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(54) **DATA ENCRYPTION SYSTEMS AND METHODS**

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Related U.S. Patent Documents

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G06F 12/14 (2006.01)
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H04L 9/08 (2006.01)

(52) **U.S. Cl.**
CPC ***G06F 12/1408*** (2013.01)

(58) **Field of Classification Search**
CPC H04L 9/0836; H04L 9/0861; H04L 9/14; H04L 63/0478; H04L 9/00; G06F 21/10; G06F 21/62; G06F 21/6209; G06F 21/6218; G06F 2221/2107
USPC 380/284; 713/165
See application file for complete search history.

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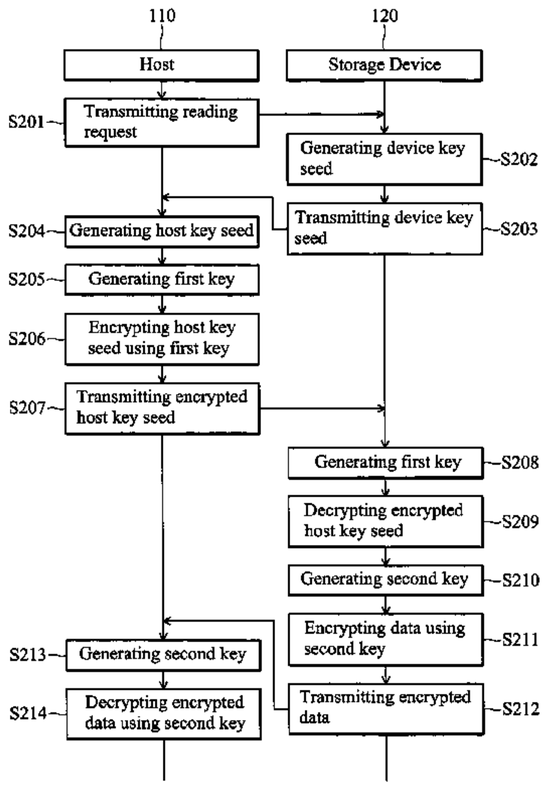
(57) **ABSTRACT**

Data encryption systems and methods. The system includes a storage device storing data and an encryption/decryption module. The encryption/decryption module randomly generates a device key seed according to the occurrence time of a specific operation or the interval between two specific operations on the storage device, and applies the device key seed to data encryption.

23 Claims, 2 Drawing Sheets



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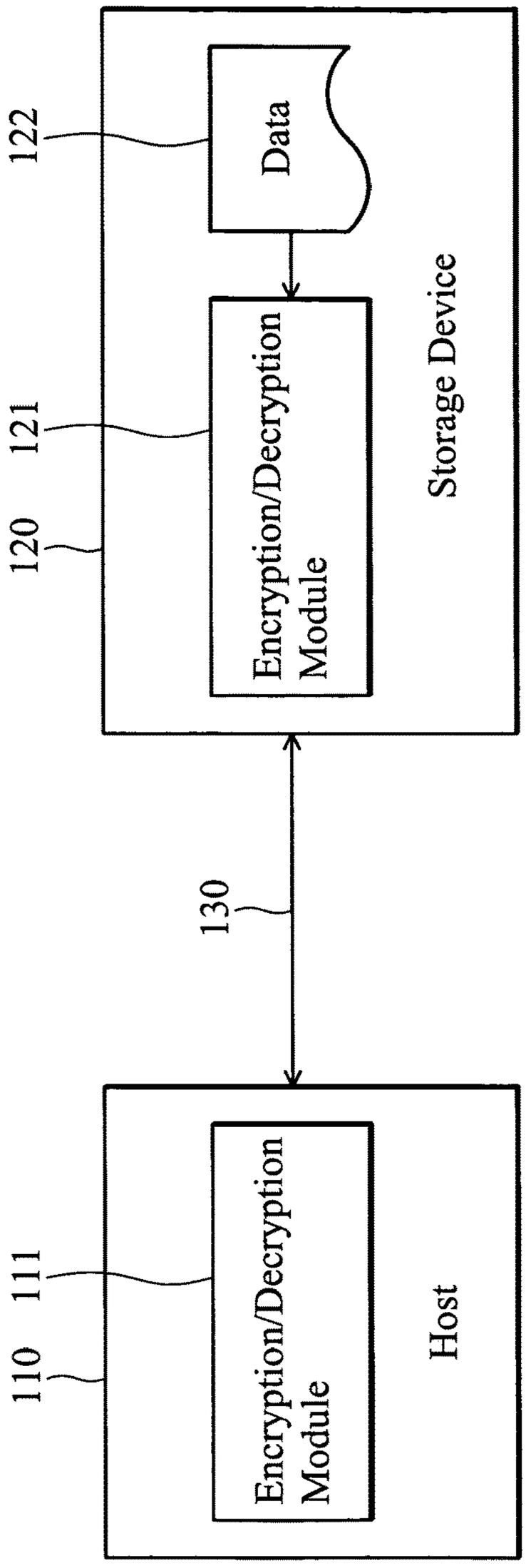
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Data
121
Encryption/Decryption Module
120
Storage Device
130
100
111
Encryption/Decryption Module
110
Host

