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(54) RADIO FREQUENCY IDENTIFICATION (RFID) TAG, PORTABLE TERMINAL, AND SERVER FOR RFID TAG

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(57) **ABSTRACT**

A hierarchical structure is established among a plurality of RFID tags, such that ID numbers can be read only from RFID tags which belong to a particular layer. RFID tag can control whether permission should be given to read its ID number therefrom to protect the ID number. Data held in the RFID tag can be read from the outside. RFID tag comprises a memory circuit having a function of holding data, and a logic circuit having a function of processing a control command received from outside. Memory circuit stores an own ID nmber for identifying the RFID tag itself, and a parent ID number for identifying a second RFID tag. When RFID tag receives an ID number read command which contains first data as a parameter from outside, the logic circuit outputs the own ID number to outside only when the first data matches the parent ID number.

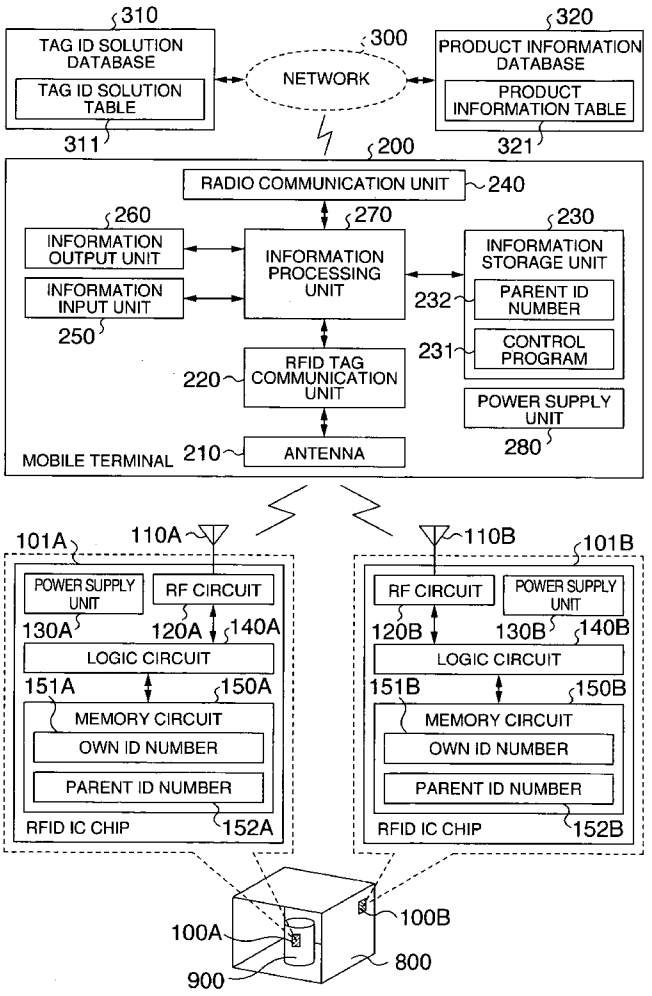

FIG. 1

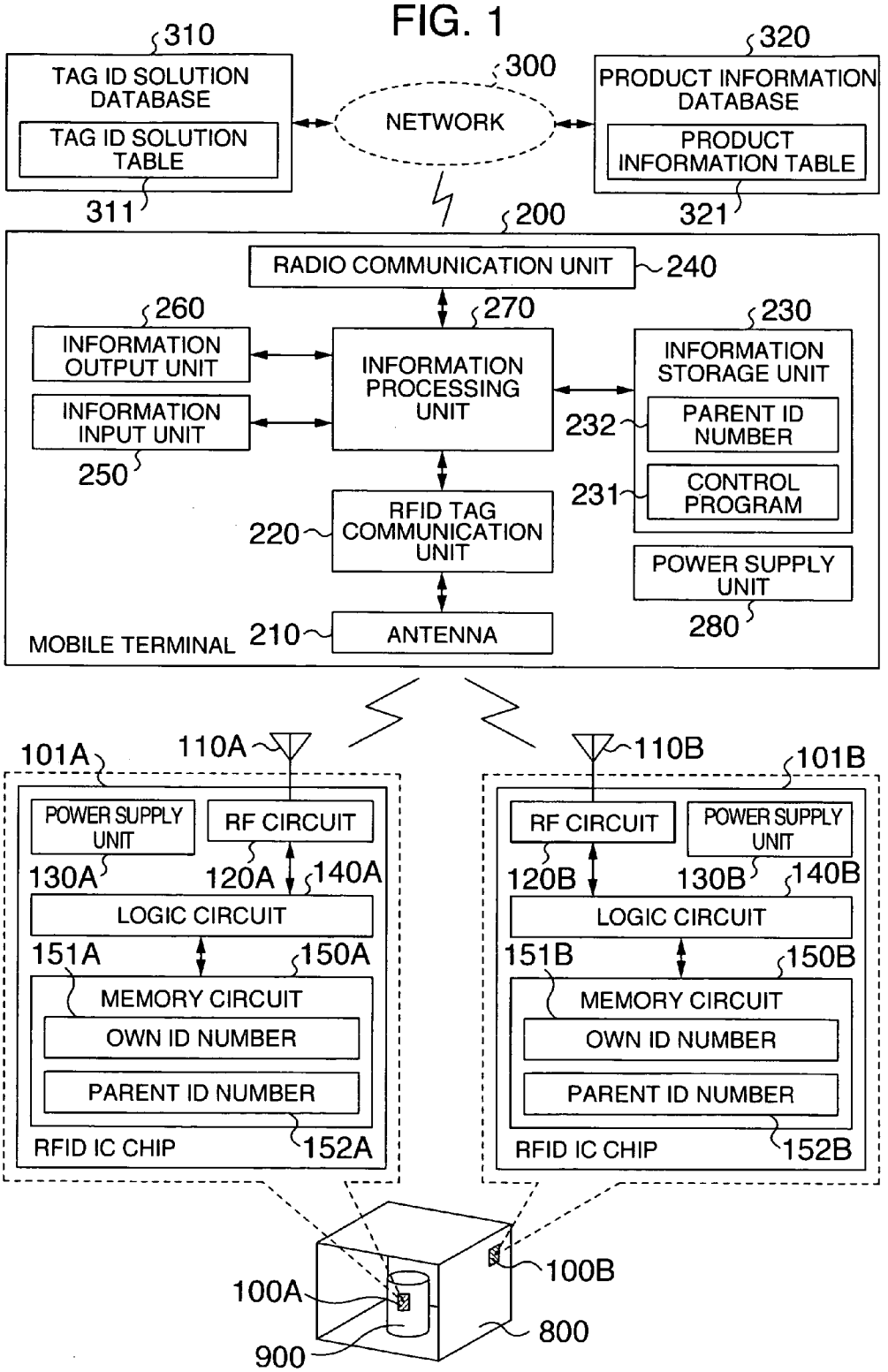
310
TAG ID SOLUTION DATABASE
TAG ID SOLUTION TABLE
311
300
NETWORK
320
PRODUCT INFORMATION DATABASE
PRODUCT INFORMATION TABLE
321
200
RADIO COMMUNICATION UNIT
240
260
INFORMATION OUTPUT UNIT
INFORMATION INPUT UNIT
250
270
INFORMATION PROCESSING UNIT
230
INFORMATION STORAGE UNIT
232
PARENT ID NUMBER
231
CONTROL PROGRAM
220
RFID TAG COMMUNICATION UNIT
POWER SUPPLY UNIT
280
MOBILE TERMINAL
210
ANTENNA
101A
110A
POWER SUPPLY UNIT
RF CIRCUIT
130A
120A
140A
LOGIC CIRCUIT
151A
150A
MEMORY CIRCUIT
OWN ID NUMBER
PARENT ID NUMBER
RFID IC CHIP
152A
110B
101B
RF CIRCUIT
POWER SUPPLY UNIT
120B
130B
140B
LOGIC CIRCUIT
151B
150B
MEMORY CIRCUIT
OWN ID NUMBER
PARENT ID NUMBER
RFID IC CHIP
152B
100A
100B
800
900

