Control and Automation of Electric Power Distribution Systems

Presented by

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- **Source for pp.3-17:**

  J.A. Momoh, ELECTRIC POWER DISTRIBUTION, AUTOMATION, PROTECTION, and CONTROL, CRC Press, 2008.

- **Source for pp.18-31:**

  J. Northcote-Green and R. Wilson, CONTROL and AUTOMATION of ELECTRICAL POWER DISTRIBUTION SYSTEMS, CRC Press, 2007.

Distribution Automation and Control Functions

- **Trouble Calls**

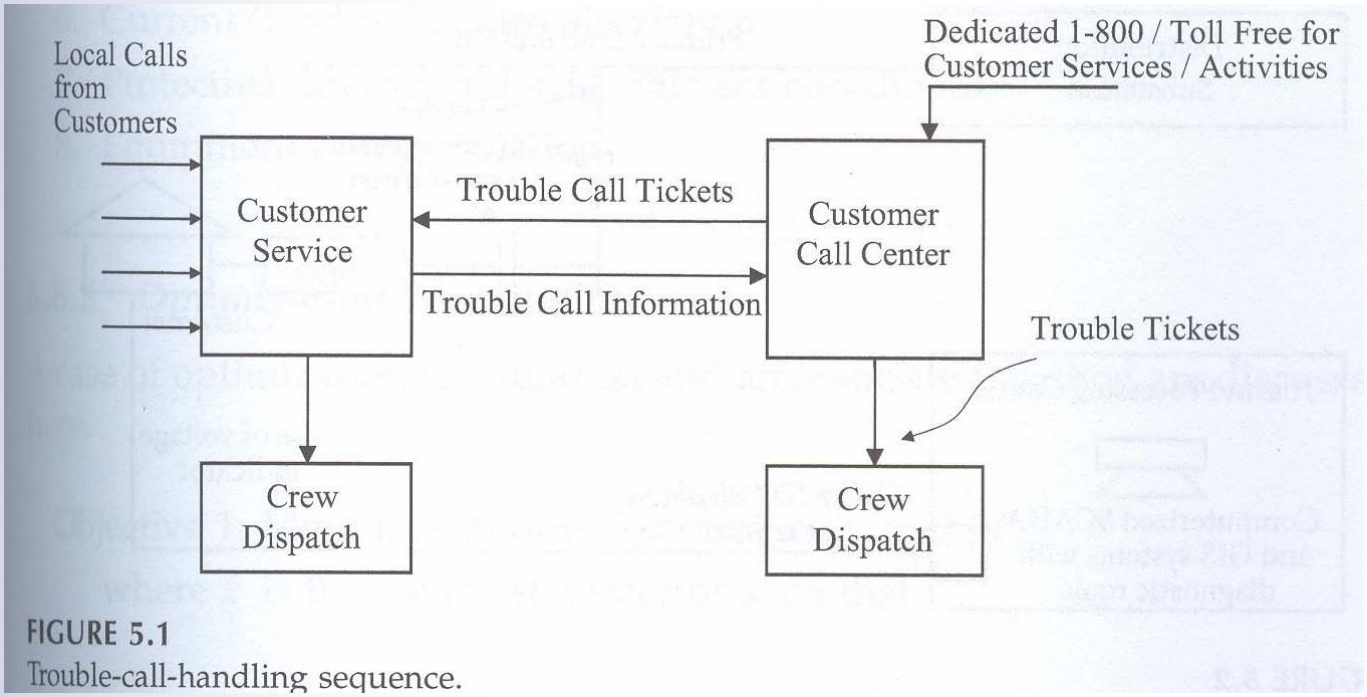

FIGURE 5.1
Trouble-call-handling sequence.

Distribution Management Systems

DMS Function

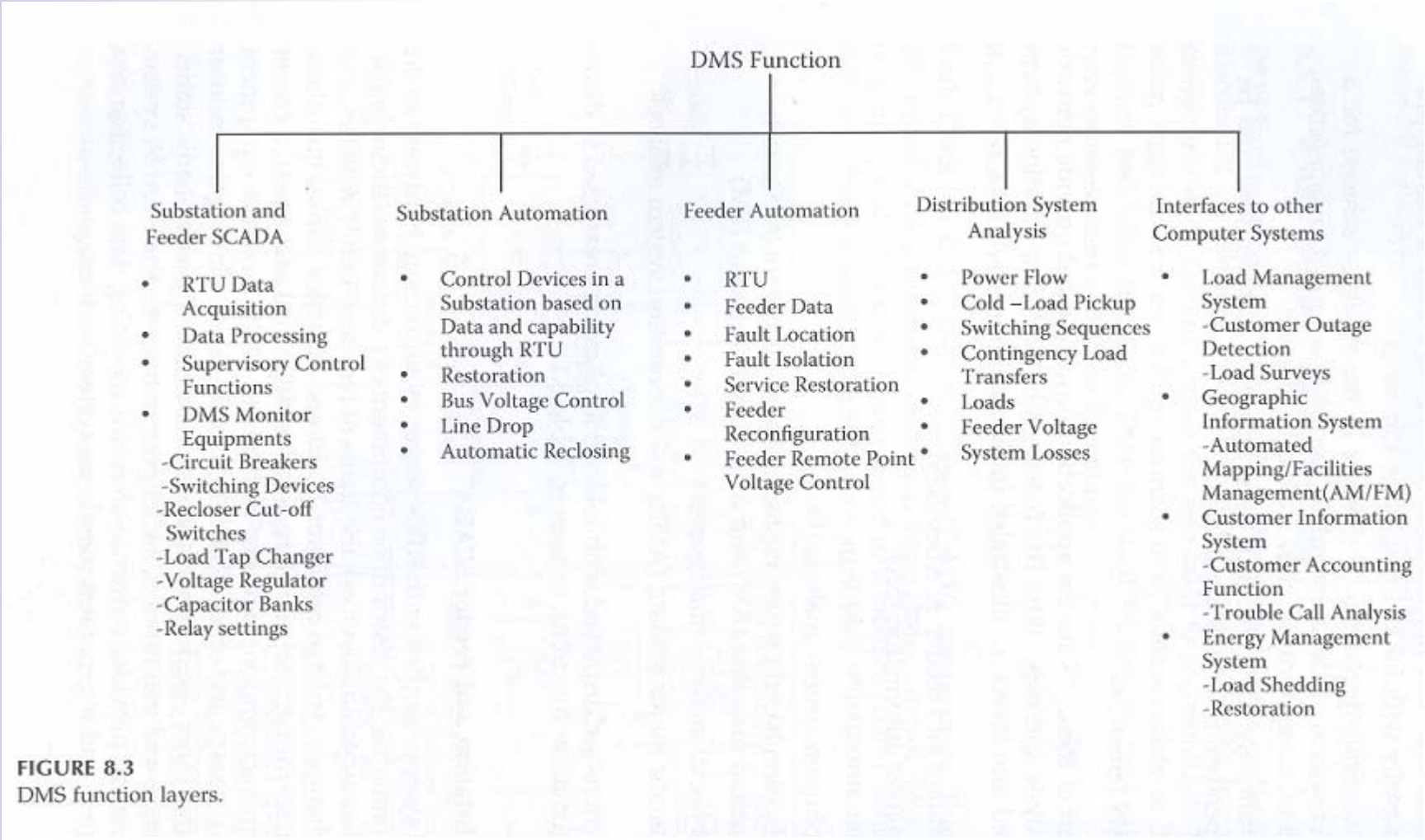

FIGURE 8.3
DMS function layers.