FIG. 1

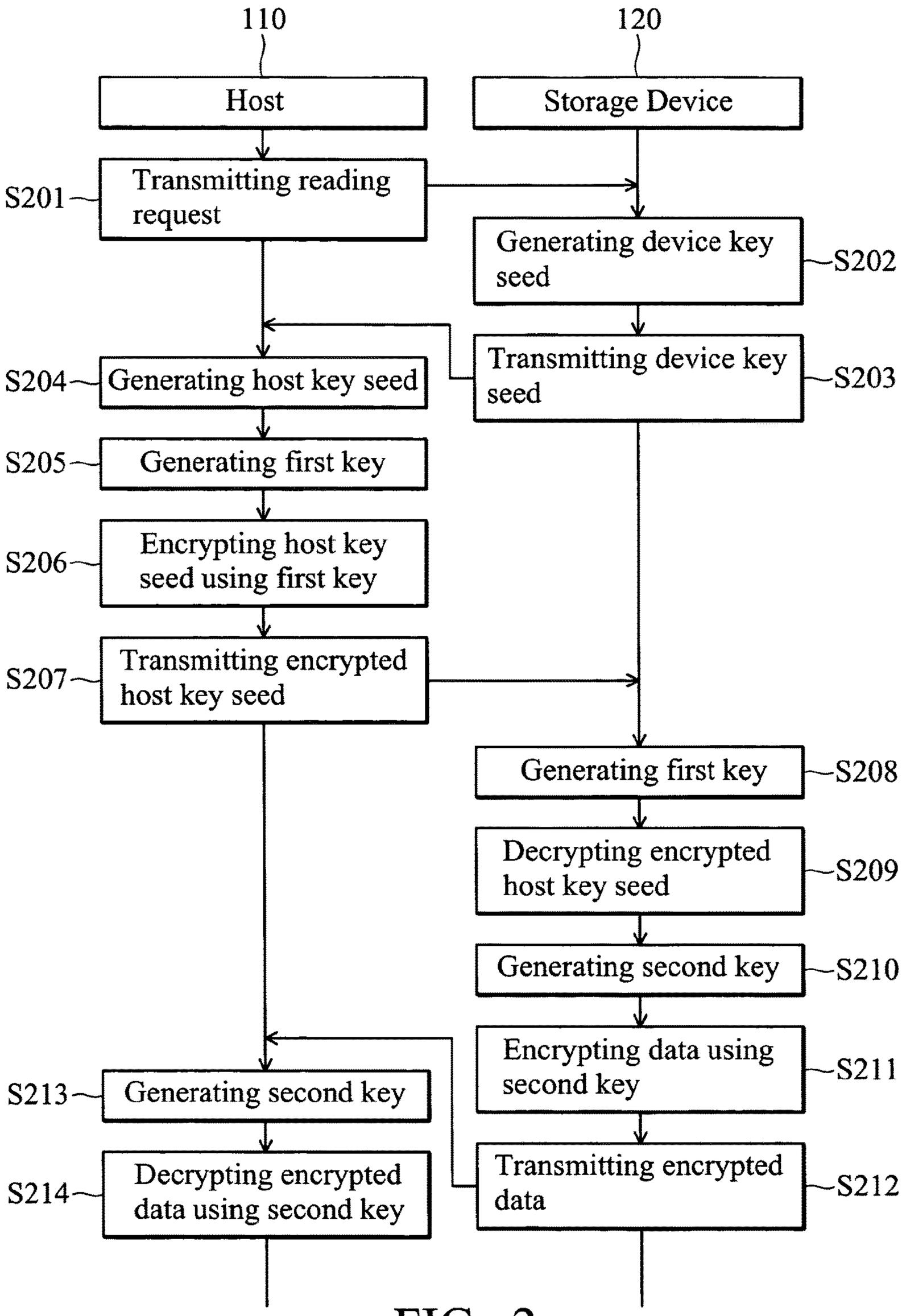
110
120
Host
Storage Device
S201
Transmitting reading request
Generating device key seed
S202
S204
Generating host key seed
Transmitting device key seed
S203
S205
Generating first key
S206
Encrypting host key seed using first key
S207
Transmitting encrypted host key seed
Generating first key
S208
Decrypting encrypted host key seed
S209
Generating second key
S210
Encrypting data using second key
S211
S213
Generating second key
S214
Decrypting encrypted data using second key
Transmitting encrypted data
S212

