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Davis

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[54] **METHOD FOR PROVIDING A ROVING SOFTWARE LICENSE FROM ONE NODE TO ANOTHER NODE**

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[73] Assignee: **Intel Corporation**, Santa Clara, Calif.

[21] Appl. No.: **472,951**

[22] Filed: **Jun. 7, 1995**

Related U.S. Application Data

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[51] **Int. Cl.**[6] **H04K 1/00**

[52] **U.S. Cl.** **380/4**; 380/23; 380/30

[58] **Field of Search** 380/3, 4, 23, 25, 380/30

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,658,093 4/1987 Hellman 380/3
4,807,288 2/1989 Ugon, et al. 380/30

OTHER PUBLICATIONS

Struif, Bruno "The Use of Chipcards for Electronic Signatures and Encryption" in: Proceedings for the 1989 Conference on VLSI and Computer Peripherals, IEEE Computer Society Press, 1989, pp. 4/155–4/158.

Dussé, Stephen R. and Burton S. Kaliski "A Cryptographic Library for the Motorola 56000" in: Damgard, I. M., Advances in Cryptology–Proceedings EUROCRYPT 90, Springer–Verlag, 1991, pp. 230–244.

DSP56000/DSP56001 Digital Signal Processor User–s Manual, Motorola, 1990, p. 2–2.

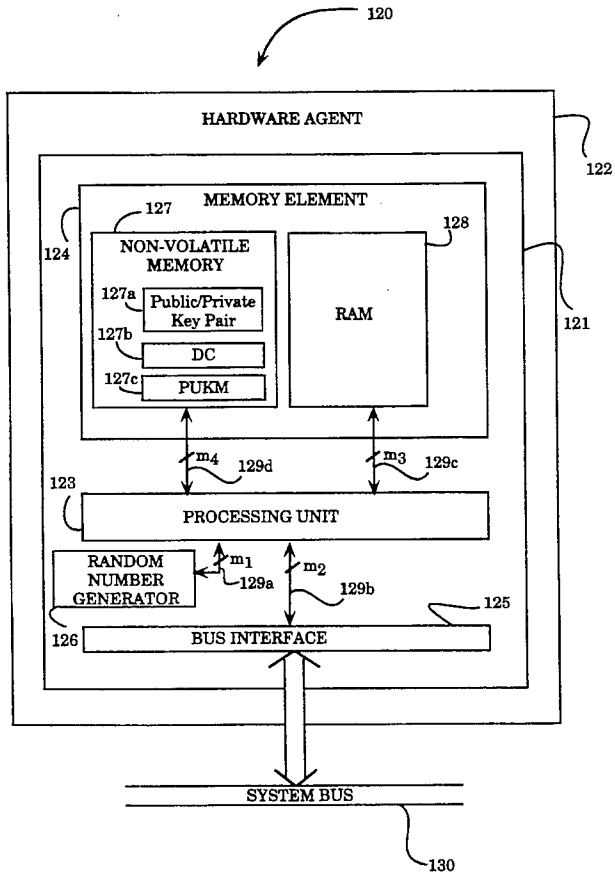
Primary Examiner—David C. Cain

Attorney, Agent, or Firm—Blakely, Sokoloff, Taylor & Zafman

[57] **ABSTRACT**

An integrated circuit component for enforcing licensing restrictions. Such enforcement is performed through remote transmission of access privileges for executing a licensed program from the integrated circuit component to another similar component. The integrated circuit component comprising a non-volatile memory for storing a uniquely designated key pair, an authentication device certificate and a manufacturer public key along with cryptographic algorithms, a processor for executing the cryptographic algorithms in order to process information inputted into the integrated circuit component and for transmitting the processed information into volatile memory and a random number generator for generating the uniquely designated key pair internally within the integrated circuit component.

16 Claims, 9 Drawing Sheets



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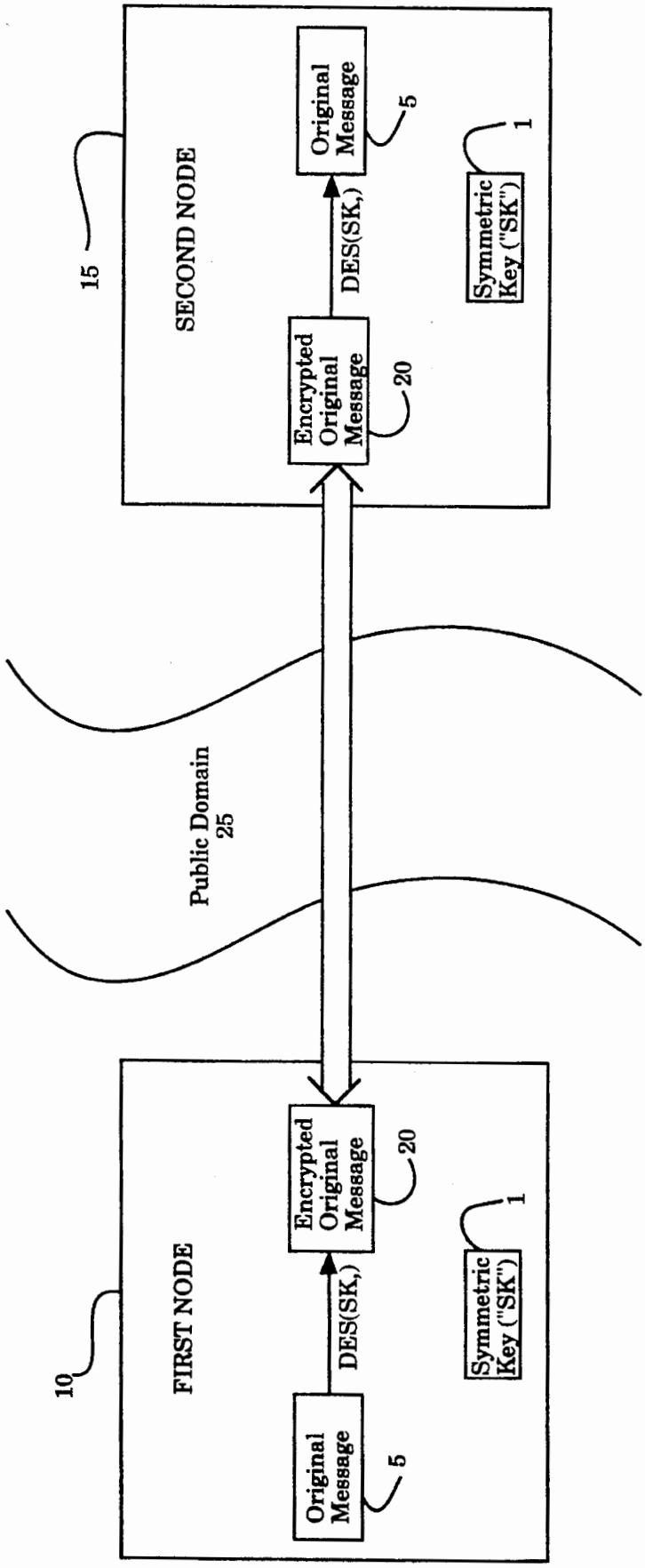
FIRST NODE
10
Original Message
5
DES(SK,)
Encrypted Original Message
20
Symmetric Key ("SK")
1
Public Domain
25
SECOND NODE
15
Encrypted Original Message
20
DES(SK,)
Original Message
5
Symmetric Key ("SK")
1