Distribution Management Systems

TABLE 8.1

Distribution Automation Functions

Substation Automation Functions	Feeder Automation Functions	Customer Interface Automation Functions
Data acquisition from: · Circuit breakers · Load tap changers · Capacitor banks · Transformers Supervisory control of: · Circuit breakers · Load tap changers Fault location Fault isolation Service restoration Substation reactive power control	Data acquisition from: · Line reclosers · Voltage regulators · Capacitor banks · Sectionalizers · Line switches · Fault indicators Supervisory control of: · Line reclosers · Voltage regulators · Capacitor banks · Sectionalizers · Line switches Fault location Fault isolation Service restoration Feeder reconfiguration Feeder reactive power control	Automated meter reading Remote reprogramming of time-of-use (TOU) meters Remote service connect/disconnect Automated customer claims analysis

Communication Systems for Distribution Automation Systems

- **Amplitude Modulation(AM)**

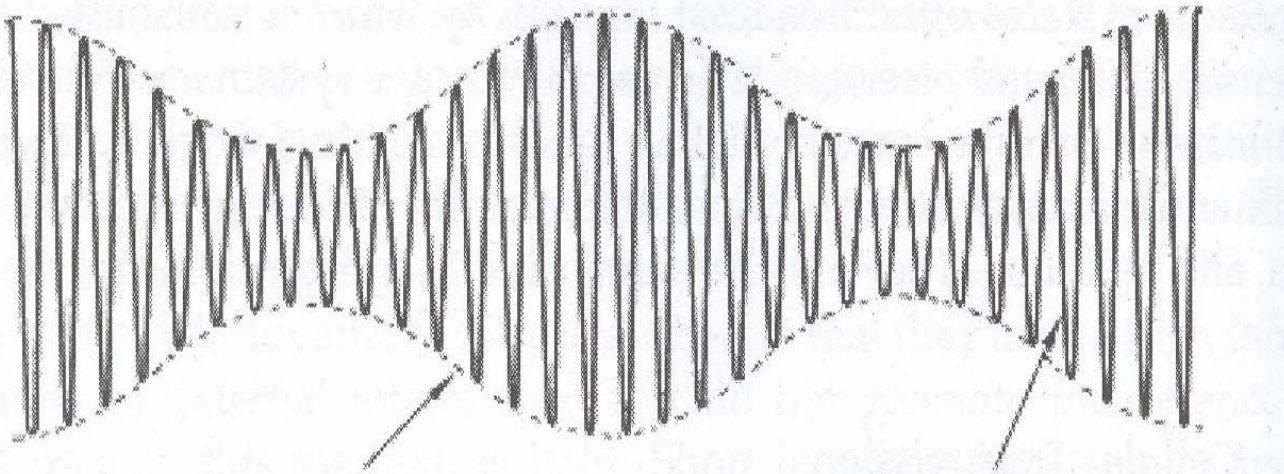

FIGURE 9.3
Amplitude modulation (AM) waveform.

Communication Systems for Distribution Automation Systems

- **Frequency Modulation(FM)**

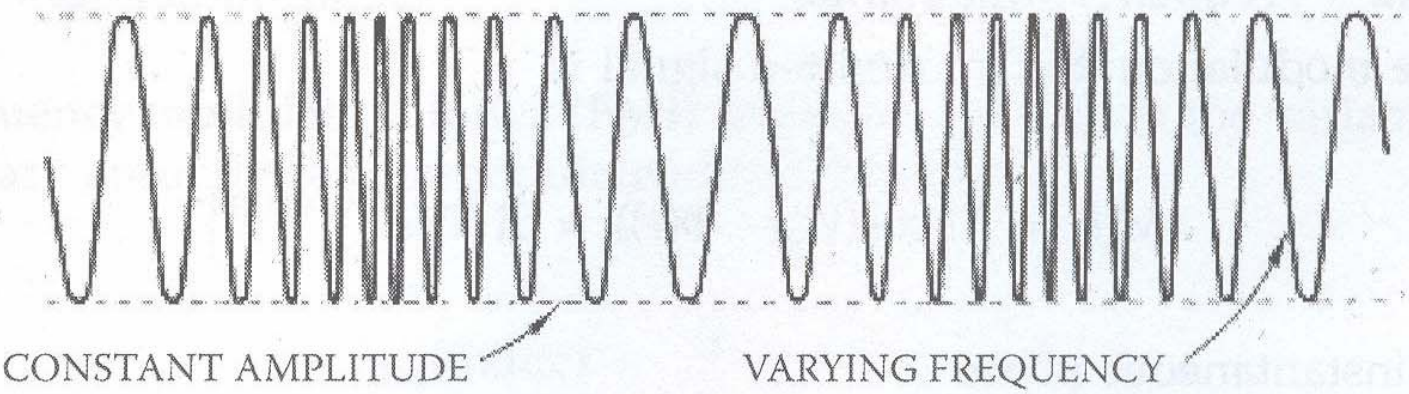

FIGURE 9.4
Frequency modulation (FM) waveform.

Communication Systems for Distribution Automation Systems

- **Frequency-Shift Keying(FSK)**

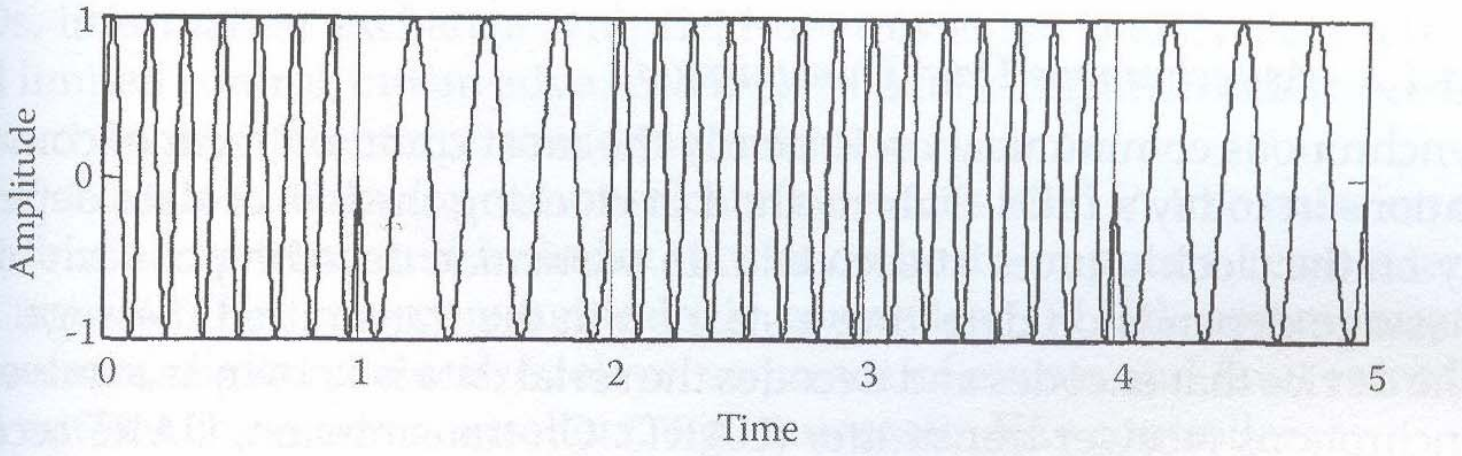

FIGURE 9.5
Frequency-shift-keying waveform.