FIG. 2

DATA ENCRYPTION SYSTEMS AND METHODS

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue; a claim printed with strikethrough indicates that the claim was canceled, disclaimed, or held invalid by a prior post-patent action or proceeding.

BACKGROUND

The present disclosure relates generally to data protection mechanisms, and, more particularly, to data encryption systems and methods.

Computers can be used to remotely authenticate and authorize digital data. Network applications are also convenient, but data protection is critical.

Conventionally, data, such as authentication data can be protected using a hardware or software based fixed or non-fixed key encryption. Authentication data, for example, can be encrypted according to public key cryptography before transmission to a service provider. Upon reception of the encrypted data, the service provider decrypts the encrypted data to obtain the authentication data, and authorize a user.

If the encryption is hardware based, additional device cost is incurred. Additionally, the authentication data is always stored in a portable device. The design of the device will become complicated due to the size limitations. If the encryption employs a fixed key, the same authentication data may result in the same encrypted data. That is, the storage device storing the authentication data can be easily imitated by a simulator or by sniffing and re-transmitting the encrypted data. If the encryption employs a non-fixed key, the non-fixed key is generated by searching for a key in a database. The database storing the file is still at risk. Further, in non-fixed key encryption, the key must be distributed to both connected sides and the key may be sniffed during transmission.

SUMMARY

Data encryption systems and methods are provided. In an exemplary embodiment of a data encryption system, the system comprises a storage device comprising data D and an encryption/decryption module. The encryption/decryption module randomly generates a device key seed S_d according to the time of a specific operation or the interval between two specific operations on the storage device, and applies the device key seed S_d and a seed generated by a host to data encryption.

An embodiment of the system further comprises a host to receive the device key seed S_d from the storage device. The host generates a host key seed S_h, generates a first key K_n according to the device key seed S_d, encrypts the host key seed S_h using the first key K_n, and transmits the encrypted host key seed $K_n(S_h)$ to the storage device. The storage device generates the first key K_n according to the device key seed S_d, and decrypts the encrypted host key seed $K_n(S_h)$ using the first key K_n to obtain the host key seed S_h. The storage device further generates a second key K_{n+1} according to the host key seed S_h and the device key seed S_d, and encrypts the data D using the second key K_{n+1}.

The host further receives the encrypted data $K_{n+1}(D)$, generates the second key K_{n+1} according to the host key seed S_h and the device key seed S_d, and decrypts the encrypted data $K_{n+1}(D)$ using the second key K_{n+1} to obtain the data D.

The specific operation is received on the storage device, and corresponds to a control transmission or normal data transmission defined by USB (Universal Serial Bus). The control transmission comprises status getting, feature clearing, feature setting, address setting, descriptor getting, descriptor setting, configuration getting, configuration setting, interface getting, interface setting, or frame synchronization.

The host key seed is randomly generated and difficult to be predicted and amended. The generation method for the host key seed, however, is not limited. The system generates the host key seed according to the operation capability of the host. In some embodiments, the system generates the host key seed using a complex algorithm requiring higher operational requirement, or according to the interval between the execution of an application and the reception of the device key seed with less operational requirements.

In an exemplary embodiment of a data encryption method, a device key seed S_d is randomly generated according to the time of a specific operation or the interval between two specific operations on the storage device. The device key seed S_d is applied to data encryption on a storage device.

