

Method for resetting a piece of trackside equipment of a secondary detection system

5 The present invention relates to a method for resetting a piece of trackside equipment of a secondary detection system, in an automatic train control architecture.

The present invention more particularly relates to an automatic train control architecture for trains traveling on a railroad network. Such an architecture is referred to as Automatic Train Control (ATC).

10 In a known manner, an ATC architecture comprises different systems cooperating with each other to allow trains to travel safely on the network.

Different ATC architectures exist; however, the present invention more specifically relates to an ATC architecture of the "communication-based train control" (CBTC) type. A CBTC architecture is diagrammatically illustrated in figure 1.

15 A CBTC architecture is based on the presence of computers onboard the trains. The computer of a train determines a certain number of operating parameters and communicates with various systems on the ground to allow the train to perform its assigned mission safely. This onboard computer on the one hand covers the functional needs of the train, i.e., for example the stations to be served, and on the other hand controls safety points, i.e., for instance verifies that the train is not traveling at an excessive speed. The computer of a train is connected to an onboard radiocommunication unit, able to establish a radio link with base stations of a communication infrastructure, which in turn is connected to a communication network of the CBTC architecture.

20 On the ground, the CBTC architecture comprises a zone controller (ZC). This zone controller is in particular responsible on the one hand for monitoring the presence of the trains on the railroad network, and on the other hand, in a centralized architecture, for providing movement authorizations to the trains that are of a nature to guarantee their safe movement, i.e., for example not to give a train a movement authorization that would cause it to go past the train preceding it. A zone controller is referenced by number 50 in figure 1.

30 The CTC architecture is part of an overall system, called signaling system (SS in figure 1), that is also able to command a plurality of pieces of equipment on the track.

The signaling system comprises an automatic train supervision (ATS) system. The ATS system is implemented in an operational unit and comprises man / machine interfaces, allowing operators to intervene on the various systems of the signaling system

and, in particular, the trackside equipment. For example, the operator can remotely control closing of the signal (turning a light red) from the ATS.

5 The signaling system also comprises an interlocking system. Such an interlocking system is able to manage the trackside equipment, such as signal lights, switching actuators, etc., that trackside equipment allowing the trains to move safely and avoiding conflicting movements between them. Once based on electromechanical relays, today the interlocking system is computerized by suitable computers able to command the trackside equipment. Such an interlocking computer is referenced by number 40 in figure 1.

10 The railroad network is made up of railroad track sections, each track section being subdivided into zones. In figure 1, three successive zones 14A, 14B and 14C are shown.

The occupancy of a zone of a track section is a key piece of information for railroad security. The determination of that information will now be described.

15 The zone controller receives information on the one hand from a primary detection system, and on the other hand from a secondary detection system.

The primary detection system makes it possible to determine the zone occupied by a train based on the instantaneous position of the train determined by the train itself. More specifically, the zone controller receives the instantaneous position of a train from each computer 26 onboard that train 16. This position is determined by the onboard computer 20 from the detection of beacons 24 placed along the track 12 and whose geographical positions are known, and from odometry means equipping the train and allowing the computer to determine the distance traveled by the train since the last beacon crossed. In another embodiment, the train uses other means to determine its position: for example, an accelerometer (in place of the odometer) or a GPS (in place of the beacons). From the 25 instantaneous position of the train, the zone controller uses a geographical map of the network, on which each zone is uniquely identified, to deduce the zone in which the train is currently located. A first state E1 of the zone in which the train is located then assumes the "occupied" value.

30 It should be noted that for safety reasons, according to the primary detection system, not only is the zone in which the train is located in the "occupied" state, but the adjacent zones before and after that central zone are as well, so as to define a safety area around the train. That additional area covers the maximum distance that the train can travel between the time when it calculates the position that it will send to the zone controller and the time when that zone controller receives the information.

Furthermore, as long as no other position information is received by the zone controller, the latter continues to extrapolate the position of the train to cover its potential movements.

5 The first state E1 of the zones in which no train is located at the current moment assumes the "free" value.

In this way, a first piece of occupancy information for each zone is determined by the zone controller.

