TITLE:

Method and device for radio communication between mutually movable objets

TECHNICAL FIELD:

The present invention relates to a method and a device for radio communication between mutually mobile objects. Especially intended is communication between a fixed object, which can be a road toll facility, and a mobile object, which can be a vehicle passing the toll facility, which shall be capable of communicating wirelessly with the road toll facility for the performance of an operation.

BACKGROUND:

It is known from US-A-4,303,904, Chasek, for example, a system for a road toll facility where radio communication with a vehicle is used to perform an identification and payment operation. The operation is supposed to be completed even if the vehicle passes at high speed. In order to obtain a selective enough communication even if several vehicles pass the road toll facility simultaneously, radiowaves with short wavelength, such as microwaves, with extremely limited range are used. This means that the operation must be performed while the vehicle passes a relatively short distance which gives a very short available time for the operation if the vehicle travels at high speed.

If the operation comprises several steps, which often must be the case, it is a problem to perform the whole operation in the short time available. In order to solve this problem, it has been suggested in for example US-A-5,144,553, Hassel, that the communication cycle is divided on several units in the road toll facility, so that a first part of the operation can be performed in a first unit in the travelling direction of the vehicle and must be continued by means of a second unit and concluded by means of a third unit. Such an arrangement will naturally be more expensive than an arrangement in which only one communication unit is required. This gives, in addition, an extended facility along the passage, which is not desirable. For each communication unit, the equipment usually requires a gantry mounted above the road, and several such gantries

one after the other will be less aesthetically appealing and give higher installation and maintenance costs.

DESCRIPTION OF THE INVENTION:

The invention describes a method by which the time required for said operation is reduced, so that also an operation in several steps can be performed by means of a single communication unit also at the highest possible vehicle speed in road traffic. The invention also describes a device for carrying out the method.

Through the invention, said disadvantage that the operation, with the content usually required, must be divided between several communication units if high vehicle speed when passing should be allowed.

DESCRIPTION OF DRAWINGS:

The following description depicts an embodiment of the invention, which is illustrated on the accompanying drawings. These show in

Fig. 1, an overview of a road toll facility with passing vehicles; and

Fig. 2, a block diagram on the units included in the device according to the invention.

PREFERRED EMBODIMENT:

The road toll facility shown in Fig. 1 is located by a road 1, marked to have three lanes in which the passing vehicles can travel in free formation. Above the road 1 extends a gantry 2, which carries a transmitter and receiver equipment 3 for radiowaves. The device 3 stands in wired connection with a computer 4 belonging to the road toll facility.

A vehicle approaching the road toll facility is designated by 5. This is also shown with dashed/dotted lines in a second position in which it is closer to the radio device 3 on the gantry 2. It is understood here that an identification and payment operation shall be possible to perform while the vehicle passes between the two designated positions.

6 designates a vehicle that has passed this distance and for which the operation therefore shall have been concluded.

The operation is performed by means of wireless connection between the transmitter and receiver unit 3 of the road toll facility via an antenna unit designated 7 and a vehicle unit, designated 8, in the vehicle 5. A communication equipment for such a purpose is described for example in US,A,3,914,762, Klensch, in which microwaves are used with the fixed transmitter and receiver equipment 3 being active, and the vehicle unit 8 being passive, so far as it receives the radio signal and reflects same, modulated so that it transmits a coded message.

The just described communication equipment is shown in the form of a block diagram in Fig. 2. The fixed equipment belonging to the road toll facility 2 is indicated with this number. The vehicle unit is designated as before by 8. The equipment of the road toll facility comprises the earlier described transmitter and receiver equipment whose electronic part in Fig. 2 is designated by 10. This is connected to said antenna 7 and to the computer 4 of the road toll facility. This comprises a calculation unit 11, a memory 12 and a unit 13 for communication with a central computer 14, which is understood to be connected to several road toll facilities.