The device key seed S_d is further transmitted from the storage device to a host. In the host, a host key seed S_h is generated, a first key K_n is generated according to the device key seed S_d, the host key seed S_h is encrypted using the first key K_n, and the encrypted host key seed $K_n(S_h)$ is transmitted to the storage device. After reception of the encrypted host key seed $K_n(S_h)$, the storage device generates the first key K_n according to the device key seed S_d, and decrypts the encrypted host key seed $K_n(S_h)$ using the first key K_n to obtain the host key seed S_h. The storage device then generates a second key K_{n+1} according to the host key seed S_h and the device key seed S_d, and encrypts the data D using the second key K_{n+1}.

The encrypted data $K_{n+1}(D)$ is further transmitted from the storage device to the host. The host generates the second key K_{n+1} according to the host key seed S_h and the device key seed S_d, and decrypts the encrypted data $K_{n+1}(D)$ using the second key K_{n+1} to obtain the data D.

The specific operation is received on the storage device, and corresponds to a control transmission or normal data transmission defined by USB. The control transmission comprises status getting, feature clearing, feature setting, address setting, descriptor getting, descriptor setting, configuration getting, configuration setting, interface getting, interface setting, or frame synchronization.

The host key seed is randomly generated and difficult to be predicted and amended. The generation method for the host key seed, however, is not limited. The system generates the host key seed according to the operation capability of the host. In some embodiments, the system generates the host key seed using a complex algorithm requiring higher operational requirements, or according to the interval between the execution of an application and the reception of the device key seed with less operational requirements.

Data encryption methods may take the form of program code embodied in a tangible media. When the program code is loaded into and executed by a machine, the machine becomes an apparatus for practicing the disclosed method.

DESCRIPTION OF THE DRAWINGS

Data encryption systems and methods will become more fully understood by referring to the following detailed description with reference to the accompanying drawings, wherein:

FIG. **1** is a schematic diagram illustrating an embodiment of a data encryption system; and

FIG. **2** is a flowchart showing an embodiment of a data encryption method.

DESCRIPTION

Data encryption systems and methods are provided. FIG. **1** is a schematic diagram illustrating an embodiment of a data encryption system.

An embodiment of the data encryption system **100** comprises a host **110** and a storage device **120**. The storage device **120** connects to the host **110** via a channel **130**, such as a USB (Universal Serial Bus) transmission channel. The host **110** may be a computer system, an electronic schoolbag, a mobile device, such as a PDA, or other processor-based electronic devices. The host **110** comprises an encryption/decryption module **111**, for generating host key seeds and keys, and performing encryption and decryption operations. The storage device **120** may be a mobile device, such as a mobile phone, USB handy disk, or a language learning machine. The storage device **120** comprises an encryption/decryption module **121**, and data **122** requiring protection during transmission, such as authentication data for digital copyright control. The encryption/decryption module **121** may be implemented in software or hardware. To reduce cost, a software implementation may be the best choice. Similarly, the encryption/decryption module **121** generates device key seeds and keys, and performing encryption and decryption operations on the data **122**.

FIG. **2** is a flowchart showing an embodiment of a data encryption method.

When an application (not shown in FIG. **1**) executes on the host **110** and must read data **122** from the storage device **120**, in step S**201**, the host **110** transmits a read data request to the storage device **120**. When the storage device **120** receives the request, in step S**202**, a device key seed S_d is randomly generated according to the time of a specific operation or the interval between two specific operations on the storage device **120**, and in step S**203**, the device key seed S_d is transmitted to the host **110**. It is understood that if the device key seed S_d is generated according to the interval between two specific operations, the two operations may be of different type.

The interval can be measured using the MCU (Micro Control Unit) tick number of the storage device **120**. The specific operation is received on the storage device **120** from the host **110**, and corresponds to a control transmission defined by USB. The control transmission comprises status getting, feature clearing, feature setting, address setting, descriptor getting, descriptor setting, configuration getting, configuration setting, interface getting, interface setting, or frame synchronization. The descriptors comprise device, configuration, interface, endpoint, and string descriptors. Additionally, the specific operation may be received on the storage device **120** from the host **110**, and correspond to a normal data transmission defined by USB. For example, if a FIFO queue of the host **110** is 64 bytes, and each transmission with 64 bytes triggers a USB data transmission. If the host **110** transmits 198 bytes of data, the storage device **120** receives three USB data transmissions each of 64 bytes, and one USB data transmissions of 6 bytes. Each of the four USB data transmissions can be candidates for the specific operations. When each of the operations occurs, an interrupt is triggered to notify the MCU of the storage device **120** regarding the requirement of the operation, and the storage device **120** can obtain the system clock wherein the operation occurred.

