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# DESCRIPTION

**[0001]** The present invention relates to a password audit system for determining the strength of user passwords in a computer system, application or network to which a plurality of users have access via a user identification and password.

## BACKGROUND OF THE INVENTION

**[0002]** Passwords are the most widely used authentication mechanism in computer environments. In the computer systems, applications and networks mentioned above, passwords are used to protect the identity of the users and to enable authenticated access to resources and data. For authentication of the users, their password data have to be stored within the protected environment, so that it can be verified if it matches the password entered by the user when accessing the system. All such protected systems typically have system administrators, which are privileged users and can access data without being limited as the normal users are. Technically, the administrators are able to extract and see the other users' password data.

**[0003]** In order to prevent the exposure of passwords, computer systems usually implement password encryption (also called password hashing). This operation transforms the actual user password (called the plain text password) into encoded data (called the cipher text password). The cipher text can be used to verify whether the entered password is correct, but it cannot be used to determine the plain text, because the employed encryption algorithm is an irreversible mathematical operation. When the user enters the password, the plain text is encoded and compared to the stored cipher text - if it matches, the password is correct.

**[0004]** In a typical computer security compromise, the cipher text data becomes exposed and the attacker tries to determine the plain text from the cipher text, in order to find the actual passwords. As the mathematical operation of encoding is irreversible, the attacker has to try different plain texts, encode them, and find one which matches the cipher text. Various strategies are employed: brute force (where all the letter, number and special character combinations are tried), dictionary (where all the words in a list are tried) and several combinations based on the above. This process is commonly called "password recovery".

**[0005]** In order to make this process take a very long time, the mathematical operations used for encoding employ complex encryption and hashing algorithms. The aim of this design is to protect the passwords by making the password recovery process take too much time to be effective in recovering the plain text password data.

**[0006]** Over the past years, the computers have become more and more powerful, being able to execute the encryption operations much faster. The encryption algorithms have also been upgraded to be harder to recover. The result of this process is that currently passwords are

relatively easy to recover if the password complexity is low, and hard to impossible if the password complexity is high. Companies and organizations typically define password policies, which specify how complex the passwords have to be which are used in their computer system, application or network.

**[0007]** Various factors can lead to the exposure of plain text passwords, such as using the same initialization password in a given company when setting up new accounts, using predictable or easy to remember passwords, using the same password in multiple systems, etc. Companies and organizations typically enforce their password policies in order to prevent such exposure. However, these policies cannot be made too strict, because then the users will start forgetting their passwords. An ideal system would enforce strong passwords, which are complex enough but possible to memorize, each user being able to choose: e.g., one will use a shorter but completely random password, while another will use a very long but relatively easy to remember password; both would be sufficiently strong.

**[0008]** The large number of successful attacks targeting passwords in the last years indicates that the current technology, or the way it is employed, does not succeed in preventing the usage of weak, predictable passwords.

**[0009]** There are basically two possibilities for the owner or administrator, respectively, of a computer system, application or network to make sure that the users in the given company or organization use strong passwords: firstly by enforcing a strong password policy when the password is changed, and secondly by actively checking the stored cipher text passwords to identify weak, predictable passwords. The first method provides the most basic protection, but very often it is not effective, as the users will try to use easy to memorize passwords, even with a strong policy. The second method could compensate the weaknesses of the first one, by actively simulating a real attack and thus detecting any weak or predictable passwords of the users. However, this method often cannot be employed due to legal restrictions, because it reveals the plain text passwords to the system administrator, or at least makes such a revelation possible. This is considered as contravening data privacy protection, and is therefore illegal in most countries. US2005/0198537A1 provides a technique for evaluating passwords. It is the object underlying the invention to provide a system which allows to determine the strength of user passwords and to provide this information to the administrator of the computer system, application or network, without revealing the passwords themselves to the administrator or any other person.

