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(54) **RAPID DECRYPTION OF DATA BY KEY SYNCHRONIZATION AND INDEXING**

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See application file for complete search history.

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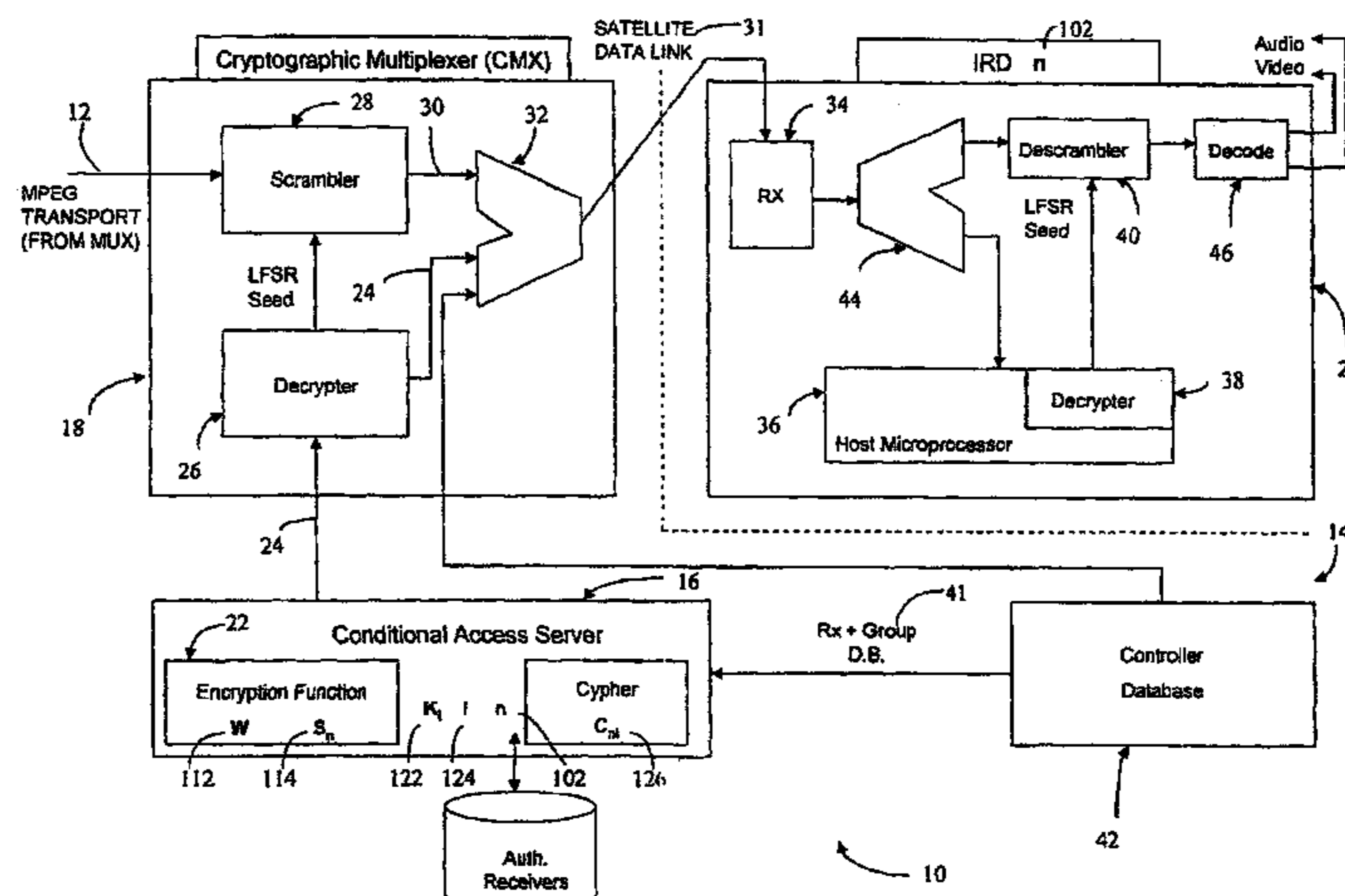
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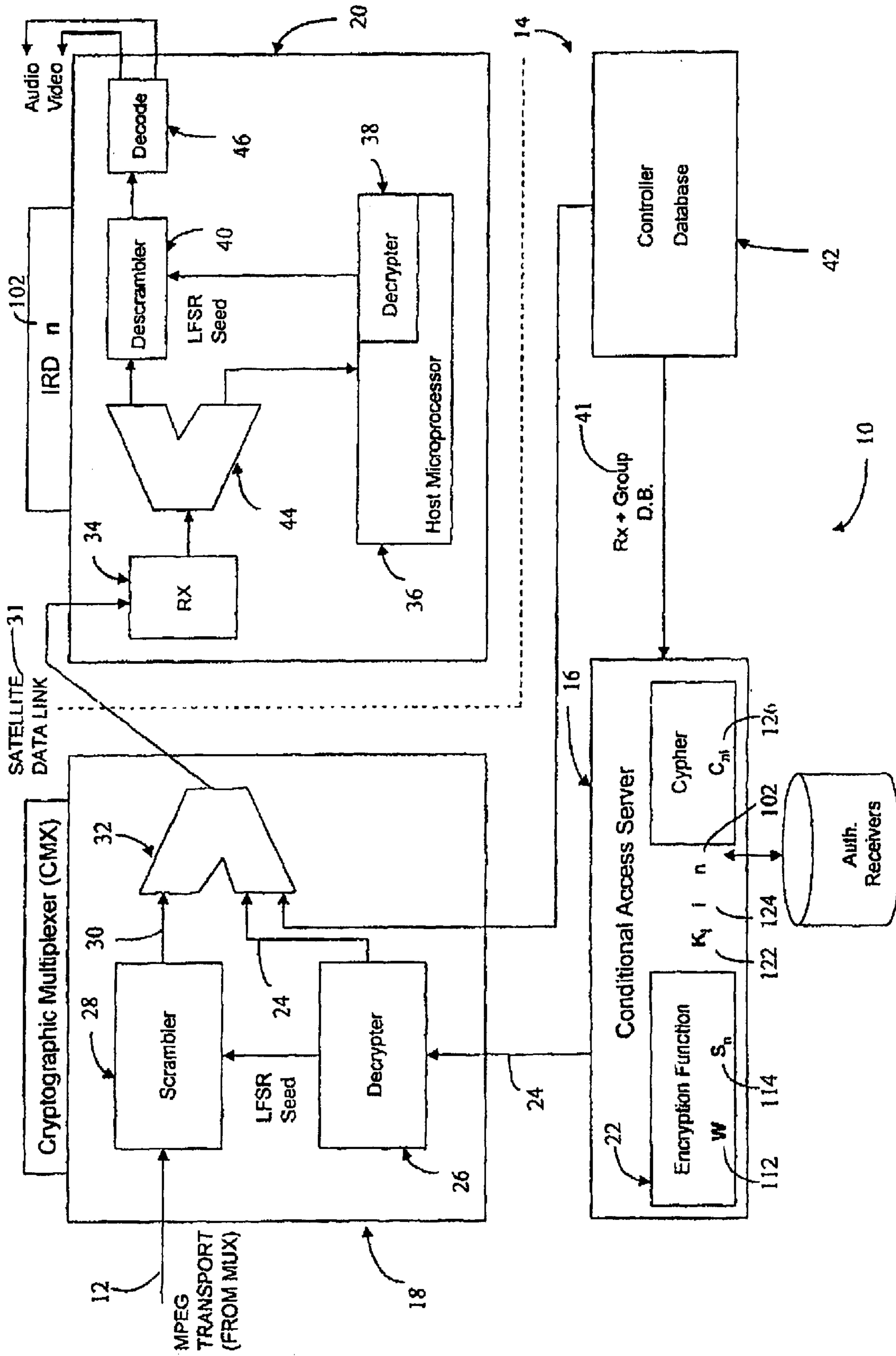


