little or no authentication assurance

Alternative requirements:

- Online self-registration and self-chosen password
- Pre-authentication by providing person number

FANR Level 2: Low authentication assurance

Alternative requirements:

- Fixed password provisioned in person or by mail to user's address in national person register
- OPT calculator without PIN, provisioned in person or by mail to address in national person reg.
- List of OTP (one-time passwords) provisioned in person or by mail to address in national pers. reg.

FANR Level 3: Moderate authentication assurance

Alternative requirements:

- OTP calculator with PIN provisioned separately in person or by mail to address in national pers. reg.
- SMS-based authentication, where enrolment of mobile phone is based on code provisioned in person or by mail to address in national pers. reg.
- Personal public-key certificate with gov. PKI
- List of OTP (one-time passwords) combined with static password and username provisioned in person or by mail to address in national pers. reg.

Example: MinID

FANR Level 4: High authentication assurance

Alternative requirements:

- Two-factor, where at least one must be dynamic, and at least one is provisioned in person (the other by mail to address in national pers. reg. Also requires logging and auditing by third party.
- Same as above, but uses trusted system instead of third party logging.

Examples: Buypass, Confides, BankID

End of lecture