AUTOMATIC REGISTRATION ALGORITHM FOR LOW-VOLTAGE DISTRIBUTION NETWORK CARRIER TERMINAL

FIELD OF THE INVENTION

The present invention relates to a method for managing an electric-power meter-reading network, and more particularly to an automatic registration algorithm for a low-voltage distribution network carrier terminal used in an electric-power carrier remote meter-reading network.

BACKGROUND OF THE INVENTION

In the prior art, an electric-power carrier remote meter-reading network usually comprises a main station computer installed in an electric-power department customer management center and one or more district(s) (also called "region" in networking meter-reading) divided according to the power supply range(s) of the district transformer(s). The main station computer is located at a center of the remote meter-reading network, and is configured to take centralization of management of multi-reading works collected by the district(s), and permanently preserve electric energy data of customers. The precinct of each district includes a district transformer, a concentrator positioned near the district transformer, one or more electric meter(s) installed on the client(s) (including a carrier meter or a non-carrier meter), and a collector. Wherein, the collector is configured to collect meter data of all customers supplied with electric power by the district transformer of the district where the collector is located; on one hand, it establishes data communication with the main station computer via GPRS or other network communication media; on the other hand, it establishes direct data communication with a carrier meter via power lines, or establishes indirect data communication with a non-carrier meter by the help of the power lines and the

collector. The collector can establish serial data communication with one or more non-carrier meter(s), and includes a functional module configured to store meter number data of the non-carrier meter(s) connected thereto. Each electric meter is configured to calculate electric energy consumed by the customers, and has a unique identification number (the meter number); a main function of the meter-reading system is to collect electric energy data of the client electric meters and other status data of the electric meters.

In general, a meter-reading process can be automatically started and completed by the concentrator; the concentrator performs roll-call type meter-reading according to electric meter numbers stored in a storage thereof, and stores meter-reading data in the storage; the main station computer regularly visits the concentrator, and aggregates the meter-reading data in the storage of the concentrator into a database of itself. However, in the initial stage of the installation of the district, since the electric meter numbers are not set in the concentrator, manually setting by the staff is required, that is, the staff collect the electric meter numbers and input the electric meter numbers into the main station computer by manual means, and the electric meter numbers are downloaded from the main station computer into the concentrator. The manual operation method is complex and inefficient, and has a high error rate. In addition, since the electric meter group in the district may often change by reason of replacements, establishing new customers, revoking old customers, etc., the electric meter numbers stored in the storage of the concentrator need to be updated in time, but the conventional manual operation method is obviously incompetent for this requirement.

At present, there have already been some automatic registration algorithms for electric meters that can solve the above-mentioned problems; however, since the automatic registration algorithms may often perform in a district group consisting of a plurality of adjacent districts, and carrier messages may transmit across the

districts, a concentrator of a district is likely to interact with electric meters that actually belong to other districts. Since a premise of electric meter registration is that the electric meters do not understand their home districts in advance, the case that the carrier messages transmit across the districts is likely to cause the phenomenon that an electric meter belonging to one district registers its meter number to a concentrator of another district, or that the meter number of one electric meter is simultaneously registered to a plurality of concentrators, and these are all factors leading to instability of the later stage of the meter-reading process and inaccuracy of the meter-reading data.

SUMMARY OF THE INVENTION

Aiming at the above problems, a purpose of the present invention is to provide an automatic registration algorithm for a low-voltage distribution network carrier terminal which enables a client electric meter to automatically and accurately register the meter number in a concentrator of a home district.

In order to achieve the above purpose, the present invention adopts the following technical solution: an automatic registration algorithm for a low-voltage distribution network carrier terminal, comprising the following steps:

1) a carrier module of a concentrator starts registration of adjacent nodes of the concentrator:

1.1) the carrier module of the concentrator broadcasts a registration command, which can be relayed and is configured to start the registration of the adjacent nodes of the concentrator, to a carrier node,

1.2) non-adjacent nodes of the concentrator receiving the registration command of the step 1.1) cancel their home domain identifications;

1.3) adjacent nodes of the concentrator receiving the registration command of the step 1.1) perform a carrier node register process;

1.4) when a register action silence timer built in the concentrator exceeds a predetermined time interval, entering a step 2);

2) the carrier module of the concentrator starts registration of non-adjacent nodes of the concentrator:

2.1) the carrier module of the concentrator broadcasts a registration command, which can be relayed and is configured to start the registration of the non-adjacent nodes of the concentrator, to a carrier node,