Figure 1

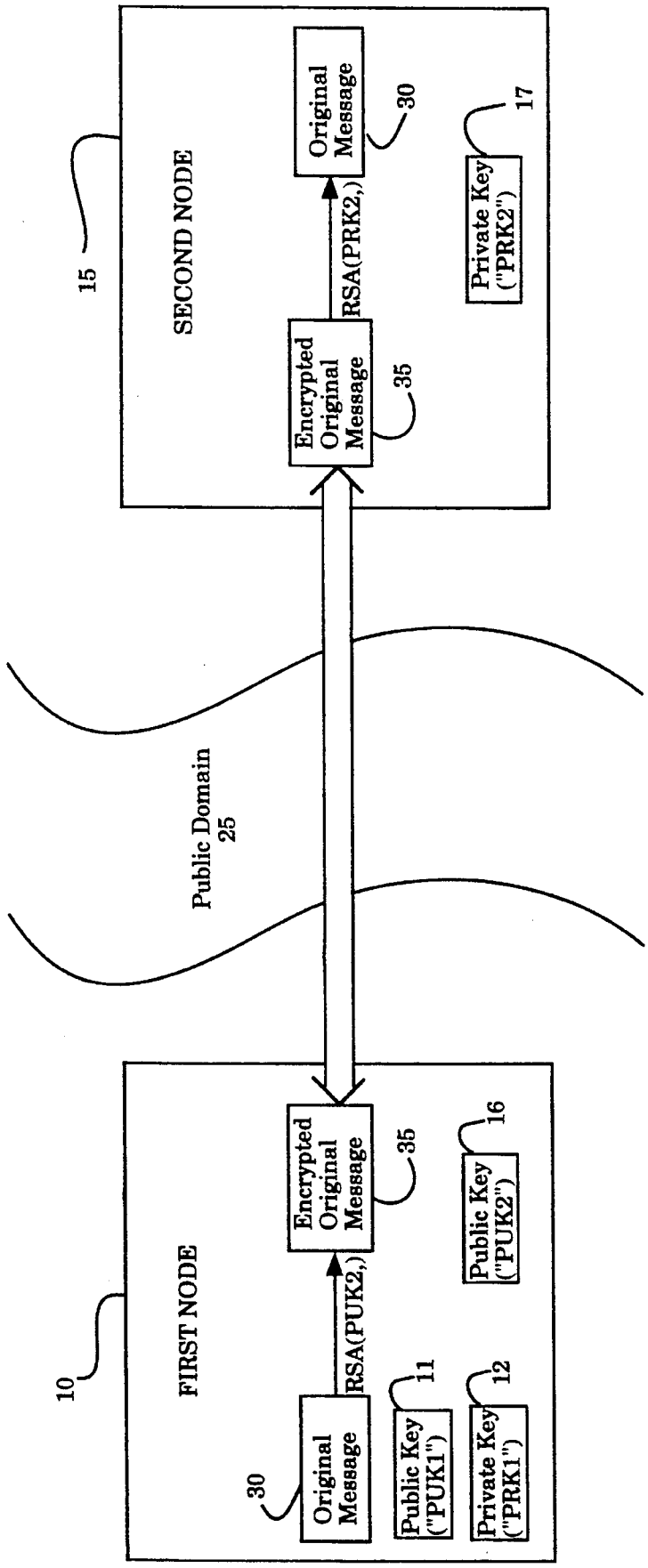
SECOND NODE
15
Original Message
30
Private Key ("PRK2")
17
RSA(PRK2,)
Encrypted Original Message
35
Public Domain
25
FIRST NODE
10
Original Message
30
RSA(PUK2,)
Encrypted Original Message
35
Public Key ("PUK1")
11
Private Key ("PRK1")
12
Public Key ("PUK2")
16

Figure 2

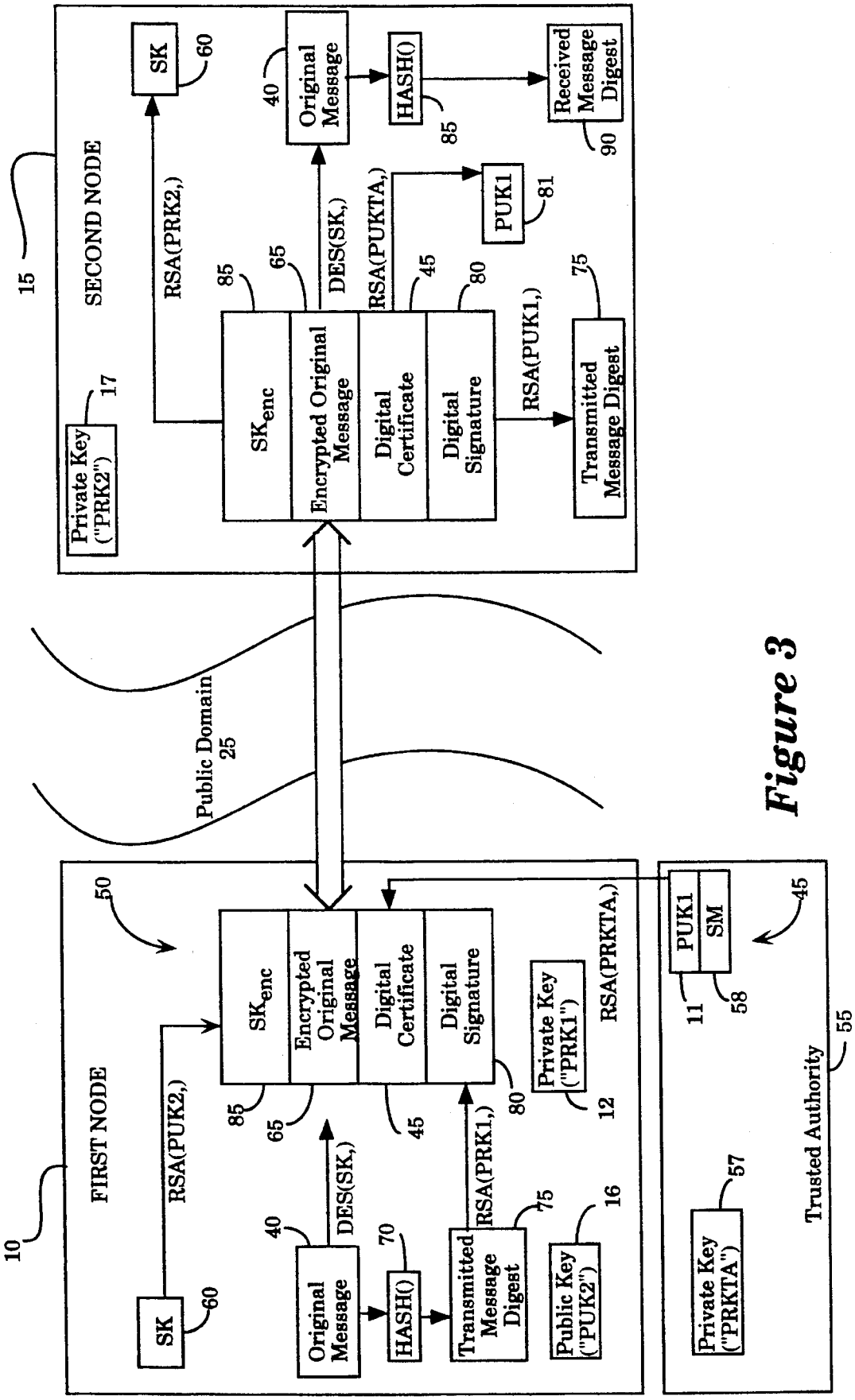
SECOND NODE
15
Private Key ("PRK2")
17
SK
60
RSA(PRK2,)
SK enc
85
Encrypted Original Message
65
Digital Certificate
45
Digital Signature
80
DES(SK,)
Original Message
40
RSA(PUKTA,)
PUK1
81
HASH()
85
Received Message Digest
90
RSA(PUK1,)
Transmitted Message Digest
75
Public Domain
25
FIRST NODE
10
50
SK
60
RSA(PUK2,)
SK enc
85
Encrypted Original Message
65
Digital Certificate
45
Digital Signature
80
Private Key ("PRK1")
12
RSA(PRKTA,)
DES(SK,)
Original Message
40
HASH()
70
RSA(PRK1,)
Transmitted Message Digest
75
Public Key ("PUK2")
16
PUK1
11
SM
58
45
Trusted Authority
55
Private Key ("PRKTA")
57

Figure 3

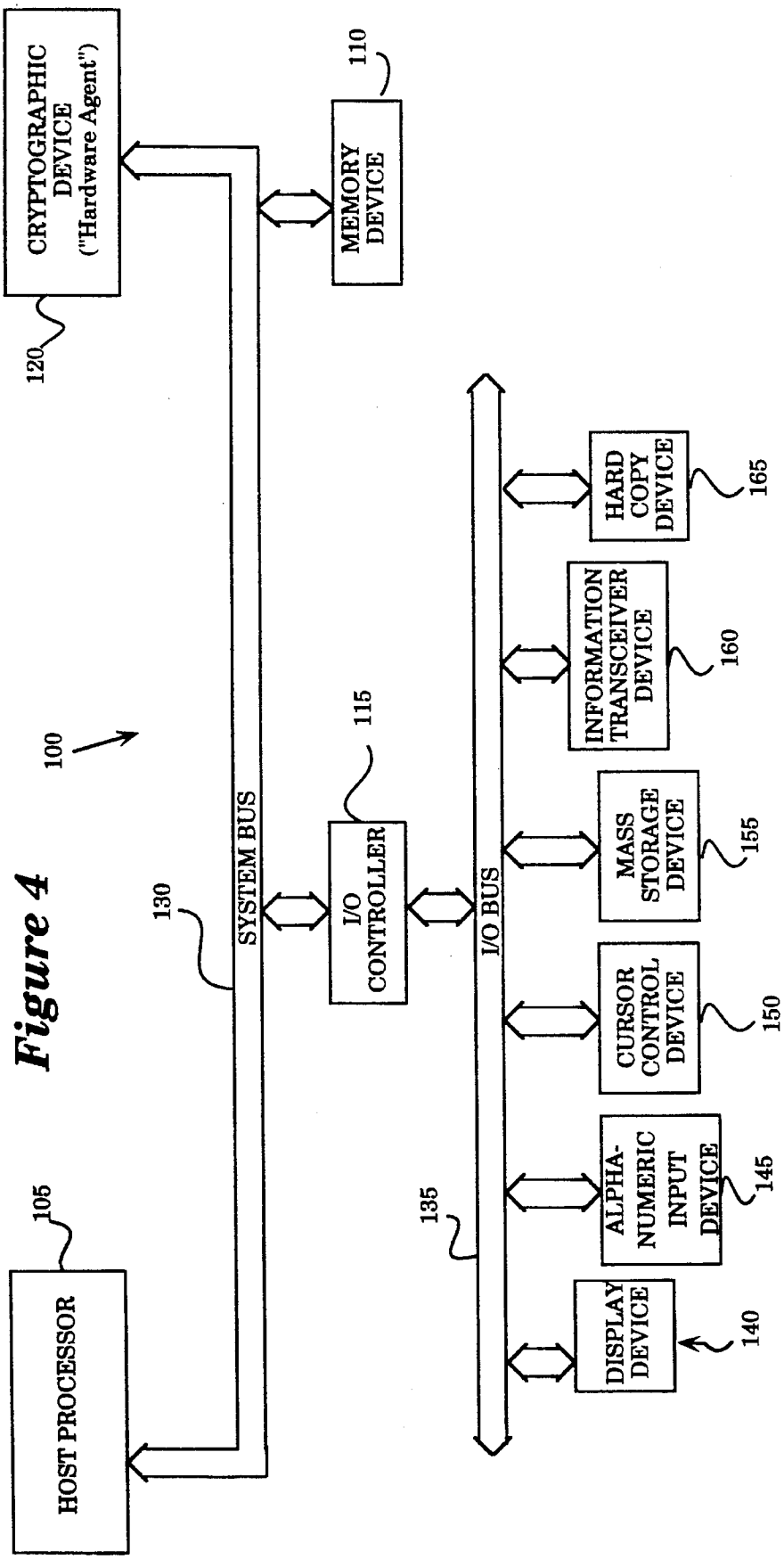
CRYPTOGRAPHIC DEVICE ("Hardware Agent")
120
MEMORY DEVICE
110
100
SYSTEM BUS
130
I/O CONTROLLER
115
I/O BUS
135
HOST PROCESSOR
105
HARD COPY DEVICE
165
INFORMATION TRANSCEIVER DEVICE
160
MASS STORAGE DEVICE
155
CURSOR CONTROL DEVICE
150
ALPHA-NUMERIC INPUT DEVICE
145
DISPLAY DEVICE
140