FIG. 1

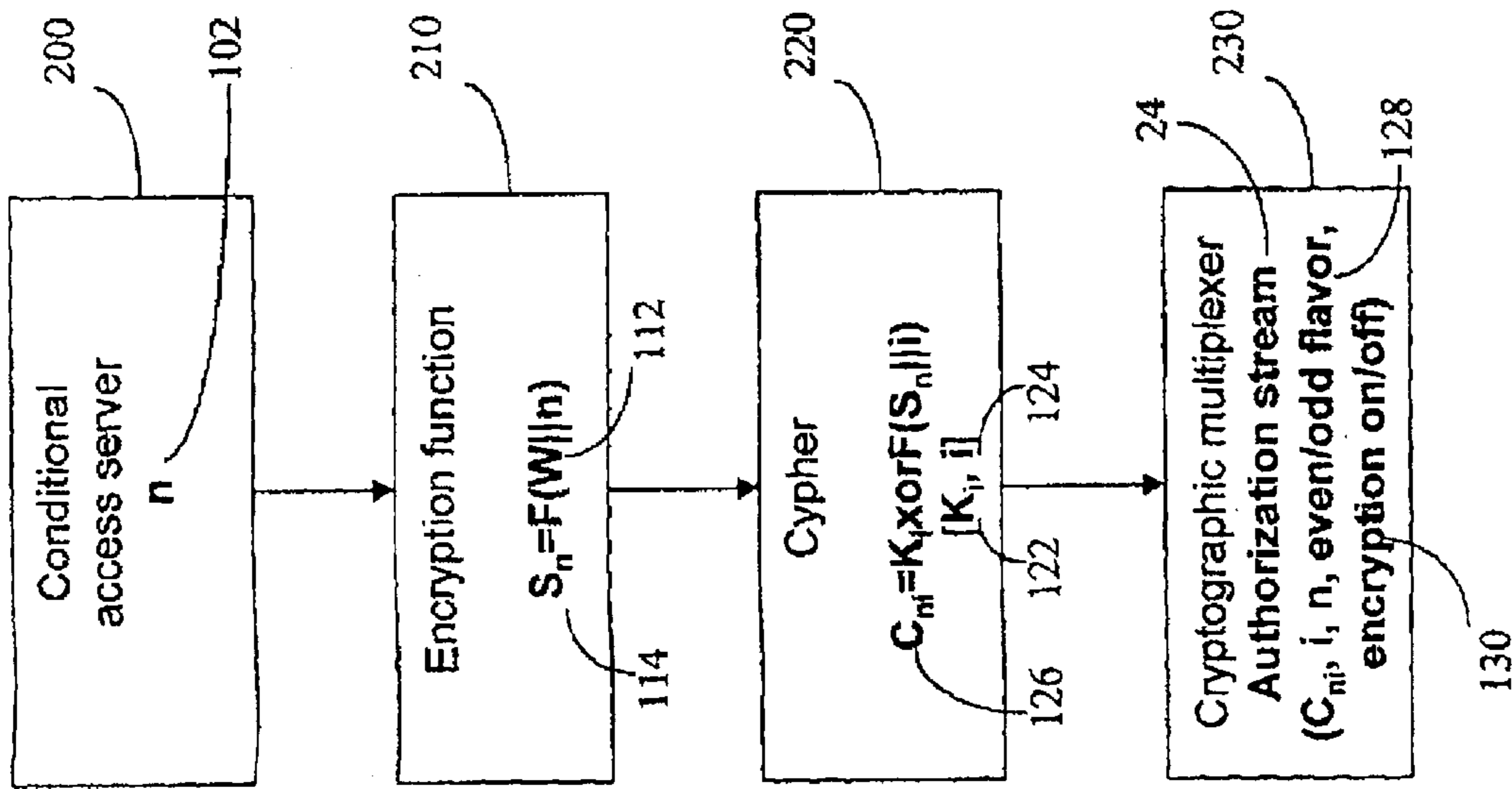


FIG. 2

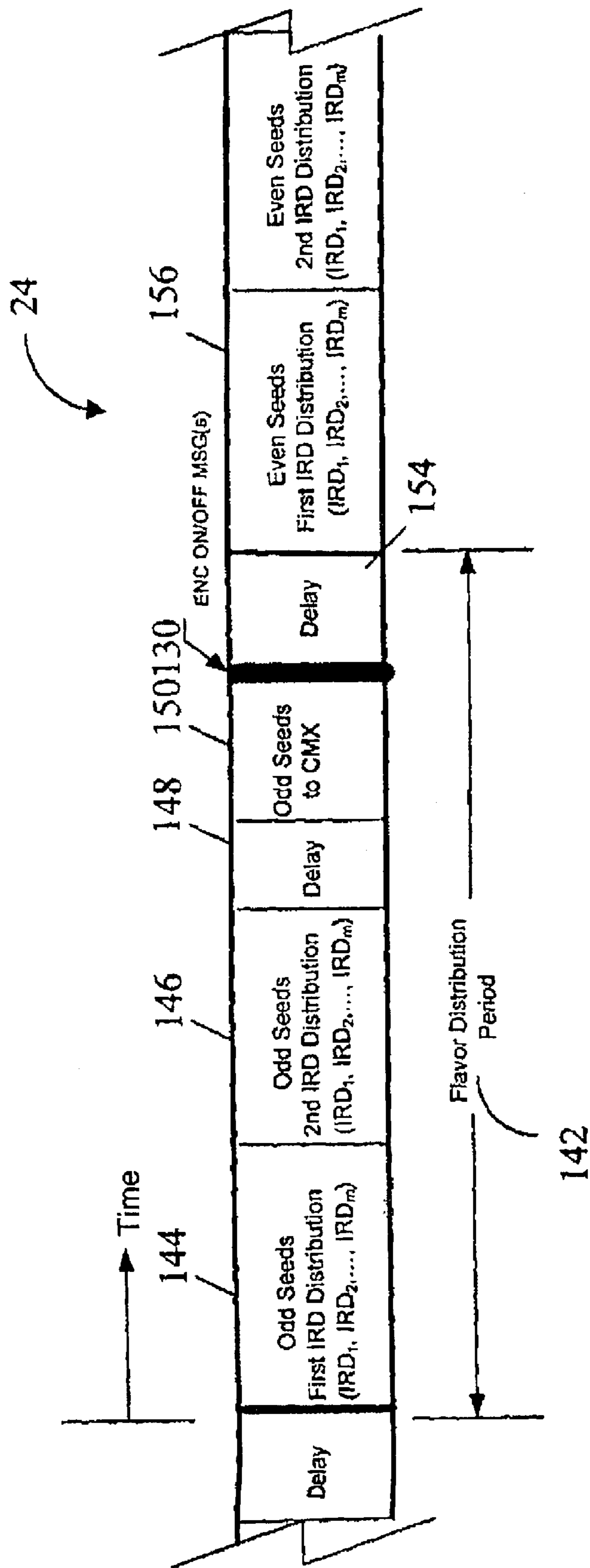


FIG. 3

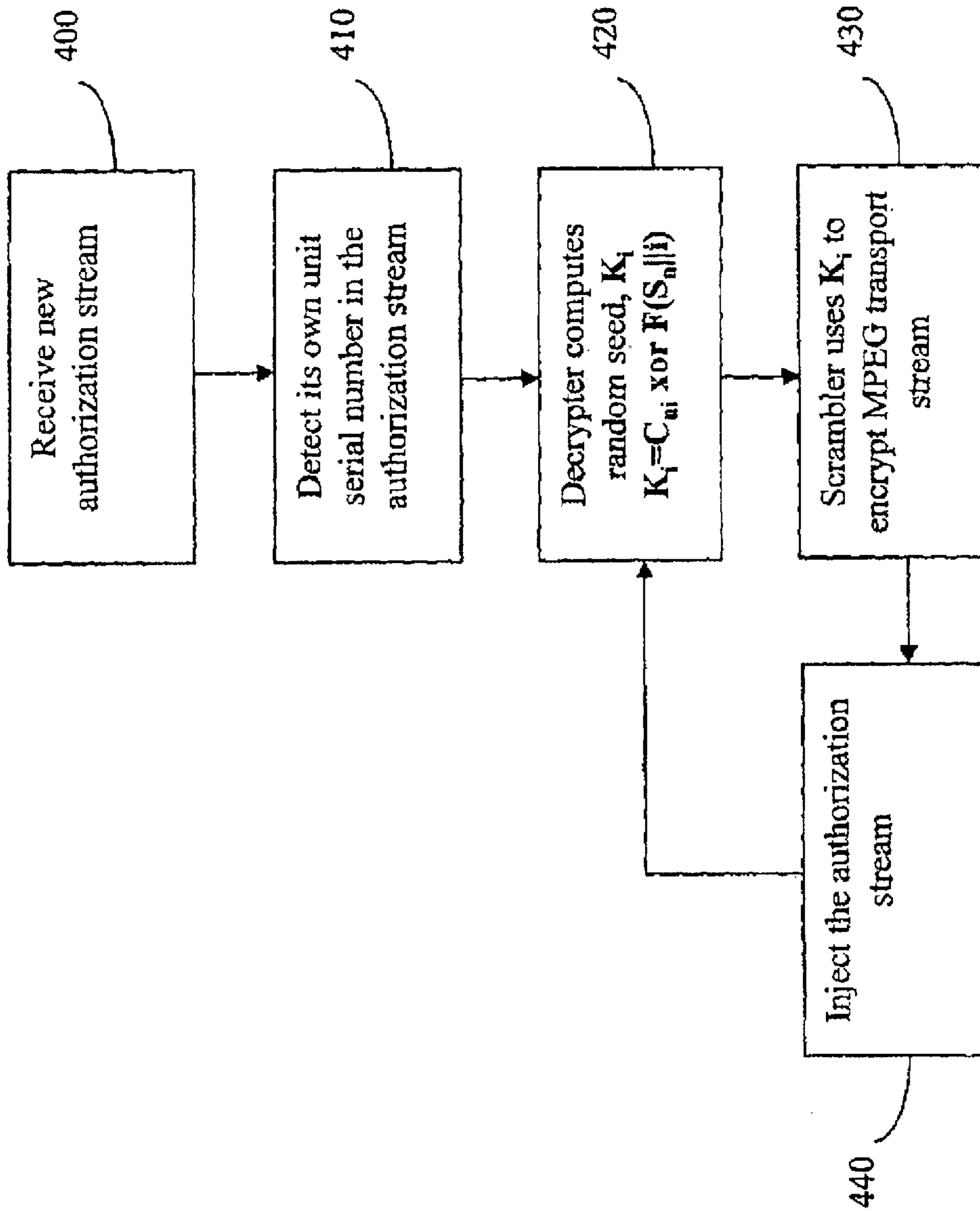


FIG. 4

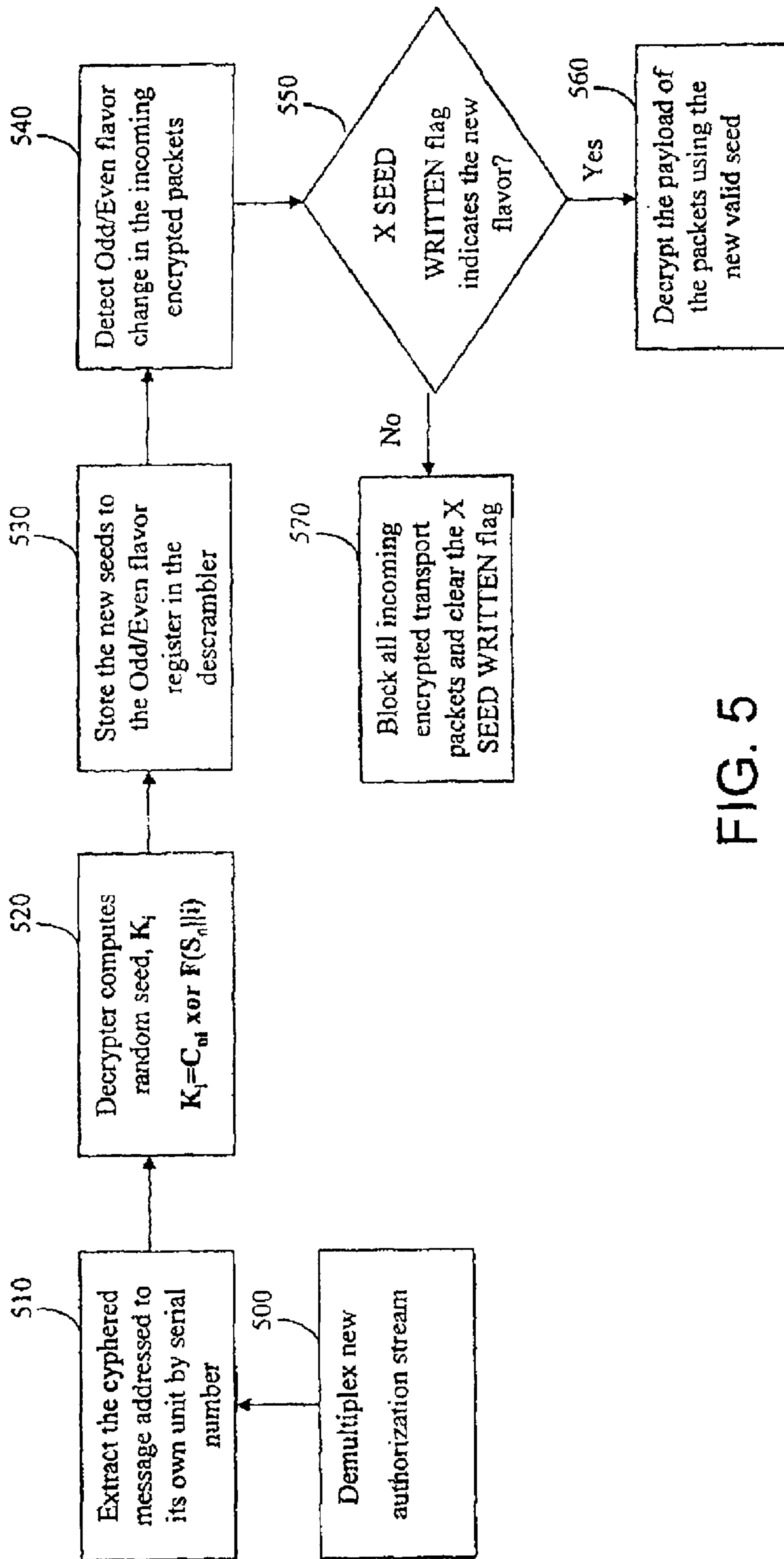


FIG. 5



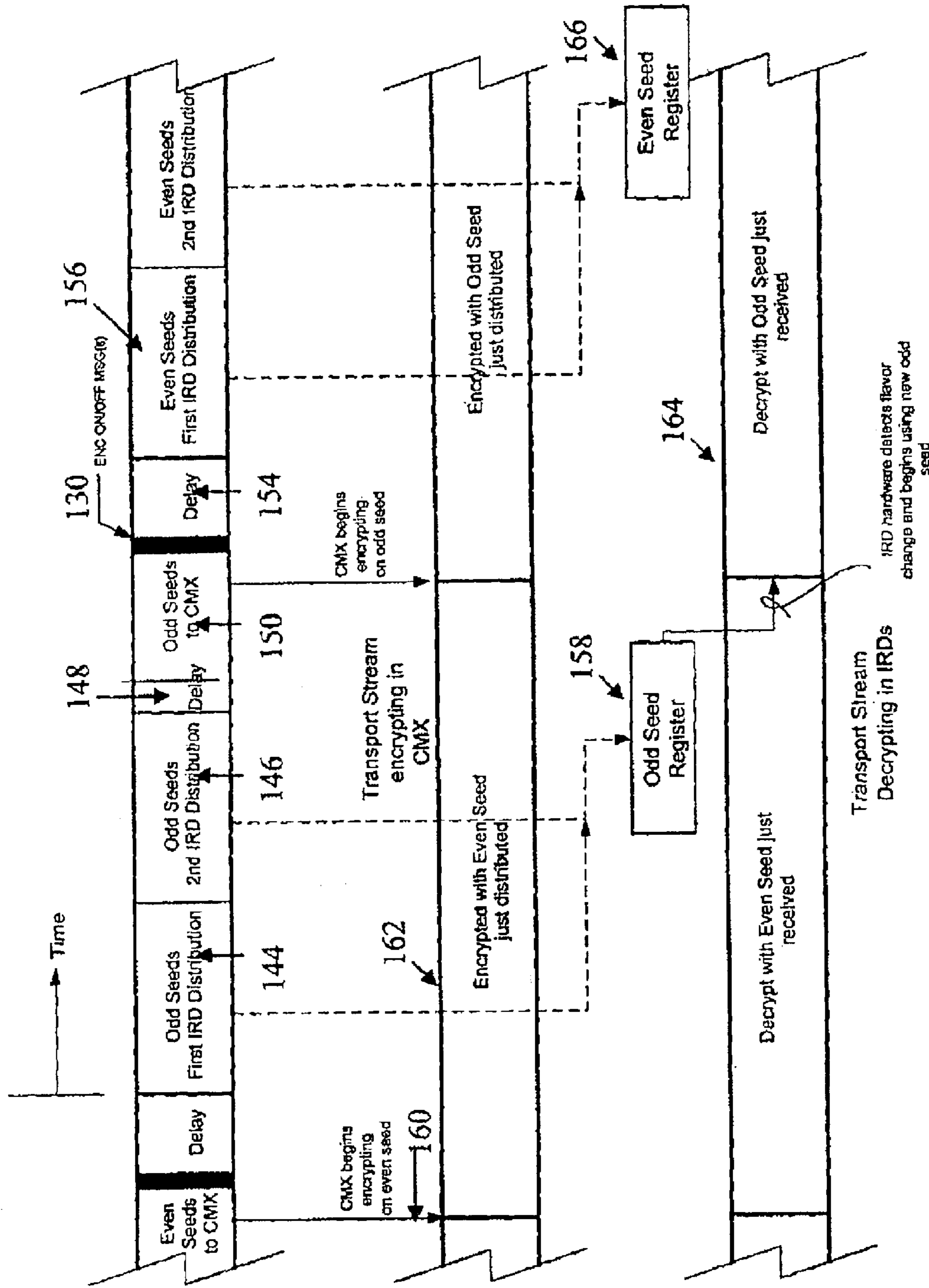


FIG. 6

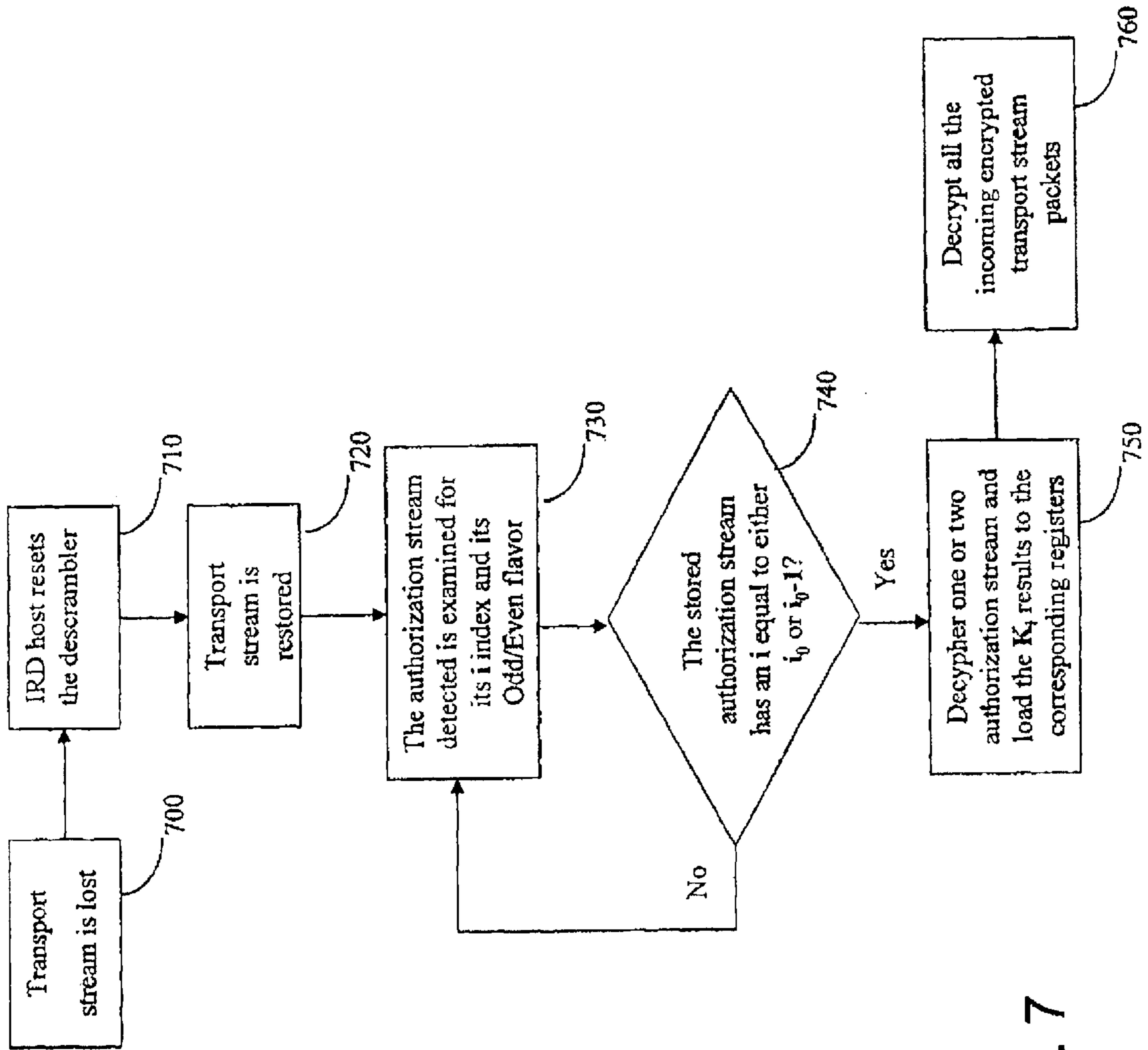


FIG. 7

**RAPID DECRYPTION OF DATA BY KEY  
SYNCHRONIZATION AND INDEXING**

**Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.**

CROSS-REFERENCE TO RELATED  
APPLICATIONS

This application claims the benefit of U.S. Provisional Application Ser. No. 60/482,235 filed Jun. 25, 2003.

STATEMENT REGARDING FEDERALLY  
SPONSORED RESEARCH OR DEVELOPMENT

Not Applicable.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to satellite broadcast systems and, more particularly, to a conditional access system for encrypting and decrypting data.

2. Related Art

A conditional access system is used to permit access to a transport stream only to subscribers who have paid for it. This is generally done by distributing the transport stream in encrypted form. Although any integrated receiver-decoder (IRD) that is connected to a satellite broadcast network can receive the encrypted transport stream, only the IRDs of those authorized subscribers are able to decrypt the encrypted transport stream. The IRD determines whether the encrypted transport stream should be decrypted and, if so, to decrypt it to produce a decrypted transport stream comprising information making up the broadcast program.

After a subscriber has purchased a service, a service provider sends messages to the subscriber's IRD with an authorization stream for the purchased services. The authorization stream may be sent with the transport stream or may be sent via a separate channel to an IRD. Various techniques have been used to encrypt the authorization stream. The authorization stream may include a seed as a key for a service of the service provider and an indication of what programs in the service the subscriber is entitled to receive. If the authorization stream indicates that the subscriber is entitled to receive the program of an encrypted transport stream, the IRD decrypts the encrypted transport stream using the received seed.

A well known problem concerning such conditional access systems is that the IRDs may suffer either carrier fades or be switched between carriers bearing the same instantiation of the service provider. It is therefore desirable for the IRDs to recover and pass a correctly decrypted transport stream to downstream processing stages as quickly as possible. However, the magnitude of time delay in the recoveries, on a typical large network (12,000 satellite IRDs) can be extremely long, such as one or two minutes in legacy systems. Other implementations of conditional access solve the problem of quick restoration of the IRD's decrypter by either risking that still-scrambled material may inadvertently be passed to the downstream processing stages, or consuming far more bandwidth in the transport stream to send cyphered seeds.

