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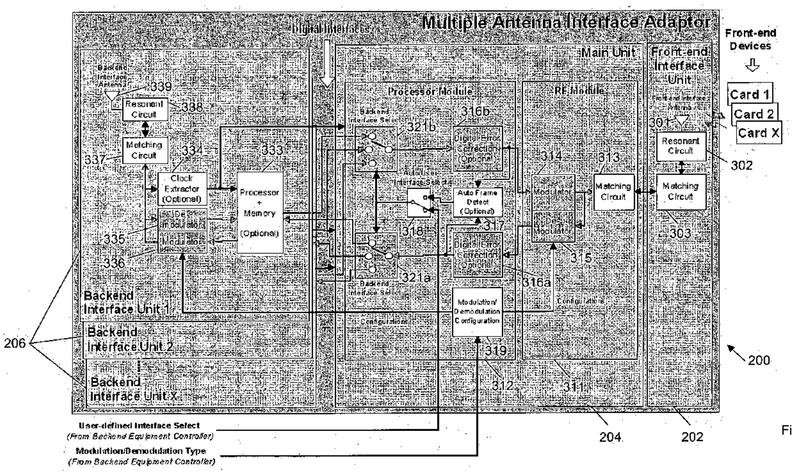

Fig. 3

(57) Abstract: A multiple antenna interface adaptor (200) for interfacing a front-end device and a plurality of backend devices, wherein each backend device comprises a transmitter and a receiver, is disclosed. The plurality of backend devices comprises a matching backend device configured to cooperate with a front-end device to perform a required operation and the multiple antenna interface adaptor (200) comprises a front-end interface unit (202) configured to communicate wirelessly with the front-end device; a plurality of backend interface units (206), each of the backend interface units (206) configured to communicate wirelessly with a respective backend device in the plurality of backend devices; and a backend interface select unit (321a) configured to successively couple each of the backend interface units (206) with the front-end interface unit (202) such that the backend interface unit (206) configured with the matching backend device is eventually coupled with the front-end interface unit (202), allowing the matching backend device to cooperate with the front-end device to perform the required operation.

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A Multiple Antenna Interface Adaptor

Field of the invention

The present invention relates to a multiple antenna interface adaptor for interfacing a front-end device (e.g. a contactless card) with a plurality of backend devices (e.g. contactless card readers), one of which is configured to cooperate with the front-end device to perform a required operation.

Background of the Invention

The use of contactless cards has become prevalent over the past few years. For example, contactless cards are now often used for access control whereby a user has to present a contactless card to a card reader placed at the entrance of a restricted area before the user can gain access to the restricted area. Furthermore, many payment systems have also switched to using contactless cards. In this case, a contactless card is presented to a reader to transmit payment information to the reader and this payment information is then used to deduct the required payment from the user's account.

Fig. 1 illustrates a conventional card-reader system 100 for reading contactless cards. This card-reader system 100 may be part of an equipment at a kiosk or at a transit gate. As shown in Fig. 1, the card-reader system 100 comprises a plurality of backend devices (Backend Device 1, Backend Device 2... Backend Device X) in the form of contactless card readers. Each backend device (backend card reader) comprises an antenna (not shown in Fig. 1) configured to transmit and receive signals between itself and a front-end device in the form of a contactless card. The backend card readers are in turn connected to a controller (Backend Equipment Controller) which is configured to control the operations of the card-reader system 100. Contactless cards 1 – X are issued by different card issuers and each backend card reader in the card-reader system 100 specifically works with only of the cards 1 – X. In other words, only

Backend Device 1 (and not Backend Devices 2 – X) is capable of cooperating with card 1 to perform the required operation, only Backend Device 2 (and not Backend Devices 1, 3 – X) is capable of cooperating with card 2 to perform the required operation and so on. Thus, a user has to first locate, among the multiple backend card readers, the backend card reader configured to work with his or her card before the user can use the card. This can be difficult, confusing and extremely inconvenient for the card user.

Although a general card reader capable of working with cards from different card issuers may be implemented, most card issuers are unwilling to disclose their software key controls for the implementation of the general card reader in the form of a single hardware due to security reasons. Because of this and possibly other commercial reasons, there remain several obstacles in implementing the general card reader as mentioned.

Summary of the invention

The present invention aims to provide a new and useful multiple antenna interface adaptor for interfacing a front-end device (e.g. a contactless card) to a plurality of backend devices (e.g. contactless card readers), one of which is configured to cooperate with the front-end device to perform a required operation.

In general terms, the present invention proposes that the multiple antenna interface adaptor successively tries to form a communication bridge between the front-end device and each of the backend devices until the backend device configured to cooperate with the front-end device to perform the required operation is located.

More specifically, a first aspect of the present invention is a multiple antenna interface adaptor for interfacing a front-end device and a plurality of backend devices, wherein each backend device comprises a transmitter and a receiver, and the plurality of backend devices comprises a matching backend device configured to cooperate with the front-end device to perform a required operation, and the multiple antenna interface adaptor comprises: a front-end interface unit configured to communicate wirelessly with the front-end device; a plurality of backend interface units, each of the backend interface units configured to communicate wirelessly with a respective backend device in the plurality of backend devices; and a backend interface select unit configured to successively couple each of the backend interface units with the front-end interface unit such that the backend interface unit configured to communicate with the matching backend device is eventually coupled with the front-end interface unit, allowing the matching backend device to cooperate with the front-end device to perform the required operation.

A second aspect of the present invention is a method for interfacing a front-end device and a plurality of backend devices, wherein each backend device comprises a transmitter and a receiver, and the plurality of backend devices comprises a matching backend device configured to cooperate with the front-end device to perform a required operation and the method comprises: successively communicating data wirelessly from each of the backend devices to a front-end interface unit and from the front-end interface unit to the front-end device such that the data from the matching backend device is eventually communicated to the front-end device, thereby allowing the matching backend device to cooperate with the front-end device to perform the required operation.

The present invention is advantageous as it takes over from the user the task of locating the specific backend device that works with the user's front-end device. For example, in a contactless card application, the user interface may simply comprise a single multiple antenna interface adaptor of the present invention (instead of multiple card readers) and the required operation can be performed by presenting a card from any card issuer to the multiple antenna interface adaptor. This increases the level of convenience for the user. Furthermore, in this application, the present invention may be integrated with a conventional card-reader system without substantially modifying the conventional card-reader system.

Brief Description of the Figures

An embodiment of the invention will now be illustrated for the sake of example only with reference to the following drawings, in which:

Fig. 1 shows a conventional contactless card-reader system;

Fig. 2 shows a multiple antenna interface adaptor according to a first embodiment of the present invention in a first application;

Fig. 3 shows details of the multiple antenna interface adaptor of Fig. 2;

Fig. 4 shows details of a multiple antenna interface adaptor according to a second embodiment of the present invention;

Fig. 5 shows details of a multiple antenna interface adaptor according to a third embodiment of the present invention;

Fig. 6 shows the multiple antenna interface adaptor of Fig. 2 in a second application; and

Fig. 7 shows the multiple antenna interface adaptor of Fig. 2 in further applications.

Detailed Description of the Embodiments

Referring to Fig. 2, a multiple antenna interface adaptor 200 according to a first embodiment of the present invention is shown. In Fig. 2, the multiple antenna interface adaptor 200 is used in a contactless card application involving cards and card readers compliant with the ISO 14443 standard.

The multiple antenna interface adaptor 200 in Fig. 2 serves to interface a front-end device (in the form of a contactless card which may be any of cards 1 – X) with a plurality of backend devices (in the form of contactless card readers). The backend devices are comprised in a backend equipment which is in the form of a contactless card-reader system 100'. Each backend device comprises a transmitter and a receiver.

The front-end device (front-end card) comprises a micro-chip which serves to control the operations of the components in the card and an antenna which serves to communicate data in the form of electromagnetic waves between the front-end card and the multiple antenna interface adaptor 200. The card further comprises a resonant circuit which is tuned to a resonant frequency f_0. This allows the resonant circuit to generate signals at this frequency f_0 for transmission to the multiple antenna interface adaptor 200 and to receive signals at this frequency f_0 from the multiple antenna interface adaptor 200.

Furthermore, the front-end card may be active or passive. While an active card comprises its own internal power source to drive its micro-chip and its transmission of data, a passive card does not. Instead, the passive card is powered by a voltage induced via inductive coupling between the resonant circuit in the card and a resonant circuit in the multiple antenna interface adaptor 200.

