3

Distribution Automation and Management

Dr. H. K. Verma

Distinguished Professor (EEE)

Sharda University, Greater Noida

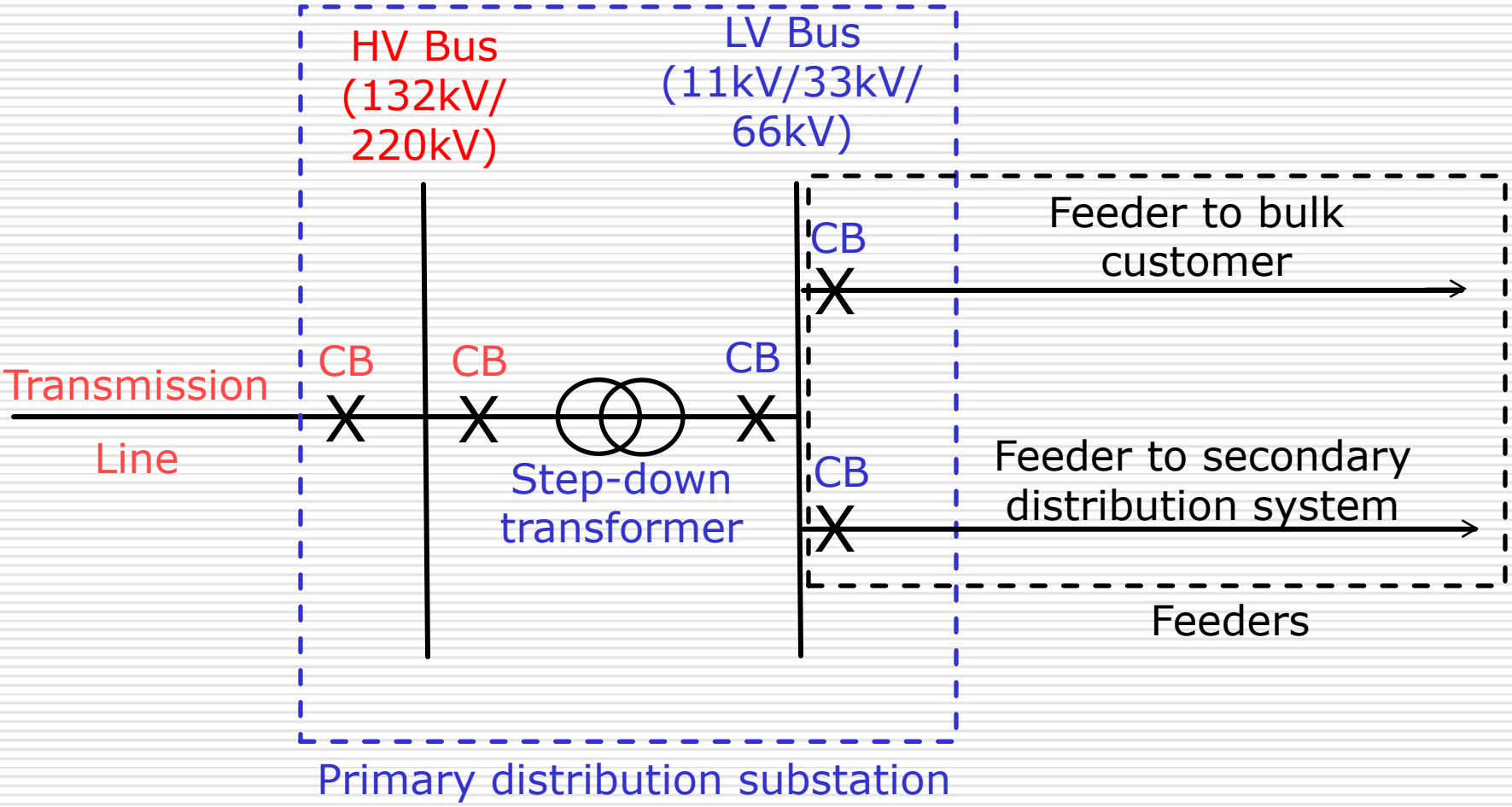
(Formerly: Deputy Director and Professor of Instrumentation

Indian Institute of Technology Roorkee)

