Managing Enterprise Cybersecurity
MIS 4596

Unit#13

Agenda

- Update on Reading Summaries &Discussion Briefs
- Introduction
- Hacker’s workflow
- Password vulnerabilities
- Password security techniques
- Password cracking
- Warning
- Lab 5: Password cracking
- Password entropy

- Note: An openssl manual – chapter 2 shows hashing commands

Password Cracking…

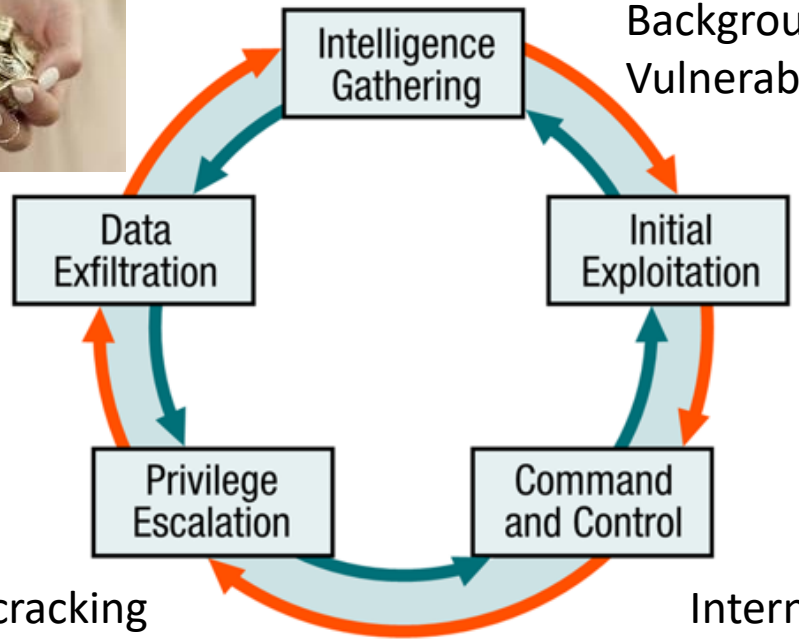
This week begins offensive security (e.g., ethical hacking & penetration testing)

- Explains techniques to crack (i.e., guess) passwords using a variety of techniques
- This lecture and the associated Lab: Password Cracking provides you with what you need to know to crack passwords on Milestone 3: Penetration Test

In Milestone 3, you may have the opportunity to crack passwords in:

- A cryptographic protocol for operating network services securely over an unsecured network
- A local Linux server's user accounts from the hashes found in /etc/shadow,
- Unsalted MD5 hashes in a local database
- And you will have the opportunity to decrypt an encrypted file by guessing its password
- …

Hacker's workflow – *Where Password Cracking fits in…*



Background research
Vulnerability scanning

Vulnerability exploitation

Internal reconnaissance

Password cracking

A penetration test is an authorized simulated cyberattack on a computer system, performed to evaluate the security of the system

Colloquially known as a "pen test", "pentest" or ethical hacking,

Note: We are teaching Password Cracking now (before vulnerability scanning and exploitation), because knowing how to secure your passwords as soon as possible is essential to providing you personally relevant secure awareness training

Password

- A (hopefully) protected string of characters used to authenticate an individual
- Authentication factor based on what a person knows
- Is one of the most often used authentication mechanism

#1	**Choose a phrase with at least 8 words.** *This is my favorite sandwich in the world*
#2	**Take the first letter of each word.** *timfsitw*
#3	**Switch one (or two) to an uppercase.** *TimFsitw*
#4	**Switch one to a number.** *T1mFsitw*
#5	**Switch one to a special character.** *T1mF$itw*
#6	**Add something unique from each site.** (i.e. add a b for banking, an f for facebook, etc.) *T1mF$itwB*

Password vulnerabilities

Although passwords are the most common authentication mechanism, they are one of the weakest security mechanisms available

Why?

- Users choose words easily guessed
- Users tell others their passwords
- Users write passwords down on a sticky note and hide it under the keyboard
- Many users consider security an unimportant uninteresting part of using computers – until someone steals their confidential information…

- This is why password policies are needed
  - With good policies passwords can provide effective security, if they are:
    - Properly generated, updated, and kept secret

