

METHOD AND APPARATUS FOR ELECTRONIC TOLL COLLECTION SYSTEM ROAD SIDE UNIT SIGNAL DOWNLINK

5 FIELD OF THE INVENTION

[0001] The present invention relates to a downlink transmission method for a Road Side Unit (RSU) of an Electronic Toll Collection (ETC) system and a function module framework for implementing the method mainly by a computer program.

10 BACKGROUND OF THE INVENTION

[0002] An Electronic Toll Collection (ETC) station is arranged with multiple lanes. For each lane, one or more Road Side Units (RSU) are provided correspondingly. An On-Board Unit (OBU) is provided on a vehicle. When the vehicle enters one of the lanes, generally the OBU receives a transaction signal sent from the RSU corresponding to the lane, and is
15 activated by the transaction signal to transact. In some cases, when the vehicle enters the lane, the RSU corresponding to the lane may fail to send a transaction signal, instead, an adjacent RSU may coincidentally send a transaction signal. As a result, the OBU may mistakenly transact with the adjacent RSU, leading to consequences such as repeated fee deduction, wrongly releasing and false warning.

20 **[0003]** To this end, the patent No.CN201508576U discloses a technical solution utilizing a synchronous signal generator (which will hereinafter be refereed to as a synchronizer). According to the patent, the synchronizer sends a synchronous transaction command to the RSUs so that each RSU synchronously sends a transaction signal to a lane corresponding to the RSU. When an OBU enters a lane, the transaction signal sent from a RSU that
25 corresponds to the lane and thus is closer to the OBU is significantly stronger than the transaction signal sent from an adjacent RSU which is farther away from the OBU. Therefore, the OBU entering the lane can transact with the RSU corresponding to the lane and will not mistakenly transact with the adjacent RSU.

[0004] The technical solution utilizing a synchronizer has the following problem in
30 practical applications. If an OBU enters a lane where the corresponding RSU is in a transaction with another OBU, since the RSU is already in a transaction, even if at that

moment the synchronizer sends a synchronous transaction command, the RSU would not send a transaction signal to establish another transaction. Therefore, the OBU subsequently entering the lane may receive a transaction signal sent from an adjacent RSU and mistakenly transacts with the adjacent RSU.

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SUMMARY OF THE INVENTION

[0005] The technical problem to be solved by the present invention is, when a Road Side Unit (RSU) is in a transaction with an On-Board Unit (OBU) in a lane corresponding to the RSU, how to prevent any other OBU entering the lane corresponding to the RSU from transacting with an adjacent RSU.

[0006] According to the present invention, it is provided a downlink transmission method for a Road Side Unit (RSU) of an Electronic Toll Collection (ETC) system, including: on receipt of a synchronous transaction command while the RSU of the ETC system is not in a transaction with an On-Board Unit (OBU), synchronously sending, by the RSU, a transaction signal to a lane corresponding to the RSU; on receipt of a synchronous transaction command while the RSU is in a transaction with an OBU in the lane corresponding to the RSU, synchronously sending, by the RSU, an interfering signal to the lane, so that any other OBU entering the lane can not parse a transaction signal synchronously sent by an adjacent RSU.

[0007] On receipt of the synchronous transaction command while the RSU is in the transaction with the OBU in the lane corresponding to the RSU, the RSU may not ignore it but may synchronously send an interfering signal to the lane. For the OBU in the lane corresponding to the RSU, the interfering signal sent by the RSU which is closer to the OBU is significantly stronger than the transaction signal sent by the adjacent RSU which is far away from the OBU. Therefore, although other OBU entering the lane corresponding to the RSU at the moment is not in a transaction with the RSU, the other OBU can not parse a transaction signal synchronously sent by an adjacent RSU under the interference of the interfering signal, and thereby may not transact with the adjacent RSU.

[0008] According to different ways for encoding the transaction signal, different ways for interfering are used. The transaction signal sent between the RSU and the OBU is encoded by using a first coding, FM0 coding, and the interfering signal is a series of data "0" encoded in the first coding, FM0 coding; and the length of time of the interfering signal ranges from 32μs

to 200 μ s.