2.2) non-adjacent nodes of the concentrator receiving the registration command of the step 2.1) perform the carrier node register process;

2.3) when a register action silence timer built in the concentrator exceeds a predetermined time interval, entering a step 3);

3) the carrier module of the concentrator starts supplementary registration of the adjacent nodes and the non-adjacent nodes of the concentrator:

3.1) the carrier module of the concentrator broadcasts a registration command, which can be relayed and is configured to start the supplementary registration of the adjacent nodes and the non-adjacent nodes of the concentrator, to a carrier node;

3.2) the adjacent nodes and the non-adjacent nodes of the concentrator that receive the registration command of the step 3.1) and have not registered perform the carrier node register process;

3.3) when a register action silence timer built in the concentrator exceeds a predetermined time interval, ending.

The carrier node register process of the steps 1)-3) includes the following steps: (1) each carrier node receiving the registration command cancels its own home domain identifications, enters a register state machine initial state, and sets a register state machine timer; (2) each carrier node in the register state machine initial state empties its own adjacent domain node table and adjacent concentrator table, enters a register state machine domain-searching state, and sets a register

state machine timer; wherein, the carrier nodes which are also collectors further receive a table searching command transmitted from the concentrator, and start built-in function modules to search non-carrier meters managed by these nodes; (3) each carrier node in the register state machine domain-searching state broadcasts a domain searching request which cannot be relayed to the concentrator and other carrier nodes, and sets the register state machine timer to a random time interval; (4) domain carrier nodes and concentrators receiving the domain searching request reversely transmit response messages which cannot be relayed to adjacent nodes which are searching domains, and each concentrator receiving the domain searching request updates a built-in register action silence timer thereof at the same time; (5) when a carrier node which is searching domains receives all response messages returned from adjacent domain carrier nodes and concentrators, it checks the signal quality of each response message, obtains signal quality parameters capable of measuring the proximity of the nodes, and stores the signal quality parameters and the home domain information in the response message into corresponding items of its own adjacent domain node table and adjacent concentrator table; (6) repeatedly performing the steps (3) to (5) according to a predetermined number of times: when the number of the response times belonging to the same home domain reaches a predetermined threshold value, performing a home domain determination algorithm to determine the home domain of the carrier node, and stopping the transmission of the domain searching request message; (7) each carrier node that has determined its home domain registers to the concentrator of its home domain: if the carrier node is a collector, entering a step (8); if the carrier node is a carrier meter, entering a step (11); (8) entering a register state machine register-data-request state, and setting a register state machine timer; (9) sending a register data request command to a function module, entering a register state machine waiting-for-data state, and setting a register state machine timer; (10) receiving a response message returned from the function module: if the response

message returned from the function module indicates that the managed non-carrier meters are all registered, the carrier node enters a register state machine register-completed state, sets a sleep timer, and enters a step (14); if the response message returned from the function module is register data of a non-carrier meter, transforming the response message into a meter number register message, and entering a step (11); (11) entering a register state machine waiting-for-active-report state, setting the register state machine timer to a random time interval, and preparing to send the meter number register message; when a predetermined time is reached, sending the meter number register message which can be relayed to a concentrator of the home domain, entering a register state machine active-report state, and setting the register state machine timer to a random time interval again; (12) a concentrator receiving the meter number register message reversely transmits a register confirmation message which can be relayed to the carrier node which is being registered, and simultaneously updates the register action silence timer; (13) the carrier node, which is being registered, receives the register confirmation message returned from the concentrator: if the carrier node is a collector, sending a confirmation message to the function module, and returning to the step (9); if the carrier node is a carrier meter, entering the register state machine register-completed state, setting a sleep timer, and entering a step (14); (14) when all carrier nodes receiving the registration command enter the register state machine register-completed state, stopping the transmission of the meter number register message.

The home domain determination algorithm of the step (6) includes the following steps:

① a carrier node checks the message signal source of a received response message;

if the response message is sent from a concentrator, entering a step ②;

if the response message is sent from a domain carrier node, entering a step ④;

② according to the home domain identification, searching the table item corresponding to the concentrator in the adjacent concentrator table;

if the table item does not exist, establishing a new table item, writing the home domain identification, storing the signal quality parameters, initializing the count of the response messages of the concentrator into 1, and the count of the concentrator is added with 1;

if the table item has already existed, the signal quality parameters are inserted into a signal quality parameter table of the table item in order, and the count of the response messages of the concentrator is added with 1;

③ checking whether the current count of the response messages of the concentrator reaches a predetermined value;

if the predetermined value is reached, entering a step ⑥;

if the predetermined value is not reached, returning to the step (3);