After the host **110** receives the device key seed S_d, in step S**204**, a host key seed S_h is generated. It is understood that the host key seed S_h is randomly generated and difficult to be predicted and amended. The generation method for the host key seed S_h, however, is not limited. The host **110** generates the host key seed S_h according to the operation capability of the host **110**. In some embodiments, the host **110** generates the host key seed S_h using a complex algorithm, or according to the interval between the execution of the application and the reception of the device key seed S_d. Then, in step S**205**, the host **110** generates a first key K_n according to the device key seed S_d, in step S**206**, encrypts the host key seed S_h using the first key K_n, and in step S**207**, transmits the encrypted host key seed $K_n(S_h)$ to the storage device **120**.

It is understood that a key seed can be performed with a predetermined number of operations, to thus generate the key for software encryption. The predetermined operations are dependent on different software encryptions. For example, if both the host key seed S_h and the device key seed S_d are 32 bits, a key with 8m bits is generated using following equation (in program language C):

$$F(S_h,S_d)=(S_h*S_d)\&0xff+((S_h<<8)*S_d)\&0xff00+((S_h<<16)*S_d)\&0xff0000+((S_h<<24)*S_d)\&0xff000000+((S_h+S_d)\&0xff+((S_d<<8)*S_h)\&0xff00+((S_d<<16)*S_h)\&0xff0000+(S_d<<24)*S_h)\&0xff000000)<<32.$$

m is an integer within 1 to 8. That is, the key is the last 8m bits of $F(S_h, S_d)$. Additionally, if any of S_h and S_d is not present, the absentee can be replaced by a predefined constant C with 32 bits. The above equation is one example, the method for generating the key is not limited thereto.

The encryption mechanism can be any symmetric encryption, and the complexity and security level of a software encryption method can be selected according to hardware and security requirements. For example, the encryption can be performed by left rotating r bits of authentication data. The value of r is determined according to K_n %64 (K_n is a key generated using $F(S_h, S_d)$ in the n-th transmission). In some embodiments, TEA (Tiny Encryption Algorithm) can be employed. In TEA, a key with 32 bits is obtained from the last 32 bits of $F(S_h, S_d)$. Similarly, the above encryption mechanisms are not limited thereto.

After reception of the encrypted host key seed $K_n(S_h)$, in step S**208**, the storage device **120** generates the first key K_n according to the device key seed S_d, and in step S**209**, decrypts the encrypted host key seed $K_n(S_h)$ using the first key K_n to obtain the host key seed S_h. Then, in step S**210**, the storage device **120** generates a second key K_{n+1} according to the host key seed S_h and the device key seed S_d, in step S**211**, encrypts the data D using the second key K_{n+1}, and in step S**212**, transmits the encrypted data $K_{n+1}(D)$ to the host **110**.

After reception of the encrypted data $K_{n+1}(D)$, in step S**213**, the host **110** generates the second key K_{n+1} according to the host key seed S_h and the device key seed S_d, and in step S**214**, decrypts the encrypted data $K_{n+1}(D)$ using the second key K_{n+1} to obtain the data D. The data D can be transmitted to the application for further processing, such as authentication.

Data encryption methods, or certain aspects or portions thereof, may take the form of program code (i.e., executable instructions) embodied in tangible media, such as products, floppy diskettes, CD-ROMS, hard drives, or any other

machine-readable storage medium, wherein, when the program code is loaded into and executed by a machine, such as a computer, the machine thereby becomes an apparatus for practicing the methods. The methods may also be embodied in the form of program code transmitted over some transmission medium, such as electrical wiring or cabling, through fiber optics, or via any other form of transmission, wherein, when the program code is received and loaded into and executed by a machine, such as a computer, the machine becomes an apparatus for practicing the disclosed methods. When implemented on a general-purpose processor, the program code combines with the processor to provide a unique apparatus that operates analogously to application specific logic circuits.