Besides the contactless card-reader system 100' shown in Fig. 2, the multiple antenna interface adaptor 200 can also interface the front-end card with other types of contactless card-reader systems. In the contactless card-reader system 100', at least one (in one example, only one) of the backend devices (backend card readers) is a matching backend card reader configured to cooperate with the front-end card to perform a required operation. The front end card only responds to data from a matching backend card reader and not to data from other backend card readers.

As shown in Fig. 2, the multiple antenna interface adaptor 200 comprises a front-end interface unit 202 connected to a plurality of backend interface units 206 (Backend Interface Unit 1 – Backend Interface Unit X) via a main unit 204. The front-end interface unit 202 serves to communicate wirelessly with the front-end card whereas each backend interface unit 206 is configured to communicate wirelessly with a respective backend card reader in the contactless card-reader system 100'.

For upstream communication from the contactless card-reader system 100' to the front-end card, data from each backend card reader is first modulated using Amplitude Shift Keying (ASK) modulation (in accordance with the ISO14443 standard) before it is transmitted in the form of electromagnetic waves to the multiple antenna interface adaptor 200. This data is demodulated using ASK demodulation, processed and then re-modulated again using ASK modulation in the multiple antenna interface adaptor 200 before it is transmitted to the front-end card in the form of electromagnetic waves. In one example, the ASK modulation/demodulation for this upstream wireless link uses a 13.56MHz carrier frequency. Note that depending on the application in which the multiple antenna interface adaptor 200 is used and the type of wireless devices involved in the application, different modulation/demodulation schemes and/or different carrier frequencies may be used for the upstream wireless link.

In the contactless card application as shown in Fig. 2, a different modulation technique is used for downstream communication from the front-end card to the contactless card-reader system 100'. Data from the front-end card is modulated using load modulation (in accordance with the ISO14443 standard) before it is transmitted in the form of electromagnetic waves to the multiple antenna interface adaptor 200. Similarly, this data is then demodulated using load demodulation, processed and re-modulated again using load modulation in the multiple antenna interface adaptor 200 before it is transmitted in the form of electromagnetic waves to a backend card reader in the contactless card-reader system 100'. In one example, the load modulation/demodulation for this downstream wireless link uses a 13.56Hz carrier frequency. Note that depending on the application in which the multiple antenna interface adaptor 200 is used and the type of wireless devices involved in the application, different modulation/demodulation schemes and/or different carrier frequencies may be used for the downstream wireless link.

Fig. 3 illustrates details of the multiple antenna interface adaptor 200. As mentioned above, the multiple antenna interface adaptor 200 comprises the main unit 204, the front-end interface unit 202 and a plurality of backend interface units 206. The main unit 204 in turn comprises a Radio Frequency (RF) module 311 and a processor module 312. The front-end interface unit 202 in turn comprises a front-end interface antenna 301, a resonant circuit 302 and a matching circuit 303 whereas each backend interface unit 206 in turn comprises components 333, 334, 335, 336, 337, 338 and 339.

The front-end interface unit 202 serves to communicate wirelessly with the front-end card using the front-end interface antenna 301 and the resonant circuit 302. The front-end interface antenna 301 serves to transmit and receive data between the multiple antenna interface adaptor 200 and the front-end card. Similar to the resonant circuit in the front-end card, the resonant circuit 302 is tuned to the resonant frequency f_0. This allows the resonant circuit 302 to generate signals at the resonant frequency f_0 for transmission to the front-end card and further allows the resonant circuit 302 to receive signals at the resonant frequency f_0 from the front-end card.

As mentioned above, if the front-end card is passive, power is drawn from a voltage induced via inductive coupling between the resonant circuit in the front-end card and a resonant circuit in the multiple antenna interface adaptor 200 which is the resonant circuit 302 as shown in Fig. 3. The inductive coupling between the resonant circuit in the front-end card and the resonant circuit 302 also allows load modulation to be performed on the data communicated from the front-end card to the multiple antenna interface adaptor 200. The load modulation is performed by varying the load of the front-end card based on the data to be transmitted. Due to the above-mentioned inductive coupling, this variation in the load of the front-end card results in amplitude changes in the voltage induced in the front-end interface antenna 301. Note that in the application as shown in Fig. 2, no phase changes are induced in the front-end interface antenna 301 by the variation in the load of the front-end card. However, in other applications (for example, Near Field Communication (NFC) card application), phase changes may be induced in the front-end interface antenna 301 by the variation in the load of the front-end device.

The main unit 204 comprises a RF module 311 and a processor module 312.

The RF module 311 in turn comprises a modulator 314, a demodulator 315 and a matching circuit 313.

The modulator 314 serves to modulate data to be transmitted to the front-end interface unit 202 whereas the demodulator 315 serves to demodulate data received from the front-end interface unit 202. In the application as shown in Fig. 2, the modulator 314 uses ASK modulation whereas the demodulator 315 uses load demodulation. However, in a different application using different types of wireless devices, the modulator 314 and demodulator 315 may use different modulation/demodulation schemes.

The matching circuit 313 cooperates with the matching circuit 303 of the front-end interface unit 202 to provide impedance matching between the main unit 204 and the front-end interface unit 202, so as to reduce RF signal loss in the communication between these two units 202, 204.

The processor module 312 comprises a digital error correction unit comprising digital error correction modules 316a, 316b, an auto frame detect module 317, an auto/user interface select switch 318, a modulation/demodulation configuration module 319, and a backend interface select unit comprising backend interface select modules 321a, 321b. The modulation/demodulation configuration module 319 serves to provide configuration data to the backend interface units 206 and the RF module 311. The modulation/demodulation schemes used by the modulator 314, the demodulator 315, the demodulating module 335 and the modulating module 336 are set based on this configuration data.

The backend interface select unit is configured to successively couple each of the backend interface units 206 with the front-end interface unit 202. This is achieved by switching the connections in the backend interface select modules 321a, 321b.

The above-mentioned successive coupling eventually forms a communication bridge between the matching backend card reader and the front-end card. Once this bridge is formed, the successive coupling stops to allow communication of data between the front-end card and the matching backend card reader, and continues after this communication of data is complete. The auto frame detect module 317 is configured to monitor the communication of data between the front-end card and the matching backend card reader to determine when the successive coupling should continue. In one example, the data communicated between the front-end card and the matching backend card reader comprises data frames and the auto frame detect module 317 is configured to monitor the start and end of the data frames. The auto frame detect module 317 is further configured to activate the backend interface select unit to couple a subsequent backend interface unit 206 with the front-end interface unit 202 upon determining that the successive coupling should continue.

Depending on the setting of the auto/user interface select switch 318, the monitoring of the communication between the matching backend card reader and the front-end card, and the activation of the backend interface select unit may alternatively be performed by the backend equipment controller. The auto/user interface select switch 318 may be set based on a user input (e.g. the "User-defined Interface Select" in Fig. 3) via the backend equipment controller.

The digital error correction unit comprises digital error correction modules 316a, 316b and serves to detect and correct errors in the data communicated between the front-end interface unit 202 and each of the backend interface units 206.

For the contactless card application as shown in Fig. 2, each backend interface unit 206 serves as a 'virtual card' configured to communicate wirelessly with a respective backend card reader in the contactless card-reader system 100'. Each backend interface unit 206 further comprises a processor 333 (with memory), a clock extractor 334, a demodulating module 335, a modulating module 336, a matching circuit 337, a resonant circuit 338 and a backend interface antenna 339.

The clock extractor 334 is configured to extract a clock signal from the data received from the respective backend card reader. This extracted clock signal is in turn input to the processor 333 and/or processor module 312. The processor 333 is configured to control the operations of the backend interface unit 206 whereby these operations are clocked using the extracted clock signal. This achieves synchronization between the backend interface unit 206 and the respective backend card reader in the contactless card-reader system 100'. The extracted clock signal may also be used in the processor module 312 for a similar synchronizing purpose. In one example as shown in Fig. 3, the clock signal is extracted from the received data before demodulation of the received data. Alternatively, the clock signal may be extracted from the received data after the received data is demodulated. Note that the clock extractor 334 is optional. In one example, the local clocks of the processor 333 and the processor module 312 are capable of achieving the synchronization as mentioned above. Thus, the above-mentioned extracted clock signal is not required and the clock extractor 334 can be omitted. In fact, in this example, it is preferable not to input the extracted clock signal to the processor 333 and the processor module 312 as too many clock signals in the processor 333 or the processor module 312 may lead to unnecessary electromagnetic interference.

The demodulating module 335 is configured to demodulate the data received from the respective backend card reader in the contactless card-reader system 100' whereas the modulating module 336 is configured to modulate the data to be transmitted to the respective backend card reader. In the application as shown in Fig. 2, the demodulating module 335 uses ASK demodulation whereas the modulating module 336 uses load modulation. However, in a different application using different types of wireless devices, the demodulating module 335 and modulating module 336 may use different modulation/demodulation schemes. The modulation/demodulation schemes used by the demodulating module 335 and the modulating module 336 are set using configuration data from the modulation/demodulation configuration module 319.