FIG. 2

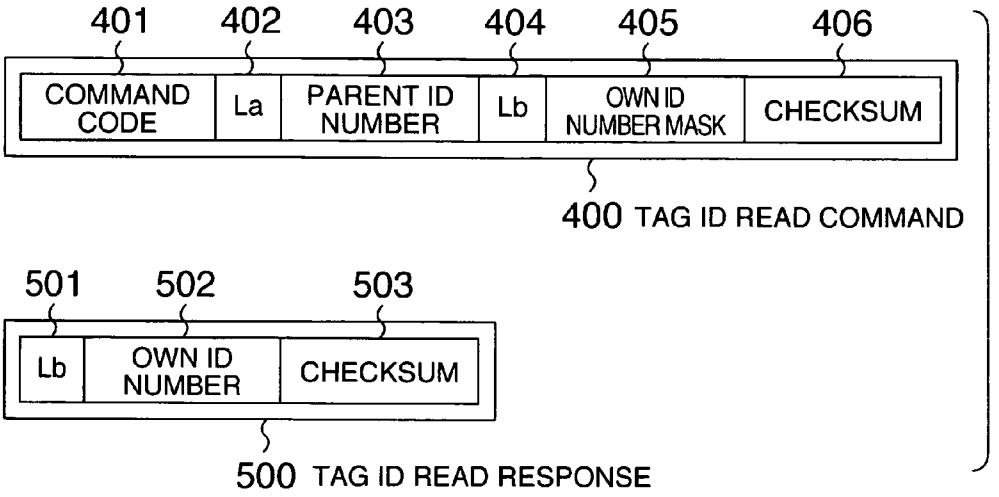
401
402
403
404
405
406
COMMAND CODE
La
PARENT ID NUMBER
Lb
OWN ID NUMBER MASK
CHECKSUM
400 TAG ID READ COMMAND
501
502
503
Lb
OWN ID NUMBER
CHECKSUM
500 TAG ID READ RESPONSE

FIG. 3

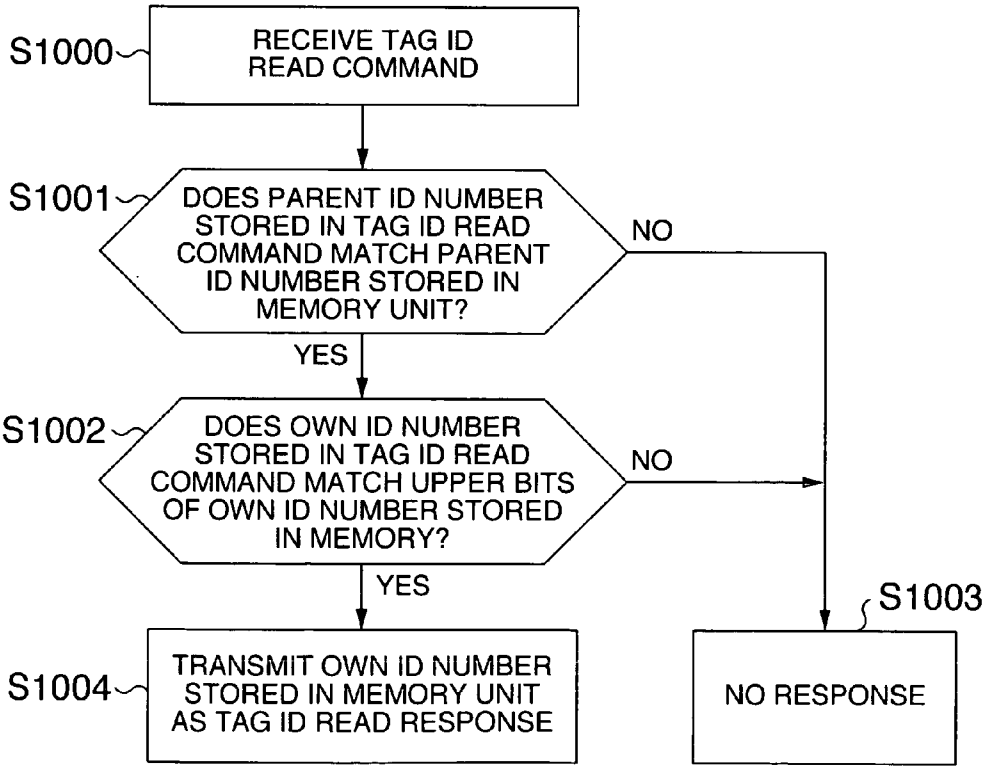
S1000
RECEIVE TAG ID READ COMMAND
S1001
DOES PARENT ID NUMBER STORED IN TAG ID READ COMMAND MATCH PARENT ID NUMBER STORED IN MEMORY UNIT?
NO
YES
S1002
DOES OWN ID NUMBER STORED IN TAG ID READ COMMAND MATCH UPPER BITS OF OWN ID NUMBER STORED IN MEMORY?
NO
YES
S1003
S1004
TRANSMIT OWN ID NUMBER STORED IN MEMORY UNIT AS TAG ID READ RESPONSE
NO RESPONSE

FIG. 4

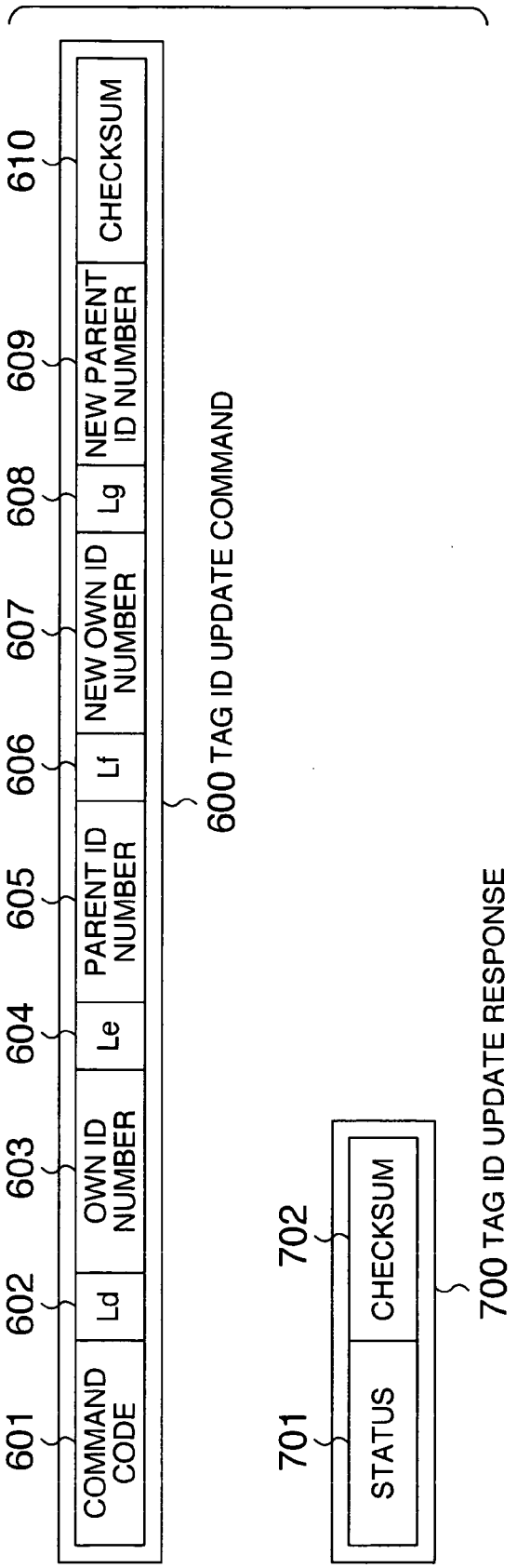
601
COMMAND CODE
602
Ld
603
OWN ID NUMBER
604
Le
605
PARENT ID NUMBER
606
Lf
607
NEW OWN ID NUMBER
608
Lg
609
NEW PARENT ID NUMBER
610
CHECKSUM
600 TAG ID UPDATE COMMAND
701
STATUS
702
CHECKSUM
700 TAG ID UPDATE RESPONSE