④ according to the home domain identification, searching the table item corresponding to the domain carrier node in the adjacent domain node table;

if the table item does not exist, establishing a new table item, writing the carrier node identification and the home domain identification, storing the signal quality parameters, initializing the count of the response messages of the domain carrier node into 1, and the count of the domain carrier node is added with 1;

if the table item has already existed, the signal quality parameters are inserted into a signal quality parameter table of the table item in order, and the count of the response messages of the domain carrier node is added with 1;

⑤ checking whether the current count of the response messages of the domain carrier node reaches a predetermined value;

if the predetermined value is reached, entering a step ⑥;

if the predetermined value is not reached, returning to the step (3);

⑥ the median of the signal quality parameters in the signal quality parameter table of each table item of the adjacent concentrator table and the adjacent domain

node table is obtained and placed into the first item of the signal quality parameter table of each table item;

⑦ respectively searching the minimums of the medians of the signal quality parameters in the adjacent concentrator table and the adjacent domain node table;

⑧ obtaining the home domain identification of the table item corresponding to each minimum, and determining the home domain according to the home domain identification.

In the step (12) and the step (13), each carrier node receiving the meter number register message or the register confirmation message relays the received message; for a carrier node in the domain searching state or the actively reporting state, when it receives the meter number register message or the register confirmation message: if the carrier node is in a non-domain state, a time avoidance algorithm is performed, and messages which are to be transmitted in the current transmission sequence are deleted; if the carrier node is in a domain state, only the time avoidance algorithm is performed.

The time avoidance algorithm is a conflict avoidance algorithm based on a physical-layer carrier sense multiple access (CSMA) technology.

The register action silence timer is configured to record the duration when there is no domain searching action and register action in a district; the registration command adopts a wildcard domain identification, wherein a data domain includes a domain identifier, which is configured to record the home domain identification of the concentrator that sends the registration command.

When receiving a domain searching request or a meter number register message, or when the number of times for broadcasting the registration command which can be relayed reaches a predetermined value, but no domain searching request and no meter number register message is received, the concentrator automatically stops broadcasting the registration command; for a carrier node in a non-domain state or an actively reporting state, when it receives a domain

searching request, no response is generated.

Due to the adoption of the above technical solution, the present invention has the following advantages: 1. the present invention uses each district concentrator as a centre, relies on a domain carrier node which has finished registration, and falls into neighbourhood node registration and non-neighbourhood node registration, and neighbourhood and non-neighbourhood node supplementary registration, etc. to complete the registration process of the electric meters of the overall electric grid in a multi-stage wave manner; compared with the prior art, the present invention enables the electric meters to quickly and accurately register their meter numbers to the concentrators of their home districts, is suitable for not only tightly coupled districts but also non-tightly coupled districts, and effectively avoids the high error rate caused by manual registration; 2. the present invention measures the proximity of the electric-grid registration nodes by virtue of signal quality parameters carried by power-line narrow-band carrier signals during cross-district propagation, and collects, calculates, and compares these parameters through a home-domain confirmation algorithm, thereby accurately determining the home district of a carrier node, and effectively solving the problem that adjacent districts may be simultaneously registered due to the cross-district propagation of the power-line narrow-band carrier signals; 3. the present invention adopts a high-efficiency conflict avoidance and multi-priority carrier packet transceiving control algorithm based on a physical-layer carrier sense multiple access (CSMA) technology to process the priorities of conflict and discharging messages, so that all types of communication nodes in a district simultaneously compete to use the same communication medium, and all electric meters in the district can simultaneously start registration to effectively save the register time. The present invention can be used for electric-meter registration of various types of electric-grid meter-reading networks, and is in particular suitable for electric-meter registration of an electric-power carrier remote meter-reading network in a

relatively complicated communication environment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention will be described in detail hereafter with reference to the accompany embodiments.

First, the concepts which are involved with the description of the algorithm are introduced:

A carrier node refers to a node capable of transmitting and receiving messages through a power-line, and particularly refers to a collector or a carrier meter here.

A domain state refers to that a carrier node has already determined its own home domain.

A non-domain state refers to that a carrier node has not determined its own home domain.

An adjacent node refers to a carrier node capable of directly communicating through power-lines, without using any relay.

A non-adjacent node refers to a carrier node that needs to use a relay to communicate through power-lines.