The resonant circuit 338 and the backend interface antenna 339 forms an antenna communication module configured to generate, transmit and receive signals between the backend interface unit 206 and the respective backend card reader. More specifically, the backend interface antenna 339 serves to transmit and receive data in the form of electromagnetic waves between the multiple antenna interface adaptor 200 and each of the backend card readers whereas the resonant circuit 338 is tuned to the predetermined frequency (f_0) to increase the strength of the signals transmitted to each backend card reader. Tuning the resonant circuit 338 to the frequency f_0 further facilitates the receiving of signals from each backend card reader.

The matching circuit 337 serves to match the impedance of the backend interface antenna 339 to the combined impedance of the components 334, 335 and 336 in the backend interface unit 206.

The multiple antenna interface adaptor 200 may or may not comprise its own power supply. In the latter case, the multiple antenna interface adaptor 200 derives its power from a voltage induced via inductive coupling between the respective backend card reader and the backend interface unit 206.

An example operation of the multiple antenna interface adaptor 200 is described below with reference to Fig. 3.

The backend interface select unit successively couples each of the backend interface units 206 to the front-end interface unit 202 in a predetermined sequence. Whenever a backend interface unit 206 is coupled to the front-end interface unit 202, the backend card reader configured to communicate with the backend interface unit 206 sends a polling data frame to the front-end interface unit 202 to check for the presence of a front-end card.

When a card is presented to the front-end interface antenna 301 of the multiple antenna interface adaptor 200, it is first powered up by the electromagnetic waves from the front-end interface antenna 301 (via inductive coupling as mentioned above) before receiving and accepting the above-mentioned polling data frame in the form of electromagnetic waves. If the polling data frame is sent from the matching backend card reader, the front-end card sends response data back to the matching backend card reader and is thus detected. On the other hand, if the polling data frame is not sent from the matching backend card reader, the front-end card does not respond and is hence, not detected. The backend select interface unit then continues the successive coupling of each of the backend interface units 206 to the front-end interface unit 202 such that the backend interface unit 206 configured to communicate with the matching backend card reader is eventually coupled with the front-end interface unit 202, allowing the front-end card to be detected.

Upon detection of the front-end card, the coupling between the front-end interface unit 202 and the backend interface unit 206 is “locked” (i.e. the successive coupling stops), allowing the matching backend card reader to cooperate with the front-end card to perform the required operation. This is achieved via further data communication between the matching backend card reader and the front-end card as elaborated below.

The response data transmitted from the front-end card is received by the front-end interface antenna 301 and is then demodulated by the demodulator 315. This demodulated data is then processed by the digital error correction module 316a before it is sent to the backend interface unit 206 via the backend interface select module 321a.

The response data received by the backend interface unit 206 is modulated by the modulating module 336 and is then transmitted via the back-end interface antenna 339 to the matching backend card reader in the contactless card-reader system 100'. Upon receiving the response data, the matching backend card reader may send response data back to the front-end card. This response data is demodulated by the demodulating module 335, processed in the digital error correction module 316b, modulated using the modulator 314 before it is sent through the front-end interface unit 202 to the front-end card.

This upstream and downstream exchange of data between the front-end card and the matching backend card reader may carry on for a while with the sending of a number of data frames before the entire communication is completed. This communication of data may be monitored by the auto frame detect module 317 or the backend equipment controller. Once the auto frame detect module 317 or the backend equipment controller detects that the communication of data between the front-end card and the matching backend card reader is complete, it activates the backend interface select unit via the auto/user interface select switch 318 to continue the successive coupling by coupling the front-end interface unit 202 to the next backend interface unit 206 in the predetermined sequence. This successive coupling continues until another card is detected.

Fig. 4 illustrates details of a multiple antenna interface adaptor 400 according to a second embodiment of the present invention. The multiple antenna interface adaptor 400 is similar to the multiple antenna interface adaptor 200 and thus, the same parts will have the same reference numerals with the addition of prime.

The multiple antenna interface adaptor 400 comprises a plurality of backend interface modules 402 configured to communicate with respective backend interface units 430. The backend interface modules 402 are formed together with the processor module 312' and the RF module 311' on a single board whereas the backend interface modules 402 and the backend interface units 430 are formed on different boards.

In the multiple antenna interface adaptor 400, each backend interface module 402 comprises a processor 333', a clock extractor 334', a demodulating module 335', a modulating module 336' and a matching circuit 337' whereas each backend interface unit 430 comprises a resonant circuit 338', a backend interface antenna 339', and a matching circuit 431. This differs from the multiple antenna interface adaptor 200 whereby the backend interface unit 206 alone comprises the components 333, 334, 335, 336, 337, 338 and 339.

The matching circuit 431 in each backend interface unit 430 serves to cooperate with the matching circuit 337' in the respective backend interface module 402 for impedance matching between the two units 402, 430.

The decision on whether to use multiple antenna interface adaptor 200 or multiple antenna interface adaptor 400 depends on the development lead-time available as multiple antenna interface adaptor 400 requires more development time on impedance matching related works.

Fig. 5 illustrates details of a multiple antenna interface adaptor 500 according to a third embodiment of the present invention. The multiple antenna interface adaptor 500 is similar to the multiple antenna interface adaptor 400 and thus, the same parts will have the same reference numerals with the addition of prime.

The backend interface units 430' and the front-end interface unit 202" of the multiple antenna interface adaptor 500 are respectively identical to the backend interface units 430 and the front-end interface unit 202' of the multiple antenna interface adaptor 400. As shown in Figs. 4 and 5, the key differences between antenna adapters 400 and 500 lie in their main units 401 and 510. The main unit 401 of the multiple antenna interface adaptor 400 comprises the processor module 312' and RF module 311' whereby the processor module 312' comprises a backend interface select unit which in turn comprises backend interface select modules 321a', 321b'. On the other hand, although the main unit 510 of the multiple antenna interface adaptor 500 also comprises a backend interface select unit configured to successively couple each of the backend interface units 430' to the front-end interface unit 202", the backend interface select unit in the multiple antenna interface adaptor 500 comprises a single RF switch 511.

The main unit 510 of the multiple antenna interface adaptor 500 further comprises two matching circuits 313" and 337". The matching circuit 313" cooperates with the matching circuit 303" to provide impedance matching between the main unit 510 and the front-end interface unit 202" so as to reduce loss in the strength of the RF signal communicated between these two units 510, 202". Similar to the matching circuit 313", the matching circuit 337" cooperates with the matching circuit 431' in each backend interface unit 430' to provide impedance matching between the main unit 510 and the backend interface unit 430' so as to reduce loss in the strength of the RF signal communicated between the two units 510, 430'.

As compared to the multiple antenna interface adaptor 400, the multiple antenna interface adaptor 500 requires more complex impedance matching. In addition, there is less flexibility in the modulation/demodulation techniques that can be used with the multiple antenna interface adaptor 500. For example, while amplitude modulation/demodulation may be used with the multiple antenna interface adaptor 500, it is difficult (although, not impossible) to use load modulation/demodulation or frequency modulation/demodulation with this multiple antenna interface adaptor 500. If load modulation/demodulation is desired, it is preferable to employ multiple antenna interface adaptor 200 or 400. This is because the implementation of load modulation with the multiple antenna interface adaptor 500 introduces very complex impedances. Thus, additional modules for extracting signals from the front-end device and for modulating signals to be transmitted to the backend devices are required, leading to increased complexity.

However, the multiple antenna interface adaptor 500 is cheaper and simpler to implement as it serves as a pure RF interface (with fixed impedances) and does not include the auto frame detect module or the digital error correction modules. In other words, it comprises fewer components and less software work.

Fig. 6 illustrates the multiple antenna interface adaptor 200 in an application involving contactless readers compliant with NFC standards. In Fig. 6, the multiple antenna interface adaptor 200 serves to interface a front-end device in the form of a NFC contactless reader and a plurality of backend devices also in the form of NFC contactless readers. Data from the front-end device is modulated in accordance with the NFC standard (instead of the ISO14443 standard as in Fig. 2) before it is transmitted to the multiple antenna interface adaptor 200. This data is then demodulated in accordance with the NFC standard, processed and re-modulated again in accordance with the NFC standard in the multiple antenna interface adaptor 200. Note that the multiple antenna interface adaptor 200 in Fig. 6 may be replaced with either multiple antenna interface adaptor 400 or 500.