Figure 4

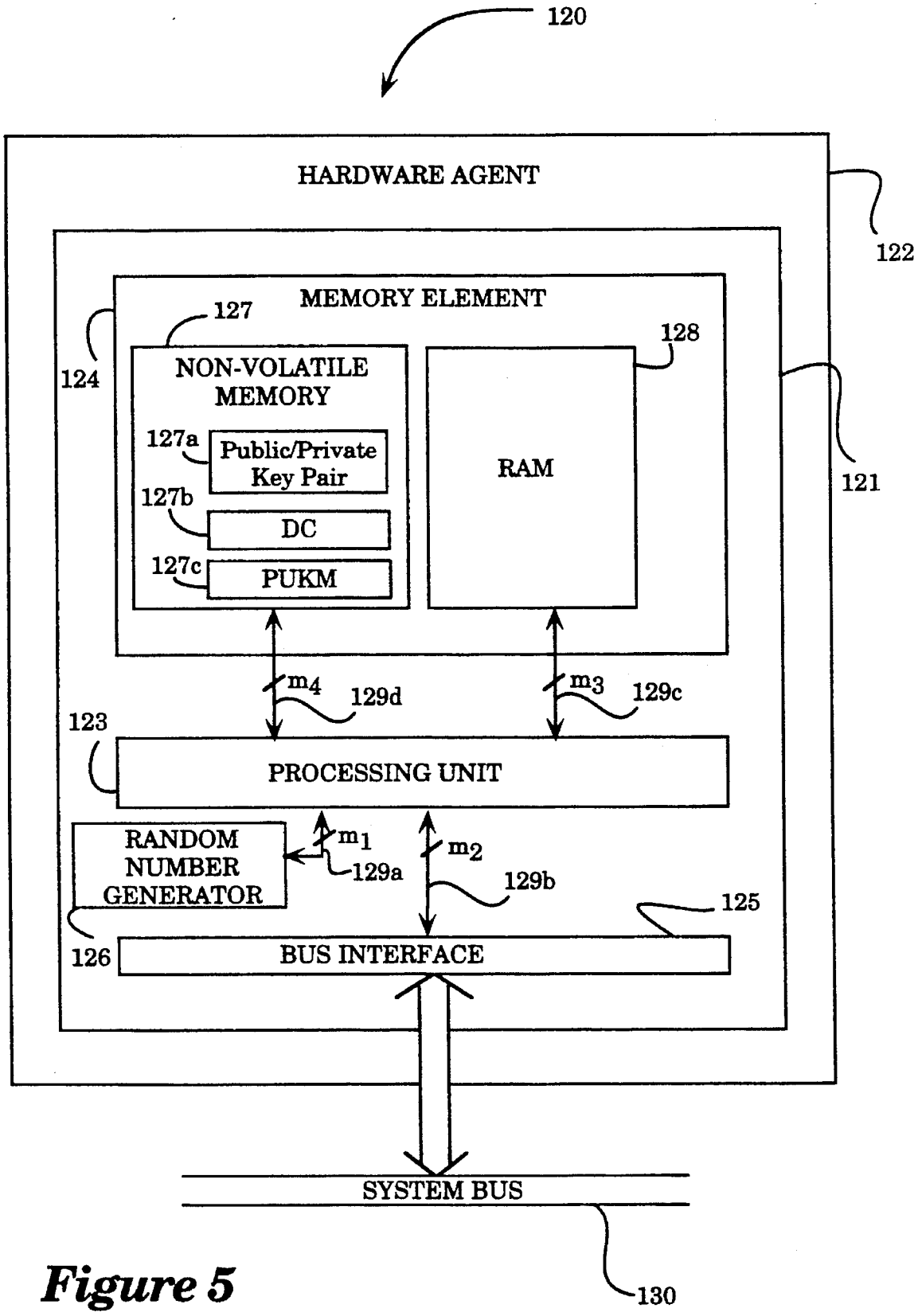
120
HARDWARE AGENT
122
MEMORY ELEMENT
127
128
124
NON-VOLATILE MEMORY
127a
Public/Private Key Pair
127b
DC
127c
PUKM
RAM
121
m4
129d
m3
129c
123
PROCESSING UNIT
RANDOM NUMBER GENERATOR
m1
129a
m2
129b
125
126
BUS INTERFACE
SYSTEM BUS
130

Figure 5

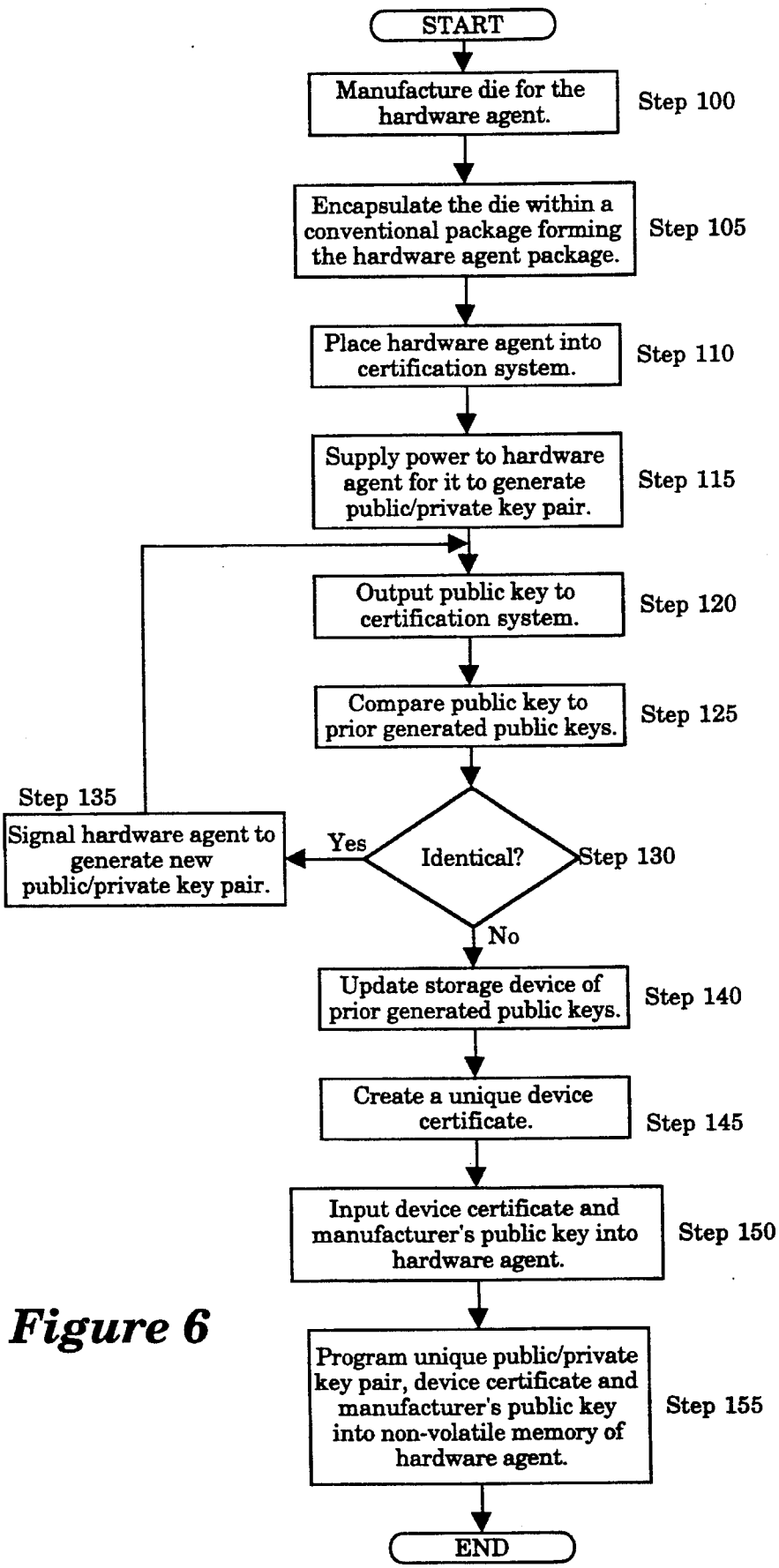
START
Manufacture die for the hardware agent.
Step 100
Encapsulate the die within a conventional package forming the hardware agent package.
Step 105
Place hardware agent into certification system.
Step 110
Supply power to hardware agent for it to generate public/private key pair.
Step 115
Output public key to certification system.
Step 120
Compare public key to prior generated public keys.
Step 125
Step 135
Signal hardware agent to generate new public/private key pair.
Yes
Identical?
Step 130
No
Update storage device of prior generated public keys.
Step 140
Create a unique device certificate.
Step 145
Input device certificate and manufacturer's public key into hardware agent.
Step 150
Program unique public/private key pair, device certificate and manufacturer's public key into non-volatile memory of hardware agent.
Step 155
END

