


Mnemonic Password Formulas

Remembering Secure Passwords

l)ruid <druid@caughq.org>

What is a Mnemonic Password Formula?

 A Mnemonic Password Formula, or “MPF”, is a mental mapping of known elements that allows a user to quickly generate an adequately sized, adequately complex, and unique password for any given authenticating system.



Why are MPFs Needed?

- ⊠ The security landscape today is cluttered with authentication systems
- ⊠ Even with single-sign-on and multi-system authentication methods, there are still a number of disconnected systems a user must interface with (business, personal, websites, etc.)
- ⊠ Remembering or managing storage of complex passwords for all these systems can be a nightmare
- ⊠ The focus of attacks on authentication systems seems to be shifting toward intelligent guessing of passwords



Shifting The Focus

- ⊠ As modern encryption, authentication, and message digest formulas get stronger, the attack vector for authentication is shifting³:
 - ⊠ Away from computationally breaking the password storage method (MD5, SHA-1, etc.) or brute-forcing the password
 - ⊠ Toward intelligently guessing a user's password (dictionary attacks and context word targets)
- ⊠ The user's choice in passwords is today's weakest link in authentication methods



The Numbers Game

- ⊠ Most users, if left to their own devices, generally will not choose complex passwords themselves, instead opting for single dictionary words not using capitalization or special characters.
- ⊠ These types of passwords require much less effort (and time) to crack than brute-forcing the key space if using an optimized dictionary attack method.
- ⊠ For these reasons, most modern attacks on authentication systems target guessing the user's password first before attempting to brute-force the password.



Problems With Passwords Today

- ⊠ If not allowed to write them down, users choose easy to remember passwords and tend to reuse passwords across multiple systems
- ⊠ If allowed to write them down, users may choose harder to remember passwords, however:
 - ⊠ They may store them in multiple insecure locations (home, work, etc.)
 - ⊠ They may store them where they could become inaccessible and will require the password to be administratively reset



Failing Stupid

- ✘ Users today are tasked with remembering so many unique passwords, it's almost standard now for authentication systems (especially on the web) to provide a 'fail stupid' method of recovering a password.
- ✘ Bypassing the (hopefully) adequate authentication system, a user can generally reset a password or have it sent to them by answering a pre-chosen, easy question, such as:
 - ✘ What is your mother's maiden name?
 - ✘ What is your favorite color?
 - ✘ What is/was your high-school mascot?
- ✘ These types of questions are ripe targets for a user-context attack, the answers to which may be easily researchable via public information.



One Solution

- ☒ Recently, at a conference hosted by AusCERT, Microsoft's Jesper Johansson suggested¹ reversing decades of Information Security best practice of not writing down passwords
- ☒ He claims that the method of password security wherein users are prohibited from writing passwords down is absolutely wrong
- ☒ Instead, he advocates allowing users to write down their passwords



One Solution (cont.)

- ☒ While Mr. Johansson correctly identifies some of the problems of password security, his approach to solving the problems is not only short-sighted, but incomprehensive
- ☒ His solution solves the problem of users having to remember multiple complex passwords
- ☒ His solution creates the problems of the written passwords being physically less secure, or prone to require administrative reset due to loss



What Could Be Better?

A better solution to the password memorization problem might be to use one of a number of mnemonic techniques, such as:

- ✘ A password constructed from the first letters of an easy to remember phrase or sentence
- ✘ A modified version of a regular password
- ✘ Pass phrases



Mnemonic Passwords

- ✘ Mnemonic passwords have been used for quite some time and are nothing new.
- ✘ An example of a mnemonic password would be to use the first letters of an easy to remember phrase:

“Jack and Jill went up the hill”

which would become:

“JaJwuth”



The Problem With Mnemonic Passwords

- ✘ In order for mnemonic passwords to be effective, the original phrase must be easy to remember
- ✘ Easy to remember phrases generally don't contain non-alphanumeric or special characters and may yield passwords that are not very complex
- ✘ Mnemonic passwords might be reused across multiple systems; a user would still have to remember a unique phrase per system



More Secure Mnemonic Passwords

⊗ MSMPs² are passwords that are derived from simple passwords that the user will easily remember but that use mnemonic substitutions to give the password a more random quality.