FIG. 5

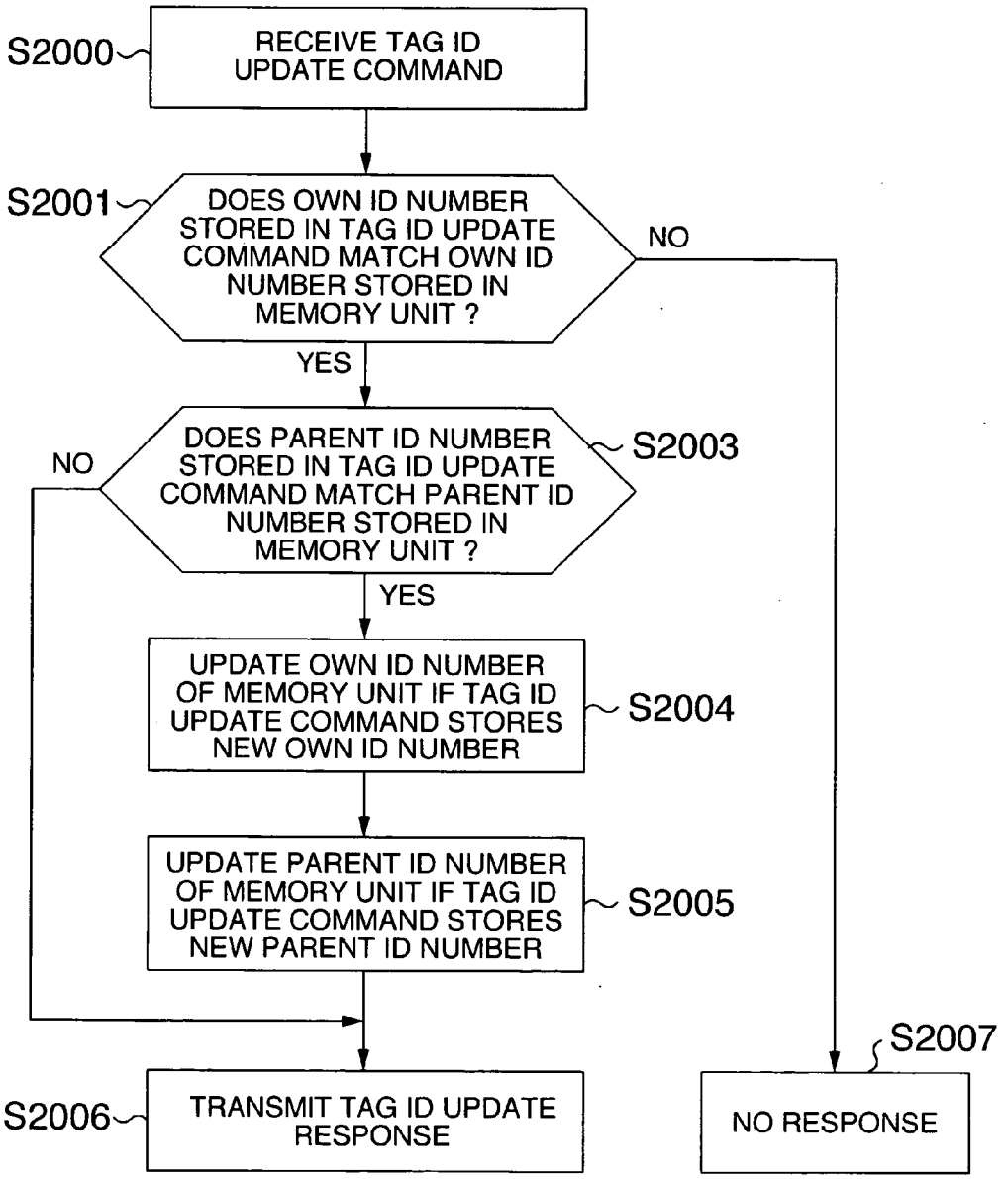
S2000
RECEIVE TAG ID UPDATE COMMAND
S2001
DOES OWN ID NUMBER STORED IN TAG ID UPDATE COMMAND MATCH OWN ID NUMBER STORED IN MEMORY UNIT ?
NO
YES
S2003
DOES PARENT ID NUMBER STORED IN TAG ID UPDATE COMMAND MATCH PARENT ID NUMBER STORED IN MEMORY UNIT ?
NO
YES
S2004
UPDATE OWN ID NUMBER OF MEMORY UNIT IF TAG ID UPDATE COMMAND STORES NEW OWN ID NUMBER
S2005
UPDATE PARENT ID NUMBER OF MEMORY UNIT IF TAG ID UPDATE COMMAND STORES NEW PARENT ID NUMBER
S2006
TRANSMIT TAG ID UPDATE RESPONSE
S2007
NO RESPONSE

FIG. 6

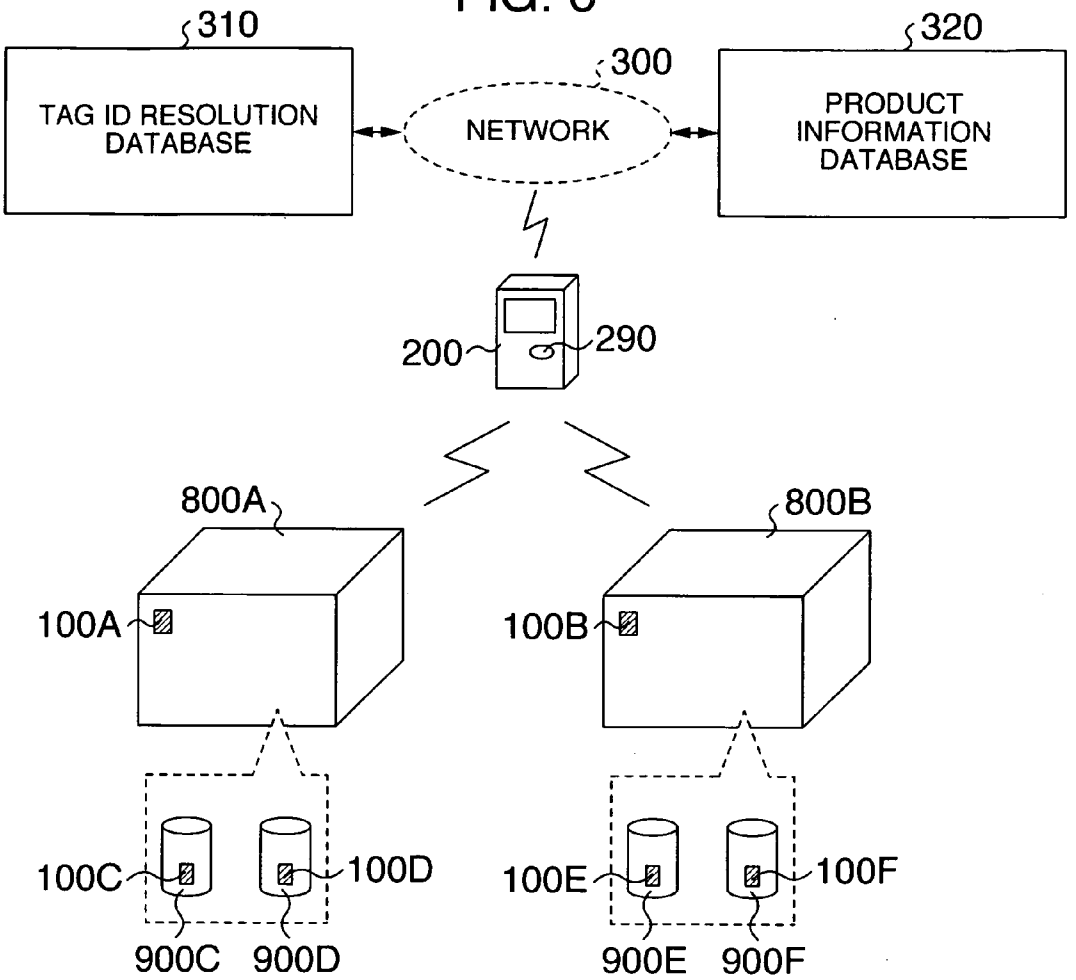

FIG. 7

	PARENT ID NUMBER	OWN ID NUMBER
RFID TAG 100A	0x0000	0x1111
RFID TAG 100B	0x0000	0x2222
RFID TAG 100C	0x1111	0x0101
RFID TAG 100D	0x1111	0x0202
RFID TAG 100E	0x2222	0x0303
RFID TAG 100F	0x2222	0x0404