Figure 6

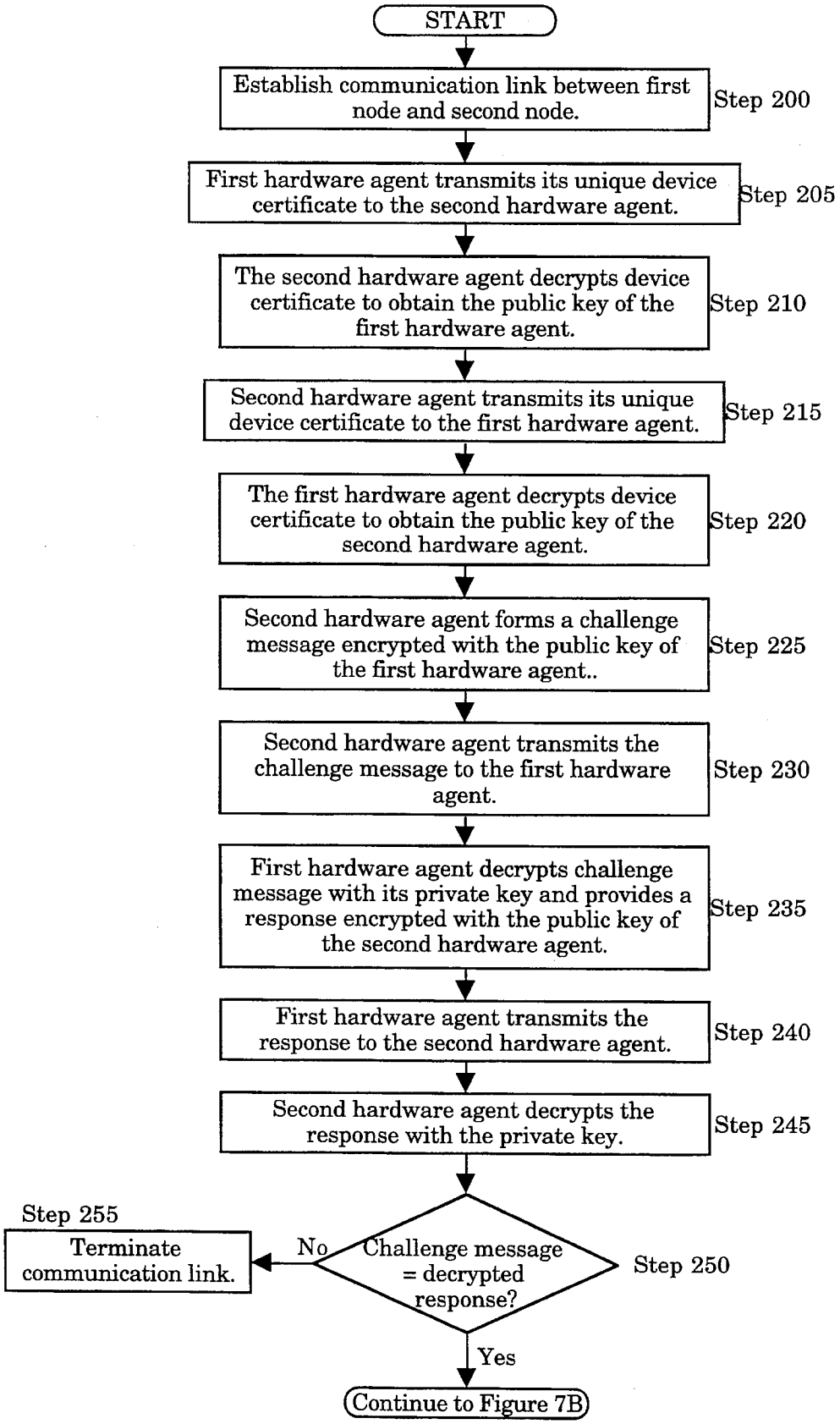
START
Establish communication link between first node and second node.
Step 200
First hardware agent transmits its unique device certificate to the second hardware agent.
Step 205
The second hardware agent decrypts device certificate to obtain the public key of the first hardware agent.
Step 210
Second hardware agent transmits its unique device certificate to the first hardware agent.
Step 215
The first hardware agent decrypts device certificate to obtain the public key of the second hardware agent.
Step 220
Second hardware agent forms a challenge message encrypted with the public key of the first hardware agent..
Step 225
Second hardware agent transmits the challenge message to the first hardware agent.
Step 230
First hardware agent decrypts challenge message with its private key and provides a response encrypted with the public key of the second hardware agent.
Step 235
First hardware agent transmits the response to the second hardware agent.
Step 240
Second hardware agent decrypts the response with the private key.
Step 245
Challenge message = decrypted response?
Step 250
No
Step 255
Terminate communication link.
Yes
Continue to Figure 7B

Figure 7A

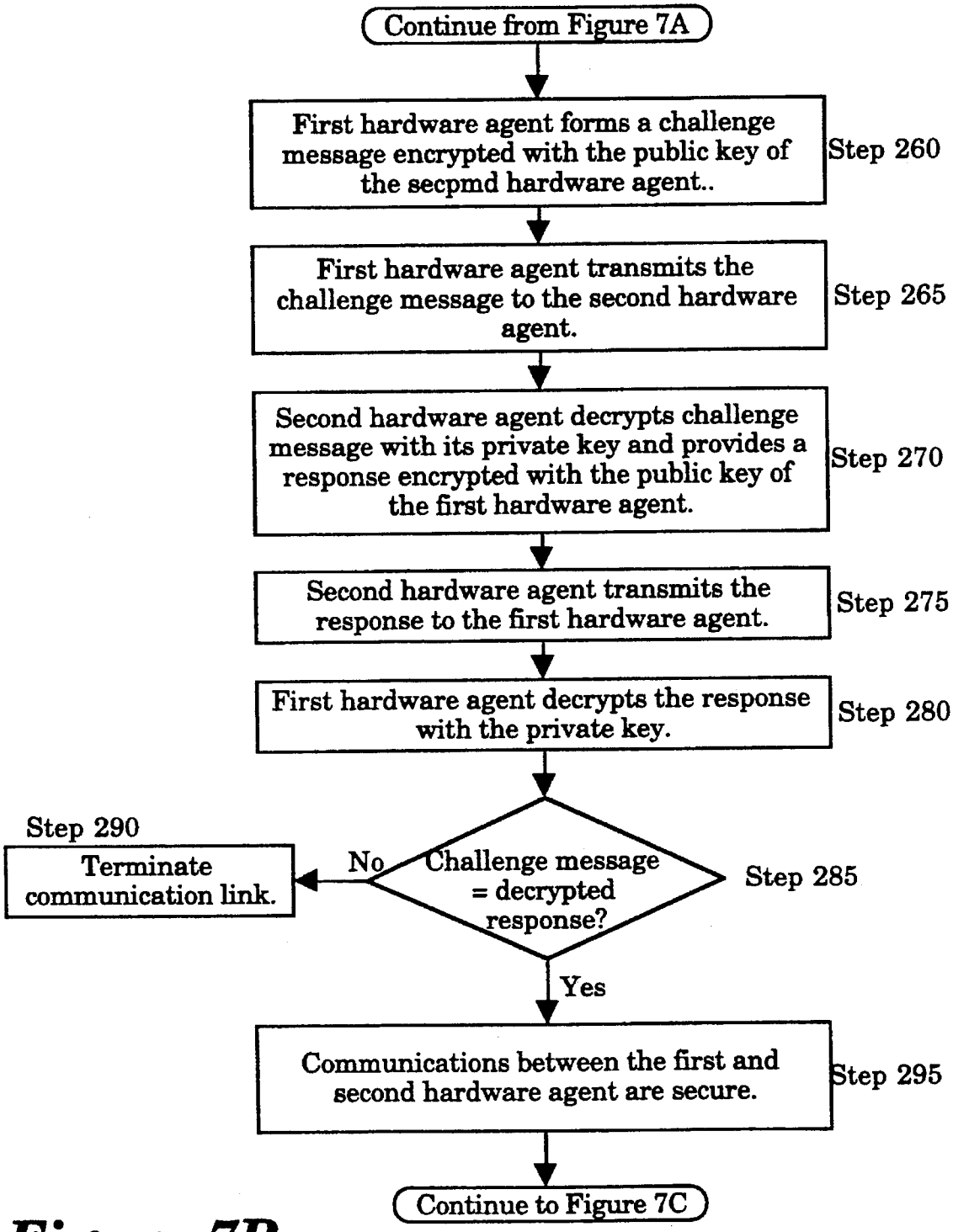
Continue from Figure 7A
First hardware agent forms a challenge message encrypted with the public key of the secpmd hardware agent..
Step 260
First hardware agent transmits the challenge message to the second hardware agent.
Step 265
Second hardware agent decrypts challenge message with its private key and provides a response encrypted with the public key of the first hardware agent.
Step 270
Second hardware agent transmits the response to the first hardware agent.
Step 275
First hardware agent decrypts the response with the private key.
Step 280
Challenge message = decrypted response?
Step 285
No
Step 290
Terminate communication link.
Yes
Communications between the first and second hardware agent are secure.
Step 295
Continue to Figure 7C