Hence, there is a need in the industry for an efficient and reliable technique for rapidly decrypting data after brief or extended loss of transport or authorization streams due to

short carrier fades or switches. For that purpose, the conditional access system should allow the IRDs to quickly determine, after restoration of the data link following a carrier fade or switch, whether their stored copies of the decryption seeds are still current and correct. Furthermore, it is needed to greatly reduce the likelihood that the carrier fade or switch could prevent the IRD from getting at least one copy of its own messages without the need for consuming large amounts of bandwidth.

SUMMARY OF THE INVENTION

It is in view of the above problems that the present invention was developed. The present invention is a satellite broadcast conditional access system with key synchronization that allows the IRDs to quickly restart the decrypting process after short carrier fades and after carrier switches when they are within the same protected network. The invention uses an indexed authorization stream allowing the IRDs to quickly decide, after restoration of the data link following a carrier fade or switch, whether their stored copies of the decrypting seeds are still current and correct. The invention also uses multiple transmissions of the cyphered seeds during each distribution period providing the IRD with multiple opportunities to receive the current seed.

For the first attribute, the index numbers on all the authorization streams are assigned in a manner such that the authorization stream may be identified and that the specific time epoch of those cyphered seeds may be determined. When a conditional access server program initializes, it randomly selects the starting index number from a domain of numbers, and applies this number to each and every authorization stream bearing a cyphered seed. Then, while in operation, it increments that index by a predefined value at each new distribution period, i.e., an odd/even flavor switch according to the preferred embodiment. The IRDs, in their turn, after reestablishing connection to the carrier-borne transport stream, may quickly retrieve the index numbers being issued in the authorization stream and compare them to the same for both flavors of the cyphered seeds it keeps in volatile storage. If those numbers match, then the IRD will then immediately decypher those seed(s) and restart decrypting on the transport stream knowing it is using the correct seed. This restart may commence very quickly after the authorization stream is detected, and that the IRD need not wait until its own messages are received and decyphered.

