*Article*

# Feeder Topology Configuration and Application Based on IEC 61850

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**Abstract:** For description the feeder topology and information exchanging between intelligent electronic devices (IEDs), it is necessary to extend IEC 61850 and add some logical model. Based on the Feeder model in IEC 61970, the Feeder model is also extended in IEC 61850 to serve as equipment container along distribution line. For the physical connection relationship of electrical equipment, Terminal and Connectivity Node logical model are added. Taking logical node XCBR as an example, the attributes for terminals are added to electrical equipment. The logical node LCNN is added to describe the connectivity node. By adding logical node LTPN to describe topological node and FTPA to describe the results of topology analysis, the description of topology analysis results is realized. Based on these logical nodes, the exchange of topology information between intelligent terminals can no longer rely on configuration files, but only need logical nodes. Through the above expansion, the topology description and information exchange of medium and low voltage feeders are realized.

**Keywords:** Feeder topology; IEC 61850; Common Information Model; Power distribution network

## 1. Introduction

Power distribution utilities implementing distribution automation may receive many benefits such as providing a fast method of improving reliability and reducing power outage time [1]. Topology analysis is an important aspect of distribution automation. It is the basis of power flow calculation, state estimation, fault location, and line loss reduction. Most distribution lines are radial [2], connecting substations to users. Due to the change of user load, such as load growth, the structure of the distribution line needs to be modified. In addition, in the process of operation, due to faults and other reasons, it is necessary to close or open the switchgear on the line, which will also affect the topology of the distribution line. Topology information configuration and exchange of distribution lines are an important subject. In recent years, distributed protection and control system has been widely concerned in smart distribution grid. The distributed system has high flexibility and adaptability, which is more suitable for the structural characteristics and operational requirements of intelligent distribution network [3-6]. So, it is a hot topic to configure and analyze the distribution line topology in distributed systems.

The description of topological model needs to be standardized to facilitate information sharing. The International Electrotechnical Commission (IEC) technical commission (TC) 57 has done a lot of work to facilitate the description of power grid information model and the interconnection of equipment and systems from different manufacturers. IEC TC 57 establishes IEC 61970, 61968, 61850, and other standards, standardizes information model and information exchange model. IEC 61970 and IEC 61968 are used for information sharing between master station systems. IEC 61850 is mainly used for information sharing of field intelligent electronic devices (IED). The description and information exchange of feeder topology need to refer to the above three standards.

A distribution feeder is an important concept in the distribution system. A feeder is one of the circuits out of the substation. In the logic view, a feeder is a collection. A collection of equipment for organizational purposes, used for grouping distribution resources [7]. A given feeder is made up of a main feeder, branches or laterals, and sublaterals. It is usually sectionalized by reclosing devices and protected by fuses [8]. Reference [9] proposed a feeder-oriented method for topology analysis of medium-voltage distribution grid. Reference [10] proposed information models (include feeder) have been used for information integration between the distribution network production repair platform (DNPRP) and other IT systems. The latest IEC 61970 common information model (CIM) (iec61970cim17v38) adopts the feeder model. System configuration language description language (SCL) of IEC 61850 is generally used for the topology configuration. In reference [11-12], the Process and Line models of SCL are used to describe the distribution grid topology. Yu Chen uses a logical node to express the topology for feeders and for exchanging information between IEDs [13]. Wei Cong uses distributed method to store feeder topology [14-15]. Reference [16] configures adjacent switches on feeders based on user-defined format. References [17-18], a local topology based on smart terminal unit (STU) storage is proposed and realized the STU by STU query of feeder real-time topology.

According to the characteristics of medium and low voltage distribution grid, combined with the information model of IEC 61970 and IEC 61850, we propose a topology configuration method based on a feeder. To facilitate the exchange of topology information between IEDs, the logical nodes of connectivity nodes and topological nodes are added. The subsequent sections of the paper are as follows: Section II discusses the structure of physical structure of feeder. Section III presents the logic model of a feeder. In Section IV and Section V, logical nodes are added to the connectivity model and topology model for information sharing between IEDs. Finally, Section VI presents summary and provides some insight for future work.