FIG. 8

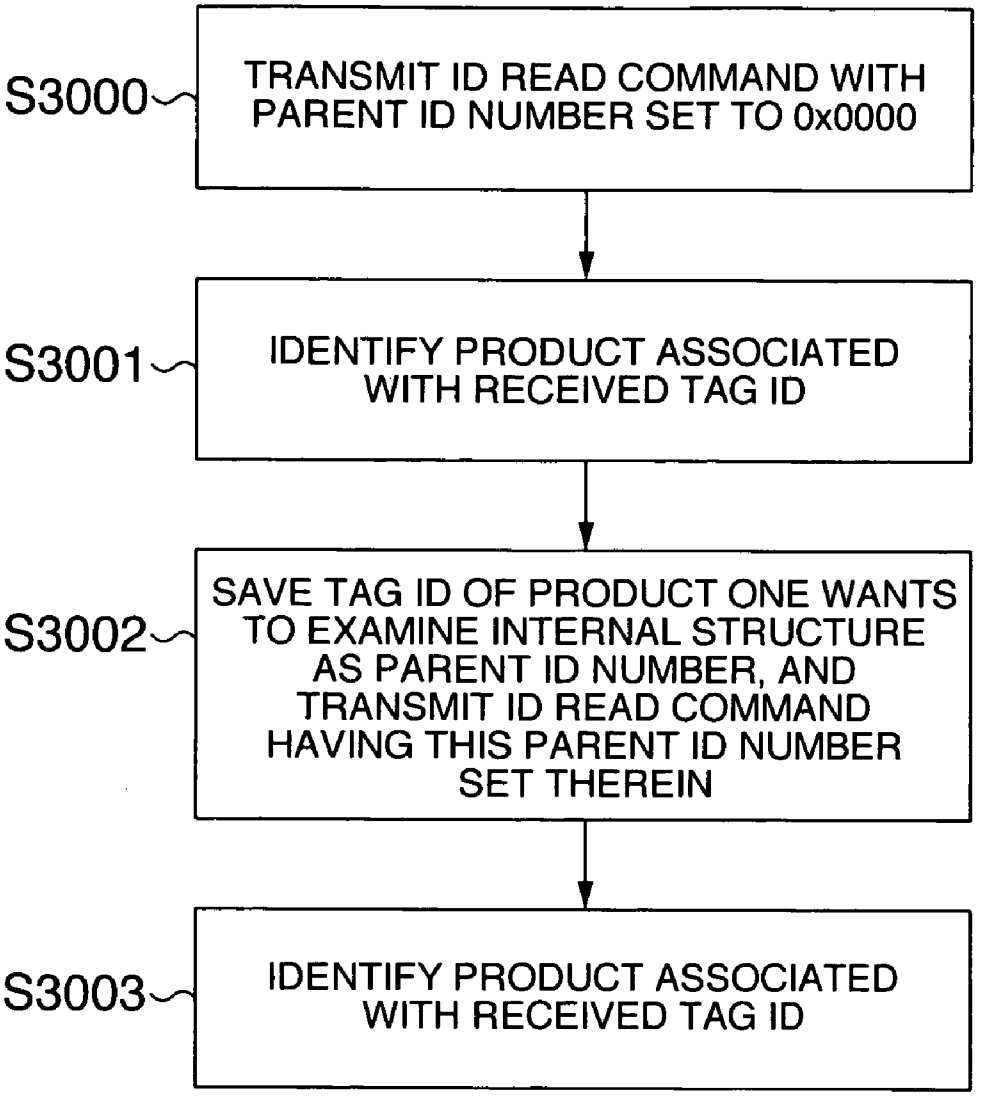
S3000
TRANSMIT ID READ COMMAND WITH PARENT ID NUMBER SET TO 0x0000
S3001
IDENTIFY PRODUCT ASSOCIATED WITH RECEIVED TAG ID
S3002
SAVE TAG ID OF PRODUCT ONE WANTS TO EXAMINE INTERNAL STRUCTURE AS PARENT ID NUMBER, AND TRANSMIT ID READ COMMAND HAVING THIS PARENT ID NUMBER SET THEREIN
S3003
IDENTIFY PRODUCT ASSOCIATED WITH RECEIVED TAG ID

FIG. 9

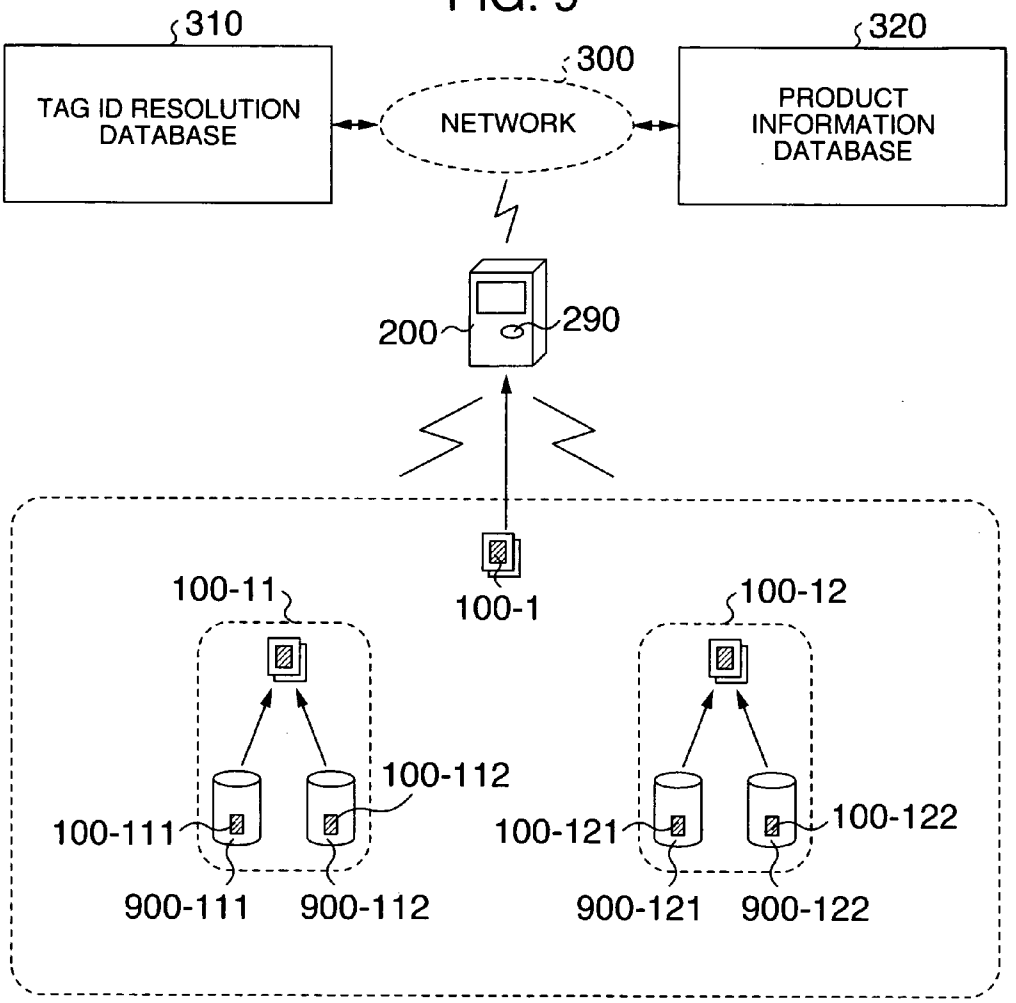
310
TAG ID RESOLUTION DATABASE
300
NETWORK
320
PRODUCT INFORMATION DATABASE
200
290
100-1
100-11
100-12
100-111
100-112
100-121
100-122
900-111
900-112
900-121
900-122

FIG. 10

	PARENT ID NUMBER	OWN ID NUMBER	ASSOCIATED INFORMATION
GROUP TAG 100-1	0x0000	0x1111	MR. YAMADA'S PROPRIETARIES
GROUP TAG 100-11	0x1111	0x2222	PROPRIETARIES NOT OPEN TO PUBLIC
GROUP TAG 100-12	0x1111	0x3333	PROPRIETARIES OPEN TO PUBLIC
RFID TAG 100-111	0x2222	0x0101	POCKETBOOK
RFID TAG 100-112	0x2222	0x0202	WALLET
RFID TAG 100-121	0x3333	0x0303	UMBRELLA
RFID TAG 100-122	0x3333	0x0404	CAMERA

FIG. 11

	PARENT ID NUMBER	OWN ID NUMBER	ASSOCIATED INFORMATION
MOBILE TERMINAL 200	0x4444	-	-
GROUP TAG 100-1	0x4444	0x1111	MR. YAMADA'S PROPRIETARIES
GROUP TAG 100-11	0x1111	0x2222	PROPRIETARIES NOT OPEN TO PUBLIC
GROUP TAG 100-12	0x1111	0x3333	PROPRIETARIES OPEN TO PUBLIC
RFID TAG 100-111	0x2222	0x0101	POCKETBOOK
RFID TAG 100-112	0x2222	0x0202	WALLET
RFID TAG 100-121	0x3333	0x0303	UMBRELLA
RFID TAG 100-122	0x3333	0x0404	CAMERA

RADIO FREQUENCY IDENTIFICATION (RFID) TAG, PORTABLE TERMINAL, AND SERVER FOR RFID TAG

INCORPORATION BY REFERENCE

[0001] The present application claims priority from Japanese application JP2004-378762 filed on Dec. 28, 2004, the content of which is hereby incorporated by reference into this application.

BACKGROUND OF THE INVENTION

[0002] The present invention relates to a radio frequency identification (RFID) tag which comprises an radio communication IC chip, and an information system using the RFID tag.

[0003] In recent years, the RFID tag has drawn attention as a technology for identifying a variety of "objects". The RFID tag is a module comprised of a very small radio communication IC chip and an antenna, and can be designed in a variety of shapes such as a card shape, a label shape and the like. The radio communication IC tip of the RFID tag has a built-in memory from which data can be read in a non-contact manner using a dedicated reader (hereinafter called the "tag reader"). There is also an RFID tag which can write data into a built-in memory in a non-contact manner using a dedicated writer. Further, some tag readers and RFID tags may comprise a mechanism for avoiding collisions of communications (anti-collision function) which can result from simultaneous responses made by a plurality of RFID tags (see, "All about RFID IC Tag", Nikkei BP Inc., Mar. 17, 2004).

[0004] The anti-collision function enables a tag reader to collectively read information from a plurality of RFID tags. An ID number for identifying an article (hereinafter called the "tag ID") can be stored in an RFID tag which has such a feature, such that the RFID tag can be attached to the associated article to permit an efficient article management).