Fig. 7 illustrates a multiple antenna interface adaptor 200 in further applications involving different modulation/demodulation techniques for example, Amplitude modulation (AM), Frequency modulation (FM) or other types of modulation. Depending on the modulation/demodulation techniques involved in the further application, the modulation/demodulation techniques implemented within the multiple antenna interface adaptor 200 are modified accordingly. The multiple antenna interface adaptor 200 in Fig. 7 may also be replaced with either multiple antenna interface adaptor 400 or 500, depending on the application. Note that adaptor 500 may be used in a NFC Active-mode Reader-to-Reader application or other AM applications but may not be able to support a contactless card application.

The multiple antenna interface adaptor 200 (or 400, 500) in the embodiments of the present invention is advantageous as it takes over from the user the task of locating the specific backend device that works with the user's front-end device. For example, in a contactless card application, instead of having multiple card readers, the user interface may simply comprise the multiple antenna interface adaptor 200 (or 400) and the required operation can be performed by presenting a card issued by any card issuer to the multiple antenna interface adaptor 200 (or 400). This increases the level of convenience for the user since there is no longer a need for the user to locate the specific card reader that works with his or her card.

As shown in Fig. 2, the multiple antenna interface adaptor 200 can be used with a contactless card-reader system 100' which is identical to the conventional contactless card-reader system 100. In other words, the multiple antenna interface adaptor 200 can be integrated with existing contactless card-reader systems without substantial modifications to the systems. Note that the multiple antenna interface adaptor 400 can also be used with conventional contactless card-reader systems in the same manner as the multiple antenna interface adaptor 200.

Furthermore, the multiple antenna interface adaptor 200 (or 400) comprises an auto frame detect module 317 (or 317') which is configured to monitor the communication of data between the front-end device and the matching backend device to determine when the connections in the backend interface select modules 321a, 321b (or 321a', 321b') should be switched. Otherwise, this monitoring and determination has to be performed by the backend equipment controller. Thus, using the auto frame detect module 317 (or 317') frees up computational resources from the backend processor (i.e. backend equipment controller) for other purposes.

The multiple antenna interface adaptor 200 (or 400) also comprises digital correction modules 316a, 316b (or 316a', 316b') for detecting and correcting errors in the data communicated between the front-end interface unit 202 (or 202') and each backend interface unit 206 (or 430). This is advantageous as it increases the accuracy of the communication.

Further variations are possible within the scope of the invention as will be clear to a skilled reader.

For example, besides a contactless card application whereby the front-end device is in the form of a contactless card and the backend devices are in the form of contactless card readers, the multiple antenna interface adaptor 200 (or 400, 500) may be used in other applications that involve other types of wireless devices. For example, each backend device and the front-end device may respectively be in the form of an AM/FM Radio/TV station "A" and an AM/FM Radio/TV station "B" whereby station "B" is configured to receive signals from station "A" and is further configured to transmit the received signals at frequencies different from the frequency at which the signals are received. Such an application may be implemented using the structure shown in Fig. 7 except that in the example application described here, the data communication is uni-directional i.e. either upstream or downstream. Depending on the application in which the multiple antenna interface adaptor 200 (or 400, 500) is used, different types of modulation/demodulation techniques may be implemented for the upstream and/or downstream communications. In addition, the modulation/demodulation techniques employed for the upstream and/or downstream communications may be the same. Also, the carrier frequencies implemented with the modulation/demodulation techniques may vary depending on the application in which the multiple antenna interface adaptor 200 (or 400) is used.

Furthermore, although the multiple antenna interface adaptor 200 (or 400) comprises digital error correction modules 316a, 316b (or 316a', 316b'), an auto frame detect module 317 (or 317') and clock extractor module 334 (or 334'), these modules are optional and need not be present. In the case where the auto frame detect module 317 (or 317') is absent, the backend equipment controller of the backend equipment (contactless card-reader system 100') is configured to monitor the communication of data between the front-end device and the matching backend device to determine when the connections in the backend interface select modules 321a, 321b (or 321a', 321b') should be switched. For cases where the clock extractor module 334 (or 334') is absent, the processor 333 (or 333') and/or processor module 312 (or 312') are configured to use their local clocks for synchronization instead.

In addition, the multiple antenna interface adaptor 200 (or 400, 500) may be integrated with a contactless card-reader system or other type of systems comprising any number of backend devices. The number of backend interface units 206 (or 430, 430') would then vary accordingly. Moreover, although a single auto frame detect module 317 (or 317'), two digital error correction modules 316a, 316b (316a', 316b') and two backend interface select modules 321a, 321b (321a', 321b') are shown in Figs. 3 and 4, the number of each of these modules may vary.

Furthermore, the components of the multiple antenna interface adaptor 200 (or 400, 500) may be divided among the units in a manner different from that shown in Figs. 3 to 5 with each unit being formed on a single board. For example, the backend interface units 206 in Fig. 3 may be formed together with the processor module 312 and RF module 311 as part of the main unit. Also, the backend interface modules 402 in Fig. 4 need not be formed as part of the main unit. In other words, they may be formed on boards different from the board on which the processor module 312' and the RF module 311' are formed.

Claims

1. A multiple antenna interface adaptor for interfacing a front-end device and a plurality of backend devices, wherein each backend device comprises a transmitter and a receiver, and the plurality of backend devices comprises a matching backend device configured to cooperate with the front-end device to perform a required operation and the multiple antenna interface adaptor comprises:

a front-end interface unit configured to communicate wirelessly with the front-end device;

a plurality of backend interface units, each of the backend interface units configured to communicate wirelessly with a respective backend device in the plurality of backend devices; and

a backend interface select unit configured to successively couple each of the backend interface units with the front-end interface unit such that the backend interface unit configured to communicate with the matching backend device is eventually coupled with the front-end interface unit, allowing the matching backend device to cooperate with the front-end device to perform the required operation.

2. A multiple antenna interface adaptor according to claim 1, wherein when the backend interface unit configured to communicate with the matching backend device is eventually coupled with the front-end interface unit, the successive coupling stops, to allow data communication between the front-end device and the matching backend device, and the multiple antenna interface adaptor further comprises:

an auto frame detect module configured to monitor the communication of data between the front-end device and the matching backend device to determine when the successive coupling should continue.

3. A multiple antenna interface adaptor according to claim 2, wherein the auto frame detect module is further configured to activate the backend interface

select unit to couple a subsequent backend interface unit to the front-end interface unit upon determining that the successive coupling should continue.

4. A multiple antenna interface adaptor according to claim 2 or 3, wherein the data communicated between the matching backend device and the front-end device comprises data frames; and

the auto frame detect module is configured to monitor the start and end of the data frames to determine when the successive coupling should continue.

5. A multiple antenna interface adaptor according to any of claims 2 – 4, further comprising a digital error correction unit configured to detect and correct errors in the data communicated between each of the backend interface units and the front-end interface unit.

6. A multiple antenna interface adaptor according to any of the preceding claims, further comprising:

a modulator configured to modulate data to be transmitted to the front-end interface unit using Amplitude Shift Keying modulation; and

a demodulator configured to demodulate data received from the front-end interface unit using load demodulation.

7. A multiple antenna interface adaptor according to any of the preceding claims, wherein each backend interface unit further comprises:

a modulating module configured to modulate data to be transmitted to the respective backend device using load modulation; and

a demodulating module configured to demodulate data received from the respective backend device using Amplitude Shift Keying demodulation.

8. A multiple antenna interface adaptor according to any of the preceding claims, wherein each backend interface unit further comprises a clock extractor configured to extract a clock signal from data received from the respective

backend device, the extracted clock signal being used to clock operations in the backend interface unit.

9. A multiple antenna interface adaptor according to any of the preceding claims, further comprising a single front-end interface antenna configured to transmit and receive data between the multiple antenna interface adaptor and the front-end device.

10. A multiple antenna interface adaptor according to any of the preceding claims, wherein each backend interface unit further comprises an antenna communication module configured to generate and transmit signals to the respective backend device and further configured to receive signals from the respective backend device.

11. A multiple antenna interface adaptor according to any of the preceding claims, wherein the backend interface select unit and the backend interface units are formed on different boards.

12. A multiple antenna interface adaptor according to claim 10 when dependent on claims 1 – 6, further comprising a plurality of backend interface modules configured to communicate with respective ones of the plurality of backend interface units;

wherein the backend interface modules and the backend interface units are formed on different boards.

13. A multiple antenna interface adaptor according to claim 12, wherein the backend interface select unit and the backend interface modules are formed on a single board.

14. A multiple antenna interface adaptor according to any of the preceding claims, wherein the front-end device is a card and the backend devices are card readers.