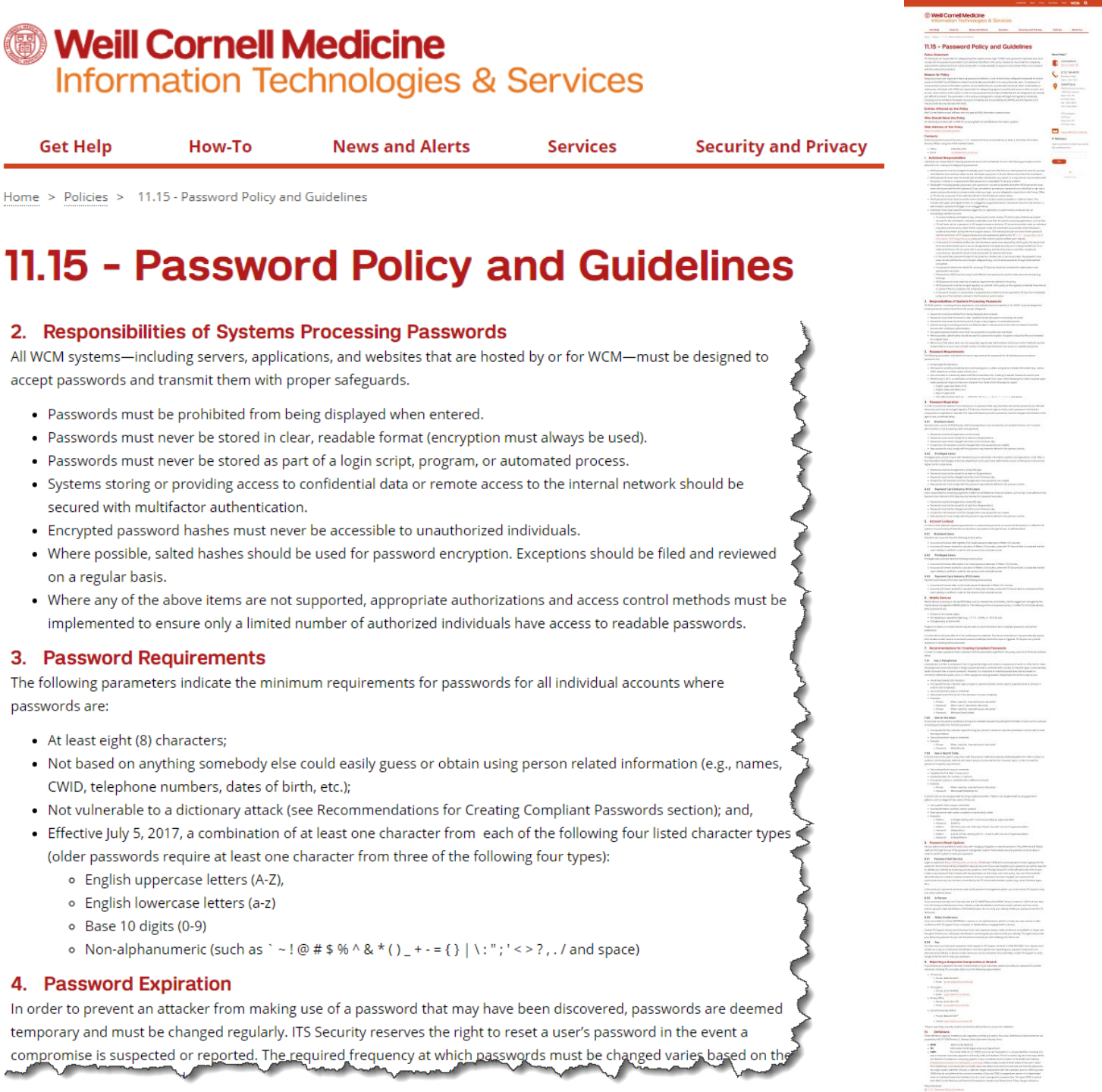
Techniques used to attack a password

- Electronic monitoring – Replay Attack
  - Listening to network traffic to capture data when a user is sending her password to an authentication server
  - The password can be copied and reused by the attacker at another time
- Access the password file
  - Usually done on an authentication server
  - Password file contains many users' passwords – if compromised can be a source of much damage
  - File should be protected with encryption and access control
- Brute-force attack
  - Performed with tools that cycle through many possible character, number, and symbol combinations to uncover a password
- Dictionary attack
  - Files of thousands of words are compared to the user's password until a match if found
- Rainbow table
  - An attacker uses a table that contains all possible passwords already in a hash format
- Social engineering
  - An attacker falsely convinces an individual that she has the necessary authorization to access specific resources

Password Policy

Is a set of rules designed to enhance computer security by encouraging users to employ strong passwords and use them properly

- Is often part of an organization's official regulations and may be taught as part of security awareness training
- Either the password policy is merely advisory, or the computer systems force users to comply with it



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Home > Policies > 11.15 - Password Policy and Guidelines

11.15 - Password Policy and Guidelines

2. Responsibilities of Systems Processing Passwords

All WCM systems—including servers, applications, and websites that are hosted by or for WCM—must be designed to accept passwords and transmit them with proper safeguards.

- Passwords must be prohibited from being displayed when entered.
- Passwords must never be stored in clear, readable format (encryption must always be used).
- Passwords must never be stored as part of a login script, program, or automated process.
- Systems storing or providing access to confidential data or remote access to the internal network should be secured with multifactor authentication.
- Encrypted password hashes must never be accessible to unauthorized individuals.
- Where possible, salted hashes should be used for password encryption. Exceptions should be filed and reviewed on a regular basis.
- Where any of the above items are not supported, appropriate authorizations and access control methods must be implemented to ensure only a limited number of authorized individuals have access to readable passwords.

3. Password Requirements

The following parameters indicate the minimum requirements for passwords for all individual accounts where passwords are:

- At least eight (8) characters;
- Not based on anything somebody else could easily guess or obtain using person related information (e.g., names, CWID, telephone numbers, dates of birth, etc.);
- Not vulnerable to a dictionary attack (see Recommendations for Creating Compliant Passwords section); and,
- Effective July 5, 2017, a combination of at least one character from each of the following four listed character types (older passwords require at least one character from three of the following four types):
  - English uppercase letters (A-Z),
  - English lowercase letters (a-z)
  - Base 10 digits (0-9)
  - Non-alphanumeric (such as ` ~ ! @ # $ % ^ & * ( ) _ + - = { } | \ : " ; ' < > ? , . / and space)

4. Password Expiration

In order to prevent an attacker from making use of a password that may have been discovered, passwords are deemed temporary and must be changed regularly. ITS Security reserves the right to reset a user's password in the event a compromise is suspected or reported. The required frequency at which passwords must be changed varies based on the

Additional Password Security Techniques

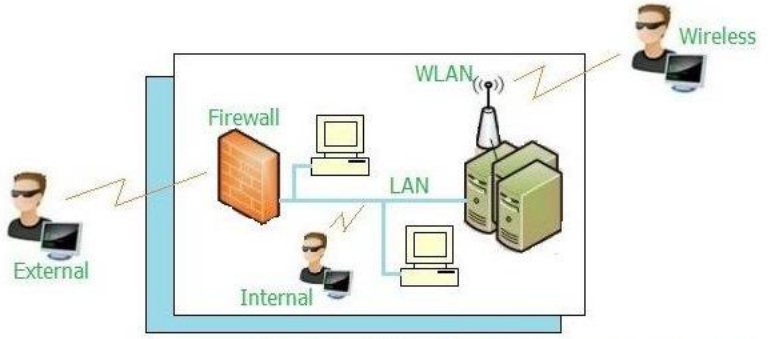
A systems' administrator can:

- Set operating parameters to **test the strength of a password** and only accept new passwords that meet password strength rules
- Set operating parameters to **lock the user out after a certain number of failed logon attempts**
  - Users can be locked out for 5 minutes or a full day based on a threshold
- Turn on **alerts sent to bring the user's attention to logon attempts** using his/her credentials
  - After each successful logon, presenting the date and time of the last successful logon and if there were any unsuccessful logon attempts
- Turn on an **audit trail to track password usage**, and both successful and unsuccessful logon attempts
  - This audit information should include: date, time, user ID, and workstation user logged in from
- **Force the user to change a password on a more frequent basis** to assure the password will not be guessed by an intruder, remembering the password history and blocking reuse of passwords (e.g. last 5 or 10)
  - A balance between protection and practicality must be enforced – too often may lead to users forgetting their passwords and unnecessary management overhead

Additional Password Security Techniques…

Password hashing

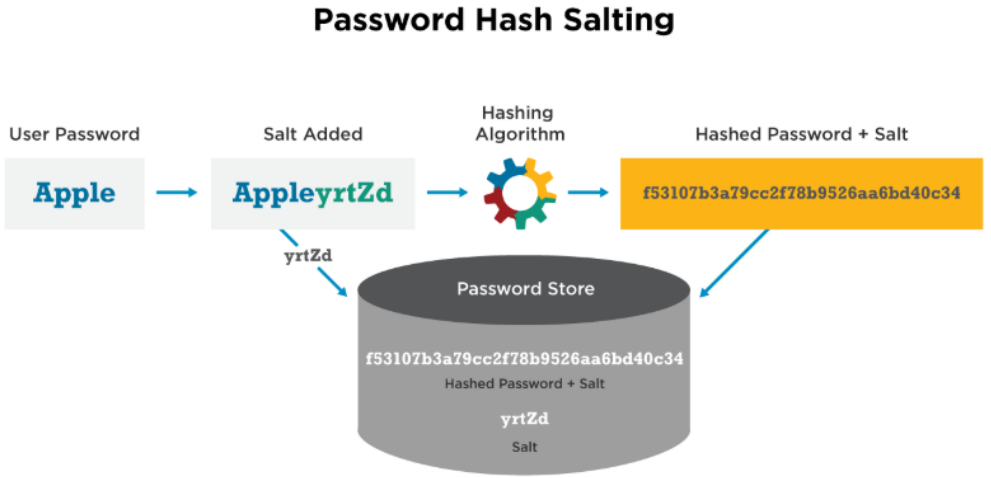
- An attacker capturing (“sniffs”) a password from the network typically has more work to do before knowing the password value because many systems hash the password with a hashing algorithm to ensure passwords are not sent nor stored in cleartext
- Linux and Unix systems do not store plaintext passwords but run the passwords through a hash algorithm and place the hashed passwords in a “shadow” file system



