CSE 484 (Winter 2010)

User Authentication

Tadayoshi Kohno

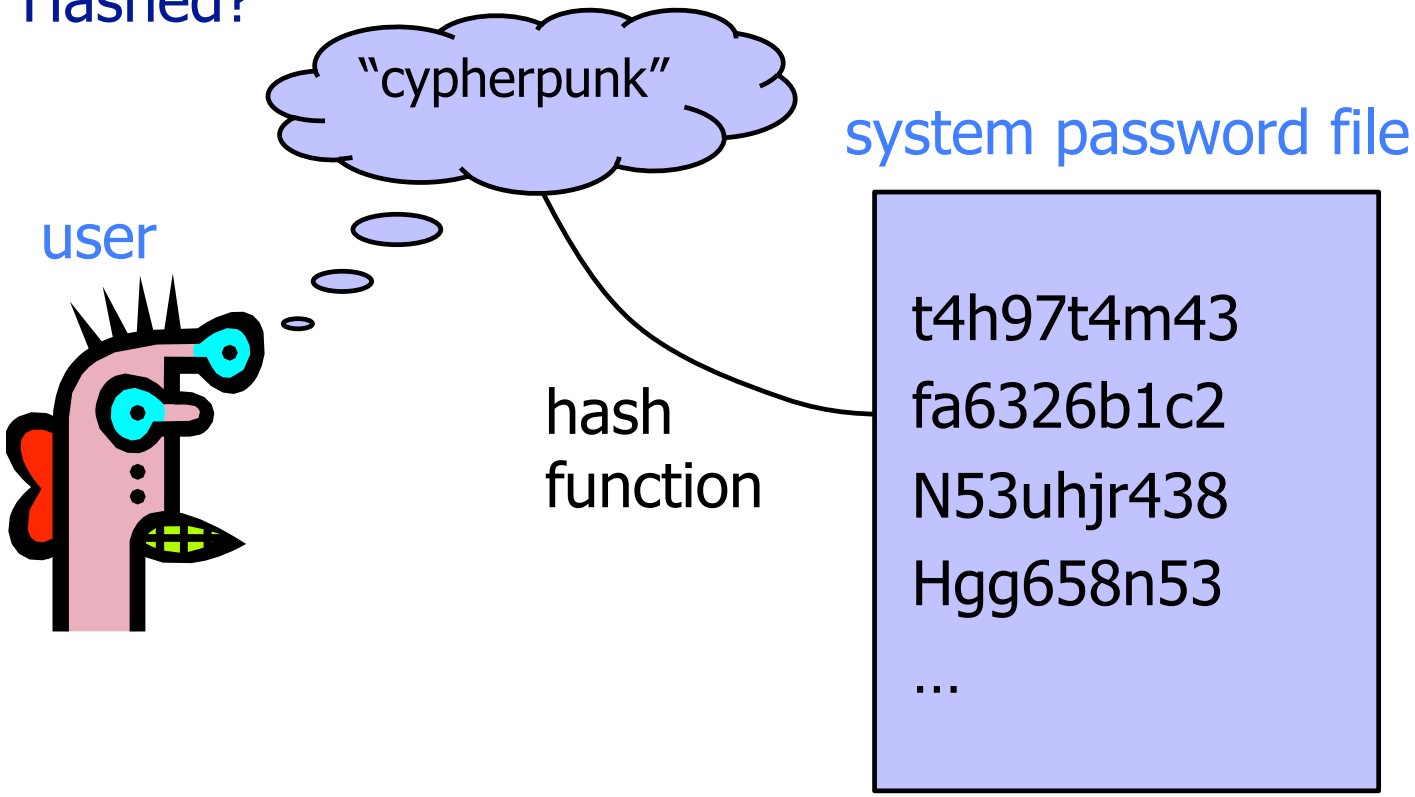
Thanks to Dan Boneh, Dieter Gollmann, John Manferdelli, John Mitchell, Vitaly Shmatikov, Bennet Yee, and many others for sample slides and materials ...

Goals for Today

- User authentication

UNIX-Style Passwords

- How should we store passwords on a server?
  - In cleartext?
  - Encrypted?
  - Hashed?