⊗ “l33t-sp34k”ing your password is a simple example of this:

beerbash > b33rb4sh
catwoman > c@w0m4n



The Problem with MSMPs

- ✘ Not all passwords can be easily transformed, limiting either choice of available passwords or the password's pseudo-randomness
- ✘ Passwords might be reused across multiple systems; a user would still have to remember a unique MSMP per system



Pass Phrases

- ❏ Pass phrases are essentially the root of mnemonic passwords
- ❏ They are easy to remember
- ❏ Pass phrases are much longer and therefore take more time to brute-force than mnemonic passwords
- ❏ Pass phrases are generally more complex than mnemonic passwords because they usually contain spaces, capital and lowercase letters, and occasionally special characters, punctuation, or numbers



The Problem With Pass Phrases

- ✘ Many systems don't support lengthy authentication tokens, thus pass phrases are not usable consistently
- ✘ Pass phrases might be reused across multiple systems; a user would still have to remember a unique pass phrase per system



Mnemonic Password Formulas

(Why you're attending this presentation)

Mnemonic Password Formulas

- ✘ Given a well designed MPF, the resultant password can be:
 - ✘ A seemingly random string of characters
 - ✘ Very complex and hard to crack
 - ✘ Easy to construct via memory of just the formula and knowledge of the target authenticating system
 - ✘ Unique for each user, class of access, and system the user is authenticating to



Formula Syntax

- ☒ For the purposes of this presentation, the following formula syntax will be used:
 - ☒ $\langle X \rangle$: An element, where $\langle X \rangle$ is meant to be replaced by something known
 - ☒ $|$: (pipe) When used within angle brackets (\langle and \rangle), represents an OR value choice
 - ☒ All other characters are literal



A Simple Formula

- ✘ First we'll look at a very simple MPF to demonstrate the concept
- ✘ Given the user authenticating and the system being authenticated to, we could construct an formula like this:

`<user>!<hostname|lastoctet>`



<user>!<hostname|lastoctet>

 This MPF would yield passwords such as:

druid!neo (druid@neo.jpl.nasa.gov)

intropy!intropy (intropy@intropy.net)

thegnome!nmrc (thegnome@nmrc.org)

druid!33 (druid@10.0.0.33)

etc...



<user>!<hostname|firstoctet>

- ⊠ This MPF generally creates adequately long passwords and contains a special character, however:
 - ⊠ The passwords are not very complex
 - ⊠ Containing the full username and hostname may make the passwords easy to crack
 - ⊠ The passwords may not be unique per system
 - ⊠ The passwords are variable length and not guaranteed to meet password length requirements



A More Complex MPF

Next we'll look at a slightly more complex MPF. Given the user authenticating and the system being authenticated to, we could construct an formula like this:

`<u>!<h>.<d>`

In this formula:

`<u>` represents the first letter of the username

`<h>` represents the first letter of the hostname or first number of the first address octet

`<d>` represents the first letters of the remaining domain name parts or first numbers of the remaining address octets concatenated together.

We also added another special character, the '.' between `<h>` and `<d>`



<u>!<h>.<d>

☒ This MPF would yield passwords such as:

d!n.jng (druid@neo.jpl.nasa.gov)

i!i.n (intropy@intropy.net)

t!n.o (thegnome@nmrc.org)

d!1.003 (druid@10.0.0.33)

etc...



<u>!<h>.<d>

⊠ This MPF creates fairly complex passwords and contains two special characters, however:

- ⊠ The passwords are variable length and not guaranteed to meet minimum password length requirements
- ⊠ The MPF is beginning to become complex and may not be easily remembered



MPF Design Goals

- ✘ Contain enough elements to always yield a minimum password length
- ✘ Contain enough complex elements such as capitol letters and special characters to yield a complex password
- ✘ Elements must be unique enough to yield a unique password per system
- ✘ Elements must be easy to remember for the user



Meeting the Design Goals

- ⊠ An adequately complex and easy to remember MPF may be something like this:

$\langle u \rangle @ \langle h \rangle . \langle d \rangle ;$

- ⊠ In this formula:

- ⊠ $\langle u \rangle$ represents the first letter of the username
- ⊠ $\langle h \rangle$ represents the first letter of the hostname or first number of the first address octet
- ⊠ $\langle d \rangle$ represents the last letter of the domain name or last number of the last address octet



`<u>@<h>.<d>;`

☒ This MPF would yield passwords such as:

`d@n.v;` (druid@neo.jpl.nasa.gov)

`i@i.t;` (intropy@intropy.net)

`t@n.g;` (thegnome@nmrc.org)

`d@1.3;` (druid@10.0.0.33)

etc...



