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(54) **METHOD AND APPARATUS FOR PROTECTING DIGITAL DATA BY DOUBLE RE-ENCRYPTION**

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(57) **ABSTRACT**

Method and an apparatus for ensuring protection of digital data are provided. Embodiments may include double re-encrypting decrypted data using multiple keys (e.g., an unchangeable key, and a changeable key). In various embodiments, the re-encrypting may be performed using hardware, software, or a combination of hardware and software (e.g., re-encrypting in hardware using an unchangeable key and re-encrypting in software using a changeable key). In some embodiments, encryption/decryption is performed with RTOS using a HAL and a device driver (e.g., a filter driver, a disk driver and a network driver, in an I/O manager).

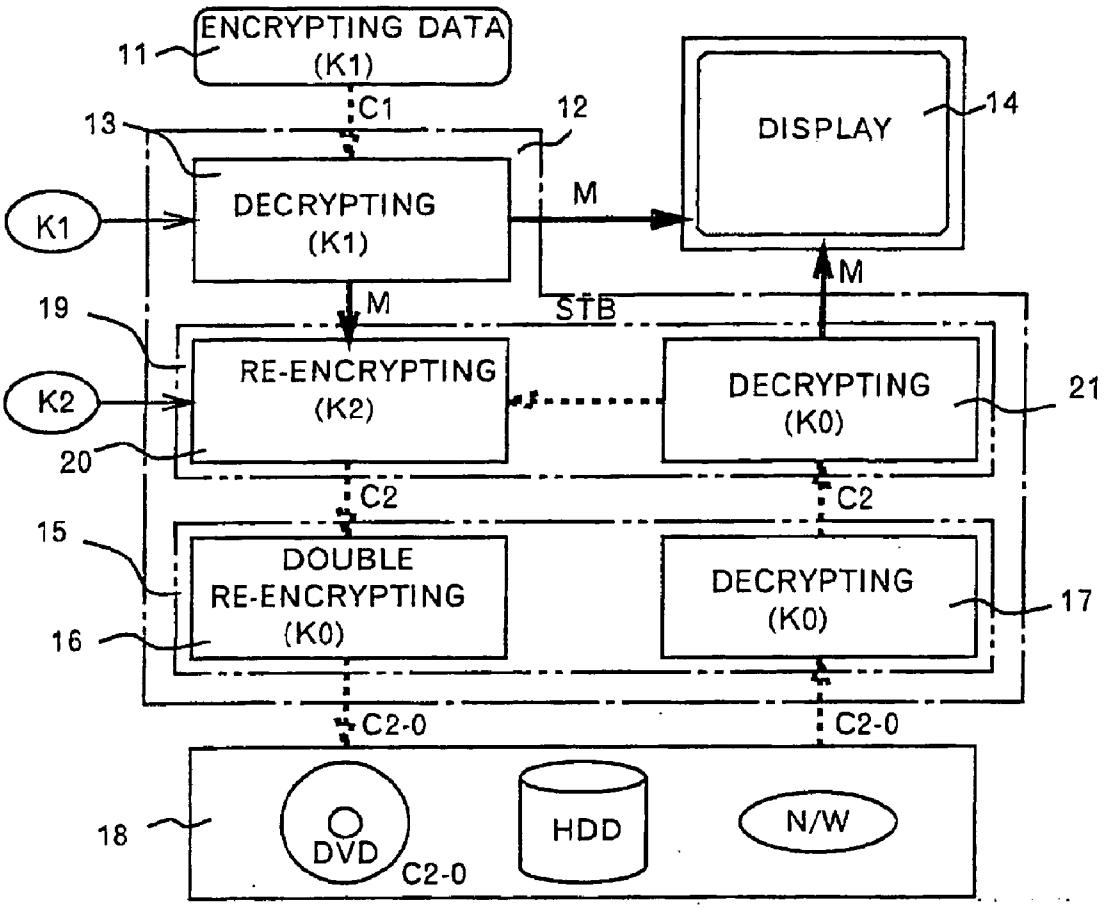


FIG. 1

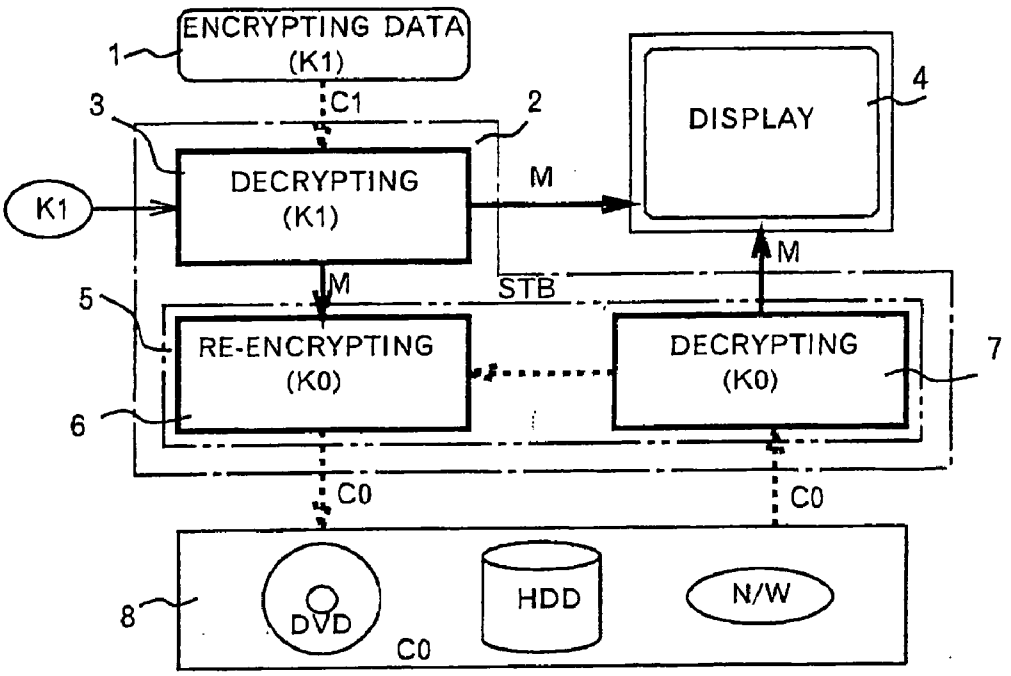

ENCRYPTING DATA
(K1)
1
C1
3
2
DECRYPTING
(K1)
K1
M
DISPLAY
4
M
M
STB
5
RE-ENCRYPTING
(K0)
DECRYPTING
(K0)
7
6
C0
C0
8
DVD
HDD
N/W
C0

FIG. 2

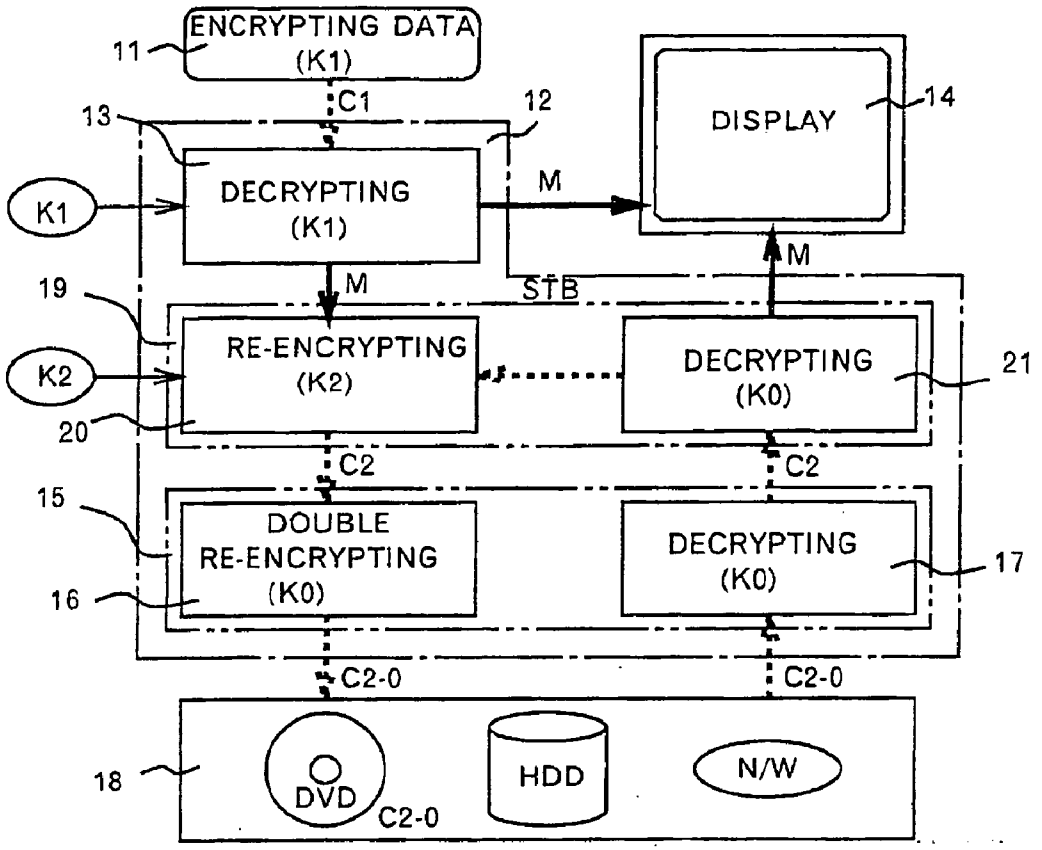

ENCRYPTING DATA
(K1)
11
C1
12
13
DISPLAY
14
DECRYPTING
(K1)
K1
M
M
M
STB
19
RE-ENCRYPTING
(K2)
K2
DECRYPTING
(K0)
21
20
C2
C2
15
DOUBLE
RE-ENCRYPTING
(K0)
DECRYPTING
(K0)
17
16
C2-0
C2-0
18
DVD
C2-0
HDD
N/W

FIG. 3

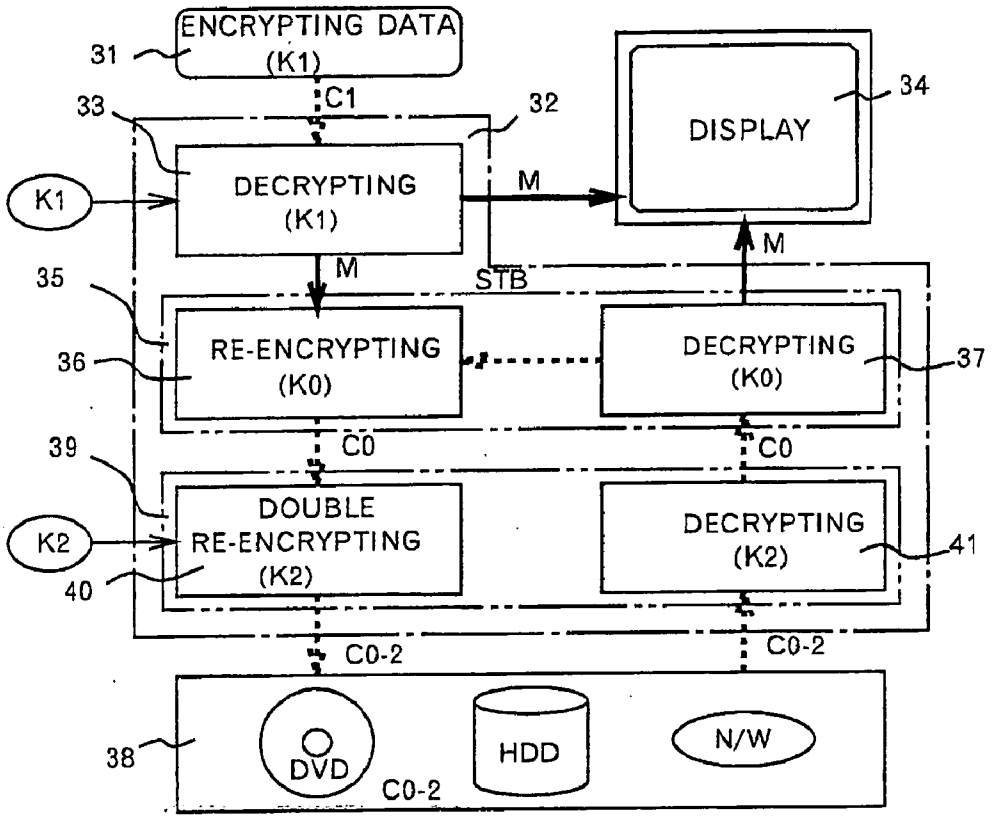

ENCRYPTING DATA
(K1)
31
C1
33
32
DISPLAY
34
DECRYPTING
(K1)
K1
M
M
M
STB
35
RE-ENCRYPTING
(K0)
36
DECRYPTING
(K0)
37
C0
C0
39
DOUBLE
RE-ENCRYPTING
(K2)
K2
40
DECRYPTING
(K2)
41
C0-2
C0-2
38
DVD
HDD
N/W
C0-2

FIG. 4

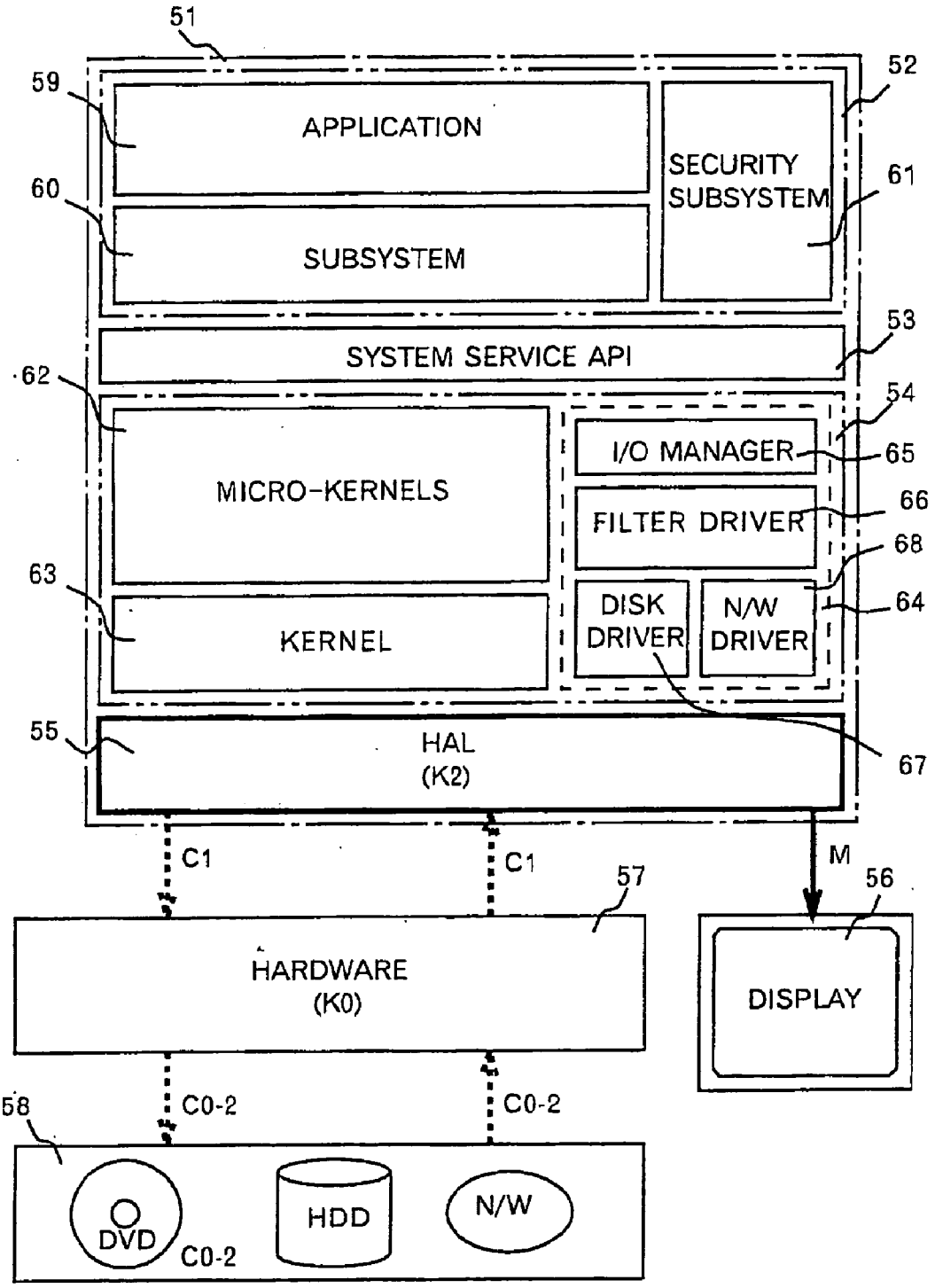
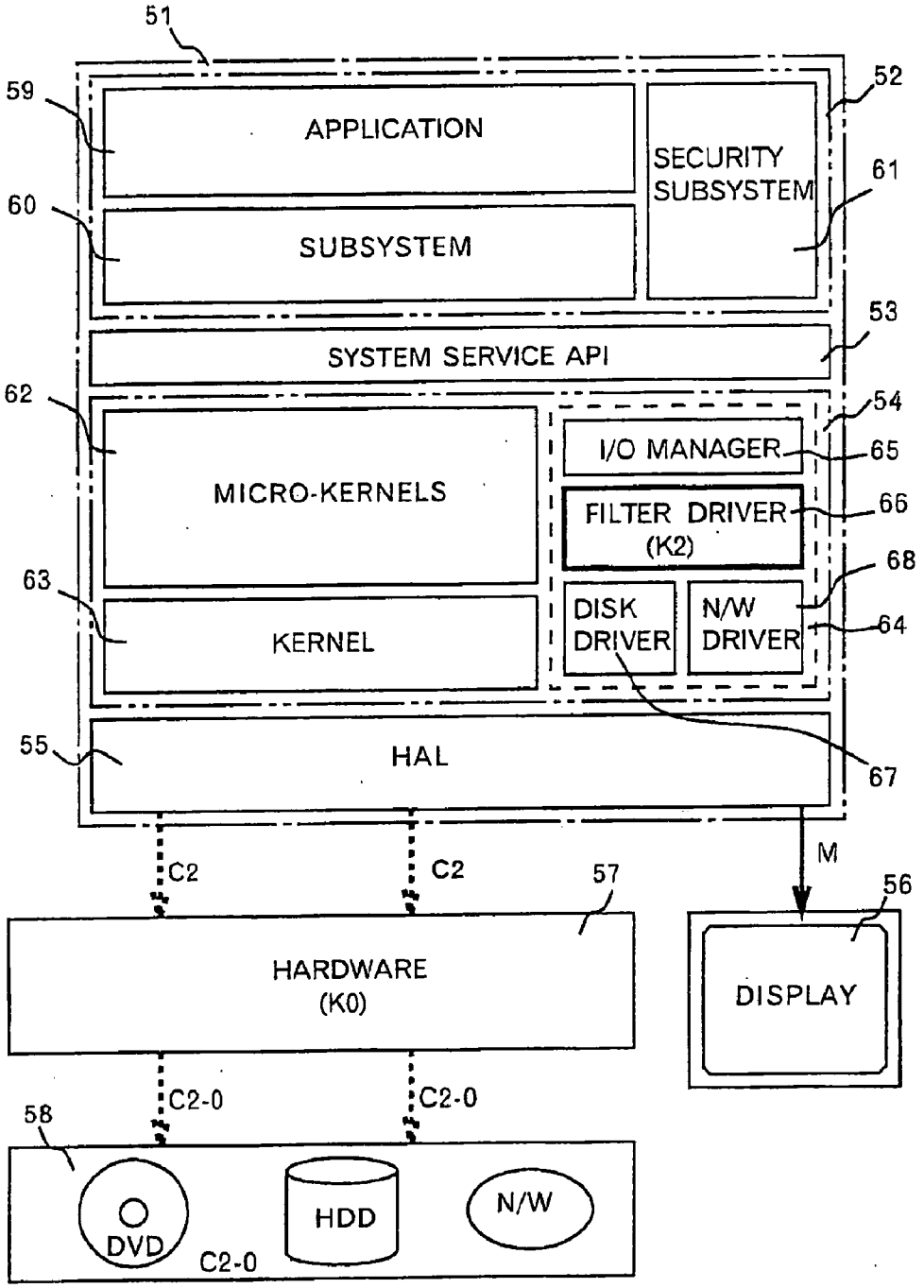