15. A method for interfacing a front-end device and a plurality of backend devices wherein each backend device comprises a transmitter and a receiver, and the plurality of backend devices comprises a matching backend device configured to cooperate with the front-end device to perform a required operation and the method comprises:

successively communicating data wirelessly from each of the backend devices to a front-end interface unit and from the front-end interface unit to the front-end device such that the data from the matching backend device is eventually communicated to the front-end device, thereby allowing the matching backend device to cooperate with the front-end device to perform the required operation.

16. A method according to claim 15, wherein the matching backend device is a single one of the plurality of backend devices.

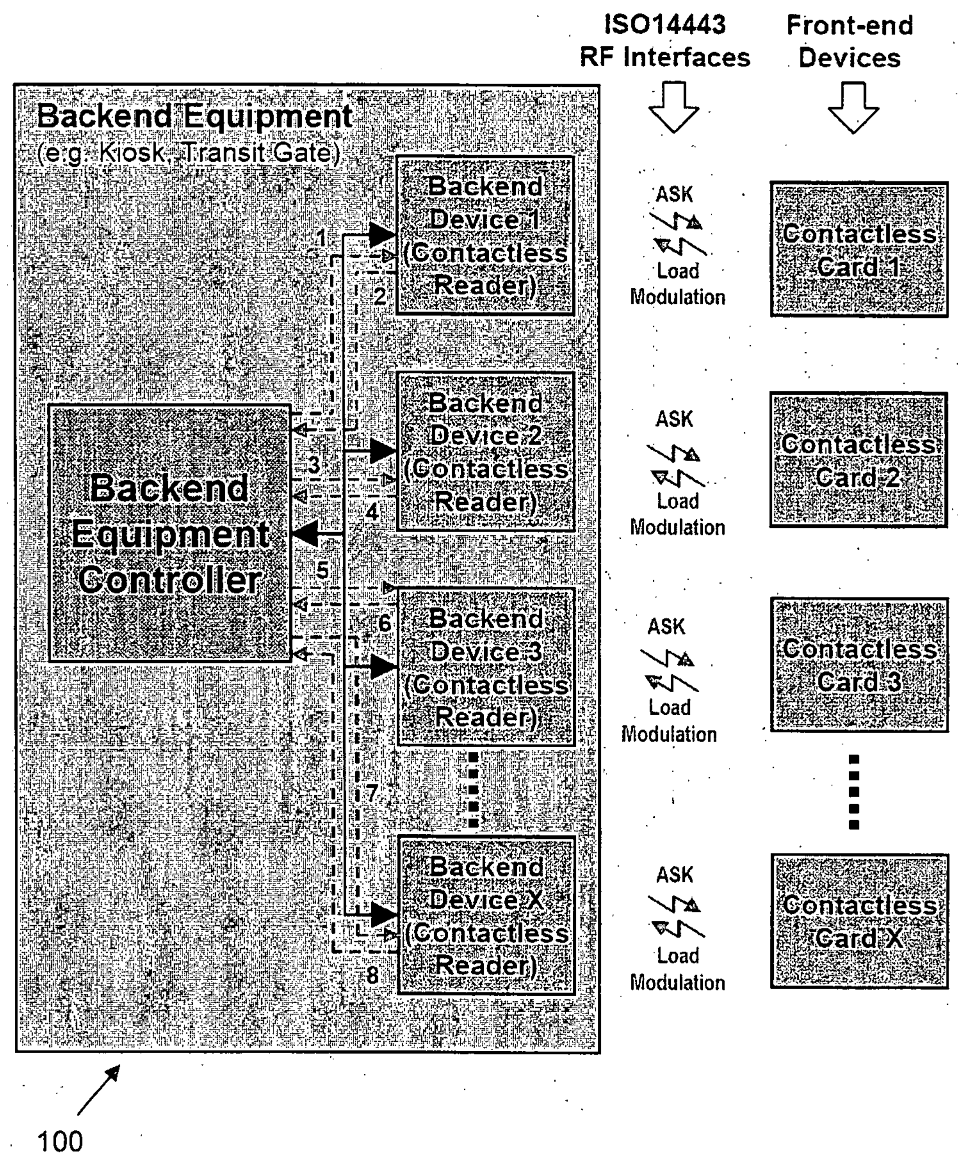
ISO14443
RF Interfaces
Front-end
Devices
Backend Equipment
(e.g. Kiosk, Transit Gate)
Backend Equipment Controller
Backend Device 1 (Contactless Reader)
Backend Device 2 (Contactless Reader)
Backend Device 3 (Contactless Reader)
Backend Device X (Contactless Reader)
1
2
3
4
5
6
7
8
ASK
Load Modulation
Contactless Card 1
Contactless Card 2
Contactless Card 3
Contactless Card X
100

Fig. 1

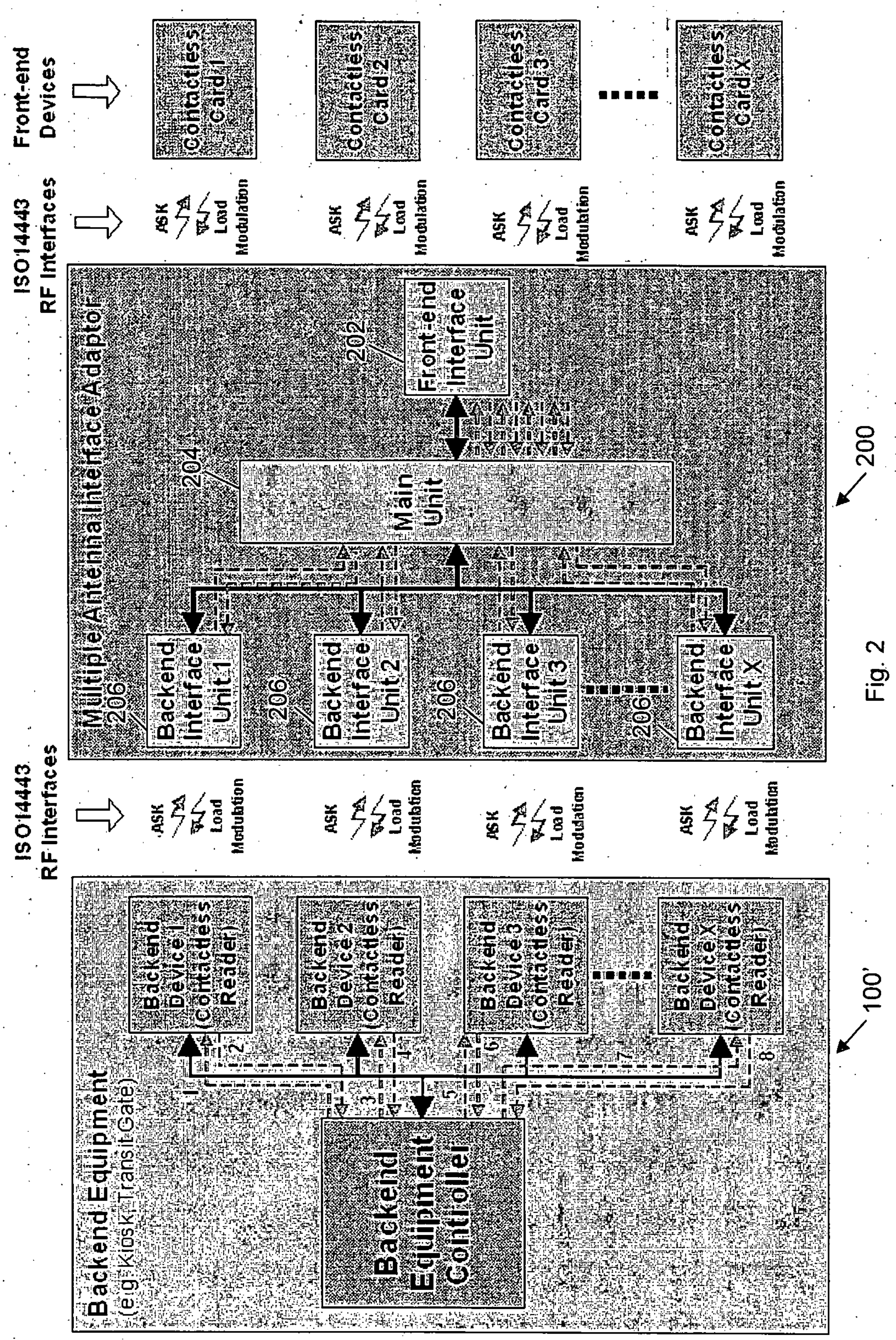
Front-end Devices
ISO14443 RF Interfaces
ISO14443 RF Interfaces
Contactless Card 1
Contactless Card 2
Contactless Card 3
Contactless Card X
ASK
Load Modulation
Multiple Antenna Interface Adaptor
202
Front-end Interface Unit
204
Main Unit
206
Backend Interface Unit 1
Backend Interface Unit 2
Backend Interface Unit 3
Backend Interface Unit X
200
Backend Equipment
(e.g. Kiosk, Transit Gate)
Backend Device 1 (Contactless Reader)
Backend Device 2 (Contactless Reader)
Backend Device 3 (Contactless Reader)
Backend Device X (Contactless Reader)
Backend Equipment Controller
1
2
3
4
5
6
7
8
100'