## 2. Physical Structure of Feeders

### *2.1. Feeder Model*

There are obvious differences between transmission lines and distribution lines. The transmission line is generally connected to two substations, the material and size of the line are the same. And there is no switchgear in the middle of the line as Figure 1 (a). Generally, when analyzing the transmission line, it is abstracted as a section of the conductor. But the distribution line is different, the distribution line includes switch, load, distributed generation, and so on. In distribution grid it is more common to use the term “feeder” instead of the term “line”. Therefore, we call distribution lines as feeder in this paper. A feeder as specified in the IEC 61970 Part 301 CIM is a static collection of conducting equipment originating at a the main distribution center and supplying one or more secondary distribution centers, one or more branch-circuit distribution centers, or any combination of these two types of equipment. The feeder is divided into several sections, namely feeder section, as shown in Figure 1 (b). Besides a feeder may also contain switch devices, MV/LV distribution transformers, capacitors, line voltage regulators. In addition, the transmission line is generally three-phase in balanced conditions (balanced voltages, balanced loads, and balanced impedances). It is like a single-phase circuit rather than a three-phase circuit. The distribution feeder has single-phase and two-phase loads. Many distribution loads are unbalanced in three phases. Therefore, we also need unbalanced analysis approaches for distribution feeders.

According to the function and voltage level, feeders can be divided into medium-voltage feeders and low-voltage feeders. A medium-voltage feeder is also called primary feeder. It is usually 600V to 35kV, mainly 10kV and 35kV in China. The primary feeder obtains electric energy from the substation and distributes it to the user. Close to each end user, a distribution transformer steps it down to a low-voltage secondary feeder (380Y/220 V in China).

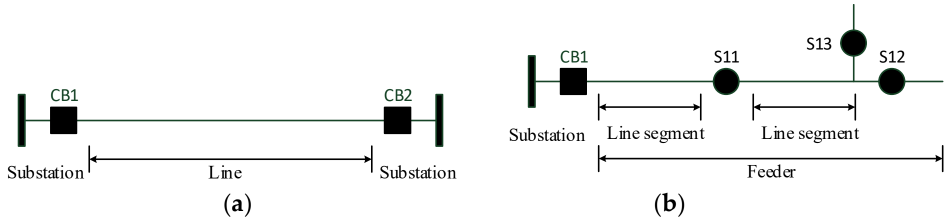


**Figure 1.** Power line: (a) Transmission line; (b) Distribution feeder.

*2.2. Primary Feeder*

The typical medium-voltage feeder is three-phase, and the loading is balanced. On three-phase circuits with balanced loading, the neutral carries almost no current. So, the neutral wire is sometimes omitted. Three-phase four-wire systems and three-phase three-wire systems are common configurations of primary feeders. The most common distribution primaries in North America are four-wire, multigrounded systems: three-phase conductors plus a multigrounded neutral. Three-phase three-wire systems are mostly used in Europe and China. In China, the neutral point of the medium-voltage distribution system is not effectively grounded, and a three-phase three-wire system is adopted. Utilities often design the primary feeder for 400 A and often allow an emergency rating of 600 A. Distribution circuits come in many different configurations and circuit lengths.

A feeder is one of the circuits out of the substation. The starting point of the feeder is generally the breaker or reclose in the substation, and the ending point is the load, distributed generation, tie switch (normally open switch) associated with another feeder, switching station, etc., as shown in Figure 1 (b). The feeder is divided into several sections through section switches (as S11, S12). The feeder is regarded as a collection of equipment, not considering the tower, foundation, stay wire, cross arm, etc., but only considering the conductor, distribution transformer, circuit breaker, disconnector, fuse, reactive power compensation device, etc.

*2.2. Secondary Feeder*

Low-voltage distribution feeders are also called secondary feeders. From the distribution transformer, the secondary feeders connect to the end user where the connection is made at the service entrance. It is composed of different types of power cables, transformer units and other equipment. Equipment specifications and construction comply with the current national standards. The voltage level of low-voltage distribution feeder in China is usually 380Y/220 V, and the connection modes are mainly radial, trunk and ring. The voltage of phase-to-phase is 380 V, and voltage of phase-to-neutral is 220 V. In most cases, only one distribution transformer supplies power to the power customers, and the loads are at the end of the distribution network. The radius of the power supply is usually less than 150 meters in the city center.

