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(54) **METHODS AND APPARATUSES FOR DIGITAL CONTENT PROTECTION**

(71) Applicant: **Mountain Top Digital, L.L.C.**, Salt Lake City, UT (US)

(72) Inventors: **Xi Chen**, Midvale, UT (US); **Stephen Wirthlin Gerritsen**, North Ogden, UT (US)

(73) Assignee: **Mountain Top Digital, L.L.C.**, Salt Lake City, UT (US)

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***H04L 29/06*** (2006.01)
***H04L 9/08*** (2006.01)

(52) **U.S. Cl.**
CPC ..... ***H04L 9/0838*** (2013.01); ***H04L 9/0877*** (2013.01)
USPC ..... **726/9**; 713/189

(58) **Field of Classification Search**
CPC ..... H04L 9/0838; H04L 9/0877
USPC ..... 726/9; 713/189
See application file for complete search history.

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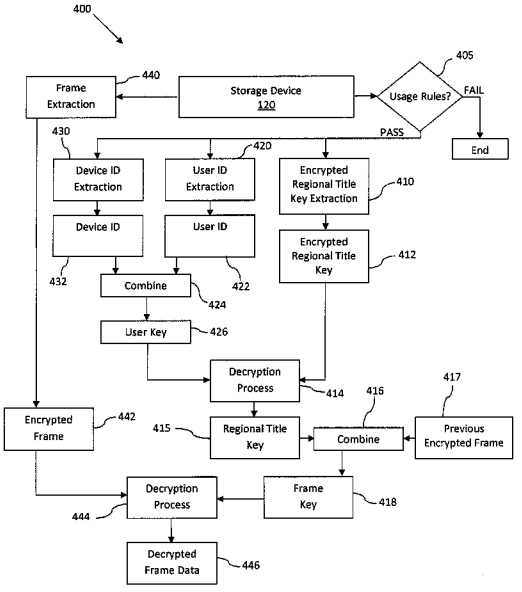
*Primary Examiner* — Pramila Parthasarathy
(74) *Attorney, Agent, or Firm* — TraskBritt

(57) **ABSTRACT**

A method for digital content protection comprises generating a plurality of frame keys, retrieving a plurality of frames from digital content, and at least one of encrypting and decrypting the digital content with a different frame key that dynamically changes for each frame of the plurality of frames. A storage device comprises a computer-readable medium including encrypted digital content stored thereon, wherein the encrypted digital content is encrypted with a frame key that is different for each frame of the encrypted digital content. A content player comprises a computer-readable medium including instructions stored thereon, that when executed cause a processor to decrypt encrypted digital content by reconstructing a plurality of frame keys that are different from each other that are used to decrypt each frame of the encrypted digital content.