Password Hashing

- Instead of user password, store H(password)
- When user enters password, compute its hash and compare with entry in password file
  - System does not store actual passwords!
  - System itself can't easily go from hash to password
    - Which would be possible if the passwords were encrypted
- Hash function H must have some properties
  - One-way: given H(password), hard to find password
    - No known algorithm better than trial and error
    - It should even be hard to find any pair p1,p2 s.t. H(p1)=H(p2) (second pre-image resistance)

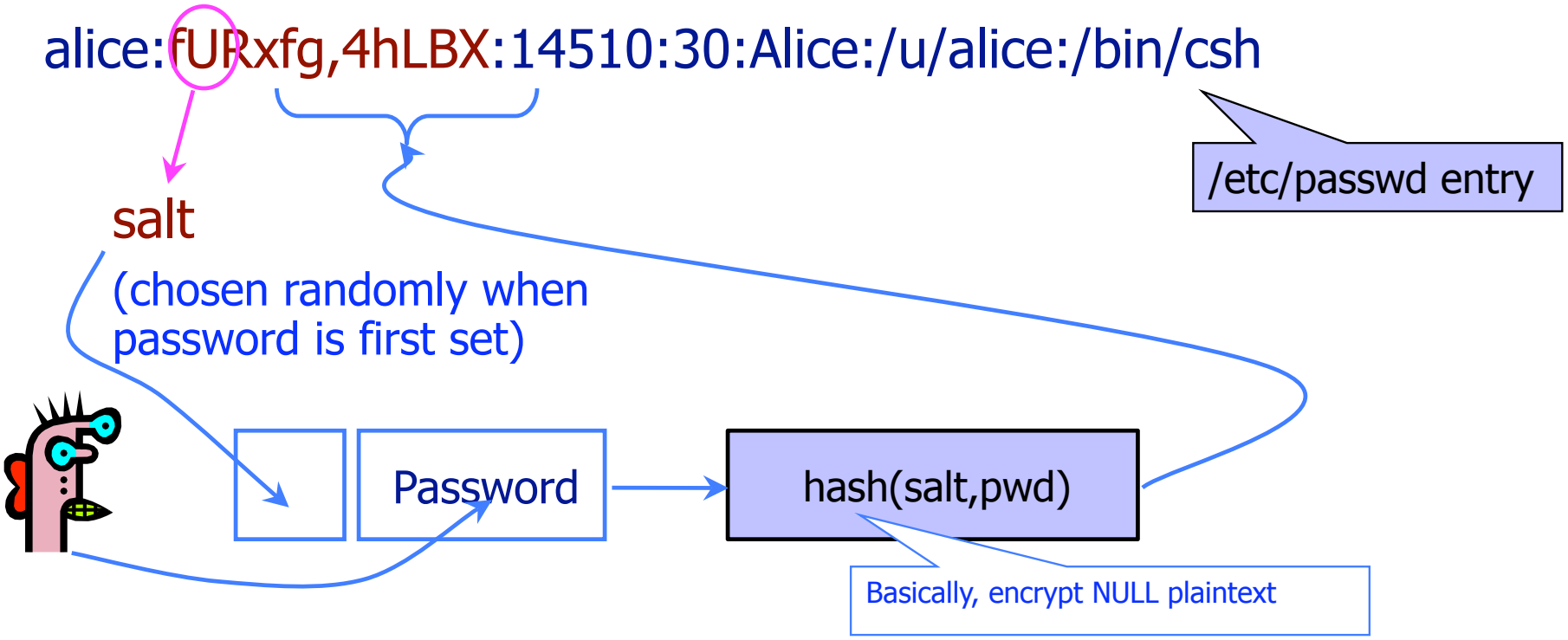
(Early) UNIX Password System

- Uses DES encryption as if it were a hash function
  - Encrypt NULL string using password as the key
    - Truncates passwords to 8 characters!
  - Artificial slowdown: run DES 25 times
    - Why 25 times? Slowdowns like these are important in practice!
  - ("Don't use DES like this at home.")
  - Can instruct modern UNIXes to use MD5 hash function
- Problem: passwords are not truly random
  - With 52 upper- and lower-case letters, 10 digits and 32 punctuation symbols, there are $94^8 \approx$ 6 quadrillion possible 8-character passwords (around 2^{52})
  - Humans like to use dictionary words, human and pet names $\approx$ 1 million common passwords