For the second attribute, the distribution of the cyphered seeds is repeatedly sent with considerable delay between the cyphered seed messages. This greatly reduces the likelihood that a carrier switch or a short fade could prevent the IRD from getting at least one copy of its own cyphered seed message during each distribution period.

Further features and advantages of the present invention, as well as the structure and operation of various embodiments of the present invention, are described in detail below with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and form a part of the specification, illustrate the embodiments of the present invention and together with the description, serve to explain the principles of the invention. In the drawings:

FIG. 1 illustrates a systematic diagram of a satellite broadcast conditional access system according to the present invention;

FIG. 2 illustrates a flowchart of operations that are performed at a conditional access server to generate authorization stream sent to cryptographic multiplexers;

FIG. 3 illustrates a diagram of how authorization stream is structured during a flavor distribution period;

FIG. 4 illustrates a flowchart of operations that are performed to decypher authorization stream and encrypt transport stream using an encryption seed at a cryptographic multiplexer;

FIG. 5 illustrates a flowchart of operations that are performed at an IRD to decypher authorization stream and maintain IRD synchronization to the conditional access system in steady state operation;

FIG. 6 illustrates a diagram of conditional access system timing for key synchronization when an authorization stream is distributed and a transport stream is encrypted at the cryptographic multiplexer and decrypted at the IRD; and

FIG. 7 illustrates a flowchart of operations that are performed at the IRD to rapidly decrypt data by key synchronization and indexing after brief or extended loss of transport stream.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the accompanying drawings in which like reference numbers indicate like elements, FIG. 1 illustrates a systematic diagram of a satellite broadcast conditional access system 10 according to the present invention. The conditional access system 10 provides dynamic scrambling security to an entire MPEG transport stream 12. The conditional access system 10 generally consists of a server 14 and receivers 20. In a preferred embodiment of the invention, the server 14 is comprised of a conditional access server 16 and cryptographic multiplexers 18. The receivers 20 are generally referred to as integrated receiver-decoders (IRDs) 20.