## SUMMARY OF THE INVENTION

**[0010]** According to the present invention, this problem is solved by a password audit system as mentioned at the beginning. The invention is as defined in the appended claims. The inventive password audit system is a separate physical entity, which retrieves the cipher text data from the system to be audited, performs a password recovery process as it is generally known from the art, and stores only the relevant information relating to the strength of the

passwords, so that this information can be provided to and evaluated by the administrator or owner, respectively, of the computer system. However, the user passwords are not compromised, because the recovered plain text passwords are not accessible at any time.

**[0011]** To ensure privacy protection by the password audit system, it is most preferred if the system is configured such that a plain text password for which a match has been found is not stored in the data storage means, or only stored in a way that it is not assignable to the corresponding user identification. In the first case, the plain text password is discarded instantly after it has been identified and the data relating to its strength has been stored, so that any access to the plain text itself is impossible. In the second case, the plain text password is stored, but not in a personalized way, e.g., by adding it to a dictionary used for the password recovery process, to make this process more effective for future audits.

**[0012]** In a preferred embodiment, the system is configured to generate a list comprising the user identifications and assigned values relating to the strength of the user passwords. This list can be generated from the stored data relating to the strength of the passwords, after completion of the password recovery process or at any later point in time. The values assigned to each user identification may be binary in the most simple case, i.e., the value is "weak" if a match has been found by the password recovery process within the predetermined time, and otherwise the value is "strong". In addition, the value can be on a numerical scale, wherein weak passwords are further classified depending on how fast a match was found.

**[0013]** It is to be noted that the value relating to the strength of a password is dependent on the predetermined time which is given for the password recovery process. It is preferred if the length of this time can be varied by the system administrator, depending on the aspired level of password security in the company or organization.

**[0014]** The value relating to the strength of the user passwords may also take into account a given password policy of the computer system, application or network. Such a policy can prescribe, e.g., that a password should have a minimum length, consist of different types of characters (letters, numbers etc.), or be not a known word from a dictionary. The inventive system can analyse the recovered passwords in view of this policy, and assign a value indicating a weaker password if one or more provisions are not met. Alternatively or in addition, the list can also include an explicit information about which of the provisions are not met by the password.

**[0015]** The interface of the inventive system is preferably configured to provide the generated list to the computer system, application or network via the data connection. There, it can be accessed by the system administrator, and brought into any desired format. Based on this information, the administrator or another authorised person on behalf of the company or organization can take pre-emptive measures to increase password security, in particular by informing the users with weak passwords, and asking them to change their password in accordance with the password policy.

**[0016]** In another embodiment of the invention, the system is configured to generate an electronic message to the corresponding user if the strength of his password is insufficient, i.e., if it has been recovered within the predetermined time. The message may be an e-mail or a system information upon the user's next login. Such an automatic notification of the users ensures that weak passwords are replaced as soon as possible, and it also facilitates the process for the system administrator, in particular in large systems with many users.

**[0017]** The interface is preferably capable of retrieving data from different software platforms running on the computer system, application or network. This means that the inventive system can be universally employed in connection with different platforms such as Microsoft Windows, Apple Mac OS X or UNIX.

**[0018]** Furthermore, the central processing unit of the inventive system is ideally capable of using different encryption algorithms being stored in the data storage means, depending on the encryption algorithm used by the computer system, application or network. In order to ensure compatibility with all commonly used systems, the corresponding encryption algorithms of all these systems should be stored, wherein the applicable algorithm is selected automatically or manually upon setup of the inventive system.

**[0019]** For the password recovery process, the central processing unit may employ any known methods to generate the different plain text passwords. In particular, they are generated by means of one or more dictionaries stored in the data storage means, and/or by a random combination of characters (brute force). A common approach is to try the words of the dictionary first, then a number of modifications of the dictionary words, and finally the brute force method. The predetermined time, which is given for the attempt to recover each user password, is generally sufficient to try all dictionary words and their modifications, and to start the brute force method if the first two methods were not successful. If the matching password has been found in a dictionary, this information can also be included in the result list and provided to the respective user, so that he knows the reason why his password is weak.

**[0020]** As already mentioned above, the inventive system may be configured to include plain text passwords, for which a match has been found, into a dictionary. By this method, relatively weak passwords that have been recovered by the brute force method will be recovered even faster in the next audit and will be identified as even weaker, in case that the same or another user again uses this password. It has to be ensured, however, that the passwords added into the dictionary are not assigned to specific users, and that they cannot be accessed from outside the inventive system.