Network Sniffer Types

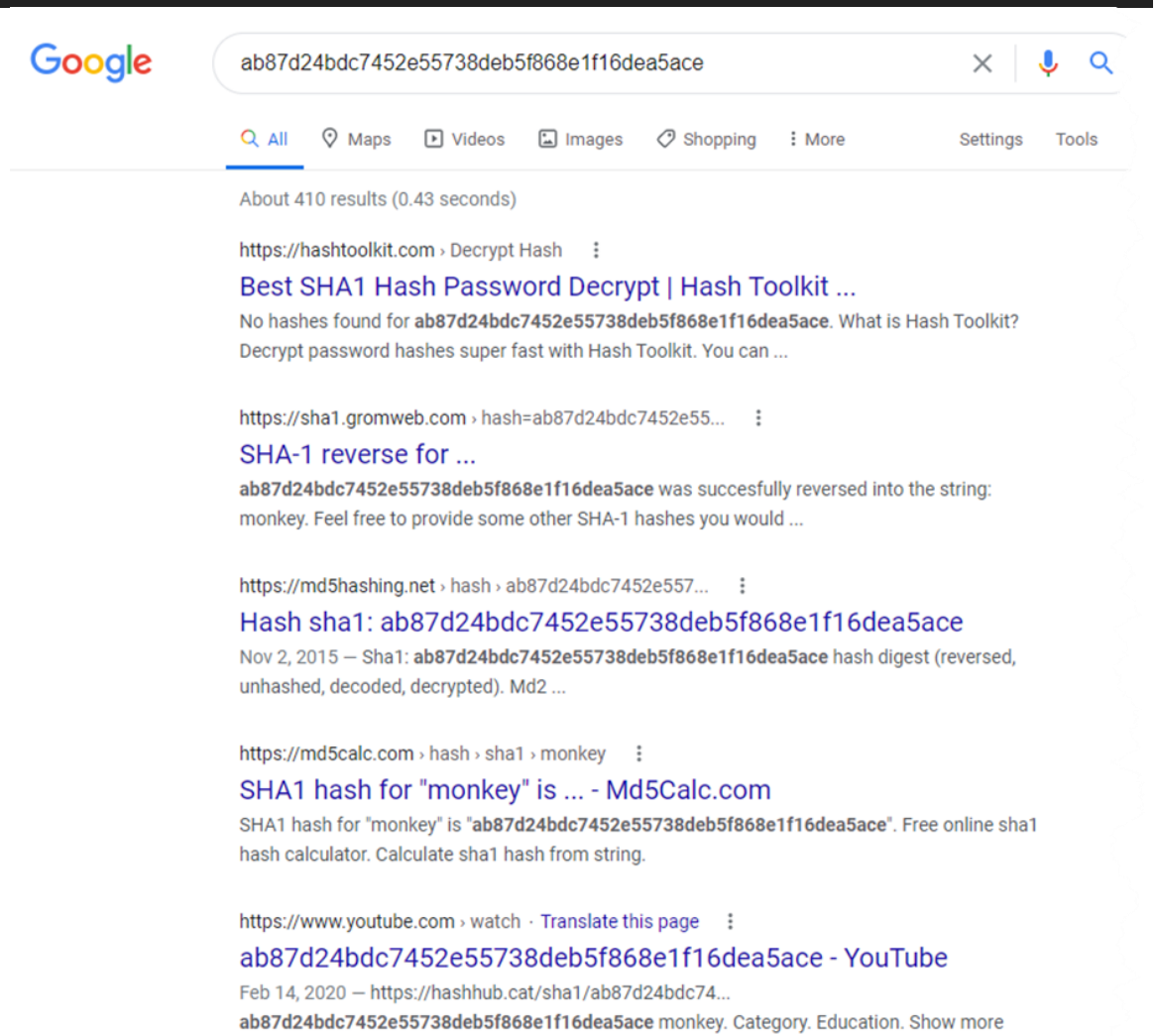
Password hashing with “salt”

- Unix systems can be set to add “salt” to its password hashing
- A salt is a random value concatenated with the password before the hashing to add more randomness and complexity into the encryption process
- This makes it harder for the hacker to decrypt and uncover the password
- Adding different salts into the hashing of the same password can result in several thousand different hashes – making it much more difficult for a hacker to attack the passwords



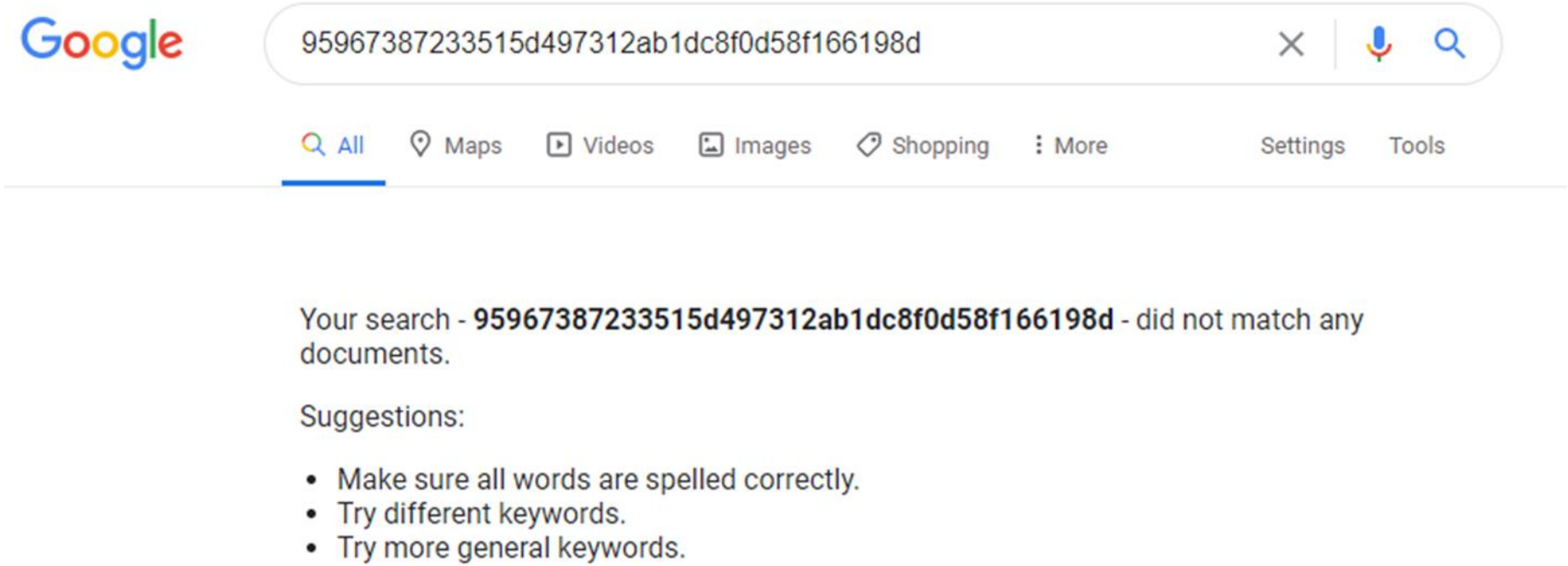
Hash without salt

```
phillipnontenure@kali:~$ echo -n "monkey" | shasum
ab87d24bdc7452e55738deb5f868e1f16dea5ace  -
```