The vehicle unit 8 consists of said passive transmitter and receiver unit, which is here designated by 16 and which in the following is called the transponder. This is connected to a vehicle computer 17 with calculation and data storage capacity. This in turn is connected to a card reader 18 for a smart card 19, that is a card whose stored data can be read in the card reader 18 and in it can also be replaced by changed data.

The purpose of the operation that shall be performed through communication between the road toll facility equipment and the vehicle unit, is to perform a payment operation where means corresponding to the toll fee of the toll facility and vehicle in question are transferred from the vehicle unit to the road toll facility equipment. These means have here the form of "electronic money", that is, means which were stored on the card 19 in connection with a corresponding payment from or account

debiting on the one who shall pay the toll fee. When passing the toll facility with the described equipment and with the card 19 inserted in the vehicle unit, the means stored on the card can be used as required through the reprogramming of the card memory by deducting the toll debitings registered in the vehicle unit.

These toll debitings are stored in connection with the respective payment operations in the memory 12 of the toll computer 4 for successive transmission to the central computer. Hereby, the debitings for the toll facility passages of the vehicles can be cleared between the interacting parties, which are partly the institution, which on instructions from the one who shall bear the cost for the toll fees programs means into the respective card 19 and thereby receives the means, and partly the one who eventually shall receive payment of the toll fees. At the same time, statistics can be obtained from the system, for example relating to the distribution of toll passages on different road toll facilities in a certain area and what type of passing vehicles.

In a system such as the one described, with a prepaid balance registered in a smart card memory shall mainly the following operational steps be performed:

1. The entrance of a vehicle within the range of action of the toll equipment is registered. This is understood to take place in that the toll facility transmitting equipment transmits signals periodically, and that such a signal being modulated is retransmitted by a vehicle transponder, thereby indicating that a vehicle has come into the toll facility. Alternatively however, the registration can be performed with other means, such as radar, ultrasound.

2. The toll facility transmitter transmits an identification code which is specific for the toll facility.

3. The vehicle unit transmits an identification code regarding the vehicle. This code identifies the vehicle type according to a classification which is pertinent for the toll fees, as these usually are different for different vehicle classes, such as motor bikes, passenger cars, buses and trucks.

The code can also contain an identification of the vehicle such as its license number. In the system with prepaid balances, this is usually not considered necessary, but on the contrary it is considered an unnecessary intrusion on integrity.

3. In the toll computer the relevant toll amount is calculated based on current fee rates and the information on class obtained from the vehicle.

4. The toll transmitter transmits a code designating the calculated amount.

5. The vehicle unit receives information regarding the amount that is to be paid.

6. The vehicle unit computer calculates the remaining balance programmed into the smart card.

7. The vehicle unit informs the toll facility of the balance.

8. The toll facility receives information on the balance.

9. The toll facility computer compares the balance with the calculated toll fee. If the balance as a minimum corresponds to the toll fee, a code is generated designating the debiting; alternatively, if the balance is not sufficient, a code is activated that the vehicle shall be captured for post-debiting. (This can take place in various ways, such as stopping the vehicle with a road barrier, which is only lifted if a code for free passage is activated, or in a system for free traffic flow through video registration of the number plate of the vehicle.)

10. The generated code is transmitted to the vehicle unit and it means either a message for free passage and order of debiting or message that payment must be performed in another way than via the wireless communication.

11. In the case of a message for free passage, the toll fee informed is deducted in the vehicle unit from the balance on the card.

12. The vehicle unit transmits a code to the toll facility informing that the toll fee has been drawn from the balance.

Usually, the described communication takes place in coded form, for example through the use of algorithms, in order to obtain higher security against manipulation.

The above steps can be said to constitute a content of which operational steps that are required. In practice, the operation is also sometimes performed in another order and with the steps given here. Such variations, however, do not constitute any important deviations from the described procedure.