10 The secondary detection system is able to back up the primary detection system; for instance, in the event the radiocommunication unit 27 of a train 16 is no longer working, the zone controller 50 cannot obtain the instantaneous position of the train. Using suitable track equipment, positioned alongside the track, the secondary detection system is able to detect the presence of a train in a given zone.

15 In one currently preferred embodiment, in order to detect the presence of a train in a zone, the secondary detection system counts the number of axles 17 entering and leaving the zone.

20 To that end, the secondary system comprises an entry sensor 28A situated at the entrance to the zone 14B in question and an exit sensor 28B situated at the exit of the zone 14B. The entry and exit sensors are connected by cables to a piece of trackside equipment 30 associated with the zone 14B, hereinafter referred to as detection equipment. The detection equipment is situated in a technical site (shared with the signaling equipment).

25 There is one piece of detection equipment per zone. However, a sensor can be connected to several pieces of detection equipment. For example, in the movement direction of the train indicated in figure 1, the sensor 28B is both the exit sensor for the zone 14B and the entry sensor for the zone 14C. It will be connected to the zone controller of the zone 14B and that of the zone 14C.

The detection equipment 30 is an electronic board to which the entry and exit sensors for the zone in question are connected. The detection equipment is able to keep a variable, called axle counter C, of the zone up to date.

30 When the train passes in front of the entry sensor, each time the passage of an axle by the entry sensor is detected, the detection equipment 30 adds one unit to the axle counter C for the zone.

35 When the train leaves the zone, each time the passage of an axle is detected by the exit sensor, the detection equipment 30 subtracts one unit from the axle counter C for the zone.

Thus, according to the secondary detection system, the zone is in a second state E2 assuming the "free" value when the axle counter C for the zone is equal to zero. Otherwise, the second state of the zone assumes the "occupied" value.

5 The second state E2 of a zone constitutes a second piece of occupancy information, which is periodically sent by the detection equipment 30 to the zone controller 50, via the interlocking computer 40.

The zone controller 50 reconciles the first and second piece of occupancy information. Different strategies are next implemented when these two pieces of information differ from one another.

10 It is important to note that a "purely" CBTC system can operate with only a primary detection. The secondary detection is present on the one hand to cover the failure modes of the CBTC communication, and on the other hand to allow trains not equipped with CBTC to travel on the same railroad network.

15 The secondary detection system of the state of the art has the following operating drawback.

As illustrated in figure 1, the train comprises N axles 17.

Initially, no train is located in the zone 14B of the railroad track 12. The axle counter CB of the zone 14B is equal to zero. The second state E2 of the zone is "free".

20 When the train 16 enters the zone 14B, the entry sensor 28A erroneously detects the passage of N-1 axles. The status counter C then assumes the value N-1 ("occupied" state).

When the train 16 leaves the zone 14B, the exit sensor 28B correctly detects the passage of N axles. The status sensor C is decremented by N and assumes the value -1. The second state E2 is therefore "occupied".

25 One can then see that in the case of an erroneous detection of the number of axles by a sensor, the axle counter indicates that the second status of the zone is "occupied", whereas no train physically occupies that zone. By indicating that the first state E1 of that same zone is "free", the primary detection system is therefore in contradiction with the secondary system.

30 In reference to figure 2, the zone controller 50 reconciles the first and second pieces of information coming to it on the one hand from the primary detection system and on the other hand from the secondary detection system.

35 While the primary detection system operates correctly, in the event of a mismatch of the first "free" status type E1 with the second "occupied" status E2, the zone controller 50 places the detection equipment 30 of the zone 14B in the "out of operation" (OOO)

mode. This means that the status counter associated with that zone has been identified as erroneous and must be reset before it can be taken into account again.

For such a reset method, the information that a piece of detection equipment is in the "out of operation" mode is sent by the zone controller 50 to the ATS system. The
5 information is then displayed on an operator's screen, for example in the form of an alarm.

Before validating such a reset, the operator asks an agent to travel along the track to physically observe that the zone in question is in fact unoccupied. Once the operator has received confirmation from the agent, he must next stop the trains that may potentially enter the zone during the reset procedure. He then validates the reset, which results in
10 sending a reset authorization to the zone controller 50.