Dictionary Attack

- Password file /etc/passwd is world-readable
  - Contains user IDs and group IDs which are used by many system programs
- Dictionary attack is possible because many passwords come from a small dictionary
  - Attacker can compute H(word) for every word in the dictionary and see if the result is in the password file
  - With 1,000,000-word dictionary and assuming 10 guesses per second, brute-force online attack takes 50,000 seconds (14 hours) on average
    - This is very conservative. Offline attack is much faster!
  - As described (H(word)), could just create dictionary of "word to H(word)" mapping once -- for all users!!

Salt



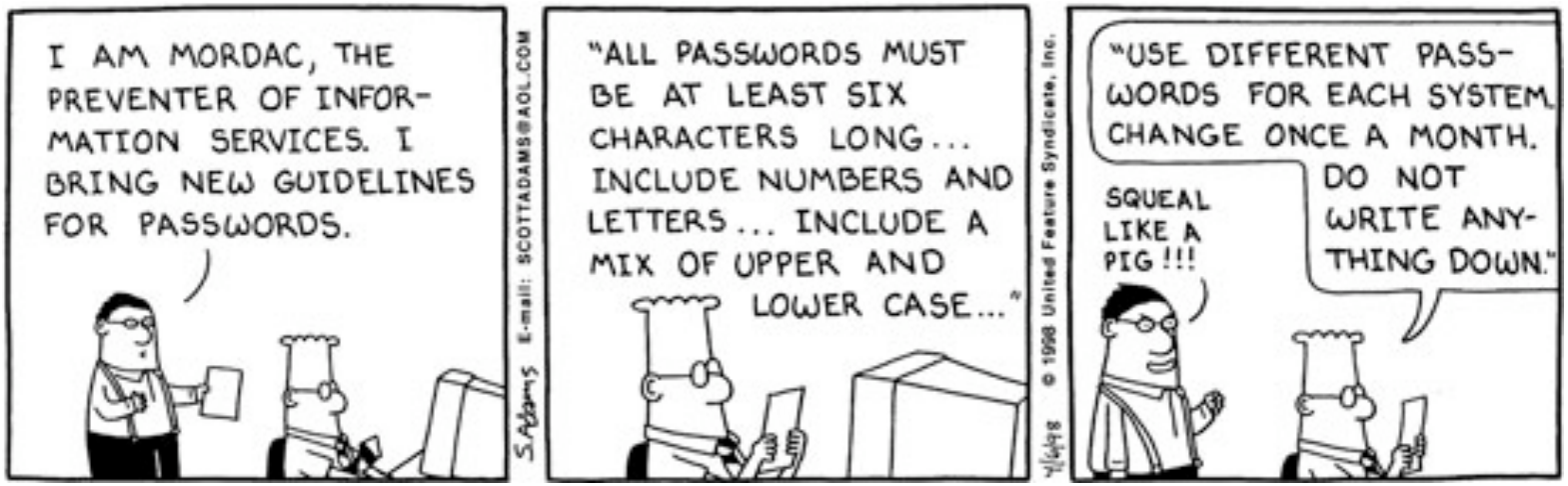
- Users with the same password have <u>different</u> entries in the password file
- Online dictionary attack is still possible! (Precomputed dictionaries possible too -- but significantly more expensive.)

Advantages of Salting

- Without salt, attacker can pre-compute hashes of all dictionary words once for all password entries
  - Same hash function on all UNIX machines
  - Identical passwords hash to identical values; one table of hash values can be used for all password files
- With salt, attacker must compute hashes of all dictionary words once for each password entry
  - With 12-bit random salt, same password can hash to 2^{12} different hash values
  - Attacker must try all dictionary words for each salt value in the password file
- Pepper: Secret salt (not stored in password file)

Other Password Issues

- Keystroke loggers
  - Hardware
  - Software / Spyware
- Shoulder surfing
  - It's happened to me!
- Online vs offline attacks
  - Online: slower, easier to respond
- Multi-site authentication
  - Share passwords?