All these operational steps must be performed in the time that the vehicle remains within the range of action of the toll facility, that is, the area in which the toll facility transmitter and receiver equipment can communicate with the vehicle transponder. This area is dependent on the range of the used radiowaves. It is therefore a requirement that communication with several vehicles within the range of action shall take place selectively. In toll facilities with free flow, one must count on high vehicle speed and these provisions in conjunction means that the operation must be performed in a time of 100 milliseconds if it is not desired to separate the toll facility communication equipment in several units along the road. In practice, great problems arise here to find time for all the steps of communication and calculation in said period of time. According to the solution of the invention, this problem is overcome in that the operational steps are formed in another way than described above and are partly put outside the period of time in which it is certain that the vehicle remains in the range of action of the toll facility.

The solution according to the invention is based on the following important part solutions:

A. The computer of the vehicle unit has such a storage space that the prepared answer codes can be programmed. Each such code contains information on vehicle class, which is unchangeable information, and current balance, which is a changeable piece of information. So, the balance is not checked during the operation, but the computer itself updates independently the balance without being activated by the transmitter equipment in any toll facility. Such a code established before the communication, here called the answer code, is selected by the computer as corresponds to information on the vehicle class together with current balance and information on the method of coding, for example current algorithm.

Corresponding answer codes must be programmed in the toll facility computer, so that starting out from the answer code informed, the corresponding balance can be compared with the toll fee for the vehicle class that is also evident from the answer code in question.

B. The vehicle computer is so arranged that during the operation it does not reduce the balance on the card, but only stores in the memory data for such deduction of the toll fee from the card balance. To carry out this operational step after the toll facility has been passed, that is, outside of said time interval, can be said to mean that instead of the conventional answer from the vehicle computer "Informed amount drawn from the card balance" the message "Informed amount will be drawn from the card balance". In order to ensure that a reduction of the card balance will in fact be carried out the vehicle unit is also so arranged that after such a message has been given, it will be unaffected from the outside by any change until the operational step has been concluded. The card is thereby electronically locked from change of data and is not usable if removed too soon, before the balance has been reduced.

The operational steps according to the invention will then be:

1. The toll facility equipment is activated by the entrance of a vehicle into its range of action.

2. The toll facility transmits its identification code to the vehicle unit.

3. The vehicle unit transmits the prepared, pertinent answer code, giving vehicle class and in addition, information regarding balance.

4. The toll facility computer activates the toll fee that corresponds to the vehicle class according to the received code, and establishes that it lies within the balance evident from the message of the vehicle unit.

5. The toll facility transmitter equipment transmits a code giving the fee that shall be drawn and that the balance holds the amount of the fee.

6. The vehicle unit answers that the amount is registered for deduction from the card.

7. The toll facility transmits an acknowledgement code to the vehicle unit and possibly to devices for passage checks, stating that free passage is obtained..

If the balance is not sufficient or if the vehicle for some other reason cannot be given free passage, a stopping or registration procedure starts according to what has been stated above.

The basic principle of the invention is then, that certain parts of the computer processing required in connection with a payment operation, are moved outside of the period of communication, so that the time required for calculation and registration does not prolong the period required for communication. This principle may be applicable also in other operations than the one described for debiting of toll fees. However, the invention should have its most important application here.

Claims

1. A method for radio communication between mutually mobile objects such as vehicles passing a road toll facility, the mutual movement of the objects and a limited range of action for the radio communication giving extremely limited time available for carrying out an operation comprising the transmission and the reception, respectively, of information and in the respective units internal operational steps such as operations for calculation, coding and data storage, c h a r a c t e r i z e d in that at least some of the calculation operations for establishing data are performed as internal operations before the communication period, in which procedure the established data are put together into answer codes made before the communication and a code adequate for the occasion of the communication is selected for the communication, and in that a final storing of the result of the operation will be performed as internal operations based on initially collected data at the occasion of communication, with locking of the respective unit against external influence during the time in which the resulting data has been established and the communication has been concluded and up to the final storing of belonging calculation operations has been carried out.