Communication Systems for Distribution Automation Systems

- **Phase-Shift Keying(PSK)**

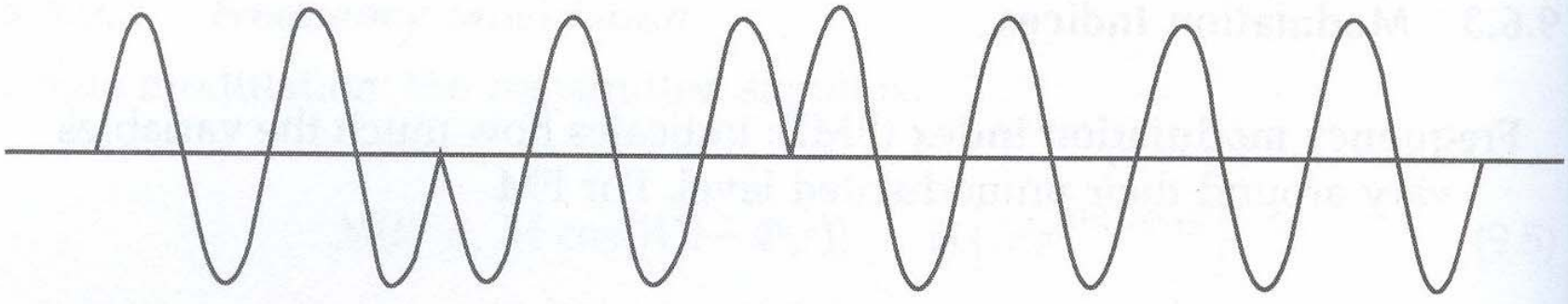

FIGURE 9.6
Phase-shift-keying waveform.

Communication Systems for Distribution Automation Systems

- **LAN Bus Topology**

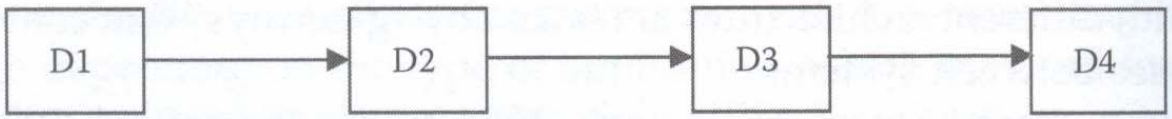

FIGURE 9.7
LAN–bus topology.

- **LAN-ring Bus Topology**

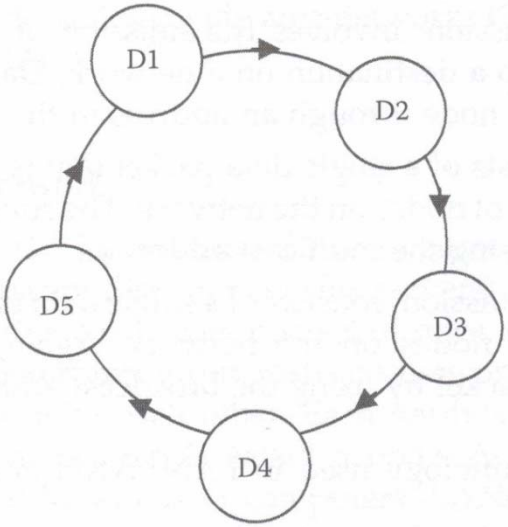

FIGURE 9.8
LAN–ring bus topology.

Communication Systems for Distribution Automation Systems

- **LAN-star Topology**

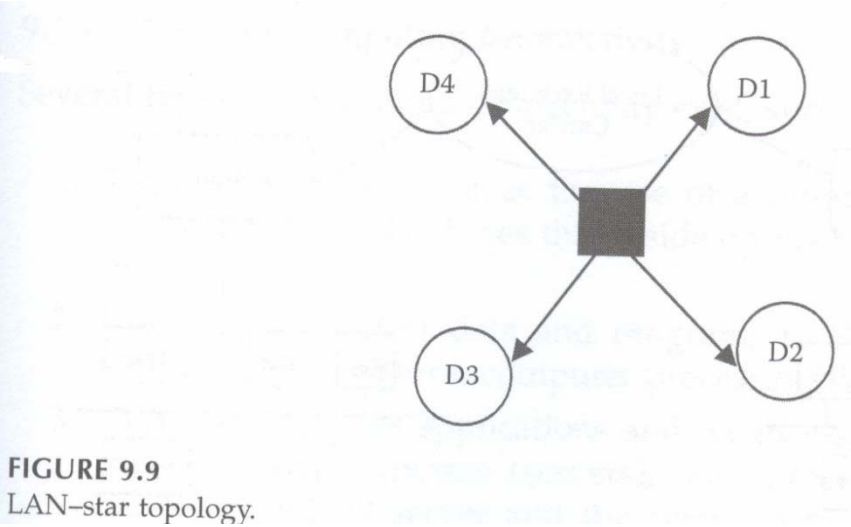

FIGURE 9.9
LAN–star topology.

- **LAN-tree Topology**

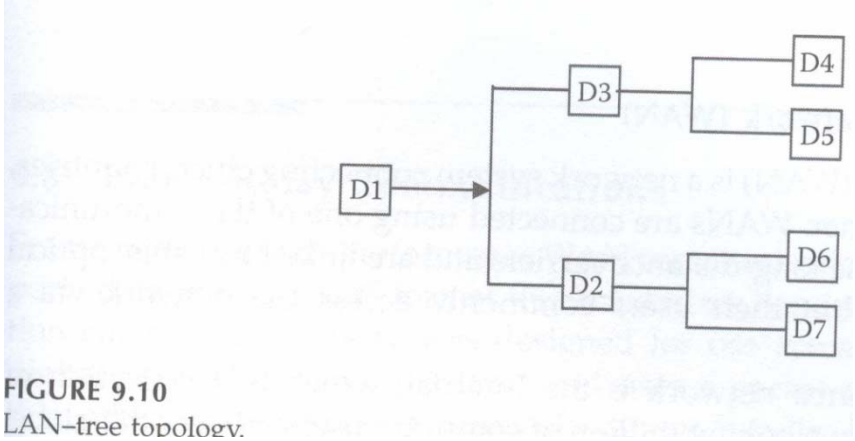

FIGURE 9.10
LAN–tree topology.