I AM MORDAC, THE PREVENTER OF INFORMATION SERVICES. I BRING NEW GUIDELINES FOR PASSWORDS.
S. Adams E-mail: SCOTTADAMS@AOL.COM
"ALL PASSWORDS MUST BE AT LEAST SIX CHARACTERS LONG... INCLUDE NUMBERS AND LETTERS... INCLUDE A MIX OF UPPER AND LOWER CASE..."
© 1998 United Feature Syndicate, Inc.
"USE DIFFERENT PASSWORDS FOR EACH SYSTEM. CHANGE ONCE A MONTH. DO NOT WRITE ANYTHING DOWN."
SQUEAL LIKE A PIG!!!

"Improving" Passwords

- Add biometrics
  - For example, keystroke dynamics or voiceprint
  - Revocation is often a problem with biometrics
- Graphical passwords
  - Goal: increase the size of memorable password space
- Password managers

Graphical Passwords

- Images are easy for humans to process and remember
  - Especially if you invent a memorable story to go along with the images
- Dictionary attacks on graphical passwords are difficult
  - Images are believed to be very "random" (is this true?)
- Still not a perfect solution
  - Need infrastructure for displaying and storing images
  - Shoulder surfing

Graphical Password Systems

- *Cognometric schemes*
  - present a set of images,
  - authentication requires selection of correct images
- *Locimetric Schemes*
  - presents a single image, with authentication requiring clicking on regions of the image
- *Drawmetric Schemes*
  - require drawing figures or doodles to authenticate.

Slides from Kate Everitt; CHI 2009, Everitt, Bragin, Fogarty, Kohno

Empirical Results

- Experimental study of 154 computer science students at Johns Hopkins and Carnegie Mellon
- Conclusions:
  - "… faces chosen by users are highly affected by the race of the user… the gender and attractiveness of the faces bias password choice… In the case of male users, we found this bias so severe that we do not believe it possible to make this scheme secure against an online attack…"
- 2 guesses enough for 10% of male users
- 8 guesses enough for 25% of male users

User Quotes

- "I chose the images of the ladies which appealed the most"
- "I simply picked the best lookin girl on each page"
- "In order to remember all the pictures for my login (after forgetting my 'password' 4 times in a row) I needed to pick pictures I could EASILY remember... So I chose beautiful women. The other option I would have chosen was handsome men, but the women are much more pleasing to look at"

More User Quotes

- "I picked her because she was female and Asian and being female and Asian, I thought I could remember that"
- "I started by deciding to choose faces of people in my own race…"
- "… Plus he is African-American like me"