When this reset authorization request is received, the zone controller 50 sends a reset request to the interlocking computer 40 managing the detection equipment 30 for the concerned zone.

When the reset request is received, the interlocking computer 40 sends a suitable
15 reset command to the detection equipment 30.

When the reset command is received, the detection equipment 30 is able to assign a default value (in this case, the value zero) to the axle counter to be reset.

Once the axle counter has been reset, the detection equipment 30 indicates that the second state E2 of the zone is "free", matching the first state E1 of that same zone.

20 Observing this mismatch, the zone controller 50 places the detection equipment 30 back in the "operational" mode.

Thus, in this first embodiment of a method for resetting the axle counter for a zone, there is no verification of the actual state of the zone by the signaling system.

Once in the "out of operation" mode, the information that the detection equipment
25 for the zone may collect is not taken into account. More specifically, the zone is considered occupied by default, irrespective of the number of axles indicated by the axle counter.

Furthermore, as indicated above, the operational procedure that precedes the sending of a reset authorization request by the operator is cumbersome. It should be
30 noted that all of the safety of this reset procedure rests with the operators, who must make sure that no trains are in the zone before and during the reset. There is a danger of returning a zone to the "free" state whereas a train is actually present in that zone.

Consequently, this reset method is long to carry out. During its performance, over the zone(s) where the pieces of detection equipment are for the "out of operation" zone
35 controller, the primary detection system is not made redundant, which presents availability

problems of the system if the radiocommunication system of a CBTC train fails or if there is trouble with a train not equipped with CBTC.

According to a second reset method of the prior art, when an alarm message is displayed on the screen of the ATS system, the operator validates the sending of a reset
5 authorization to the zone controller.

When that authorization is received, the zone controller uses the primary detection system to verify not only that no train is present in the zone whose status counter must be reset, but also that no train is in an approach area around that zone.

The approach area defines a distance upstream and downstream from a zone,
10 making it possible to guarantee that no train will enter the zone during implementation of the reset method. The approach area corresponds to a reset time multiplied by a maximum travel speed of the trains in the zones upstream and downstream from the considered zone. The approach area depends on each zone.

The reset time accounts for the delay introduced by the communication between
15 the zone controller and the interlocking computer and between the interlocking computer and the detection equipment, as well as the time necessary for the detection equipment to perform the reset strictly speaking.

The distance from each side of the zone in question is significant, for example 300 m upstream or downstream from that zone.

20 Thus, the zone controller only sends a reset request to the detection equipment if all of the zones of the approach area associated with the zone are in a first "free" state.

Otherwise, if a train is in the approach area when the reset is initiated, the zone controller does not send a reset request to the detection equipment, which then remains in the "out of operation" mode. Consequently, the alarm does not disappear from the screen
25 of the ATS system.

This reset method has the advantage of being intrinsically safe, since it is the signaling system itself that verifies the absence of trains in and around the zone. In other words, this method is not based on the operator, unlike the previous one. However, it also has a certain number of implementation difficulties. For instance, it is impossible to
30 implement it during peak usage times of the network, the trains being too close to each other, such that the approach area associated with a zone is very rarely free. In that scenario, the only alternative is a so-called "local" reset of the detection system, i.e., via human intervention directly on the electronic board of the detection equipment, which has a reset button.

35 The present invention aims to resolve the aforementioned problems.

To that end, the invention relates to a method for resetting a piece of trackside detection equipment of a secondary detection system according to the claims.

The invention will be better understood using the following description, provided solely as a non-limiting example and done in reference to the appended drawings, in which:

- figure 1 is a diagrammatic view of an automatic railroad traffic control architecture on a railroad track and a train traveling on the railroad track;

- figure 2 is a diagrammatic view of the first and second occupancy states of successive zones, received by the zone controller of the architecture of figure 1;

10 - figures 3 to 5 are illustrations of the reset method according to the invention;

- figure 6 is a timing diagram showing the signals processed by the detection equipment according to the method of figures 4 and 5; and

- figures 7 to 9 are diagrams showing situations that the present reset method makes it possible to resolve without human intervention, unlike the methods of the state of the art.