Figure 7B

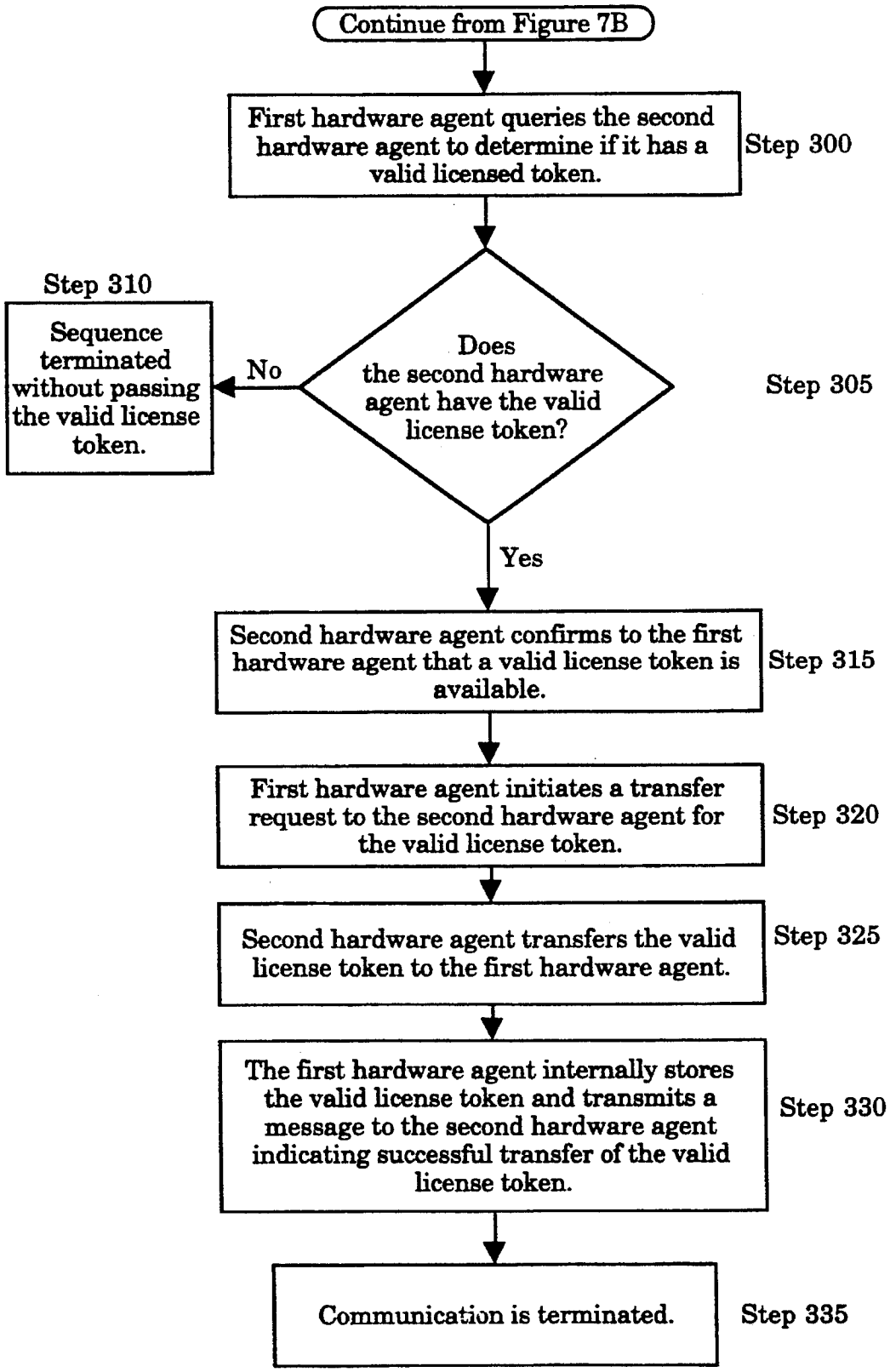
Continue from Figure 7B
First hardware agent queries the second hardware agent to determine if it has a valid licensed token.
Step 300
Does the second hardware agent have the valid license token?
Step 305
No
Step 310
Sequence terminated without passing the valid license token.
Yes
Second hardware agent confirms to the first hardware agent that a valid license token is available.
Step 315
First hardware agent initiates a transfer request to the second hardware agent for the valid license token.
Step 320
Second hardware agent transfers the valid license token to the first hardware agent.
Step 325
The first hardware agent internally stores the valid license token and transmits a message to the second hardware agent indicating successful transfer of the valid license token.
Step 330
Communication is terminated.
Step 335

Figure 7C

METHOD FOR PROVIDING A ROVING SOFTWARE LICENSE FROM ONE NODE TO ANOTHER NODE

RELATED APPLICATIONS

This is a divisional of a U.S. patent application (application Ser. No. 08/303,084) filed Sep. 7, 1994. The named inventor of the present application also has filed a number of co-pending United States patent applications entitled "Apparatus and Method for Providing Secured Communications" (Ser. No. 08/251,486) and "Key Cache Security System" (Ser. No. 08/365,347). These applications are owned by the same assignee of the present Application.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to licensing software. More particularity, the present invention relates to an apparatus and method for transferring access privileges for executing a licensed software program from an authorized node having a first hardware agent to a non-authorized node having a second hardware agent without violating a specific-user license.

2. Background of Art Related to the Invention

Early in the evolution of computer systems, modernized businesses typically employed a room-sized, centralized mainframe having several "dumb" terminals connected to the mainframe. With the emergence of smaller, faster and more powerful computers, many of these modernized businesses have removed their centralized mainframes in favor of employing a number of stand-alone computers or a distributed network (e.g., a local area network) having a collection of personal computers, wherein each user has control over his or her own personal computer.

Observing this decentralizing trend, many software developers are licensing their software according to a particular licensing scheme commonly referred to as a "user-specific" license. The user-specific license generally permits a predetermined number of individuals to operate a particular software program in a specific manner at any given time. Thus, the license is associated with the select number of individuals and not to certain nodes. For the scope of this application, a "node" is defined as an hardware product having "intelligence" such as a computer, printer, facsimile machine and the like, preferably including the present invention. A paramount problem associated with user-specific software licenses is that it indirectly encourages unauthorized usage and/or copying of the licensed software which erodes potential licensing revenue for software developers.

For many years, software developers have sought a way of protecting their software from being used and copied beyond the terms of the user-specific license while business licensees have been attempting to greatly mitigate any potential vicarious liability from illegal usage or copying of licensed software by their employees. Thus, there exists an interest by both the software developers and the business licensees alike to prevent the proliferation of software beyond the terms of the user-specific license.

Currently, compliance with a user-specific software license is sometimes accomplished by using a physical hardware device referred to as a "dongle". A dongle is a physical hardware device that is packaged with the licensed software program when initially purchased. It typically couples to a parallel port of a node e.g., a personal computer.