51
52
59
APPLICATION
SECURITY SUBSYSTEM
61
60
SUBSYSTEM
53
SYSTEM SERVICE API
62
54
I/O MANAGER
65
MICRO-KERNELS
66
FILTER DRIVER
68
63
DISK DRIVER
N/W DRIVER
64
KERNEL
55
HAL (K2)
67
C1
C1
M
57
56
HARDWARE (K0)
DISPLAY
58
C0-2
C0-2
DVD
C0-2
HDD
N/W

FIG. 5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APPLICATION
SECURITY SUBSYSTEM
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SUBSYSTEM
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SYSTEM SERVICE API
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I/O MANAGER
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MICRO-KERNELS
FILTER DRIVER (K2)
66
68
63
KERNEL
DISK DRIVER
N/W DRIVER
64
55
HAL
67
C2
C2
57
M
56
HARDWARE (K0)
DISPLAY
C2-0
C2-0
58
DVD
HDD
N/W
C2-0

FIG. 6

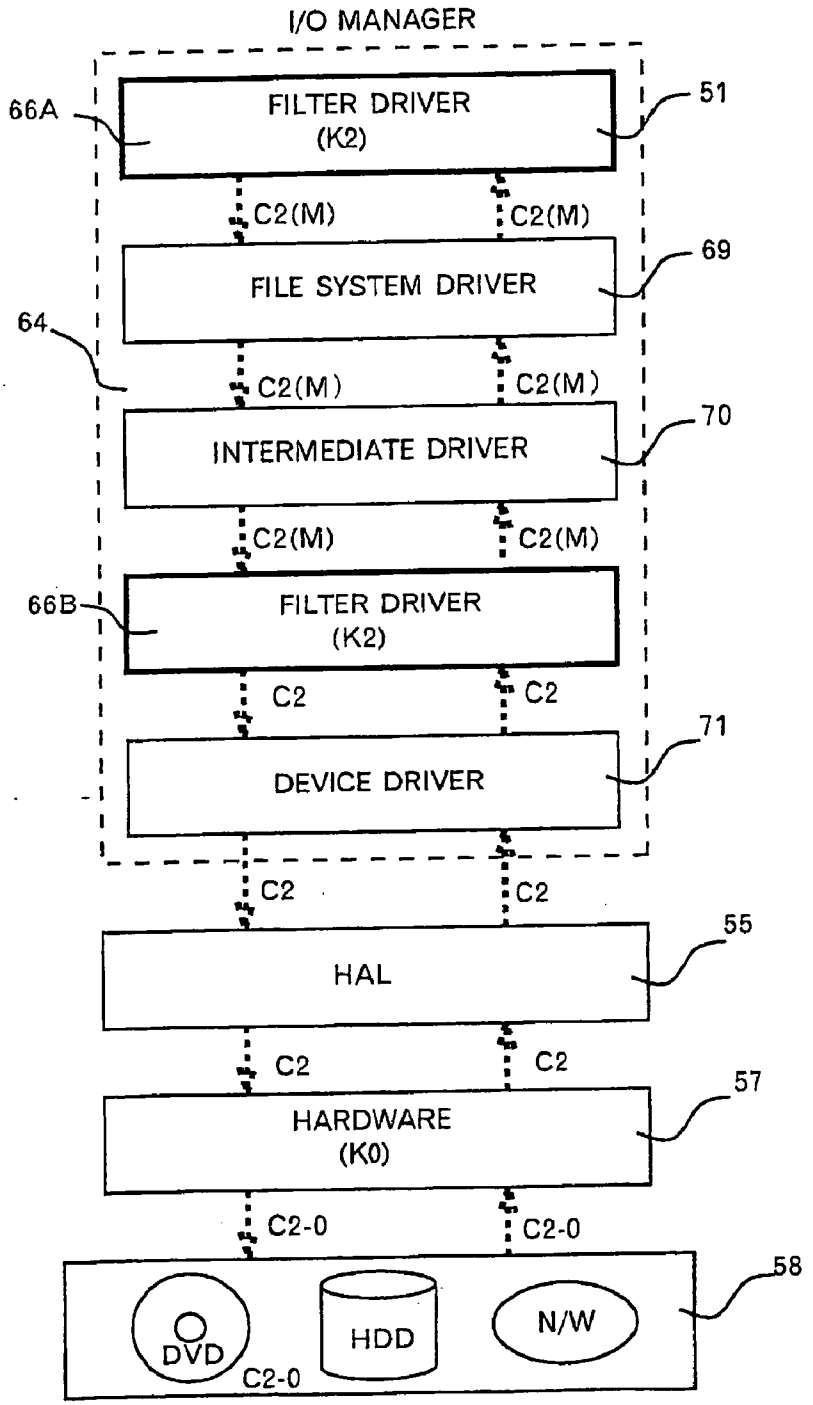
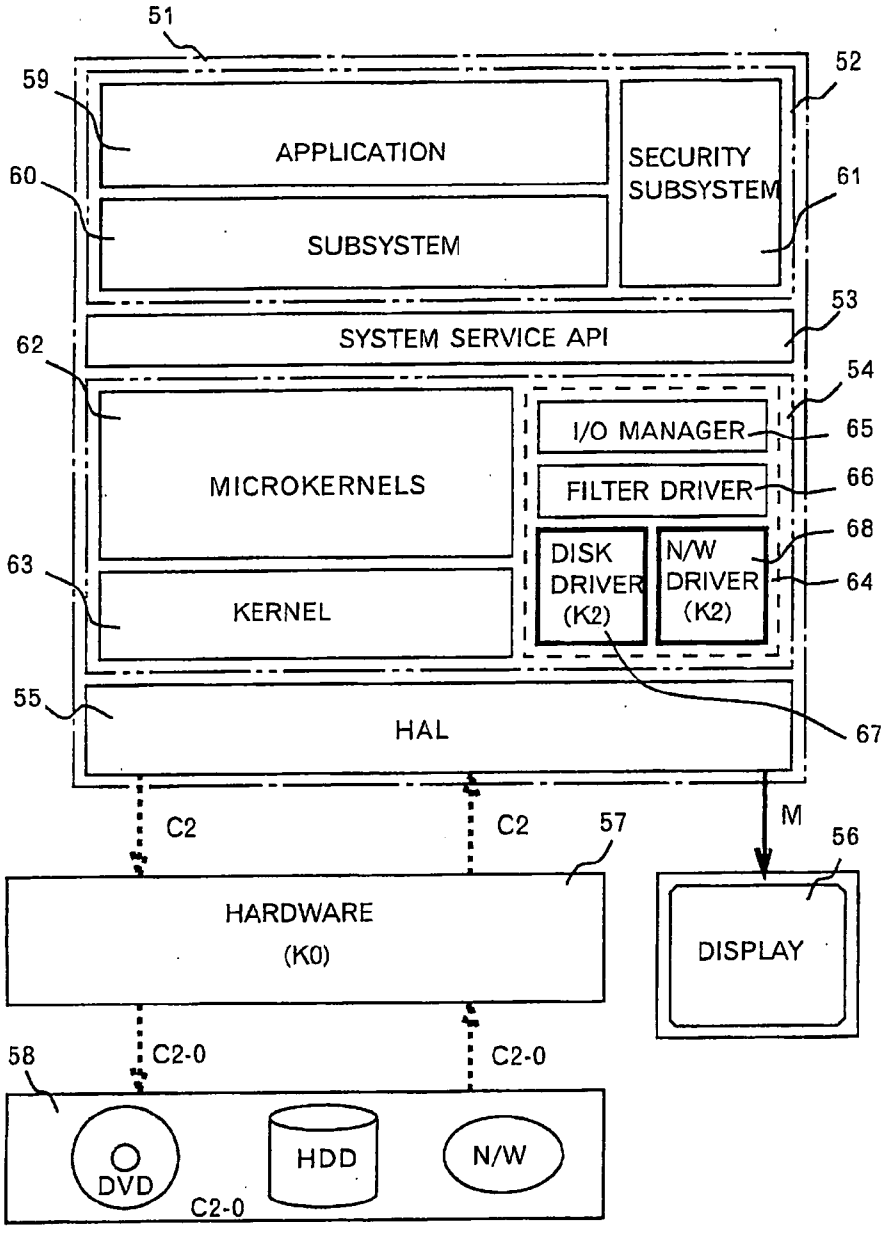

I/O MANAGER
66A
FILTER DRIVER
(K2)
51
C2(M)
C2(M)
FILE SYSTEM DRIVER
69
64
C2(M)
C2(M)
INTERMEDIATE DRIVER
70
C2(M)
C2(M)
66B
FILTER DRIVER
(K2)
C2
C2
DEVICE DRIVER
71
C2
C2
HAL
55
C2
C2
HARDWARE
(K0)
57
C2-0
C2-0
DVD
C2-0
HDD
N/W
58

FIG. 7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APPLICATION
SECURITY SUBSYSTEM
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SUBSYSTEM
53
SYSTEM SERVICE API
62
54
I/O MANAGER
65
MICROKERNELS
FILTER DRIVER
66
68
DISK DRIVER (K2)
N/W DRIVER (K2)
63
64
KERNEL
55
HAL
67
C2
C2
57
M
56
HARDWARE (K0)
DISPLAY
58
C2-0
C2-0
DVD
HDD
N/W
C2-0

FIG. 8

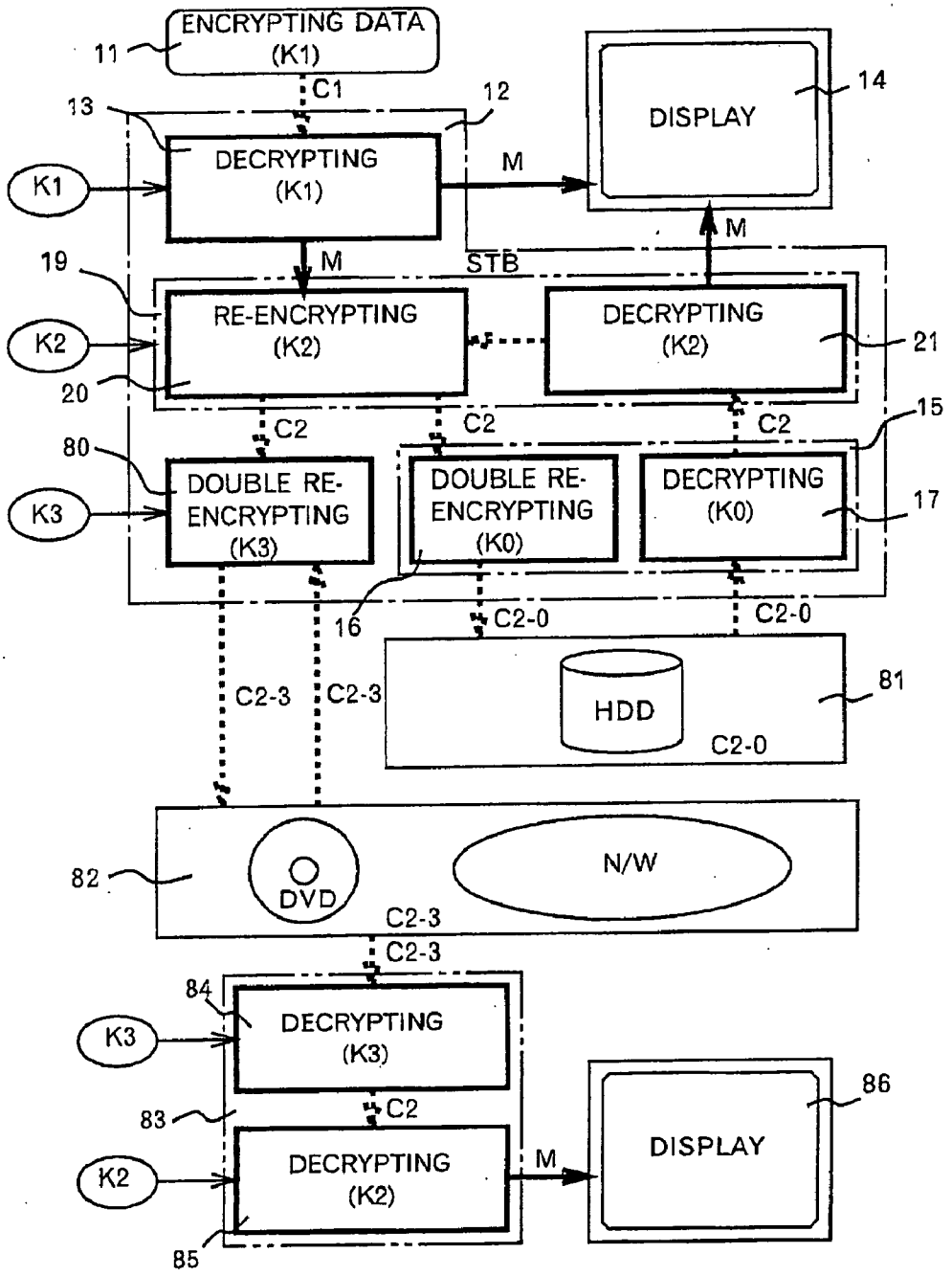

ENCRYPTING DATA
(K1)
11
C1
12
13
DECRYPTING
(K1)
K1
M
DISPLAY
14
M
STB
19
RE-ENCRYPTING
(K2)
K2
20
DECRYPTING
(K2)
21
C2
C2
C2
15
80
DOUBLE RE-
ENCRYPTING
(K3)
K3
DOUBLE RE-
ENCRYPTING
(K0)
DECRYPTING
(K0)
17
16
C2-0
C2-0
C2-3
C2-3
HDD
C2-0
81
82
DVD
N/W
C2-3
C2-3
84
DECRYPTING
(K3)
K3
C2
83
DECRYPTING
(K2)
K2
M
DISPLAY
86
85