15 One preferred embodiment of the reset method 100 will now be described in reference to figures 3 and 5.

The architecture for implementing the method 100 is according to that of the prior art diagrammatically shown in figure 1. It differs in that the detection equipment 30 is able to keep up to date not only an axle counter C, indicating the number of axles in the zone at the current moment t, but also a variation counter CV for the number of axles detected by the entry and exit sensors of the zone during a sliding time window. The window extends over a predetermined duration D before the current moment t. More specifically, this counter CV has two states: the first indicates that an interaction with the entry/exit sensors of the zone has occurred during the duration D preceding the current moment t. The second state, on the contrary, indicates that no interaction with the entry/exit sensors of the zone has occurred during the duration D preceding the current moment t.

While the train 16 has left the zone 14B, the axle counter C does not return to the zero value, one of the entry or exit sensors of the zone 14B not having detected the correct number of axles.

30 In step 110 (figure 3), the detection equipment 30 sends a message M0 indicating that the second state E2 of the zone 14B is "occupied", to the interlocking computer 40.

In step 120, following the reception of the message M0, the interlocking computer 40 sends a message M1 relaying the information that the second state E2 of the zone 14B is "occupied" to the zone controller 50.

In step 130, carried out at moment t_1 , the zone controller ZC 50 compares the first state E1 of the zone 14B with the second state E2 of the zone 14B.

The first state E1 of the zone 14B is that delivered at the current moment t_1 by the primary detection system. The train 16 indicates an instantaneous position at the moment t_1 such that the zone controller 50 can conclude that the first state E1 of the zone 14B is "free".

The second state E2 of the zone 14B is that indicated by the secondary detection system in the message M1. In the scenario indicated in the introduction, the zone controller 50 can conclude that the second state E2 of the zone 14B is "occupied".

There is therefore a mismatch between the first piece of occupancy information delivered by the primary detection system and the second piece of occupancy information delivered by the secondary detection system.

However, the zone controller 50 identifying that the primary system is operational, in particular because the zone controller periodically receives instantaneous position information from the computers 26 onboard the trains, it deduces that the mismatch is caused by an erroneous axle counter C.

It should be noted that for the moment, the detection element 30 is kept in the "operational" mode by the zone controller 50. The latter will first try to reset the detection equipment 30 (as explained below) before deciding whether to place it "out of operation", in the event the reset fails.

The zone controller 50 then itself initiates the reset of the axle counter C. In step 140, the zone controller 50 is able to request a reset of the status counter C for the zone 14B by sending a reset request RI to the interlocking computer 46.

In step 150, following the reception of the request RI, the interlocking computer 40 sends a reset command CI relaying the information that the axle counter C of the zone 14B must be reset.

At moment t_2 , in step 160, the detection equipment 30 receives the reset command CI.

In step 170, the detection equipment 30 then launches the reset of the counter C. The reset ends at moment t_3 .

In step 180, which begins at moment t_4 (offset by a predetermined duration after moment t_3), the detection equipment 30 verifies the value of the variation counter CV.

The duration D of the window used for the counter CV is greater than or equal to the duration between the moments t_1 and t_3 .

Thus, if the variation counter CV is zero, this means that no train has entered the zone since the moment t1 when the zone controller requested the reset. The reset is thus validated by the detection equipment 30. The zone is therefore in the free state at moment t4, matching the current value of the reset axle counter C.

5 In step 180 (figure 4), the detection equipment 30 then sends a validation message M2 indicating that the reset was done successfully and that the zone is in the second "free" state.

In step 190, following the reception of the message M2, the interlocking computer 40 sends a message M3 relaying the information that the second state of the zone 14B is "free", to the zone controller 50.
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In step 200, the zone controller 50 compares the first state E1 of the zone 14B with the second status E2 of the zone 14B. These two states are kept matching one another. The reset is successful. It is important to note that, from an operational standpoint, the detection equipment has never entered the "out of service" mode. In other words, the reset method has been completely transparent to the operator and in no way has it disrupted the nominal operation of the system as a whole.
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However, in the event the variation counter CV is not zero, this means that a train has entered the zone 14B since the moment t1 when the zone controller 50 requested the reset, the duration D being sized so as to cover the transmission times between the different subsystems.
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In that case, in step 180 (figure 5), the reset is not validated by the detection equipment 30 and the zone therefore remains in the "occupied" state at the current moment.