2. A method according to Claim 1 and applied for performing a payment operation between a stationary unit (2) and a vehicle unit (8) in a road toll facility, c h a r a c t e r i z e d in that means for the payment operation in a way known per se, are kept accessible in the vehicle unit (8) in the form of a balance in a special storage medium that is separable from the unit, such as a smart card from which paid fees in the toll facility can be deducted and to which fresh means can be supplied against payment of the corresponding money amount, in which arrangement prepared answer codes are stored in the vehicle unit (8) designating a payment class assigned to the vehicle as well as current balance, which is communicated to the stationary unit, and in which arrangement there are stored in the stationary unit (2) said answer codes in such a way that from these codes in the stationary unit a vehicle class and current balance can be established by decoding a received code, and in which arrangement the result of a performed payment operation is communicated by the vehicle unit to the stationary unit in the form of a message



that the toll fee, established during the payment operation, shall be deducted from the balance of said storage medium (19), while the operation of deduction is carried out after the completion of the communication with the vehicle unit including said storage medium, and thereafter is locked against external influence from the instant when the fee that shall be deducted has been established and temporarily stored and until the deduction from the balance of the storage medium has been finalized, in such a way that the deduction always corresponds to said temporarily stored data.

3. A method according to Claim 2, c h a r a c t e r i z e d in that the payment operation comprises the following operational steps before the radio communication starts:

- establishing said answer codes, representing vehicle class, and an established balance in the storage medium of the vehicle unit;

- selecting, in the vehicle unit for communication, an answer code corresponding to current balance in the storage medium;

and, during the communication period, the following operational steps:

- transmitting from the stationary unit a code identifying the identity of the toll facility in question;

- after reception in the vehicle unit, transmitting from same the answer code selected for communication;

- after reception in the stationary unit, transmitting data designating the toll fee;

- after the reception of these data in the vehicle unit, transmitting data constituting a confirmation that the toll fee is to be deducted from the balance of the storage medium;



and after the communication period:

- deducting in the storage medium the communicated toll fee based on data herefor stored temporarily in the vehicle unit.

4. A device for carrying out the method according to any one of Claims 1-3 and arranged to be performed by means of wireless communication between two mutually mobile objects (3, 8) for the performance of an operation comprising several operational steps, c h a r a c t e r i z e d in that both objects (3, 8) comprise a radio communication equipment having each a computer equipment for calculation and data storage operations and one object (8) a special data storage medium (19) with changeable contents, such as a smart card, which is arranged to allow storage of an amount of data representing a balance, in which arrangement said operation includes deduction from an amount of data at one occasion of communication between the objects, which amount of data is established at the occasion of communication, the object with the special data storage medium being arranged to store answer codes representing different contents of balance and the data equipment being arranged to select an answer code before each occasion of communication, which answer code represents the current balance for the client, and the other object being arranged to store said answer codes and what they represent with regard to contents of balance and, as the case may be, other data, and the first object being arranged to store temporarily, at the occasion of communication, the established amount of data that shall be deducted from the balance, and the first object including the special storage medium being arranged to lock against external influence on the stored value and, after the communication is concluded, to transfer the temporarily stored amount of data to the special storage medium for the reduction of the balance.

5. A device according to Claim 4, arranged for fee collecting in a road toll facility with one object corresponding to a unit (8) carried by a vehicle and the other object being a radio communication and computer equipment (3, 4) which is stationary at the road toll facility, c h a r a c t e r i z e d in that said answer codes,

in addition to data representing said balance, comprise data representing the class of the vehicle in question, and in that the vehicle unit (8) is so arranged that in connection with the communication it stores in a temporary memory an amount of data corresponding to the toll fee and that after a concluded communication it transfers it to the special data storage medium (19) for deduction from said balance and that in the time between said temporary storage and the deduction from the balance to keep said temporary storage and the special data storage medium locked against external influence until the time when the deduction has been carried out in the special data storage medium.

6. A device according to any one of Claims 4 and 5, c h a r a c t e r i z e d in that the communication equipment in the vehicle unit (8) consists of a transponder (16) and in that the stationary transmitter and receiver equipment (3) is arranged to work with microwaves and in that the specific storage medium (19) consists of a smart card.