Communication Systems for Distribution Automation Systems

- **Metropolitan Area Network(MAN)**

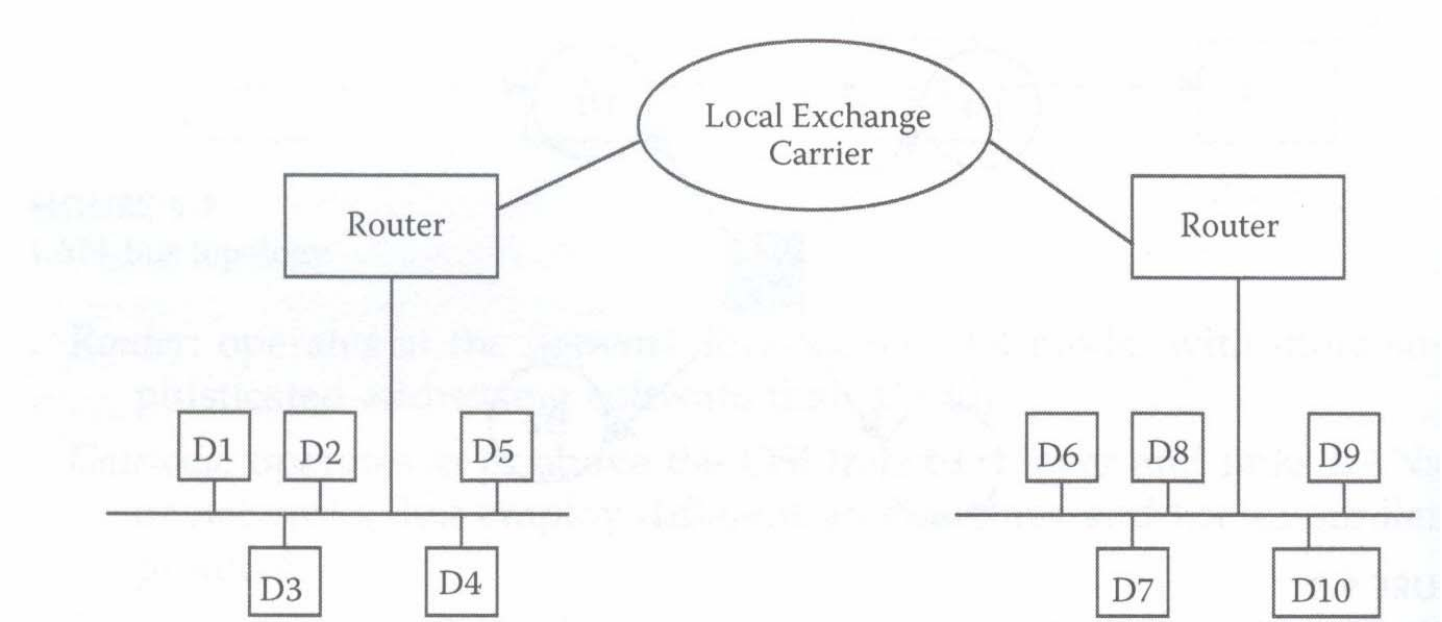

FIGURE 9.11
MAN configuration.

Communication Systems for Distribution Automation Systems

- **Simple frame-relay network**

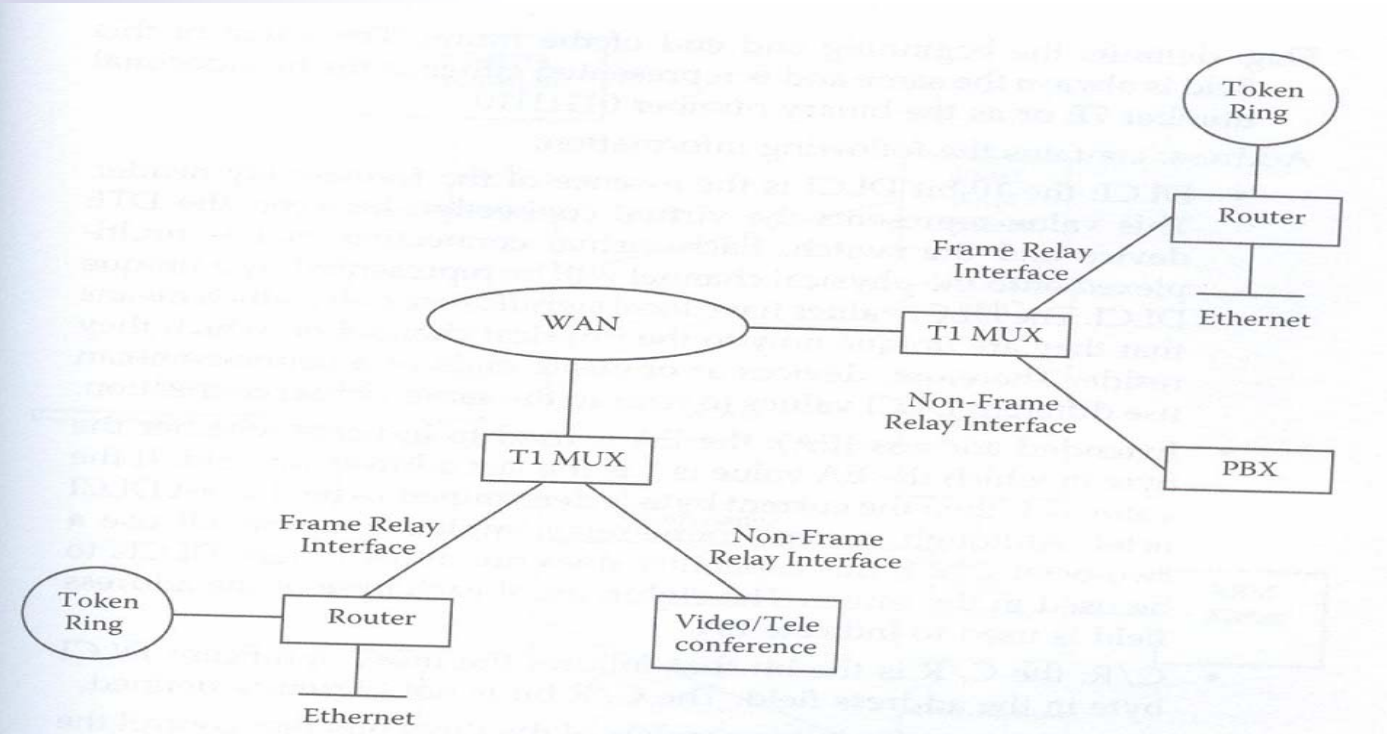

FIGURE 9.12
Simple frame-relay network.

Communication Systems for Distribution Automation Systems

- **Frame-relay frame**

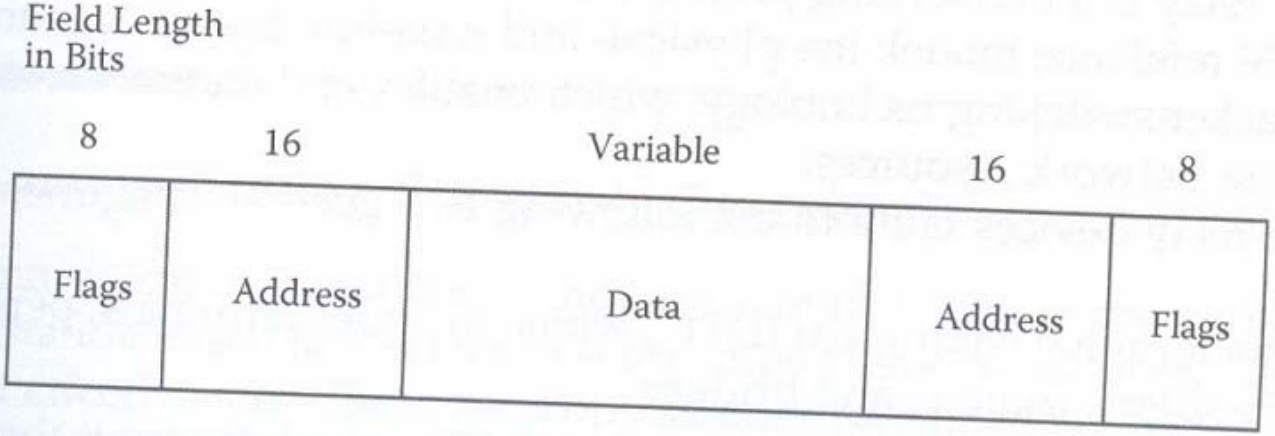

FIGURE 9.13
Frame-relay frame.