Fig. 2

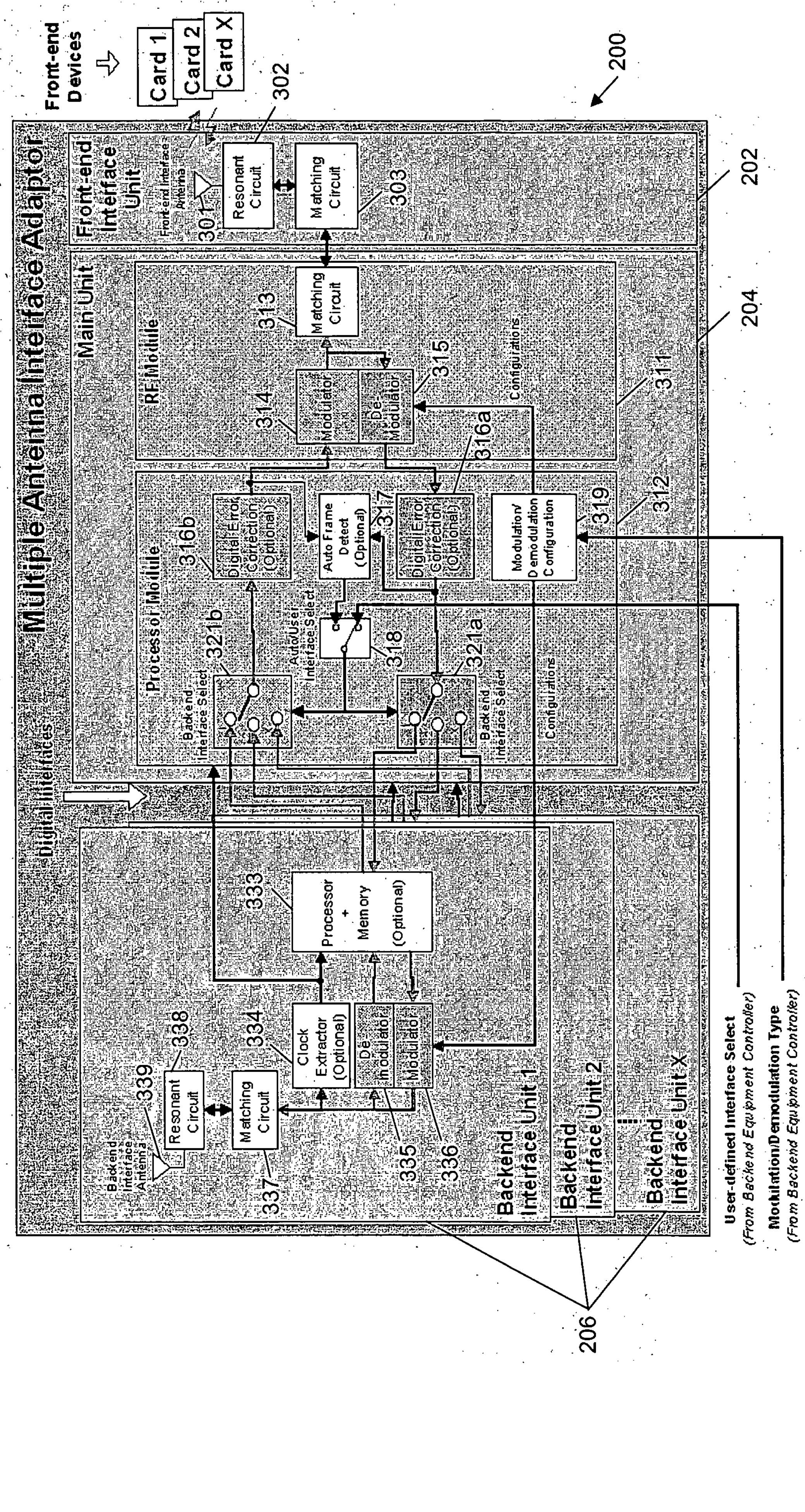
Front-end Devices
Card 1
Card 2
Card X
200
302
Multiple Antenna Interface Adaptor
Front-end Interface Unit
Front-end Interface Antenna
301
Resonant Circuit
Matching Circuit
303
202
Main Unit
RF Module
313
Matching Circuit
314
Modulator
De-Modulator
315
Configurations
311
204
Processor Module
316b
Digital Error Correction (Optional)
Auto Frame Detect (Optional)
317
316a
Digital Error Correction (Optional)
Modulation/ Demodulation Configuration
319
312
Auto/User Interface Select
318
321b
321a
Backend Interface Select
Configurations
Digital Interfaces
333
Processor + Memory (Optional)
334
Clock Extractor (Optional)
338
339
Resonant Circuit
Matching Circuit
Backend Interface Antenna
De-modulator
Modulator
337
335
336
Backend Interface Unit 1
Backend Interface Unit 2
Backend Interface Unit X
User-defined Interface Select
(From Backend Equipment Controller)
Modulation/Demodulation Type
(From Backend Equipment Controller)
206

Fig. 3

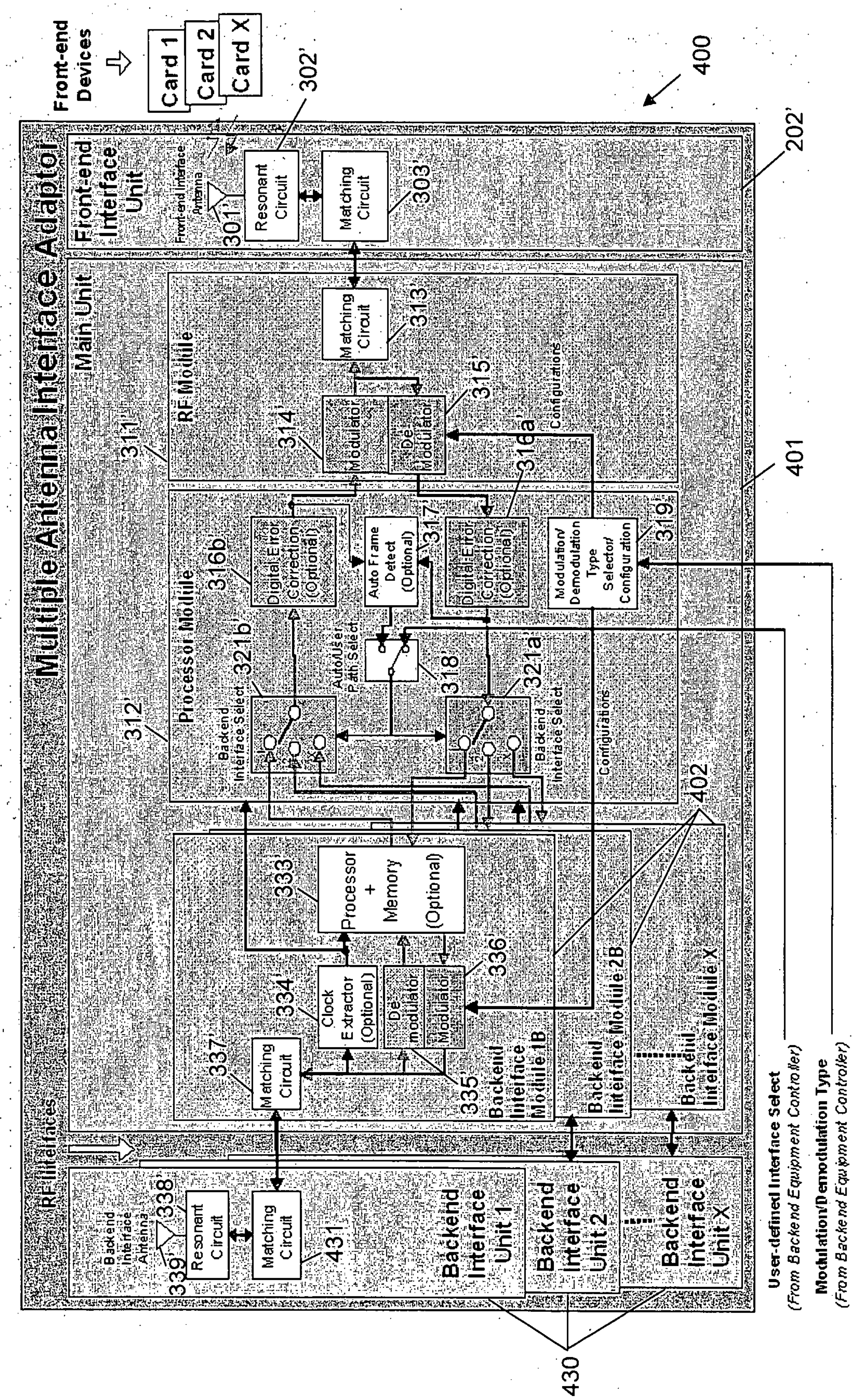
Multiple Antenna Interface Adaptor
Front-end Devices
Card 1
Card 2
Card X
Front-end Interface Unit
Front-end Interface Antenna
Resonant Circuit
Matching Circuit
Main Unit
RF Module
Matching Circuit
Modulator
De-modulator
Configurations
Processor Module
Digital Error Correction (Optional)
Auto Frame Detect (Optional)
Auto/User Path Select
Backend Interface Select
Modulation/ Demodulation Type Selector/ Configuration
Processor + Memory (Optional)
Clock Extractor (Optional)
Backend Interface Module 1B
Backend Interface Module 2B
Backend Interface Module X
RF Interfaces
Backend Interface Antenna
Backend Interface Unit 1
Backend Interface Unit 2
Backend Interface Unit X
User-defined Interface Select
(From Backend Equipment Controller)
Modulation/Demodulation Type
(From Backend Equipment Controller)
400
302'
301'
303'
202'
311'
312'
313'
314'
315'
316a
316b
317'
318'
319'
321a
321b
333
334
335'
336
337'
338'
339'
401
402
430
431