The circuit from the distribution transformer to the end user can be divided into two parts, mainline and lateral. The mainline is a common trunk line from the distribution transformer to the customers' buildings. Overhead lines and Underground cables with modestly large conductors, such as 120mm$^2$, 150mm$^2$, and 185mm$^2$ aluminum conductors are normally used as mainline. Overhead lines are installed on outdoor poles. Low-voltage overhead lines are generally three-phase four-wire systems. Cross-linked polyethylene (XLPE) insulated overhead cables are generally used. The distance between conductor and conductor shall not be less than 1000 m. Underground cables are generally buried in underground cable trenches. Low-voltage cables are generally made of three-phase and four-wire, and cross-linked polyethylene insulated power cables can be selected. Branching from the mainline to end uses are one or more laterals. These laterals may be single phase, two phase, or three phase. Laterals normally have fused to separate them from the mainline if they are faulted. Low-voltage cross-linked polyethylene copper-core insulated conductor is used for household connection. The conductor cross-section shall be selected according to the continuous current carrying capacity and voltage loss, generally 10mm², 20mm², etc.

## 3. Abstract Model of Feeder

### *3.1. Feeder Supervisory Control and Automation*

As a basic content of smart distribution grid and distribution automation, feeder automation (FA) realizes fault detection, location, isolation of distribution feeders and restoration of power supply in safety sections. Distributed feeder automation (DFA) is an automation mode independent of the master station. The communication network and the distribution terminals on the feeder are used to communicate with each other to collect the fault information of the adjacent switches. After comprehensive comparison, the fault section is judged. The switches at both ends of the section are tripped to complete the fault isolation action. Then the power supply of the safety section is restored by closing the tie switch. Finally, the processing results are reported to the main distribution station system. Distributed control is especially suitable for distribution grid. The feeder is generally bounded by the medium-voltage bus in the substation. The number of control nodes will not be too many, and the structure and algorithm design of the control system is relatively simple. In distributed control, it is necessary to configure the model of distribution lines within the control range, and exchange topology information in real time according to the change of section switch.

In recent years, power utilities have made great progress in monitoring and management of low-voltage power grid. The application of automatic meter reading and line loss management system improves the level of low-voltage power grid monitoring. It improves the power quality of end users and reduces the loss of low-voltage feeders. To realize these functions, a large number of distributed monitoring terminals need to be installed, and the configuration and information exchange of low-voltage feeder topology is need.

### *3.2. Feeder Information Model*

The feeder model as specified in the IEC 61970 Part 301 CIM is a static collection of conducting equipment originating at a main distribution center and supplying one or more secondary distribution centers, one or more branch-circuit distribution centers, or any combination of these two types of equipment. A feeder can contain Equipment just as a Substation or Bay as in Figure 2 [7]. In distribution grid, all conducting equipment shall be a member of either a substation or a feeder. All substation equipment is housed. A feeder is generally outside a physical enclosure and consists of a collection, or a connected set, of AC line segments, switches, transformers (which may or may not be considered as a substation) [19], etc. It is usually sectionalized by reclosing devices and protected by fuses.