The automatic registration algorithm for a low-voltage distribution network carrier terminal provided by the present invention is substantially a process that client electric meters determine their home districts and automatically register to concentrators of their home districts. Since the whole electric-grid is a district set formed by a plurality of adjacent district groups, carrier messages may transmit across the districts. Therefore, in order to realize accurate registration of the electric meters of the whole electric-grid, the algorithm adopts a stage-type automatic register process for the electric meters:

Stage 1: a carrier module of a concentrator starts registration of adjacent nodes of the concentrator;

Stage 2: the carrier module of the concentrator starts registration of non-adjacent nodes of the concentrator;

Stage 3: the carrier module of the concentrator starts supplementary registration of the adjacent nodes and the non-adjacent nodes of the concentrator.

Wherein, the stage 1 includes the following steps:

1) The carrier module of the concentrator broadcasts a registration command, which can be relayed and is configured to start registration of the adjacent nodes of the concentrator, to a carrier node, and thereby prompts the adjacent nodes of the concentrator to start registration.

2) Non-adjacent nodes of the concentrator receiving the registration command (hereinafter referred to as non-adjacent nodes) cancel their home domain identifications, and thus come into an initial non-domain state.

3) Adjacent nodes of the concentrator receiving the registration command (hereinafter referred to as adjacent nodes) perform the following carrier node register process:

3.1) Canceling their home domain identifications, entering a register state machine initial state, and setting a register state machine timer. At this time, in the whole district set, only the concentrator has a home domain identification.

Wherein, setting the register state machine timer refers to setting a time interval between actions of the register state machine; every time when the timer exceeds the time interval, a next action of the register state machine is performed.

3.2) Each adjacent node in the register state machine initial state empties its own adjacent domain node table, adjacent concentrator table, and relevant state data, enters a register state machine domain-searching state, and sets a register state machine timer; wherein, the adjacent nodes which are also collectors further receive a table searching command transmitted from the concentrator, and start built-in function modules to search non-carrier meters managed by these nodes.

The adjacent domain node table is a table used by the adjacent node to record

domain carrier nodes capable of directly communicating with the adjacent node itself, and the adjacent concentrator table is a table used by the adjacent node to record concentrators capable of directly communicating with the adjacent node itself.

3.3) Each adjacent node in the register state machine domain-searching state broadcasts a domain searching request which cannot be relayed to the concentrator and other carrier nodes, so that responses of adjacent domain carrier nodes and concentrator(s) (the number of which can be more than one) are obtained, and thus the distribution of adjacent domains thereof is grasped. Meanwhile, in order to keep the adjacent node being in the domain searching state, the register state machine timer needs to be set to a random time interval, so that the domain searching request is transmitted again when the adjacent node comes into the same state next time.

3.4) Domain carrier nodes and concentrators receiving the domain searching request reversely transmit response messages which cannot be relayed to adjacent nodes which are searching domains, and thereby report their home domains; moreover, each concentrator receiving the domain searching request updates a built-in register action silence timer thereof at the same time.

The register action silence timer is configured to record the duration when there is no domain searching action and register action in the district where the concentrator is positioned; and every time when there is a domain searching action or a register action, the concentrator will update this timer again.

3.5) When an adjacent node which is searching domains receives all response messages returned from adjacent domain carrier nodes and concentrators, it checks the signal quality of each response message, obtains signal quality parameters capable of measuring the proximity of the nodes, and stores the signal quality parameters and the home domain information in the response message into corresponding items of its own adjacent domain node table and adjacent

concentrator table.

3.6) Repeatedly performing the steps 3.3) to 3.5) according to a predetermined number of times, thereby collecting a plurality of samples of the response messages; when the number of the response times belonging to the same home domain reaches a predetermined threshold value, performing a home domain determination algorithm (this algorithm will be detailed in the following), determining the home domain of the adjacent node according to the signal quality parameters of the collected response messages, and stopping the transmission of the domain searching message.

3.7) Each adjacent node that has determined its home domain registers to the concentrator of its home domain:

if the adjacent node is a collector, entering the step 3.8);

if the adjacent node is a carrier meter, entering the step 3.11).

3.8) Entering a register state machine register-data-request state, and setting a register state machine timer.

3.9) Sending a register data request command to a function module, entering a register state machine waiting-for-data state, and setting a register state machine timer.

3.10) Receiving a response message returned from the function module:

if the response message returned from the function module indicates that the managed non-carrier meters are all registered, the adjacent node enters a register state machine register-completed state, sets a sleep timer, and enters the step 3.14);

if the response message returned from the function module is register data of a non-carrier meter, transforming the response message into a meter number register message, and entering the step 3.11).