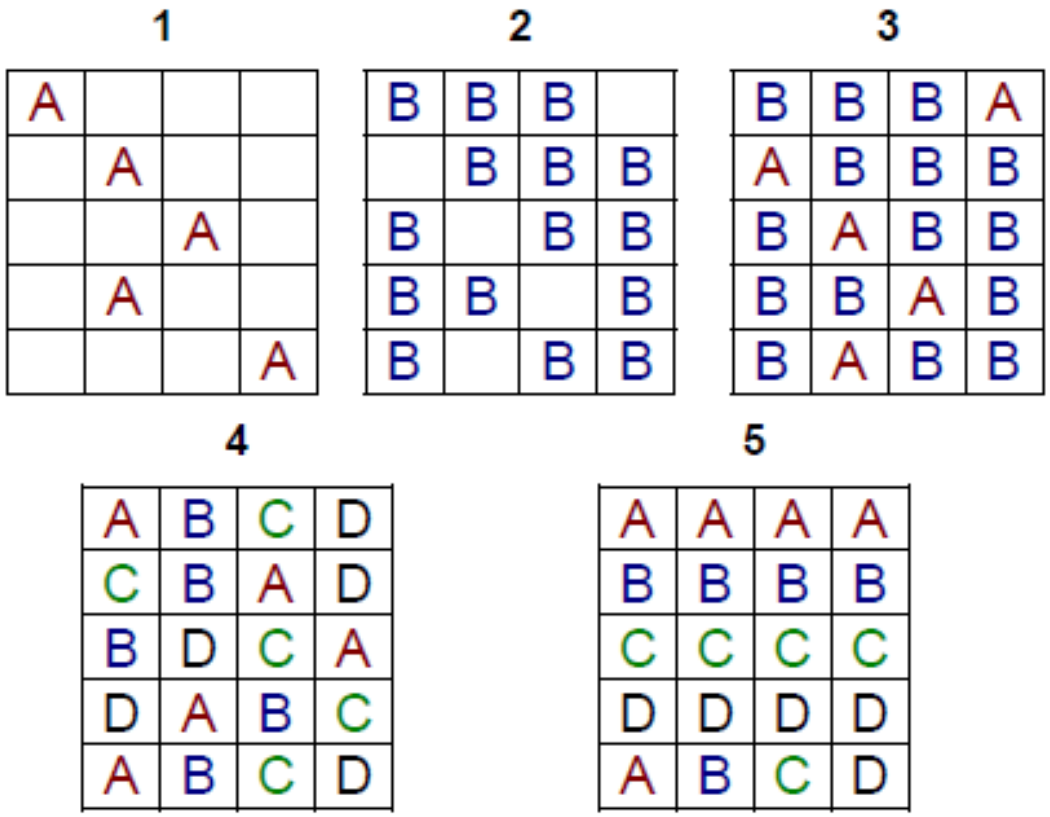
- Recommendation: system picks passfaces
- But is that still memorable? What issues could arise?

What about multiple passwords?

- 109 participants in a 5 week study
- Email-based prompts to access the study website and authenticate
- Study emails were sent on Tuesday, Wednesday, Thursday, and Friday
- Participants were allowed a maximum of three login attempts

Slides from Kate Everitt; CHI 2009, Everitt, Bragin, Fogarty, Kohno

Study Conditions



Frequency, interference, and training do play a role in memorability

Slides from Kate Everitt; CHI 2009, Everitt, Bragin, Fogarty, Kohno

Variants...

- Plus click-based graphical passwords, drawing-based passwords, ...

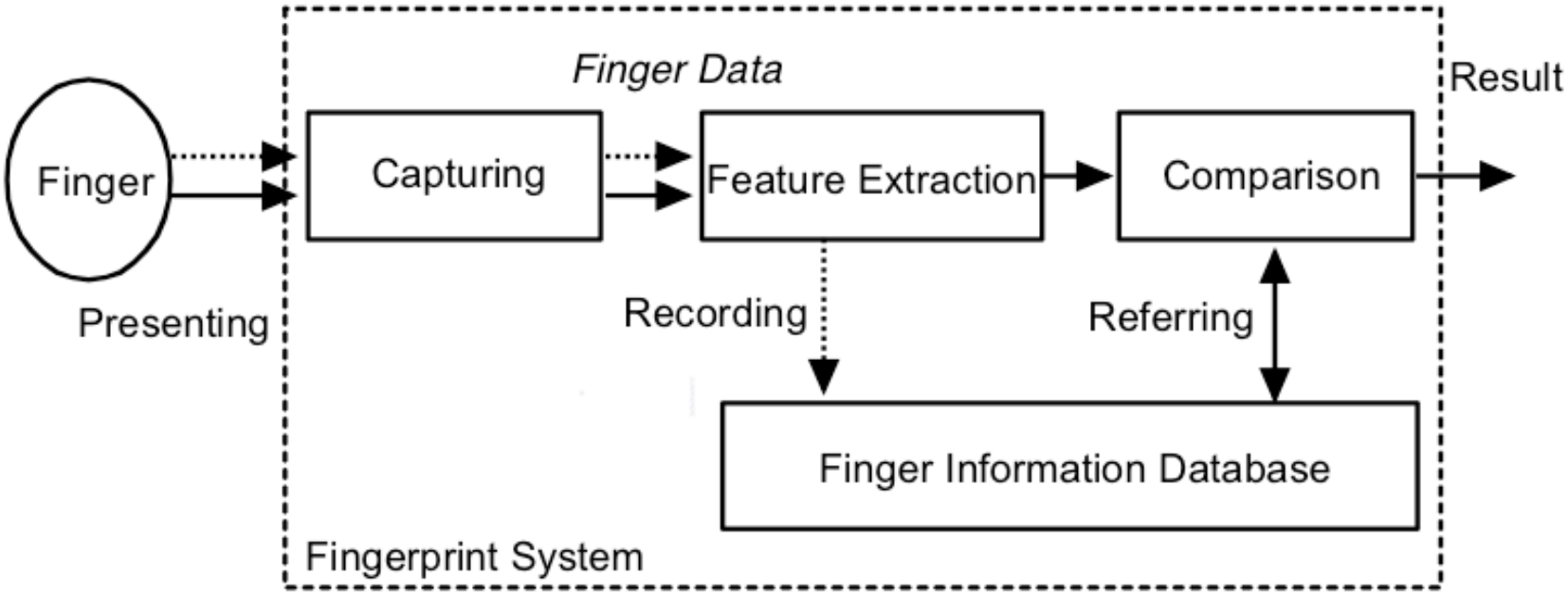
Uses of graphical passwords?