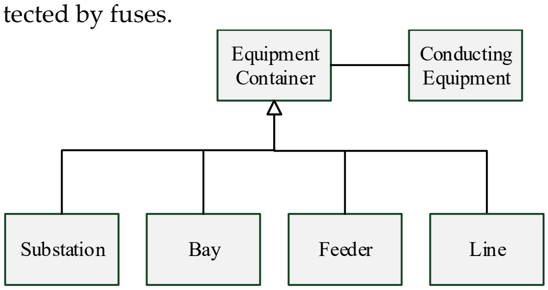


**Figure 2.** Feeder model.

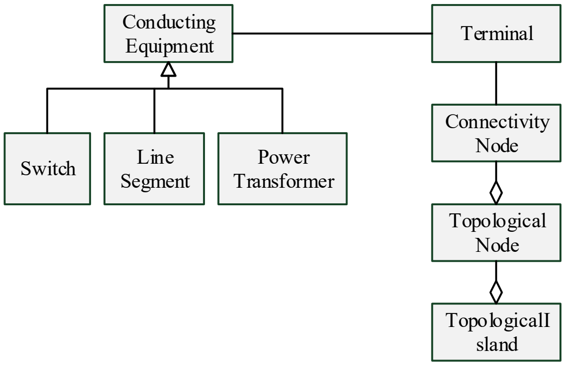


**Figure 3.** Topology model.

*3.3. Topology Model*

The topology of feeder refers to the connection relationship of outgoing break, sectional switch, and line segments of the feeder. Figure 3 shows the Topology class diagram which models connectivity between different types of Conducting Equipment. In IEC 61970, it is divided into connectivity model and topology model. The connectivity model is the physical definition of how equipment is connected together. It is in association with the Terminal class and ConnectivityNode class as in Figure 4 (a). The connectivity model is a relatively static model, which is only related to the planning and design of the distribution grid and has nothing to do with the operation mode. The topology model is the logical definition of how equipment is connected via closed switches using TopologicalNode class and TopologicalIsland class as in Figure 4 (b). Topology model is a dynamic model. The change of switch position and operation mode will cause the change of topology model. In addition, for different applications, the topology model is not complete same. For example, in fault location and isolation, we are concerned with the topology of a single feeder. When the power supply is restored, it is necessary to consider the topology of all feeders connected to the fault section. Therefore, the topology model is also related to specific applications, so we also call it application topology.

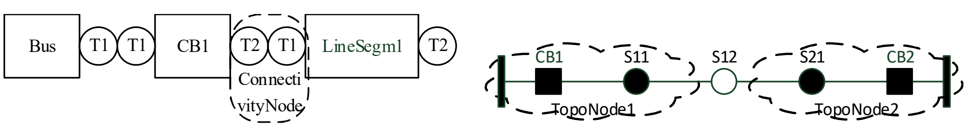


**Figure 4.** Feeder topology model: (a) Connectivity model; (b) Topology model

## 4. Connectivity Model and Configuration

*4.1. Connectivity model*

The feeder connectivity model describes the connection relationship of distribution grid equipment along the feeder. To model connectivity, Terminal and ConnectivityNode classes are used. As defined in the CIM of IEC 61970, each conducting equipment has one, two or more terminals. Each Terminal belongs to one ConductingEquipment, and may be connected to a ConnectivityNode, as shown in Figure 4 (a). A ConnectivityNode is a point where terminals of conducting equipment are connected together with zero impedance. Distribution equipment can be divided into two categories: component equipment and station equipment. Component equipment is specific primary and secondary equipment, such as circuit breaker, load switch, disconnector, current transformer, voltage transformer, etc. Station equipment refers to the collection of a group of equipment to complete the functions of feeder line segmentation, power distribution, collection, etc., including ring main unit, switching station, power distribution room, etc. The purpose of setting up substation equipment is to simplify the topology of feeder. The topology of internal station equipment needs to be described in detail, and only a few terminals are mentioned for external station equipment. For example, ring main unit is a station equipment. Inside, the detailed connection relationship of several switches needs to be described. Externally, as a component on the feeder, only two terminals are required.

### *4.2. SCL Description for Connectivity Model*

According to IEC 61850-6 and IEC 61850-90-6 [22], SCL can be used to describe and configure the connectivity model. Each IED only needs to configure the relevant connection relationship. The SCL defined in IEC 61850-6 can describe the connection relationship of equipment along the feeder. For describing the feeder and the equipment on the feeder, the feeder model as in Figure 2 is used. A feeder, like a substation, is an EquipmentContainer. The equipment in the substation belongs to the Substation class, and the equipment along the feeder belongs to the Feeder class.

The phase attribute needs to be in the connection model. In distribution networks, especially in low-voltage distribution network, single-phase lines and two-phase lines are very common. The connection node may be single-phase connection (A, B, C), two-phase connection (AB, BC, AC), or three-phase connection (ABC). It is necessary to extend the Terminal in IEC 61850-6 to include phases attribute. With the Terminal.phases attribute, phase information of each Conducting Equipment can be expressed for a multi-phase distribution networks. The data type of phase is "tPhaseEnum", and the data value may be "A", "B", "C", "N", "all", "none", "AB", "BC", or "CA", and the default value is all. In this way, it can be compatible with the original version.

Taking the S11 load switch in Figure 1 (b) as an example, the description is as follows:

```
<ConductingEquipment name=" S11" type="LBS">
    <Terminal connectivityNode="E1/F01/L2" voltageLevelName="E1" feederName="F01" phases=”all” cNodeName ="L2"/>
    <Terminal connectivityNode="E1/F01/L3" voltageLevelName="E1" feederName="F01" phases=”all” cNodeName="L3"/>
</ConductingEquipment>
```

In Figure 1 (b), S13 is a single-phase switch.

```
<ConductingEquipment name=" S13" type="LBS">
    <Terminal connectivityNode="E1/F01/L4" voltageLevelName="E2" feederName="F01" phases=”A” cNodeName ="L4"/>
    <Terminal connectivityNode="E1/F01/L5" voltageLevelName="E2" feederName="F01" phases=”A” cNodeName="L5"/>
</ConductingEquipment>
```