**18 Claims, 5 Drawing Sheets**



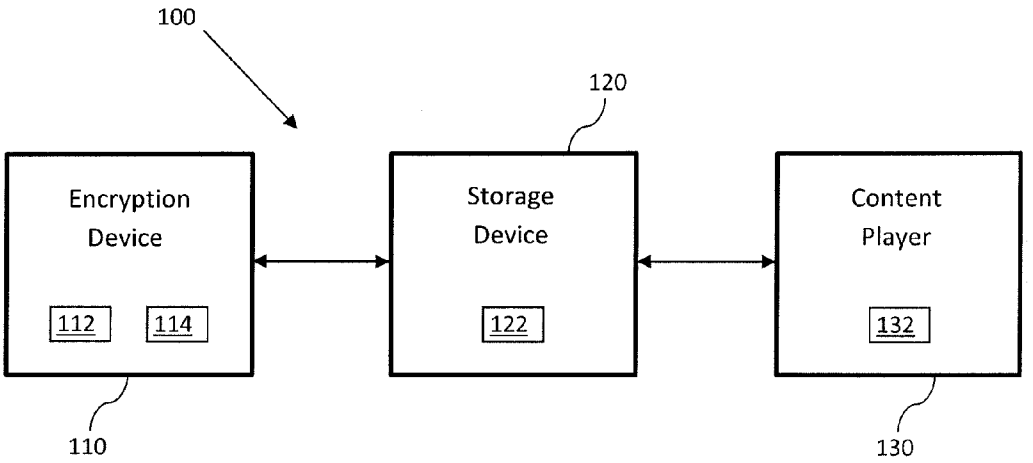

100
120
Encryption Device
112
114
Storage Device
122
Content Player
132
110
130

FIG. 1

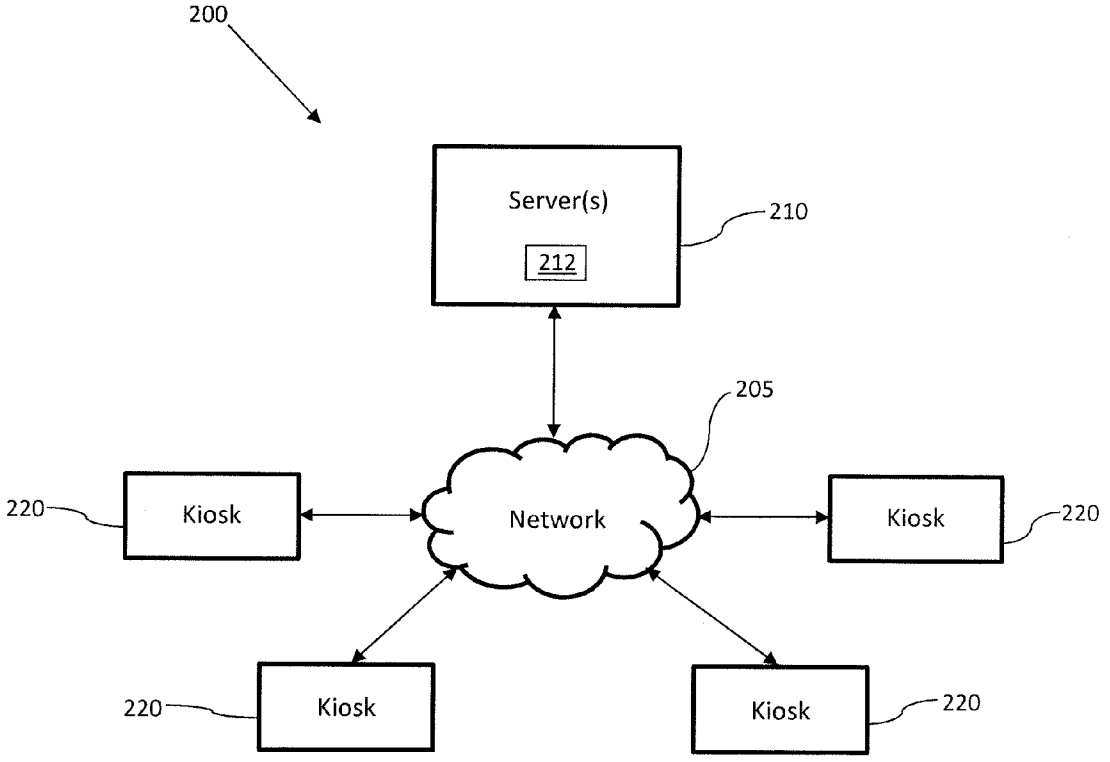

200
Server(s)
212
210
205
Network
220
Kiosk
220
Kiosk
220
Kiosk
220
Kiosk

FIG. 2

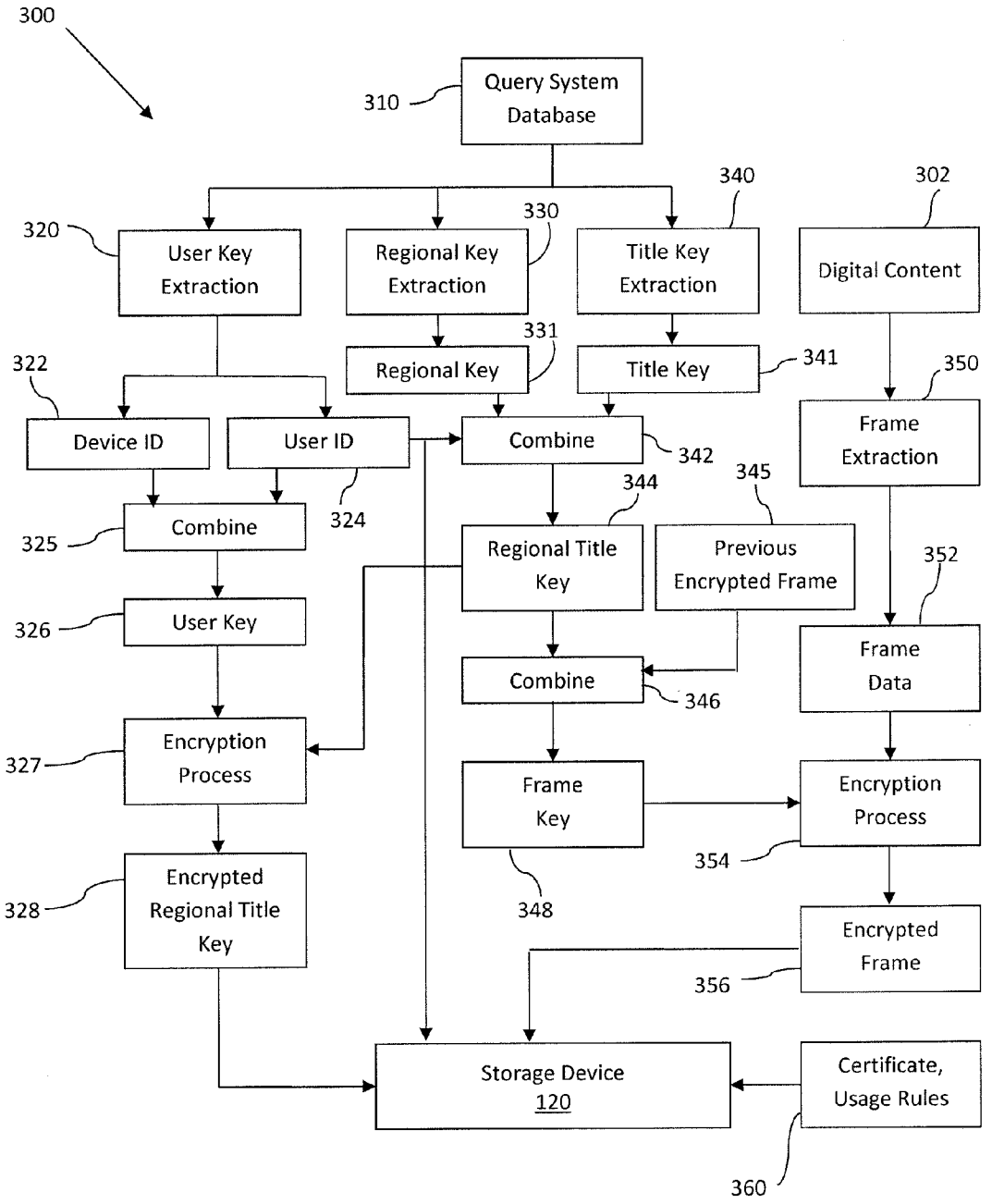

300
310
Query System Database
340
302
320
330
User Key Extraction
Regional Key Extraction
Title Key Extraction
Digital Content
331
322
Regional Key
Title Key
341
350
Device ID
User ID
Combine
342
Frame Extraction
344
345
325
324
Combine
Regional Title Key
Previous Encrypted Frame
352
326
User Key
Frame Data
Combine
346
327
Encryption Process
Frame Key
Encryption Process
354
328
Encrypted Regional Title Key
348
Encrypted Frame
356
Storage Device 120
Certificate, Usage Rules
360