Fig. 4

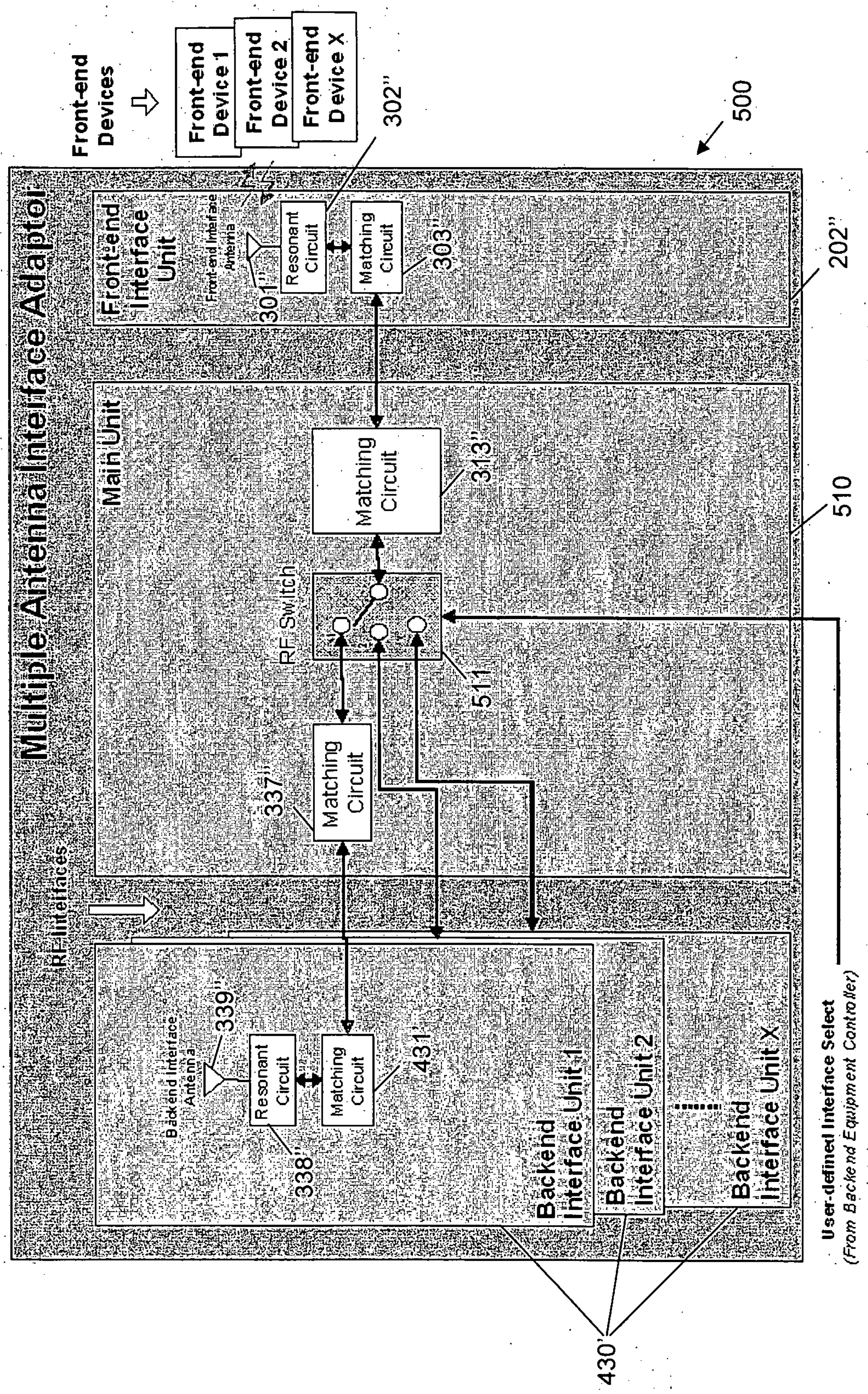
Multiple Antenna Interface Adaptor
Front-end Devices
Front-end Device 1
Front-end Device 2
Front-end Device X
302''
500
Front-end Interface Unit
Front-end Interface Antenna
301''
Resonant Circuit
Matching Circuit
303''
202''
Main Unit
Matching Circuit
313''
510
RF Switch
511
Matching Circuit
337''
RF Interfaces
Backend Interface Antenna
339''
Resonant Circuit
Matching Circuit
431'
338''
Backend Interface Unit 1
Backend Interface Unit 2
Backend Interface Unit X
User-defined Interface Select
(From Backend Equipment Controller)
430'