[0009] The transaction signal sent between the RSU and the OBU is encoded by using a second coding, Manchester coding, and the interfering signal is a series of data "0" or "1" encoded in a first coding, FM0 coding; and the length of time of the interfering signal ranges
5 from 120 μ s to 400 μ s.

[0010] Preferably, the interfering signal is sent at the moment when the adjacent RSU sends a frame header, frame information or a frame trailer of the transaction signal.

[0011] A function module framework may be established so that all or a portion of the steps in the given method may be implemented by a computer system controlled through computer
10 program instructions. The computer program instructions are stored in a computer-readable storage medium. Hereinafter, an apparatus is described in a way exactly corresponding to the steps of the method. It should be understood that each component in the apparatus is a function module needed to be established to implement each step of the method. It should be understood that the apparatus defined by such a set of function modules is the function
15 module framework which implements the corresponding method mainly by computer programs. However, it should not be understood that the apparatus is a physical apparatus which implements the method mainly by hardware.

[0012] The other object of the present invention is to provide a downlink transmission apparatus for a Road Side Unit (RSU) of an Electronic Toll Collection (ETC) system,
20 including: a searching device, adapted to synchronously send a transaction signal to a lane corresponding to the RSU on receipt of a synchronous transaction command by the RSU while the RSU is not in a transaction with an On-Board Unit (OBU), wherein the downlink transmission apparatus further includes: an interfering device, adapted to synchronously send an interfering signal to the lane corresponding to the RSU on receipt of a synchronous
25 transaction command by the RSU while the RSU is in a transaction with an OBU in the lane corresponding to the RSU, so that any other OBU entering the lane can not parse a transaction signal synchronously sent by an adjacent RSU.

[0013] Preferably, the downlink transmission apparatus further includes a first coding device, adapted to encode so that the transaction signal sent between the RSU and the OBU is
30 encoded by using a first coding, FM0 coding, and the interfering signal sent by the interfering device is a series of data "0" encoded in the first coding, FM0 coding. Alternatively,

preferably, the downlink transmission apparatus further includes a second coding device instead of the first coding device, so that the transaction signal sent between the RSU and the OBU is encoded by using a second coding, Manchester coding, and the interfering signal is a series of data "0" or "1" encoded in a first coding, FM0 coding.

5 [0014] Preferably, the interfering device is adapted to send the interfering signal at the moment when the adjacent RSU sends a frame header, frame information or a frame trailer of the transaction signal.

[0015] Preferably, in the case where the first coding device is used, the length of time of the interfering signal sent by the interfering device ranges from 32 μ s to 200 μ s; in the case where
10 the second coding device is used, the length of time of the interfering signal ranges from 120 μ s to 400 μ s.

[0016] The advantageous effect of the present invention is that, when a RSU is in a transaction with an OBU in a lane corresponding to the RSU, any other OBU entering the lane corresponding to the RSU is prevented from transacting with an adjacent RSU.

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BRIEF DESCRIPTION OF THE DRAWINGS

[0017] Figure 1 is a schematic diagram of communication status between an electronic toll collection (ETC) system and an on-board unit (OBU);

[0018] Figure 2 is an exemplary waveform of data encoded by using a first coding, FM0
20 coding, according to a first embodiment;

[0019] Figure 3 is a timing diagram of transaction signals synchronously sent by road side units (RSUs) according to the first embodiment;

[0020] Figure 4 is a timing diagram of signals in the case where a RSU b interferes a frame header of a transaction signal sent by an adjacent RSU according to the first embodiment;

25 [0021] Figure 5 is a timing diagram of signals in the case where a RSU b interferes frame information of a transaction signal sent by an adjacent RSU according to the first embodiment;

[0022] Figure 6 is a timing diagram of signals in the case where a RSU b interferes a frame trailer of a transaction signal sent by an adjacent RSU according to the first embodiment;

[0023] Figure 7 is an exemplary waveform of data encoded by using a second coding, Manchester coding according to a second embodiment;

[0024] Figure 8 is a timing diagram of transaction signals synchronously sent by RSUs according to the second embodiment;

5 [0025] Figure 9 is a timing diagram of signals in the case where a RSU b interferes a frame header of a transaction signal sent by an adjacent RSU according to the second embodiment;

[0026] Figure 10 is a timing diagram of signals in the case where a RSU b interferes frame information of a transaction signal sent by an adjacent RSU according to the second embodiment; and

10 [0027] Figure 11 is a timing diagram of signals in the case where a RSU b interferes a frame trailer of a transaction signal sent by an adjacent RSU according to the second embodiment.