FIG. 3

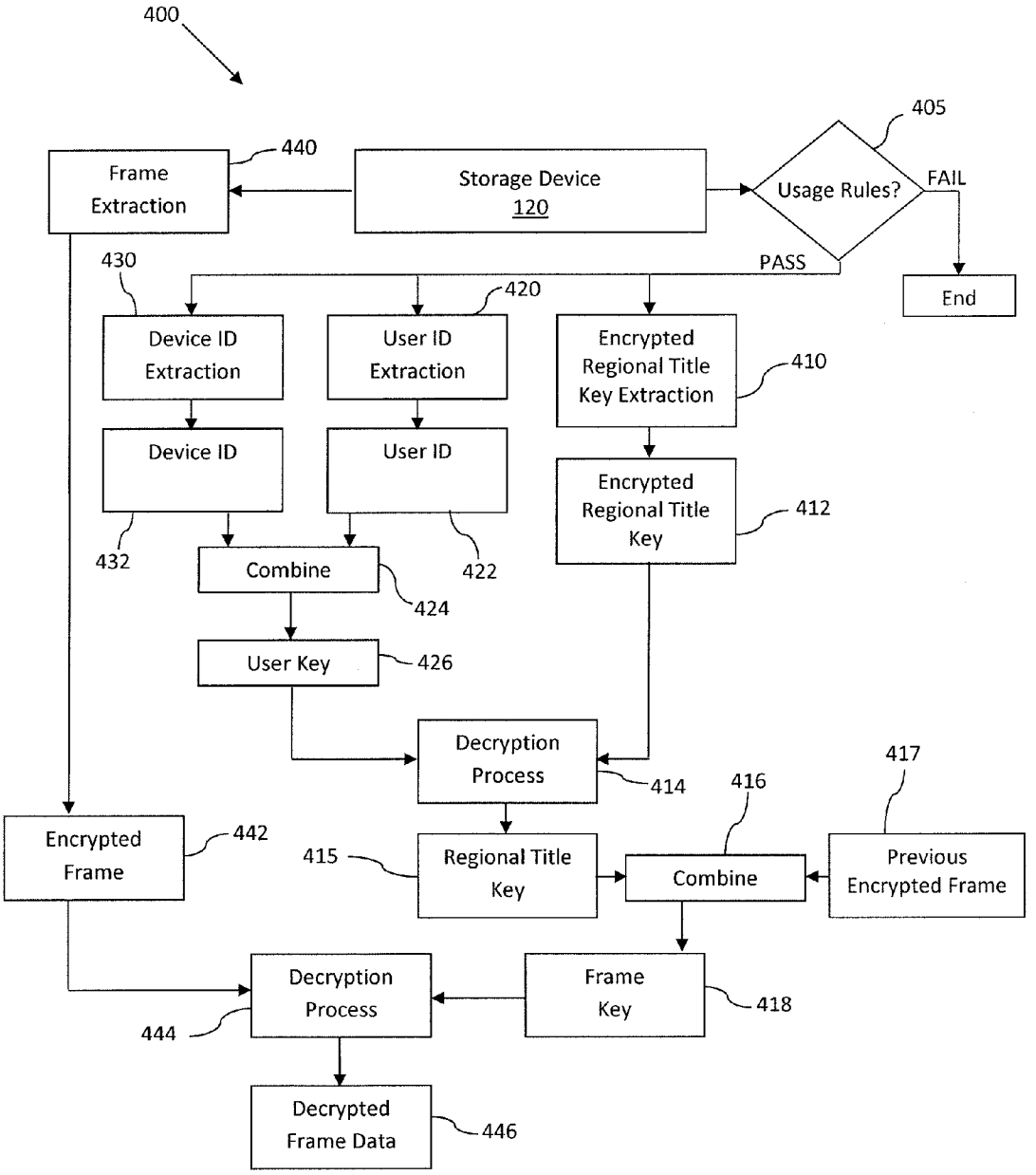

400
405
440
Frame Extraction
Storage Device 120
Usage Rules?
FAIL
End
PASS
430
420
Device ID Extraction
User ID Extraction
Encrypted Regional Title Key Extraction
410
Device ID
User ID
Encrypted Regional Title Key
412
432
422
Combine
424
User Key
426
Decryption Process
414
416
417
Encrypted Frame
442
415
Regional Title Key
Combine
Previous Encrypted Frame
Decryption Process
Frame Key
418
444
Decrypted Frame Data
446

FIG. 4

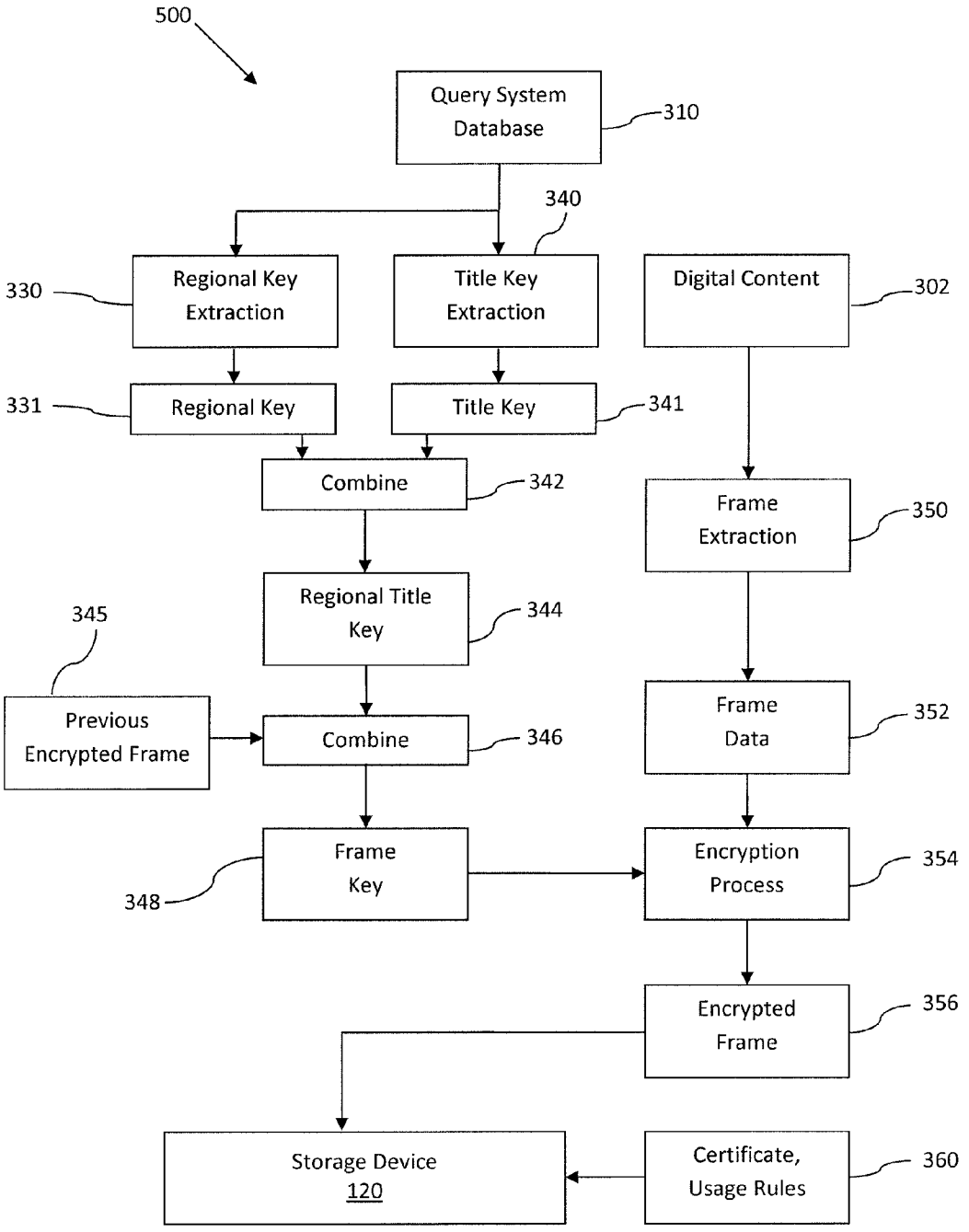

500
Query System Database
310
340
330
Regional Key Extraction
Title Key Extraction
Digital Content
302
331
Regional Key
Title Key
341
Combine
342
Frame Extraction
350
Regional Title Key
344
345
Previous Encrypted Frame
Combine
346
Frame Data
352
348
Frame Key
Encryption Process
354
Encrypted Frame
356
Storage Device 120
Certificate, Usage Rules
360