At various times during execution, the licensed software program of interest will transmit an authorization message (referred to as a "challenge") to an active device employed within the dongle. The active device within the dongle processes the challenge using secret information (hereinafter referred to as a "valid license token") stored internally within the dongle and generates a return message (referred to as a "response"). The software program compares this response to an expected response and permits further execution only if these responses are identical.

Thus, while the user is able to copy the licensed software program and load it onto multiple personal computers, only a first personal computer, to which the dongle is connected, would be able to execute this software program. In order to execute the licensed software program on another personal computer, the dongle must be physically removed from the first personal computer and coupled to the other personal computer. As a result, the software on the first personal computer is disabled. It is clear that multiple installations of the licensed software program do not cause any adverse fiscal effects to the software developer because the number of dongles provided to the business licensee is generally limited to the number of persons agreed to under the user-specific software license.

Although the dongles ensure compliance with the user-specific license, it affords a number of disadvantages. One disadvantage is that the dongle must be physically delivered to the customer. Thus, while systems for electronic delivery of software (referred to as "content distribution") are being proposed and implemented to increase convenience and reduce distribution costs, the dongle, as a physical device, still requires the traditional distribution methodology with its associated costs. By requiring a dongle to protect the fiscal interests of the software developer, the customer would have to endure the onerous task of (i) directly obtaining the dongle at a chosen location and thereafter attaching the dongle to the node before being able to use the licensed software program, or (ii) ordering the licensed software program prior to its intended use so that the content distributor has time to mail the dongle to the customer. In any event, the dongle impedes the efficiency and appealability of content distribution.

Another disadvantage is that the removal and attachment of the dongle is a time-consuming process. In a time-sensitive business, the exchange of the dongle effects the overall performance of the business. A further disadvantage is continual removal and attachment of the dongle increases the likelihood of the dongle becoming damaged and non-functional, requiring the business to await the new dongle before being able to use the software application again.

Yet another disadvantage is that although the license is directed toward individuals, the dongle generally is attached to the node. Thus, if the user travels to another machine (e.g., a personal computer located at his or her home), he or she is precluded from using the licensed software program unless the user has possession of the dongle.

BRIEF SUMMARY OF THE INVENTION

Based on the foregoing, it would be desirable to construct a cryptographic device with the functionality of an electronic dongle as an integrated circuit component internally implemented within a node. Accordingly, it is an object of the present invention to provide an integrated circuit component for providing a roving software license without requiring continual physical manipulations of hardware.

The integrated circuit component, generally referred to as a hardware agent, comprising a processing unit for performing operations for identification purposes and a memory element including (i) non-volatile memory which stores a unique public/private key pair, (ii) a digital certificate which verifies the authenticity of the key pair and (iii) a public key of a chosen entity (preferably the manufacturer of the integrated circuit component) which enables communication between the integrated circuit component and other similar components fabricated by the manufacturer. The non-volatile memory also may be used contain cryptographic algorithms. The integrated circuit component further includes volatile memory that stores information processed by the processing unit, an interface in order to receive information in encrypted or decrypted format from and/or transmit information to other similar component(s) via a communication bus and a random number generator that produces the unique public/private key pair.

BRIEF DESCRIPTION OF THE DRAWINGS

The objects, features and advantages of the present invention will become apparent from the following detailed description of the present invention in which:

FIG. **1** is a block diagram illustrating a bidirectional symmetric key encryption and decryption process.

FIG. **2** is a block diagram illustrating a bidirectional asymmetric key encryption and decryption process.

FIG. **3** is a block diagram illustrating a digital certification process from a trusted authority.

FIG. **4** is a block diagram of a computer system incorporating an embodiment of the present invention.

FIG. **5** is a block diagram of an embodiment of the present invention.

FIG. **6** is a flowchart illustrating the method for implementing pair and digital certificate into an integrated circuit component.

FIGS. **7A–7C** are flowcharts illustrating the operations of a first hardware agent establishing communications with a second hardware agent in order to transfer a valid license token between the second hardware agent having licensed privileges and the first hardware agent.

DETAILED DESCRIPTION OF THE INVENTION

The present invention relates to an apparatus and method for enabling a roving software license to be transferred between appropriately configured hardware agents thereby eliminating the need for a distributable physical hardware device. In the following description, numerous details are set forth in order to provide a thorough understanding of the present invention. However, it is apparent to one skilled in the art that the present invention may be practiced through many different embodiments than that illustrated without deviating from the spirit and scope of the present invention. In other instances, well-known circuits, elements and the like are not set forth in detail in order to avoid unnecessarily obscuring the present invention.

In the detailed description, a number of cryptography-related terms are frequently used to describe certain characteristics or qualities which is defined herein. A "key" is an encoding and/or decoding parameter for a conventional cryptographic algorithm. More specifically, the key is a sequential distribution ("string") of binary data being "n" bits in length, where "n" is an arbitrary number. A "message" is generally defined as information (e.g., encrypted keys address and data) being transferred in a sequence of bus cycles. The information may include a challenge or a return response. A "digital certificate" is defined as any information pertaining to an entity initiating communications, typically its public key, encrypted through use of a private key by a widely published trusted authority (e.g., bank, governmental entity, trade association, etc.). A "digital signature" is similar to a digital certificate but is used for authentication of the message itself, not the sender.

In recent years, it is becoming more and more desirable to transmit digital information from one location to another. As a result, many entities are now using cryptographic technology so that the information is transferred in a manner which is clear and unambiguous to a legitimate receiver, but incomprehensible to any illegitimate recipients. Typically, cryptographic technology operates in accordance with one of two conventional techniques; namely, symmetric key cryptography or asymmetric (or public) key cryptography or a combination of these cryptographic technologies.

Referring to FIG. **1**, an illustrative embodiment of the symmetric key cryptography technique is illustrated. This technique requires the use of an identical i.e., symmetric secret key (labeled "SK") **1** to encrypt an original message **5** being transmitted between a first node **10** and a second node **15** to form an encrypted original message **20** and to decrypt the encrypted original message **20** to recover the original message **5**. Such encryption and decryption is performed through well-known conventional cryptographic algorithms such as, for example, the Data Encryption Algorithm, more commonly referred to as "DES". The original message **5** is (i) encrypted at the first node **10**, (ii) transmitted from the first node **10** to the second node **15** through a public domain **25** such as a telephone lines and the like and (iii) decrypted at the second node **15**. However, this technique is difficult to support with a large number of users because it requires prior establishment of secret keys ("SK").

Referring now to FIG. **2**, an illustrative embodiment of the asymmetric key technique is shown. This technique employs two separate keys (referred to as a "public key" and "private key") being used separately for encryption and decryption purposes. For establishing bidirectional communications from the first node **10** to the Second node **15**, a "public" key **16** of the key pair of the second node **15** (labeled "PUK2") is stored in and generally used by the first node **10** to encrypt an original message **30** under an asymmetric "RSA" algorithm well known in cryptography. This forms an encrypted original message **35** to be transmitted to the second node **15**. A public and private key pair **11** and **12** of the first node **10** (labeled "PUK1" and "PRK1") are further stored in the first node **10**.

A "private" key **17** of the key pair of the second node **15** (labeled "PRK2") is exclusively known and used by the second node **15** for many purposes, including to decrypt the encrypted message **35** from the first node **10** under the RSA algorithm as shown in FIG. **2**. However, this technique is susceptible to attempts by an illegitimate entity (e.g., commercial spy) to impersonate a legitimate entity (e.g., employee, joint-venturer, etc.) by sending fraudulent messages to another legitimate entity for the purpose of disrupting work flow or obtaining confidential information. Thus, additional protocols are commonly used to authenticate a message and legitimize the entity sending the message.

Authentication of the sender (i.e., verifying that the sender of a public key is, in fact, the true owner of the public

key) is a problem when communications are initially established between previously unknown parties. This problem is commonly avoided by incorporating a digital certificate **45** within a transmission message **50**. The digital certificate **45** is issued by a mutually trusted authority **55** (e.g., a bank, governmental entity, trade association, etc.) by encrypting a public key of the node initiating the communications ("PUK1") **11** with a signature statement (labeled "SM") **58** with a private key ("PRKTA") **57** of the trusted authority **55** so that fraudulent attempts to use PUK2 **16** will simply result in an unreadable response to the transmission message by its recipient. The selected trusted authority **55** depends on the parties involved. For example, two individuals employed by the same business could both trust the certificates issued by a corporate security office of the business. Employees of two independent business entities, however, would require not only the certificates from the respective security offices, but also the certificates from, for example, some industry trade organization that certifies such business entities.

In this approach, multiple operations are concurrently performed to construct the transmission message **50**. One operation is that the original message **40** is encrypted using a symmetric secret key (SK") **60** via the DES algorithm to form the encrypted message **65** which is input into the transmission message **50** along with the digital certificate **45**. The original message **40** also undergoes a hash algorithm **70** (e.g., "MD5") to form a transmitted message digest **75**. The transmitted message digest **75** is further encrypted using a private key of the first node ("PRK1") **12** to form a digital signature **80** which is input into the transmission message **50**. Additionally, the symmetric key ("SK") **60** is encrypted with a public key of the second node ("PUK2") **16** under the RSA algorithm resulting in "SK_{enc}" **85** and further input to the transmission message **50**.