The detection equipment 30 then sends a failed reset message M4 indicating that the reset was not done and the zone 14B is still occupied.
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In step 290, the interlocking computer 40 in turn sends the zone controller 50 a message M5 indicating that the zone 14B is still occupied.

In step 300, the zone controller 50 notes that at least one reset attempt has already been made unsuccessfully. At that time, it places the detection equipment 30 in the "out of operation" mode and, in step 310, sends an alarm message MA to the ATS system.
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In step 320, when the alarm message MA is received, the ATS system displays alarm on one of the screens of the control unit.

An operator validates the reset of the status counter of the detection equipment 30, by making a validation gesture, such as pressing a specific button or, in the case of a
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touchscreen, a zone of the screen associated with the displayed alarm. This results, in step 330, in sending an initialization authorization MAI to the zone controller 50 using the supervisory system.

5 This validation by an operator may involve different information sources allowing the operator to make sure that the zone 14B is in fact free.

The zone controller 50 receives the authorization MAI and, once the primary detection system allows the zone controller 30 to conclude that the zone 14B is free, the different steps 140 to 180, then 190 and 200 are then reiterated.

10 Once the axle counter has been reset, the detection equipment 30 indicates that the second state E2 of the zone is "free", matching the first state E1 of that same zone. Observing this match, the zone controller 50 resituates the detection equipment 30 in the "operational" mode (step 410) and sends a suitable message to the ATS allowing the latter to stop the alarm displayed on the operator's screen (step 420).

15 On the timing diagram in figure 6, the first three graphs show: at moment t1, the zone controller 50, knowing that according to the primary system the zone 14B is free, sends a reset request; at moment t2, the detection equipment 30 receives the corresponding reset request; and at moment t3, the axle counter is reset to the zero value.

20 The following two graphs show the case of figure 4. Since in the sliding window D, between t3-D and t3, the variation counter CV has remained at zero, no axle of a train entering or leaving the zone 14B having been detected, the zone 14B is in fact free.

At moment t4, the detection equipment then sends a successful reset message M2, i.e., a validation message assuming the unit value. The zone will therefore return to the "free" state.

25 The last two graphs of figure 6 show the case of figure 5. Since in the sliding window D, between t3-D and t3, the variation counter CV has assumed the unit value, one axle of a train entering or leaving the zone 14B having been detected, the reset is not validated and the zone remains occupied.

30 At moment t4, the detection equipment sends a failed reset message M4, i.e., a validation message assuming a zero value. It should be noted that at that moment, the detection equipment 30 resets the counter CV.

Alternatively, upon receiving the reset command, the detection equipment is able to verify the current value of the variation counter CV for a first time.

35 If the latter is zero, the detection equipment goes on to the reset step 170 and, at the end of the reset, verifies the value of the variation counter CV a second time as described above in reference to step 180.

On the contrary, if the latter is different from zero, the detection equipment goes directly to step 180 and sends a failed reset message M4.

The method has a certain number of advantages relative to the state of the art.

In particular, it allows resets in the following operating cases, shown in figures 7 to 5 9.

In figure 7, a train not equipped with an onboard computer is traveling on the network. It is stopped in a zone belonging to the approach area of the zone that is out of operation. This situation cannot be handled by the state of the art, since the train is located in the approach area of the out-of-operation zone. With the method described 10 above, service is restored to the zone, since it is detected that no train has entered the zone between the moments when the reset request was sent and when the reset ended.

In figure 8, a train equipped with an onboard computer is traveling on the network. It is stopped in front of a restrictive signal in a zone belonging to the approach area of the out-of-operation zone. This situation cannot be handled by the state of the art, since the 15 train is located in the approach area of the out-of-operation zone. With the method described above, service is restored to the zone, since it is detected that no train has entered the zone between the moments when the reset request was sent and when the reset ended.