SUMMARY OF THE INVENTION

[0005] However, supposing the widespread proliferation of the RFID tags and tag readers which have the anti-collision function in the future, if ID numbers of such RFID tags are collectively read using a tag reader, the tag reader can read unnecessary ID numbers from unintended RFID tags. For example, when one wishes to identify the ID number of an RFID tag attached to an object placed in his bag, he/she may read ID numbers of RFID tags attached to objects outside the bag. In this event, great difficulties will be experienced in finding which RFID tag is attached to the object placed in the bag, possibly degrading the convenience of the RFID tag. Also, if tag readers are incorporated in mobile terminals such as mobile telephones so that a large number of persons carry the mobile terminal together with the tag readers, the ID number of a certain RFID tag attached to a personal effect of a person can be read by other persons without permission. In this event, a problem will be the leak of information related to the privacy, such as which type of objects a certain person owns.

[0006] The present invention has been made in view of the problem mentioned above, and it is an object of the invention to provide an RFID tag which is placed in a hierarchical structure established among a plurality of the RFID tags, such that ID numbers can be read only from those RFID tags which belong to a particular layer, and is capable of controlling whether permission should be given to read its ID number to protect the ID number. The present invention also provides an information system using the RFID tags.

[0007] To achieve the above object, an RFID tag according to the present invention holds data which can be read from the outside over the air. The RFID tag includes a memory circuit for holding data, and a logic circuit for processing a control command received from the outside over the air, wherein the memory circuit stores an own ID number for identifying the RFID tag itself, and one or more parent ID numbers for identifying other RFID tags, and when the RFID tag receives an ID number read command which contains first data as a parameter from the outside, the logic circuit outputs the own ID number to the outside over the air only when the first data matches the parent ID number.

[0008] Also, a mobile terminal according to the present invention is capable of reading and writing data held by an RFID tag over the air. The mobile terminal includes an RFID tag communication unit for communicating with the RFID tag over the air, an information storage unit for storing data and a control program, an radio communication unit having a function of communicating with a wide area communication network over the air, and an information processing unit for controlling the mobile terminal in accordance with the control program, wherein the control program causes the RFID tag communication unit to transmit an ID number read command containing an ID number of a known RFID tag as a parameter, and causes the RFID tag communication unit to receive an ID number of an unknown RFID tag as a response to the ID number read command.

[0009] Further, an RFID tag server according to the present invention is connected to a mobile terminal through a network for searching for information on an RFID tag which holds data that can be read by the mobile terminal from the outside over the air, wherein the RFID tag stores an own ID number for identifying the RFID tag itself, and one or more parent ID numbers for identifying other RFID tags in a memory circuit, and upon receipt of an ID number read command containing first data as a parameter from the mobile terminal, outputs the own ID number to the outside over the air only when the first data matches the parent ID number, and the RFID tag server comprises a database for storing information associated with the tag ID, and searches the database for information associated with the tag ID upon receipt of the tag ID read from the RFID tag by the mobile terminal through the network.

[0010] Accordingly, the present invention can provide a RFID tag which can protect the ID number of the RFID tag, and an information system which uses the RFID tag.

[0011] Other objects, features and advantages of the invention will become apparent from the following description of the embodiments of the invention taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] **FIG. 1** is a block diagram illustrating the configuration of an RFID tag system according to a first embodiment;

[0013] **FIG. 2** shows a control command and a response which are used to read a tag ID;

[0014] **FIG. 3** is a flow diagram illustrating a sequence of processing executed by an RFID tag **100**A which has received a tag ID read command **400**;

[0015] **FIG. 4** shows a control command and a response which are used to update a tag ID;

[0016] **FIG. 5** is a flow diagram illustrating a sequence of processing executed by the RFID tag **100**A which has received a tag ID update command **400**;

[0017] **FIG. 6** is a diagram illustrating the configuration of the RFID tag system according to the first embodiment;

[0018] **FIG. 7** is a table showing a list of a parent ID number and an own ID number of each RFID tag;

[0019] **FIG. 8** is a flow diagram illustrating a sequence of processing executed by a mobile terminal **200** when it reads a tag ID of each RFID tag;

[0020] **FIG. 9** is a diagram illustrating the configuration of an RFID tag system according to a second embodiment;

[0021] **FIG. 10** is a table (No. 1) showing a list of a parent ID number and an own ID number of each RFID tag; and

[0022] **FIG. 11** is a table (No. 2) showing a list of a parent ID number and an own ID number of each RFID tag.

DESCRIPTION OF THE EMBODIMENTS

[0023] In the following, embodiments of the present invention will be described with reference to the accompanying drawings.

[0024] To begin with, a first embodiment will be described. **FIG. 1** is a block diagram illustrating components of an RFID tag system according to the first embodiment. In **FIG. 1**, the RFID tag system comprises RFID tags **100**A, **100**B, a mobile terminal **200**, a network **300**, a tag ID solution database **310**, and a product information database **320**. Each of the RFID tags **100**A, **100**B has a function of reading and writing a tag ID stored therein using radio communications, and is attached to an associated product.

[0025] In **FIG. 1**, the RFID tag **100**A is attached to a product **900**, while the RFID tag **100**B is attached to a container **800**. The container **800** represents a bock, a shelf or the like which can accommodate the product **900**. Alternatively, the container **800** may not be a physical entity but may represent a logical set that has the product **900** as an element, such as a group to which the product **900** belongs, within the scope of the present invention. Also, the RFID tags may use any frequency band within the scope of the present invention.

[0026] The mobile terminal **200** has a function of reading and writing a tag ID from and into an RFID tag, and also has a function of inquiring of a variety of databases as to a tag ID read from an RFID tag through a network, and may be implemented, for example, by a PDA, a mobile telephone, or a personal computer.

[0027] The network **300** is a wide area communication network which can be accessed over the air or through a line, and may be implemented, for example, by the Internet or a mobile communication network for mobile telephones.

[0028] The tag ID solution database **310** has a function of searching a tag ID solution table **311** for the address (for example, URL or the like) of a database which stores information on an associated product from a tag ID read from an RFID tag. The product information database **310** has a function of searching a product information table **321** for information on a product associated with a tag ID read from an RFID tag.

[0029] The tag ID solution database can form part of a server for ID solution.

[0030] Next, the RFID tag **100**A will be described in greater detail. The RFID tag **100**A comprises an RF IC chip **101**A and an antenna **110**A. The RF IC chip **101**A is a semiconductor module which can be accessed over the air for data stored therein, and comprises an RF circuit **120**A, a power supply unit **130**A, a logic circuit **140**A, and a memory circuit **150**A. While the antenna **110**A can be externally attached to the RFID IC chip **101**A or built in the RFID IC chip **101**A, any implementation is within the scope of the present invention. The RF circuit **120**A demodulates a high-frequency signal received by the antenna **110**A to reproduce a digital signal or modulates a digital signal for radio transmission. Here, any frequency band and modulation/demodulation method may be used by the RF circuit **120**A within the scope of the present invention.

[0031] The power supply unit **130**A generates the power for driving the RF IC chip **101**A from a high-frequency signal received by the antenna **110**A. The logic circuit **140**A demodulates a control command from a digital signal received by the RF circuit **120**A to conduct a control in accordance with the control command. The logic circuit **140**A also encodes the result of the control into a digital signal which is outputted to the RF circuit **120**A. The memory circuit **150**A has a non-volatile storage area, and comprises, for example, a semiconductor memory such as EEPROM.

[0032] The memory circuit **150**A provides the logic circuit **140**A with a data read/write function. The memory circuit **150**A stores an own ID number **151**A and a parent ID number **152**A. The own ID number **151**A represents a tag ID associated with a product **900**A to which the RFID tag **100**A is attached. The parent ID number **152**A represents a tag ID associated with the container **800** which stores the product **900**A, and is used to identify an aggregate to which the own ID number **151**A belongs.

[0033] The RFID tag **100**B which is attached to the container **800** has the same internal configuration as the RFID tag **100**A, but when the container **800** is stored in a higher-rank container, a tag ID associated with the higher-rank container is stored in the memory circuit **150**B as a parent ID number **152**B. In another case, when the container **800** is the highest-rank container, a special number is stored in the memory circuit **150**B as the parent ID number **152**B. For example, the container **800** may be identified to be the highest-rank container by setting zero to all the digits of the parent ID number.

[0034] Next, the mobile terminal **200** will be described in greater detail. The mobile terminal **200** comprises an antenna **210**, an RFID tag communication unit **220**, an information storage unit **230**, an radio communication unit **240**, an information input unit **250**, an information output

unit **260**, an information processing unit **270**, and a power supply unit **280**. The antenna **210** is used to make communications with RFID tags over the air.