The following example describes the feeder in Figure 1 (b).

```
<Feeder name="F1">
  <ConductingEquipment name=" LN1" type="LIN">
    <Terminal connectivityNode="E1/F01/L1" voltageLevelName="E1" feederName="F01" phases=”all” cNodeName ="L1"/>
    <Terminal connectivityNode="E1/F01/L2" voltageLevelName="E1" feederName="F01" phases=”all” cNodeName="L2"/>
  </ConductingEquipment>
  <ConductingEquipment name=" S11" type="LBS">
    <Terminal connectivityNode="E1/F01/L2" voltageLevelName="E1" feederName="F01" phases=”all” cNodeName ="L2"/>
    <Terminal connectivityNode="E1/F01/L3" voltageLevelName="E1" feederName="F01" phases=”all” cNodeName="L3"/>
  </ConductingEquipment>
  <ConductingEquipment name=" LN2" type="LIN">
    <Terminal connectivityNode="E1/F01/L3" voltageLevelName="E1" feederName="F01" phases=”all” cNodeName ="L3"/>
```

```
    <Terminal connectivityNode="E1/F01/L4" voltageLevelName="E1" feederName="F01" phases=”all” cNodeName="L4"/>
  </ConductingEquipment>
  <ConductingEquipment name=" S13" type="LBS">
    <Terminal connectivityNode="E1/F01/L4" voltageLevelName="E1" feederName="F01" phases=”A” cNodeName ="L4"/>
    <Terminal connectivityNode="E1/F01/L5" voltageLevelName="E1" feederName="F01" phases=”A” cNodeName="L5"/>
  </ConductingEquipment>
  <ConductingEquipment name=" S12" type="LBS">
    <Terminal connectivityNode="E1/F01/L4" voltageLevelName="E1" feederName="F01" phases=” all” cNodeName ="L4"/>
    <Terminal connectivityNode="E1/F01/L6" voltageLevelName="E1" feederName="F01" phases=” all” cNodeName="L6"/>
  </ConductingEquipment>
  < ConnectivityNode name="L1" pathName="E1/F01/L1" />
  < ConnectivityNode name="L2" pathName="E1/F01/L2" />
  < ConnectivityNode name="L3" pathName="E1/F01/L3" />
  < ConnectivityNode name="L4" pathName="E1/F01/L4" />
  < ConnectivityNode name="L5" pathName="E1/F01/L5" />
</ Feeder >
```

### *4.3. Logical Nodes for Connectivity Model*

The logical node is the smallest part of a function that exchanges data. It is more convenient to use logical nodes for information exchange between IEDs. According to the functional requirements, the logical node can also be expanded. In distributed feeder automation, intelligent terminals need to exchange connection information of distribution lines. For this part of information, there is no necessary logical node to support information exchange. Therefore, it is necessary to extend the logical nodes. The extension requirements of logical nodes mainly include: (1) terminal information, for electrical equipment, terminal information needs to be added; (2) connectivity node information description needs to be added.

#### 4.3.1. Terminal

For the conductive equipment, the description of terminal information should be added, including circuit breaker (XCBR), circuit switch (XSWI), overhead line (ZLIN), cable (ZCAB), transformer (YPTR), and other logical nodes. Take the circuit breaker logical node XCBR as an example.

| **XCBR (Circuit breaker)** | | | |
|---|---|---|---|
| **Data object name** | **Common data class** | **Explanation** | **M/O** |
| **logical node data in IEC 61950-7-4:2010** | | | |
| **Settings** | | | |
| NumTerm | INT32 | Number of terminals | O |
| Terminals | ARRAY[0…NumTerm] of VISIBLE STRING255 | terminals of this equipment | O |

Similarly, other logical nodes like SXWI, ZLIN, ZCAB, and YPTR should add the description of terminal as XCBR.