Referring still to FIG. **3**, upon receipt of the transmission message **50** from the first node **10** being transmitted through the public domain **25**, the second node **15** decrypts the SK_{enc} **85** with its private key CPRK2") **17** and the digital certificate **45** with a published public key ("PUBTA") of the trusted authority **55** to obtain SK **60** and PUK1 **11**. These SK and PUK1 keys **60** and **11** are used to decrypt the encrypted original message **65** and the digital signature **80** to retrieve the transmitted message digest **75** and the original message **40**, respectively. The original message **40** then undergoes a hash algorithm **85**, identical to that performed in the first node **10**. The results (referred to as a "received message digest") **90** are compared to the transmitted message digest **75**. If the transmitted message digest **75** is identical to the received message digest **90**, communications are maintained between these legitimate nodes.

Referring to FIG. **4**, an illustrative embodiment of a computer system **100** utilizing the present invention is illustrated. The computer system **100** comprises a plurality of bus agents including a host processor **105**, a memory device **110**, an input/output ("I/O") controller **115** and a cryptographic device referred to as a "hardware agent" **120**. The plurality of bus agents are coupled together through a system bus **130** which enables information to be communicated between these bus agents.

Being well-known in the computer industry, it is contemplated that more than one host processor could be employed within the computer system **100** although only the host processor **105** is illustrated in this embodiment. Moreover, the memory device **110** may include dynamic random access memory ("DRAM"), read only memory ("ROM"), video random access memory ("VRAM") and the like. The memory device **110** stores information for use by the host processor **105**.

The I/O controller **115** is an interface between an I/O bus **135** and the system bus **130** which provides a communication path (i.e., gateway) for transferring information between components coupled to the system bus **130** or the I/O bus **135**. The I/O bus **135** transfers information into and from at least one peripheral device in the computer system **100** including, but not limited to a display device **140** (e.g., cathode ray tube, liquid crystal display, etc.) for displaying images; an alphanumeric input device **145** (e.g., an alphanumeric keyboard, etc.) for communicating information and command selections to the host processor **105**; a cursor control device **150** (e.g., a mouse, trackball, touch pad, etc.) for controlling cursor movement; a mass data storage device **155** (e.g., magnetic tapes, hard disk drive, floppy disk drive, etc.) for storing information; an information transceiver device **160** (fax machine, modem, scanner etc.) for transmitting information from the computer system **100** to another device and for receiving information from another device; and a hard copy device **165** (e.g., plotter, printer, etc.) for providing a tangible, visual representation of the information. It is contemplated that the computer system shown in FIG. **4** may employ some or all of these components or different components than those illustrated.

Referring now to an embodiment of the present invention as shown in FIG. **5**, the hardware agent **120** is coupled to the system bus **130** establishing a communication path with the host processor **105** as well as the memory and I/O controllers (not shown). The hardware agent **120** comprises a single integrated circuit in the form of a die **121** (e.g., a microcontroller) encapsulated within an integrated circuit component package **122**, preferably hermetically, to protect the die **121** from damage and harmful contaminants. The die **121** comprises a processing unit **123** coupled to a memory element **124**, a bus interface **125** and a number generator **126**. The bus interface **125** enables communication from the hardware agent **120** to another device (e.g., the host processor, another hardware agent in another device, etc.). The processing unit **123** performs computations internally within a secured environment within the die **121** to confirm a valid connection with an authorized receiver. Such computations include executing certain algorithms and protocols, activating circuitry (e.g., the number generator **126** being preferably random in nature) for generating a device-specific public/private key pair and the like. The processing unit **123** is placed within the die **121** to prevent access of the private key through virus attack, which is a common method of disrupting a computer system to obtain its private key and other information.

The memory element **124** includes a non-volatile memory element **127**, such as flash memory, which stores appropriate cryptographic algorithms such as "RSA" and "DES", the public/private key pair **127*a***, a digital certificate for verifying the authenticity of the key pair (labeled "DC") **127*b*** and a public key of the manufacturer of the integrated circuit component ("PUKM") **127*c*** for enabling communication between the integrated circuit component and another similar device fabricated by the manufacturer (discussed in more detail in FIG. **6**). This non-volatile memory **127** is used primarily because it retains its contents when supply power is discontinued. The memory unit **124** further includes random access memory ("RAM") **128** in order to store certain results from the processing unit **123**.

Although the hardware agent **120** is implemented as a peripheral device on the system bus **130** for greater security, it is contemplated that the hardware agent **130** could be implemented in several other ways at the PC platform level such as, for example, as a disk controller or PCMCIA card

to automatically decrypt and/or encrypt information being inputted and outputted from a hard disk. Another alternative implementation would be for the hardware agent to be one component of a multi-chip module including the host processor as discussed below. Furthermore, even though the hardware agent is described in connection with PC platforms, it is contemplated that such hardware agent could be implemented within node such as a fax machine, printer and the like or on a communication path between a computer and the I/O peripheral device.

Referring to FIG. **6**, a flowchart of the operations for manufacturing the present invention is illustrated. First, in Step **100**, the die of the hardware agent is manufactured according to any conventional well-known semiconductor manufacturing technique. Next, the die is encapsulated within a semiconductor package so as to form the hardware agent itself (Step **105**). The hardware agent is placed onto a certification system which establishes an electrical and mechanical coupling between the hardware agent and the certification system (Step **110**). The certification system comprises a carrier coupled to a printed circuit board for generating and receiving electrical signals for certification of the hardware agent. The certification system further comprises a storage device (e.g., a database) of previously generated public keys to guarantee unique key generation. Thereafter, the certification system supplies power to the hardware agent which powers the random number generator enabling it to generate a device-specific public/private key pair internally within the hardware agent (Step **115**).

After the public/private key pair has been generated within the hardware agent, the public key of the public/private key pair is transmitted to the certification system (Step **120**). The public key is compared with those previously generated public keys from previously manufactured hardware agents being stored in the storage device (Step **125**). In the unlikely event that the public key is identical to one of the previously generated public keys (Step **130**), the hardware agent is signaled by the certification system to generate another such public/private key pair (Step **135**) and continue this process from Step **120** to ensure that each public/private key pair is unique.

In the event that the public key is unique, the storage device is updated with this unique public key (Step **140**). Thereafter, in Step **145**, the certification system creates a unique device certificate verifying the authenticity of the key pair (hereinafter referred to as the "authentication device certificate"). The authentication device certificate will include at least the public key of the device "digitally signed" with the secret private manufacturing key (i.e. in general terms, encrypting the public key of the device with the manufacturer's private key). This authentication device certificate along with the manufacturer's generally known public key are input to the hardware agent (Step **150**) and the hardware agent permanently programs the unique public/private key pair, the authentication device certificate and the manufacturer's public key into its non-volatile memory (Step **155**). It is contemplated, however that the public key of another entity (e.g., distributor) may be used in lieu of the manufacturer requiring modification of the authentication device certificate as well. At this point, the hardware agent is physically unique and is now capable of securely establishing communications with another hardware agent.

After the hardware agent is constructed, it is implemented into an electronic device such as the computer system illustrated in FIG. **4**. This is accomplished by establishing a secure communication path between the licenser and the hardware agent through authentication procedures such as challenge/response as well as any other well-known procedures. After the communication path is secure, the valid license token is downloaded into flash memory of the hardware agent through the secure communication link. It is further contemplated that the license token may be incorporated within multiple hardware agents to exist in either a "valid" or "invalid" state whereby the license token is validated or invalidated rather than being transferred between hardware agents.

Referring to FIGS. **7A** and **7B**, an illustrative embodiment of mutual remote identification of authentication of two hardware agents is illustrated. In Step **200**, a communication link is established between a "non-authorized" first node (i.e., a node not currently permitted to operate a licensed software application) incorporating a first hardware agent and an authorized second node incorporating a second hardware agent which is authorized to operate the licensed software application. This communication link may be established through any conventional means such as modems, networks, etc. The first hardware agent outputs a message including its unique authentication device certificate to the second hardware agent (Step **205**). Since the manufacturer's public key ("PUKM") is programmed in non-volatile memory of both hardware agents, the second hardware agent decrypts the authentication device certificate with the manufacturer's public key ("PUKM") to obtain the public key of the first hardware agent (Step **210**). Thereafter, in Steps **215–220**, operations similar to those discussed in Steps **205–210** are also conducted so that the first agent obtains the public key ("PUK2") of the second hardware agent.