Communication Systems for Distribution Automation Systems

- **DA Frame-relay**

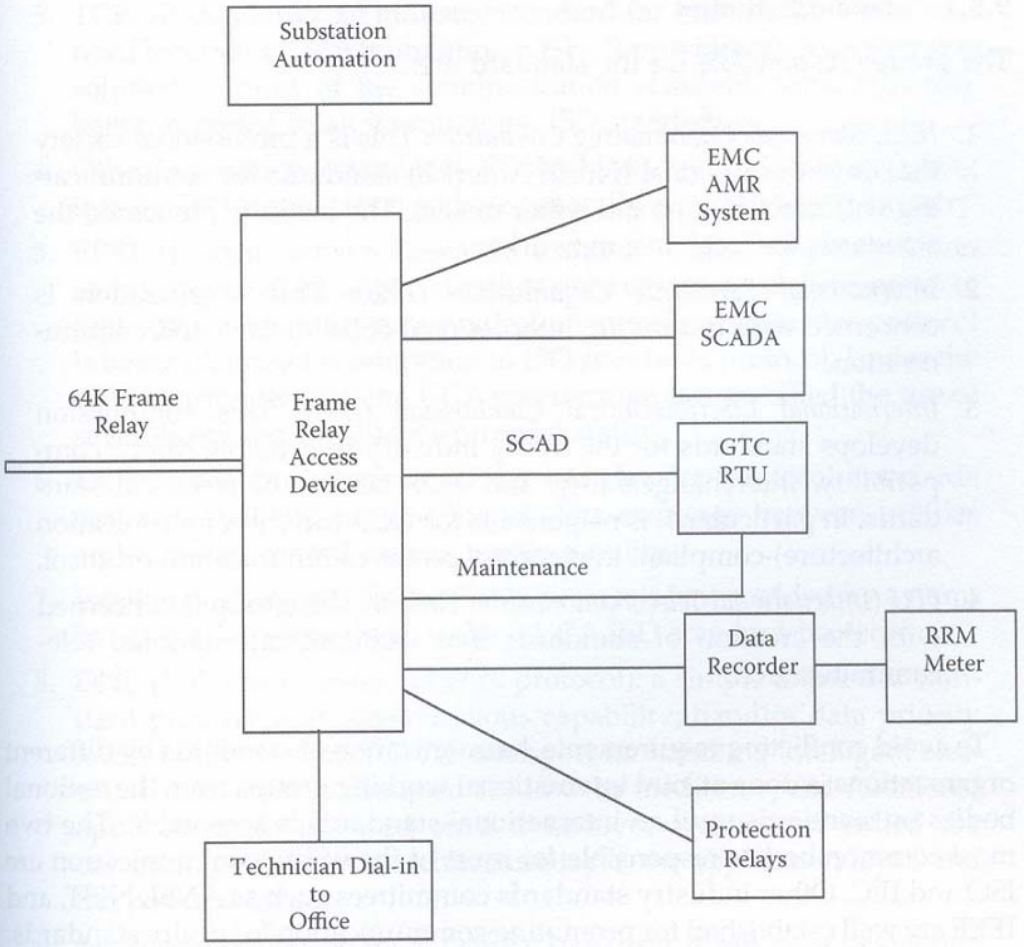

FIGURE 9.14
Typical use of a frame relay in distribution automation.

Communication Systems for Distribution Automation Systems

- OSI

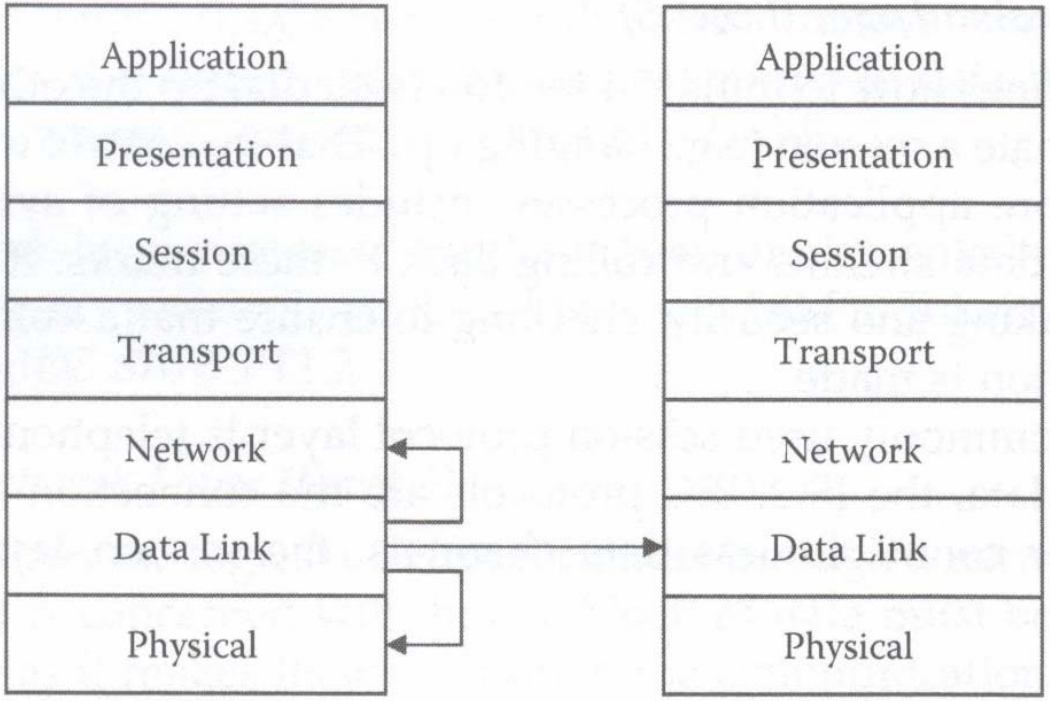

FIGURE 9.15
OSI model layers communicating with other layers.

