Reliability of Network Maps

The invention arises from the field of mapping physical networks, in particular electrical distribution grids.

Management of an electrical distribution grid requires performing many tasks, in particular responding quickly to repair the facilities in case of an incident, connecting new nodes to the existing grid, performing real-time balancing of power on the grid in order to limit the risks of local overload, and planning for operations for improving the grid in anticipation of future needs and constraints. Conventionally, Geographical Information Systems (GIS) are one type of tool available to grid managers for performing such tasks. Such GIS normally contain maps of the electric distribution grid. The maps contain data organized so as to represent, the most faithfully possible, the physical grid and facilities that constitute it. In practice, the data for the GIS must be entered and updated manually each time needed or that an action on the grid is taken. Human errors lead to inaccuracies and inconsistencies in the GIS relative to the physical reality of the grids. Hence, each difference between the physical distribution grid and the information relating to it can lead to inefficient or counterproductive incidents and operations.

Often, the detection of such errors arises by chance. For example, an operator in the field notices an error in a map and the signal. Often, repairing such an error requires the travel of a second operator to precisely identify the error, characterize it and finally correct it. Keeping the GIS data up-to-date is complex, costly and inefficient. Data verification is rarely implemented. For some electrical grids, the data are not cataloged and organized by computer. The GIS are nonexistent and still to be created.

Further, the numerous GIS have a structure which is not standardized and are therefore not directly compatible with each other. In situations where several people from the sector must cooperate, the exchange of information is complex.

The invention aims to improve the situation.

Summary

According to a first aspect, a method implemented by computer is proposed for constructing a map of an electrical distribution grid comprising at least one source node including a plurality of outputs and a plurality of consumer nodes each supplied by a single output. To each pair of nodes there corresponds a link connecting the two nodes to each other. Each of the consumer nodes is able

to communicate with the source node by at least one communication route through the electrical distribution grid. Each route is formed of:

- a single link directly connecting the source node to the consumer nodes; or
- a series of links indirectly connecting the source node to the consumer node through at least one other consumer node forming a relay node.

The method comprises:

a) during at least one observation period and for each pair of consumer nodes, counting the number of times that the corresponding link forms part of a communication route between the source node and consumer node;

b) building a graph in which each vertex corresponds to a consumer node and the weight of each edge between two vertices is assigned depending on the number of times the link which connects the corresponding pair of consumer nodes forms part of a communication route established between the source node and a consumer node;

c) partitioning the vertices of the graph into groups by applying algorithms arranged such that:

- two vertices between which the weight of the edge is large and/or two vertices sharing a high number of common neighbors tending to be classified in a single group; whereas
- two vertices classified in distinct groups tending to have a low or zero link weight and/or having few common neighbors.

Such a process serves to automate the construction of maps, by creation of new maps, or even by verification and/or correction of existing maps. Most errors can be detected preventively, without waiting for possible detection by an operator sent to the field. By detecting errors quickly, the simplest ones can be quickly corrected and the correction of the more complex ones can be planned in advance. Identified errors can be corrected before harming the management of the grid. In most cases, the correction of the errors themselves can be automated, or can at least be implemented without the involvement of an operator in the field being necessary. The method can be implemented, for example, by means of existing communicating devices in the grid. In this case, the installation of dedicated equipment is superfluous. For example, communicating meters, known under the brand name “Linky” are being deployed in France. Such meters comprise a communication module able to implement the method, with each meter corresponding to a consumer node, sometimes called “Delivery Point” (DP).

According to a second aspect, a system is proposed comprising at least one concentrator and one processing unit, where the processing unit includes memory able to store at least one map of an electric distribution grid. The electrical distribution grid comprises at least one source node

including a plurality of outputs and a plurality of consumer nodes each supplied by a single output. To each pair of nodes there corresponds a link connecting the two nodes to each other. Each of the consumer nodes is able to communicate with the source node by at least one communication route through the electrical distribution grid. Each route is formed of:

- a single link directly connecting the source node to the consumer nodes; or
- a series of links indirectly connecting the source node to the consumer node through at least one other consumer node forming a relay node.

The concentrator is arranged for:

a) during at least one observation period and for each pair of consumer nodes, collecting and sending the processing unit data from counting the number of times that the corresponding link forms part of a communication route between the source node and consumer node;

The processing unit is arranged for receiving the counting data and

b) building a graph in which each vertex corresponds to a consumer node and the weight of each edge between two vertices is assigned depending on the number of times the link which connects the corresponding pair of consumer nodes forms part of a communication route established between the source node and a consumer node;

c) partitioning the vertices of the graph into groups by applying algorithms arranged such that:

- two vertices between which the weight of the edge is large and/or two vertices sharing a high number of common neighbors tending to be classified in a single group; whereas
- two vertices classified in distinct groups tending to have a low or zero link weight and/or having few common neighbors.

According to a third aspect, a computer program is proposed able to be used in a method for construction of a map such as the method defined in the first aspect. According to a fourth aspect, a nonvolatile computer readable storage medium is proposed on which a program is recorded comprising instructions for the implementation of the method proposed in the first aspect.

The following features can optionally be implemented. They can be implemented independently of each other or in combination of ones with others:

- The weights are assigned depending on the number of times that the corresponding link forms part of a route for a constant number of routes between each source node and consumer node pair. In this way, the representativeness of the observation period can be improved, including if some consumer nodes are more active than others by establishing more communication routes during the observation period than during a typical functional period.