**[0021]** In order to increase the computing power of the inventive system for generating the different plain text passwords and encoding them into cipher text passwords, it is preferred if the system further comprises a co-processor to support the functions of the central processing unit. In particular, graphics processing units (GPU) can be advantageously used as co-processors, as they are very powerful in password recovery.

**[0022]** In another preferred embodiment of the invention, the password audit system further comprises one or more sensors to detect physical impacts on the housing, such as vibration, tilting or shock. As the housing is not intended to be opened during the normal setup and operation of the inventive system, any attempt to open it can be considered as an unauthorized intervention, against which protective measures should be taken.

**[0023]** Preferably, the inventive system can be configured (after it has been positioned and connected to the computer system) to shut down and prevent any access to the stored data if a physical impact on the housing is detected. Most preferably, the stored data is deleted in such an event, which provides the highest level of protection against any attempt to access password data stored by the system.

**[0024]** Similarly, the inventive system can also be configured to shut down and prevent any access to the stored data if an unauthorized access via the interface is detected. That is, the password audit system also protects itself against logical attacks via the computer system, application or network.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

**[0025]** These and further advantages of the invention will be explained in connection with the following preferred embodiments, making reference to the figures.

**[0026]** The figures show:

**FIG. 1:**

a schematic illustration of the deployment of an inventive password audit system in a cluster configuration; and

**FIG. 2:**

a schematic illustration of the components of an inventive password audit system.

#### **DETAILED DESCRIPTION OF THE INVENTION**

**[0027]** The inventive password audit system can be deployment in a cluster configuration within a typical client network, where the operators of the password audit system and of the audit target reside. An exemplary configuration of such a cluster is schematically shown in Figure 1.

**[0028]** In this configuration, an operator console 1-1 is connected via an audit network 1-3 to several targets 1-2 for the password audit, i.e., computers systems, applications or networks. Also connected via the audit network 1-3 are multiple instances of the inventive password audit

system 1-4, comprising one master/controller unit 1-5 and several slave units 1-6, which cooperate in performing the operations described below. This configuration allows for a scaling of the inventive system 1-4, wherein the multiple instances 1-5 and 1-6 perform simultaneous operations in auditing one or more of the targets 1-2.

**[0029]** A schematic illustration of an inventive password audit system or an instance thereof, respectively, is shown in Figure 2 as an exemplary embodiment. This system comprises a housing 2-1, which encloses the following components: a central processing unit 2-2, a co-processor 2-3 which is a graphics processing unit (GPU) as an encryption accelerator, a physical impact sensor 2-4, a housing intrusion sensor 2-5, a trusted platform module (TPM) 2-6, hard disks as data storage means comprising an encrypted storage 2-7, an unencrypted storage 2-8 and an upgrade module, as well as an interface for establishing a data connection to a computer system, application or network and an interface for establishing a data connection to an audit network according to Figure 1.

**[0030]** The inventive system is a separate entity from the computer system, application or network to be audited. Any attempt to open or access the housing 2-1 during operation of the system will be detected by the sensors 2-4 and 2-5, leading to a shut-down of the system and prevention of any access to the stored data. In addition, the password audit system stores all the application and user data, including operational and customization information, only in an encrypted format, which provides further protection against any revelation of sensible data, in particular of password data.

**[0031]** The operations which are performed by the inventive system, according to the embodiment described herein, can be summarized as follows:

- At start-up, the system first employs TPM functions in order to make sure that the software and hardware environment has not been tampered with while the system was not turned on; if tampering has been detected, the system will not start;
- after the tampering test has been passed successfully, the system retrieves from the TPM the first half of the encryption key (hardware key) used for the data storage protection and prompts the operator for the second half;
- after the operator provides the second half of the key (user key), it is combined with the hardware key and the result is used to decrypt the storage and start the operating system and the application software; the system is now operational;
- the system starts applications which monitor the environment: logical attacks and hardware intrusion are monitored, and if detected, the event is logged and the system is shut down;
- the system operator can now authenticate and use the system functionality: after the system has been initialized, the operator can define targets for the password audit; the system will store the information and, at the scheduled time, will perform the audit operation, will then generate a report, and inform the operator or other defined users;
- the system operator first defines a new target for password audit, by specifying the network address, the type of system, the cipher text password retrieval method; the

information is verified and the target saved;