The encryption function 22 in the conditional access server 16 provides an authorization stream 24 bearing cyphered messages which can only be decyphered and read by authorized devices. These messages give the cryptographic multiplexers 18, at the satellite uplink, and the authorized IRDs 20, at the downlink sites, a sequence of cyphered encrypting seeds. The cryptographic multiplexers 18 extract their own cyphered encryption seeds using their own serial number, and their decrypter 26 decyphers the cyphered encrypting seeds to get an encryption seed. These seeds initialize scrambler 28, in the cryptographic multiplexers 18 which appears to randomly encrypt the encryptable portions of the MPEG transport stream 12. The authorization stream 24 and the encrypted transport stream 30 are transmitted through an interposed satellite broadcast network 31 by the multiplexer 32 and received by the input module 34 of the IRDs 20. Like the cryptographic multiplexers 18, the host microprocessor 36 of IRDs extract their own cyphered encryption seeds using their own serial number, and their decrypters 38 decypher the cyphered encrypting seeds to get an original encryption seed. Since the encrypting operation is symmetric, the encrypting seed sent to the IRDs 20 allows descrambler 40 to decrypt the transport stream encrypted by the cryptographic multiplexer 18.

At the uplink site, a conditional access server 16 runs the conditional access system 10. It can retrieve database information 41 from a conditional access database 42 by a network connection to the conditional access server 16 if on separate machines. This information is used to build and edit a list of authorized IRDs 20 by serial number n 102 under local operator control. FIG. 2 illustrates a flowchart of operations that are performed at a conditional access server 16 to generate authorization stream 24 sent to cryptographic multiplexers 18. At initialization, or after any change to the

authorized list, the conditional access server 16 accesses its encryption function 22 (operation 200). This function contains a secret identification number W 112 unique to the particular customer (operation 210). In the case where the conditional access system 10 is controlled by a service provider and one or more customers are using the system, the secret identification number is only known by each respective customer and is not known to or accessible by any person at the service provider. The serial numbers 102 are reported to the encryption function 22 (operation 200) and, for each one, the encryption function 22 finds the encrypted serial number  $S_n$  114 by implementing the function  $S_n = F(W || n)$ ; where "||" is the concatenation operator, and where "F( )" is a one-way hash function, i.e., a function that is computationally easy to perform in one direction, but extremely difficult to reverse (operation 210). The encryption function 22 then provides the  $S_n$ 's 114 to the conditional access server 16.

When the conditional access server's encryption engine is activated, it generates a sequence of random numbers  $K_i$  122 and associated index numbers i 124 (operation 220). While each  $K_i$  in the sequence is independently random, the i values preferably begin with a randomly selected number, i.e., the initial index number is randomly generated. In a preferred embodiment of the invention, the i index then increments by a given value, preferably one, for each new ( $K_i, i$ ) pair 122, 124 that is generated. For each pair 122, 124 in the sequence, the conditional access server 16 creates a cyphered message for every authorized IRD 20 plus all encrypting cryptographic multiplexers 18. It does this using the list of secret serial numbers  $S_n$  114. Each cyphered message (CM) contains a value  $C_{ni}$  126, the index i, 124 the destination unit serial number n 102, and an even/odd flavor indicator 128. The value  $C_{ni}$  is calculated (operation 220):  $C_{ni} = K_i \text{ xor } F(S_n || i)$  and it is called the cyphered seed 126. After the entire set of cyphered messages is distributed, the conditional access server 16 sends either an encryption ON or OFF message 130, addressed to all. The aggregate of all these messages ( $C_{ni}$  126, i 124, n 102, an even/odd flavor indicator 128, an encryption ON or OFF message 130) is generally called the authorization stream 24. This stream then feeds the cryptographic multiplexers 18 (operation 230).

The authorization stream 24 is preferably structured as shown in FIG. 3. The time interval over which cyphered messages are used to distribute a ( $K_i, i$ ) pair 122, 124 to the universe of IRDs 20 and cryptographic multiplexers 18 is the odd/even flavor distribution period 142. Within this period, all the cyphered messages 144 intended for the downlink IRDs 20 are sent first as an ordered group. The ordered group is a set of cyphered messages ( $CM_1, CM_2, \dots, CM_m$ ) corresponding with the group of IRDs ( $IRD_1, IRD_2, \dots, IRD_m$ ), respectively. For each distribution period, the cyphered messages will all contain the same index number and even/odd flavor indicator, but will vary according to the IRD<sub>n</sub> serial numbers ( $S_{n1}, S_{n2}, \dots, S_{nm}$ ). Of course, the cyphered seed 126 will also vary according to the different serial numbers based on operation 220. Then that whole set of messages 146 is repeated in the same order. Following this, there is a delay period 148 where no messages are transmitted. Then cyphered messages 150 addressed to all the cryptographic multiplexers 18 listed in the conditional access database 42 are sent, in order, just once. This is followed preferably, without delay, by some number of encryption ON or OFF commands 130. After this, there is another delay 154 before transmission of the next ( $K_i, i$ ) pair 122, 124 begins, which preferably has the opposing odd/even flavor 156.

In a preferred embodiment of the invention, the conditional access system **10** may be in one of three states. They are (1) encryption off; (2) encryption on and starting up; (3) encryption on static. In the first state, the engine continues to create the  $(K_i, i)$  pairs **122**, **124**, but only a single encryption off authorization message is sent at the end of each distribution period. In the second state, the engine begins distribution of the encrypting seeds. At the end of the first two distribution periods, the conditional access server **16** sends an encryption off message **130** to all devices. After the second state, the conditional access system **10** enters the third state. Here, after the seeds have been distributed to the IRDs **20** and cryptographic multiplexers **18**, an encryption on message **130** is sent to all devices. Note that there is no similar transition from the encryption on state to the off state. As soon as the user orders encryption to stop, distribution of new seeds ceases immediately and the very next authorization message sent is an encryption off message **130**.

In the preferred embodiment of the invention, the list of all cryptographic multiplexers **18** which may do encryption is found in the associated conditional access database **42**. The presence or absence of the cryptographic multiplexer **18** from conditional access system's authorized list does not mean the same thing as the presence or absence of an IRD **20**, as shall be seen. If a cryptographic multiplexer **18** is in the conditional access database **42**, then, when the conditional access state is encryption on, the cryptographic multiplexer **18** will always be receiving addressed authorization messages from the conditional access system **10**. However, the cryptographic multiplexer behavior is then affected by the conditional access mode in use while encryption is on. In the preferred embodiment of the invention, only the authorized cryptographic multiplexers **18** receive addressed encryption on commands, while the unauthorized cryptographic multiplexers (in the conditional access database but not authorized in conditional access) receive addressed encryption off commands. For all networks logically connected to those unauthorized cryptographic multiplexers **18**, this has the effect of leaving them completely in the clear (unencrypted).

The cryptographic multiplexer **18** has three functions within the conditional access system **10**: (1) to receive and decypher the next encrypting seed, (2) to encrypt the required program IDs (PIDs) in the MPEG transport stream **12** using that seed, and to (3) inject the authorization stream into a ghost PID of the transport stream for use by the authorized IRDs. In support of these functions, the cryptographic multiplexer **18** accepts the authorization stream **24** from the conditional access server **16**. In addition, it accepts an MPEG transport stream **12**, provides the encrypting processing, and then outputs it, preferably for ultimate distribution to a network of downlink IRDs **20**.

FIG. **4** illustrates a flowchart of operations that are performed to decypher authorization stream **24** and encrypt transport stream **12** using an encryption seed **122** at a cryptographic multiplexer **18**. Near the end of the flavor distribution period **142** of a particular odd/even flavor **128**, there is sequence of authorization streams **24** directed to cryptographic multiplexers **18**. If the host processor in a cryptographic multiplexer receiving the stream detects its own unit serial number  $n$  **102** in an authorization stream **24** (operations **400** and **410**), then that stream is passed to a decrypter **26**. This decrypter, when it was programmed at the factory, had been given the unit's pre-calculated, encrypted serial number  $S_n$  **114**. This is the same  $S_n$  also calculated by the encryption function **22** in the conditional access server **16**. So the decrypter **26** then takes the incoming  $(C_{ni}, i)$  pair

and computes the corresponding  $K_i$  **122** from the equation (operation **420**):  $K_i = C_{ni} \text{ xor } F(S_n, i)$ . This is the same  $K_i$  value which originated in the conditional access server **16**. It is an encryption seed value **122**, which is then loaded into the encrypting hardware, scrambler **28**.