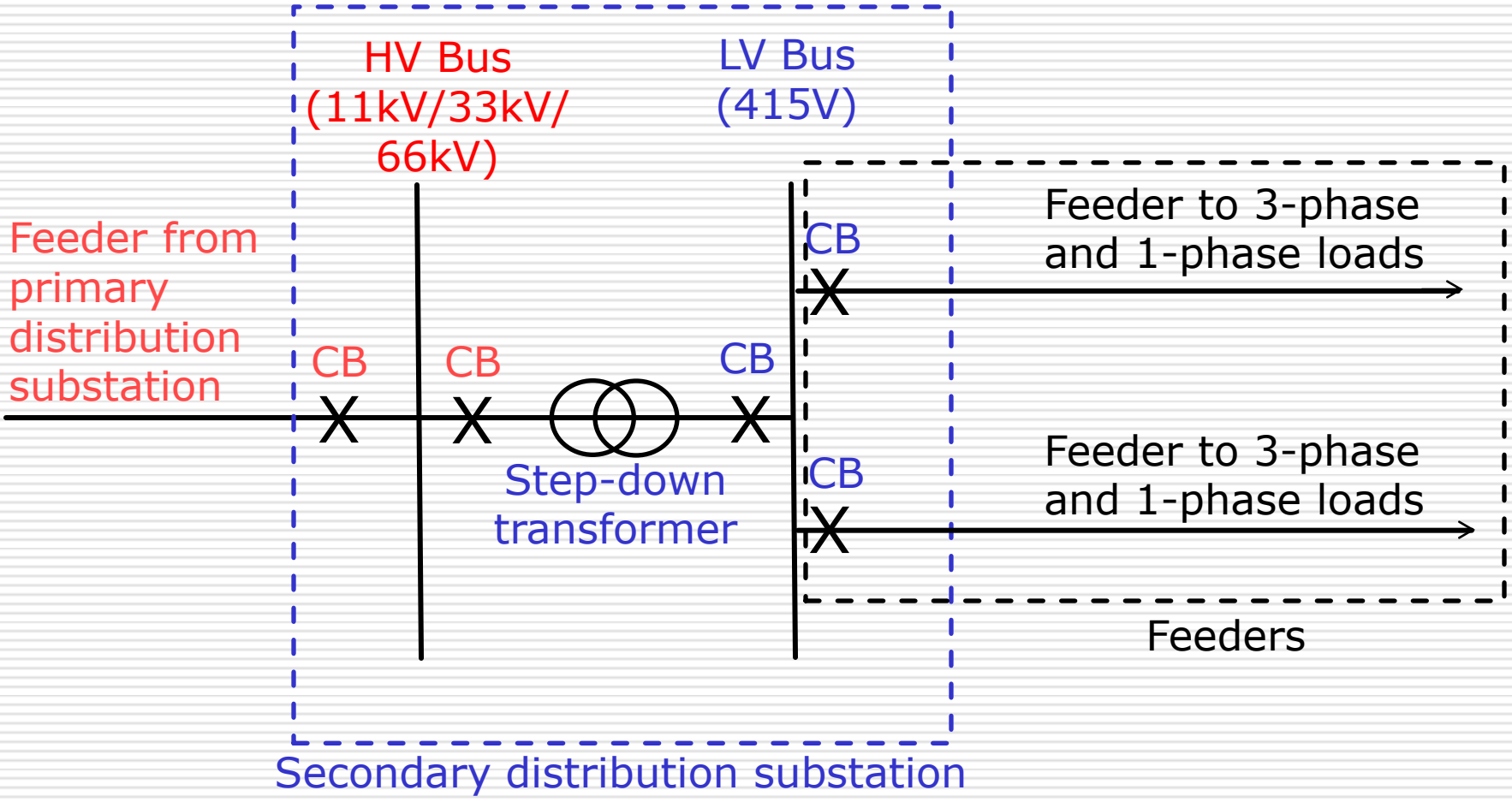
website : www.profhkverma.info

CONTENTS

Basic Primary Distribution System



Basic Secondary Distribution System



Components of Distribution System

- A basic distribution system can be divided into two major parts:
  a) Distribution substation
  b) Feeders
- Major components of a distribution substation:
  - High-voltage (HV) bus
  - Low-voltage (LV) bus
  - Distribution (step-down) transformer
  - Switch-gear (circuit breakers, isolators, earthing switches, etc.)
  - Current and voltage transformers
- Major components of a feeder circuit:
  - Line or feeder
  - Switch-gear (circuit breakers, isolators, earthing switches, etc.)
  - Fuses.