FIG. 9

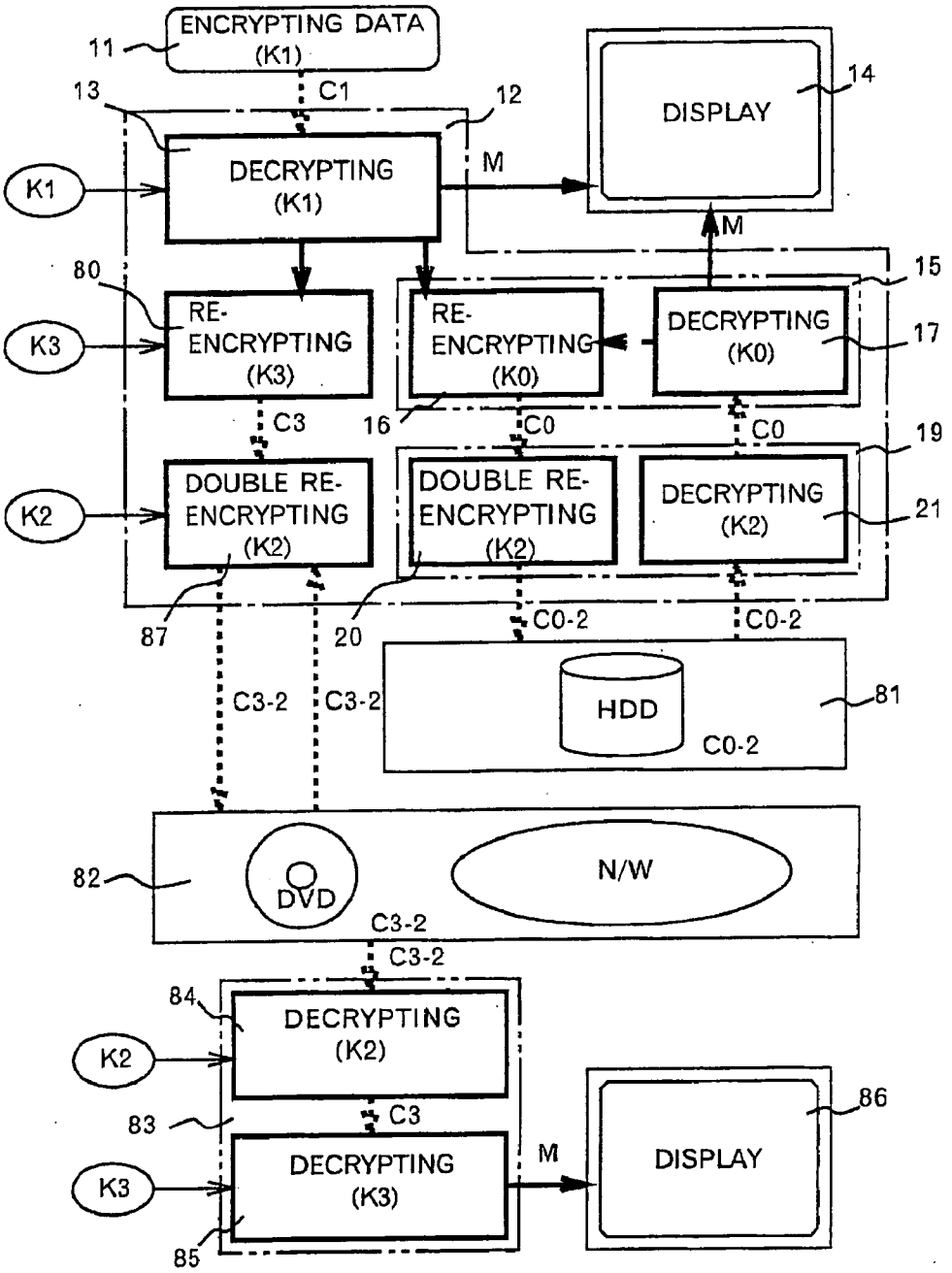
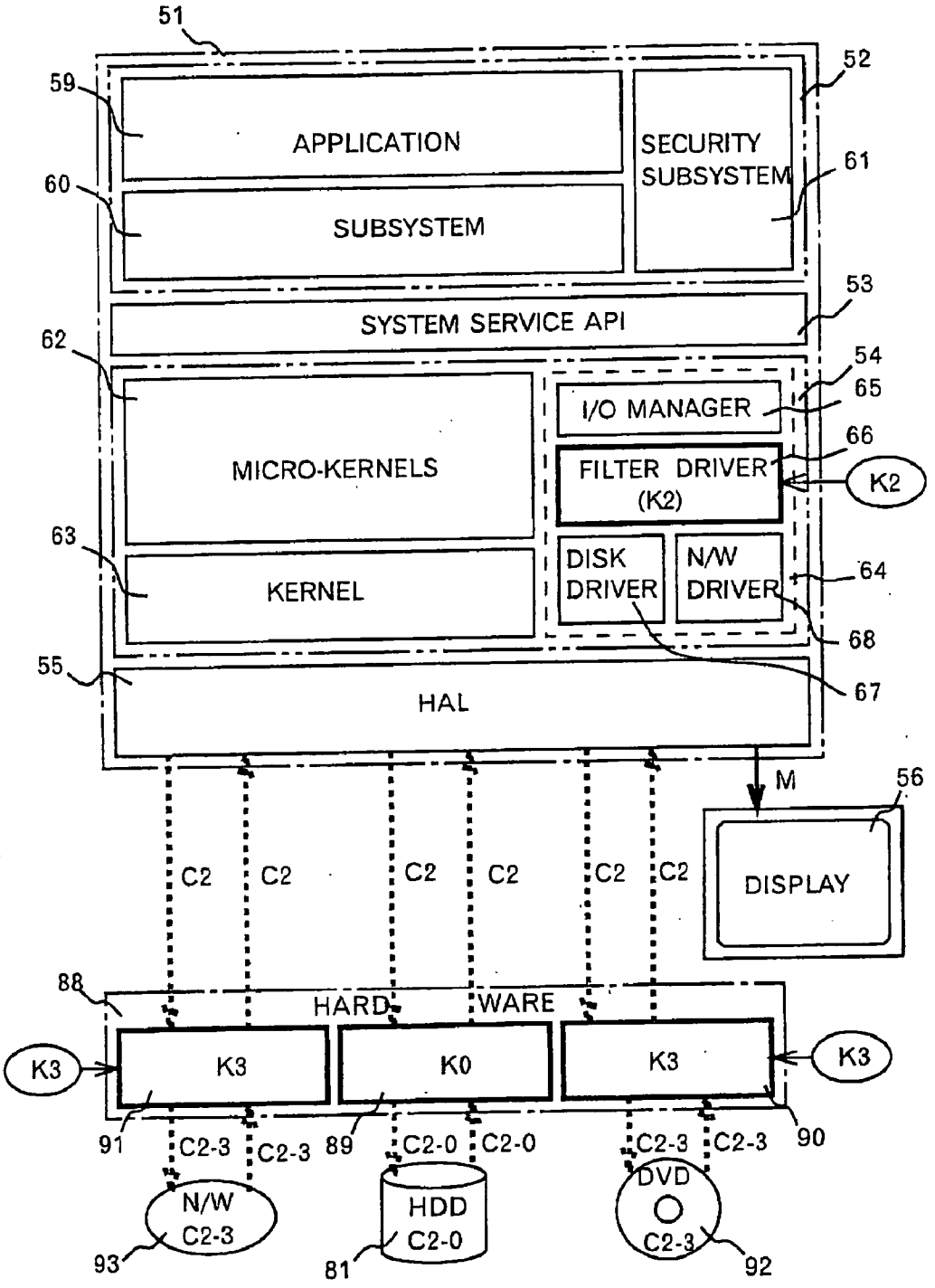

ENCRYPTING DATA (K1)
11
C1
13
12
DISPLAY
14
DECRYPTING (K1)
K1
M
M
80
15
RE-ENCRYPTING (K3)
K3
RE-ENCRYPTING (K0)
DECRYPTING (K0)
17
C3
16
C0
C0
19
DOUBLE RE-ENCRYPTING (K2)
K2
DOUBLE RE-ENCRYPTING (K2)
DECRYPTING (K2)
21
87
20
C0-2
C0-2
C3-2
C3-2
HDD
81
C0-2
82
DVD
N/W
C3-2
C3-2
84
DECRYPTING (K2)
K2
C3
83
DECRYPTING (K3)
K3
M
DISPLAY
86
85

FIG. 10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K2
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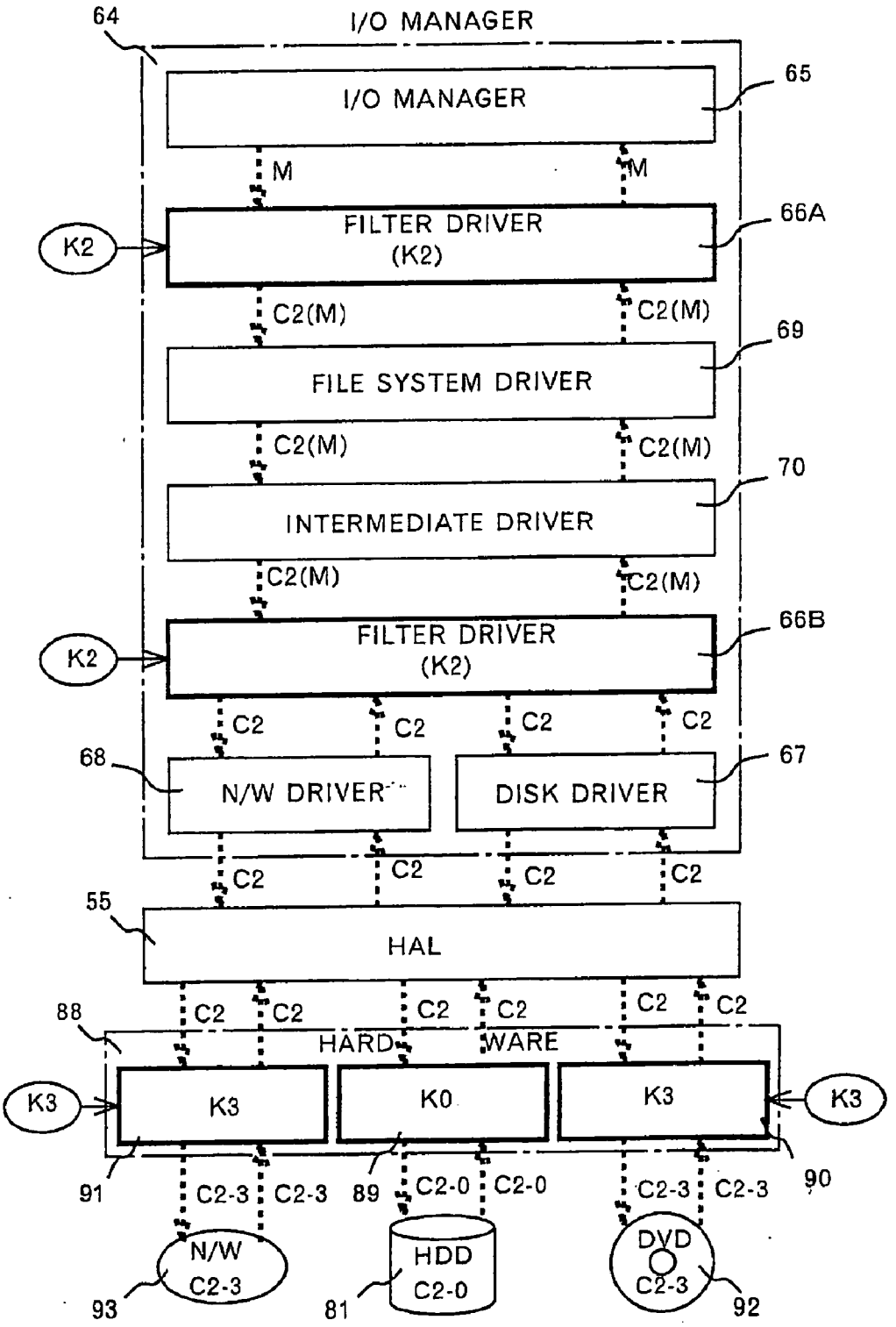
N/W DRIVER
64
68
67
55
HAL
M
56
DISPLAY
C2
C2
C2
C2
C2
C2
88
HARDWARE
K3
K3
K0
K3
K3
91
89
90
C2-3
C2-3
C2-0
C2-0
C2-3
C2-3
N/W C2-3
HDD C2-0
DVD C2-3
93
81
92

FIG. 11


64
I/O MANAGER
I/O MANAGER
65
M
M
FILTER DRIVER
(K2)
66A
K2
C2(M)
C2(M)
FILE SYSTEM DRIVER
69
C2(M)
C2(M)
INTERMEDIATE DRIVER
70
C2(M)
C2(M)
FILTER DRIVER
(K2)
66B
K2
C2
C2
C2
C2
68
N/W DRIVER
DISK DRIVER
67
C2
C2
C2
C2
55
HAL
C2
C2
C2
C2
C2
C2
88
HARD
WARE
K3
K3
K0
K3
K3
91
C2-3
C2-3
89
C2-0
C2-0
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N/W
C2-3
HDD
C2-0
DVD
C2-3
93
81
92

FIG. 12

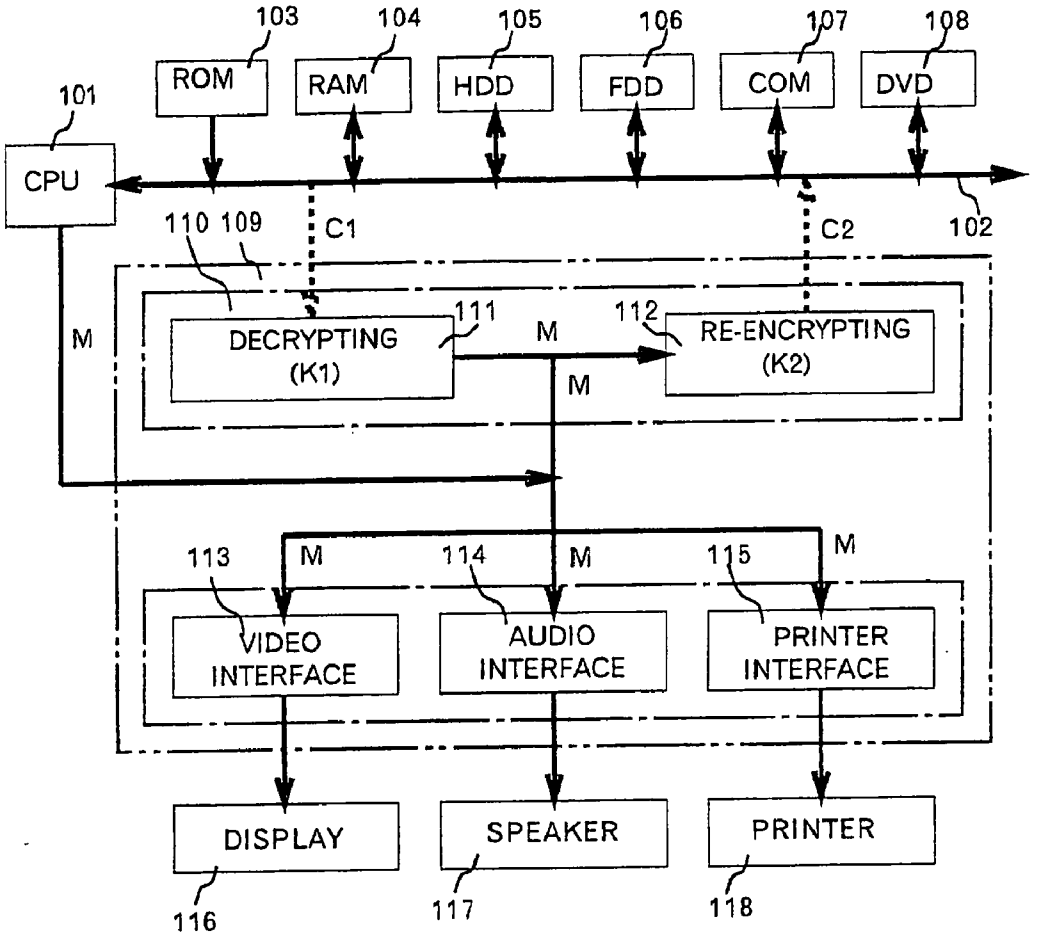

103
104
105
106
107
108
ROM
RAM
HDD
FDD
COM
DVD
101
CPU
110 109
C1
C2
102
M
DECRYPTING (K1)
111
M
112
RE-ENCRYPTING (K2)
M
113
M
114
M
115
M
VIDEO INTERFACE
AUDIO INTERFACE
PRINTER INTERFACE
DISPLAY
SPEAKER
PRINTER
116
117
118