While the invention has been described by way of example and in terms of preferred embodiment, it is to be understood that the invention is not limited thereto. Those who are skilled in this technology can still make various alterations and modifications without departing from the scope and spirit of this invention. Therefore, the scope of the present invention shall be defined and protected by the following claims and their equivalents.

What is claimed is:

[1. A data encryption system, comprising:

a storage device adapted to store data D, the storage device including:

an encryption/decryption module adapted to randomly generate a device key seed S_d according to a time interval between two specific operations on the storage device, and adapted to apply the generated device key seed S_d to data encryption of the data D,

wherein the storage device is adapted to randomly generate the device key seed S_d in response to interrupts that notify the storage device of occurrence of the two specific operations.**]**

2. **[**The system of claim **1**, further**]** *A data encryption system,* comprising:

a storage device adapted to store data D, the storage device including:

an encryption/decryption module adapted to randomly generate a device key seed S_d according to a time interval between two specific operations on the storage device, and adapted to apply the generated device key seed S_d to data encryption of the data D,

wherein the storage device is adapted to randomly generate the device key seed S_d in response to interrupts that notify the storage device of occurrence of the two specific operations, and

a host adapted to receive the generated device key seed S_d from the storage device, to generate a host key seed S_h, to generate a first key K_n according to the received device key seed S_d, to encrypt the generated host key seed S_h using the generated first key K_n, and to transmit the encrypted host key seed $K_n(S_h)$ to the storage device,

wherein the storage device is further adapted to generate the first key K_n according to the device key seed S_d, to decrypt the transmitted encrypted host key seed $K_n(S_h)$ using the generated first key K_n to obtain the host key seed S_h, to generate a second key K_{n+1} according to the obtained host key seed S_h and the device key seed S_d, and to encrypt the data D using the generated second key K_{n+1}.

3. The system of claim **2** wherein the host is further adapted to receive the encrypted data $K_{n+1}(D)$ from the storage device, to generate the second key K_{n+1} according to the host key seed S_h and the device key seed S_d, and to decrypt the encrypted data $K_{n+1}(D)$ using the generated second key K_{1+1} to obtain the data D.

[4. The system of claim **1** wherein one of the specific operations is received on the storage device, and corresponds to a control transmission defined by USB (Universal Serial Bus).**]**

[5. The system of claim **4** wherein the control transmission includes at least one of status getting, feature clearing, feature setting, address setting, descriptor getting, descriptor setting, configuration getting, configuration setting, interface getting, interface setting, or frame synchronization.**]**

6. **[**The system of claim **1]** *A data encryption system, comprising:*

a storage device adapted to store data D, the storage device including:

an encryption/decryption module adapted to randomly generate a device key seed S_d according to a time interval between two specific operations on the storage device, and adapted to apply the generated device key seed S_d to data encryption of the data D,

wherein the storage device is adapted to:

randomly generate the device key seed S_d in response to interrupts that notify the storage device of occurrence of the two specific operations,

use the device key seed S_d to create a first encryption key,

decrypt an encrypted host key seed S_h using the first encryption key,

use the host key seed S_h to generate a second encryption key, and

encrypt the data D using the second encryption key;

wherein one of the specific operations is received on the storage device, and corresponds to a normal data transmission defined by USB (Universal Serial Bus).

[7. A data encryption method, comprising:

randomly generating a device key seed S_d according a time interval between two specific operations on a storage device; and

applying the generated device key seed S_d to data encryption of data D,

wherein the device key seed S_d is said randomly generated in response to interrupts that notify the storage device of occurrence of the two specific operations.**]**

8. **[**The method of claim **7**, further**]** *A data encryption method,* comprising:

randomly generating a device key seed S_d according a time interval between two specific operations on a storage device; and

applying the generated device key seed S_d to data encryption of data D,

wherein the device key seed S_d is said randomly generated in response to interrupts that notify the storage device of occurrence of the two specific operations;

transmitting by the storage device the generated device key seed S_d to a host;

receiving by the storage device from the host an encrypted host key seed $K_n(S_h)$, wherein S_h is a host key seed generated by the host and K_n is a first key generated by the host according to the device key seed S_d transmitted by the storage device;

generating by the storage device the first key K_n according to the device key seed S_d;

decrypting by the storage device the received encrypted host key seed $K_n(S_h)$ using the generated first key K_n to obtain the host key seed S_h;

generating by the storage device a second key K_{n+1} according to the obtained host key seed S_h and the device key seed S_d; and

encrypting by the storage device the data D using the generated second key K_{n+1}.