3.11) Entering a register state machine waiting-for-active-report state, setting the register state machine timer to a random time interval, and preparing to send the meter number register message; when a predetermined time is reached, sending

the meter number register message which can be relayed to a concentrator of the home domain, and entering a register state machine active-report state. At the same time, since the registration of each electric meter should be confirmed by the concentrator, otherwise the register operation for the next electric meter cannot be performed, the adjacent node needs to be kept being in an actively reporting state, that is, the register state machine timer needs to be set to a random time interval again, so that the meter number register message can be resent when a register confirmation message is not received.

3.12) A concentrator receiving the meter number register message reversely transmits a register confirmation message which can be relayed to the adjacent node which is being registered, and simultaneously updates the register action silence timer.

3.13) The adjacent node, which is being registered, receives the register confirmation message returned from the concentrator:

if the adjacent node is a collector, sending a confirmation message to the function module, and returning to the step 3.9);

if the adjacent node is a carrier meter, entering the register state machine register-completed state, setting a sleep timer, and entering the step 3.14).

3.14) When all adjacent nodes receiving the registration command enter the register state machine register-completed state, stopping the transmission of the meter number register message.

4) When the register action silence timer of the concentrator exceeds a predetermined time interval, the concentrator terminates the electric meter registration process of this stage, and can enter an electric meter registration process of a next stage according to the requirement. At this time, each district forms an island area that uses the concentrator as a center and is surrounded by registered carrier nodes of the same district.

The step that the concentrator enters the stage 2 to perform electric meter

registration is similar to stage 1, however, in this stage, the registration command broadcast to the carrier node by the carrier module of the concentrator is replaced by a registration command which can be relayed and is configured to start registration of the non-adjacent nodes of the concentrator; correspondingly, the subjects performing the carrier node registration process are replaced by the non-adjacent nodes of the concentrator.

The step that the concentrator enters the stage 3 to perform electric meter supplementary registration is still similar to stage 1, however, in this stage, the registration command broadcast to the carrier node by the carrier module of the concentrator is replaced by a registration command which can be relayed and is configured to start supplementary registration of the adjacent nodes and the non-adjacent nodes of the concentrator; correspondingly, the subjects performing the carrier node registration process are replaced by the adjacent nodes and the non-adjacent nodes of the concentrator which have not been registered, so that the nodes missed by the former registration are now registered.

In the network formed by the concentrator and the carrier meters, the registration process including the above three stages forms a wave process that uses the concentrator as a center, the carrier nodes in the non-domain state rely on the carrier nodes that have finished registration and are in the domain state to gradually finish their register processes, until the whole network becomes calm.

Furthermore, in order to improve the success rate of the electric meter registration, on the basis of the adjacent node registration, the non-adjacent node registration, and the adjacent and non-adjacent node supplementary registration, the adjacent and non-adjacent node supplementary registration can also be performed extra once or twice according to the requirements, that is, the whole registration process of the present invention can be expanded to have a plurality of stages (more than three stages), and it is unnecessary to go into details here.

In the above process, the registration command broadcast to the carrier node

by the carrier module of the concentrator adopts a wildcard domain identification, wherein the data domain includes a domain identifier, which is configured to record the home domain identification of the concentrator that sends the registration command.

In the above process, in order to avoid conflicts between physical channels during registration of the carrier nodes, the time intervals for the carrier nodes to send commands or messages need to be as different as possible; therefore, according to the requirement, the present invention sets the register state machine timer to a random time interval, so that the time interval for sending commands or messages equals the sum of a constant time interval, a random time interval, and a random physically-waiting time interval for transmission.

In the above process, in order to avoid conflicts between physical channels during registration of the carrier nodes, the present invention further adopts a time avoidance algorithm based on a physical-layer carrier sense multiple access (CSMA) technology, which determines whether to avoid the currently received package or not according to the register state of the carrier nodes and the transmission waiting time for the carrier nodes to transmit packages:

① For a carrier node in the domain searching state, when it receives a domain searching request or a response message sent from another node that is not a concentrator:

if the transmission waiting time is still in the constant time interval, the time of a register state timer is recalculated;

if the transmission waiting time enters the random time interval, the time is not recalculated.

② For a carrier node in the domain searching state, when it receives a response message sent from a concentrator, the time of a register state timer is recalculated.

③ For a carrier node in the actively reporting state, when it receives a domain

searching request or a response message sent from another node:

if the transmission waiting time of the carrier node is still in the constant time interval, the time of a register state timer is recalculated;

if the transmission waiting time enters the random time interval, the time is not recalculated.