FIG. 13

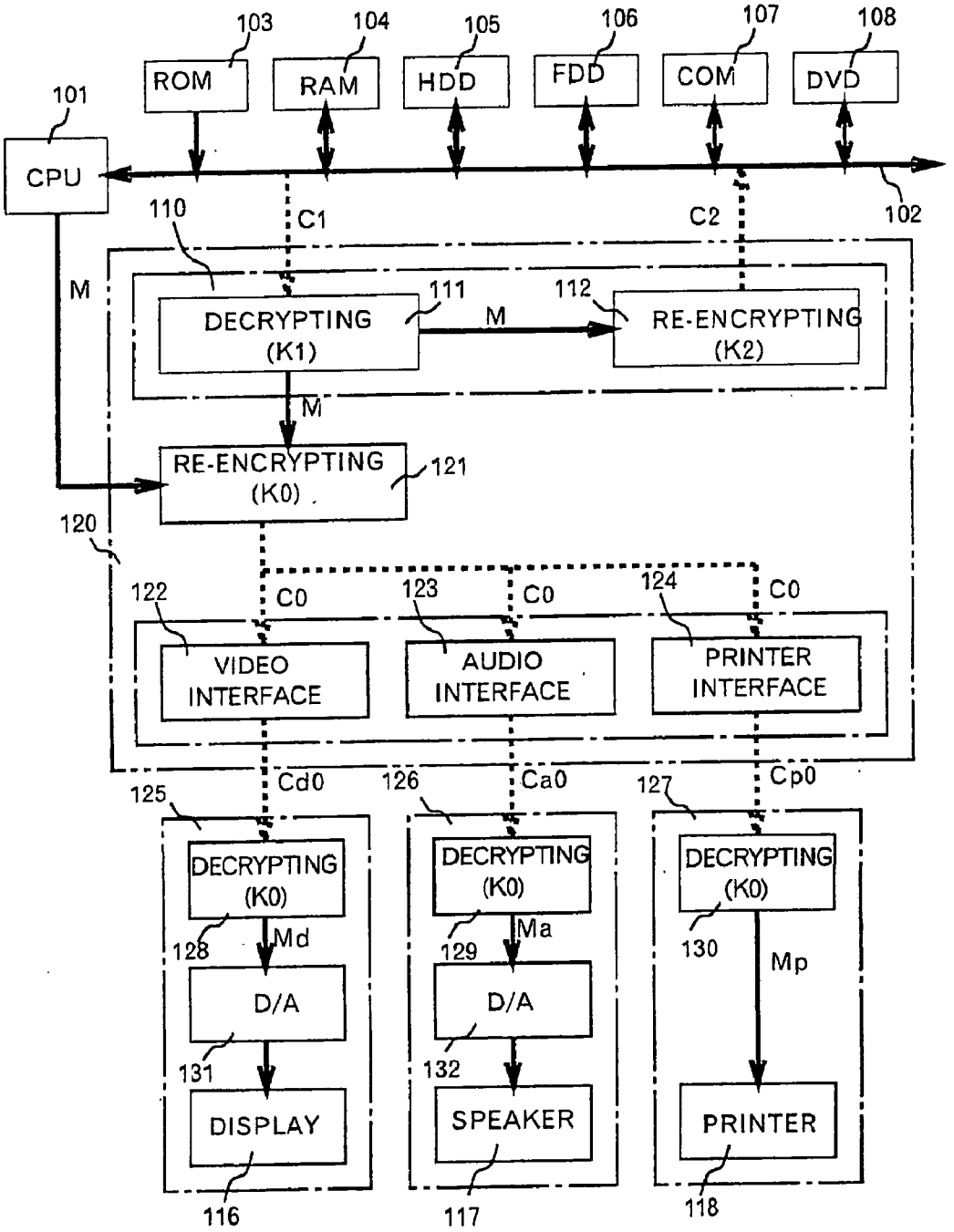
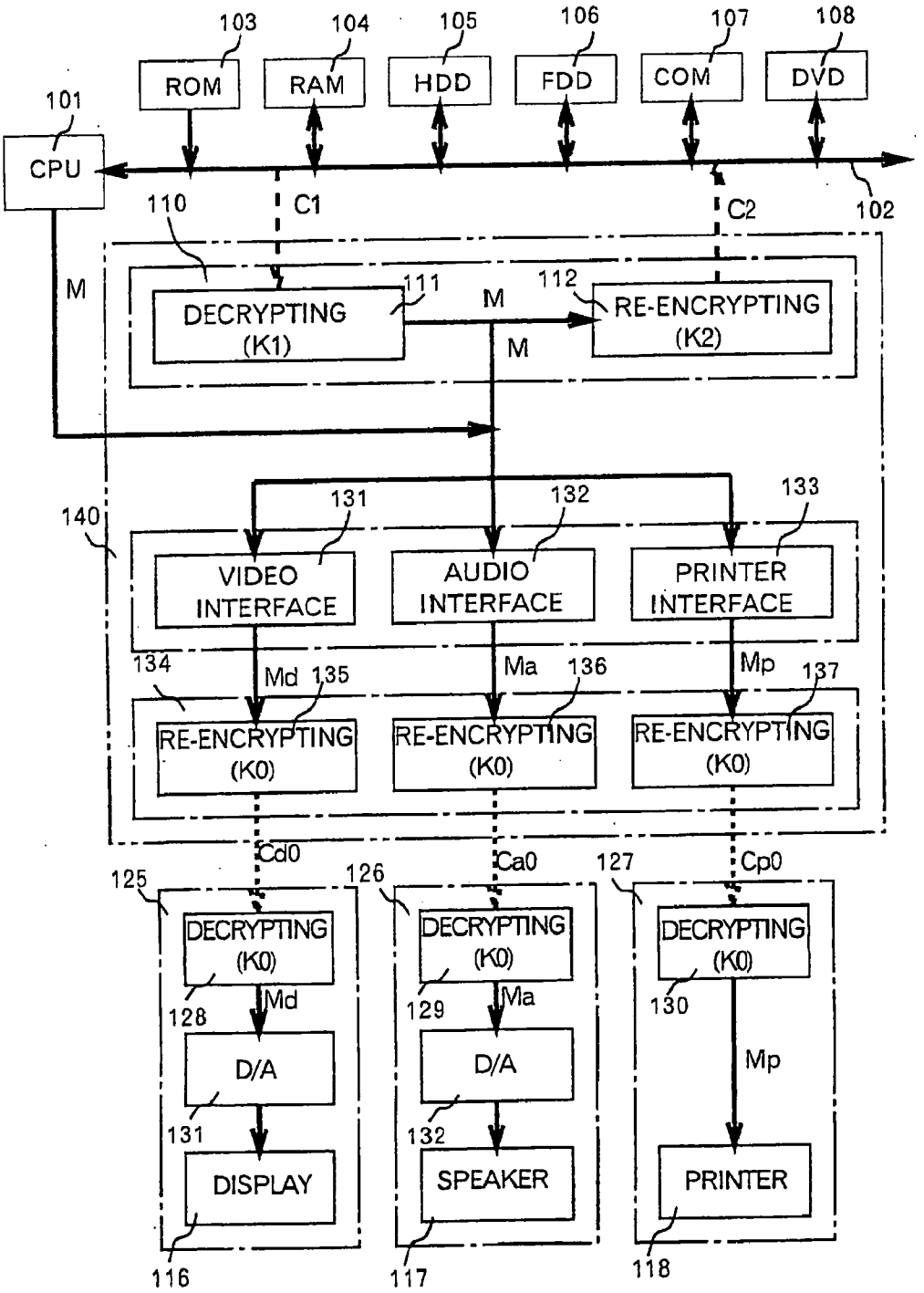

103
104
105
106
107
108
ROM
RAM
HDD
FDD
COM
DVD
101
CPU
102
110
C1
C2
M
DECRYPTING (K1)
111
M
112
RE-ENCRYPTING (K2)
M
RE-ENCRYPTING (K0)
121
120
122
C0
123
C0
124
C0
VIDEO INTERFACE
AUDIO INTERFACE
PRINTER INTERFACE
Cd0
Ca0
Cp0
125
126
127
DECRYPTING (K0)
DECRYPTING (K0)
DECRYPTING (K0)
128
Md
129
Ma
130
Mp
D/A
D/A
131
132
DISPLAY
SPEAKER
PRINTER
116
117
118

FIG. 14


103
104
105
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107
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ROM
RAM
HDD
FDD
COM
DVD
101
CPU
102
110
C1
C2
M
111
112
DECRYPTING (K1)
RE-ENCRYPTING (K2)
140
131
132
133
VIDEO INTERFACE
AUDIO INTERFACE
PRINTER INTERFACE
134
Md
135
Ma
136
Mp
137
RE-ENCRYPTING (K0)
Cd0
Ca0
Cp0
125
126
127
DECRYPTING (K0)
128
129
130
D/A
131
132
DISPLAY
SPEAKER
PRINTER
116
117
118

METHOD AND APPARATUS FOR PROTECTING DIGITAL DATA BY DOUBLE RE-ENCRYPTION

FIELD OF THE INVENTION

[0001] The present invention relates to a system for managing digital contents. In particular, the present invention relates to a system used for managing copyrights of digital content, for which copyrights are claimed, and for protecting the secrecy of the digital content so as to achieve enhanced digital content distribution and to realize digital content commerce.

PRIOR ART

[0002] Hitherto, widely spread analog content deteriorate in quality each time it is stored, copied, edited and transferred. Hence, no serious detriment from copyright violations occurs during these operations. However, digital content does not deteriorate in quality after repeated storing, coping, editing and transferring. Thus, the control of digital content copyright is an important issue.

[0003] Digital data such as digital video data, digital audio data, etc. is usually supplied to users on a payment basis accompanying a broadcast, transfer of a DVD, etc. In these cases, the data is encrypted and supplied in a manner which excludes unpaid viewing. The encrypted and supplied digital data is decrypted using a crypt key, which is supplied to the user by certain means, before the data is viewed. Because the quality of decrypted digital data does not deteriorate even when it is stored, copied or transferred, if the data is stored, copied or transferred by the user, secondary viewing free of charge may occur. Non-authorized re-use of the decrypted digital data content is against the benefit of the data content provider. In this respect, systems and equipment have been developed to prohibit re-use, i.e., secondary utilization such as storage, copying or transferring the digital data content.

[0004] However, the prohibition of the secondary utilization makes it less attractive for users of the digital data content and it is now recognized that this may hinder the propagation of the use of the digital data content. In this respect, it is now proposed to prevent illegitimate use by re-encrypting the decrypted digital data content so that the use of the digital data content is more attractive for users.

[0005] When the digital data, which is stored in a medium and is given or lent to a user or which is transferred to the user, is used for secondary utilization such as storing, copying or transferring, it is impossible for the copyright owner to protect his or her copyright(s) in the digital data, which is in the hands of the users. Therefore, a certain method is required to protect copyrights automatically and forcibly.

[0006] Under such circumstances, the present inventor has made various proposals with the purpose of protecting digital content copyrights.

[0007] In Japanese Patent Laid-Open Publications 46419/1994 (GB-2269302; U.S. Ser. No. 08/098,415) and 141004/1994 (USP5,794,115; USP5,901,339), the present inventor proposed a system for managing copyrights by obtaining a permit key from a key control center via a public telephone line, and also, an apparatus for such a purpose in Japanese Patent Laid-Open Publication 132916/1994 (GB-2272822; U.S. Ser. No. 08/135,634).

[0008] Also, in Japanese Patent Laid-Open Publications 271865/1995 (EP0677949A2; U.S. Ser. No. 08/416,037) and 185448/1996 (EP0704785A2; U.S. Ser. No. 08/536,747), a system for copyright management of the digital contents was proposed.

[0009] In these systems and apparatus, those who wish to view an encrypted program makes a viewing request to a management center via a communication line using a communication device. Upon receipt of the viewing request, the management center transmits a permit key and charges and collects a fee.

[0010] Upon receipt of the permit key, the requestor transmits the permit key to a receiving device by on-line or off-line means. When the permit key is received, the receiving device decrypts the encrypted program by using the permit key.

[0011] The system described in Japanese Patent Laid-Open Publication 271865/1995 (EP0677949A2; U.S. Ser. No. 08/416,037), uses a program for managing the copyright and copyright information, in addition to a key for use permission, to manage the copyright of the digital content in displaying (including process to sound), storing, copying, editing and transferring the digital contents, including real-time transmission of digital video content, in a database system. The program for copyright management watches and manages in a manner that the digital content is not used outside the use permission or user's request.

[0012] Japanese Patent Laid-Open Publication 271865/1995 (EP0677949A2; U.S. Ser. No. 08/416,037) describes that the digital content is supplied from a database in the encrypted state and is decrypted by the copyright management program only when it is displayed or edited, and is again in the encrypted state when it is stored, copied or transferred. Further, it describes that the copyright management program itself is encrypted and is decrypted by using a permit key, and the decrypted copyright management program performs decryption and encryption of the copyrighted data, and that, when a utilization other than storing and displaying the data is performed, copyright information including information of the person who performed the utilization is added to the original copyright information and stored as history.

[0013] Japanese Patent Laid-Open Publication 287014/1996 (USP5,867,579; EP0715241A2) proposed an apparatus for decryption/re-encryption having a configuration of a board, a PCMCIA card, an IC card or an IC for the copyright management and a crypt key escrow system. This application also describes the copyright management method applied to a video conference system and an electronic commerce system. USP5,805,706, also describes an apparatus for decryption/re-encryption having an IC configuration.

[0014] Japanese Patent Laid-Open Publication 272745/1996 (USP5,646,999; EP0709760) proposed a system, in which the copyright of original data and the copyright of new data produced by editing the original data or editing a plurality of original data are protected by confirming the validity of a use request based on a digital signature on an edit program, in combination with the use of a secret-key cryptosystem and a public-key cryptosystem.

[0015] Japanese Patent Laid-Open Publication 288940/1996 (USP5,740,246; EP0719045A2) proposed various forms for applying the copyright management system to a database system, a video-on-demand (VOD) system or an electronic commerce system.

[0016] Japanese Patent Laid-Open Publication 329011/1996 (USP5,848,158; EP0746126A2) proposed a system, in which copyrights of original data and new data are protected

by using a third crypt key and a copyright label in case of using and editing a plurality of data.

[0017] As it can be understood from the data copyright management systems and the data copyright management apparatus proposed by the present inventor as described above, the management of data copyrights can be accomplished by encryption/decryption/re-encryption and limiting usage of digital content by the copyright management program. The cryptography technique and usage limitation can be realized by using a computer.

[0018] In a case where secret information is exchanged via a network, the information is encrypted for preventing piracy.

[0019] It is described in USP5,504,818 and USP5,515,441 that information piracy during transmission is prevented by encryption. Using a plurality of keys in such a case is described in USP5,504,816, 5,353,351, 5,475,757 and 5,381,480, and performing re-encryption is described in USP5,479,514.

[0020] The protection of copyrights in the secondary utilization of digital data by the copyright management program can be realized by re-encryption/re-decryption of the decrypted digital data and by managing and performing the re-encryption/re-decryption by using the copyright management program.

[0021] Of course, it goes without saying that the means for carrying out re-encryption/re-decryption includes cases where software is used and cases where hardware is used.

[0022] Here, the operation to obtain encrypted data C from non-encrypted data M by using a key K is expressed as:

$$C=E(M,K),$$

[0023] and to obtain decrypted data M from encrypted data C by using the key K is expressed as:

$$M=D(C,K).$$

[0024] When re-encryption/re-decryption of the decrypted data M is repeated, re-encryption is expressed as:

$$\forall i: Ci=E(D(Ci-1,Ki-1),Ki),$$

where i is a positive integer, and re-decryption is expressed as:

$$\exists: M=D(E(Ci-1,Ki-1),Ki).$$

[0025] Referring to FIG. **1**, description will be given on an arrangement of a conventional set-top box (STB) and on a method for protecting the digital data performed in the set-top box.

[0026] Description is not given here on peripheral circuits not directly related to encryption/decryption, e.g., the description for an amplifier unit and a compression/expansion unit is omitted.

[0027] In FIG. **1**, reference numeral **1** represents digital data supplied by broadcasting means such as digital terrestrial wave broadcasting, digital CATV broadcasting, digital satellite broadcasting, etc., by network means such as the Internet, or by a digital storage medium such as a DVD, a CD, etc. The data is encrypted by using a first changeable key K**1** to prevent illegitimate use:

$$C1=E(M,K1)$$

and is supplied to a set-top box **2**.

[0028] When the encrypted digital data C**1** is supplied to the set-top box **2**, the encrypted digital data C**1** is decrypted by a decryption unit **3** using the first changeable key K**1** obtained from a key center via the same route as or via a different route from that of the encrypted digital data C**1**:

$$M=D(C1,K1)$$

and data M thus decrypted is outputted to a display unit **4** or the like.

[0029] In a case where the decrypted data M is stored in a medium such as a digital versatile disk (DVD) RAM or a hard disk, etc., or it is transferred externally via a network, the decrypted data M is re-encrypted by an encryption unit **6** within an unchangeable key encryption/decryption unit **5**, using an unchangeable key K**0**:

$$\forall 0: C0 = E(M, K0)$$
$$= E(D(C1, K1), K0)$$

and re-encrypted data C**0** is stored in or transferred to an external device **8**.

[0030] In a case where the re-encrypted data C**0** is used again, the re-encrypted data C**0** read from a storage medium of the external device **8** or transferred via the network is re-decrypted using the unchangeable key K**0** by a decryption unit **7** of the unchangeable key encryption/decryption unit **5**:

$$\exists: M = D(C0, K0)$$
$$= D(E(D(C1, K1), K0)$$

and the decrypted data M is outputted to the display unit **4** or the like.

[0031] In this case, in order to ensure security, it may be arranged in such a manner that the re-encrypted data C**0** in the storage medium is erased when the re-encrypted data C**0** is read from the storage medium via a route shown by a broken line in the figure and that the data re-encrypted again by using the unchangeable key K**0** is re-stored.

[0032] In USP5,805,706, an integrated circuit for performing re-encryption/re-decryption is described.

[0033] In the set-top box as arranged above, it is easy to handle because re-encryption/re-decryption is automatically carried out by the hardware by using the unchangeable key K**0**, and it is effective for forcible re-encryption/re-decryption of the digital data, which must be protected.

[0034] However, since the unchangeable key K**0** is placed in the device, and since there is the possibility that the unchangeable key K**0** may be known to others, it may become impossible to protect the digital data thereafter.

SUMMARY OF THE INVENTION

[0035] To solve the above problem, the present invention provides a method and an apparatus for double re-encrypting the data by using a changeable key in addition to re-encrypting by using an unchangeable key.

[0036] In use of the unchangeable key and the changeable key, there are cases where the changeable key is used first and the unchangeable key is then used, and where the unchangeable key is used first and the changeable key is then used.

[0037] The key used first when re-encrypting is the final key used when decrypting, and accordingly, even if data, which is subsequently re-encrypted, is cryptanalyzed, security is highly ensured. Therefore, in a case where a changeable key is used first and an unchangeable key is next used for

re-encryption, the possibility that the changeable key is known to others is very low even when the unchangeable key has been known to the others.

[0038] In the aspects of the embodiments of the present invention, software and/or hardware may be used. In an embodiment using hardware, hardware using the unchangeable key developed for digital video can be used.

[0039] In an embodiment using software, in order to ensure the security of the program and the key used, encryption/decryption is performed in a region under a kernel which cannot be handled by users. More concretely, encryption/decryption is performed at a filter driver, a device driver, i.e., a disk driver/network driver, and a real-time OS using HAL in an I/O manager. There are two filter drivers with a file system driver interposed between them, and either one of the filter drivers may be used, or both may be used.

BRIEF DESCRIPTION OF THE DRAWINGS

[0040] FIG. **1** shows a general arrangement of a conventional set-top box;

[0041] FIG. **2** shows a general arrangement of a first embodiment of the present invention applied to a set-top box;

[0042] FIG. **3** shows a general arrangement of a second embodiment of the present invention applied to a set-top box;

[0043] FIG. **4** shows a general arrangement of a third embodiment applied to an apparatus using a personal computer;

[0044] FIG. **5** shows a general arrangement of a fourth embodiment applied to an apparatus using a personal computer;

[0045] FIG. **6** is a drawing to give detailed explanation for the fourth embodiment; and

[0046] FIG. **7** shows a general arrangement of a fifth embodiment applied to an apparatus using a personal computer.

[0047] FIG. **8** shows a general arrangement of a sixth embodiment set-top box, which is a variation of the first embodiment;

[0048] FIG. **9** shows a general arrangement of a seventh embodiment set-top, which is a variation of the sixth embodiment;

[0049] FIG. **10** shows a general arrangement of an eighth embodiment using a personal computer;

[0050] FIG. **11** illustrates a detailed description on the eighth embodiment;

[0051] FIG. **12** illustrates an embodiment of a copyright management apparatus;

[0052] FIG. **13** illustrates another embodiment of the copyright management apparatus; and

[0053] FIG. **14** illustrates still another embodiment of the copyright management apparatus.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0054] The following describes embodiments of the present invention.

[0055] Referring to FIG. **2**, description will be given on an arrangement of a set-top box (STB) of a first embodiment of the present invention, and a method for protecting the digital data in the set-top box.

[0056] In the set-top box of this embodiment, as with the conventional set-top box example as shown in FIG. **1**, description is not given on peripheral circuits not directly related to encryption/decryption, e.g., an amplifier unit, a compression/expansion unit and an interface unit to the outside.