9. The method of claim **8**, further comprising:

transmitting by the storage device the encrypted data $K_{n+1}(D)$ to the host so as to enable the host to:

generate the second key K_{n+1} according to the host key seed S_h and the device key seed S_d in the host; and

decrypt the encrypted data $K_{n+1}(D)$ using the generated second key K_{1+1} to obtain the data D.

10. **[**The method of claim **7]** *A data encryption method comprising:*

randomly generating a device key seed S_d according a time interval between two specific operations on a storage device, wherein the device key seed S_d is randomly generated in response to interrupts that notify the storage device of occurrence of the two specific operations;

using the device key seed S_d to create a first encryption key,

decrypting an encrypted host key seed S_h using the first encryption key,

using the host key seed S_h to generate a second encryption key,

encrypting data using the second encryption key, and

transmitting the encrypted data to another device;

wherein one of the specific operations is received on the storage device, and corresponds to a control transmission defined by USB (Universal Serial Bus).

11. The method of claim **10** wherein the control transmission includes at least one of status getting, feature clearing, feature setting, address setting, descriptor getting, descriptor setting, configuration getting, configuration setting, interface getting, interface setting, or frame synchronization.

12. The method of claim **7** wherein one of the specific operations is received on the storage device, and corresponds to a normal data transmission defined by USB (Universal Serial Bus).

[13. The system of claim **1** wherein the encryption/decryption module is further adapted to randomly generate the device key seed S_d according to an occurrence time of one of the specific operations as obtained from a clock.**]**

[14. The method of claim **7**, further comprising randomly generating the device key seed S_d according to an occurrence time of one of the specific operations as obtained from a clock.**]**

[15. A tangible non-transitory computer-readable medium having stored thereon, computer-executable instructions that, if executed by a computing device, cause the computing device to perform a method comprising:

randomly generating a device key seed S_d according a time interval between two specific operations on a storage device; and

applying the generated device key seed S_d to data encryption of data D,

wherein the device key seed S_d is said randomly generated in response to interrupts that notify the storage device of occurrence of the two specific operations.**]**

16. **[**The**]** *A* tangible *non-transitory* computer-readable medium **[**of claim **15** wherein the**]** *having stored thereon* computer-executable instructions *that*, if executed by **[**the**]** *a* computing device, cause the computing device to perform **[**the**]** *a* method **[**that further comprises**]** *comprising*:

randomly generating a device key seed S_d according a time interval between two specific operations on a storage device;

applying the generated device key seed S_d to data encryption of data D,

wherein the device key seed S_d is said randomly generated in response to interrupts that notify the storage device of occurrence of the two specific operations;

transmitting by the storage device the generated device key seed S_d to a host;

receiving by the storage device from the host an encrypted host key seed $K_n(S_h)$, wherein S_h is a host key seed generated by the host and K_n is a first key generated by the host according to the device key seed S_d transmitted by the storage device;

generating by the storage device the first key K_n according to the device key seed S_d;

decrypting by the storage device the received encrypted host key seed $K_h(S_h)$ using the generated first key K_n to obtain the host key seed S_h;

generating by the storage device a second key K_{n+1} according to the obtained host key seed S_h and the device key seed S_d; and

encrypting by the storage device the data D using the generated second key K_{n+1}.

17. The tangible *non-transitory* computer-readable medium of claim **16** wherein the computer-executable instructions, if executed by the computing device, cause the computing device to perform the method that further comprises:

transmitting by the storage device the encrypted data K_{n+1}(D to the host so as to enable the host to:

generate the second key K_{n+1} according to the host key seed S_h and the device key seed S_d in the host; and

decrypt the encrypted data $K_{n+1}(D)$ using the generated second key K_{n+1} to obtain the data D.

18. A tangible *non-transitory* computer-readable medium having stored thereon, computer-executable instructions that, if executed by a computing device, cause the computing device to perform a method comprising:

sending by a host a request for data D to a storage device, wherein the storage device randomly generates a device key seed S_d according a time interval between two specific operations on the storage device;

receiving by the host the generated device key seed S_d;

generating by the host a host key seed S_h;

generating by the host a first key K_n according to the received device key seed S_d;

encrypting by the host the host key seed S_h using the generated first key K_n; and

transmitting by the host the encrypted host key seed $K_n(S_h)$ to the storage device to enable the storage device to:

generate the first key K_n according to the device key seed S_d;

decrypt the transmitted encrypted host key seed $K_n(S_h)$ using the generated first key K_n to obtain the host key seed S_h;

generate a second key K_{n+1} according to the obtained host key seed S_h and the device key seed S_d; and

encrypt the data D using the generated second key K_{n+1} to obtain encrypted data $K_{n+1}(D)$.