DETAILED DESCRIPTION OF THE INVENTION

15 [0028] In the following, the invention will be further illustrated in conjunction with the drawings.

First embodiment

[0029] The Electronic Toll Collection (ETC) system has three lanes A, B and C in the identical orientation, as shown in Figure 1. For each lane, a Road Side Unit (RSU) is provided correspondingly. A transaction signal sent between a RSU and an On-Board Unit (OBU) is encoded by using a first coding, FM0 coding (an exemplary waveform of data encoded by using the first coding, FM0 coding, is shown in Figure 2). The signal encoded by using the first coding, FM0 coding, has a waking-up signal, a lead code, a frame header, frame information and a frame trailer sequentially arranged in a timing sequence. The waking up signal is provided to wake up an OBU, the lead code is provided for an OBU to synchronize a signal, and the frame header and the frame trailer are provided for an OBU to identify the position of the frame information in the timing sequence. It is assumed that a vehicle (on which there is an OBU 4) enters the lane B, and no vehicle enters the lanes A and C. A synchronizer 3 sends a synchronous transaction command to RSUs a, b and c, so that each of the RSUs synchronously sends a transaction signal to the lane corresponding to the RSU, the

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timing sequence diagram of the transaction signal is shown in Figure 3. In the lane B, since the lane B is closest to the RSU b, the transaction signals sent by the RSUs a and c are significantly weaker than the transaction signal sent by the RSU b. Therefore, the OBU 4 on the vehicle first entering the lane B may transact with the RSU b but do not transact with the RSUs a, c.

[0030] While the RSU b is in a transaction with the OBU 4, another vehicle (on which there is an OBU 5) also enters the lane B, and still no vehicle enters lanes A and C. The synchronizer 3 sends a synchronous transaction command to RSUs a, b and c, thereby each of the RSUs a and c synchronously sends a transaction signal to the lane corresponding to the RSU. Since the RSU b is in the transaction with the OBU 4, the RSU b synchronously sends an interfering signal to the lane B corresponding to the RSU b. Following the rules of the first coding, FM0 coding, the frame header of the transaction signal sent by each of the RSUs a and c is “01111110”, and the length of time of the frame header is 32 μ s. Preferably, the RSU b sends the interfering signal at the moment when each of the RSUs a and c sends the frame header of the transaction signal, as shown in Figure 4. The advantage is that the OBU 5 can not parse the frame header of the transaction signal sent by each of the RSUs a and c, and thereby the OBU 5 may not receive the frame information and the frame trailer following the frame header. The level converting frequency of data “0” encoded in the first coding, FM0 coding, is larger than that of data “1” encoded in the first coding, FM0 coding, (see Figure 2), and therefore the data “0” encoded in the first coding, FM0 coding, is more easy to be identified. Therefore, a series of data “0” encoded in the first coding, FM0 coding, are preferably used as the interfering signal, so as to achieve a better interfering effect. If the length of time of the interfering signal is shorter than that of the frame header, the interfering effect may not be good. If the length of time of the interfering signal is too long, the transaction being performed between the RSU b and the OBU 4 may be influenced. All things considered, the length of time of the interfering signal should be properly chosen. Considering that the length of time of the frame header in the first coding, FM0 coding, is 32 μ s, the length of time of the interfering signal in this embodiment is preferably 120 μ s (as for the frame header in the first coding, FM0 coding, it is suitable that the length of time of the interfering signal ranges from 32 μ s to 200 μ s).

[0031] Non-preferably, the interfering signal may also be sent at the moment when the frame information (as shown in Figure 5) or the frame trailer (as shown in Figure 6) of the

transaction signal is sent by an adjacent RSU.