In the above process, the system adopts a multi-priority carrier packet transceiving control algorithm to process the priorities of conflict and discharging messages. Wherein, meter number register messages and register confirmation messages are prior packages, and each carrier node receiving a meter number register message or a register confirmation message will relay the received message. For a carrier node in the domain searching state or the actively reporting state, when it receives a meter number register message sent from another node or a register confirmation message sent from a concentrator:

If the carrier node is in the non-domain state, the time avoidance algorithm is performed, and messages which are to be transmitted in the current transmission sequence are deleted, so that the meter number register message or the register confirmation message obtains a transmission path.

If the carrier node is in the domain state, only the time avoidance algorithm is performed.

In the above process, for a carrier node in the non-domain state or the actively reporting state, when it receives a domain searching request, no response is generated.

In the above process, when receiving a domain searching request or a meter number register message, or when the number of times for broadcasting the registration command which can be relayed reaches a predetermined value, but no domain searching request and no meter number register message is received, the concentrator will automatically stop broadcasting the registration command.

In the home domain determination algorithm adopted by the above step 3.6),

each carrier node uses its own adjacent concentrator table and adjacent domain node table to record concentrators and domain carrier nodes that can directly communicate with itself and communication signal qualities of the concentrators and the domain carrier nodes, and determines its own home domain by comparing the communication signal qualities. Each table item of the adjacent concentrator table stores a home domain identification of a concentrator, the signal quality parameters of each response message of the concentrator, and the count of the response messages of the concentrator. Each table item of the adjacent domain node table stores the node identification and the home domain identification of a domain carrier node, the signal quality parameters of each response message of the node, and the count of the response messages of the node. The signal quality parameters in the adjacent concentrator table and the adjacent domain node table are sorted and stored according to their numerical values. The specific steps of the home domain determination algorithm are as follows:

① The carrier node checks the message signal source of a received response message;

if the response message is sent from a concentrator, entering the step ②;

if the response message is sent from a domain carrier node, entering the step ④;

② According to the home domain identification, searching the table item corresponding to the concentrator in the adjacent concentrator table;

if the table item does not exist, establishing a new table item, writing the home domain identification, storing the signal quality parameters, initializing the count of the response messages of the concentrator into 1, and the count of the concentrator is added with 1;

if the table item has already existed, the signal quality parameters are inserted into a signal quality parameter table of the table item in order, and the count of the response messages of the concentrator is added with 1.

③ Checking whether the current count of the response messages of the concentrator reaches a predetermined value;

if the predetermined value is reached, entering the step ⑥;

if the predetermined value is not reached, returning to the step 3.3);

④ According to the home domain identification, searching the table item corresponding to the domain carrier node in the adjacent domain node table;

if the table item does not exist, establishing a new table item, writing the carrier node identification and the home domain identification, storing the signal quality parameters, initializing the count of the response messages of the domain carrier node into 1, and the count of the domain carrier node is added with 1;

if the table item has already existed, the signal quality parameters are inserted into a signal quality parameter table of the table item in order, and the count of the response messages of the domain carrier node is added with 1.

⑤ Checking whether the current count of the response messages of the domain carrier node reaches a predetermined value;

if the predetermined value is reached, entering the step ⑥;

if the predetermined value is not reached, returning to the step 3.3).

⑥ The median of the signal quality parameters in the signal quality parameter table of each table item of the adjacent concentrator table and the adjacent domain node table is obtained and placed into the first item of the signal quality parameter table of each table item.

⑦ Respectively searching the minimums of the medians of the signal quality parameters in the adjacent concentrator table and the adjacent domain node table;

⑧ Obtaining the home domain identification of the table item corresponding to each minimum, and determining the home domain according to the home domain identification.

The above embodiments are merely to illustrate the invention, in which the structures of the components, the connection means, etc. may be varied, and all

equivalent changes and modifications based on the technical solution of the present invention are not excluded from the scope of protection of the present invention.