[0057] The difference of the present embodiment from the conventionally proposed set-top box shown in FIG. **1** is that a changeable key encryption/decryption unit **19** for performing encryption/decryption using a second changeable key K**2** is inserted between an unchangeable key encryption/decryption unit **15** performing encryption/decryption by using the unchangeable key K**0** and a decryption unit **13**.

[0058] In FIG. **2**, reference numeral **11** represents digital data supplied by broadcasting means such as digital terrestrial wave broadcasting, digital CATV broadcasting, digital satellite broadcasting, etc., by network means such as Internet, or by digital storage medium such as a DVD, a CD, etc. The digital data is encrypted by using a first changeable key K**1** to prevent illegitimate use:

$$C1=E(M,K1)$$

and is supplied to a set-top box **12**.

[0059] When the encrypted digital data C**1** is supplied to the set-top box **12**, the encrypted digital data C**1** is decrypted by the decryption unit **13** using the first changeable key K**1** obtained from a key center via the same route as or via a route different from that of the encrypted digital data C**1**:

$$M=D(C1,K1)$$

and the decrypted data M is outputted to a display unit **14** or the like.

[0060] In a case where the decrypted data M, for which copyrights are claimed, is stored in an external device **18**, i.e., in a medium of a digital versatile disk (DVD) RAM or a hard disk, or in a case where the data is transferred externally via a network, the decrypted data M is re-encrypted using a second changeable key K**2** at an encryption unit **20** of the changeable key encryption/decryption unit **19**:

$$\forall 2{:}C2 = E(M, K2)$$
$$= E(D(C1, K1), K2),$$

further, the re-encrypted data C**2** is double re-encrypted using an unchangeable key K**0** by an encryption unit **16** of the unchangeable key encryption/decryption unit **15**:

$$\forall 2-0{:}C2-0 = E(C2, K0)$$
$$= E(E(D(C1, K1), K2), K0),$$

and the double re-encrypted data C**2-0** is stored in the external device **18** or transferred.

[0061] In a case where the double re-encrypted data C**2-0** is used again, the re-encrypted data C**2-0** read from the storage medium of the external device **18** or transferred from the network is re-decrypted by a decryption unit **17** of the unchangeable key encryption/decryption unit **15** using the unchangeable key K**0**:

$$\exists 2{:}C2 = E(C2-0, K0)$$
$$= D(E(E(D(C1, K1), K2), K0),$$

further, the re-decrypted data C**2** is decrypted using the second changeable key K**2** by a decryption unit **21** of the changeable key encryption/decryption unit **19**:

$$\exists : M = D(C2, K2)$$
$$= D(E(D(C1, K1), K2),$$

and the decrypted data M is outputted to the display unit **14** or the like.

[0062] In this case, in order to ensure the security, it may be arranged in such a manner that, when the re-encrypted data C**2-0** is read from the storage medium via a route shown by a broken line in the figure, the re-encrypted data C**2-0** in the storage medium is deleted and the data re-encrypted by using the changeable key K**2** and the unchangeable key K**0** is restored.

[0063] As described above, because the re-encryption using the second changeable key K**2** is performed before the re-encryption using the unchangeable key, even when the unchangeable key K**0** is discovered by others, since the data is also encrypted by using the second changeable key K**2**, it is very difficult to cryptanalyze the encrypted data without further finding out the second changeable key K**2**.

[0064] Also, the second changeable key K**2** is first used for re-encryption, and it is again used for re-decryption after the unchangeable key K**0** is used for double re-encryption and re-decryption. Accordingly, the security of the second changeable key K**2** is highly ensured, and because it is used first, it strongly governs the encrypted data in the most effective manner.

[0065] In the description of the above embodiment, the encryption unit **20** and the decryption unit **21** are contained in the changeable key encryption/decryption unit **19** and the encryption unit **16** and the decryption unit **17** are contained in the unchangeable key encryption/decryption unit **15**. Of course, it goes without saying that these units **16**, **17**, and **21** may also be separately provided.

[0066] The operations as described above can be easily implemented by providing a computer arrangement having a CPU and a system-bus in the set-top box **12**.

[0067] Now, referring to FIG. **3**, description will be given on another arrangement of the set-top box, which is a second embodiment of the present invention, and also, on a method for protecting the digital data carried out in this set-top box.

[0068] In this second embodiment set-top box, as with the conventional set-top box example shown in FIG. **1**, description is not given on peripheral circuits not directly related to encryption/decryption, e.g., an amplifier unit and a compression/expansion unit.

[0069] The difference of the second embodiment set-top box from the first embodiment set-top box shown in FIG. **2** is that the positions are switched between the unchangeable key encryption/decryption unit **35** for encryption/decryption using the unchangeable key K**0** and the changeable key encryption/decryption unit **39** for encryption/decryption using the second changeable key K**2**.

[0070] An unchangeable key encryption/decryption unit **35** for encryption/decryption using the unchangeable key K**0** is connected to a decryption unit **33** and a display **34**, and an external changeable key encryption/decryption unit **39** for encryption/decryption using the second changeable key K**2** is connected to an external device **38**. The second changeable key K**2** may be supplied from the outside or may be generated in the set-top box.

[0071] In FIG. **3**, reference numeral **31** represents digital data supplied by broadcasting means such as digital terrestrial wave broadcasting, digital CATV broadcasting, digital satellite broadcasting, etc., by network means such as Internet, or by a digital storage medium such as a DVD, a CD, etc. The data is encrypted by using a first changeable key K**1** to prevent illegitimate use:

$$C1 = E(M, K1)$$

and is supplied to a set-top box **32**.

[0072] When the encrypted digital data C**1** is supplied to the set-top box **32**, the encrypted digital data C**1** is decrypted by the decryption unit **33** using the first changeable key K**1** obtained via the same route as or via a route different from that of the encrypted digital data C**1**:

$$M = D(C1, K1)$$

and the decrypted data M is outputted to a display unit **34** or the like.

[0073] In a case where the decrypted data M, for which copyrights are claimed, is stored in an external device **38**, i.e., in a medium such as a digital versatile disk (DVD) RAM or a hard disk, etc., or is transferred externally via a network, the decrypted data M is re-encrypted using the unchangeable key K**0** at the encryption unit **36** of the unchangeable key encryption/decryption unit **35**:

$$\forall 0 : C0 = E(M, K0)$$
$$= E(D(C1, K1), K0),$$

further, the re-encrypted data C**0** is double re-encrypted at an encryption unit **40** of the changeable key encryption/decryption unit **39** by using the second changeable key K**2**:

$$\forall 0 - 2 : C0 - 2 = E(C0, K2)$$
$$= E(E(D(C1, K1), K0), K2),$$

and double re-encrypted data C**0-2** is stored in the external device **38** or transferred.

[0074] In a case where the double re-encrypted data C**0-2** is used again, the re-encrypted data C**0-2** read from the storage medium of the external device **38** or transferred from the network is re-decrypted using the external changeable key K**2** by the re-decryption unit **41** of the external changeable key encryption/decryption unit **39**:

$$\exists : 0 : C0 = D(C0 - 2, K2)$$
$$= D(E(E(D(C1, K1), K0), K2),$$

further, the re-decrypted data C**0** is again re-decrypted using the unchangeable key K**0** by a decryption unit **37** of the unchangeable key encryption/decryption unit **35**:

$$\exists : M = D(C0, K0)$$

$$= D(E(D(C1, K1), K0)$$

and the decrypted data M is outputted to the display unit **34** or the like.

[0075] In this case, in order to ensure the security, it may be arranged in such a manner that, when the re-encrypted data C**2**-**0** is read from the storage medium via a route shown by a broken line in the figure, the double re-encrypted data C**0**-**2** in the storage medium is erased and the data re-encrypted by using the unchangeable key K**0** and the external changeable key K**2** is re-stored.

[0076] As described above, because the re-encryption is performed using the unchangeable key K**0** before the re-encryption using the second changeable key K**2**, even when the unchangeable key K**0** is discovered by others, since the data is also encrypted by using the second changeable key K**2**, it is very difficult to cryptanalyze the encrypted data without further finding out the second changeable key K**2**.

[0077] In this arrangement, the changeable key encryption/decryption unit **39** is simply added to the unchangeable key encryption/decryption unit **35** of the conventionally proposed set-top box shown in FIG. **1**, and accordingly, a set-top box employing the present invention can be easily achieved.

[0078] In the description of this embodiment, the encryption unit **36** and the decryption unit **37** are contained in the unchangeable key encryption/decryption unit **35** and the encryption unit **40** and the decryption unit **41** are contained in the changeable key encryption/decryption unit **39**. Of course, it goes without saying that these units **36**, **37**, **40** and **41** may also be separately provided.

[0079] The operation as described above can be easily implemented by providing a computer arrangement having a CPU and a system-bus in the set-top box **32**.

[0080] Digital data content is handled not only in the set-top box but also in a computer such as a personal computer.

[0081] Referring to FIG. **4** through FIG. **7**, description will be given on embodiments of the present invention applied to an apparatus using a personal computer.

[0082] Unlike the set-top box where all components are constituted of hardware and are operated only by the hardware, a personal computer is an apparatus, which is operated by controlling the hardware incorporated in the apparatus using software.

[0083] In order to efficiently operate the computer, an operating system (OS) is used, which manages the overall operation of the computer.

[0084] A conventional operating system used in the personal computer comprises a kernel for providing basic services such as memory management, task management, interrupt handling and communication between processes, and an operating system service providing other services.

[0085] However, with the advances in computer developments, for example, the functional improvements of a microprocessor and the price decrease of RAM used as main memory, and also the user's demand for an increase of the performance ability of computers, improvements in the functions of the operation system to manage the overall computer operation has been required. Accordingly, the scale of the operating system has become comparatively larger than before.

[0086] Since such an enlarged operating system itself occupies a large amount of space in the hard disk where it is to be stored, the space to store application programs or data needed by the user is liable to be rather limited, and that may lead to inconvenience for the user in using the computer.

[0087] To cope with such situations, newer operating systems are often designed with user-dependent subsystem parts (such as an environmental subsystem for performing emulation of the other operating systems and graphics, and a core subsystem such as a security subsystem) removed from a kernel. Basic parts of an operating system consist of a HAL (hardware abstraction layer) to absorb differences of hardware, micro-kernels to provide a scheduling function, an interrupt function, an I/O management function, etc., and a system service API (application programming interface) interposed between the subsystem and the micro-kernel.

[0088] With the above arrangement, expandability of the operating system needing changes or additions of function is improved, and portability of the operating system corresponding to the intended purpose can be made much easier.

[0089] By the distributed arrangement of elements of the micro-kernel to a plurality of network computers, it is now possible to easily realize a distributed operating system.

[0090] Computers are used in computer peripheral units, various types of control units, communication devices, etc., in addition to personal computers typically represented by the desk-top type or notebook type personal computers. In such cases, unlike the operating system for a general-purpose personal computer, in which importance is put on the man-machine interface, a real-time operating system is adopted, in which importance is placed on speedy execution. An operating system, especially one for embedding, is suitable for each of these units and devices.

[0091] Of course, the cost for development is increased when developing an operating system specially tailored for different embedded devices. For this reason, it is recently proposed to use a general-purpose operating system in the personal computer also for the embedded type real-time operating system. By arranging a program specific for the embedded type in a subsystem combined with a micro-kernel, it is now practical to obtain an embedded type real-time operating system.

[0092] Major functions of the operating system include task management such as scheduling or interrupt processing.

[0093] The task management has mainly two different types in the operating system: single task type, which only performs one task processing at the same time, and multi-task type for performing a plurality of task processings at the same time. The multi-task type is divided into a multi-task type where changeover of the task depends upon the task to be processed, and a multi-task type not dependent upon the task to be processed.

[0094] Among these, the single task type allocates one process to an MPU so that the MPU is not free until the process is completed. A non-preemptive multi-task type allows the MPU to be allocated a plurality of processes by time division, so that process is not executed unless the process in execution gives the control back to the operating system. A preemptive multi-task type interrupts the process in execution at a certain time interval, so that the control is forcibly transferred to the other process.

[0095] Therefore, real-time multi-tasking can be achieved only by the preemptive type.

[0096] The task management in the computer is carried out according to the process, which is a unit having system resources such as a memory, a file, etc., and the process is managed according to a thread, which is a unit to allocate CPU time with divided processes. In this case, the system resources are shared by all threads in the same process. This means that there are more than one thread to share system resources in one process.

[0097] Each task to be processed by the multi-task type has a priority spectrum, which is generally divided into 32 steps. The normal task performing no interrupt is classified into dynamic classes, which are divided into 0-15 steps, and the task performing interrupt is classified to real-time classes to be divided into 16-31 steps.

[0098] Interrupt processing is executed using an interrupt enable time (normally 10 milliseconds) called a "time slice" unit. Ordinary interrupt is executed at 10-millisecond time slices.

[0099] Under such circumstances, a time slice has been recently proposed, in which an interrupt enable time called a "real-time slice" is 100 microseconds. If this real-time slice is used, it is possible to execute an interrupt with priority over the conventional interrupt of 10 milliseconds.

[0100] In a third embodiment shown in FIG. **4**, changeable key encryption/decryption processing by software and the management of a crypt key in the computer are carried out by a real-time OS provided in the HAL.

[0101] In FIG. **4**, reference numeral **51** represents an operating system in a computer; **56** a display unit for displaying output from the computer; **57** an unchangeable key encryption/decryption unit; and **58** a data storage medium such as a digital versatile disk (DVD) RAM or a hard disk, or a data transfer system such as a network.

[0102] The operating system **51** comprises an operating system service **52** and a system service API **53**, which are user regions, and a kernel **54** and a HAL **55**, which are non-user regions. The system service API **53** is arranged between the operating system service **52** and the kernel **54** and serves to mediate between the operating system service **52** and the kernel **54**. The HAL **55** is arranged at the lowermost layer of the operating system **51** and serves to absorb differences in the hardware for the software.

[0103] The operating system service **52** comprises an application **59**, a subsystem **60** and a security subsystem **61**. The kernel **54** comprises a plurality of micro-kernels **62** and **64** and a kernel **63**. The micro-kernel **62** has task management functions such as scheduling, interrupt, etc., and the micro-kernel **64** has an I/O management function.

[0104] The micro-kernel **64** having the I/O management function comprises an I/O manager **65**, device drivers such as a disk driver **67** and a network driver **68**, which are managed by the I/O manager, and a filter driver **66** which is inserted when necessary between the I/O manager **65** and the device drivers such as the disk driver **67** and the network driver **68**.

[0105] The changeable key encryption/decryption processing in the computer is executed by software. In case of the third embodiment, the changeable key encryption/decryption processing is carried out by the aforementioned real-time OS (RTOS) with priority over other tasks in the HAL **55** in the operating system **51**.

[0106] Similar to the first embodiment shown in FIG. **2**, digital data supplied by broadcasting means such as digital terrestrial wave broadcasting, digital CATV broadcasting, digital satellite broadcasting, etc., by network means such as Internet, or by a digital storage medium such as a DVD, a CD, etc., is encrypted using a first changeable key K**1** to prevent illegitimate use:

$$C1=E(M,K1)$$

and is supplied. The supplied encrypted digital data C**1** is decrypted by the operating system service **52** using the first changeable key K**1** provided from the key center via the same route as or via a route different from that of the encrypted digital data C**1**:

$$M=D(C1,K1)$$

and the decrypted data M is outputted to the display unit **56** or the like.

[0107] In a case where the decrypted data M, for which copyrights are claimed, is stored in a medium such as a digital versatile disk (DVD) RAM or a hard disk, or where it is transferred externally via a network, the decrypted data M is mandatorily re-encrypted by HAL **55** using a second changeable key K**2**:

$$\forall 2: C2 = E(M, K2)$$
$$= E(D(C1, K1), K2).$$

Further, the re-encrypted data C**2** is double re-encrypted at the unchangeable key encryption/decryption unit **57** by using an unchangeable key K**0**:

$$\forall 2\text{-}0: C2\text{-}0 = E(C2, K0)$$
$$= E(E(D(C1, K1), K2), K0),$$

and the double re-encrypted data C**2-0** is stored in an external device or transferred. The changeable key K**2** may be provided from the outside or may be generated in a set-top box.

[0108] When the double re-encrypted data C**2-0** is utilized, the double re-encrypted data C**2-0** read from the storage medium or transferred via the network is re-decrypted using the unchangeable key K**0** at the unchangeable key encryption/decryption unit **57**:

$$\exists 2: C2 = D(C2\text{-}0, K0)$$
$$= D(E(E(D(C1, K1), K2), K0).$$

Further, the re-decrypted data C**2** is decrypted using the second changeable key K**2** by the HAL **55** having the changeable key encryption/decryption function:

$$\exists: M = D(C2, K2)$$
$$= D(E(D(C1, K1), K2),$$

and the decrypted data M thus obtained is outputted to the display unit **56** or the like.

[0109] The real-time OS is executed in priority over every other task. In the third embodiment, the real-time OS is implemented by the HAL, being a contact point with the hardware

in the operating system. Accordingly, the re-encryption of the digital data is performed in a reliable manner, and it is impossible for decrypted data M, as it is, to be stored into the external device or to be transferred. Also, re-encryption is performed using the second changeable key K**2** before the re-encryption using the unchangeable key K**0**. As a result, even if the unchangeable key K**0** is known, it is very difficult to cryptanalyze the encrypted data by finding out the second changeable key K**2**, as the data is also encrypted by the second changeable key K**2**.

[0110] Because the second changeable key K**2** is used first and is then used after the unchangeable key K**0** has been used, key security can be ensured. Because the second changeable key K**2** is used first, it strongly governs the encrypted data.

[0111] The above operations can be easily implemented by arranging the unchangeable key encryption/decryption unit **57** as a sub-computer structure having a CPU and a system-bus.

[0112] In a fourth embodiment shown in FIG. **5**, the changeable key encryption/decryption is provided by software carried out at a filter driver **66** placed in the I/O management micro-kernel **64** in the kernel **54**.

[0113] FIG. **6** shows an arrangement of the I/O management micro-kernel **64** with the filter driver **66** placed in it.