Second embodiment

[0032] Similarly, the Electronic Toll Collection system (ETC) has three lanes A, B and C in the identical orientation, as shown in Figure 1. For each lane, a Road Side Unit (RSU) is provided correspondingly. In this embodiment, a signal sent between a RSU and an On-Board Unit (OBU) is encoded by using a second coding, Manchester coding, (an exemplary waveform of data encoded by using the second coding, Manchester coding, is shown in Figure 7). The signal encoded by using the second coding, Manchester coding, has a lead code, a frame header, frame information and a frame trailer sequentially arranged in a timing sequence. The lead code is provided to wake up an OBU and is provided for the OBU to synchronize a signal, and the frame header and the frame trailer are provided for an OBU to identify the position of the frame information in the timing sequence. It is assumed that a vehicle (on which there is an OBU 4) enters the lane B, and no vehicle enters the lanes A and C. A synchronizer 3 sends a synchronous transaction command to RSUs a, b and c, so that each of the RSUs synchronously sends a transaction signal to the lane corresponding to the RSU, the timing sequence of the transaction signal is shown in Figure 8. In the lane B, since the lane B is closest to the RSU b, the transaction signals sent by the RSUs a and c are significantly weaker than the transaction signal sent by the RSU b. Therefore, the OBU 4 on the vehicle first entering the lane B may transact with the RSU b but do not transact with the RSUs a, c.

[0033] While the RSU b is in a transaction with the OBU 4, another vehicle (on which there is an OBU 5) also enters the lane B, and still no vehicle enters lanes A and C. The synchronizer 3 sends a synchronous transaction command to RSUs a, b and c, thereby each of the RSUs a and c synchronously sends a transaction signal to the lane corresponding to the RSU. Since the RSU b is in the transaction with the OBU 4, the RSU b synchronously sends an interfering signal to the lane B corresponding to the RSU b. Following the rules of the second coding, Manchester coding, the length of time of the frame header of the transaction signal sent by each of the RSUs a and c is 120 μ s. Preferably, the RSU b sends the interfering signal at the moment when each of the RSUs a and c sends the frame header of the transaction signal, as shown in Figure 9. The advantage is that the OBU 5 can not parse the frame header of the transaction signal sent by each of the RSUs a and c, and thereby the OBU 5 may not

receive the frame information and the frame trailer following the frame header. If the length of time of the interfering signal is shorter than that of the frame header, the interfering effect may not be good. If the length of time of the interfering signal is too long, the transaction being performed between the RSU b and the OBU 4 may be influenced. All things considered, the length of time of the interfering signal should be properly chosen. Considering that the length of time of the frame header in the second coding, Manchester coding, is 120 μ s, the length of time of the interfering signal in this embodiment is preferably 300 μ s (as for the frame header in the second coding, Manchester coding, it is suitable that the length of the interfering signal ranges from 120 μ s to 400 μ s).

[0034] In general, in the case where the transaction signal sent between the RSU and the OBU is encoded by using the second coding, Manchester coding, as a rule, the interfering signal is also encoded by using the second coding, Manchester coding. However, specifically in this embodiment, the interfering signal is a series of data “0” or “1” encoded in the first coding, FM0 coding, that is, the interfering signal is encoded by using a coding different from that of the transaction signal. Comparing the data encoded by using the first coding, FM0 coding, (as shown in Figure 2) with the data encoded by using the second coding, Manchester coding, (as shown in Figure 7), it follows that the level converting frequency of data “0” or “1” encoded in the first coding, FM0 coding, is quite larger than that of data “0” or “1” encoded in the second coding, Manchester coding. Therefore, the data “0” or “1” encoded in the first coding, FM0 coding, is more easy to be identified, so as to achieve a better interfering effect. Furthermore, the level converting frequency of data “0” encoded in the first coding, FM0 coding, is larger than that of data “1” encoded in the first coding, FM0 coding (see Figure 2), and therefore the data “0” encoded in the first coding, FM0 coding, is more easy to be identified. Therefore, more preferably, data “0” encoded in the first coding, FM0 coding, is used as the interfering signal, so as to achieve a better interfering effect.