- the system operator then defines a new audit operation, by specifying the target, the audit details, such as what dictionaries are to be used, if GPU acceleration is to be employed, how long the predetermined time for finding a match should be, and what the password policy is; the operator also specifies when the audit will take place and if it is repeated on a regular basis, who should be informed about the results, and if the users affected by weak passwords should be automatically informed; the audit process information is saved;
- at the scheduled time, the system will start the audit operation by retrieving the cipher text passwords from the target, start the password recovery process as defined by the operator parameters, and wait for its completion; any weak passwords detected will be assessed, by determining why the password was found and why the password is weak (e.g., the password is too short or present in a dictionary); the data relating to the strength of the password is saved together with the user identification, whereas the plain text password itself will not be saved in connection with the user;
- after completion of the audit process, the system generates a report with the results, including a list with the affected user identifications and a value relating to the strength of the detected passwords; the report is sent or made available to the system operator; optionally, if chosen, the affected users are informed automatically by e-mail;
- after generation of the report, all the retrieved cipher text passwords are destroyed; the report remains in storage;
- multiple targets and audit operations can be defined on the same password audit system; the targets can be different, corresponding to computer systems, applications and networks from various different vendors, including custom applications.

#### LIST OF REFERENCE NUMERALS

##### [0032]

1-1 operator console  
 1-2 targets (computer systems, applications or networks)  
 1-3 audit network  
 1-4 password audit system  
 1-5 master/controller unit  
 1-6 slave units

- 2-1 housing
- 2-2 central processing unit
- 2-3 co-processor (graphics processing unit)
- 2-4 physical impact sensor
- 2-5 housing intrusion sensor
- 2-6 trusted platform module (TPM)
- 2-7 encrypted storage (hard disk)
- 2-8 unencrypted storage (hard disk)
- 2-9 upgrade module (hard disk)
- 2-10 interface to computer system, application or network
- 2-11 interface to audit network

## REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

### Patent documents cited in the description

- [US20050198537A1 \[0009\]](#)

**Patentkrav**

1. Adgangskodeeftterprøvningssystem til bestemmelse af styrken af brugeradgangskoder i et computersystem, -applikation eller -netværk hvortil en flerhed af brugere har adgang via en brugeridentifikation og adgangskode, hvilket adgangskodeeftterprøvningssystem omfatter:
  - et interface til etablering af en dataforbindelse mellem adgangskodeeftterprøvningssystemet og computersystemet, -applikationen eller -netværket, der er konfigureret til at hente chiffertekst-brugeradgangskoder lagret på computersystemet, -applikationen eller -netværket;
  - en centralenhed (CPU), der er konfigureret til successivt at generere forskellige klartekst-adgangskoder ved hjælp af en eller flere ordbøger og ved tilfældige kombinationer af tegn, at kode klartekst-adgangskoderne til tilsvarende chiffertekst-adgangskoder med en krypteringsalgoritme, og sammenligne de kodede chiffertekst-adgangskoder med en given en af de hentede chiffertekst-adgangskoder, indtil et match er fundet eller en forudbestemt tidsperiode er udløbet; og
  - datalagringsorgan til at lagre data, der relaterer til hver af brugeradgangskodernes styrke, hvor styrken er afhængig af den anvendte fremgangsmåde til at generere de forskellige klartekst-adgangskoder og den nødvendige tid til at finde et match, hvor centralenheden (CPU) er yderligere konfigureret til øjeblikkeligt at afvise hver brugeradgangskode for hvilken et match er blevet fundet,
- 25 hvor komponenterne af adgangskodeeftterprøvningssystemet er indesluttet i et hus, der er separat fra computersystemet, -applikationen eller -netværket.
2. Systemet ifølge krav 1, hvor systemet er konfigureret til at generere en liste omfattende brugeridentifikationerne og de tildelte værdier, der relaterer til 30 styrken af brugeradgangskoderne.