DA COMMUNICATION PHYSICAL LINK OPTIONS

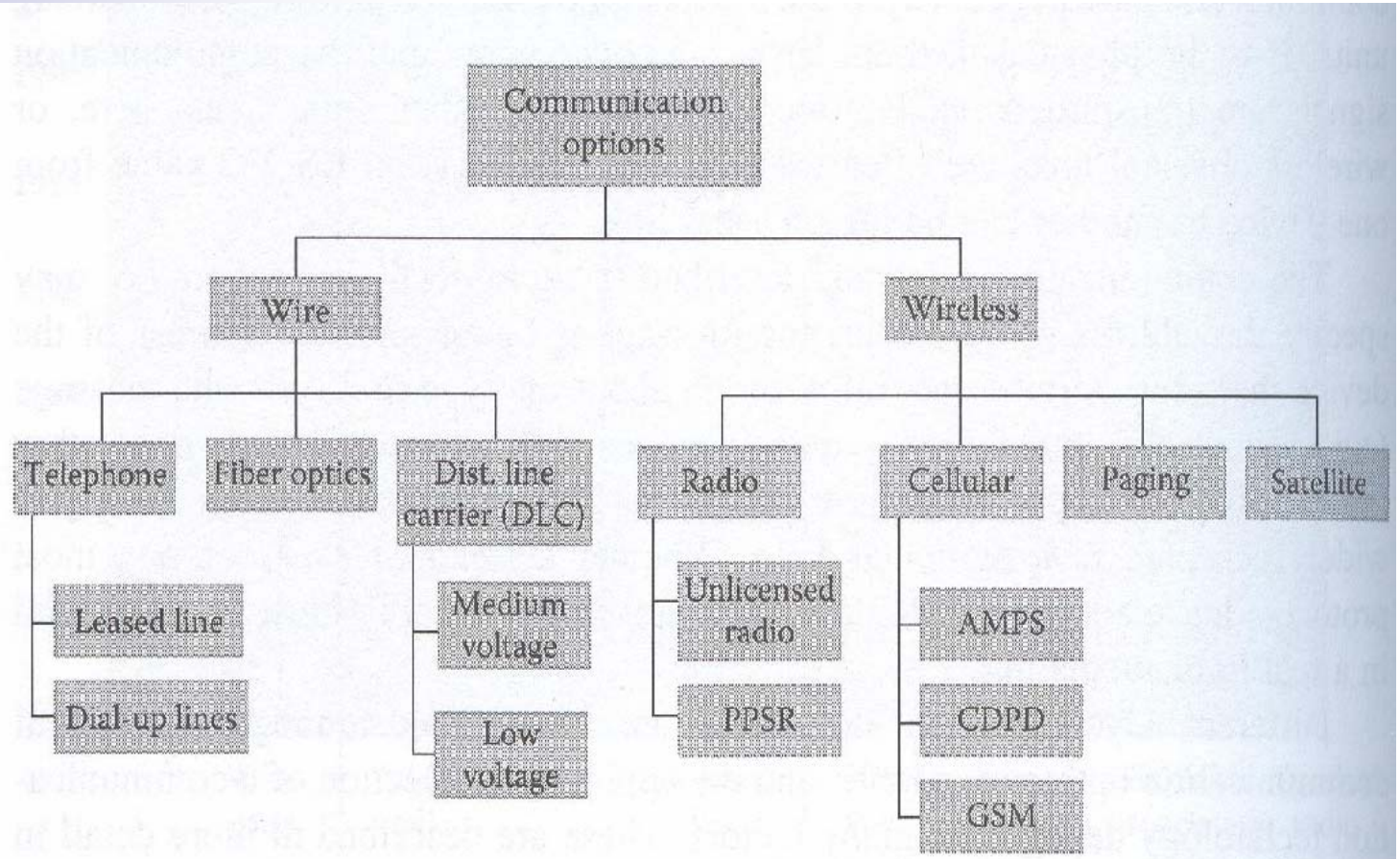

FIGURE 7.4 Distribution automation communication technology options.

DA COMMUNICATION PHYSICAL LINK OPTIONS

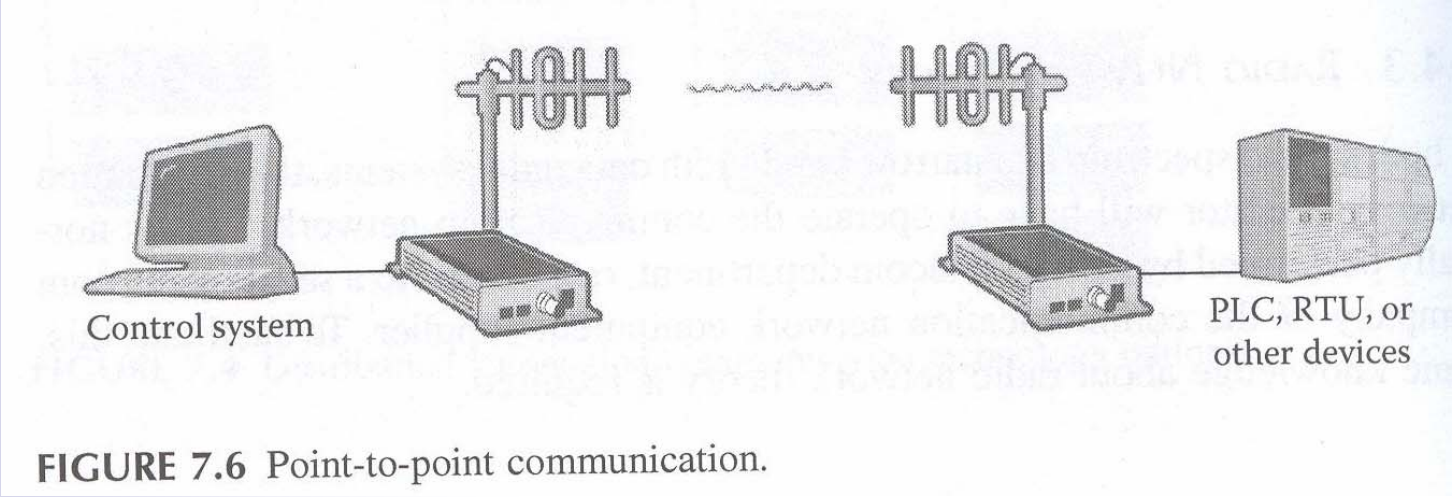

FIGURE 7.6 Point-to-point communication.