[**0035**] The RFID tag communication unit **220** modulates a digital signal for controlling an RFID tag, and outputs the modulated signal through the antenna **210**. In addition, the RFID tag communication unit **220** demodulates a high-frequency signal received by the antenna **210** to extract a digital signal. Here, any frequency band and modulation/demodulation method may be used by the RFID tag communication unit **220** within the scope of the present invention.

[**0036**] The information storage unit **230** has a function of temporarily or permanently storing a program and data processed by the information processing unit **270**, and may comprise, for example, a semiconductor memory such as ROM (Read Only Memory), RAM (Random Access Memory), flash memory or the like. The radio communication unit **240** has a function of connecting to the network **300** over the air, and may use radio communications for wireless LAN and mobile telephone, by way of example. Here, the mobile telephone **200** may be connected to the network **3300** through a line within the scope of the present invention.

[**0037**] The information input unit **250** provides the user with a function of operating the mobile terminal **200**, and may comprise, for example, a numeral key pad, cursor buttons, a liquid crystal display with a touch sensor. The information output unit **260** provides a function of displaying the result of information processing executed by the mobile terminal **200** to the user, and may comprise, for example, a liquid crystal display or the like. The information processing unit **270**, which is based on a microprocessor or the like, executes a control program **231** stored in the information storage unit **230** to govern the control over the entire mobile terminal **200**. The power supply unit **280** supplies the power for operating the mobile terminal **200**.

[**0038**] Next, a control command and a response, used by the mobile terminal **200** for reading the tag ID's of the RFID tags **100**A and **100**B, will be described with reference to **FIGS. 2**. In **FIG. 2**, a tag ID read command is generally designated by **400**, and a tag ID read response by **500**. The tag ID read command **400** is a command transmitted by the mobile terminal **200** when it acquires tag ID's of RFID tags located around the mobile terminal **200**, and is received by all RFID tags which are located around the mobile terminal **200**. The tag ID read response **500**, in turn, is returned by only an RFID tag that satisfies response conditions, among the RFID tags which have received the tag ID read command **400**.

[**0039**] Fields which make up the tag ID read command **400** include a command code field **401**, an La field **402**, a parent ID number field **403**, an Lb field **404**, an own ID number mask field **405**, and a check sum field **406**. The command code field **401** stores a code for identifying the type of the command. The La field **402** indicates the length of the parent ID number field **403**. The parent ID number field **403** stores a parent ID number. The Lb field **404** indicates the length of the own ID number mask field **405**. The own ID number mask field **405** stores part of an own ID number. The check sum field **406** stores a code for checking a command for possible errors upon reception. For example, a CRC code may be stored in the check sum field **406**. Alternatively, another error check code may be used within the scope of the present invention.

[**0040**] Fields which make up the tag ID read response **500** include an Lc field **501**, an own ID number field **502**, and a check sum field **503**. The Lc field **501** stores the length of the own ID number field **502**. The own ID number field **502** stores the own ID number of an RFID tag which has responded. The check sum field **503** stores a code for checking a response for possible errors upon reception. For example, a CRC code may be stored in the check sum field **503**. Alternatively, another error check code may be used within the scope of the present invention.

[**0041**] Next, **FIG. 3** illustrates a processing flow of the RFID tag **100**A which has received the tag ID read command **400**. In **FIG. 3**, first, upon receipt of the tag ID read command **400** at step S**1000**, the RFID tag **100**A checks at step S**1001** whether or not the value of a parent ID number stored in the parent ID number field **403** of the tag ID read command **400** matches the parent ID number **152**A stored in the memory circuit **150**A. If they do not match, the RFID tag **100**A terminates the processing flow at step S**1003** without returning a response (no response). On the other hand, if they match, the RFID tag **100**A checks at step S**1002** whether or not the own ID number stored in the own ID number mask field **405** of the tag ID read command **400** matches upper bits of the own ID number **151**A stored in the memory circuit **150**A. Assume, for example, that the own ID number has a length of 16 bits, and the own ID number **151**A is "1111 0101 0000 1010" in binary notation.

[**0042**] In this event, when the own ID number mask field **405** stores "1111" in binary notation, the check at step S**1002** is successful because the upper four bits of the own ID number **151**A match the value stored in the own ID number mask field **405**. On the other hand, when the own ID number mask field **405** stores "1010" in binary notation, the check at step S**1002** fails because the upper four bits of the own ID number **151**A do not match the value stored in the own ID number mask field **405**. If the check fails at step S**1002**, the RFID tag **100**A terminates the processing flow at step S**1003** without returning a response (no response). Conversely, if the check is successful at step S**1002**, the RFID tag **100**A returns the tag ID read response **500** which contains the own ID number **151**A stored in the memory circuit **150**A in the own ID number field **502** at step S**1004**.

[**0043**] In the tag ID read process described above, executed by the RFID tag, the RFID tag can be prevented from responding if the parent ID number stored therein does not match the parent ID number contained in the tag ID read command **400**, with the execution of step S**1001**. Also, with the execution of step S**1002**, the RFID tag can implement an anti-collision function for avoiding a collision resulting from simultaneous responses made by a plurality of RFID tags when there are a plurality of RFID tags, the parent ID number of which matches the parent ID number contained in the tag ID read command **400**, as determined at step S**1001**.

[**0044**] For example, the mobile terminal **200** may first transmit the tag ID read command **400** without the own ID number mask field **405** (the Lb field is set to zero). If a plurality of RFID tags respond to the command **400** to cause a collision, the mobile terminal **200** may next transmit the tag ID read command **400** which contains 1-bit data "0" stored in the own ID number mask field **405**. If a collision

occurs again, the mobile terminal **200** may again transmit the tag ID read command **400** which contains 2-bit data "00" stored in the own ID number mask field **405**. In this way, the mobile terminal **200** may change the number of bits and the value stored in the own ID number mask field **405** until a collision no longer occurs. Here, as long as the parent ID number field is defined in the tag ID read command **400** such that a response can be made only by an RFID tag, the parent ID number of which matches the value stored in the parent ID number field, an anti-collision mechanism different from the foregoing method may be used within the scope of the present invention.

[**0045**] Next, a control command and a response, used by the mobile telephone **200** for updating the tag ID's of the RFID tags **100**A and **100**B, will be described with reference to **FIG. 4**.

[**0046**] In **FIG. 4**, a tag ID update command is generally designated by **600**, and a tag ID update response by **700**. Fields which make up the tag ID update command **600** include a command code field **601**, an Ld field **602**, an own ID number field **603**, an Le field **604**, a parent ID number field **605**, an Lf field **606**, and a new own ID number field **607**, an Lg field **608**, and a new ID number field **609**, and a check sum field **610**.

[**0047**] The command code field **610** stores a code for identifying the type of the command. The Ld field **602** indicates the length of the own ID number field. The own ID number field **603** stores a current own ID number of an RFID tag to which the command is to be transmitted. The Le field **604** indicates the length of the parent ID number field **605**. The parent ID number field **605** stores a current parent ID number field of the RFID tag to which the command is to be transmitted. The Lf field **606** indicates the length of the new own ID number field **607**. The new own ID number field **607** stores an updated own ID number. The Lg field **608** indicates the length of the new parent ID number field **609**. The new parent ID number field **609** stores an updated parent ID number. The check sum field **610** stores a code for checking the command for possible errors upon reception.

[**0048**] Field which make up the tag ID update response **700** include a status field **701** and a check sum field **702**. The status field **701** indicates whether or not the tag ID has been successfully updated. The check sum field **702** stores a code for checking the response for possible errors upon reception.

[**0049**] Next, **FIG. 5** illustrates a processing flow of the RFID tag **100**A when it has received the tag ID update command. In **FIG. 5**, first, upon receipt of the tag ID update command **600** at step S**2000**, the RFID tag **100**A checks whether or not an own ID number stored in the own ID number field **603** of the tag ID update command **600** matches the own ID number **151**A stored in the memory circuit **150**A. If they do not match, the RFID tag **100**A terminates the processing flow at step S**2007** without returning a response (no response). If they match, the RFID tag **100**A next checks at step S**2003** whether or not a parent ID number stored in the parent ID number field **605** of the tag ID update command **600** matches the parent ID number **152**A stored in the memory circuit **150**A.

[**0050**] If they do not match, the RFID tag **100**A transmits the tag ID update response **700** which contains data indicative of a failed update, set in the status field **701**, at step S**2006**. Conversely, if they match, the RFID tag **100**A rewrites the value of the own ID number **151**A stored in the memory circuit **150**A to a value stored in the new own ID number field **607** at step S**2004**, provided that the Lf field **606** contains a value other than zero, indicating that the new own ID number field **607** stores the value. Next, at step S**2005**, if the Lg field **608** contains a value other than zero, indicating that the new parent ID number field **609** stores a value, the RFID tag **100**A rewrites the value of the parent ID number **152**A stored in the memory circuit **150**A to the value stored in the new parent ID number field **609**. Next, at step S**2006**, the RFID tag **100**A sets data indicative of a successful update in the status field **701**, and transmits the resulting tag ID update response **700**.