19. The tangible *non-transitory* computer-readable medium of claim **18** wherein the computer-executable instructions, if executed by the computing device, cause the computing device to perform the method that further comprises:

receiving by the host the encrypted data K_{n+1} (D);

generating by the host the second key K_{n+1} according to the host key seed S_h and the device key seed S_d; and

decrypting by the host the encrypted data $K_{n+1}(D)$ using the generated second key K_{n+1} to obtain the data D.

20. The tangible *non-transitory* computer-readable medium of claim **18** wherein the device key seed S_d is also randomly generated by the storage device according to an occurrence time of one of the specific operations as notified by an interrupt.

21. A host apparatus, comprising:

means for sending a request for data D to a storage device, wherein the storage device randomly generates a device key seed S_d according a time interval between two specific operations on the storage device;

encryption/decryption means for:

receiving the generated device key seed S_d;

generating a host key seed S_h;

generating a first key K_n according to the received device key seed S_d;

encrypting the host key seed S_h using the generated first key K_n; and

transmitting the encrypted host key seed $K_n(S_h)$ to the storage device to enable the storage device to:

generate the first key K_n according to the device key seed S_d;

decrypt the transmitted encrypted host key seed $K_n(S_h)$ using the generated first key K_n to obtain the host key seed S_h;

generate a second key K_{n+1} according to the obtained host key seed S_h and the device key seed S_d; and

encrypt the data D using the generated second key K_{n+1} to obtain encrypted data $K_{n+1}(D)$.

22. The host apparatus of claim **21** wherein the encryption/decryption means further is for:

receiving the encrypted data $K_{n+1}(D)$;

generating the second key K_{n+1} according to the host key seed S_h and the device key seed S_d; and

decrypting the encrypted data $K_{n+1}(D)$ using the generated second key K_{n+1} to obtain the data D.

23. The host apparatus of claim **21** wherein the device key seed S_d is also randomly generated by the storage device according to an occurrence time of one of the specific operations as notified by an interrupt.

24. A data encryption system, comprising:

a storage device including:

an encryption/decryption module adapted to randomly generate a device key seed S_d according to a time interval between two specific operations on the storage device,

wherein the storage device is adapted to randomly generate the device key seed S_d in response to interrupts that notify the storage device of occurrence of the two specific operations; and

a host adapted to receive the generated device key seed S_d from the storage device, to generate a host key seed S_h to generate a first key K_n according to the received device key seed S_d, to encrypt the generated host key seed S_h using the generated first key K_n, and to transmit the encrypted host key seed $K_n(S_h)$ to the storage device;

wherein the storage device is further adapted to generate the first key K_n according to the device key seed S_d, to decrypt the transmitted encrypted host key seed $K_n(S_h)$ using the generated first key K_n to obtain the host key seed S_h to generate a second key K_{n+1} according to the obtained host key seed S_h and the device key seed S_d.

25. A data encryption method comprising:

generating, at a first device, a first seed based at least partly on a time interval between execution of an application and previous receipt of a second seed from a second device;

generating an encryption key based at least partly on the first seed at the first device;

encrypting the first seed at the first device to produce an encrypted first seed;

electronically transmitting the encrypted first seed to the second device to enable the second device to encrypt data for transmission to the first device based at least partly on the first seed;

receiving encrypted data at the first device from the second device; and

decrypting the encrypted data at the first device using the encryption key.

26. The data encryption method of claim 25, wherein the first device is a host and the second device is a storage device.

27. The data encryption method of claim 25, wherein the first device is a computer system and the second device is a mobile device.

28. The data encryption method of claim 25, wherein one or both of the first seed and the second seed are 32 bits.

29. The data encryption method of claim 28, wherein the encryption key has 8m bits, where m is an integer from 1 to 8.

30. The data encryption method of claim 25, wherein said encrypting the first seed comprises using symmetric encryption.

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