In a preferred embodiment of the invention, once the new encryption seed value is available, the host processor immediately sets the scrambler **28** to begin encrypting using that value if (1) the conditional access server **16** has previously sent an encryption ON command **130** more recently than an encryption OFF command, and (2) the cryptographic multiplexer **18** has been set to accept those commands. The encryption seed value used for encrypting is the starting state of a linear feedback shift register (LFSR) generator of the scrambler **28** (operation **430**), a device which creates a pseudo-random bit sequence. This sequence of bits is XOR'd with several of the low-order bits in nearly every byte of the payload of the eligible MPEG packets **12**, not including the authorization stream-carrying packets. The encryption bit on those packets is then set to indicate to IRD descrambler **40** that those packets are encrypted. In addition, the even-odd bit is set to show which flavor of seed was used to do that encrypting. When the next encryption seed is received by the cryptographic multiplexer **18**, it will have the opposing flavor, and when transport streams are encrypted using that new encryption seed, the odd-even bit in the transport streams is toggled to that new opposing state.

While the cryptographic multiplexer **18** is decyphering new encryption seeds and using them to encrypt the transport stream **12**, it is also injecting the authorization stream **24** into the transport (operation **440**). This operates as a simple logical pipe from the cryptographic multiplexer host processor to all the IRD host processors **36**. The authorization stream **24** is inserted as the payload into MPEG packets. As these packets are built, they are queued within the cryptographic multiplexer **18**. Each authorized IRD **20** in the receiving network has three tasks to perform within this conditional access system **10**: (1) extract and decypher its own authorization streams to get new encryption seeds, (2) decrypt the encrypted transport stream packets **30** and pass the new clear packets to the payload processing portion of the IRD **20**, and (3) achieve and maintain synchronization to the timing of the cryptographic multiplexer scrambler **28**, to ensure that decrypting is done with the correct seed.

FIG. **5** illustrates a flowchart of operations that are performed at an IRD **20** to decypher authorization stream **24** and maintain IRD synchronization to the conditional access system **10** in steady state operation. In each IRD **20** receiving the encrypted transport stream **30**, the authorization stream **24** is demultiplexed out by the transport demux chip **44** (operation **500**). This stream **24** is passed to the local host microprocessor **36** and it extracts the secret  $(C_{ni}, i)$  **126**, **124** message addressed to that particular unit by serial number **102** (operation **510**). In a preferred embodiment of the invention, every IRD's  $(C_{ni}, i)$  message is sent twice (refer to FIG. **3**), which greatly reduces the likelihood that a carrier switch or a short fade could prevent the IRD **20** from getting at least one copy of its own cyphered seed message during each flavor distribution period. As received, cyphered messages are passed to the decrypter **38**. This decrypter **38** is preferably identical to the decrypter **26** installed in cryptographic multiplexers **18**. It proceeds to decypher the new  $K_i$  seed values **122** in the same manner as the decrypter **26** within the cryptographic multiplexer **18** (operation **520**). Those new seeds are then loaded to the odd/even flavor register in the descrambler **40** corresponding to that seed's flavor (operation **530**). When this is done, a flag is set in the

descrambler **40** to signal that a new valid seed of a particular odd/even flavor is available.

As described above, the IRD **20** detects authorization streams **24** addressed to itself and routes the enclosed ( $C_{mi,i}$ ) pair **126, 124** to the decrypter **38**. In addition, it maintains a circular buffer in volatile memory where the last messages received of each odd/even flavor are stored. When new messages are received, they overwrite the previous message of the same flavor. The purpose of this, which shall be discussed in more detail below, is to provide a way for IRDs **20** to recover from brief losses of transport stream input and, of course, loss of the authorization stream as well.

The IRD **20** accepts an incoming MPEG transport stream **12**, either from a satellite carrier or from a terrestrial interface. It applies a process of decrypting the transport stream which is essentially identical to the encrypting operation. The payload of the transport stream packets are XOR'd by the same pseudo-random bit sequence which encrypted them in the cryptographic multiplexer **18**. This process restores the payloads of those transport stream packets back to the clear or normal state. Those packets are then routed to the downstream processing circuitry **46** within the IRD **20**.

IRD synchronization to the conditional access system **10** differs depending on the state of the system. Steady state operation of an authorized IRD **20** and the several transient states are discussed in detail below: (1) authorization by conditional access system, (2) de-authorization by conditional access system, (3) brief transport stream loss, and (4) extended transport stream loss.

In steady state operation of the system, authorization streams bearing the cyphered seeds of a particular flavor are distributed to the cryptographic multiplexers **18** and IRDs **20** while those same units are encrypting and decrypting with the previously distributed seed of the opposing odd/even flavor. Within the IRDs themselves, the synchronization is maintained as follows. When a seed of a particular flavor is received, decyphered, and loaded to the IRD **20**, an X\_SEED\_WRITTEN flag is SET within the IRD **20** (where X designates the seed's odd/even flavor). When the IRD detects that the odd/even flavor bit in the incoming encrypted transport streams changes (operation **540**, referring to FIG. **5**), it looks to see if the X\_SEED\_WRITTEN flag corresponding to the new flavor is set (test **550**). If so, it knows it has a valid seed for that new flavor, and it begins decrypting immediately (operation **560**). If not, it blocks all incoming encrypted transport streams **30** from entering the IRD demux chip **44** and clears the X\_SEED\_WRITTEN flag (operation **570**). When the very next flavor change occurs in the incoming encrypted transport packet stream **30**, that same flag clears in anticipation of the distribution of the next seed of that flavor.

FIG. **6** illustrates a diagram of conditional access system timing for key synchronization when an authorization stream is distributed and a transport stream is encrypted at the cryptographic multiplexer **18** and decrypted at the IRD **20**. The new odd seed is written to odd seed register **158**, setting the ODD\_SEED\_WRITTEN flag. At that moment, the incoming transport stream is still being encrypted with the previous even seed **160** at the cryptographic multiplexer **18** during an even flavor period **162**. Later, the transport stream flavor **128** switches from even to odd. The odd seed then begins being used to decrypt at the IRD **20** during an odd flavor period **164**. At the next flavor switch within the transport stream, from odd back to even, the ODD\_SEED\_WRITTEN flag will be cleared. But the authorization stream distribution period **164** for odd seeds is just beginning, and

soon a new odd seed will be received, setting the flag once again. At that time, new even seed is written to even seed register **166**, setting the EVEN\_SEED\_WRITTEN flag.

When an IRD **20** is unauthorized in the conditional access system **10**, it does not receive the cyphered authorization streams, addressed to itself, bearing its own ( $C_{mi,i}$ ) value pair. Without the ( $C_{mi,i}$ ) pair **126, 124**, seeds cannot be decyphered, so the X\_SEED\_WRITTEN flags remain continuously clear, and the IRD removes all incoming encrypted transport streams and substitutes null streams. When the IRD **20** is first authorized in the conditional access system **10**, authorization streams addressed to it begin to be received. In the flavor distribution period corresponding to the first addressed stream received by the IRD **20**, the IRD basically performs the following steps: (1) a seed of a particular flavor is later received, decyphered, and loaded to the descrambler **40**, setting that respective X\_SEED\_WRITTEN flag; (2) the odd/even flavor bit in the incoming encrypted transport stream packets later changes over to that flavor; and (3) the seed is used to decrypt the encrypted transport streams. Starting with the steady state described earlier, when an IRD **20** is de-authorized by conditional access system **10**, it stops receiving authorization streams.

Since the IRDs **20** may suffer either short carrier fades or deliberate carrier switches between carriers bearing the same instantiation of a conditional access system **10**, transport streams could be briefly lost. FIG. **7** illustrates a flowchart of operations that are performed at the IRD **20** to rapidly decrypt data by key synchronization and indexing after brief or extended loss of transport stream. When the transport stream is first lost (operation **700**), the IRD host **36** resets the descrambler **40** (operation **710**). This clears the X\_SEED\_WRITTEN flags and will block encrypted transport packets from entering the IRD demux chip **44**. But, authorization stream will not be blocked. Later, when the host **36** detects the restored transport stream (operation **720**), it will begin monitoring the authorization stream channel (if available). The first authorization stream **24** detected, even if not addressed to itself, will be examined for its  $i$  index **124** and its odd/even flavor **128** (operation **730**). The IRD host **36** will then exploit the simple knowledge that if the currently distributed encryption seed has an index of  $i_0$ , then the current encrypting is being done using the seed associated with index  $i_0-1$ . If either of the stored authorization streams has an  $i$  index value equal to either  $i_0$  or  $i_0-1$  (test **740**), then the assumption is made that (1) the new transport stream bears the same authorization stream as before and (2) the IRD **20** already has the stored authorization streams corresponding at least to the current seed being used to encrypt. In this case, the IRD **20** then progresses through the following sequence: (1) the stored authorization streams whose  $i$  index values equal  $i_0$  or  $i_0-1$  are sent by the IRD host **36**, in order of increasing magnitude, to the decrypter **38**; (2) the decrypter **38** decyphers one or two authorization streams and the  $K_i$  **122** results are loaded to the respective odd/even flavor encrypting register(s) (operation **750**); (3) the X\_SEED\_WRITTEN flags corresponding to whichever flavor seed(s) was/were loaded are set; (4) the next arriving encrypted transport stream is treated as if it was logically an odd/even flavor change and, if the X\_SEED\_WRITTEN flag for the new incoming encrypting flavor is set; (5) the IRD descrambler **40** commences to decrypt all the incoming encrypted transport streams (operation **760**). The IRD then functions as described in the steady state operation.