[**0051**] In the tag ID update process described above, executed by the RFID tag, the RFID tag can be prevented from updating the tag ID if the current parent ID number stored therein does not match the parent ID number contained in the tag ID update command **600**, with the execution of step S**2003**. Thus, the RFID tag cannot update the tag ID unless it knows the current parent ID number, so that the tag ID can be updated without permission with lower possibility to improve the security.

[**0052**] Next, for describing the operation of the mobile terminal **200**, **FIG. 6** illustrates an exemplary configuration of a RFID tag system related to this embodiment. In **FIG. 6**, a product **900**C to which an RFID tag **100**C is attached, and a product **900**D to which an RFID tag **100**D is attached are stored in a container **800**A. The RFID tag **100**A is attached to the container **800**A. Also, a product **900**E to which an RFID tag **100**E is attached, and a product **900**F to which an RFID tag **100**F is attached are stored in a container **800**B. The mobile terminal **200** reads these RFID tags for attempting to recognize in which container each product is stored. Here, the mobile terminal **200** comprises an RFID tag read button **290** which, when depressed by the user, triggers an RFID tag read process.

[**0053**] While the RFID tags **100**A, **100**B, **100**C, **100**D, **100**E, **100**F have the same configuration as the RFID tag described in connection with **FIG. 1**, they differ from one another in the own ID number and parent ID number. **FIG. 7** shows a table which lists the correspondence between the own ID numbers and parent ID numbers assigned to the RFID tags **10**A, **100**B, **100**C, **100**D, **100**E, **100**F. Here, while both the own ID number and parent ID number are assumed to have a length of two bytes (16 bits) in the following description, the present invention can be applied irrespective of the lengths of the respective ID numbers.

[**0054**] In **FIG. 7**, the RFID tags **100**A, **100**B store a parent ID number equal to "0x0000". Assume that this means that no parent ID number is assigned to the RFID tags **100**A, **100**B. The RFID tags **100**C, **100**D store a parent ID number equal to the own ID number of the RFID tag **10**A. In this way, an association can be established in that the product **900**C to which the RFID tag **100**C is attached, and the product **900**D to which the RFID tag **100**D is attached are components of the container **800**A to which the RFID tag **100**A is attached. On the other hand, the RFID tags **100**E, **100**F store a parent ID number equal to the own ID number of the RFID tag **100**B. In this way, an association can be established in that the product **900**E to which the RFID tag **100**E is attached, and the product **900**F to which the RFID

tag **100**F is attached are components of the container **800**B to which the RFID tag **100**B is attached.

[**0055**] Next, a processing flow executed by the mobile terminal **200** for reading the tag ID of each RFID tag will be described with reference to **FIG. 8**. In **FIG. 8**, as the RFID tag read button **290** is depressed, the mobile terminal **200** first transmits a tag ID read command **400** which contains the parent ID number set to 0x0000. As a result, the RFID tags **100**A, **100**B respond to the command **400**, and the mobile terminal **200** acquires their respective own ID numbers as tag ID's. Here, the RFID tags **100**C, **100**D, **100**E, **100**F do not respond because they have parent ID numbers different from that specified by the tag ID read command **400**.

[**0056**] Next, at step S**3001**, the mobile terminal **200** inquires of the tag ID solution database **310** and product information database **320** as to information on products associated with the tag ID's received thereby, and recognizes that the RFID tag **100**A is attached to the container **800**A, and the RFID tag **100**B is attached to the container **800**B. Next, at step S**3002**, for examining products stored in the container **800**A, the mobile terminal **200** sets the tag ID of the RFID tag **100**A attached to the container **800**A in the parent ID number of a tag ID read command ID, and transmits the tag ID read command **400**. As a result, the RFID tags **100**C, **100**D respond to the command **400**, and the mobile terminal **200** acquires their respective own ID numbers as tag ID's. Here, the RFID tags **100**A, **100**B, **100**E, **100**F do not respond because they have parent ID numbers different from that specified by the tag ID read command **400**.

[**0057**] Next, at step S**3003**, the mobile terminal **200** inquires of the tag ID solution database **310** and product information database **320** as to information on products associated with the tag ID's received thereby, and the mobile terminal **200** recognizes that the RFID tag **100**C is attached to the product **900**C, and the RFID tag **100**D is attached to the product **900**D, and also recognizes that the products **900**C, **900**D are stored in the container **800**A. By repeating steps S**3002**, S**3003** in a similar manner, the mobile terminal **200** can recognize that the products **900**E, **900**F are stored in the container **800**B.

[**0058**] By the method described above, a hierarchical structure can be established among the RFID tags, so that the mobile terminal **200** can read only tag ID's of those RFID tags which belong to a particular layer, rather than collectively reading the tag ID's of RFID tags located around the mobile terminal **200**. In this way, the mobile terminal **200** can acquire a particular RFID tag, and information on a product associated with this RFID tag, without reading information on unnecessary RFID tags. Since the mobile terminal **200** does not read information on unnecessary RFID tags, the mobile terminal **200** does not inquire of the databases as to information on unnecessary products, thus expecting an increase in the speed of processing and improving the usability for the user.

[**0059**] Also, in the present invention, the mobile terminal **200** is provided with the RFID tag read button **290**, such that the RFID tag read process is triggered by a depression onto the RFID tag read button **290**. While the RFID tag read process consumes the power as required, the mobile terminal **200** will not perform the tag ID read process for nothing as long as the RFID tag read button **290** is not depressed. This can limit the power consumption caused by the tag ID read process. When the mobile terminal **200** is implemented in a mobile telephone, the foregoing process is presumably important because a reduction in power consumption is essential for the mobile telephone.

[**0060**] Also, when the mobile terminal **200** is implemented in a mobile telephone, the network **300** is a mobile communication network for the mobile telephone. In this situation, the mobile telephone transmits radiowaves to a base station connected to the mobile communication network using the radio communication unit **240** on a periodic basis to confirm an incoming call and the like. In the present invention, on the other hand, the mobile terminal **200**, which is a mobile terminal, generates radiowaves for communicating with RFID tags using the RFID tag communication unit **220**. If radiowaves transmitted to the base station are generated simultaneously with the radiowaves transmitted to RFID tags, an interference can occur depending on the frequencies of the respective radiowaves, resulting in a failure in the transmission to the base station or the communication with RFID tags. To avoid this problem, in the present invention, the mobile terminal **20** controls the RFID tag communication unit **220** to wait without transmitting radiowaves while the radio communication unit **240** is transmitting radiowaves, and to transmit radiowaves after the radio communication unit **240** has transmitted radiowaves.

[**0061**] Next, a second embodiment will be described. **FIG. 9** illustrates the configuration of an RFID tag system according to the second embodiment. In **FIG. 9**, the RFID tag system comprises group tags **100-1**, **100-11**, **100-12**; RFID tags **100-111**, **100-112**, **100-121**, **100-122**; a mobile terminal **200**; a network **300**; a tag ID solution database **310**; and a product information database **320**. The group tags **100-1**, **100-11**, **100-12** are RFID tags for identifying logical sets. For example, they indicate such sets as "Mr. Yamada's proprietaries" or "proprietaries which an owner does not want others to know that he owns." The group tags **100-1**, **100-11**, **100-12** have the same internal configuration as the RFID tag **100**A. The RFID tags **100-111**, **100-112**, **100-121**, **100-122** are RFID tags attached to products.

[**0062**] In **FIG. 9**, the RFID tag **100-111** is attached to a product **900-111**; the RFID tag **100-112** to a product **900-112**; the RFID tag **100-121** to a product **900-121**; and the RFID tag **100-122** to a product **900-122**. The RFID tags **100-111**, **100-112**, **100-121**, **100-122** have the same internal configuration as the RFID tag **100**A described in the first embodiment. The mobile terminal **200**, network **300**, tag ID solution database **310**, and product information database **320** have the same functions as those described in the first embodiment. Here, the group tags **100-1**, **100-11**, **100-12** may be, for example, in a card shape. Otherwise, the group tags may be in any other shape within the scope of the present invention.

[**0063**] Next, **FIG. 10** shows a list of a parent ID number and an own ID number stored in each of the group tags and RFID tags, and information associated with tag ID's. Here, while both the own ID number and parent ID number are assumed to have a length of two bytes (16 bits) in the following description, the present invention can be applied irrespective of the lengths of the respective ID numbers.

Also, the information associated with the tag ID's is managed using the tag ID solution database **310** and product information database **320** which is connected to the network **300**.