CLAIMS

What is claimed is:

1. An automatic registration algorithm for a low-voltage distribution network carrier terminal, comprising the following steps:

1) a carrier module of a concentrator starts registration of adjacent nodes of the concentrator:

1.1) the carrier module of the concentrator broadcasts a registration command, which can be relayed and is configured to start the registration of the adjacent nodes of the concentrator, to a carrier node,

1.2) non-adjacent nodes of the concentrator receiving the registration command of the step 1.1) cancel their home domain identifications;

1.3) adjacent nodes of the concentrator receiving the registration command of the step 1.1) perform a carrier node register process;

1.4) when a register action silence timer built in the concentrator exceeds a predetermined time interval, entering a step 2);

2) the carrier module of the concentrator starts registration of non-adjacent nodes of the concentrator:

2.1) the carrier module of the concentrator broadcasts a registration command, which can be relayed and is configured to start the registration of the non-adjacent nodes of the concentrator, to a carrier node,

2.2) non-adjacent nodes of the concentrator receiving the registration command of the step 2.1) perform the carrier node register process;

2.3) when a register action silence timer built in the concentrator exceeds a predetermined time interval, entering a step 3);

3) the carrier module of the concentrator starts supplementary registration of the adjacent nodes and the non-adjacent nodes of the concentrator:

3.1) the carrier module of the concentrator broadcasts a registration command, which can be relayed and is configured to start the supplementary registration of

the adjacent nodes and the non-adjacent nodes of the concentrator, to a carrier node;

3.2) the adjacent nodes and the non-adjacent nodes of the concentrator that receive the registration command of the step 3.1) and have not registered perform the carrier node register process;

3.3) when a register action silence timer built in the concentrator exceeds a predetermined time interval, ending.

2. The automatic registration algorithm for a low-voltage distribution network carrier terminal according to claim 1, wherein, the carrier node register process of the steps 1)-3) includes the following steps:

(1) each carrier node receiving the registration command cancels its own home domain identifications, enters a register state machine initial state, and sets a register state machine timer;

(2) each carrier node in the register state machine initial state empties its own adjacent domain node table and adjacent concentrator table, enters a register state machine domain-searching state, and sets a register state machine timer; wherein, the carrier nodes which are also collectors further receive a table searching command transmitted from the concentrator, and start built-in function modules to search non-carrier meters managed by these nodes;

(3) each carrier node in the register state machine domain-searching state broadcasts a domain searching request which cannot be relayed to the concentrator and other carrier nodes, and sets the register state machine timer to a random time interval;

(4) domain carrier nodes and concentrators receiving the domain searching request reversely transmit response messages which cannot be relayed to adjacent nodes which are searching domains, and each concentrator receiving the domain searching request updates a built-in register action silence timer thereof at the same time;

(5) when a carrier node which is searching domains receives all response messages returned from adjacent domain carrier nodes and concentrators, it checks the signal quality of each response message, obtains signal quality parameters capable of measuring the proximity of the nodes, and stores the signal quality parameters and the home domain information in the response message into corresponding items of its own adjacent domain node table and adjacent concentrator table;

(6) repeatedly performing the steps (3) to (5) according to a predetermined number of times:

when the number of the response times belonging to the same home domain reaches a predetermined threshold value, performing a home domain determination algorithm to determine the home domain of the carrier node, and stopping the transmission of the domain searching request message;

(7) each carrier node that has determined its home domain registers to the concentrator of its home domain:

if the carrier node is a collector, entering a step (8);

if the carrier node is a carrier meter, entering a step (11);

(8) entering a register state machine register-data-request state, and setting a register state machine timer;

(9) sending a register data request command to a function module, entering a register state machine waiting-for-data state, and setting a register state machine timer;

(10) receiving a response message returned from the function module:

if the response message returned from the function module indicates that the managed non-carrier meters are all registered, the carrier node enters a register state machine register-completed state, sets a sleep timer, and enters a step (14);

if the response message returned from the function module is register data of a non-carrier meter, transforming the response message into a meter number register

message, and entering a step (11);

(11) entering a register state machine waiting-for-active-report state, setting the register state machine timer to a random time interval, and preparing to send the meter number register message; when a predetermined time is reached, sending the meter number register message which can be relayed to a concentrator of the home domain, entering a register state machine active-report state, and setting the register state machine timer to a random time interval again;

(12) a concentrator receiving the meter number register message reversely transmits a register confirmation message which can be relayed to the carrier node which is being registered, and simultaneously updates the register action silence timer;

(13) the carrier node, which is being registered, receives the register confirmation message returned from the concentrator:

if the carrier node is a collector, sending a confirmation message to the function module, and returning to the step (9);

if the carrier node is a carrier meter, entering the register state machine register-completed state, setting a sleep timer, and entering a step (14);

(14) when all carrier nodes receiving the registration command enter the register state machine register-completed state, stopping the transmission of the meter number register message.