DA COMMUNICATION PHYSICAL LINK OPTIONS

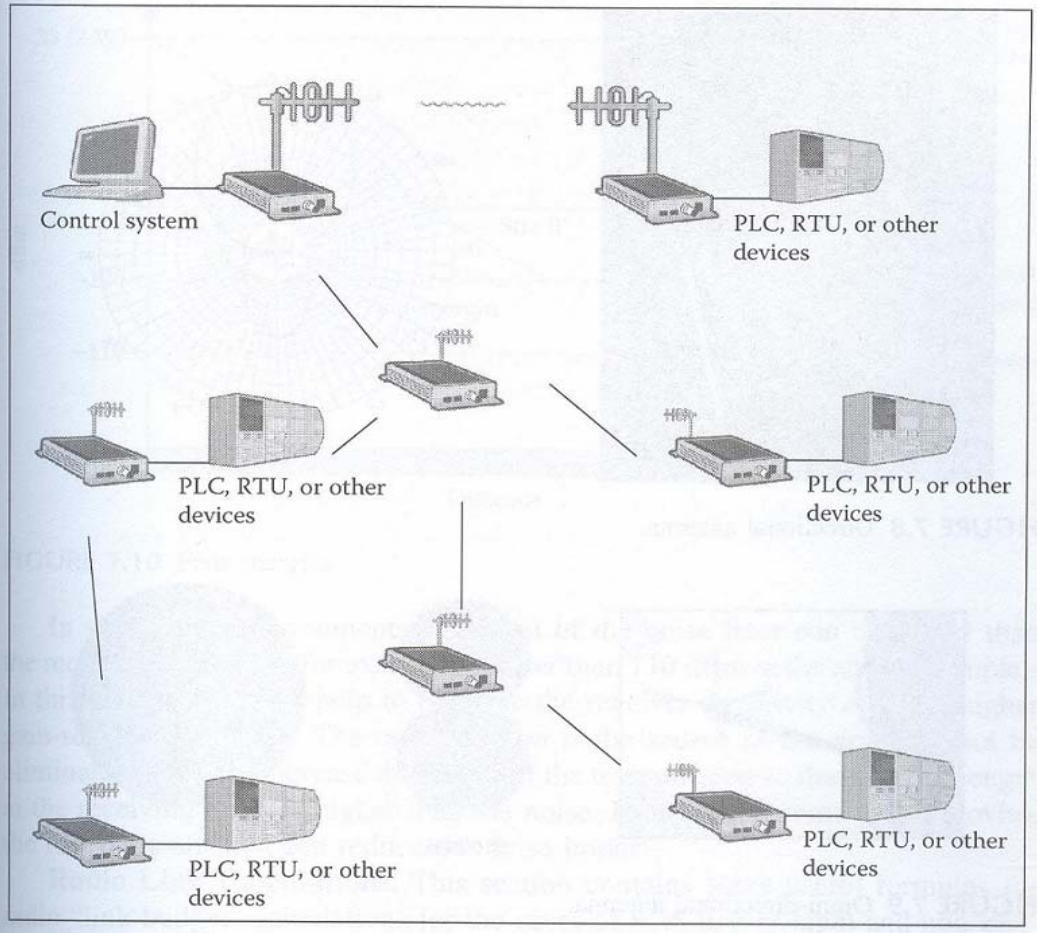

FIGURE 7.7 Point-to-multipoint communication.

DA COMMUNICATION PHYSICAL LINK OPTIONS

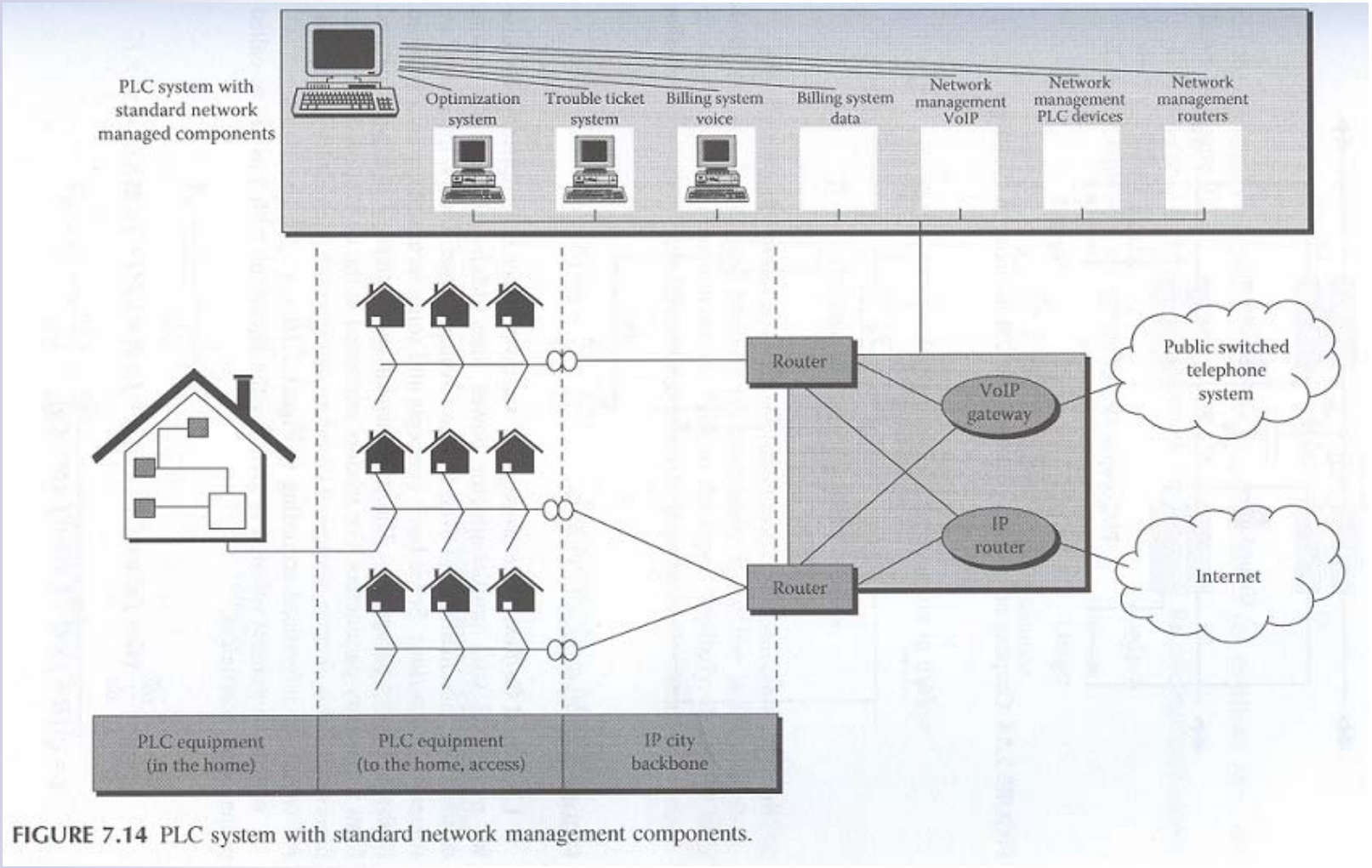

FIGURE 7.14 PLC system with standard network management components.

DISTRIBUTION AUTOMATION COMMUNICATIONS PROTOCOLS

- **MODBUS**
  - Transferring control signals between programmable logic controllers

DISTRIBUTION AUTOMATION COMMUNICATIONS PROTOCOLS

- **DNP3.0**
- Fragmented messages
- Multiple Application Layer messages may be built and transmitted sequentially
- A message may be either a single-fragment message or multifragment message

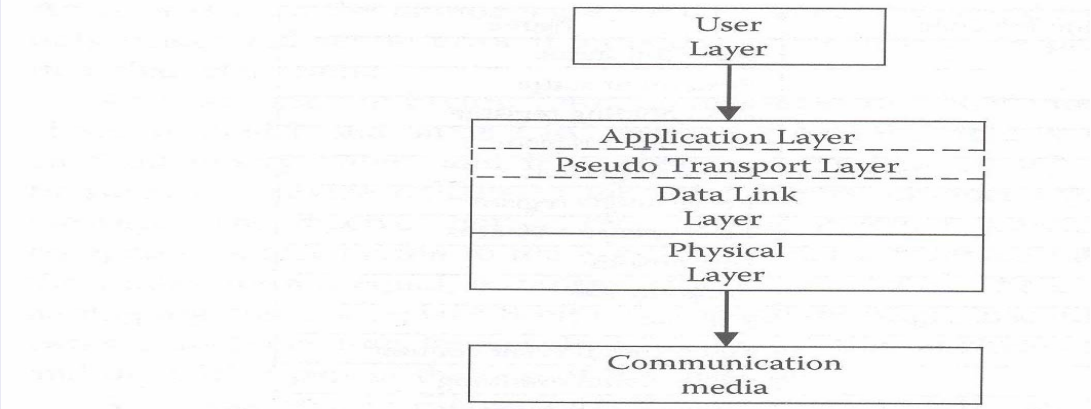

FIGURE 7.43 DNP layer architecture.