FIG. 5

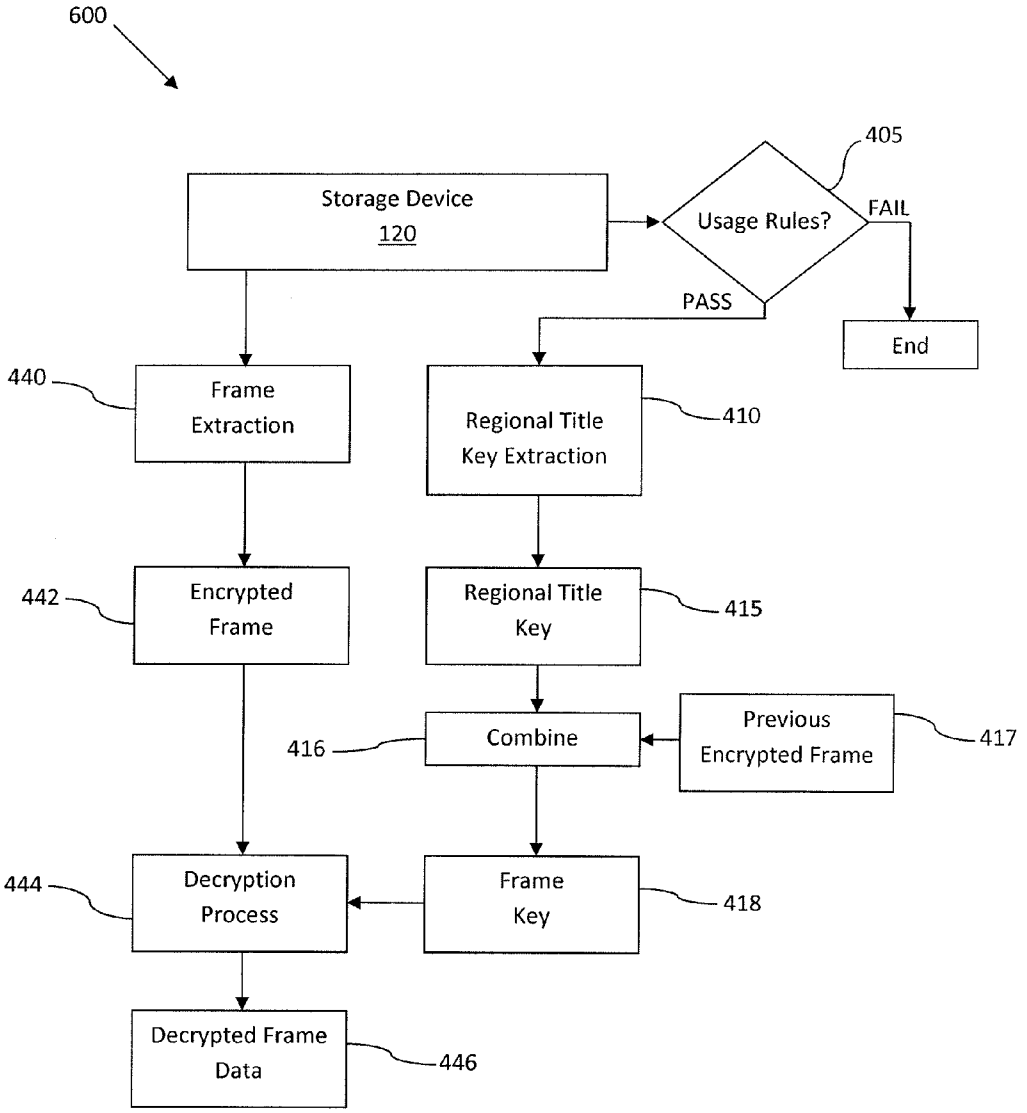

600
Storage Device
120
405
Usage Rules?
FAIL
PASS
End
440
Frame
Extraction
Regional Title
Key Extraction
410
442
Encrypted
Frame
Regional Title
Key
415
416
Combine
Previous
Encrypted Frame
417
444
Decryption
Process
Frame
Key
418
Decrypted Frame
Data
446

FIG. 6

# METHODS AND APPARATUSES FOR DIGITAL CONTENT PROTECTION

## CROSS-REFERENCE TO RELATED APPLICATION

This application claims the benefit of U.S. Provisional Patent Application Ser. No. 61/537,733, filed Sep. 22, 2011, and entitled "Novel Method of Encryption for Data Stored on USB, SD, Hard Drives, or Other Portable Memory Devices, the entire disclosure of which is hereby incorporated herein by this reference.

## FIELD

The present disclosure generally relates to security of digital content. More particularly, embodiments of the present disclosure relate to encryption and decryption of digital content as well as the delivery, storage, and access of such encrypted digital content.

## BACKGROUND

Storing and transmitting content, such as songs, video, and other data in digital form has become commonplace as the use of various electronic devices is more ubiquitous, and as delivery of such digital content becomes more convenient. Distributing digital content to users may pose security issues, including confidentiality and copyright protection issues. Various methods of data encryption have been developed to offer secure methods of authorized storing and transportation of digital content to users.

Conventional digital rights management systems expose security holes that are frequently used by attackers to invade the security system, which may result in illegally obtaining digital content. The security layers for media, such as DVDs and Blu-ray discs, have various defects that allow attackers to obtain the encryption key with relative ease. For example, with conventional encryption methods, the memory block that stores the encryption key to the encrypted content is often not protected. As a result, memory snooping attacks may result in the encryption key being discovered. Attackers often scan memory blocks within the hardware that decrypts such content to search for the encryption key.

Once the encryption key is discovered, the digital content may be accessed and/or copied by unauthorized parties. Because the storage media (e.g., DVDs) often are mass produced, each media device may include the same encryption key for identical digital content. As a result, once one attacker is able to "crack" the DVD and obtain the encryption key, the attacker can easily share the encryption key for others to do the same for their copies. In addition, if the security layer is compromised for one of the media devices, it may be difficult to ascertain information regarding the offending media device or the user using the conventional encryption methods.

## BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

FIG. **1** is a block diagram of a digital content delivery system according to an embodiment of the present disclosure;

FIG. **2** is a block diagram of a digital content delivery system according to an embodiment of the present disclosure;

FIG. **3** is a block diagram illustrating a method for encrypting digital content according to an embodiment of the present disclosure;



FIG. **4** is a block diagram illustrating a method for decrypting encrypted digital content according to an embodiment of the present disclosure;

FIG. **5** is a block diagram illustrating a method for encrypting digital content according to an embodiment of the present disclosure; and

FIG. **6** is a block diagram illustrating a method for decrypting encrypted digital content according to an embodiment of the present disclosure.

## DETAILED DESCRIPTION

In the following description, reference is made to the accompanying drawings in which is shown, by way of illustration, specific embodiments of the present disclosure. Other embodiments may be utilized and changes may be made without departing from the scope of the disclosure. The following detailed description is not to be taken in a limiting sense, and the scope of the claimed invention is defined only by the appended claims and their legal equivalents.

Furthermore, specific implementations shown and described are only examples and should not be construed as the only way to implement or partition the present disclosure into functional elements unless specified otherwise herein. It will be readily apparent to one of ordinary skill in the art that the various embodiments of the present disclosure may be practiced by numerous other partitioning solutions.

Those of ordinary skill in the art would understand that information and signals may be represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits, symbols, and chips that may be referenced throughout the above description may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof. Some drawings may illustrate signals as a single signal for clarity of presentation and description. It will be understood by a person of ordinary skill in the art that the signal may represent a bus of signals, wherein the bus may have a variety of bit widths and the present disclosure may be implemented on any number of data signals including a single data signal.

The various illustrative logical blocks, modules, and circuits described in connection with the embodiments disclosed herein may be implemented or performed with a general-purpose processor, a special-purpose processor, a Digital Signal Processor (DSP), an Application Specific Integrated Circuit (ASIC), a Field Programmable Gate Array (FPGA) or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general-purpose processor may be a microprocessor, but in the alternative, the processor may be any conventional processor, controller, microcontroller, or state machine. A general-purpose processor may be considered a special-purpose processor while the general-purpose processor executes instructions (e.g., software code) stored on a computer-readable medium. A processor may also be implemented as a combination of computing devices, such as a combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration. A computer-readable medium may include storage media, such as ROMs, EPROMs, EEPROMs, Flash memories, optical disks, and other storage devices.

It should be understood that any reference to an element herein using a designation such as "first," "second," and so forth does not limit the quantity or order of those elements,

unless such limitation is explicitly stated. Rather, these designations may be used herein as a convenient method of distinguishing between two or more elements or instances of an element. Thus, a reference to first and second elements does not mean that only two elements may be employed there or that the first element must precede the second element in some manner. In addition, unless stated otherwise, a set of elements may comprise one or more elements.