Taking the switch S11 in Figure 1 (b) as an example, the attribute values of logical node XCBR are as Table 1:

**Table 1.** Logical node and its value.

| Logica Node | Attribute | Value |
|---|---|---|
| XCBR | NumTerm | 2 |
| | Terminals | connectivityNode="E1/F01/L1" voltageLevelName = "E1" feederName="F01" phases=”all” connectivityNode="E1/F01/L2" voltageLevelName = "E1" feederName="F01" phases=”all” |
| LCNN | NamPlt | L1 |
| | PathName | E1/F01/L1 |

4.3.2. Connectivity Node

Connectivity nodes are points where terminals of conducting equipment are connected together with zero impedance. The connectivity node in a substation is generally limited to one bay. For feeder automation, the connectivity node can be in the feeder. Its name attribute identifies the ConnectivityNode instance within the bay; its pathName is an absolute reference within the SCL file. For instance, if the connectivity node L1 is within feeder F1 of voltage level E1, then the pathname is “E1/F1/L1”.

| LCNN (Connectivity Node) | | | |
|---|---|---|---|
| **Data object name** | **Common data class** | **Explanation** | **M/O** |
| **logical node data in IEC 61950-7-4:2010** | | | |
| **Settings** | | | |
| NamPlt | LPL | Name plate of the logical node | O |
| PathName | VISIBLE STRING255 | terminals connections to different connectivity nodes | O |

Take the leftmost connectivitynode in Figure 1 (b) as an example, and its data attributes are as Table 1.

## 5. Topology Model and Application

### *5.1. Topology model*

Topology is the logical definition of how equipment is connected via closed switches. The topology definition is independent of the other electrical characteristics, such as impedance. To model topology, TopologicalNode and TopologicalIsland classes in IEC 61970 are needed. A TopologicalNode is a group of ConnectivityNodes connected by closed switches in the current network state. It will change with the switch state. A TopologicalIsland is an electrically connected subset of the network. It can change as the current network state changes. Only energized TopologicalNodes shall be part of the TopologicalIsland. In this way, a topological island forms a power supply area, and a topological island is adjacent to another topological island through a tie switch. If a topological island has several tie switches connected with other topological islands, there are several power supply recovery paths.

*5.2. Logical node for Topology*

For an IED, topology analysis is to synthesize a topological node from the connectivity node connected by the closed switch. The number of topological nodes and the connectivity nodes contained in each topological node needs to be informed when exchanging topology information between adjacent IEDs. The master IED is needed to calculate the topology of the whole feeder. The master IED starts the whole feeder topology analysis and obtains the topology information through successive polling adjacent IEDs.

For topology information exchanging, new logical nodes **LTPN** and **FTPA** need to be added. The logical node LTPN start topology analysis and report topology results. When a switch position changes, the topology analysis (FTPA.str=1) is started, and it indicates the topology analysis state. The topology analysis results in the logical node LTPN. Connectivity nodes at both terminal are combined into one topological node through the closed switch. Merge connectivity nodes at both terminals of the line segment into one topological node.

| **LTPN (Topological node)** | | | |
|---|---|---|---|
| **Data object name** | **Common data class** | **Explanation** | **M/O** |
| **logical node data in IEC 61950-7-4:2010** | | | |
| **Settings** | | | |
| NamPlt | LPL | Name of the topological node | O |
| PathName | VISIBLE STRING255 | A full object reference | O |
| **Status information** | | | |
| NumCnNode | INT32 | Number of terminals | O |
| CnNodes | ARRAY[0…NumTerm] of VISIBLE STRING255 | Connectivity nodes | O |

| **FTPA (Topology analysis)** | | | |
|---|---|---|---|
| **Data object name** | **Common data class** | **Explanation** | **M/O** |
| **logical node data in IEC 61950-7-4:2010** | | | |
| **Control** | | | |
| Str | SPC | Topology analysis start | |
| **Status information** | | | |
| NumTpNode | INT32 | Number of topological nodes | O |
| TpNodes | ARRAY[0…NumTerm] of VISIBLE STRING255 | topological nodes | O |

As shown in Figure 3 (b), when the S12 switch is in the open state, two LTPN logical nodes are formed in the figure. The LTPN and FTPA logical nodes as Table 2.

**Table 2.** Logical node LTPN and FTPA.

| Logica Node | Attribute | Value |
|---|---|---|
| LTPN | NamPlt | TPN1 |
| | PathName | E1/TPN1 |
| | NumCnNode | 5 |
| | CnNodes | B1 L1 L2 L3 L4 |
| LTPN | NamPlt | TPN2 |
| | PathName | E1/TPN2 |
| | NumCnNode | 5 |
| | CnNodes | B2 L8 L7 L6 L5 |
| FTPA | NumTpNode | |
| | TpNodes | TPN1 TPN2 |

### *5.3. Topology Analysis of IED*

For an IED, there is a little equipment monitored, and the method of topology analysis is relatively simple. The depth-first method can be used to generate topological nodes. The following steps are taken:

1) With IED starts or a switch state changes, topology analysis starts, FTPA.Str=1;

2) Clear all topological nodes. Set the unprocessed flag of topological node to 1;

3) The depth-first method is used to traverse all the connectivity nodes.