DISTRIBUTION AUTOMATION COMMUNICATIONS PROTOCOLS

- Unsolicited response
- Error detection
- Duplicate frame detection
- Handles states of the media
- Synchronization across the media

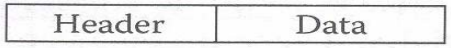

FIGURE 7.44 DNP frame.

FIGURE 7.45 DNP header segment.

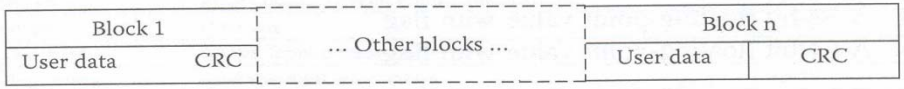

FIGURE 7.46 DNP data segment.

DISTRIBUTION AUTOMATION COMMUNICATIONS PROTOCOLS

- Frame size
- Data link control information
- Help the remote receivers determine where the frame begins
- To coordinate their activities
- “All-call-message” in which the frame should be processed by all devices
- Cyclic redundancy check tasks
- A pair of CRC octets are included ,transmission errors can be detected

DISTRIBUTION AUTOMATION COMMUNICATIONS PROTOCOLS

- **IEC 60870-5-101**
- Enhanced performance architecture
- Perform their local application tasks called application processes
- Communication process between station A and station B

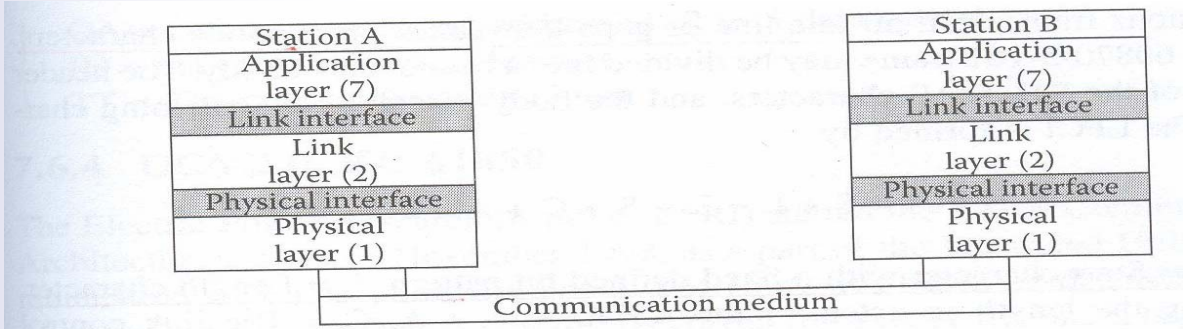

FIGURE 7.50 IEC layer architecture.

DISTRIBUTION AUTOMATION COMMUNICATIONS PROTOCOLS

- The application data pass down through all layers
- All control data are dropped until the original application data are received
- Application service data unit(ASDU)

OA = Information object address (1, 2 or 3 data octets).
IE = Set of information elements.
TT = Time tag information object.

- With no idle line or gaps between asynchronous characters

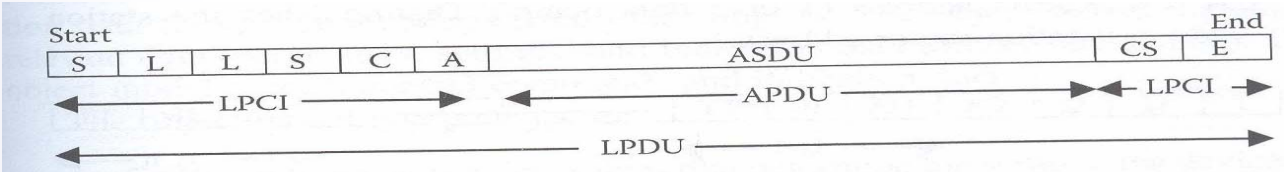

FIGURE 7.51 IEC messaging structure.

DISTRIBUTION AUTOMATION COMMUNICATIONS PROTOCOLS

- LPCI=S+L+L+S+C+A+CS+E
- S=Start character with a fixed defined bit pattern, L=Length character, C=The link control character, A=The link address field, CS=The check sum character, and E=End character with a fixed defined bit pattern

DISTRIBUTION AUTOMATION COMMUNICATIONS PROTOCOLS

T = Type identification (1 data octet).
Q = Variable structure qualifier (1 data octet). Indicates the number of information objects or information elements.
C = Cause of transmission (1 or 2 data octets). Causes include periodic/cyclic, spontaneous, request/requested, activation, etc.
CA = Common address (1 or 2 data octets). Distinguishes the station address/station sector address.

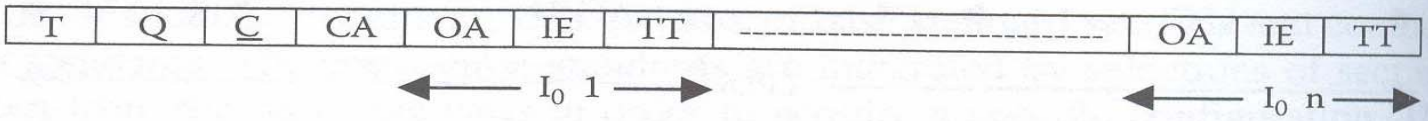

FIGURE 7.52 IEC 60870-5-101, application service data units structure.

OA = Information object address (1, 2 or 3 data octets).
IE = Set of information elements.
TT = Time tag information object.

DISTRIBUTION AUTOMATION COMMUNICATIONS PROTOCOLS

- **UCA 2.0, IEC 61850**
- Manufacturing Message Specification(MMS)
- Open System Interconnection reference model, and seven layers integrate the communication protocol
- Application Layer standard ISO/IEC 9506
- These object models have named variables instead of point lists.
- When the objects are accessed by MMS, common data formats and variables are associated to the object model

DISTRIBUTION AUTOMATION COMMUNICATIONS PROTOCOLS

- Two main levels of field device object models, the basic
- A switch control, and the specialized
- Breaker control or breaker reclose control
- The object model components are
  - Configuration parameters: Values that determine the setup of the device and are not expected to change often

DISTRIBUTION AUTOMATION COMMUNICATIONS PROTOCOLS

- Settings: Values that determine the operation of the device and can change often
- Operation: Values that represent the actual output decisions or commands of the model to perform its functions.
- Status: Represents the indication or values directly concerned with the functions of the device
- Associated parameters