Embodiments of the present disclosure may enable digital content owners to offer digital content to a user for storing, delivery, and other access. Thus, embodiments of the present disclosure may support one or more of the following business models: safe and secure rental of digital content, sale or subscription services of digital content including online streaming of digital content, and safe and secure controlled sharing of digital content. When the user downloads the digital content to a physical storage device, encryption authentication and authorization software may also be downloaded with the digital content. As a result, digital content owners in a variety of different industries may distribute their digital content in a way that may reduce the risk of digital piracy while helping to increase their content selection they are able to offer. In some embodiments, the authentication and authorization software may require the use of a storage device that is pre-registered with the user's account. In some embodiments, the storage device may be registered with the user's account at the time of content storage. Distribution of the digital content may be secure, and authorized use of the digital content may be enhanced, while reducing the risk of theft or loss.

Embodiments of the present disclosure may further include a frame key that is used to encrypt frames of the digital content. As used herein, a "frame" is intended to refer to a portion of the digital content. Using the term "frame" is not intended to imply that the digital content is limited to video content, unless specifically described as such. The frame key may dynamically change for each frame of the digital content.

FIG. **1** is a block diagram of a digital content delivery system **100** according to an embodiment of the present disclosure. The digital content delivery system **100** may include an encryption device **110**, a storage device **120**, and a content player **130**. The encryption device **110** may be configured to provide the storage device **120** with encrypted digital content. The encrypted digital content may be stored on the storage device **120**. The encrypted digital content may be decrypted and played by the content player **130**.

Digital content may include video content, audio content, electronic book (eBook) content, video game content, software, and various documents (e.g., financial records, health records, government records, military records, business documents, etc.). As a result, embodiments of the present disclosure may assist a variety of industries (e.g., entertainment industry, motion picture industry, television industry, music industry, health care industry, finance industry, publishing industry, eBook industry, software industry, among others) in protecting content from unauthorized access, such as viewing, copying, or sharing the digital content.

The encryption device **110** may include a processor **112** coupled with a computer-readable medium **114**. The computer-readable medium **114** may have instructions stored thereon, which may be executed by the processor **112**. The instructions may cause the processor to perform one or more of the operations described below relating to providing encrypted digital content to the storage device **120**. The encryption device **110** may include a computer, a server, a kiosk, or other similar device for encrypting digital content and providing encrypted digital content to another device. The digital content may be stored in a cloud environment, a local network environment, a kiosk, or other location for the user to access and download onto the storage device **120**.

The storage device **120** may include a computer-readable medium **122** configured to store the encrypted digital content from the encryption device **110**. For example, the storage device **120** may include a Flash memory drive (e.g., USB Flash memory), a secure digital (SD) memory card, a hard drive, an optical disc (e.g., DVD, Blu-Ray), etc.

The content player **130** may be a device configured to read the storage device **120**, decrypt the encrypted digital content, and reproduce the digital content for the user. For example, the content player **130** may include a computer-readable medium **132** that includes instructions stored thereon, which may cause a processor to perform one or more of the operations described below relating to the decryption of encrypted digital content. In some embodiments, the computer-readable medium **132** may include a software application stored thereon configured to read, decrypt, and reproduce the digital content. The user may also download and store a plug-in in the computer-readable medium **132**, the plug-in being configured to enable a larger software application (e.g., such as those commonly found in commercial digital content readers and players) to perform the decryption methods described herein. In addition, the content player **130** may include a display for displaying the reproduced digital content. Depending on the type of digital content, the content player **130** may include a personal computer, television, set top box, laptop computer, tablet computer, cellular phone, smart phone, eBook reader, audio player, gaming device, etc.

In some embodiments, the storage device **120** and the content player **130** may be separate devices, such as the storage device **120** being a USB Flash memory drive and the content player **130** being a personal computer that may receive the storage device **120** and read the digital content stored thereon. In some embodiments, the storage device **120** and the content player **130** may be integrally within the same form factor. For example, the storage device **120** may be internal memory as part of a smart phone, a tablet computer (content player **130**), a hard drive of a computer, or other similar device. In some embodiments, the encryption device **110**, the storage device **120**, and the content player **130** may all be formed integrally within the same form factor.

FIG. **2** is a block diagram of a digital content delivery system **200** according to an embodiment of the present disclosure. The digital content delivery system **200** may include one or more servers **210** that are coupled with a plurality of kiosks **220** through a network **205**. Each kiosk **220** may be located at various locations for a user to receive the digital content. For example, the kiosks **220** may be located at supermarkets, gas stations, restaurants, shopping centers, etc.

The server **210** may distribute digital content to each kiosk **220**. Thus, in some embodiments, the kiosks **220** may hold the preliminary digital content. A user may insert a storage device **120** (FIG. **1**) into the kiosk **220** to receive digital content. The server **210** may maintain a user database **212** that includes user information, such as customer licenses, name, address, payment information, etc., associated with a user. As a result, a user may access the digital content delivery system **200** through any of the kiosks **220**.

As an example, and referring to FIGS. **1** and **2**, the user may insert the storage device **120** to purchase or rent a movie. The kiosk **220** may read user information (if any) from the storage device **120**. The kiosk **220** may access the database **212** (or a local version stored on the kiosk **220**) access the user account associated with the particular storage device **120**. If the storage device **120** is not associated with an existing user account,

the user may be required to open a user account prior to receiving any digital content from the kiosk **220**. If a user account is authenticated for the storage device **120**, the digital content may be provided from the kiosk **220** to the storage device **120**. The digital content may be encrypted according to embodiments described more fully below.

Additional configurations for digital content delivery systems are also contemplated. For example, rather than having a kiosk-based system that requires the user to find a kiosk at a specific location, embodiments of the present disclosure may enable users to access a web-based digital content delivery system or other online streaming applications. In such a web-based content delivery system, a user may insert their storage device **120** into a computer connected to the Internet (e.g., their home computer). The user's account may be authenticated, after which the user may be access their user account and other content through a website. Through such a website, the user may select digital content to download to the storage device **120**. When the digital content is downloaded to the storage device **120**, the digital content may be encrypted and stored on the storage device **120**. The digital content may be encrypted on the server **210** before being downloaded to the storage device **120**. In other words, the full digital content may be encrypted on the server **210** and then transmitted to the storage device **120**. When the digital content is accessed from the storage device **120**, the digital content may be decrypted by the content player **130**. Encryption and decryption of the digital content may be described more fully below with respect to FIGS. **3-6**.

In some embodiments, the storage device **120** may be memory on a computing device rather than a separate storage device. For example, a user may simply use a smart phone, a tablet computer, a personal computer, etc., with an internal hard drive as the storage device **120** to access a web-based content delivery system to download digital content to the device. Accessing the web-based content delivery system may occur through a web site as discussed above, or through an application stored on the device that provides access to the digital content and user account information.

Embodiments of the present disclosure may include accessing encrypted digital content for a variety of different settings. For example, consumer settings may be as discussed above (e.g., kiosks, web-enabled devices, etc.). In other embodiments, commercial settings are also contemplated. For example, a movie studio may desire to distribute digital movie content to movie theaters around the world. The movie studio may deliver a portable hard drive to the movie theater with the digital movie content. In such embodiments, the digital movie content may be encrypted on the hard drive prior to being delivered to the theater. In some embodiments, commercial users, such as movie theaters, may be provided access to download encrypted digital content using an online account.