Hash with a salt

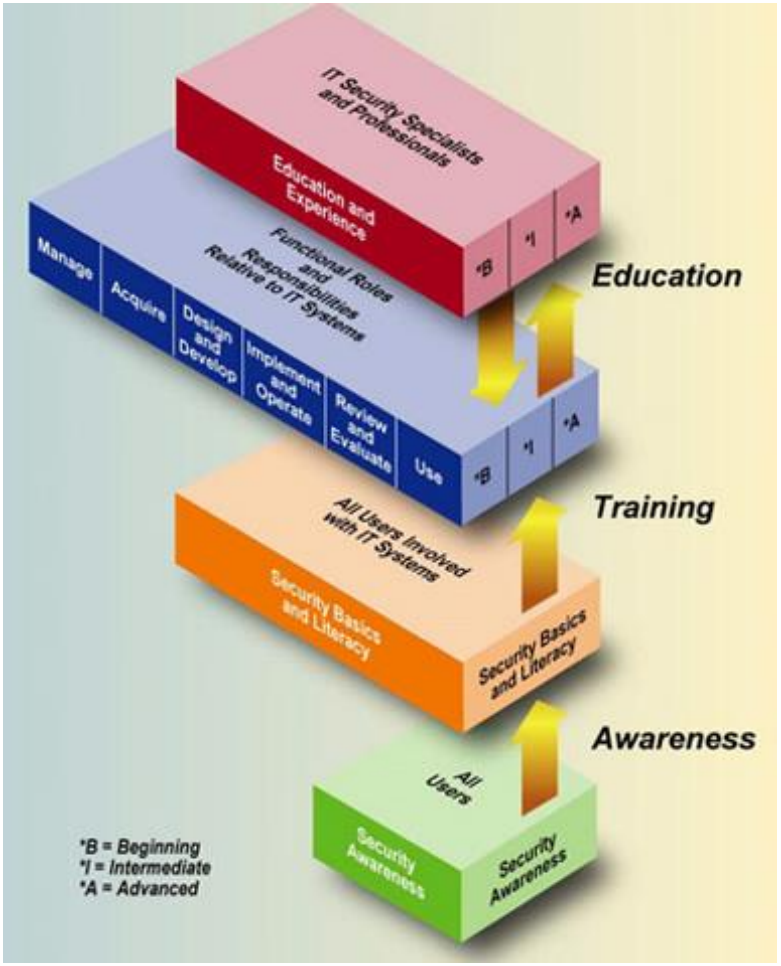
```
phillipnontenure@kali:~$ echo -n "2u9fh928""monkey" | shasum
95967387233515d497312ab1dc8f0d58f166198d  -
```

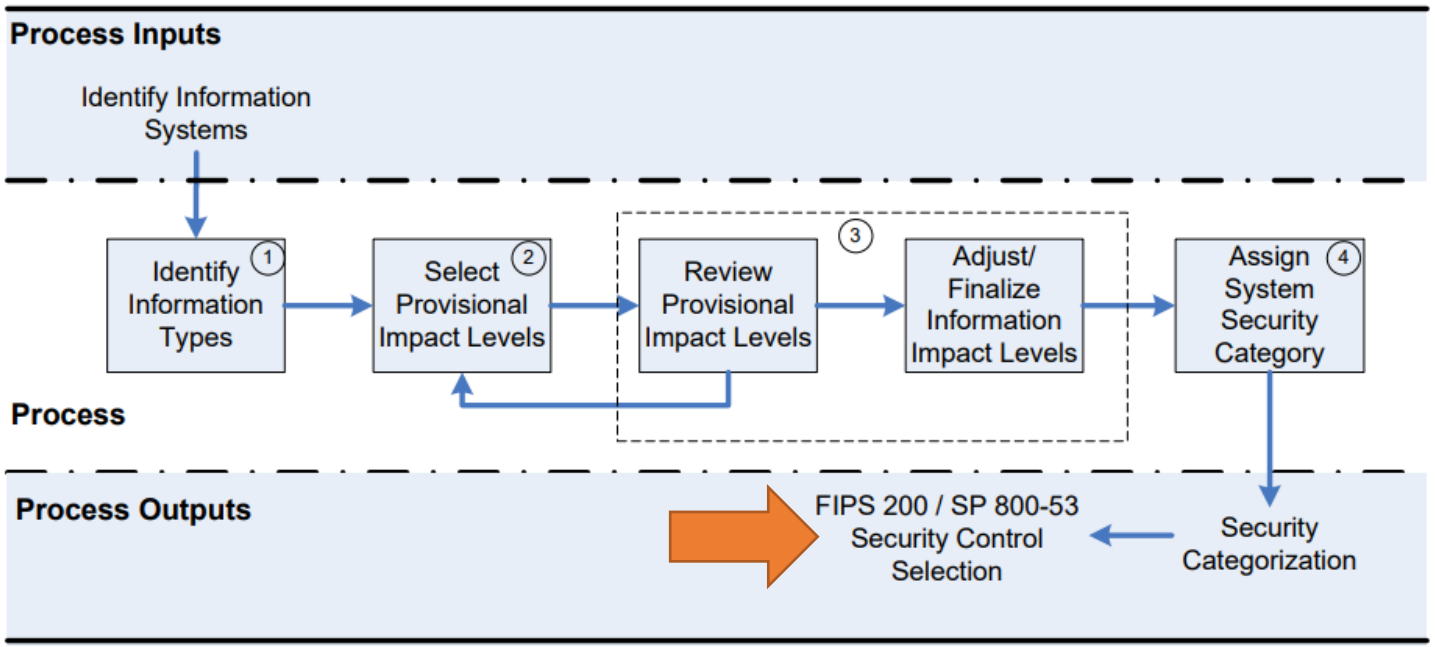


Additional Password Security Techniques…

Education is the key!