- At the end of counting, an intermediate random sampling operation is done and the partitioning operations are done based on the resulting samples; the succession of sampling, graph construction and partitioning operations are the subject of an iterative loop. In that way the measurement biases are reduced.

- The communication between the nodes is established according to a distributed architecture by Power Line Carrier on the electric distribution grid. The presence of a dedicated communication network is then superfluous. The electrical distribution networks provided with communication modules can be made compatible with little or no equipment modifications.

- In an example, the method further comprises:

d) comparing the composition of the groups resulting from assignment of consumer nodes to outputs according to a pre-existing map;

e) deducing from the comparison the accuracy of the map or the existence of at least one error;

f) in case of deducing at least one error, correcting the map based on the composition of the resulting groups.

This way the existing maps can be verified, corrected and/or updated. The partitioning into groups can be combined and crossed with other data already contained in the existing maps.

- The partitioning includes implementation of a dividing algorithm, and agglomerating algorithm, an optimization algorithm by density verification or a combination of such algorithms. Such algorithms can be implemented in large part by automation while making it possible to achieve a high reliability of the map information.

Other features, details and advantages of the invention will appear upon reading the following detailed description and analyzing the attached drawings, on which:

- Figure 1 is a partial representation of the data from a map to be verified/corrected;
- Figures 2 and 3 each show a functional diagram of an embodiment of at least a part of one method according to the invention;
- Figures 4 and 5 each show a graph prepared during a method according to the invention;
- Figures 6, 7 and 8 show details of a method according to the invention;
- Figure 9 shows a partition implemented according to the method;
- Figures 10, 11 and 12 each show a portion of an embodiment according to the invention;
- Figure 13 shows a portion of an embodiment according to the invention; and

Claims

1. A method implemented by computer is proposed for constructing a map of an electrical distribution grid comprising at least one source node including a plurality of outputs and a plurality of consumer nodes each supplied by a single output where for each pair of nodes there corresponds a link connecting the two nodes to each other.

where each of the consumer nodes is able to communicate with the source node by at least one communication route through the electrical distribution grid,

each route is formed of:

- a single link directly connecting the source node to the consumer nodes; or
- a series of links indirectly connecting the source node to the consumer node through at least one other consumer node forming a relay node, the method comprising:

a) during at least one observation period and for each pair of consumer nodes, counting the number of times that the corresponding link forms part of a communication route between the source node and a consumer node;

b) build a graph in which each vertex corresponds to a consumer node and the weight of each edge between two vertices is assigned depending on the number of times the link which connects the pair of consumer nodes forms part of a communication route established between a source node and a terminal consumer node.

c) partitioning the vertices of the graph into groups by applying algorithms arranged such that:

- two vertices between which the weight of the edge is large and/or two vertices sharing a high number of common neighbors tending to be classified in a single group; whereas
- two vertices classified in distinct groups tending to have a low or zero link weight and/or having few common neighbors.

2. The method according to claim 1, wherein the weights are assigned depending on the number of times that the corresponding link forms part of a route for a constant number of routes between each source node and consumer node pair.

3. The method according to one of the preceding claims, wherein, at the end of counting, an intermediate random sampling operation is done and the partitioning operations are done based on the resulting samples; the succession of sampling, graph construction and partitioning operations are the subject of an iterative loop.

4. The method according to one of the preceding claims, wherein the communication between the nodes is established according to a distributed architecture by Power Line Carrier on the electric distribution grid.

5. The method according to one of the preceding claims, further comprising:

d) comparing the composition of the groups resulting from assignment of consumer nodes to outputs according to a pre-existing map;

e) deducing from the comparison the accuracy of the map or the existence of at least one error;

f) in case of deducing at least one error, correcting the map based on the composition of the resulting groups.

6. The method according to one of the preceding claims, wherein the partitioning includes implementation of a dividing algorithm, and agglomerating algorithm, an optimization algorithm by density verification or a combination of such algorithms.

7. The system comprising at least one concentrator and one processing unit, where the processing unit includes memory able to store at least one map of an electric distribution grid, the electrical distribution grid comprising at least one source node including a plurality of outputs and a plurality of consumer nodes each supplied by a single output where for each pair of nodes there corresponds a link connecting the two nodes to each other.

where each of the consumer nodes is able to communicate with the source node by at least one communication route through the electrical distribution grid,

each route is formed of:

- a single link directly connecting the source node to the consumer nodes; or
- a series of links indirectly connecting the source node to the consumer node through at least one other consumer node forming a relay node,

where the concentrator is arranged for:

a) collecting and sending the processing unit data from counting the number of times that each link corresponding to each pair of consumer notes forms a part of the communication route between the source node and a consumer node during at least one observation period,

where the processing unit is arranged for receiving the counting data and

b) build a graph in which each vertex corresponds to a consumer node and the weight of each edge between two vertices is assigned depending on the number of times the link which connects the pair of consumer nodes forms part of a communication route established between a source node and a terminal consumer node.

c) partitioning the vertices of the graph into groups by applying algorithms arranged such that:
- two vertices between which the weight of the edge is large and/or two vertices sharing a high number of common neighbors tending to be classified in a single group; whereas
- two vertices classified in distinct groups tending to have a low or zero link weight and/or having few common neighbors.

8. A computer program comprising instructions for implementing the method according to one of claims 1 to 6 when this program is executed by a processor.

9. A nonvolatile computer readable storage medium on which a program is recorded comprising instructions for the implementation of the method according to one of claims 1 to 6.