FIG. **3** is a block diagram **300** illustrating a method for encrypting digital content **302** according to an embodiment of the present disclosure. The encryption method provides for user authentication and authorization in order to reduce or eliminate unauthorized access of the digital content **302**. As a result, the distribution of the digital content **302** may be secured.

The method for encrypting digital content **302** may include a unique security layer that may be enforced with one or more of the following keys: a title key **341**, a regional key **331**, and a user key **326**. The title key **341** includes an identifier associated with a particular title of the digital content **302**. For example, a particular movie (e.g., "Star Wars") may have a title key **341** associated therewith. The title key **341** may be common for each version of the digital content of the same title. In other words, each instance of the digital content **302** for a particular title may have the same title key **341**. Thus, the title key **341** for digital content **302** of a first title (e.g., "Star Wars") may be different than the title key **341** used for the digital content **302** of a second title (e.g., "Lord of the Rings").

The regional key **331** includes an identifier associated with a particular geographic location of the user of the digital content **302**. For example, the regional key **331** may be based on a region in which the digital content **302** is downloaded to the storage device **120**. In other words, the downloads for a common region may share a regional key **331**. A common region may be, for example, a city, a state, a zip code, an area code, a province, or other defined areas as desired by the content provider. When the user downloads the digital content **302** to the storage device **120**, the region of the user may be determined. The region may be determined based on the known fixed location of a kiosk **220** (FIG. **2**), the area code of a phone number of the user, the current global positioning system (GPS) coordinates of a device, an IP address, an address of the user registered in the user account, or other methods to determine the region where the user is located or where the download occurred. In some embodiments, each kiosk **220** may have its own unique identifier that is used as the regional key **331**.

The user key **326** includes an identifier associated with a particular user of the digital content **302**. Each user may be assigned a unique identifier that is different than the other potential users. The user key **326** may include an identifier that is device specific, such that each storage device **120** may have a user key **326** associated therewith even if the same user has more than one storage device **120**. The device-specific identifier may include a device serial code that is stored in the storage device **120**. In some embodiments, the user key **326** may include a combination of both a device-specific identifier and a user-specific identifier. For example, the user key **326** may include a combination of a device ID **322** and a user ID **324**.

Referring now more specifically to FIG. **3**, a user may desire to download or stream the digital content **302**. As discussed above, the user may access the digital content **302** through a website, an application, a kiosk **220** or other interface in order to download the digital content **302** to a storage device **120** (e.g., USB Flash memory device, SD card, smartphone, tablet computer, laptop, television, personal computer, etc.).

At operation **310**, the content management system database may be queried. For example, the content management system database may include information regarding user accounts, storage device information, the region for the user, and information regarding the title (i.e., digital content) to be downloaded.

At operation **320**, a user key extraction process may be initiated to generate a user key **326**. The user key **326** may include an indicator related to the intended user of the digital content. In some embodiments, a device ID **322** and a user ID **324** may be combined (operation **325**) to form the user key **326**. As a non-limiting example, the combination of the device ID **322** and the user ID **324** may include performing an XOR function of the device ID **322** and the user ID **324**. Other logic functions are also contemplated.

The device ID **322** may be a device-specific identifier for the storage device **120**. For example, a USB Flash drive may have a device serial number unique to the device, which is stored in memory (in the ROM) by the device manufacturer and may be retrieved as the device ID **322**. The user ID **324**

may be a unique identifier associated with a particular user. Each of the device ID **322** and the user ID **324** may be hashed. In other words, the device ID **322** and the user ID **324** may be processed using a specific hash function for additional protection.

When each user establishes a user account and registers a storage device **120**, the user may be assigned a user ID **324**. In some embodiments, a user account may include have a plurality of storage devices **120** registered to the user account. In other embodiments, each user account may be allowed to have only a single storage device **120** associated registered per user account.

In some embodiments, the storage device **120** may be pre-formatted and loaded with the user ID **324** for a particular user. In other words, the content provider may issue storage devices **120** that are already formatted for storing the encrypted digital content. In some embodiments, the user may use an arbitrary storage device **120** that is not pre-formatted. Thus, during user key extraction process of operation **320**, it may be determined that the storage device **120** has not yet been formatted to include the user ID **324**, which may be remedied by formatting the arbitrary storage device **120** to include the user ID **324** for the particular user.

As described above, the device ID **322** may be a hardware serial code that may not be the result of formatting by the content provider, while the user ID **324** may be the result of formatting by the content provider. As a result, the user ID **324** may be revoked by the content provider if desired, while the device ID **322** may remain fixed in the storage device **120**.

In some embodiments, the encryption method using the regional title key **344** may be performed on the fly at the time that the digital content **302** is provided to the user. For example, the user may select digital content to download from a kiosk, over the Internet, etc. In some embodiments, the encryption method using the regional title key **344** may first encrypt and store the encrypted digital content on a storage device **120** that is then delivered to the user. For example, a hard drive may be loaded with encrypted digital content for one or more movies, and then the hard drive may be delivered to a movie theater. The content provider may assign each movie theater with its own unique user ID **324**. As a result, the hard drive may be loaded with a regional title key **344** that includes a multi-tier key that includes the user ID **324**, the regional key **331**, and the title key **341**. Thus, if information regarding the encrypted digital content were leaked, the specific movie theater where the content was leaked may be determined.

At operation **330**, a regional key extraction process may be initiated to generate a regional key **331**. The regional key **331** may include an identifier associated with a particular geographic location of the user of the digital content. The regional key **331** may be determined from information stored in the user account, the system database, or by determining the region based on other factors (e.g., current GPS location). At operation **340**, a title key extraction process may be initiated to generate a title key **341**. The title key **341** may include an identifier associated with a particular title of the digital content. The title key **341** may be determined by querying the system database to obtain the unique title key associated with the digital content **302** selected by the user.

The regional key **331** and the title key **341** combine (operation **342**) to form a regional title key **344**. Combining the regional key **331** and the title key **341** may occur through an XOR function as one non-limiting example of a combining operation. In some embodiments, the user ID **324** may also combine with the regional key **331** and the title key **341** to form the regional title key **344**. As a result, the regional title key **344** may include the user ID **324** embedded therein, and the regional title key **344** may be unique for each user. Combining the user ID **324** with the regional key **331** and the title key **341** may occur through a first XOR function, or other suitable combination, of the user ID **324** and the regional key **331** and a second XOR function, or other suitable combination, with the title key **341**. The user ID **324** may be stored in the storage device **120** for extraction during decryption.

The user key **326** may be used to encrypt the regional title key **344** through an encryption process **327** to generate an encrypted regional title key **328**. The encryption process **327** may include an encryption algorithm, such as, for example, Advanced Encryption Standard (AES) algorithm. It is contemplated that the encryption process **327** be implemented using encryption techniques, such as 128 bit, 256 bit, etc. The encrypted regional title key **328** may be stored in the storage device **120** for extraction during decryption.

The regional title key **344** may also be used to generate a frame key **348**. The frame key **348** may be used to encrypt the frame data **352** through an encryption process **354**. The frame key **348** may dynamically change throughout the encryption process **354** for each frame data **352**. In other words, the frame key **348** may change for each frame of the frame data **352** that is encrypted. For example, the frame key **348** used to encrypt the first frame may be different than the frame key **348** used to encrypt the second frame, and so on. The encryption process **354** may employ a variety of different encryption techniques (e.g., AES). The encrypted frames **356** may be stored in the storage device **120**.