[0114] In an I/O management micro-kernel with no filter driver placed in it, a file system driver **69**, an intermediate driver **70** and a device driver **71** are arranged from an upper hierarchy to a lower hierarchy. When necessary, a filter driver **66**A or a filter driver **66**B is placed above the file system driver **69** or between the intermediate driver **70** and the device driver **71**.

[0115] Because the I/O management micro-kernel can be designed to have these filter drivers **66**A and **66**B perform re-encryption/re-decryption and management of the key, the filter drivers **66**A or **66**B is designed to carry out the re-encryption/re-decryption processing and the key management in this embodiment.

[0116] The filter driver is arranged, not in the operating system service unit **52** which can be handled by the user, but in the kernel **54** which cannot be handled by the user. On the other hand, it is generally practiced to make the specification change to fit the particular computer using the operating system. In particular, it is not very rare to change the I/O manager therein.

[0117] Utilizing the above, the modules having the function of re-encryption/re-decryption processing and the key management are placed in the I/O manager as the filter driver **66**A or the filter driver **66**B in the fourth embodiment.

[0118] Similar to the first embodiment shown in FIG. **2**, digital data supplied by broadcasting means such as digital terrestrial wave broadcasting, digital CATV broadcasting, digital satellite broadcasting, etc., by network means such as Internet, or by digital storage medium such as a DVD, a CD, etc. is encrypted using a first changeable key K**1** to prevent illegitimate use:

$$C1=E(M,K1)$$

and it is supplied. The encrypted and supplied digital data C**1** is decrypted by the operating system service unit **52** using the first changeable key K**1** provided from the key center via the same route as or via a route different from that of the encrypted digital data C**1**:

$$M=D(C1,K1)$$

and the decrypted data M is outputted to the display unit **56** and the like.

[0119] In a case where the decrypted data M, for which copyrights are claimed, is stored in a medium such as a digital versatile disk (DVD) RAM or a hard disk, or in a case where it is transferred externally via a network, the decrypted data M is mandatorily re-encrypted by the filter driver **66**A or **66**B using the external changeable key K**2**:

$$\forall 2{:}C2=E(M,K2)=E(D(C1,K1),K2).$$

Further, the re-encrypted data C**2** is double re-encrypted at the internal unchangeable key encryption/decryption unit **57**, using an unchangeable key K**0**:

$$\forall\ 2\text{-}0{:}\ C2\text{-}0 = E(C2, K0) = E(E(D(C1, K1), K2), K0),$$

and double re-encrypted data C**2-0** is stored into the external device or transferred. The changeable key K**2** may be provided from the outside or may be generated in a set-top box.

[0120] When the double re-encrypted data C**2-0** is utilized again, the double re-encrypted data C**2-0** read from the storage medium or transferred via the network is re-decrypted using the unchangeable key K**0** at the internal unchangeable key encryption/decryption unit **57**:

$$\exists 2\ C2 = D(C2\text{-}0, K0) = D(E(E(D(C1, K1), K2), K0).$$

Further, the re-decrypted data C**2** is decrypted by the filter driver **66**A or **66**B, using the second changeable key K**2**:

$$\exists{:}\ M = D(C2, K2) = D(E(D(C1, K1), K2)$$

and the decrypted data M thus obtained is outputted to the display unit **56** or the like.

[0121] The filter driver can be easily placed into the kernel of the operation system in a part of the I/O manager. In so doing, the function of the re-encryption/re-decryption processing and the key management can be easily incorporated into the operation system. Also, since re-encryption is performed using the second changeable key K**2** before the re-encryption using the unchangeable key K**0**, even if the unchangeable key K**0** is discovered by others, it is very difficult to cryptanalyze the encrypted data without finding out the second changeable key K**2** because the data is also encrypted by the second changeable key K**2**.

[0122] Further, because the second changeable key K**2** is used first, and is then, used after the unchangeable key K**0** is used, the key security can be highly ensured. Also, because the second changeable key K**2** is used first, it strongly governs the encrypted data.

[0123] The above operations can be easily implemented by arranging the unchangeable key encryption/decryption unit **57** as a sub-computer structure having a CPU and a system-bus.

[0124] In a fifth embodiment shown in FIG. **7**, the changeable key encryption/decryption and the key management is provided by software carried out at the disk driver **67** and the network driver **68** contained in the I/O management micro-kernel **64** in the operating system **51**.

[0125] As already explained in connection with FIG. **6**, the file system driver **69**, the intermediate driver **70**, and the device driver **71** are arranged from an upper hierarchy to a lower hierarchy in the I/O management micro-kernel. The changeable key encryption/decryption processing and the key management can be carried out also in the device driver **71** positioned at the lowermost layer.

[0126] Similar to the first embodiment shown in FIG. **2**, the digital data supplied by broadcasting means such as digital terrestrial wave broadcasting, digital CATV broadcasting, digital satellite broadcasting, etc., by network means such as Internet, or by digital storage medium such as a DVD, a CD, etc., is encrypted using the first changeable key K**1** to prevent illegitimate use:

$$C1=E(M,K1)$$

and it is supplied. The encrypted and supplied digital data C**1** is decrypted by the operating system service unit **52** using the first changeable key K**1** provided from the key center via the same route as or a route different from that of the encrypted digital data C**1**:

$$M=D(C1,K1)$$

and the decrypted data M is outputted to the display unit **56** or the like.

[0127] In a case where the decrypted data M, for which copyrights are claimed, is stored in a medium such as a digital versatile disk (DVD) RAM or a hard disk, or in a case where it is transferred externally via a network, the decrypted data M is mandatorily re-encrypted by the device driver **71**, i.e., the disk driver **67** and the network driver **68**, using the second changeable key K**2**:

$$\forall\, 2:\ C2 = E(M, K2)$$
$$= E(D(C1, K1), K2).$$

Further, the re-encrypted data C**2** is double re-encrypted at the unchangeable key encryption/decryption unit **57** using the unchangeable key K**0** placed in the unchangeable key encryption/decryption unit **57**:

$$\forall\, 2\text{-}0:\ C2\text{-}0 = E(C2, K0)$$
$$= E(E(D(C1, K1), K2), K0),$$

and double re-encrypted data C**2-0** is stored in the external device or transferred. The changeable key K**2** may be provided from the outside or may be generated in a set-top box.

[0128] When the double re-encrypted data C**2-0** is utilized again, the double re-encrypted data C**2-0** read from the storage medium or transferred via a network is re-decrypted using the unchangeable key K**0** by the internal unchangeable key encryption/decryption unit **57**:

$$\exists\, 2:\ C2 = D(C2\text{-}0, K0)$$
$$= D(E(E(D(C1, K1), K2), K0).$$

Further, the re-decrypted data C**2** is decrypted by the device driver **71**, i.e., the disk driver **67** and the network driver **68**, using the second changeable key K**2**:

$$\exists:\ M = D(C2, K2)$$
$$= D(E(D(C1, K1), K2)$$

and the decrypted data M thus obtained is outputted to the display unit **56** or the like.

[0129] For the device driver, it is generally practiced to make the specification change to fit the particular computer using the operating system or when the corresponding device has been modified.

[0130] Since the function of the re-encryption/re-decryption processing and the key management is incorporated into such a device driver, it allows the easy incorporation of the function into the kernel of the operating system. Also, since re-encryption is performed using the second changeable key K**2** before the re-encryption using the unchangeable key K**0**, even if the unchangeable key K**0** is discovered by others, it is very difficult to cryptanalyze the encrypted data without finding out the second changeable key K**2** because the data is also encrypted using the second changeable key K**2**.

[0131] There is a possibility that the second changeable key K**2** may be discovered by others, when it is repeatedly used. In such a case, it is preferably designed in such a manner that the second changeable key K**2** used for encryption is abandoned and generated again when necessary for decryption, as described in Japanese Patent Laid-Open Publication 185448/1996 (EP0704885A2, U.S. Ser. No. 08/536,749). If it is necessary to have the key for decryption, it should be obtained from the key center again.

[0132] For security purposes, K**1**, K**2** and K**0** may be based on different crypt algorithms.

[0133] These operations can be easily implemented by arranging the unchangeable key encryption/decryption unit **57** as a sub-computer structure having a CPU and a system-bus.

[0134] In the embodiments described above, the second changeable key K**2** and the unchangeable key K**0** are used in addition to the first changeable key K**1**. In the embodiments described below, a third changeable key K**3** is used additionally so that more reliable copyright management of digital content is provided.

[0135] Referring to FIG. **8**, description will be given on an arrangement of a set-top box in a sixth embodiment of the present invention, which is a variation of the first embodiment, and also on a method for protecting digital data carried out in the set-top box.

[0136] In the set-top box of this embodiment, similar to the set-top box of the first embodiment, no description is given on peripheral circuits not directly related to encryption/decryption, e.g., an amplifier unit and a compression/decompression unit.

[0137] The set-top box of the sixth embodiment has a difference from that of the first embodiment in distinguishing between a case where the decrypted data M is stored in a storage medium **81** such as a hard disk, which is incorporated in or dedicated to the set-top box, and another case where the decrypted data M is stored in a removable medium, e.g., a DVD-RAM, in an external **82** or is transferred externally via a network.

[0138] The internal unchangeable key encryption/decryption unit **15** and further a changeable key encryption unit **80** are provided. In a case where the decrypted copyrighted data is stored, for example, in a hard disk as a storage medium **81**, which is incorporated in or dedicated to the set-top box, it is double re-encrypted using an internal unchangeable key K**0**. On the other hand, in a case where it is stored in a removable medium, i.e., a DVD-RAM, or is transferred externally via the network, it is double re-encrypted, not by the internal unchangeable key K**0** but by a third changeable key K**3**.

[0139] In FIG. **8**, reference numeral **11** represents digital data, which is supplied by broadcasting means such as digital terrestrial wave broadcasting, digital CATV broadcasting, digital satellite broadcasting, etc., by network means such as Internet, or by a digital storage medium such as a DVD, a CD, etc. The digital data is encrypted using a first changeable key K**1** to prevent illegitimate use:

$$C1=E(M,K1)$$

and encrypted digital data C**1** is supplied to a set-top box **12**.

[0140] When the encrypted digital data C**1** is supplied to the set-top box **12**, the encrypted digital data C**1** is decrypted by a decryption unit **13** using a first changeable key K**1** obtained from a key center:

$$M=D(C1,K1)$$

[0141] and the decrypted data M is outputted to a display unit **14** or the like.

[0142] In a case where the decrypted copyrighted data M is stored in a storage medium **81** such as a hard disk, which is incorporated in or is dedicated to the set-top box **12**, or in a removable medium such as a DVD-RAM, or where it is transferred externally via a network, the decrypted data M is re-encrypted by an encryption unit **20** of a changeable key encryption/decryption unit **19** using a second changeable key K**2**, which is obtained from the key center or generated in the set-top box **12**:

$$\forall\, 2:\ C2 = E(M, K2)$$
$$= E(D(C1, K1), K2).$$

[0143] In a case where the re-encrypted data C**2** is stored in a hard disk of the storage medium **81** incorporated into or dedicated to the set-top box **12**, the re-encrypted data C**2** is double re-encrypted by an encryption unit **16** of an internal unchangeable key encryption/decryption unit **15** using an unchangeable crypt key K**0** placed in the internal unchangeable key encryption/decryption unit **15**:

$$\forall\, 2\text{-}0:\ C2\text{-}0 = E(C2, K0)$$
$$= E(E(D(C1, K1), K2), K0)$$

and the double re-encrypted data C**2-0** is stored in the storage medium **81** or the like.

[0144] When the re-encryption data C**2-0** stored in the storage medium **81** is utilized, the double re-encryption data C**2-0** read from the storage medium **81** is decrypted using the unchangeable crypt key K**0** placed in a decryption unit **17** of the internal unchangeable key encryption/decryption unit **15**:

$$\exists\, 2:\ C2 = D(C2\text{-}0, K0)$$
$$= D(E(E(D(C1, K1), K2), K0)$$
$$= E(E(D(C1, K1), K2),$$

further, the re-decrypted data C**2** is decrypted using the changeable key K**2** by a decryption unit **21** of the changeable key encryption/decryption unit **19**:

$$\exists:\ M = D(C2, K2)$$
$$= D(E(D(C1, K1), K2)$$

and the decrypted data M is outputted to the display unit **14** or the like.

[0145] In this case, in order to ensure security, when the double re-encrypted data C**2-0** is read from the storage medium **81** via a path shown by a broken line in the figure, it may be designed in a manner that the double re-encrypted data C**2-0** in the storage medium **81** is erased at that time, and that the data re-encrypted using the changeable key K**2** and the internal unchangeable key K**0** is stored again.

[0146] In a case where the re-encrypted data C**2** is stored in a DVD-RAM of a removable medium, or it is transferred externally via a network at the externals **82**, the re-encrypted data C**2** is double re-encrypted using a third changeable key K**3**, which is obtained from the key center or generated in the set-top box **12**, by a changeable key encryption unit **80**:

$$\forall\, 2\text{-}3:\ C2\text{-}3 = E(C2, K3)$$
$$= E(E(M, K2), K3).$$

[0147] When the double re-encrypted data C**2-3** sent to the externals **82** is utilized, the double re-encrypted data C**2-3** is decrypted using the third changeable key K**3** stored at a decryption unit **84** of a changeable key encryption/decryption unit **83**:

$$\exists\, 2:\ C2 = D(C2\text{-}3, K3)$$
$$= D(E(M, K2), K3), K3)$$
$$= E(M, K2),$$

further, the re-encrypted data C**2** thus obtained is decrypted using the second changeable key K**2** by a decryption unit **85** of the changeable key encryption/decryption unit **83**:

$$\exists:\ M = D(C2, K2)$$
$$= D(E(M, K2), K2)$$

and the decrypted data M thus obtained is outputted to a display unit **86** or the like.

[0148] These operations can be easily achieved by providing a sub-computer arrangement having a CPU and a system-bus in the set-top box **12**.

[0149] Referring to FIG. **9**, description will be given on an arrangement of a set-top box of a seventh embodiment, which is a variation of the sixth embodiment, and also on a method for protecting digital data carried out in the set-top box.

[0150] In the set-top box of this embodiment again, similar to the set-top box of the sixth embodiment, no description is given on peripheral circuits not directly related to encryption/decryption, e.g., an amplifier unit and a compression/decompression unit.

[0151] The seventh embodiment set-top box is different from that of the sixth embodiment in that the inserted positions are exchanged between the unchangeable key encryption/decryption unit **15** for performing encryption/decryption using the unchangeable key K**0** and the changeable key encryption/decryption unit **19** for performing encryption/decryption using the second changeable key K**2**, and in that there is further provided a changeable key encryption unit **87** for performing encryption/decryption using the second changeable key K**2** for the case where the data is stored in a DVD-RAM of a removable medium or is transferred externally via a network at the externals **82**.

[0152] The digital data **11**, which is supplied by broadcasting means such as digital terrestrial wave broadcasting, digital CATV broadcasting, digital satellite broadcasting, etc., by network means such as Internet, or by a digital storage medium such as a DVD, a CD, etc., is encrypted using a first changeable key K**1** in order to prevent illegitimate use:

$$C1=E(M,K1)$$

and encrypted digital data C**1** is supplied to the set-top box **12**.

[0153] When the encrypted digital data C**1** is supplied to the set-top box **12**, the encrypted digital data C**1** is decrypted by the decryption unit **13** using the first changeable key K**1** obtained from the key center:

$$M=D(C1,K1)$$

and the decrypted data M thus obtained is outputted to the display unit **14** or the like.

[0154] In a case where the copyrighted and decrypted data M is stored in the storage medium **81** such as a hard disk incorporated in or dedicated to the set-top box **12**, the decrypted data M is re-encrypted to re-encrypted data C**0** using the unchangeable crypt key K**0** by the internal unchangeable key encryption/decryption unit **15**:

$$\forall 0:\ C0 = E(M, K0)$$
$$= E(D(C1, K1), K0).$$

[0155] The re-encrypted data C**0** is double re-encrypted by the encryption unit **20** of the changeable key encryption/decryption unit **19** using the second changeable key K**2** obtained from the key center or generated in the set-top box **12**:

$$\forall 0\text{-}2:\ C0\text{-}2 = E(C0, K2)$$
$$= E(E(M, K0), K2)$$

and the double re-encrypted data C**0-2** is stored in the storage medium **81** or the like.

[0156] When the double re-encrypted data C**0-2** stored in the storage medium **81** is utilized, the double re-encrypted data C**0-2** read from the storage medium **81** is re-decrypted by the decryption unit **21** of the changeable key encryption/decryption unit **19** using the second changeable key K**2**:

$$\exists 0:\ C0 = D(C0\text{-}2, K2)$$
$$= D(E(C0, K2), K2),$$

further, the re-decrypted data C**0** is re-decrypted again using the unchangeable key K**0** at the decryption unit **17** of the unchangeable key encryption/decryption unit **15**:

$$\exists:\ M = D(C0, K0)$$
$$= D(E(M, K0), K0)$$

and the decrypted data M thus obtained is outputted to the display unit **14** or the like.

[0157] In this case, in order to ensure security, when the double re-encrypted data C**0-2** is read from the storage medium **81** via a route shown by a broken line in the figure, it may be designed in a manner that the double re-encrypted data C**0-2** in the storage medium **81** is erased at that time, and that the data re-encrypted using the second changeable key K**2** and the unchangeable key K**0** is stored again.

[0158] In a case where the decrypted data M is stored in a DVD-RAM of a removable medium or is transferred outside via a network at the externals **82**, the decrypted data M is re-encrypted to re-encrypted data C**3** using a third changeable key K**3** obtained from the key center or generated in the set-top box **12** by the changeable key encryption unit **80**:

$$\forall 3:\ C3 = E(M, K3)$$
$$= E(D(C1, K1), K3).$$

[0159] The re-encrypted data C**3** is encrypted to double re-encrypted data C**3-2** by the changeable key encryption unit **87** using the second changeable key K**2** obtained from the key center or generated at the set-top box **12**:

$$\forall 3\text{-}2:\ C3\text{-}2 = E(C3, K2)$$
$$= E(E(D(C1, K1), K3), K2)$$

and the double re-encrypted data C**3-2** is stored in the DVD-RAM or is transferred via a network in the externals **82**.