[0035] Non-preferably, the interfering signal may also be sent at the moment when the frame information (as shown in Figure 10) or the frame trailer (as shown in Figure 11) of the transaction signal is sent by an adjacent RSU.

[0036] Likewise, the above-mentioned method is also applicable to lanes in different orientations.

[0037] A function module framework may be established so that all or a portion of the steps

in the given method herein may be implemented by a computer system controlled through computer program instructions. The computer program instructions are stored in a computer-readable storage medium.

[0038] According to the above-mentioned disclosure and teaching of the specification, variations and changes may be made to the above-mentioned embodiments by any skilled in the art to which this invention pertains. Therefore, the invention is not limited to the specific embodiments disclosed and described above. Some changes and variations made to the invention should also fall within the scope of protection of the claims of the present invention. Furthermore, although certain particular terminologies appear in the specification, the terminologies are used only for ease of illustration, without any limitation on the present invention.

CLAIMS

- 5 1. A downlink transmission method for a Road Side Unit (RSU) of an Electronic Toll Collection (ETC) system, comprising:
- on receipt of a synchronous transaction command while the RSU of the ETC system is not in a transaction with an On-Board Unit (OBU), synchronously sending, by the RSU, a transaction signal to a lane corresponding to the RSU; and
- 10 on receipt of a synchronous transaction command while the RSU is in a transaction with the OBU in the lane corresponding to the RSU, synchronously sending, by the RSU, an interfering signal to the lane, so that any other OBU entering the lane can not parse a transaction signal synchronously sent by an adjacent RSU.
- 15 2. The downlink transmission method according to claim 1, wherein the transaction signal sent between the RSU and the OBU is encoded by using a first coding, FM0 coding, and the interfering signal is a series of data "0" encoded in the first coding, FM0 coding.
3. The downlink transmission method according to claim 1, wherein the transaction signal
- 20 sent between the RSU and the OBU is encoded by using a second coding, Manchester coding, and the interfering signal is a series of data "0" or "1" encoded in a first coding, FM0 coding.
4. The downlink transmission method according to claim 2 or 3, wherein the interfering signal is sent at the moment when the adjacent RSU sends a frame header, frame information or a
- 25 frame trailer of the transaction signal.
5. The downlink transmission method according to claim 2, wherein the length of time of the interfering signal ranges from 32 μ s to 200 μ s.

6. The downlink transmission method according to claim 3, wherein the length of time of the interfering signal ranges from 120 μ s to 400 μ s.

7. A downlink transmission apparatus for a Road Side Unit (RSU) of an Electronic Toll Collection (ETC) system, comprising: a searching device, adapted to synchronously send a transaction signal to a lane corresponding to the RSU on receipt of a synchronous transaction command while the RSU is not in a transaction with an On-Board Unit (OBU),

wherein the downlink transmission apparatus further comprises: an interfering device, adapted to synchronously send an interfering signal to the lane corresponding to the RSU on receipt of a synchronous transaction command while the RSU is in a transaction with an OBU in the lane corresponding to the RSU, so that any other OBU entering the lane can not parse a transaction signal synchronously sent by an adjacent RSU.

8. The downlink transmission apparatus according to claim 7, further comprising:

a first coding device, adapted to encode so that the transaction signal sent between the RSU and the OBU is encoded by using a first coding, FM0 coding, and the interfering signal sent by the interfering device is a series of data "0" encoded in the first coding, FM0 coding.

9. The downlink transmission apparatus according to claim 7, further comprising:

a second coding device, adapted to encode so that the transaction signal sent between the RSU and the OBU is encoded by using a second coding, Manchester coding, and the interfering signal is a series of data "0" or "1" encoded in a first coding, FM0 coding.

10. The downlink transmission apparatus according to claim 7, wherein the interfering device is adapted to send the interfering signal at the moment when the adjacent RSU sends a frame header, frame information or a frame trailer of the transaction signal.

11. The downlink transmission apparatus according to claim 8, wherein the length of time of

the interfering signal sent by the interfering device ranges from 32 μ s to 200 μ s.

12. The downlink transmission apparatus according to claim 9, wherein the length of time of the interfering signal ranges from 120 μ s to 400 μ s.