The digital content **302** may be encrypted based on a plurality of frame keys generated from the digital content itself. As an example, the regional title key **344** may be combined (operation **346**) with previous encrypted frames **345** to generate the frame key **348**. The combination of the previous encrypted frame **345** and the regional title key **344** may be implemented using an XOR function. In some embodiments, the data used from the previous encrypted frame **345** may not necessarily be the entire previous encrypted frame. Rather, the data from the previous encrypted frame **345** that is used to generate the frame key **348** may be a selected subset of data (e.g., 128 bits) from the previous encrypted frame **345**.

The frame data **352** may be generated from a frame extraction procedure **350** of the digital content **302**. The frame key **348** may then be used to encrypt the each individual frame data **352** rather than the digital content **302** as a whole. As a result, the encryption process **354** may generate the encrypted frames **356**. A previous encrypted frame **345** may be combined with the regional title key **344** to form each frame key **348** used in the encryption process **354**. In some embodiments, the previous encrypted frame **345** may be the encrypted frame **356** that was encrypted immediately prior to the frame data **352** that is encrypted. In other words, the frame data **352** may be encrypted **354** using a frame key **348** that includes the previous encrypted frame **345** that was just previously encrypted. The previous encrypted frame **345** may be extracted from the storage device **120** when needed for operation **346**. In some embodiments, the previous encrypted frame **345** may be any previously encrypted frame according to a rule governing the encryption. For example, if additional delay is desired during the encryption, the previous encrypted frame **345** may be more than one encrypted frame **356** prior to the frame data **352** being encrypted. In addition, when encrypting the first frame data of the digital content **302**, there may not yet exist a previous encrypted frame **345**. In such a situation, the regional title key **344** alone may be used as the frame key **348** for the first frame data **352** of the digital content.

Because each previous encoded frame **345** is combined with the regional title key **344** to generate the frame key **348**, the frame key **348** is unique for each frame of the digital content. As a result, the encryption and decryption devices that access the content on the storage device storage device **120** may not have a fixed key sitting in memory as is the case with conventional encryption methods. Rather, the frame key **348** is a dynamic key that is generated for each frame data **352** that is encrypted. In addition, each frame key **348** may not even need to be stored on the storage device **120**. For example, a refresh algorithm may be used to generate a frame key **348** for each frame dynamically in order to encrypt and decrypt each frame of the digital content **302**. During encryption and decryption, the frame key **348** may be constantly refreshing. As a result, if an attacker were to scan the memory cache (i.e., memory snooping) for the frame key **348** when not in use, the frame key **348** itself would not be available. In addition, during encryption or decryption, the attacker may have greater difficulty detecting a pattern in the block of memory than with the situation of using a static key as in conventional encryption methods.

In some embodiments, the storage device **120** may also be loaded with certificates and/or usage rules **360** that may restrict the use of the encrypted digital content according to some criteria. For example, in situations where renting the digital content **302** rather than owning the digital content **302** is desired, one criteria of the usage rules **360** may be the amount of time (e.g., 5 days) that the encrypted digital content may be available to the user. It is contemplated that other usage rules **360** may exist. For example, a restriction may be placed on the number of times, frequency, etc. that the encrypted digital content may be accessed.

Because the regional title key **344** is generated using a user ID **324**, information regarding the user and/or storage device **120** may be embedded with the encrypted digital content. As a result, each storage device **120** may have customized encryption keys rather than being mass produced on a large scale. Because the frame key **348** and the encrypted regional title key **328** may include the user ID **324**, a specific "traitor" may be identified. A traitor may be a user who may contribute to unauthorized access or copying of the encrypted digital content. For example, the content provider may obtain the compromised digital content and reverse the process to discover which user contributed to the digital content being compromised. For example, comparing the extracted user ID **324** against the system database may narrow the traitor down to a single user.

For embodiments using the device ID **322** in the encryption, even if the user ID **324** and the method for generating the frame key **348** were cracked, the encrypted digital content would not decrypt on a different device because the different device would have a different device ID **322**. For example, if someone were to hack the digital content **302** and load on a second device, the second device and the first device would have different device IDs **322**. As a result, the user key **326** for the second device would not match the user key **326** for the first device, which may result in the encrypted data content not being readable on the second device.

FIG. **4** is a block diagram **400** illustrating a method for decrypting encrypted digital content according to an embodiment of the present disclosure. The encrypted digital content may be encrypted according to embodiments of the present disclosure and stored in the storage device **120**. The decryption method may be implemented with a content player **130** (FIG. **1**). For example, the content player **130** may include a software application (and in some embodiments an additional plug-in) that is configured to perform the decryption method. In some embodiments, the decryption method used may be approximately the reverse of the encryption method used. For example, the decryption method in FIG. **4** may be used as a decryption method for encrypted digital content that is encrypted by the encryption method of FIG. **3**.

At operation **405**, usage rules may be examined to determine if the usage rules permit decryption of the encrypted digital content. As discussed above, usage rules may place limits on the availability of the digital content to a user. If the usage rules do not permit decryption, the method may end. If the usage rules do permit decryption, the following decryption method may begin.

At operation **410**, the encrypted regional title key **412** may be extracted from the storage device **120**. As discussed above, the encrypted regional title key **412** may have been stored on the storage device **120** during encryption. In addition, the regional title key **412** may include a combination of a region key, a title key, and a user ID.

At operation **420**, the user ID **422** may be extracted from the storage device **120**. As discussed above, the user ID **422** may have been stored on the storage device **120** during encryption. The user ID **422** may be a unique identifier associated with a specific user. The user ID **422** may be assigned to a user when the user creates a user account, and may be stored on the storage device **120** during formatting of the storage device **120**. As discussed with respect to FIG. **3**, the user ID **422** may have been hashed during the encryption process. As a result, the user ID **422** may also be hashed when retrieved from the storage device **120** during the decryption process as well.

At operation **430**, the device ID **432** may be extracted from the storage device **120**. As discussed above, the device ID **432** may have been stored on the storage device **120** during the manufacturing process of the storage device **120**. The device ID **432** may be a unique identifier associated with the storage device **120** itself, such as a device serial code prewritten in the ROM section of the storage device **120** by the manufacturer. As discussed with respect to FIG. **3**, the device ID **432** may have been hashed when being used to combine with the user ID **422** and/or the other keys. Because in some embodiments the device ID **432** may be stored in the storage device by the manufacturer and not the content provider, the device ID **432** may not be hashed as stored in the storage device **120**. In such an embodiment, the device ID **432** may also need to be hashed during the decryption process to match the encryption process.

At operation **440**, the frames may be extracted from the digital content to obtain encrypted frames. The encrypted frames may be retrieved one by one to be decrypted individually and to generate decrypted frame data **446**.

The user ID **422** and the device ID **432** may be combined (e.g., operation **424**) to generate a user key **426**. The user key **426** and the encrypted regional title key **412** may be decrypted (e.g., through decryption process **414**) to generate the regional title key **415**. The decryption process **414** may be a reverse of the encryption process **327** (FIG. **3**) used to generate the encrypted regional title key **412**. Thus, the decryption process **414** (and decryption process **444**) may employ a reverse AES function.