Thereafter, in Step **225** and **230**, using the derived public key of the first hardware agent, the second hardware agent encrypts a challenge message according to a chosen cryptographic algorithm (e.g., RSA) and transmits the challenge message to the first hardware agent. In step **235** and **240**, the first hardware agent decrypts the challenge message with its private key ("PRK1") and generates a response message by encrypting the decrypted challenge message with the public key of the second hardware agent ("PUK2") and transmits the response message to the second hardware agent. Then, the second hardware agent decrypts the response with its private key ("PUK1") as previously determined through decryption of the previously transmitted manufacturer's device certificate (Step **245**). In Step **250**, the second hardware agent compares the original challenge message to the decrypted response message and if not identical, the communications are terminated (step **255**). Otherwise, in Steps **260–290**, a challenge/response procedure similar to Steps **225–260** is conducted to verify that the second hardware agent is in fact receiving the information transmitted from the first hardware agent. Successful completion of these steps (**225–290**) assures that both hardware agents are authentic and communications between them are secure (Step **295**).

Referring now to FIG. **7C**, an illustrative embodiment of the process of securely transferring the valid license token within the second hardware agent to the first hardware agent under secure communications is illustrated. After secure communications are established, the first hardware agent queries the second hardware agent as to whether it has possession of a valid license token (Step **300**). If the system incorporating the second hardware agent does not have the valid license token (Step **305**), communications between the hardware agents are terminated (Step **310**). However, if the system incorporating the second hardware agent has the valid license token, it transmits a message to the first hardware agent accordingly (Step **315**).

Upon receiving this message, the first hardware agent initiates a transfer request of the valid license token allowing the first hardware agent to operate the licensed software application (Step **320**). The second hardware agent responds to the transfer request by transferring the valid license token causing it to lose its license privileges (Step **325**). The first hardware agent receives the valid license token and stores the token within the its non-volatile memory and thereafter, it would transmit a message to the second hardware agent that it has received the valid license token enabling its copy of the licensed software (Step **330**). At this point, communications would be terminated (Step **335**).

It is contemplated that an additional level of protocol integrity could be obtained by introducing challenge/response sequences between Steps **320** and **325** and Steps **325** and **330**. This prevents "replay" of previous license token transfer events.

Concurrently with the communication between the first and second hardware agents, each hardware agent would store the contents of its transmissions in non-volatile memory as an audit log. Thus, in case communications are disconnected after the second hardware agent disabled its copy but before the first hardware agent enabled its copy, both hardware agents could review the audit logs after communications are re-connected to determine which hardware agent (if any) has authorization to operate the licensed software application.

The present invention described herein may be designed in many different methods and using many different configurations. While the present invention has been described in terms of various embodiments, other embodiments may come to mind to those skilled in the art without departing from the spirit and scope of the present invention. The invention should, therefore, be measured in terms of the claims which follows.

What is claimed is:

1. A method for transferring a valid license token between a first and second nodes which allows execution of a licensed software program after the valid license token had been initially provided by a software supplier, the method comprising the steps of:

establishing a communication link between a first cryptographic device of the first node and a second cryptographic device of the second node;

authenticating said first and second cryptographic devices prior to transferring the valid license token there between;

transmitting a query message from said first cryptographic device to said second cryptographic device in order to determine whether said second cryptographic device possesses said valid license token;

generating a transfer request message from said first cryptographic device to said second cryptographic device if said second cryptographic device possesses said valid license token;

transferring said valid license token from said second cryptographic device to said first cryptographic device;

generating a token received message from said first cryptographic device to said second cryptographic device after receipt of said valid license token; and

terminating said communication link.

2. The method according to claim **1**, wherein the authenticating step includes the steps of:

transmitting a unique device certificate stored in said first hardware agent to said second hardware agent; and

decrypting said unique device certificate to obtain a public key of the first hardware agent for communicating with and authenticating said first hardware agent.

3. The method according to claim **2**, wherein the authenticating step further includes the steps of:

transmitting a unique device certificate stored in said second hardware agent to said first hardware agent; and

decrypting said unique device certificate to obtain a public key of the second hardware agent for communicating with and authenticating said second hardware agent.

4. The method according to claim **3**, wherein the authenticating step further includes the steps of:

generating a first challenge message being encrypted by said public key of said second cryptographic device;

transmitting said first challenge message from said first cryptographic device to said second cryptographic device;

decrypting said first challenge message and responding to said first challenge message by said second cryptographic device;

generating a second challenge message being encrypted by said public key of said first cryptographic device;

transmitting said second challenge message from said second cryptographic device to said first cryptographic device; and

decrypting said second challenge message and responding to said second challenge message by said first cryptographic device.

5. The method according to claim **1**, wherein prior to the step of generating a transfer request, the method further include the steps of:

determining by said second hardware agent as to whether said second hardware agent possesses said valid license token thereby:

terminating said communication link if said second hardware agent does not possess said valid license token, and

generating a response message to said query message if said second hardware agent possesses said valid license token.

6. A method for acquiring a valid license token from a second cryptographic device of a second node currently possessing the valid license token initially obtained from a software supplier that allows a first node having a first cryptographic device to gain access privileges to execute a licensed software program, the method comprising the steps of:

establishing a communication link between the first and second cryptographic devices;

authenticating said first and second cryptographic devices by exchanging messages in an encrypted format between said first and second cryptographic devices;

transferring said valid license token from said second cryptographic device to said first cryptographic device; and

terminating said communication link.

7. The method according to claim **6**, wherein the authenticating step includes the steps of

transmitting a unique device certificate stored in said first hardware agent to said second hardware agent; and

decrypting said unique device certificate to obtain a public key of the first hardware agent for communicating with and authenticating said first hardware agent.

8. The method according to claim **7**, wherein the authenticating step further includes the steps of

transmitting a unique device certificate stored in said second hardware agent to said first hardware agent; and

decrypting said unique device certificate to obtain a public key of the second hardware agent for communicating with and authenticating said second hardware agent.

9. The method according to claim **8**, wherein the authenticating step further includes the steps of

generating a first challenge message being encrypted by said public key of said second cryptographic device;

transmitting said first challenge message from said second cryptographic device to said first cryptographic device;

decrypting said first challenge message and responding to said first challenge message by said first cryptographic device;

generating a second challenge message being encrypted by said public key of said first cryptographic device;

transmitting said second challenge message to said first cryptographic device; and

decrypting said second challenge message and responding to said second challenge message by said first cryptographic device.

10. The method according to claim **6**, wherein prior to the transferring step, the method further includes the step of transmitting a query message from said first hardware agent to said second hardware agent in order to determine whether said second hardware agent possesses a valid license token.

11. The method according to claim **10**, wherein after the transmitting step, the method further includes the steps of generating a transfer request message from said first hardware agent to said second hardware agent if said second hardware agent possesses said valid license token.

12. The method according to claim **11**, wherein prior to the step of generating a transfer request, the method further include the steps of:

determining by said second hardware agent as to whether said second hardware agent possesses said valid license token, wherein

terminating said communication link if said second hardware agent does not possess said valid license token, and alternatively

generating a response message to said query message if said second hardware agent possesses said valid license token.

13. The method according to claim **12**, wherein before the terminating step, the method further comprises the step of generating a token received message from said first hardware agent to said second hardware agent after receipt of said valid license token.

14. A method for transferring a valid license token between a first cryptographic device of a first node and a second cryptographic device of a second node in order to gain access privileges to execute a licensed software program after the valid license token has been initially provided to a software supplier, the method comprising the steps of:

establishing a communication link between the first and second cryptographic devices;

authenticating the first and second cryptographic devices by exchanging messages in an encrypted format between said first and second cryptographic devices;

determining whether the second cryptographic device possesses a valid license token; and

transferring said valid license token from said second cryptographic device to said first cryptographic device if the second cryptographic device possesses said valid license token.

15. A first integrated circuit component adapted for exchanging a license token, necessary for executing a licensed software program, with a second integrated circuit component distantly separated from the first integrated circuit component, said first integrated circuit component comprising:

a first memory which contains a designated key pair, a device certificate of a manufacturer of the first integrated circuit component, a public key of said manufacturer and the license token;

a second memory element which contains information;

a processing unit coupled to said first memory element and said second memory element, said processing unit receiving and, internally processing information transmitted from the second integrated circuit component so that the key pair, the device certificate and the public key are not accessible outside the first integrated circuit component; and

a random number generator coupled to said processing unit, said random number generator producing said key pair internally within the first integrated circuit component.

16. A system adapted for transferring a license token to and from a remote system, the system comprising:

a bus;

a memory element coupled to said bus;

a host processor coupled to said bus; and

a cryptographic device coupled to said bus, said cryptographic device internally decrypting input information including the license token encrypted by said remote system and encrypting output information including the license token prior to transmission to said remote system, said cryptographic device including

a processor which executes an encryption and decryption program within said cryptographic device to obtain the license token,

a designated key pair, an authentication device certificate and a manufacturer public key contained in a first storage element coupled to said processor, all of said key pair, said authentication device certificate and said manufacturer public key is being used to decrypt said input information and encrypt said output information,

a second storage element coupled to said processor, said second storage element contains said input and output information processed by said processor, and

a random number generator coupled to said processor, said random number generator producing said key pair inaccessible outside said cryptographic device.

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