- Users should be an extension of a security team, not the opposition
- Security awareness programs should help users
  - Understand what is expected of them
  - Why they should protect their passwords
  - How passwords can be stolen
  - How to protect passwords





NIST Special Publication 800-53
Revision 5

Security and Privacy Controls for Information Systems and Organizations

JOINT TASK FORCE

This publication is available free of charge from:
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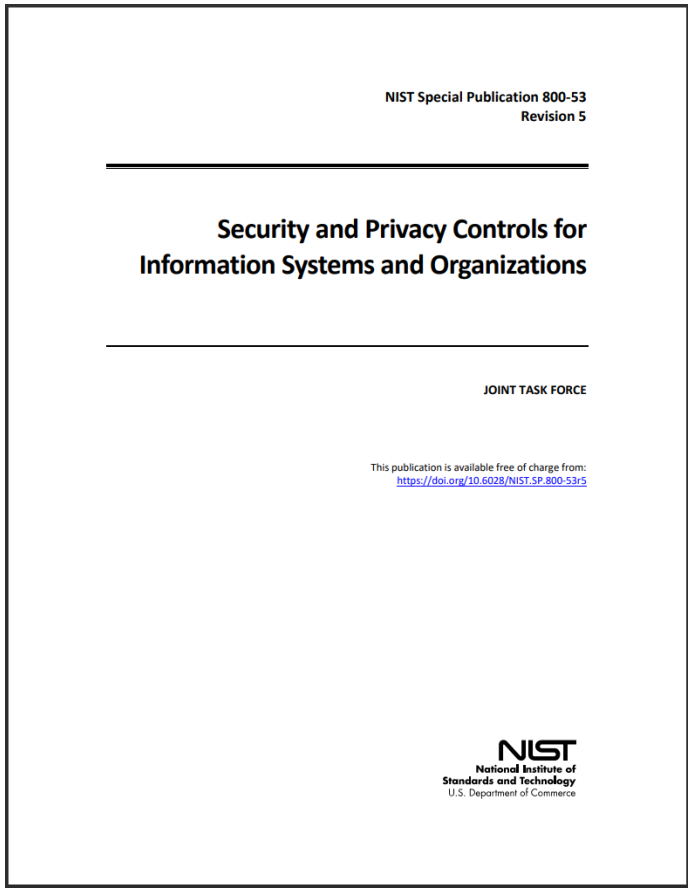
NIST
National Institute of Standards and Technology
U.S. Department of Commerce

Security control class designations help clarify controls in preparation of system security plans



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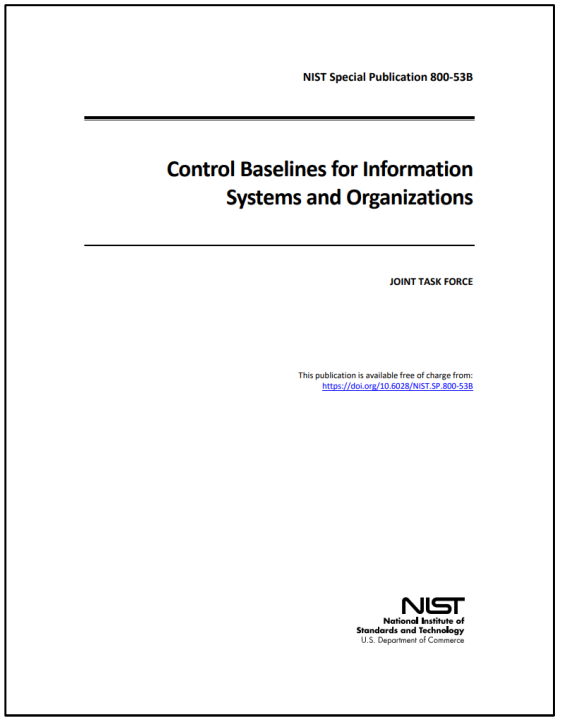
NIST
National Institute of Standards and Technology
U.S. Department of Commerce

CLASS	FAMILY	IDENTIFIER
Management	Risk Assessment	RA
Management	Planning	PL
Management	System and Services Acquisition	SA
Management	Certification, Accreditation, and Security Assessments	CA
Operational	Personnel Security	PS
Operational	Physical and Environmental Protection	PE
Operational	Contingency Planning	CP
Operational	Configuration Management	CM
Operational	Maintenance	MA
Operational	System and Information Integrity	SI
Operational	Media Protection	MP
Operational	Incident Response	IR
Operational	Awareness and Training	AT
Technical	Identification and Authentication	IA
Technical	Access Control	AC
Technical	Audit and Accountability	AU
Technical	System and Communications Protection	SC

Table 2: Security Control Class, Family, and Identifier

Management controls focus on management of the information system and management of risk for a system
Operational controls address security methods focusing on mechanisms primarily implemented and executed by people (as opposed to systems) with technical expertise and/or management expertise
Technical controls focus on automated security controls that the computer system(s) executes

Identification and Authentication Control Family



NIST Special Publication 800-53B

Control Baselines for Information Systems and Organizations

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This publication is available free of charge from: https://doi.org/10.6028/NIST.SP.800-53B