Fig. 5

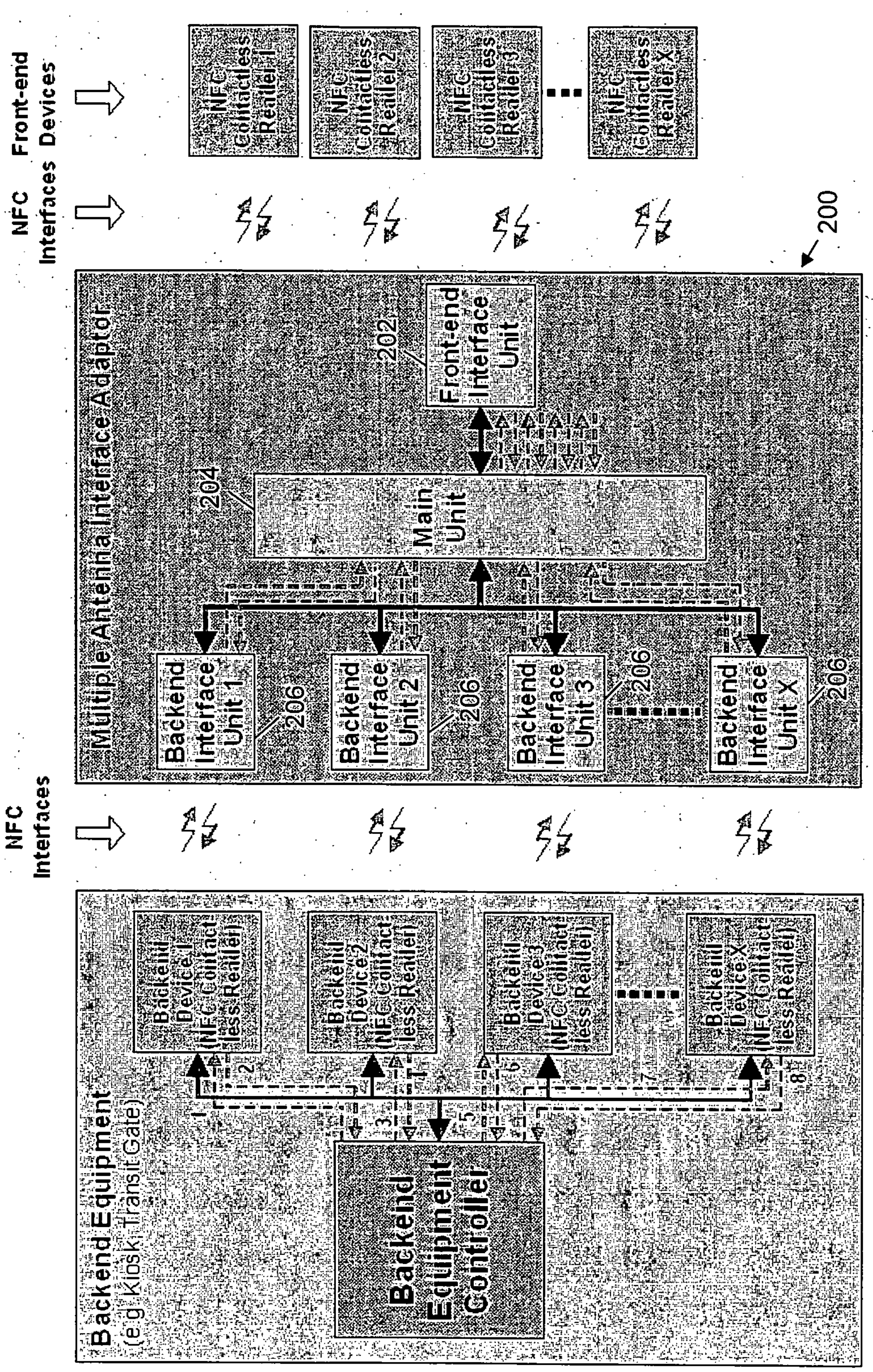
Front-end Devices
NFC Interfaces
NFC Contactless Reader 1
NFC Contactless Reader 2
NFC Contactless Reader 3
NFC Contactless Reader X
200
Multiple Antenna Interface Adaptor
202
Front-end Interface Unit
204
Main Unit
Backend Interface Unit 1
Backend Interface Unit 2
Backend Interface Unit 3
Backend Interface Unit X
206
NFC Interfaces
Backend Equipment
(e.g. Kiosk, Transit Gate)
Backend Device 1 (NFC Contactless Reader)
Backend Device 2 (NFC Contactless Reader)
Backend Device 3 (NFC Contactless Reader)
Backend Device X (NFC Contactless Reader)
Backend Equipment Controller

Fig. 6

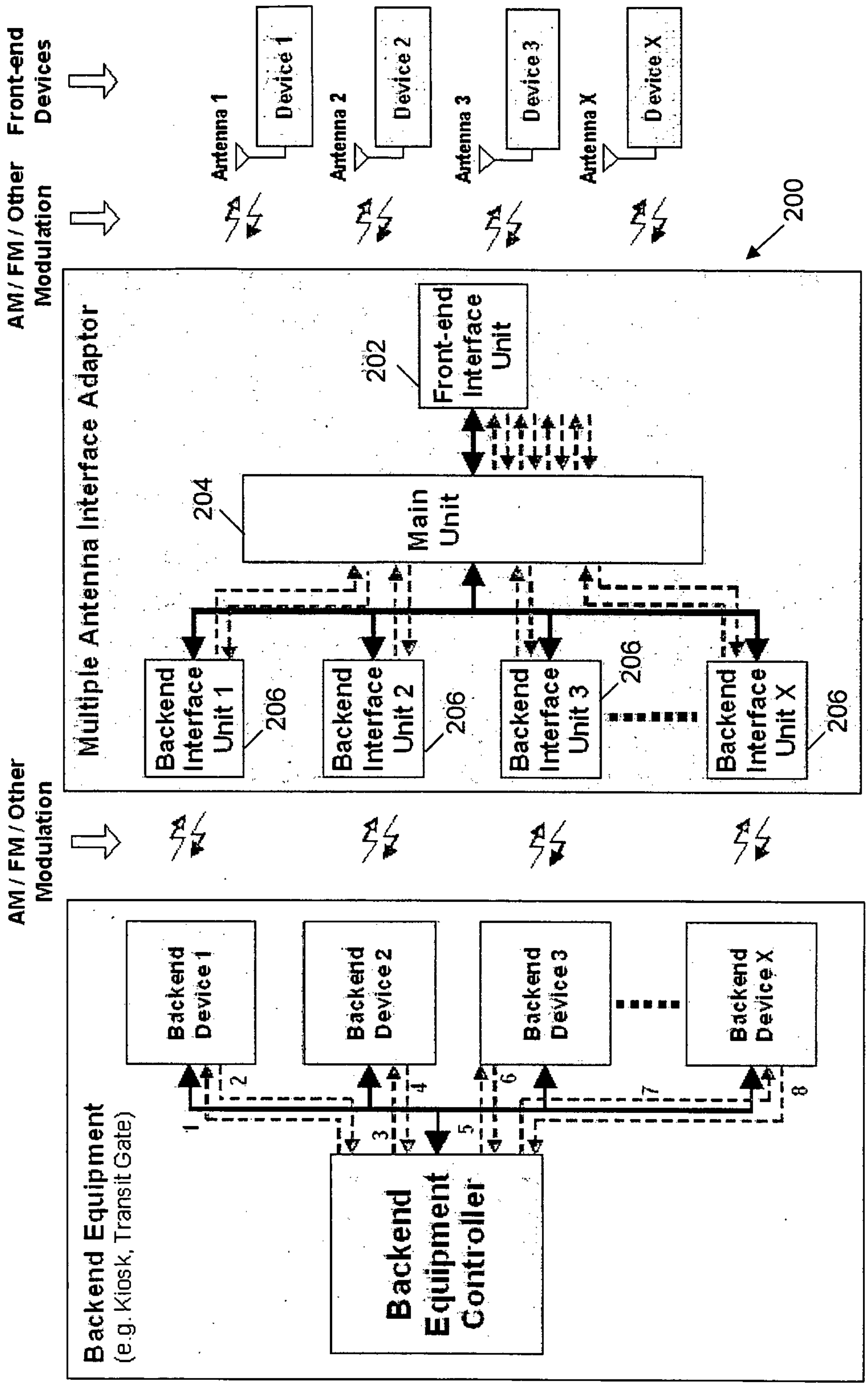
Front-end Devices
AM / FM / Other Modulation
Device 1
Device 2
Device 3
Device X
Antenna 1
Antenna 2
Antenna 3
Antenna X
200
Multiple Antenna Interface Adaptor
202
Front-end Interface Unit
204
Main Unit
Backend Interface Unit 1
Backend Interface Unit 2
Backend Interface Unit 3
Backend Interface Unit X
206
AM / FM / Other Modulation
Backend Equipment
(e.g. Kiosk, Transit Gate)
Backend Device 1
Backend Device 2
Backend Device 3
Backend Device X
1
2
3
4
5
6
7
8
Backend Equipment Controller

Fig. 7

INTERNATIONAL SEARCH REPORT

International application No.

PCT / SG 2010/000450

A. CLASSIFICATION OF SUBJECT MATTER
IPC: ***G06K 7/00*** (2006.01); ***G06F 13/00*** (2006.01); ***G06K 19/07*** (2006.01)
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G06F, G06K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPODOC, WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2010223412 A1 (JUNG HONG-JIP) 02 September 2010 (02.09.2010) abstract; paragraphs 7 - 11, 24; claim 1	1 - 16
X	EP 2075744 A1 (MOTOROLA, INC) 01 July 2009 (01.07.2009) abstract; paragraphs 7, 8; claims 1, 2	1 - 16
X	US 2008182623 A1 (YOUN JIN-SOO) 31 July 2008 (31.07.2008) abstract; paragraphs 10 - 16; claims 1 - 3	1 - 16

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 November 2011 (15.11.2011)	24 November 2011 (24.11.2011)
Name and mailing address of the ISA/AT Austrian Patent Office Dresdner Straße 87, A-1200 Vienna Facsimile No. +43 / 1 / 534 24-535	Authorized officer ENGLISCH M. Telephone No. +43 / 1 / 534 24-565

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT / SG 2010/000450

Patent document cited in search report			Patent family member(s)			Publication date
US	A1	2010223412	KR	A	20100098834	2010-09-10
			US	A1	2010223412	2010-09-02
EP	A1	2075744	EP	A1	2075744	2009-07-01
			US	A1	2009166423	2009-07-02
			WO	A1	2009088705	2009-07-16
US	A1	2008182623	KR	A	20080071008	2008-08-01
			US	A1	2008182623	2008-07-31