**3.** Systemet ifølge krav 2, hvor værdien, der relaterer til styrken af brugeradgangskoderne også tager en given adgangskodepolitik af computersystemet, -applikationen eller -netværket i betragtning.

**5 4.** Systemet ifølge krav 2 eller krav 3, hvor interfacet er konfigureret til at forsyne den genererede liste til computersystemet, -applikationen eller -netværket via dataforbindelsen.

**5.** Systemet ifølge et hvilket som helst af de foregående krav, hvor systemet er konfigureret til at generere en elektronisk besked til den tilsvarende bruger, hvis styrken af hans adgangskode er utilstrækkelig.

**6.** Systemet ifølge et hvilket som helst af de foregående krav, hvor centralenheden (CPU) er i stand til at anvende forskellige krypteringsalgoritmer, der er lagret i datalagringsorganet, afhængigt af krypteringsalgoritmen anvendt af computersystemet, -applikationen eller -netværket.

**7.** Systemet ifølge et hvilket som helst af de foregående krav, hvor systemet er konfigureret til at inkludere klartekst-adgangskoder, for hvilke et match er blevet fundet, i en ordbog.

**8.** Systemet ifølge et hvilket som helst af de foregående krav, yderligere omfattende en eller flere sensorer til at detektere fysiske indvirkninger på huset, såsom vibration, vipning eller chok, hvor systemet kan konfigureres til at lukke ned og forhindre enhver adgang til det lagrede data, hvis en fysisk indvirkning på huset detekteres.

**9.** Systemet ifølge et hvilket som helst af de foregående krav, hvor systemet kan konfigureres til at lukke ned og forhindre enhver adgang til det lagrede data, hvis en uautoriseret adgang via interfacet detekteres.

**10.** Fremgangsmåde til at bestemme styrken af brugeradgangskoder i et computersystem, -applikation eller -netværk, hvortil en flerhed af brugere har adgang via en brugeridentifikation og adgangskode, hvilken fremgangsmåde omfatter:

5        - at hente chiffertekst-brugeradgangskoder lagret på computersystemet, - applikationen eller -netværket;

10      - successivt at generere forskellige klartekst-adgangskoder ved hjælp af en eller flere ordbøger og ved tilfældige kombinationer af tegn, at kode klartekst-adgangskoderne til tilsvarende chiffertekst-adgangskoder med en krypteringsalgoritme, og sammenligne de kodede chiffertekst-adgangskoder med en given en af de hentede chiffertekst-adgangskoder, indtil et match er fundet eller en forudbestemt tidsperiode er udløbet; og

15      - at lagre data, der relaterer til hver af brugeradgangskodernes styrke, hvor styrken er afhængig af den anvendte fremgangsmåde til at generere de forskellige klartekst-adgangskoder og den nødvendige tid til at finde et match, og øjeblikkeligt afvise hver brugeradgangskode for hvilken et match er blevet fundet.

**11.** Fremgangsmåden ifølge krav 10, yderligere omfattende at generere en liste 20 omfattende brugeridentifikationerne og de tildelte værdier, der relaterer til styrken af brugeradgangskoderne.

**12.** Fremgangsmåden ifølge krav 11, hvor værdien, der relaterer til styrken af brugeradgangskoderne også tager en given adgangskodepolitik af 25 computersystemet, -applikationen eller -netværket i betragtning.