- For what applications might graphical passwords be particularly useful?

What About Biometrics?

- Authentication: What you are
- Unique identifying characteristics to authenticate user or create credentials
  - Biological and physiological: Fingerprints, iris scan
  - Behaviors characteristics - how perform actions: Handwriting, typing, gait
- Advantages:
  - Nothing to remember
  - Passive
  - Can’t share (generally)
  - With perfect accuracy, could be fairly unique

Overview [Matsumoto]



Tsutomu Matsumoto's image, from http://web.mit.edu/6.857/OldStuff/Fall03/ref/gummy-slides.pdf

Dashed lines for enrollment; solid for verification or identification

Biometric Error Rates (Non-Adversarial)

- "Fraud rate" vs. "insult rate"
  - Fraud = system incorrectly accepts (false accept)
  - Insult = system rejects valid user (false reject)
- Increasing acceptance threshold increases fraud rate, decreases insult rate
- For biometrics, U.K. banks set target fraud rate of 1%, insult rate of 0.01% [Ross Anderson]

Biometrics

- Face recognition (by a computer algorithm)
  - Error rates up to 20%, given reasonable variations in lighting, viewpoint and expression
- Fingerprints
  - Traditional method for identification
  - 1911: first US conviction on fingerprint evidence
  - U.K. traditionally requires 16-point match
    - Probability of false match is 1 in 10 billion
    - No successful challenges until 2000
  - Fingerprint damage impairs recognition

Other Biometrics

- Iris scanning
  - Irises are very random, but stable through life
    - Different between the two eyes of the same individual
  - 256-byte iris code based on concentric rings between the pupil and the outside of the iris
  - Equal error rate better than 1 in a million
  - Best biometric mechanism currently known
- Hand geometry
  - Used in nuclear premises entry control, INSPASS (discontinued in 2002)

Other Biometrics

- Vein
  - Pattern on back of hand
- Handwriting
- Typing
  - Timings for character sequences
- Gait
- DNA

Any issues with this?

Canon Files For DSLR Iris Registration Patent

Posted by kdawson on Tuesday February 12, @07:39PM
from the **biological-metadata** dept.

An anonymous reader writes

> "Canon has filed for a patent for using iris watermarking (as in the iris of your eye) to take photographer's copyright protection to the next level. You set up the camera to capture an image of your eye through the viewfinder. Once captured, this biological reference is embedded as metadata into every photo you take. Canon claims this will help with copyright infringement of photos online."

Issues with Biometrics

- Private, but not secret
  - Maybe encoded on the back of an ID card?
  - Maybe encoded on your glass, door handle, ...
  - Sharing between multiple systems?
- Revocation is difficult (impossible?)
  - Sorry, your iris has been compromised, please create a new one...
- Physically identifying
  - Soda machine to cross-reference fingerprint with DMV?