For all losses of transport streams, the X\_SEED\_WRITTEN flags are cleared, the IRD host **36** resets the descrambler **40**. As just described, when the transport stream

is restored, the IRD host **36** examines the first authorization streams received. In the case where the first incoming authorization stream's *i* index value is not exactly equal to, or is not equal to one more than either of the *i* index values in the stored authorization streams, then the IRD host **36** assumes that the stored cyphered seeds are unusable. From then on, it behaves as if it had just boot up. The IRD **20** remains unauthorized until the IRD first gets an addressed cyphered seed through authorization stream and, thence until the succeeding transport encrypting flavor switch. Note that this holds true if the IRD **20** switched to an encrypted transport stream with a different authorization stream, or if the IRD **20** has been disconnected from the original authorization stream for an extended period. In a preferred embodiment of the invention, an extended period would be any outage exceeding half of the difference between flavor distribution period **142** and the total delays **148**, **154** where double-sending of the cyphered seeds is employed (referring to FIG. **3**). Failing to use double-sending of the seeds could cause an IRD **20** to miss its current seed distribution on even the shortest outages. In this case, the IRD **20** will appear to initially recover after an outage, but revert to unauthorized at the next flavor switch and remain that way through that next flavor distribution period.

In view of the foregoing, it will be seen that the several advantages of the invention are achieved and attained. The embodiments were chosen and described in order to best explain the principles of the invention and its practical application to thereby enable others skilled in the art to best utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated.

As various modifications could be made in the constructions and methods herein described and illustrated without departing from the scope of the invention, it is intended that all matter contained in the foregoing description or shown in the accompanying drawings shall be interpreted as illustrative rather than limiting. Thus, the breadth and scope of the present invention should not be limited by any of the above-described exemplary embodiments, but should be defined only in accordance with the following claims appended hereto and their equivalents.

What is claimed is:

**1.** A method of encrypting data for rapid decryption, the method comprising the steps of:

- sequentially generating a plurality of random numbers;
- sequentially generating a plurality of index numbers respectively associated with said random numbers, wherein a first index number is initially generated and said index numbers increment by a predefined value;
- calculating a plurality of cyphered seeds according to a combination of each one of said random numbers and each one of said respectively associated index numbers;
- sending said plurality of cyphered seeds and said corresponding index numbers from a server to at least one receiver; and
- resending each one of said plurality of cyphered seeds and said corresponding index numbers from said server to said receiver, wherein a cyphered seed and index number pair is resent before sending a subsequent cyphered seed and index number pair.

**2.** The method according to claim **1**, wherein said generating of said index numbers is further comprised of the step of randomly generating said first index number.

**3.** The method according to claim **1**, wherein said sending and resending steps further comprise the steps of sending a

first flavored cyphered seed and index number pair and resending said first flavored cyphered seed and index number pair.

**4.** The method according to claim **3**, wherein said sending and resending steps further comprise the steps of: sending a second flavored cyphered seed and index number pair; resending said second flavored cyphered seed and index number pair; and repeating said sending and resending steps for a plurality of first flavored cyphered seed and index number pairs and for a plurality of second flavored cyphered seed and index number pairs.

**5.** The method according to claim **1**, further comprising the steps of: decyphering said cyphered seed and index number pair; storing said decyphered seed and index number pair in a memory; repeating said decyphering and storing steps for a plurality of subsequent cyphered seed and index number pairs until an occurrence of a reset; after said reset, decyphering a most recently received index number and comparing said most recently received index number with said stored index number; and continuing with said decyphering and storing steps if said most recently received index number is within a defined tolerance of said stored index number.

**6.** The method according to claim **5**, further comprising the steps of: when a cyphered seed of a particular flavor is received, decyphered, and loaded to said receiver, setting a flavor seed flag to designate said flavor; and when said receiver detects that a flavor in incoming encrypted transport streams changes to a new flavor, examining whether said flavor seed flag is set to correspond said new flavor for checking if said decyphered seed is valid to decrypt said incoming encrypted transport streams.

**7.** The method according to claim **5**, further comprising the step of defining said tolerance of said stored index number to one.

**8.** The method according to claim **5**, further comprising the steps of: sending a group of cyphered seed and corresponding index number pairs from said server to a respective group of receivers during a flavor distribution period; resending said group of cyphered seed and corresponding index number pairs to said respective group of receivers during said flavor distribution period; and repeating said sending and resending steps for a plurality of subsequent groups of cyphered seed and corresponding index number pairs to said respective group of receivers.

**9.** The method according to claim **8**, wherein said repeating step further comprises the step of switching between a first flavor and a second flavor.

**10.** The method according to claim **8**, further comprising the step of sending an authorization stream from said server to said group of receivers during said flavor distribution period, said authorization stream comprising said group of cyphered seed and corresponding index number pairs, a plurality of serial numbers corresponding to said respective group of receivers, a flavor indicator, and an encryption on/off message.

**11.** The method according to claim **10**, further comprising the step of indicating to said group of receivers whether corresponding transport streams are encrypted according to said encryption on/off message.

**12.** The method according to claim **10**, further comprising the step of generating a plurality of secret serial numbers according to a combination of a secret identification number and a serial number associated with each of said receivers.

**13.** The method according to claim **12**, further comprising the step of allowing a customer controlling said group of receivers to generate said secret identification number unique to said customer.

14. The method according to claim 12 wherein said step for calculating a plurality of cyphered seeds is further comprised of the step of combining each one of said random numbers and said respectively associated index numbers with each one of said secret serial numbers.

15. A method of encrypting data for rapid decryption, the method comprising the steps of: sequentially generating a plurality of random numbers; sequentially generating a plurality of index numbers respectively associated with said random numbers, wherein a first index number is initially generated and said index numbers increment by a predefined value; calculating a plurality of cyphered seeds according to a combination of each one of said random numbers, each one of said respectively associated index numbers, and a plurality of serial numbers respectively associated with a group of receivers; sending a group of cyphered seed and corresponding index number pairs from a server to said group of receivers during a flavor distribution period; resending said group of cyphered seed and corresponding index number pairs to said group of receivers during said flavor distribution period; repeating said sending and resending steps for a plurality of subsequent groups of cyphered seed and corresponding index number pairs to said group of receivers, extracting a cyphered seed using its serial number from said cyphered seed and index number pairs in each one of said receivers; decyphering said cyphered seed and index number pairs in each one of said receivers; storing said decyphered seed and index number pair in a memory of each one of said receivers; repeating said decyphering and storing steps for a plurality of subsequent cyphered seed and index number pairs until an occurrence of a reset; after said reset, decyphering a most recently received index number and comparing said most recently received index number with said stored index number; and continuing with said decyphering and storing steps if said most recently received index number is within a defined tolerance of said stored index number.

16. The method according to claim 15, wherein said generating of said index numbers is further comprised of the step of randomly generating said first index number.

17. The method according to claim 15, further comprising the step of sending an authorization stream from said server to said group of receivers during said flavor distribution period, said authorization stream comprising said group of cyphered seed and corresponding index number pairs, said plurality of serial numbers corresponding to said respective group of receivers, a flavor indicator, and an encryption on/off message.

18. The method according to claim 15, further comprising the step of generating a plurality of secret serial numbers according to a combination of a secret identification number and a serial number associated with each of said receivers.

19. The method according to claim 18, further comprising the step of allowing a customer controlling said group of receivers to generate said secret identification number unique to said customer.

20. The method according to claim 18, wherein said secret serial numbers are used as said serial numbers in calculating said cyphered seeds.

21. The method according to claim 15, further comprising the steps of: receiving, decyphering, and loading at least one of said cyphered seeds of an indicated flavor in each one of said receivers; respectively setting a flavor seed flag in each one of said receivers to designate said indicated flavor; detecting a flavor change associated with a new flavor in incoming encrypted transport streams in each one of said receivers; determining whether said flavor seed flag is set to

correspond with said new flavor and whether said decyphered seed is valid in each one of said receivers; and decrypting said incoming encrypted transport streams in each one of said receivers when said decyphered seed is valid.

22. The method according to claim 15, further comprising the step of defining said tolerance of said stored index number to one.

23. A system for encrypting and decrypting data, comprising: means for sequentially generating a plurality of random numbers and a plurality of index numbers respectively associated with said random numbers, wherein a first index number is initially generated and said index numbers increment by a predefined value; means for calculating a plurality of cyphered seeds according to a combination of each one of said random numbers, each one of said respectively associated index numbers, and a plurality of serial numbers respectively associated with a group of receivers; means for sending a group of cyphered seed and corresponding index number pairs from a server to said group of receivers during a flavor distribution period, and resending said group of cyphered seed and corresponding index number pairs to said group of receivers during said flavor distribution period; means for extracting a cyphered seed and corresponding index number from said cyphered seed and index number pairs, wherein at least one of said serial numbers is used to extract said cyphered seed; a decrypter in operative communication with said extracting means receives said extracted cyphered seed and said index number and decyphers said cyphered seed into a decyphered seed; a memory device in operative communication with said decrypter receives and stores said decyphered seed and index number; means for setting a reset command and thereafter comparing a new index number with said stored index number according to a defined tolerance.