NIST National Institute of Standards and Technology U.S. Department of Commerce

CONTROL NUMBER	CONTROL NAME CONTROL ENHANCEMENT NAME	PRIVACY CONTROL BASELINE	SECURITY CONTROL BASELINES		
			LOW	MOD	HIGH
IA-1	**Policy and Procedures**		x	x	x
IA-2	**Identification and Authentication (Organizational Users)**		x	x	x
IA-2(1)	MULTI-FACTOR AUTHENTICATION TO PRIVILEGED ACCOUNTS		x	x	x
IA-2(2)	MULTI-FACTOR AUTHENTICATION TO NON-PRIVILEGED ACCOUNTS		x	x	x
IA-2(3)	LOCAL ACCESS TO PRIVILEGED ACCOUNTS	W: Incorporated into IA-2(1)(2).			
IA-2(4)	LOCAL ACCESS TO NON-PRIVILEGED ACCOUNTS	W: Incorporated into IA-2(1)(2).			
IA-2(5)	INDIVIDUAL AUTHENTICATION WITH GROUP AUTHENTICATION				x
IA-2(6)	ACCESS TO ACCOUNTS — SEPARATE DEVICE				
IA-2(7)	NETWORK ACCESS TO NON-PRIVILEGED ACCOUNTS — SEPARATE DEVICE	W: Incorporated into IA-2(6).			
IA-2(8)	ACCESS TO ACCOUNTS — REPLAY RESISTANT		x	x	x
IA-2(9)	NETWORK ACCESS TO NON-PRIVILEGED ACCOUNTS — REPLAY RESISTANT	W: Incorporated into IA-2(8).			
IA-2(10)	SINGLE SIGN-ON				
IA-2(11)	REMOTE ACCESS — SEPARATE DEVICE	W: Incorporated into IA-2(6).			
IA-2(12)	ACCEPTANCE OF PIV CREDENTIALS		x	x	x
IA-2(13)	OUT-OF-BAND AUTHENTICATION				
IA-3	**Device Identification and Authentication**			x	x
IA-3(1)	CRYPTOGRAPHIC BIDIRECTIONAL AUTHENTICATION				
IA-3(2)	CRYPTOGRAPHIC BIDIRECTIONAL NETWORK AUTHENTICATION	W: Incorporated into IA-3(1).			
IA-3(3)	DYNAMIC ADDRESS ALLOCATION				
IA-3(4)	DEVICE ATTESTATION				
IA-4	**Identifier Management**		x	x	x
IA-4(1)	PROHIBIT ACCOUNT IDENTIFIERS AS PUBLIC IDENTIFIERS				
IA-4(2)	SUPERVISOR AUTHORIZATION	W: Incorporated into IA-12(1).			
IA-4(3)	MULTIPLE FORMS OF CERTIFICATION	W: Incorporated into IA-12(2).			
IA-4(4)	IDENTIFY USER STATUS			x	x
IA-4(5)	DYNAMIC MANAGEMENT				
IA-4(6)	CROSS-ORGANIZATION MANAGEMENT				
IA-4(7)	IN-PERSON REGISTRATION	W: Incorporated into IA-12(4).			
IA-4(8)	PAIRWISE PSEUDONYMOUS IDENTIFIERS				
IA-4(9)	ATTRIBUTE MAINTENANCE AND PROTECTION				
IA-5	**Authenticator Management**		x	x	x
IA-5(1)	PASSWORD-BASED AUTHENTICATION		x	x	x
IA-5(2)	PUBLIC KEY-BASED AUTHENTICATION			x	x
IA-5(3)	IN-PERSON OR TRUSTED EXTERNAL PARTY REGISTRATION	W: Incorporated into IA-12(4).			
IA-5(4)	AUTOMATED SUPPORT FOR PASSWORD STRENGTH DETERMINATION	W: Incorporated into IA-5(1).			
IA-5(5)	CHANGE AUTHENTICATORS PRIOR TO DELIVERY				
IA-5(6)	PROTECTION OF AUTHENTICATORS			x	x
IA-5(7)	NO EMBEDDED UNENCRYPTED STATIC AUTHENTICATORS				
IA-5(8)	MULTIPLE SYSTEM ACCOUNTS				
IA-5(9)	FEDERATED CREDENTIAL MANAGEMENT				
IA-5(10)	DYNAMIC CREDENTIAL BINDING				
IA-5(11)	HARDWARE TOKEN-BASED AUTHENTICATION	W: Incorporated into IA-2(1) and IA-2(2).			
IA-5(12)	BIOMETRIC AUTHENTICATION PERFORMANCE				
IA-5(13)	EXPIRATION OF CACHED AUTHENTICATORS				
IA-5(14)	MANAGING CONTENT OF PKI TRUST STORES				
IA-5(15)	GSA-APPROVED PRODUCTS AND SERVICES				
IA-5(16)	IN-PERSON OR TRUSTED EXTERNAL PARTY AUTHENTICATOR ISSUANCE				
IA-5(17)	PRESENTATION ATTACK DETECTION FOR BIOMETRIC AUTHENTICATORS				
IA-5(18)	PASSWORD MANAGERS				
IA-6	**Authentication Feedback**		x	x	x
IA-7	**Cryptographic Module Authentication**		x	x	x
IA-8	**Identification and Authentication (Non-Organizational Users)**		x	x	x
IA-8(1)	ACCEPTANCE OF PIV CREDENTIALS FROM OTHER AGENCIES		x	x	x
IA-8(2)	ACCEPTANCE OF EXTERNAL AUTHENTICATORS		x	x	x
IA-8(3)	USE OF FICAM-APPROVED PRODUCTS	W: Incorporated into IA-8(2).			
IA-8(4)	USE OF DEFINED PROFILES		x	x	x
IA-8(5)	ACCEPTANCE OF PIV-I CREDENTIALS				
IA-8(6)	DISASSOCIABILITY				
IA-9	**Service Identification and Authentication**				
IA-9(1)	INFORMATION EXCHANGE	W: Incorporated into IA-9.			
IA-9(2)	TRANSMISSION OF DECISIONS	W: Incorporated into IA-9.			
IA-10	**Adaptive Authentication**				
IA-11	**Re-authentication**		x	x	x
IA-12	**Identity Proofing**			x	x
IA-12(1)	SUPERVISOR AUTHORIZATION				
IA-12(2)	IDENTITY EVIDENCE			x	x
IA-12(3)	IDENTITY EVIDENCE VALIDATION AND VERIFICATION			x	x
IA-12(4)	IN-PERSON VALIDATION AND VERIFICATION				x
IA-12(5)	ADDRESS CONFIRMATION			x	x
IA-12(6)	ACCEPT EXTERNALLY-PROOFED IDENTITIES				

NIST Special Publication 800-53

IA-5 AUTHENTICATOR MANAGEMENT

Control: Manage system authenticators by:

a. Verifying, as part of the initial authenticator distribution, the identity of the individual, group, role, service, or device receiving the authenticator;

b. Establishing initial authenticator content for any authenticators issued by the organization;

c. Ensuring that authenticators have sufficient strength of mechanism for their intended use;

d. Establishing and implementing administrative procedures for initial authenticator distribution, for lost or compromised or damaged authenticators, and for revoking authenticators;

e. Changing default authenticators prior to first use;

f. Changing or refreshing authenticators [*Assignment: organization-defined time period by authenticator type*] or when [*Assignment: organization-defined events*] occur;

g. Protecting authenticator content from unauthorized disclosure and modification;

h. Requiring individuals to take, and having devices implement, specific controls to protect authenticators; and

i. Changing authenticators for group or role accounts when membership to those accounts changes.

Control Enhancements:

(1) AUTHENTICATOR MANAGEMENT | PASSWORD-BASED AUTHENTICATION

For password-based authentication:

(a) Maintain a list of commonly-used, expected, or compromised passwords and update the list [*Assignment: organization-defined frequency*] and when organizational passwords are suspected to have been compromised directly or indirectly;

(b) Verify, when users create or update passwords, that the passwords are not found on the list of commonly-used, expected, or compromised passwords in IA-5(1)(a);

(c) Transmit passwords only over cryptographically-protected channels;

(d) Store passwords using an approved salted key derivation function, preferably using a keyed hash;

(e) Require immediate selection of a new password upon account recovery;

(f) Allow user selection of long passwords and passphrases, including spaces and all printable characters;

(g) Employ automated tools to assist the user in selecting strong password authenticators; and

(h) Enforce the following composition and complexity rules: [*Assignment: organization-defined composition and complexity rules*].

Additional Password Security Techniques

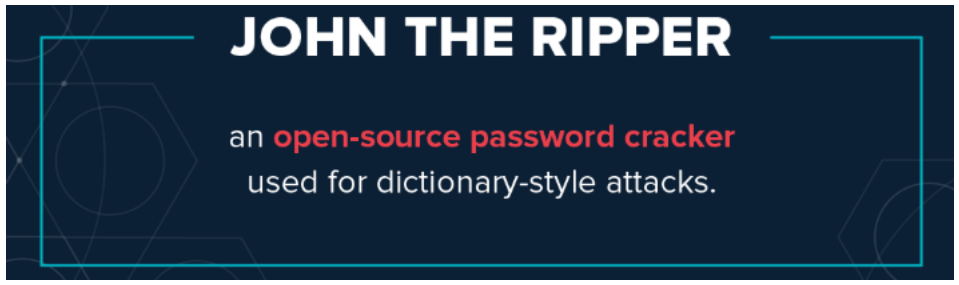
Password Checker

- Is a tool used by a security professional to test the strength of a password
- Performs brute-force, dictionary attacks and/or hybrid techniques to detect weak passwords and fix them before an attacker find the vulnerabilities

Password Cracker

- Is the same tool (i.e. Password Checker) but used by a hacker to uncover vulnerabilities to exploit before the security professional can fix them

Most security tools have this dual nature!