In figure 9, a train equipped with an onboard computer is traveling on the railroad 20 network. It is moving over a zone of the approach area of the out-of-operation zone, but downstream from the latter. This situation cannot be handled by the state of the art, since the train is located in the approach area of the out-of-operation zone. With the method described above, service is restored to the zone, since it is detected that no train has entered the zone between the moments when the reset request was sent and when the 25 reset ended.

This reset method is simpler than the known methods and does not lead to the escalation of information to the ATS system unless a configurable number (equal to one in the embodiment shown above in detail) of failed reset attempts initiated by the zone controller occurs. The first reset attempts being done automatically, a reset is done more 30 quickly than by implementing the methods of the state of the art. But above all, the automatic nature eliminates the operational procedures to be established for resets according to the state of the art.

CLAIMS

1. A method for resetting a piece of trackside detection equipment (30) of a secondary system for the detection of the occupancy of a zone (14B) of a railroad network, said secondary system belonging to a CBTC architecture, said CBTC architecture further comprising a primary system for the detection of the occupancy of said zone, based on a transmission of an instantaneous position of each train by computers (26) onboard trains (16) traveling on the network, comprising the following steps:
- using the piece of trackside detection equipment (30) of the secondary detection system to detect the trains entering and/or leaving the zone (14B) and periodically sending a second piece of occupancy information of the zone to a zone controller (50);
 - using the zone controller (50) to send (140) a reset request for the piece of trackside detection equipment following reception of a second piece of occupancy information of the zone by said piece of trackside detection equipment indicating that the zone (14B) is in a second "occupied" state (E2), while a first piece of occupancy information of the zone by the primary detection system for occupancy of the zone indicates, at the same time, that the zone is in a first "free" state (E1);
 - receiving (160) the reset request by the piece of trackside detection equipment (30); and
 - resetting (170) the piece of trackside detection equipment, characterized in that, at the end of the reset step for the piece of trackside detection equipment, the piece of trackside detection equipment verifies (180) that no train has been detected entering and/or leaving the zone (14B) between a moment of sending (t1), by the zone controller, of the reset request and a moment (t3) of conclusion of the reset of the piece of detection equipment; and the piece of trackside detection equipment sends, in the affirmative, a successful reset message (M2) to the zone controller (50), and, in the negative, a failed reset message (M4) to the zone controller.
2. The method according to claim 1, characterized in that, following the step of receiving (160) the reset request by the piece of trackside detection equipment (30), the piece of trackside detection equipment (30) verifies that no train has been detected entering and/or leaving the zone between a moment (t1) when the zone controller (50) has sent the reset request and a moment (t2) when the piece of trackside detection equipment has received the reset request; and, in the affirmative, the piece of trackside detection equipment carries out the step of resetting (170); and, in the negative, the piece of trackside

detection equipment does not carry out the step of resetting and sends a failed reset message (M4) to the zone controller (50).

- 5 3. The method according to claim 1 or claim 2, characterized in that the uplink communications from the piece of trackside detection equipment (30) to the zone controller (50) and downlink communications from the zone controller (50) to the piece of trackside detection equipment (30) are realized through an interlocking computer (40) acting as a communication relay.
- 10 4. The method according to any one of claims 1 to 3, characterized in that the piece of trackside detection equipment (30) being connected to two axle sensors (28A, 28B), an entry sensor situated at an entry border of the zone (14B) and an exit sensor situated at an exit border of the zone, the resetting of the piece of trackside detection equipment (30) consists of resetting an axle counter (C).
- 15 5. The method according to any one of claims 1 to 4, characterized in that the piece of trackside detection equipment (30) is able to keep a variation counter (CV) up to date for the variation of the number of axles detected over the zone during a sliding window, whose time depth (D) relative to the current moment is greater than the time separating
- 20 the moment (t1) of sending, by the zone controller, of a reset request and the moment (t3) of conclusion of the reset step that follows the reception of said reset request by the piece of trackside detection equipment.
- 25 6. The method according to any one of claims 1 to 5, characterized in that, after a predefined number of reset attempts of the piece of trackside detection equipment (30) by the zone controller (50), when a failed reset message (M4) is received, the zone controller (50) sends an alarm message (MA) to an ATC system of the CBTC architecture for the validation, by an operator, of the reset of the detection equipment.