24. The system according to claim 23, wherein said first index number is further comprised of a randomly generated number.

25. The system according to claim 23, wherein said means for generating said random numbers and said index numbers is comprised of a server with a computer processor.

26. The system according to claim 23, wherein said means for calculating said cyphered seeds is comprised of an encryption function in said server.

27. The system according to claim 23, wherein said means for sending and resending said cyphered seed and index number pairs from said server to said receivers is comprised of a multiplexer controlled by said server.

28. The system according to claim 23, wherein said means for extracting said cyphered seed, setting said reset command, and returning to said steady state operation is comprised of a host microprocessor in at least one of said receivers.

29. The system according to claim 23, wherein said defined tolerance of said stored index number is one.

30. The system according to claim 23, wherein said plurality of serial numbers are further comprised of a combination of a secret identification number, and wherein said secret identification number is unique to a customer controlling said group of receivers.

31. A server for encrypting data, comprising: means for sequentially generating a plurality of random numbers and a plurality of index numbers respectively associated with said random numbers, wherein a first index number is initially generated and said index numbers increment by a predefined value; means for calculating a plurality of cyphered seeds according to a combination of each one of said random num-



bers and each one of said respectively associated index numbers; and means for sending a group of cyphered seed and corresponding index number pairs from a server to a respective group of receivers during a flavor distribution period, and resending said group of cyphered seed and corresponding index number pairs to said respective group of receivers during said flavor distribution period.

32. The system according to claim 31, wherein said first index number is further comprised of a randomly generated number.

33. The system according to claim 31, wherein said cyphered seeds are further comprised according to a combination of said random numbers and said index numbers with a plurality of serial numbers respectively associated with said group of receivers.

34. The system according to claim 33, wherein said plurality of serial numbers are further comprised of a combination of a secret identification number, and wherein said secret identification number is unique to a customer controlling said group of receivers.

35. An integrated receiver decoder for decrypting data, comprising: means for extracting a cyphered seed and a corresponding index number from a group of cyphered seed and index number pairs; wherein a plurality of serial numbers are used to generate a plurality of cyphered seeds and wherein at least one of said serial numbers is used to extract said cyphered seed; a decrypter in operative communication with said extracting means receives said extracted cyphered seed and said corresponding index number and decyphers said cyphered seed into a decyphered seed; a memory device in operative communication with said decrypter receives and stores said decyphered seed and index number; and means for setting a reset command and thereafter comparing a new index number with said stored index number according to a defined tolerance.

36. The system according to claim 35, wherein said defined tolerance of said stored index number is one.

37. A computer-implemented method, comprising:

*sending, by an access server, one or more ciphersed seeds and one or more index numbers associated with the one or more ciphersed seeds to at least one content receiver; and*

*resending, by the access server, the one or more ciphersed seeds and the one or more index numbers, wherein a ciphersed seed and index number pair are sent before sending subsequent ciphersed seed and index number pairs.*

38. The computer-implemented method as recited in claim 37, further comprising determining one or more ciphersed seeds by:

*sequentially generating a plurality of random numbers; sequentially generating a plurality of index numbers associated with the random numbers; and*

*combining each random number with each index number associated with the random number.*

39. The computer-implemented method as recited in claim 38, wherein a first index number is generated randomly and subsequent index numbers are generated by incrementing the first index number by a value.

40. The computer-implemented method as recited in claim 37, wherein the one or more ciphersed seeds and the one or more index numbers are sent and resent during a first flavor distribution period.

41. The computer-implemented method as recited in claim 40, further comprising:

*sending, by the access server, a ciphersed seed and an index number pair during a second flavor distribution period; and*

*resending, by the access server, the ciphersed seed and the index number pair during the second flavor distribution period.*

42. The computer-implemented method as recited in claim 37, further comprising sending, by the access server, an authorization stream, the authorization stream comprising the one or more ciphersed seeds, the one or more index numbers, one or more numbers associated with one or more content receivers, a flavor indicator, and an encryption message.

43. The computer-implemented method as recited in claim 42, wherein the one or more numbers associated with one or more content receivers are configured to enable decryption of the one or more ciphersed seeds.

44. The computer-implemented method as recited in claim 42, wherein the flavor indicator is configured to indicate an odd/even flavor of the one or more ciphersed seeds.

45. The computer-implemented method as recited in claim 42, wherein the encryption message is configured to indicate whether a transport stream is encrypted.

46. A system for encrypting data, comprising:

*an access server configured to generate one or more ciphersed seeds; and*

*a cryptographic multiplexer configured to:*

*send the one or more ciphersed seeds and one or more index numbers to one or more content receivers during a flavor distribution period; and*

*resend the one or more ciphersed seeds and the one or more index numbers to the one or more content receivers during the flavor distribution period.*

47. The system as recited in claim 46, wherein the cryptographic multiplexer is further configured to:

*send a ciphersed seed and an index number pair during a second flavor distribution period; and*

*resend the ciphersed seed and the index number pair during the second flavor distribution period.*

48. A computer-implemented method, comprising:

*receiving, by a content receiver, an encrypted data stream;*

*extracting, by the content receiver, a ciphersed seed and index number pair from the encrypted data stream using a number associated with the content receiver;*

*deciphering, by the content receiver, the ciphersed seed to create a decyphered seed;*

*storing, by the content receiver, the decyphered seed and index number in memory;*

*detecting, by the content receiver, a reset, and responsive to the reset:*

*comparing a received index number with the stored index number; and*

*deciphering and storing additional ciphersed seeds responsive to the received index number corresponding to the stored index number.*

49. The computer-implemented method, as recited in claim 48, wherein the received index number corresponds to the stored index number when the received index number is within a defined tolerance of the stored index number.

50. The computer-implemented method, as recited in claim 49, wherein the defined tolerance is one.

51. The computer-implemented method, as recited in claim 48, further comprising deciphering and storing, by the content receiver, additional ciphersed seed and index number pairs until a reset is detected.

52. The computer-implemented method, as recited in claim 48, further comprising:

*deciphering, by the content receiver, a ciphersed seed corresponding to a first flavor;*

## 15

detecting, by the content receiver, a second flavor;  
 determining, by the content receiver, whether the deciphered seed is valid by comparing the second flavor with the first flavor; and

decrypting, by the content receiver, the encrypted data stream responsive to the deciphered seed being valid.

53. The computer-implemented method, as recited in claim 52, further comprising blocking, by the content receiver, the encrypted data stream responsive to the deciphered seed being invalid.

54. A system for decrypting data, comprising:

a demultiplexer configured to extract a ciphered seed from an encrypted data stream using a number associated with a content receiver;

a decrypter configured to decipher the extracted ciphered seed;

a processor configured to:

detect a reset; and

validate the deciphered seed responsive to the reset; and

a descrambler configured to decrypt the encrypted data stream using the deciphered seed responsive to the deciphered seed being valid.

55. The system, as recited in claim 54, wherein the processor is configured to validate the deciphered seed by comparing an index number associated with the deciphered seed with a stored index number.

56. The system, as recited in claim 55, wherein the processor is configured to validate the deciphered seed by comparing the index number associated with the deciphered seed with the stored index number according to a defined tolerance.

57. The system, as recited in claim 54, wherein the processor detects a reset responsive to not receiving an encrypted data stream.

58. The system, as recited in claim 54, wherein the processor detects a reset responsive to a change in an odd/even flavor associated with the encrypted data stream.

## 16

59. The system, as recited in claim 54, wherein the descrambler is further configured to block an encrypted data stream responsive to the deciphered seed being invalid.

60. A computer-implemented method, comprising:

detecting, by a content receiver, a loss of an encrypted data stream;

determining, by the content receiver, an index number and odd/even flavor associated with a restored encrypted data stream;

determining, by the content receiver, whether the index number corresponds to a stored index number; and

decrypting, by the content receiver, the restored encrypted data stream using an encryption seed corresponding to the stored index number if the index number corresponds to the stored index number.

61. The computer-implemented method as recited in claim 60, wherein an index number (i) corresponds to a stored index number ( $i_0$ ) when the index number (i) is equal to  $i_0$  or  $i_0-1$ .

62. The computer-implemented method as recited in claim 60, further comprising resetting, by the content receiver, a descrambler configured to descramble the encrypted data stream.

63. The computer-implemented method as recited in claim 60, further comprising blocking, by the content receiver, one or more encrypted data packets associated with the restored encrypted data stream.

64. The computer-implemented method as recited in claim 60, further comprising deciphering, by the content receiver, at least one authorization stream to acquire an encryption seed.

65. The computer-implemented method as recited in claim 60, further comprising waiting, by the content receiver, to receive an addressed ciphered seed responsive to the index number not corresponding to the stored index number.

\* \* \* \* \*