Brutalis

At one time, this was the: “Fastest, meanest, most hardcore password cracker money can buy, …clawing through hashes at unprecedented speeds”

- Sold online for: $21,169
- Shipped with 3-year warranty and full commercial support

- Used Graphics Processing Units (GPU)
  - Their highly parallel structure makes them more efficient than general-purpose central processing units (CPUs) for algorithms that process large blocks of data in parallel

- Used
  - 8 NVIDIA GTX GPUs
  - 2 Intel Xeon E5-2600 v4 CPUs
  - Up to 3 TB memory
  - 18 TB Solid State Device storage

Open Source: [L0phtCrack]


STOP
STOP

WARNING

Never use the tools you learn in this class to test, attack, or break a computer that you do own or have written permission to do so!

For example, you need to obtain management's approval before attempting to test employees' passwords with the intent of identifying weak passwords.

Explaining you are trying to help the situation, and not hurt it, after the fact is not a good situation to be in.

Lab 5: Online & Offline password attacks

Lab: Password Cracking

Part 1: Test Password Security

Part 2: Check an Account for a Prior Data Breach

Part 3. Sign-up for Two Factor Authentication

Part 4. Install and Set up a Password Manager

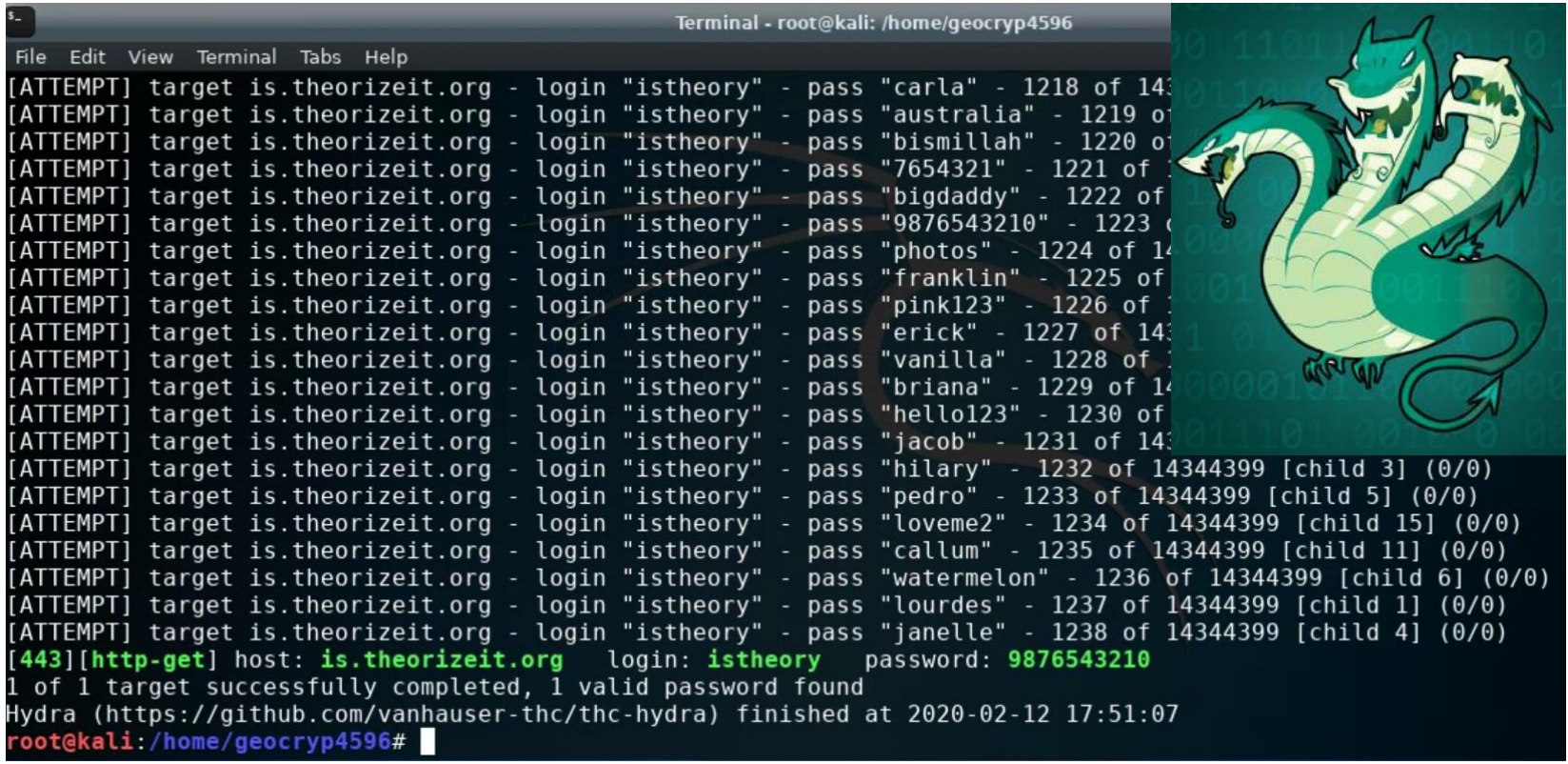
Part 5: Online Password Attack

Part 6: Offline Attack Using Hashcat

Part 7. Cracking LinkedIn Hashes Using Hashcat

Part 8. Secure Password Hashing

Part 9. Create a Targeted Wordlist Using CeWL



Use Caution!

- Never test a password you are currently using and dependent on!
- If you wish to test your password's strength, try a "similarly structured" password
  - Similar length
  - Similar structured use of letters, capitals, special characters, numbers…

Lab: Password Cracking

By Drs. Anthony Vance and Dave Eargle

This lab uses the following VMs:

- Kali

Part 1: Test Password Security

1. Visit the following URL:

   https://lowe.github.io/tryzxcvbn/

   This website estimates the strength of passwords you enter. Passwords never leave your browser – if you are so inclined, you can confirm as much by perusing the source code and/or by opening your browser developer tools and observing the (java)script that runs when you enter passwords.

2. Try out different passwords to see how strong they are.

   Optional: If you want to learn more about password strength estimation, see this video and paper.

Part 2: Check an Account for a Prior Data Breach

1. Check to see if one of your online accounts has already been breached.

   Visit: https://haveibeenpwned.com. Type in one of your email accounts or usernames to see if it has already been compromised in a data breach.

2. Next visit: https://haveibeenpwned.com/Passwords

   Try out some passwords to see if they have already been compromised in a data breach.

3. Finally, visit: https://haveibeenpwned.com/NotifyMe

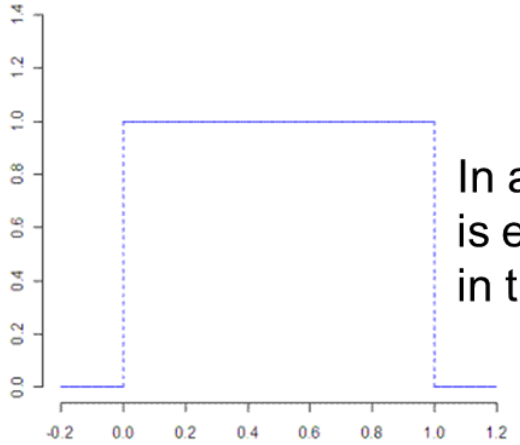
   Sign up to be notified when one of your accounts is breached in the future.