[**0064**] In **FIG. 10**, the group tag **100-1** stores a parent ID number equal to "0x0000." This means that no parent ID number is set in the group tag **100-1** and that the group tag **100-1** is positioned in the highest layer. Information associated with the group tag **100-1** indicates "Mr. Yamada's proprietary," meaning that RFID tags located in lower layers, which can be referenced with the group tag **100-1** positioned at a base point, are all attached to Mr. Yamada's proprietaries.

[**0065**] Next, the group tag **100-11** stores a parent ID number equal to the own ID number of the group tag **100-1**. Also, information associated with the group tag **100-11** indicates "proprietaries not open to the public," meaning that RFID tags located in lower layers, which can be referenced with the group tag **100-11** positioned at a base point, are all attached to Mr. Yamada's proprietaries which should not be open to the public. Next, the tag group **100-12** stores a parent ID number equal to the own ID number of the group tag **100-1**. Also, information associated with the group tag **100-12** indicates "proprietaries open to the public," meaning that RFID tags located in lower layers, which can be referenced with the group tag **100-12** positioned at a base point, are all attached to Mr. Yamada's proprietaries which may be open to the public.

[**0066**] Next, the RFID tag **100-111** stores a parent ID number equal to the own ID number of the group tag **100-11**. Also, information associated with the RFID tag **100-111** indicates a "pocketbook" so that this pocketbook is one of Mr. Yamada's proprietaries not open to the public. Next, the RFID tag **100-112** stores a parent ID number equal to the own ID number of the group tag **100-11**. Also, information associated with the RFID tag **100-112** indicates a "wallet" so that this wallet is one of Mr. Yamada's proprietaries not open to the public. Next, the RFID tag **100-121** stores a parent ID number equal to the own ID number of the group tag **100-12**. Also, information associated with the RFID tag **100-121** indicates an "umbrella" so that this umbrella is one of Mr. Yamada's proprietaries which may be open to the public. Next, the RFID tag **100-122** stores a parent ID number equal to the own ID number of the group tag **100-12**. Also, information associated with the RFID tag **100-122** indicates a "camera" so that this camera is one of Mr. Yamada's proprietaries which may be open to the public.

[**0067**] With the configuration described above, when one attempts to identify, for example, the product **900-111** (corresponding to the "wallet"), the group tag **100-1** is first identified, then the group tag **100-11** is identified using a tag ID read command which contains the tag ID of the group tag **100-1** in the parent ID number, the RFID tag **100-111** is next recognized using a tag ID read command which contains the tag ID of the group tag **100-11** in the parent ID number, and the product **900-1111** is identified from the tag ID of the RFID tag **100-111**. This identification will fail unless the group tags **100-1**, **100-11** are not located. Thus, if a certain group tag is left in a separate place or covered with a shielding plate such that it does not respond to radiowaves, no one can read information associated with an RFID tag which stores an parent ID number equal to the tag ID of that group tag. In the example of **FIG. 9**, when Mr. Yamada goes out, he may leave the group tag **100-11** indicative of "proprietaries not open to the public" in the house, and may carry the remaining group tags and the products to which the RFID tags are attached. In this way, Mr. Yamada can prevent others from reading, without permission, the tag ID's of RFID tags attached to products which Mr. Yamada wants not to be open to the public in places away from home.

[**0068**] It is further possible to set a parent ID number in the group tag **100-1**, and store this parent ID number in the information storage unit **230** of the mobile terminal **200** owned by the user as the parent ID number **232**. For example, ID numbers have been set as shown in **FIG. 11**. In **FIG. 11**, the parent ID number of the group tag **100-1** is set in the mobile terminal **200**. Thus, it is only the mobile terminal **200** which knows the parent ID number of the group tag **100-1** that can read the own ID number of the group tag **100-1**, and information associated with other group tags and RFID tags. In this way, even if one carries all products, to which the group tags and RFID tags are attached, when he goes out, a third party can be prevented from reading information associated with the RFID tags without permission.

[**0069**] While the foregoing embodiments have been described in connection with an RFID tag which stores one parent ID number, the RFID tag may store two or more different parent ID numbers within the scope of the present invention. When an RFID tag has two or more parent ID numbers, an associated product can belong to a plurality of sets, and the own ID number of the RFID tag can be acquired using a tag ID read command which contains any of the parent ID numbers stored in the RFID tag.

[**0070**] As described above, according to the present invention, a hierarchical structure is established among a plurality of RFID tags, so that one can read only ID numbers of RFID tags which belong to a particular layer. The RFID tag can control whether permission should be given to read its ID number to protect the ID number.

[**0071**] It should be further understood by those skilled in the art that although the foregoing description has been made on embodiments of the invention, the invention is not limited thereto and various changes and modifications may be made without departing from the spirit of the invention and the scope of the appended claims.

1. An RFID tag which hold data that can be read therefrom from outside over the air, said RFID tag co rising:

a memory circuit for holding data; and

a logic circuit for processing a control command received from outside over the air,

wherein said memory circuit stores an own ID number for identifying said RFID tag itself, and one or more parent ID numbers for identifying other RFID tags, and

when said REID tag receives an ID number read command which contains first data as a parameter from outside, said logic circuit outputs the own ID number to outside over the air only when the first data matches the parent ID number.

2. A mobile terminal capable of reading and writing data held by an RFID tag over the air, comprising:

an RFID tag communication unit for communicating with said RFID tag over the air;

an information storage unit for storing data and a control program;

an radio communication unit having a function of communicating with a wide area communication network over the air; and

an information processing unit for controlling said mobile terminal in accordance with the control program,

wherein said control program causes said RFID tag communication unit to transmit an ID number read command which contains an ID number of a known RFID tag as a parameter, and causes said RFID tag communication unit to receive an ID number of an unknown RFID tag as a response to the ID number read command.

3. The mobile terminal according to claim 2, wherein said control program disables said RFID tag communication unit to make a communication over the air while said radio communication unit is communicating with said wide area communication network over the air, and enables said RFID tag communication unit to make a communication over the air when said radio communication unit is not making a communication over the air.

4. An RFID tag system comprising a first RFID tag attached to a first product, a second RFID tag attached to a second product, and a mobile terminal for reading over the air data stored in said first RFID tag and said second RFID tag, wherein:

said first RFID tag includes a memory circuit for holding a first own ID number for identifying said first RFID tag, and a first parent ID number for identifying another RFID tag,

said second RFID tag includes a memory circuit for holding a second own ID number for identifying said second RFID tag, and a second parent ID number for identifying another RFID tag, and

said first parent ID number has the same value as the second own ID number, and said second parent ID number has the same value as an ID number for identifying a third RFID tag.

5. The RFID tag system according to claim 4, wherein:

when said first RFID tag receives an ID number read command from the outside, said ID number read command containing first data as a parameter of a parent ID number, said firth RFID tag outputs the first own ID number to outside over the air only when the first data matches the first parent ID number, and

when said second RFID tag receives an ID number read command from outside, said ID number read command containing second data as a parameter of a parent ID number, said second RFID tag outputs the second own ID number to outside over the air only when the second data matches the second parent ID number.

6. The RFID tag system according to claim 4, wherein:

said mobile terminal comprises an RFID tag communication unit for communicating with said first RFID tag and said second RFID tag over the air, an information storage unit for storing data and a control program, an radio communication unit for communicating with a wide area communication network over the air, and an information processing unit for controlling said mobile terminal in accordance with said control program, and

said control program causes said RFID tag communication unit to transmit an ID number read command which contains the ID number of said third RFID tag as a parameter to acquire the ID number of said second RFID tag, and subsequently causes said RFID tag communication unit to transmit an ID number read command which contains the ID number of said second RFID tag as a parameter to acquire the ID number of said first RFID tag.

7. An RFID tag which hold data that can be read therefrom from outside over the air, said RFID tag comprising:

a memory circuit for holding data; and

a logic circuit for processing a control command received from outside over the air,

wherein said memory circuit stores an own ID number for identifying said RFID tag itself, and one or more parent ID numbers for identifying other RFID tags, and

when said RFID tag receives an ID number read command which contains first data as a parameter from outside, said logic circuit outputs the own ID number to outside over the air only when the first data matches the parent ID number.

8. An RFID tag server connected to a mobile terminal through a network for searching for information on an RFID tag which holds data that can be read by said mobile terminal from outside over the air, wherein:

said RFID tag stores an own ID number for identifying said RFID tag itself, and one or more parent ID numbers for identifying other RFID tags in a memory circuit, and upon receipt of an ID number read command from said mobile terminal, said ID number read command containing first data as a parameter, outputs the own ID number to outside over the air only when the first data matches the parent ID number, and

said RFID tag server comprises a database for storing information associated with said tag ID, and searches said database for information associated with the tag ID upon receipt of the tag ID read from said RFID tag by said mobile terminal through said network.

9. The RFID tag server according to claim 8, wherein:

said RFID tag is attached to a product, and

said database has a tag ID solution table which includes the tag ID and an address of another database which stores information on the product to which said RFID tag is attached.

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