The regional title key **415** and the previous encrypted frame **417** may be combined (operation **416**) to generate frame key **418** that is used for decrypting (e.g., through decryption process **444**) current encrypted frame **442**. As a result, the decrypted frame data **446** may be generated.

As with the encryption process, the frame key **418** may be dynamically generated rather than having a static key used for decryption. The frame key **418** may be generated on the fly

during the decryption method rather than being saved in the decrypting device. As a result, memory snooping to recover the frame key **418** may be less successful than conventional methods.

In addition, the frame key **418** may be reconstructed from the encrypted digital content. For example, the frame key **418** used for decryption may be based on the digital content itself as the previous encrypted frame **417** may be used to generate a new frame key **418** for decryption of each encrypted frame. In some embodiments, the previous encrypted frame **417** may be the encrypted frame that is immediately prior to the current encrypted frame **442** being decrypted, or some other separation between the two. In addition, the first frame key **418** used may be the regional title key **415** alone as there would be no previous encrypted frame **417** available.

FIG. **5** is a block diagram **500** illustrating a method for encrypting digital content **502** according to an embodiment of the present disclosure. The encryption method of FIG. **5** may include operations similar to those discussed above with respect to FIG. **3**. The difference between the encryption method of FIG. **5** compared with FIG. **3** is that the block diagram **500** does not include the portions pertaining to the user ID and device ID. As a result, the regional title key **344** may not include the user ID. The encryption method of FIG. **5** does show the frame key **348** that may be generated based on the digital content **302** itself, such as, for example, by combining the regional title key **344** with previous encrypted frames **345**.

Such an embodiment may be desired if the encryption of the frame data is performed at a point in time other than the actual downloading the digital content **302** to the storage device **102**. For example, one potential drawback from such an embodiment is that the ability to narrow a traitor to a single individual user may be lost. However, the regional key **331** may include a region that is narrow enough to obtain a manageable list of users who may be the traitor. In other words, a region for the traitor may be determined and the content provider (or other entity) may query the system database to determine which users are in that region, and which other those users have downloaded the digital content **302** (e.g., title) that has been compromised. For example, it may be known which defined region in which the user was located to load the digital content **302**. As a result, the system database may be queried to identify each of the users in that region who may have downloaded that title. From that list, a relatively small list of possible offenders may be created for further investigation.

FIG. **6** is a block diagram **600** illustrating a method for decrypting encrypted digital content according to an embodiment of the present disclosure. The decryption method of FIG. **6** may include operations similar to those discussed above with respect to FIG. **4**. The difference between the decryption method of FIG. **6** compared with FIG. **4** is that the block diagram **600** does not include the portions pertaining to the user ID and device ID. Thus, the decryption method in FIG. **6** may be used as a decryption method for the encrypted digital content encrypted by the encryption method of FIG. **5**. As a result, the regional title key **415** may not include the user ID. The encryption method of FIG. **6** does show the frame key **418** that may be generated based on the digital content itself, such as, for example, by combining the regional title key **415** with previous encrypted frames **417**.

## CONCLUSION

In some embodiments, a method for digital content protection is disclosed. The method comprises generating a plurality of frame keys, retrieving a plurality of frames from digital content, and at least one of encrypting and decrypting the digital content with a different frame key that dynamically changes for each frame of the plurality of frames.

In another embodiment, a storage device comprises a computer-readable medium including encrypted digital content stored thereon, wherein the encrypted digital content is encrypted with a frame key that is different for each frame of the encrypted digital content.

In yet another embodiment a content player comprises a computer-readable medium including instructions stored thereon, that when executed cause a processor to decrypt encrypted digital content by reconstructing a plurality of frame keys that are different from each other that are used to decrypt each frame of the encrypted digital content.

While the present disclosure has been described herein with respect to certain embodiments, those of ordinary skill in the art will recognize and appreciate that it is not so limited. Rather, many additions, deletions and modifications to the described embodiments may be made without departing from the scope of the disclosure as hereinafter claimed, including legal equivalents. In addition, features from one embodiment may be combined with features of another embodiment while still being encompassed within the scope of the disclosure as contemplated by the inventor.

What is claimed is:

**1**. A method for digital content protection, the method comprising:

generating a plurality of frame keys;

retrieving a plurality of frames from digital content; and

at least one of encrypting and decrypting the digital content with a different frame key of the plurality of frame keys that dynamically changes for each frame of the plurality of frames;

encrypting a regional title key with a user key to generate an encrypted regional title key; and

storing the encrypted regional title key and the encrypted digital content in a storage device.

**2**. The method of claim **1**, wherein generating the plurality of frame keys further comprises generating a frame key of the plurality of frame keys that includes using at least a portion of the digital content to contribute to the frame key.

**3**. The method of claim **2**, wherein generating the frame key of the plurality of frame keys further includes using a previously encrypted frame for encrypting a current frame.

**4**. The method of claim **2**, wherein generating the frame key of the plurality of frame keys further includes using a previously encrypted frame for decrypting a current encrypted frame.

**5**. The method of claim **2**, wherein generating the frame key of the plurality of frame keys further includes combining the regional title key with the previous encrypted frame.

**6**. The method of claim **5**, wherein generating the frame key of the plurality of frame keys further includes using the regional title key as a frame key for a frame in which no previous encrypted frame exists.

**7**. The method of claim **5**, wherein generating the frame key of the plurality of frame keys further includes combining a regional key and a title key with a user ID to generate the regional title key.

**8**. The method of claim **1**, further comprising:

generating the user key by combining a device ID and a user ID; and

storing the user ID in the storage device.

**9**. A storage device, comprising:

a computer-readable medium including encrypted digital content and an encrypted regional title key stored

thereon, wherein the encrypted digital content is encrypted with a frame key that is different for each frame of the encrypted digital content, and wherein the encrypted regional title key is encrypted with a user key and a combination of a regional key and a title key.

**10**. The storage device of claim **9**, wherein the user key includes a combination of a user-specific identifier and a device-specific identifier.

**11**. The storage device of claim **9**, wherein the regional key is associated with a region selected from the group consisting of a city, an area code, a zip code, a region served by a kiosk, and sub-regions thereof.

**12**. The storage device of claim **9**, further comprising a portable storage device that comprises the computer-readable medium, the portable storage device selected from the group consisting of a Flash memory device, a smart phone, an eBook reader, a laptop computer, and a tablet computer.

**13**. The storage device of claim **9**, wherein the digital content is selected from the group consisting of video content, audio content, video game content, health records, financial records, government records, and military records.

**14**. The storage device of claim **9**, wherein the frame key is embedded with a user ID that identifies a specific user of the storage device.

**15**. A content player, comprising:

a computer-readable medium including instructions stored thereon, that when executed cause a processor to decrypt encrypted digital content by reconstructing a plurality of frame keys that are different from each other that are used to decrypt each frame of the encrypted digital content and an encrypted regional title key encrypted with a user key and a regional title key.

**16**. The content player of claim **15**, wherein the instructions are stored on the computer-readable medium as a software application.

**17**. The content player of claim **16**, wherein the instructions are stored on the computer-readable medium as a plug-in to a larger software application.

**18**. The content player of claim **15**, wherein the plurality of different frame keys include a selected subset of data from a previous encrypted frame for decrypting a current encrypted frame.

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