Question: Was one of your accounts breached? If so, which one(s)?

Password Entropy

Password entropy is a measurement of how unpredictable a password is

- Password strength is usually expressed in terms of ”information entropy”
- A password based on a random selection of 64 bits (8 8-bit ASCII characters) would require 2^{64} (18,446,744,073,709,551,616) attempts to exhaust all possibilities during a brute force search
  - Thus, by increasing the entropy of the password by one more randomly selected bit doubles the number of guesses, making an attacker's task twice as difficult
  - On average, an attacker will have to try half the possible number of passwords before finding the correct one



In a uniform distribution any number is equally likely, the average is right in the middle, or half the distribution

Diceware Exercise – Part 1

In teams of 2:

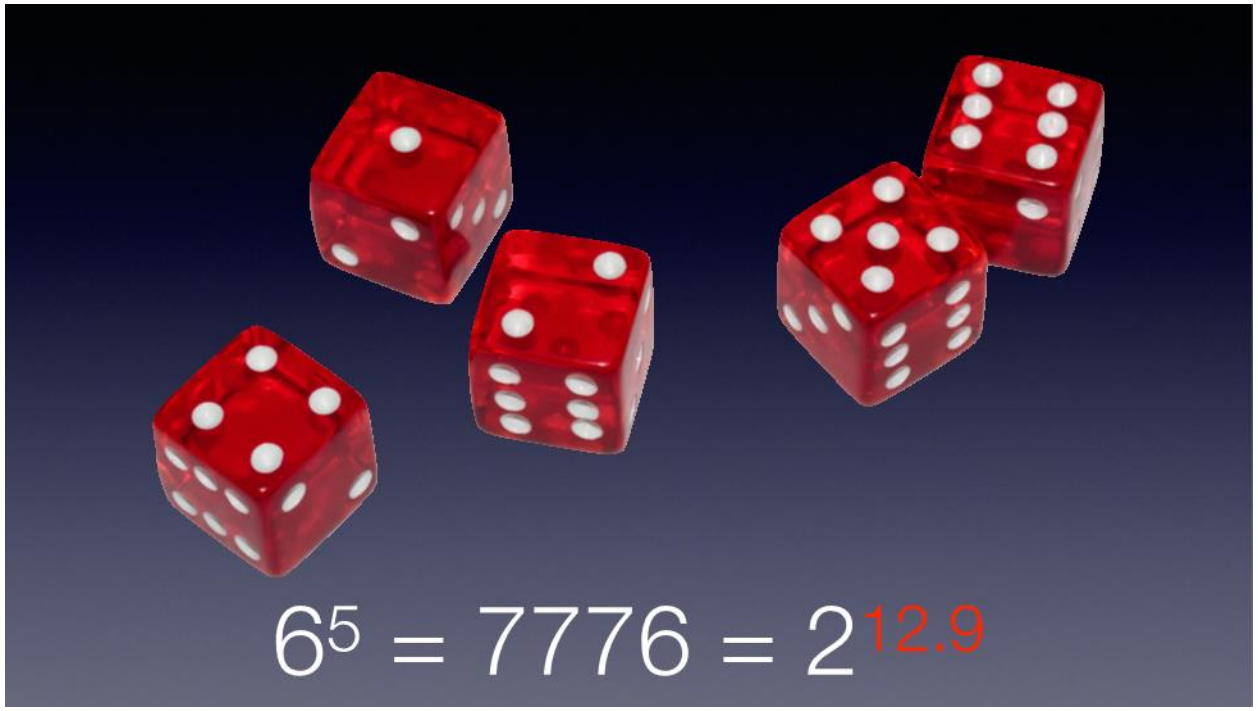
- Role the 5 dice to generate a random 5-digit number
  - https://www.random.org/dice/

- Use the 5-digit to select a “random” word from:
  - https://www.eff.org/files/2016/07/18/eff_large_wordlist.txt

```
11111   abacus
11112   abdomen
11113   abdominal
11114   abide
11115   abiding
11116   ability
11121   ablaze
11122   able
11123   abnormal
11124   abrasion
11125   abrasive
11126   abreast
11131   abridge
11132   abroad
11133   abruptly
11134   absence
11135   absentee
11136   absently
11141   absinthe
11142   absolute
11143   absolve
11144   abstain
11145   abstract
```

```
66634   zealous
66635   zebra
66636   zen
66641   zeppelin
66642   zero
66643   zestfully
66644   zesty
66645   zigzagged
66646   zipfile
66651   zipping
66652   zippy
66653   zips
66654   zit
66655   zodiac
66656   zombie
66661   zone
66662   zoning
66663   zookeeper
66664   zoologist
66665   zoology
66666   zoom
```

Diceware Exercise



The strength of a Diceware passphrase depends on how many words it contains. If you choose one word (out of a list of 7,776 words), an attacker has a 1 in 7,776 chance of guessing your word on the first try. To guess your word it will take an attacker at least one try, at most 7,776 tries, and on average 3,888 tries (because there's a 50 percent chance that an attacker will guess your word by the time they are halfway through the word list).

This means that with two words, there are $7{,}776^2$, or 60,466,176 different potential passphrases. On average, a two-word Diceware passphrase could be guessed after the first 30 million tries.

And a five-word passphrase, which would have $7{,}776^5$ possible passphrases, could be guessed after an average of 14 quintillion tries (a 14 with 18 zeroes).

The amount of uncertainty in a passphrase (or in an encryption key, or in any other type of information) is measured in bits of entropy. You can measure how secure your random passphrase is by how many bits of entropy it contains.

Each word from the Diceware list is worth about 12.92 bits of entropy (because $2^{12.92}$ is about 7,776). Therefore, if you choose seven words – you will end up with a passphrase with about 90.5 bits of entropy (because 12.92 times seven is about 90.5).

https://theintercept.com/2015/03/26/passphrases-can-memorize-attackers-cant-guess/

Diceware Exercise – Part 2

- Answer the following questions:
  1. Using dice, create a five-word Diceware passphrases. What passphrases did you create?

  2. What is the amount of entropy in bits for your five-word Diceware passphrases? How many possible passwords does that represent?

     ***Note**: Each Diceware word is worth an additional 12.9 bits of entropy. This is because $2^{12.9} \approx 7776$, the length of the Diceware word list.*

  1. On average, how long in hours would it take to guess a five-word Diceware passphrase if you could try 1 billion passwords a second? How many years? Show your work.

     ***Note:** The average of a uniform distribution is half the numbers in a set.*

Agenda

- ✓Introduction
- ✓Hacker’s workflow
- ✓Password vulnerabilities
- ✓Password security techniques
- ✓Password cracking
- ✓Warning
- ✓Lab 5: Password cracking
  - ✓Caution
- ✓Password entropy