[0160] When the double re-encrypted data C**3-2** sent to the externals **82** is utilized, the double re-encrypted data C**3-2** is decrypted using the second changeable key K**2** by the decryption unit **84** of the changeable key encryption/decryption unit **83**:

$$\exists 3:\ C3 = D(C3\text{-}2, K2)$$
$$= D(E(C3, K2), K2),$$

Further, the re-encrypted data C**3** thus obtained is decrypted using the third changeable key K**3** by the decryption unit **85** of the changeable key encryption/decryption unit **83**:

$$\exists:\ M = D(C3, K3)$$
$$= D(E(M, K3), K3)$$

and the decrypted data M thus obtained is outputted to the display unit **86** or the like.

[0161] In the above embodiment, the third changeable key K**3** is used by the changeable key encryption unit **80** and the second changeable key K**2** is used by the changeable key encryption unit **87**, while this may be performed in reverse order.

[0162] Also, it may be designed in a manner that the encryption unit **20** of the changeable key encryption/decryption unit **19** serves the function of the changeable key encryption unit **87**.

[0163] While description has been given on the above in the case where the encryption unit **16** and the decryption unit **17** are contained in the unchangeable key encryption/decryption unit **15** and the encryption unit **20** and the decryption unit **21** are contained in the changeable key encryption/decryption unit **19**, it goes without saying that these units **16**, **17**, **20** and **21** may be separately provided.

[0164] These operations can be easily achieved by providing a sub-computer arrangement having a CPU and a system-bus in the set-top box **12**.

[0165] Description will be given on a variation, which is applied to an embodiment using a personal computer.

[0166] The eighth embodiment shown in FIG. **10** is a variation of the fourth embodiment shown in FIG. **5**. In the embodiment, detailed description common to the fourth embodiment arrangement is not given here.

[0167] The eighth embodiment is different from the fourth embodiment in distinguishing between the cases where the decrypted data M is stored in a storage medium **81** such as a hard disk incorporated in or dedicated to the computer, and where it is stored in a removable medium **92** such as a DVD-RAM or is transferred externally via a network **93**.

[0168] For this purpose, changeable key encryption units **90** and **91** are provided as hardware **88**, in addition to the unchangeable key encryption/decryption unit **89**. In a case where the copyrighted and decrypted data is stored in the hard disk **81** of the storage medium incorporated in or dedicated to the computer, it is double re-encrypted and decrypted using the unchangeable key K**0** by the encryption/decryption unit **89** via a disk driver **67**. In a case where the data is stored in the DVD-RAM **92** of the removable medium, it is double re-encrypted and decrypted using the third changeable key K**3** by the encryption/decryption unit **90** via the disk driver **67**. In a case where the data is transferred externally via the network **93**, it is double re-encrypted and decrypted using the third changeable key K**3** by the changeable key encryption/decryption unit **91** via a network driver **68**.

[0169] Similar to the first embodiment shown in FIG. **2**, the digital data supplied by broadcasting means such as digital terrestrial broadcasting, digital CATV broadcasting, digital satellite broadcasting, etc., by network means such as Internet, or by a digital storage medium such as a DVD, a CD, etc. is encrypted using a first changeable key K**1** to prevent illegitimate use:

$$C1=E(M,K1)$$

and is supplied. The encrypted, digital data C**1** thus supplied is decrypted by the operating system service **52** using the first changeable key K**1** provided from the key center via the same route as or a route different from that of the encrypted digital data C**1**:

$$M=D(C1,K1)$$

and the decrypted data M is outputted to the display unit **56** or the like.

[0170] In cases where the decrypted data M is stored in the storage medium **81** incorporated in or dedicated to the computer, such as a hard disk, where it is stored in a medium such as the DVD-RAM, and where it is transferred externally via a network, the decrypted data M is re-encrypted by a filter driver **66** using the second changeable key K**2** obtained from the key center or generated in the operating system service **52**:

$$\forall 2:\ C2 = E(M, K2)$$
$$= E(D(C1, K1), K2).$$

[0171] Further, when the re-encrypted data C**2** is stored in a storage medium **81** incorporated in or dedicated to a computer, the re-encrypted data C**2** is double re-encrypted using an unchangeable key K**0** by the encryption/decryption unit **89** in the hardware **88**:

$$\forall 2\text{-}0: C2\text{-}0=E(C2,K0)=E(E(D(C1,K1),K2),K0)$$

and re-encrypted data C**2-0** is stored in the hard disk **81** or the like.

[0172] In the case where the double re-encrypted data C**2-0** stored in the storage medium **81** is utilized, the double re-encrypted data C**2-0** read from the storage medium **81** is re-decrypted using the unchangeable key K**0** by the encryption/decryption unit **89** in the hardware **88**:

$$\exists 2: C2=D(C2\text{-}0,K0)=D(E(E(D(C1,K1),K2),K0),$$

further, the re-decrypted data C**2** is decrypted using the second changeable key K**2** by the filter driver **66** having encryption/decryption function:

$$\exists: M=D(C2,K2)=D(E(D(C1,K1),K2),$$

and the decrypted data M is outputted by the operating system of the computer to the display unit **56** or the like, to be utilized.

[0173] When the re-encrypted data C**2** is stored in a DVD-RAM of the removable medium, the re-encrypted data C**2** is double re-encrypted using the third changeable key K**3** by the changeable key encryption/decryption unit **90** of the hardware.

$$\forall 2\text{-}3: C2\text{-}3=E(C2,K3)=E(E(C1,K1),K2),K3)$$

and double re-encrypted data C**2-3** is stored in the removable medium, the DVD-RAM.

[0174] In a case where the double re-encrypted data C**2-3** stored in the removable medium **92** is utilized, the double

re-encrypted data C**2-3** read from the removable medium **92** is re-decrypted using the third changeable key K**3** obtained from the key center or generated in the operating system service **52** by the encryption/decryption unit **90** in the hardware:

$$\exists 2{:}C2=E(C2\text{-}3,K3=D(E(E(D(C1,K1),K2),K3),$$

further, the re-decrypted data C**2** is decrypted using the second changeable key K**2** by the filter driver **66** having encryption/decryption function:

$$\exists{:}M=D(C2,K2)=D(E(D(C1,K1),K2)$$

and the decrypted data M is outputted by the operating system of the computer to the display unit **56** or the like to be utilized.

[0175] When the re-encrypted data C**2** is transferred externally via the network **93**, the re-encrypted data C**2** is double re-encrypted using the second changeable key K**2** by the encryption/decryption unit **91**:

$$\forall 2\text{-}3{:}C2\text{-}3=E(C2,K3)=E(E(D(C1,K1),K2),K3)$$

and double re-encrypted data C**2-3** is transferred externally via the network **93**.

[0176] In a case where the double re-encrypted data C**2-3** transferred from the outside via the network **88** is utilized, the encrypted re-encrypted data C**2-3** is re-decrypted using the third changeable key K**3** by the encryption/decryption unit **91**:

$$\exists 2{:}C2=E(C2\text{-}3,K3)=D(E(E(D(C1,K1),K2)K3),$$

further, the re-decrypted data C**2** is decrypted using the second changeable key K**2** by the filter driver **66** having encryption/decryption function:

$$\exists{:}M=D(C2,K2)=D(E(D(C1,K1),K2)$$

and the decrypted data M is outputted by the operating system of the computer to the display unit **56** or the like to be utilized.

[0177] When the re-encrypted data C**2** is transferred outside via the network **93**, the re-encrypted data C**2** is double re-encrypted using the second changeable key K**2** at the encryption/decryption unit **91**:

$$\forall 2\text{-}3{:}C2\text{-}3=E(C2,K3)=E(E(D(C1,K1),K2),K3)$$

and double re-encrypted data C**2-3** is transferred outside via the network **93**.

[0178] In a case where the double re-encrypted data C**2-3** transferred from the outside via the network **88** is utilized, the encrypted data C**2-3** is re-decrypted using the third changeable key K**3** at the encryption/decryption unit **91**:

$$\exists 2{:}C2E(C2\text{-}3,K3)=D(E(E(D(C1,K1),K2)K3),$$

further, the re-decrypted data C**2** is decrypted using the second changeable key K**2** at the filter driver **66** having encryption/decryption function:

$$\exists{:}M=D(C2,K2)=D(E(D(C1,K1),K2)$$

and the decrypted data M is outputted by the operating system of the computer to the display unit **56** or the like to be utilized.

[0179] In the above embodiment, in order to facilitate the explanation, it has been described that the encryption/decryption units **90** and **91** are separate, but it goes without saying that these units may be a single unit.

[0180] The encryption/decryption as described above is managed by a real-time OS (RTOS) as already explained, with priority over other tasks in the HAL **55** in the operating system **51**.

[0181] These operations can be easily achieved by designing the hardware **88** as the sub-computer arrangement having a CPU and a system-bus.

[0182] FIG. **11** shows a concrete arrangement of the encryption/decryption using the I/O management micro-kernel **64** having the filter driver **66** which serves as the changeable key encryption/decryption processing of the eighth embodiment.

[0183] In the I/O management micro-kernel **64**, a file system driver **69**, an intermediate driver **70**, and device drivers, i.e., a disk driver **67** and a network driver **68**, are arranged from an upper hierarchy to a lower hierarchy. When necessary, a filter driver **66**A or a filter driver **66**B for performing changeable key encryption/decryption is inserted above the file system driver **69** or between the intermediate driver **70** and the device driver.

[0184] Because these filter drivers **66**A and **66**B can perform re-encryption/re-decryption, it is designed to have the filter driver **66**A or **66**B carry out the re-encryption/re-decryption processing and the management of crypt keys in this embodiment.

[0185] In cases where the copyrighted and decrypted data M is stored in a storage medium such as a hard disk, incorporated therein or dedicated thereto, where it is stored in a removable medium such as a DVD-RAM or where it is transferred outside via a network, the decrypted data M is re-encrypted by the filter driver **66**A or **66**B using the second changeable key K**2** obtained from the key center or generated in the I/O management micro-kernel **64**:

$$\forall 2{:}C2=E(M,K2)=E(D(C1,K1),K2).$$

[0186] Further, in a case where the re-encrypted data C**2** is stored in a computer-incorporated or -dedicated storage medium **81**, the re-encrypted data C**2** is double re-encrypted using the unchangeable key K**0** by the encryption/decryption unit **89** in the hardware **88**:

$$\forall 2\text{-}0{:}C2\text{-}0=E(C2,K0)=E(E(D(C1,K1),K2),K0)$$

and double re-encrypted data C**2-0** is stored in the hard disk **81** or the like.

[0187] When the double re-encrypted data C**2-0** stored in the storage medium **81** is utilized, the double re-encrypted data C**2-0** read from the storage medium **81** is re-decrypted using the unchangeable key K**0** by the encryption/decrypted unit **89** in the hardware **88**:

$$\exists 2{:}C2=D(C2\text{-}0,K0)=D(E(E(D(C1,K1),K2),K0),$$

further, the re-decrypted data C**2** is decrypted using the second changeable key K**2** by the filter driver **66** having encryption/decryption function:

$$\exists{:}M=D(C2,K2)=D(E(D(C1,K1),K2)$$

and the decrypted data M is outputted by the operating system of the computer to the display unit **56** or the like to be utilized.

[0188] Also, in a case where the re-encrypted data C**2** is stored in the removable medium such as a DVD-RAM, the re-encrypted data C**2** is double re-encrypted using the third changeable key K**3** obtained from the key center or generated in the I/O management micro-kernel **64**, by the encryption/decryption unit **90** in the hardware **88**:

$$\forall 2\text{-}3{:}C2\text{-}3=E(C2,K3)=E(E(D(C1,K1),K2),K3)$$

and double re-encrypted data C**2-3** is stored in a removable medium such as the DVD-RAM.

[0189] When the double re-encrypted data C**2-3** stored in the removable medium **92** is utilized, the re-encrypted data C**2-3** read from the removable medium **92** is re-decrypted using the third changeable key K**3** by the encryption/decryption unit **90** in the hardware **88**:

$$\exists 2{:}C2=D(C2\text{-}3,K3)=D(E(E(D(C1,K1),K2),K3),$$

further, the re-decrypted data C**2** is decrypted using the second changeable key K**2** by the filter driver **66** having encryption/decryption function:

$$\exists M=D(C2,K2)=D(E(D(C1,K1),K2)$$

and the decrypted data M is outputted by the operating system of the computer to the display unit **56** or the like to be utilized.

[0190] Also, in a case where the re-encrypted data C**2** is transferred externally via the network **93**, the re-encrypted data C**2** is double re-encrypted using the second changeable key K**2** by the encryption/decryption unit **91**:

$$\forall 2\text{-}3{:}C2\text{-}3=E(C2,K3)=E(E(D(C1,K1),K2),K3)$$

and double re-encrypted data C**2-3** is transferred externally via the network **93**.

[0191] When the double re-encrypted data C**2-3** transferred from the outside via the network **93** is utilized, the re-encrypted data C**2-3** is re-decrypted using the third changeable key K**3** by the encryption/decryption unit **91**:

$$\exists 2{:}C2=E(C2\text{-}3,K3)=D(E(E(D(C1,K1),K2),K3),$$

further, the re-decrypted data C**2** is decrypted using the second changeable key K**2** by the filter driver **66** having encryption/decryption function:

$$\exists{:}M=D(C2,K2)=D(E(D(C1,K1),K2)$$

and the decrypted data M is outputted by the operating system of the computer to the display unit **56** or the like to be utilized.

[0192] It is generally practiced that the specification of the device driver is changed to fit the particular computer using the operating system or according to the corresponding device modified.

[0193] By providing the device driver with the function for the re-encryption/re-decryption processing and the management of a key, it allows the easy incorporation of the function into the kernel of the operation system. Also, by re-encrypting the data using the second changeable key K**2** before it is re-encrypted using the unchangeable key K**0**, it is very difficult to cryptanalyze the encrypted data, even if the unchangeable key is discovered by others, without finding out the second changeable key K**2** because the data is also encrypted using the second changeable key K**2**.

[0194] Further, because the second changeable key K**2** is used first and then, is used after the unchangeable key K**0** is used, high security of the key is ensured. Because the second changeable key K**2** is used first, it also strongly governs the encrypted data.

[0195] However, when the second changeable key K**2** is repeatedly used, there is a possibility it may be discovered by others. In such a case, it is preferably designed in such a manner that the second changeable key K**2** used for encryption is abandoned and it is again obtained from the key center or generated, when necessary for decryption, as described in Japanese Patent Laid-Open Publication 185448/1996 (EP0704885A2, U.S. Ser. No. 08/536,749).

[0196] For security purposes, K**1**, K**2**, K**3**, and K**0** may be based on different crypt algorithms.

[0197] These operations can be easily implemented as a sub-computer structure having a CPU and a system bus.

[0198] In order to perform re-encryption/re-decryption of digital data as above, it is necessary to add, to the digital data, information to indicate that storage or transfer of the digital data is restricted. In a case where the digital data is stored or transferred without being edited, illegitimate use of the digital data can be prevented by the method and the apparatus for re-encryption/re-decryption as described above.

[0199] However, when the digital data is edited, there is a possibility that the information to identify the restriction of storage or transfer may be lost.

[0200] In such the case, it may be designed in a manner that all of the data are re-encrypted/re-decrypted using a key specific to the device (a master key).

[0201] In so doing, even the digital data which has been edited, for example, by the "cut & paste" method, can be prevented from illegitimate use by re-encryption/re-decryption.

[0202] Also, it may be designed in a manner that the digital data without the information to identify the restriction of storage or transfer only is re-encrypted/re-decrypted using the master key, and that the digital data provided with the information to identify the restriction of storage or transfer is re-encrypted/re-decrypted using the method and the apparatus as explained in the above embodiments.

[0203] In a case where the copyrighted and encrypted digital data is utilized in a specific device such as a set-top box, illegitimate storing, copying or transferring can be relatively easily prevented. Also, in a case where the copyrighted and encrypted digital data is utilized on a computer, the management of storing, copying or transferring the decrypted digital data can be executed by using the decryption/re-encryption apparatus described in Japanese Patent Laid-Open Publication 287014/1996 (USP5,867,579; EP0715241A2) or by using the decryption/re-encryption apparatus described in USP5,805,706.

[0204] However, the digital data decrypted for the purpose of displaying or printing is present on the bus of the computer, and it is possible to store, copy or transfer the decrypted digital data via a device connected to the bus. In the following, description will be given on a copyright management apparatus, which solves this problem.

[0205] FIG. **12** shows a structural example of a copyright management apparatus, in which a first changeable key and a second changeable key are used.

[0206] Also, this copyright management apparatus can be realized in a configuration such as a sub-board, a PCMCIA card, an IC card or an IC package for the purpose of security.

[0207] In FIG. **12**, reference numeral **101** represents a CPU, A ROM **103**, a RAM **104**, a hard disk drive **105**, a flexible disk drive **106**, a CD-ROM drive **107**, a modem **108**, etc. are connected to a system-bus **102** connected to the CPU **101**.

[0208] Reference numeral **109** represents a copyright management apparatus, which comprises a decryption/encryption unit **110**, a video interface **113**, an audio interface **114**, and a printer interface **115**.

[0209] A display unit **116**, a speaker **117** and a printer **118** are connected to the video interface **113**, the audio interface **114**, and the printer interface **115** respectively on the outer side of the computer.

[0210] The decryption/encryption unit **110** comprises a decryption unit **111** and an encryption unit **112**.

[0211] The decryption unit **111** and the encryption unit **112** of the decryption/encryption unit **110** are connected to the system-bus **102** of the computer. The video interface **113**, the audio interface **114**, and the printer interface **115** are connected to the decryption unit **111**.

[0212] This arrangement can be easily achieved by designing the copyright management apparatus **109** as a sub-computer arrangement having a CPU and a system-bus.