3. The automatic registration algorithm for a low-voltage distribution network carrier terminal according to claim 2, wherein, the home domain determination algorithm of the step (6) includes the following steps:

① a carrier node checks the message signal source of a received response message;

if the response message is sent from a concentrator, entering a step ②;

if the response message is sent from a domain carrier node, entering a step ④;

② according to the home domain identification, searching the table item

corresponding to the concentrator in the adjacent concentrator table;

if the table item does not exist, establishing a new table item, writing the home domain identification, storing the signal quality parameters, initializing the count of the response messages of the concentrator into 1, and the count of the concentrator is added with 1;

if the table item has already existed, the signal quality parameters are inserted into a signal quality parameter table of the table item in order, and the count of the response messages of the concentrator is added with 1;

③ checking whether the current count of the response messages of the concentrator reaches a predetermined value;

if the predetermined value is reached, entering a step ⑥;

if the predetermined value is not reached, returning to the step (3);

④ according to the home domain identification, searching the table item corresponding to the domain carrier node in the adjacent domain node table;

if the table item does not exist, establishing a new table item, writing the carrier node identification and the home domain identification, storing the signal quality parameters, initializing the count of the response messages of the domain carrier node into 1, and the count of the domain carrier node is added with 1;

if the table item has already existed, the signal quality parameters are inserted into a signal quality parameter table of the table item in order, and the count of the response messages of the domain carrier node is added with 1;

⑤ checking whether the current count of the response messages of the domain carrier node reaches a predetermined value;

if the predetermined value is reached, entering a step ⑥;

if the predetermined value is not reached, returning to the step (3);

⑥ the median of the signal quality parameters in the signal quality parameter table of each table item of the adjacent concentrator table and the adjacent domain node table is obtained and placed into the first item of the signal quality parameter

table of each table item;

⑦ respectively searching the minimums of the medians of the signal quality parameters in the adjacent concentrator table and the adjacent domain node table;

⑧ obtaining the home domain identification of the table item corresponding to each minimum, and determining the home domain according to the home domain identification.

4. The automatic registration algorithm for a low-voltage distribution network carrier terminal according to claim 2 or claim 3, wherein, in the step (12) and the step (13), each carrier node receiving the meter number register message or the register confirmation message relays the received message; for a carrier node in the domain searching state or the actively reporting state, when it receives the meter number register message or the register confirmation message:

if the carrier node is in a non-domain state, a time avoidance algorithm is performed, and messages which are to be transmitted in the current transmission sequence are deleted;

if the carrier node is in a domain state, only the time avoidance algorithm is performed.

5. The automatic registration algorithm for a low-voltage distribution network carrier terminal according to claim 4, wherein, the time avoidance algorithm is a conflict avoidance algorithm based on a physical-layer carrier sense multiple access (CSMA) technology.

6. The automatic registration algorithm for a low-voltage distribution network carrier terminal according to any one of claims 1, 2, 3, and 5, wherein, the register action silence timer is configured to record the duration when there is no domain searching action and register action in a district; the registration command adopts a wildcard domain identification, wherein a data domain includes a domain identifier, which is configured to record the home domain identification of the concentrator that sends the registration command.

7. The automatic registration algorithm for a low-voltage distribution network carrier terminal according to claim 4, wherein, the register action silence timer is configured to record the duration when there is no domain searching action and register action in a district; the registration command adopts a wildcard domain identification, wherein a data domain includes a domain identifier, which is configured to record the home domain identification of the concentrator that sends the registration command.

8. The automatic registration algorithm for a low-voltage distribution network carrier terminal according to any one of claims 1, 2, 3, 5, and 7, wherein, when receiving a domain searching request or a meter number register message, or when the number of times for broadcasting the registration command which can be relayed reaches a predetermined value, but no domain searching request and no meter number register message is received, the concentrator automatically stops broadcasting the registration command; for a carrier node in a non-domain state or an actively reporting state, when it receives a domain searching request, no response is generated.

9. The automatic registration algorithm for a low-voltage distribution network carrier terminal according to claim 4, wherein, when receiving a domain searching request or a meter number register message, or when the number of times for broadcasting the registration command which can be relayed reaches a predetermined value, but no domain searching request and no meter number register message is received, the concentrator automatically stops broadcasting the registration command; for a carrier node in a non-domain state or an actively reporting state, when it receives a domain searching request, no response is generated.

10. The automatic registration algorithm for a low-voltage distribution network carrier terminal according to claim 6, wherein, when receiving a domain searching request or a meter number register message, or when the number of

times for broadcasting the registration command which can be relayed reaches a predetermined value, but no domain searching request and no meter number register message is received, the concentrator automatically stops broadcasting the registration command; for a carrier node in a non-domain state or an actively reporting state, when it receives a domain searching request, no response is generated.