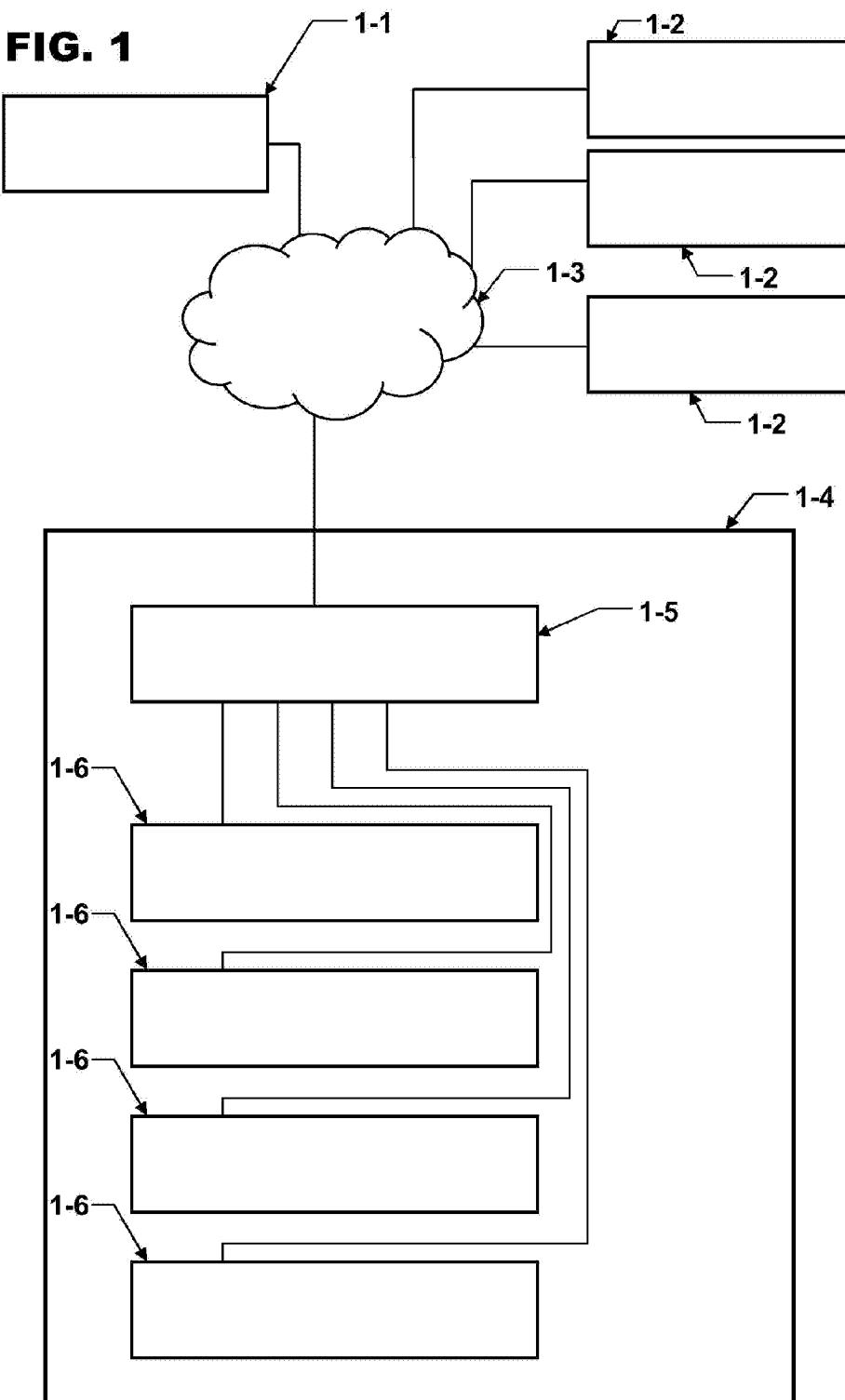
**13.** Fremgangsmåden ifølge krav 11 eller krav 12, yderligere omfattende at forsyne den genererede liste til computersystemet, -applikationen eller - netværket via dataforbindelsen.

**14.** Fremgangsmåden ifølge et hvilket som helst af kravene 10 til 13, yderligere omfattende at generere en elektronisk besked til den tilsvarende bruger, hvis styrken af hans adgangskode er utilstrækkelig.

5 **15.** Fremgangsmåden ifølge et hvilket som helst af kravene 10 til 14, yderligere omfattende at inkludere klartekst-adgangskoder, for hvilke et match er blevet fundet, i en ordbog.

# DRAWINGS

**FIG. 1**



**FIG. 2**