[0213] In cases where the decrypted digital data M is stored in the hard disk drive **105**, where it is copied at the flexible disk drive **106** or where it is transferred via the modem **108**, the decrypted digital data is re-encrypted using the second changeable key K**2** by the encryption unit **112**:

$$\forall 2:\ C2 = E(M, K2)$$
$$= E(D(C1, K1), K2),$$

the re-encrypted digital data C**2** is supplied to the system-bus **102**, and is stored in the hard disk drive **105**, copied in the flexible disk drive **106** or transferred via the modem

[0214] The encrypted digital data C**1** encrypted using the first changeable key K**1** is supplied to **108**. the decryption unit **111** from the system-bus **102**, and is decrypted using the first changeable key K**1**:

$$M=D(C1,K1).$$

[0215] In a case where the decrypted digital data M is outputted to the display unit **116** or the speaker **117**, it is turned to analog at the video interface **113** and the audio interface **114** in the copyright management apparatus **109** and is outputted in a predetermined signal form.

[0216] When the decrypted digital data M is outputted to the printer **118**, print data is outputted via the printer interface **115**.

[0217] When this copyright management apparatus **109** is used, the decrypted digital data other than the data outputted to the printer is not present outside the copyright management apparatus **109**. Because the data outputted to the printer is still data, digital data of a moving picture or of audio data is not present outside the copyright management apparatus **109**.

[0218] In the computer, non-encrypted digital data is also present in addition to the decrypted digital data.

[0219] In order to process the non-encrypted digital data and the decrypted data by distinguishing between them, it is necessary to provide a video interface, an audio interface and a printer interface, and this would make the system more complicated and costly. To avoid such situation, it may be designed in a manner that non-encrypted digital data is processed at the video interface **113** and the audio interface **114** in the copyright management system **109**.

[0220] FIG. **13** shows another arrangement example of a copyright management apparatus, in which an unchangeable key is used in addition to the first and the second changeable keys.

[0221] This copyright management apparatus can be realized in a configuration such as a sub-board, a PCMCIA card, an IC card, or an IC package for security purpose.

[0222] In FIG. **13**, reference numeral **101** represents a CPU, A ROM **103**, a RAM **104**, a hard disk drive **105**, a flexible disk drive **106**, a CD-ROM drive **107**, a modem **108**, etc. are connected to a system-bus **102** connected to the CPU **101**.

[0223] Reference numeral **120** represents a copyright management apparatus. The copyright management apparatus **120** has, in addition to the decryption/encryption unit **110**, an unchangeable key encryption unit **121**, a crypt video interface **122**, a crypt audio interface **123**, and a crypt printer interface **124**.

[0224] The decryption/encryption unit **110** has a decryption unit **111** and an encryption unit **112**.

[0225] Also, an encrypted digital video display unit **125**, an encrypted digital audio player **126**, and an encrypted digital data printer **127**, which arranged outside of the computer, are connected to the crypt video interface **122**, the crypt audio interface **123**, and the crypt printer interface **124**.

[0226] The decryption unit **111** and the encryption unit **112** of the decryption/encryption unit **110** are both connected to the computer system-bus **102**. The unchangeable key encryption unit **121** is further connected to the decryption unit **111**.

[0227] The crypt video interface **122**, the crypt audio interface **123**, and the crypt printer interface **124** are connected to the unchangeable key encryption unit **121**.

[0228] The encrypted data display unit **125** is connected to the crypt video interface **122**, the encrypted audio data player **126** is connected to the crypt audio interface **123** and the encrypted data printer **127** is connected to the crypt printer interface **124**.

[0229] The above arrangement can be easily realized by designing the copyright management apparatus **120** as a sub-computer arrangement having a CPU and a system-bus.

[0230] The encrypted data display unit **125** has an unchangeable key decryption unit **128** connected to the crypt video interface **122**, a D/A converter **131** connected to the unchangeable key decryption unit **128**, and a display unit **116** connected to the D/A converter **131**.

[0231] The encrypted audio data player **126** has an unchangeable key decryption unit **129** connected to the crypt audio interface **123**, a D/A converter **132** connected to the unchangeable key decryption unit **129**, and a speaker **117** connected to the D/A converter **132**.

[0232] The encrypted data printer **127** has an unchangeable key decryption unit **130** connected to the crypt printer interface **124** and a printer **118** connected to the unchangeable key decryption unit **130**.

[0233] Needless to say, the encrypted data display unit **125**, the encrypted audio data player **126** and the encrypted data printer **127** have other components such as an amplifier.

[0234] The encrypted digital data C**1** encrypted using the first changeable key K**1** is supplied to the decryption unit **111** from the system-bus **102**, and it is decrypted using the first changeable key K**1**:

$$M=D(C1,K1).$$

[0235] When the decrypted digital data M is stored at the hard disk drive **105** or is copied at the flexible disk drive **106** or is transferred via the modem **108**, it is re-encrypted using the second changeable key K**2** by the encryption unit **112**:

$$\forall=2:\ C2 = E(M, K2)$$
$$= E(D(C1, K1), K2),$$

the re-encrypted digital data C**2** is supplied to the system-bus **102**, and it is stored at the hard disk drive **105**, copied at the flexible disk drive **106**, or transferred via the modem **108**.

[0236] When the decrypted digital data M is outputted to the encrypted data display unit **125**, the encrypted audio data player **126** or the encrypted data printer **127**, it is re-encrypted using the unchangeable key K**0** by the unchangeable key encryption unit **121** in the copyright management apparatus **120**:

$$\forall 0:\ C0 = E(M, K0)$$
$$= E(D(C1, K1), K0).$$

[0237] The re-encrypted digital data C**0** is arranged to be provided to the encrypted data display unit **125**, the encrypted audio data player **126** and the encrypted data printer **127** at the crypt video interface **122**, the crypt audio interface **123** and the crypt printer interface **124** respectively, and an encrypted display signal Cd**0**, an encrypted audio signal Ca**0** and an encrypted print signal Cp**0** are respectively outputted.

[0238] When the encrypted display signal Cd**0** is inputted to the encrypted data display unit **125** from the crypt video interface **122**, it is decrypted using the unchangeable key K**0** at the unchangeable key decryption unit **128**:

$$Md=D(Cd0,K0),$$

the decrypted display signal MA is converted to a displayable analog signal by the D/A converter **131** and it is displayed on the display unit **116**.

[0239] If the display unit **116** is a digital display unit, which can display the digital data as it is, the D/A converter **131** is unnecessary.

[0240] When the encrypted audio signal Ca**0** is inputted to the encrypted audio data player **126** from the crypt audio interface **123**, it is decrypted using the unchangeable key K**0** by the unchangeable key, decryption unit **129**:

$$Ma=D(Ca0,K0),$$

the decrypted audio signal Ma is converted to a playable analog signal by the D/A converter **132**, and it is played by the speaker **117**.

[0241] The encrypted print signal Cp**0** inputted to the encrypted data printer **127** from the crypt printer interface **124** is decrypted using the unchangeable key K**0** by the unchangeable key decryption unit **130**:

$$Mp=D(Cp0,K0)$$

and the decrypted print signal Mp is printed by the printer **118**.

[0242] When this copyright management apparatus **120** is used, no decrypted data is present outside the copyright management apparatus **120**.

[0243] As aforementioned, non-encrypted digital data is also present in addition to the decrypted digital data in the computer.

[0244] In order to process the non-encrypted digital data and the decrypted digital data by distinguishing between them, it is necessary to provide a video interface, an audio interface and a printer interface, and this would make the system more complicated and costly. To avoid such situation, it may be designed in a manner that the non-encrypted digital data is processed by the unchangeable key re-encryption unit **121** of the copyright management apparatus **120**.

[0245] FIG. **14** shows another arrangement example of the copyright management apparatus, in which an unchangeable key encryption unit is provided to follow the video interface, the audio interface and the printer interface.

[0246] The copyright management apparatus can be realized in a configuration such as a sub-board, a PCMCIA card, an IC card or an IC package for security purpose.

[0247] In FIG. **14**, reference numeral **101** represents a CPU. A ROM **103**, a RAM **104**, a hard disk drive **105**, a flexible disk drive **106**, a CD-ROM drive **107**, a modem **108**, etc., are connected to a system-bus **102** connected to the CPU **101**.

[0248] The copyright management apparatus can be realized in a configuration such as a sub-board, a PCMCIA card, an IC card or an IC package for security purpose.

[0249] In FIG. **14**, reference numeral **101** represents a CPU. A ROM **103**, a RAM **104**, a hard disk drive **105**, a flexible disk drive **105**, a CD-ROM drive **107**, a modem **108**, etc., are connected to a system-bus **102** connected to the CPU **101**.

[0250] Reference numeral **140** represents a copyright management apparatus, which comprises a decryption/encryption unit **110**, a video interface **113**, an audio interface **114**, a printer interface **141**, and an unchangeable key encryption unit **134**.

[0251] The decryption/encryption unit **110** has a decryption unit **111** and an re-encryption unit **112**.

[0252] The unchangeable key encryption unit **134** has an unchangeable key encryption unit for video **135**, an unchangeable key encryption unit for audio **136**, and an unchangeable key encryption unit for print **137**. The unchangeable key encryption units for video, audio, and print may be arranged in a single unit if it is available for sufficient encryption capacity.

[0253] The decryption unit **111** and the re-encryption unit **112** of the decryption/encryption unit **110** are connected to the system-bus **102** of the computer. Further, the video interface **131**, the audio interface **132** and the printer interface **133** are connected to the decryption unit **111**, and the unchangeable key encryption unit for video **135**, the unchangeable key encryption unit for audio **136** and the unchangeable key encryption unit for print **137** are connected to these interfaces.

[0254] An encrypted digital video display unit **125**, an encrypted digital audio player **126** and an encrypted digital data printer **127** arranged outside the computer are connected respectively to the unchangeable key encryption unit for video **135**, the unchangeable key encryption unit for audio **163** and the unchangeable key encryption unit for print **137**.

[0255] The above arrangement can be easily realized by designing the copyright management apparatus **140** as a sub-computer arrangement having a CPU and a system-bus.

[0256] The encrypted data display unit **125** has an unchangeable key decryption unit **128** connected to the unchangeable key encryption unit for video **135**, a D/A converter **131** connected to the unchangeable key decryption unit **128**, and a display unit **116** connected to the D/A converter **131**.

[0257] The encrypted audio data player **126** has an unchangeable key decryption unit **129** connected to the unchangeable key encryption unit for audio **136**, a D/A converter **132** connected to the unchangeable key decryption unit **129**, and a speaker **117** connected to the D/A converter **132**.

[0258] The encrypted data printer **127** has an unchangeable key decryption unit **130** connected to the unchangeable key encryption unit for print **137** and a printer **118** connected to the unchangeable key decryption unit **130**.

[0259] Needless to say, the encrypted data display unit **125**, the encrypted audio data player **126** and the encrypted data printer **127** have other components such as an amplifier.

[0260] The encrypted digital data C**1** encrypted using the first changeable key K**1** is supplied to the decryption unit **111** from the system-bus **102** and it is decrypted using the first changeable key K**1**:

$$M=D(C1,K1).$$

[0261] When the decrypted digital data M is stored at the hard disk drive **105** or copied at the flexible disk drive **106** or transferred via the modem **108**, it is re-encrypted using the second changeable key K**2** by the encryption unit **112**:

$$\forall 2:\ C2 = E(M, K2)$$
$$= E(D(C1, K1), K2),$$

the re-encrypted digital data C**2** is supplied to the system-bus **102**, and it is then stored at the hard disk drive **105**, copied at the flexible disk drive **106** or transferred via the modem **108**.

[0262] When the decrypted digital data M is outputted to the encrypted data display unit **125**, the encrypted audio data player **126** or the encrypted data printer **127**, the decrypted digital data M is arranged to digital data Md, Ma and Mp to be provided to the display unit **116**, the speaker **117** and the printer **118** respectively at the video interface **131**, the audio interface **132** and the printer interface **133** in the copyright management apparatus **140**. Then, these digital data are encrypted using the unchangeable key K**0** by the unchangeable key encryption unit for video **135**, the unchangeable key encryption unit for audio **136** and the unchangeable key encryption unit for print **137**:

$$Cd0=E(Md,K0)$$

$$Ca0=E(Ma,K0)$$

$$Cp0=E(Mp,K0)$$

and the encrypted display signal Cd**0**, the encrypted audio signal Ca**0** and the encrypted print signal Cp**0** are outputted.

[0263] The encrypted display signal Cd**0** is inputted to the encrypted data display unit **125** from the unchangeable key encryption unit for video **135**, and it is decrypted using the unchangeable key K**0** at the unchangeable key decryption unit **128**:

$$Md=D(Cd0,K0).$$

The decrypted display signal Md is converted to a displayable analog signal at the D/A converter **131**, and is displayed on the display unit **116**.

[0264] If the display unit **116** is a digital display unit, which can display the digital data as it is, the D/A converter **131** is unnecessary.

[0265] The encrypted audio signal Ca**0** is inputted to the encrypted audio data player **126** from the unchangeable key encryption unit **136**, and it is decrypted using the unchangeable key K**0** by the unchangeable key decryption unit **129**:

$$Ma=D(Ca0,K0).$$

The decrypted audio signal Ma is converted to a playable analog signal at the D/A converter **132**, and is played at the speaker **116**.

[0266] The encrypted print signal Cp**0** is inputted to the encrypted data printer **127** from the unchangeable key encryption unit **137**, and it is decrypted using the unchangeable key K**0**:

$$Mp=D(Cp0,K0).$$

The decrypted print signal Mp is printed by the printer **118**.

[0267] When this copyright management apparatus **140** is used, no decrypted data is present outside the copyright management apparatus **140**.

[0268] As aforementioned, non-encrypted digital data is also present in addition to the decrypted digital data in the computer.

[0269] In order to process the non-encrypted digital data and the decryption data by distinguishing between them, it is necessary to provide a video interface, an audio interface and a printer interface, and this would make the system more complicated and costly. To avoid such situation, it may be designed in a manner that the non-encrypted digital data is processed at the video interface **131**, the audio interface **132** and the printer interface **133** of the copyright management apparatus **140**.

[0270] A secret-key cryptosystem is often used as a cryptosystem for encrypting digital data. The most popular DES (Data Encryption Standard) in the secret-key cryptosystems carries out encryption/decryption per 64-bit block unit of data. It is a typical block cipher method in the secret-key cryptosystem and has been widely adopted. Using this encryption/decryption per block processing allows the realization of a more high speed encryption/decryption processing.

[0271] In doing so, a plurality of encryption units and decryption units are provided in the encryption/decryption unit. It allows these plurality of encryption units and decryption units to be, in order, allocated the encryption/decryption processings of data blocks to be carried out. And then, encryption/decryption processing results, thus obtained, are synthesized.

[0272] Further, it brings a supplemental effect that it is possible to use a respective crypt key for each data block and also to adopt a respective crypto system for each data block. Then, more high security for digital data is possible.

1-86. (canceled)

87. A method, comprising:

receiving double-encrypted data at a computer system;

decrypting, the double-encrypted data to produce decrypted data, wherein the decrypting the double-encrypted data includes the computer system using a changeable key and using a non-changeable key.

88. The method of claim **87**, wherein the decrypting the double-encrypted data to produce the decrypted data includes:

decrypting the double-encrypted data using the non-changeable key to produce single-encrypted data; and

decrypting the single-encrypted data using the changeable key to produce the decrypted data.

89. The method of claim **88**,

wherein the decrypting the double-encrypted data using the non-changeable key includes decrypting using a hardware decryption unit.

90. The method of claim **88**,

wherein the decrypting the double-encrypted data using the non-changeable key includes using software-implemented decryption.

91. The method of claim **88**,
wherein the decrypting the single-encrypted data using the changeable key includes decrypting using a hardware decryption unit.
92. The method of claim **88**,
wherein the decrypting the single-encrypted data using the changeable key includes decrypting using software-implemented decryption.
93. The method of claim **87**,
wherein the non-changeable key is specific to the computer system.
94. The method of claim **87**, further comprising:
generating the changeable key at the computer system.
95. The method of claim **87**, further comprising:
receiving the changeable key at the computer system.
96. The method of claim **87**, wherein the decrypting the double-encrypted data to produce the decrypted data includes:
decrypting the double-encrypted data using the changeable key to produce single-encrypted data; and
decrypting the single-encrypted data using the non-changeable key to produce the decrypted data.
97. The method of claim **96**,
wherein the non-changeable key is specific to the computer system.
98. An apparatus, comprising:
a processor;
memory, coupled to the processor, having instructions stored thereon that are executable by the apparatus to cause the apparatus to encrypt, using a first key and a second key, unencrypted data to produce double-encrypted data;
wherein the first key is configured to be updatable, and wherein the second key is configured to be static.
99. The apparatus of claim **98**, wherein the apparatus encrypting the unencrypted data to produce the double-encrypted data includes:
encrypting the unencrypted data using the first key to produce single-encrypted data; and
encrypting the single-encrypted data using the second key to produce the double-encrypted data.
100. The apparatus of claim **98**, wherein the apparatus encrypting the unencrypted data to produce the double-encrypted data includes:
encrypting the unencrypted data using the second key to produce single-encrypted data; and
encrypting the single-encrypted data using the first key to produce the double-encrypted data.
101. The apparatus of claim **98**, further comprising:
a hardware decryption portion;
wherein the using the second key includes using the hardware decryption portion.
102. The apparatus of claim **98**,
wherein the using the second key includes using software-implemented decryption.
103. The apparatus of claim **98**,
wherein the first key is generated by the apparatus.
104. The apparatus of claim **98**,
wherein the first key is received by the apparatus.
105. A method, comprising:
encrypting unencrypted data to produce double-encrypted data, wherein the encrypting the unencrypted data includes a computer system using a changeable key and a non-changeable key, the changeable key being updatable, and the non-changeable key being static;
decrypting the double-encrypted data to produce decrypted data, wherein the decrypting the double-encrypted data includes the computer system using the changeable key and the non-changeable key.
106. The method of claim **105**,
wherein the encrypting the unencrypted data to produce double-encrypted data includes:
encrypting the unencrypted data using the changeable key to produce single-encrypted data; and
encrypting the single-encrypted data using the non-changeable key to produce the double-encrypted data; and
wherein the decrypting the double-encrypted data to produce decrypted data includes:
decrypting the double-encrypted data using the non-changeable key to produce single-encrypted data; and
decrypting the single-encrypted data using the changeable key to produce the decrypted data.

* * * * *