If the unprocessed flag of the connectivity node is 1, a new topological node is enabled and the connectivity node information is filled into the topological node. Combine connectivity nodes connected by closed switch or line segment into one topological node.

4) Fill the generated topology nodes array information into FTPA. The topology analysis is completed.

### *5.4. Topology Analysis for Feeder*

For the topology analysis of the whole feeder or multiple feeders, the cooperation between several IEDs is needed. Reference [18, 21] provides a successive polling method for feeder topology analysis. The following steps are taken:

1) The master IED sends the network topology query command to its adjacent IEDs.

2) The IED receiving the query command replies the information of the monitored switches to the inquirer and forwards the query command to its next level neighbor IEDs.

Repeat this step until the end of the feeder.

3) The master IED obtains the feeder real-time topology according to all the returned topology information.

Exchanging information to be exchanged by this method includes connectivity information and topology information. The connectivity information is exchanged with the terminal information of the device in Section 4.3. And the topology analysis results can be exchanged through the topological node information in Section 5.2.

### *5.5 Case Analysis*

Based on IEEE 13 node test feeder, section switches and IEDs are arranged on the feeder as shown in Figure 4.

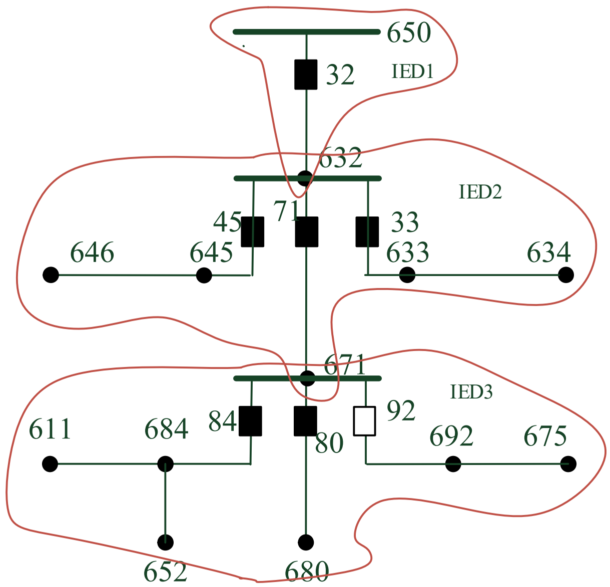


**Figure 5** IEEE 13 node feeder and IEDs

As shown in Figure 5, three IEDs are placed on the IEEE 13 node feeder, and each IED is configured with a local topology. When analyzing the feeder topology, first, the three IEDs analyze the local topology according to the algorithm in 5.3, then use IED1 as the main control IED, and analyze the feeder topology according to the algorithm in 5.4. The information exchange among IED1, IED2and IED3 is carried out according to the logical nodes in sections 4.3 and 5.2.

Firstly, local topology analysis is carried out, ied2 and ied3 respectively. IED1 is relatively simple. After local topology analysis, one topology node is formed. The switches 45, 71 and 33 in IED2 are all closed, forming one topology node. In IED3, switch 92 is open, forming two topology nodes.

Next, IED1 initiates a level-by-level query, IED1→IED2→IED3, after level by level query, merge with topology node. The wiring diagram shown in Figure 4 finally forms two topology nodes.

So far, the topology analysis is completed and correct.

## 6. Conclusions

Topology is important information about medium-voltage and low-voltage distribution automation. The configuration language and LogicalNodes of IEC 61850 can be used to realize the configuration and exchanging of topology information. As a set of equipment, the Feeder class defined in IEC 61970 needs to be extended and applied in IEC 61850. The connection information of equipment is described by SCL of IEC 61850. The exchange between terminal devices can extend the relevant terminal information and add the description of the connection node logical node LCNN. For the result information exchange of topology analysis, it is necessary to add topology analysis and topology logical node (FTPA), and logical node for topological node (LTPN) for information exchange.

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