`<u>@<h>.<d>;`

- ⊠ This MPF creates adequately complex passwords and contains multiple special characters
- ⊠ This MPF always creates passwords 6 characters in length
- ⊠ The MPF is fairly easy to remember:
 - ⊠ The elements read in a natural way: “user at host dot domain”
 - ⊠ It was designed by a C programmer, who will be able to remember to put a ‘;’ at the end.



Even More Complexity

☒ You can make your MPF's output even more complex with a few simple techniques:

- ☒ Repeating Elements

- ☒ Variable Elements

- ☒ Rotating and Incrementing Elements

☒ These techniques may make the MPF harder to remember, so use sparingly



Repeating Elements

- ✘ Your MPF can generate longer and even more complex passwords by repeating elements
- ✘ For example, you may want to repeat an element such as the first letter of the hostname:

```
<u>@<h><h>.<d>;
```



Variable Elements

- ✘ Your MPF can generate even more complex passwords by including variable elements
- ✘ For example, you may want to include an element indicating whether the target system is personal or business by adding the characters 'p:' or 'b:' to the beginning of the formula:

```
<p|b>:<u>@<h>.<d>;
```



Variable Elements (cont.)

☒ To take the previous example even further, the variable element could be the first letter of the system's managing entity:

`<x>:<u>@<h>.<d>;`

☒ `<x>` could be:

☒ personal: p

☒ Exxon-Mobil: E

☒ dc214: d



Variable Elements (cont.)

- Variable elements can be used to differentiate between classes of access
- For example, using the same formula for super-user and normal-user access on the same system may result in passwords that have only minor differences
- Adding a variable element helps to mitigate this similarity. By adding the characters '0:' (super-user) or '1:' (normal-user) to the beginning of the formula, we can increase complexity and identify class of access:

`<0|1>:<u>@<h>.<d>;`



Rotating and Incrementing Elements

- ☒ You can use rotating or incrementing elements to help manage password changes required to conform to a password policy
- ☒ A rotating element is a variable element that rotates through a list of values such as:
 - ☒ apple, orange, banana, etc.
- ☒ An incrementing element is a linear sequence of values to be stepped through such as:
 - ☒ 1,2,3, etc.
 - ☒ one, two, three, etc.



Rotating and Incrementing Elements (cont.)

Each time a system requests that you change your password, rotate or increment the variable element:

`<u>@<h>.<d>:<#>` would result in passwords like `d@c.g:1`, `d@c.g:2`, `d@c.g:3`, etc.

`<u>@<h>.<d>:<fruit>` would result in passwords like `d@c.g:apple`, `d@c.g:orange`, `d@c.g:banana`, etc.

The only additional piece of information the user must remember in addition to the formula itself is the current value of the rotating or incrementing element.



Managing Enterprise MPFs

- ⊠ Large organizations could use assigned MPFs for dual-access to a user's accounts across the enterprise.
- ⊠ If the enterprise's Security group assigns unique MPFs to its staff, Security Officers are then able to access the user's accounts without intrusively modifying the account.
- ⊠ This type of management may be used for:
 - ⊠ Account access when staff are absent
 - ⊠ Shared accounts between multiple staff members
 - ⊠ Staff surveillance by the Security group



MPF Weaknesses

- ⊗ If the MPF is compromised, all passwords to systems that the user uses the MPF for are compromised
- ⊗ Without rotating or incrementing elements, MPF generated passwords are not resilient to password expiration policies



Research Paper

Uninformed Journal Vol. 7

 <http://www.uninformed.org/?v=7&a=3&t=sumry>

Alternate Copy

 <http://druid.caughq.org/papers/Mnemonic-Password-Formulas.pdf>



Q&A

Any questions?

References and Further Reading

- ☒ [1] Microsoft Security Guru: Jot Down Your Passwords (Munir Kotadia, News.com.com, May 23, 2005)
☒ <http://news.com.com/Microsoft+security+guru+Jot+down+your+password>
- ☒ [2] More Secure Mnemonic-Passwords (Stephan Vladimir Bugaj)
☒ <http://www.cs.uno.edu/Resources/FAQ/faq4.html>
- ☒ [3] How to Choose a Passphrase FAQ
☒ <http://www.skuz.net/passfaq.html>
- ☒ The Memorability and Security of Passwords – Some Empirical Results (Yan, Blackwell, Anderson, & Grant, Cambridge University Computer Laboratory)
☒ <http://www.ftp.cl.cam.ac.uk/ftp/users/rja14/tr500.pdf>