Issues with Biometrics

- Criminal gives an inexperienced policeman fingerprints in the wrong order
  - Record not found; gets off as a first-time offender
- Can be attacked using recordings
  - Ross Anderson: in countries where fingerprints are used to pay pensions, there are persistent tales of "Granny's finger in the pickle jar" being the most valuable property she bequeathed to her family
- Birthday paradox
  - With false accept rate of 1 in a million, probability of false match is above 50% with only 1609 samples

Issues with Biometrics

- Anecdotally, car jackings went up when it became harder to steal cars without the key
- But what if you need your fingerprint to start your car?
  - Stealing cars becomes harder
  - So what would the car thieves have to do?

Risks of Biometrics

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Malaysia car thieves steal finger

By Jonathan Kent
BBC News, Kuala Lumpur

Police in Malaysia are hunting for members of a violent gang who chopped off a car owner's finger to get round the vehicle's hi-tech security system.

The car, a Mercedes S-class, was protected by a fingerprint recognition system.

Accountant K Kumaran's ordeal began when he was run down by four men in a small car as he was about to get into his Mercedes in a Kuala Lumpur suburb.

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Biometric Error Rates (Adversarial)

- Want to minimize "fraud" and "insult" rate
  - "Easy" to test probability of accidental misidentification (fraud)
  - But what about adversarial fraud
    - Besides stolen fingers
- An adversary might try to steal the biometric information
  - Malicious fingerprint reader
    - Consider when biometric is used to derive a cryptographic key
  - Residual fingerprint on a glass

Voluntary: Making a Mold

[Matsumoto]

Put the plastic into hot water to soften it.

Press a live finger against it.

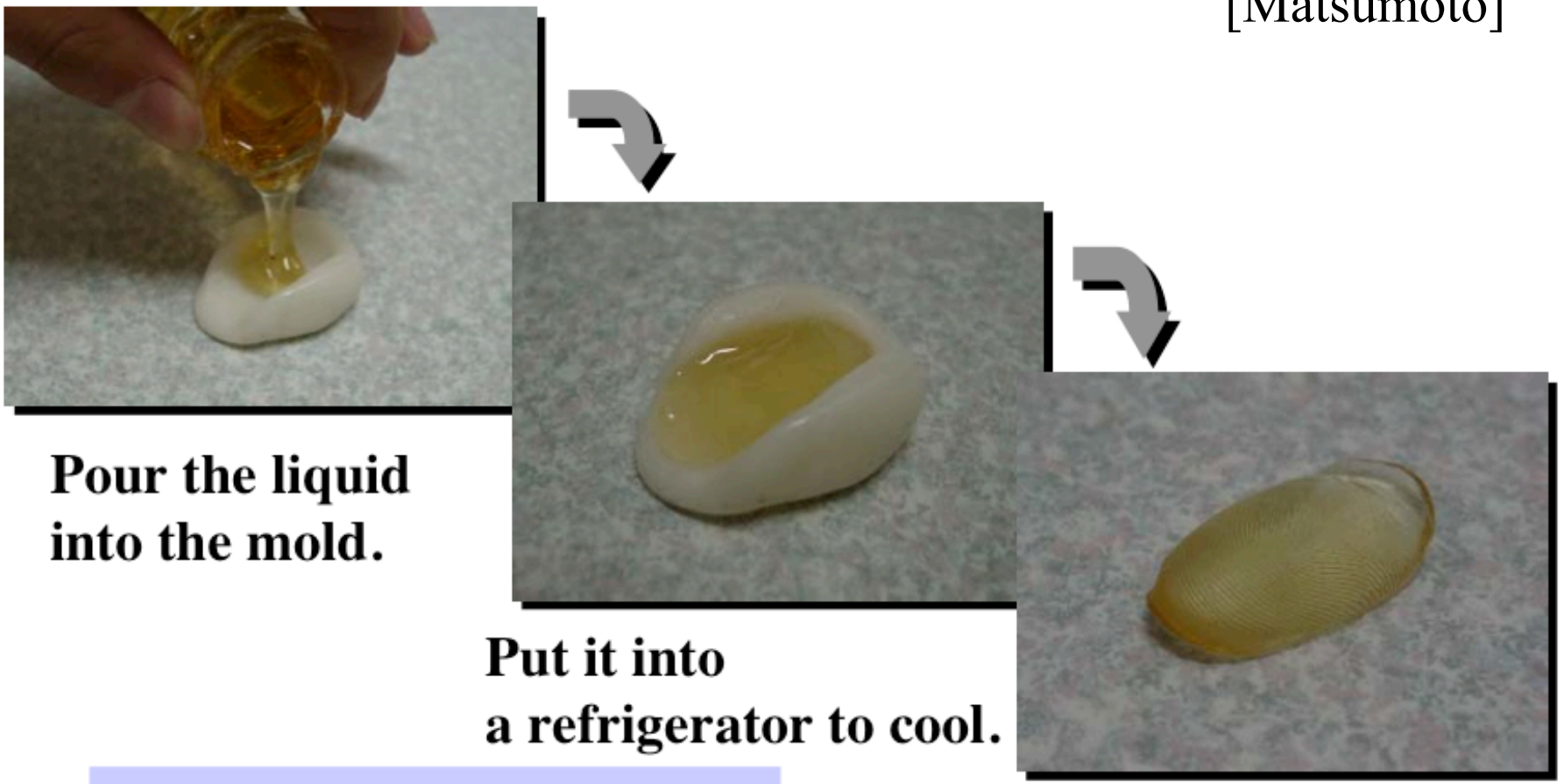
The mold

It takes around 10 minutes.

http://web.mit.edu/6.857/OldStuff/Fall03/ref/gummy-slides.pdf

Voluntary: Making a Finger

[Matsumoto]



Pour the liquid into the mold.

Put it into a refrigerator to cool.

It takes around 10 minutes.

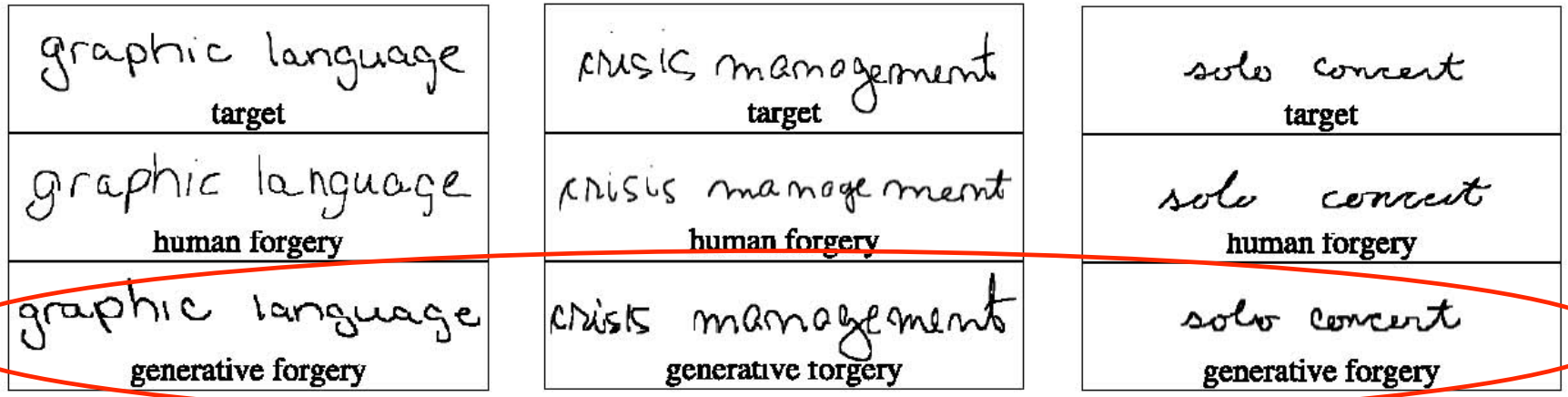
The gummy finger

http://web.mit.edu/6.857/OldStuff/Fall03/ref/gummy-slides.pdf

Authentication by Handwriting

[Ballard, Monrose, Lopresti]

- Maybe a computer could also forge some biometrics



Generated by computer algorithm trained on handwriting samples