Distribution Automation

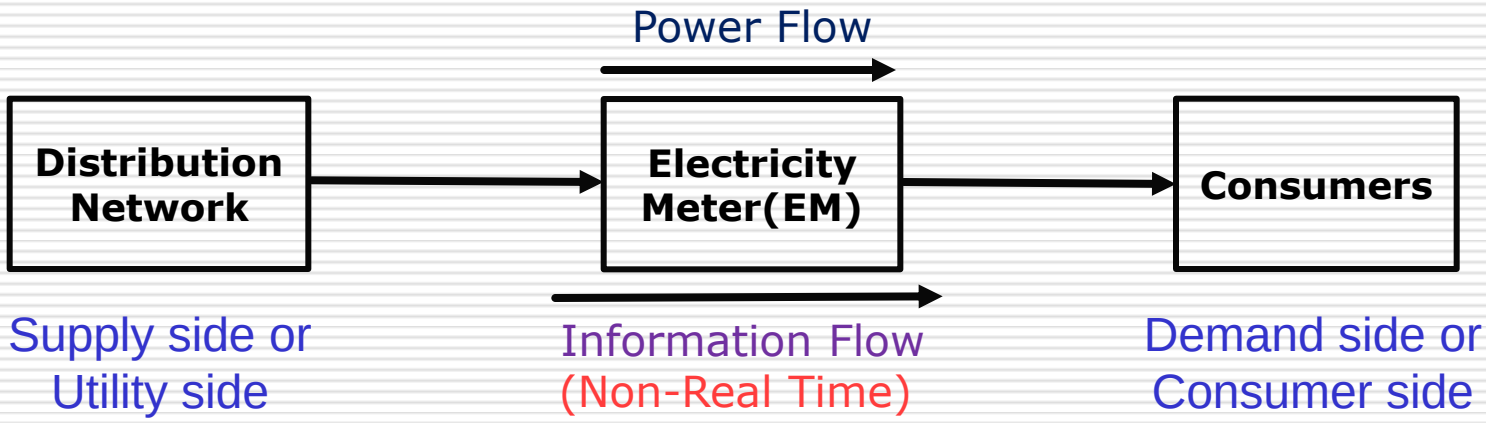
- **Meaning:** Distribution automation means automating the entire process of power distribution.
- **Objectives:** Broad objectives of distribution automation are:
  1. To improve efficiency of operation of the distribution system
  2. To improve quality and reliability of power supply to customers
  3. To support demand side participation through demand-side management (DSM) and demand response (DR).
- The objectives can be met only if the demand side resources are integrated with the utility side resources by moving from traditional distribution to **smart distribution** (see next slide).

Details of Smart Distribution were covered

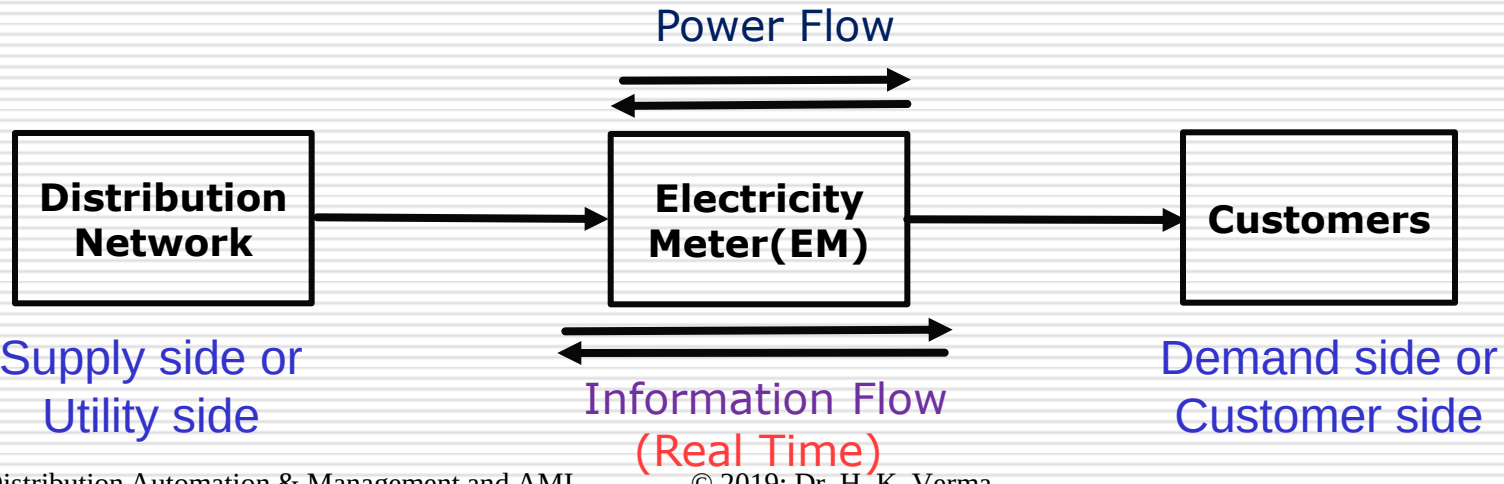
in Chapter 2 of this monograph

Traditional versus Smart Distribution

❑ Traditional Distribution



❑ Smart Distribution



Components of Distribution Automation

1. Automation equipment in distribution substation
2. Automation equipment on feeders
3. Smart meters and automation equipment relevant to DSM/DR at bulk customers' premises
4. Supervisory control and data acquisition (SCADA) system operating from a central location, called distribution control room (DCR)
5. Distribution management system (DMS) (software).

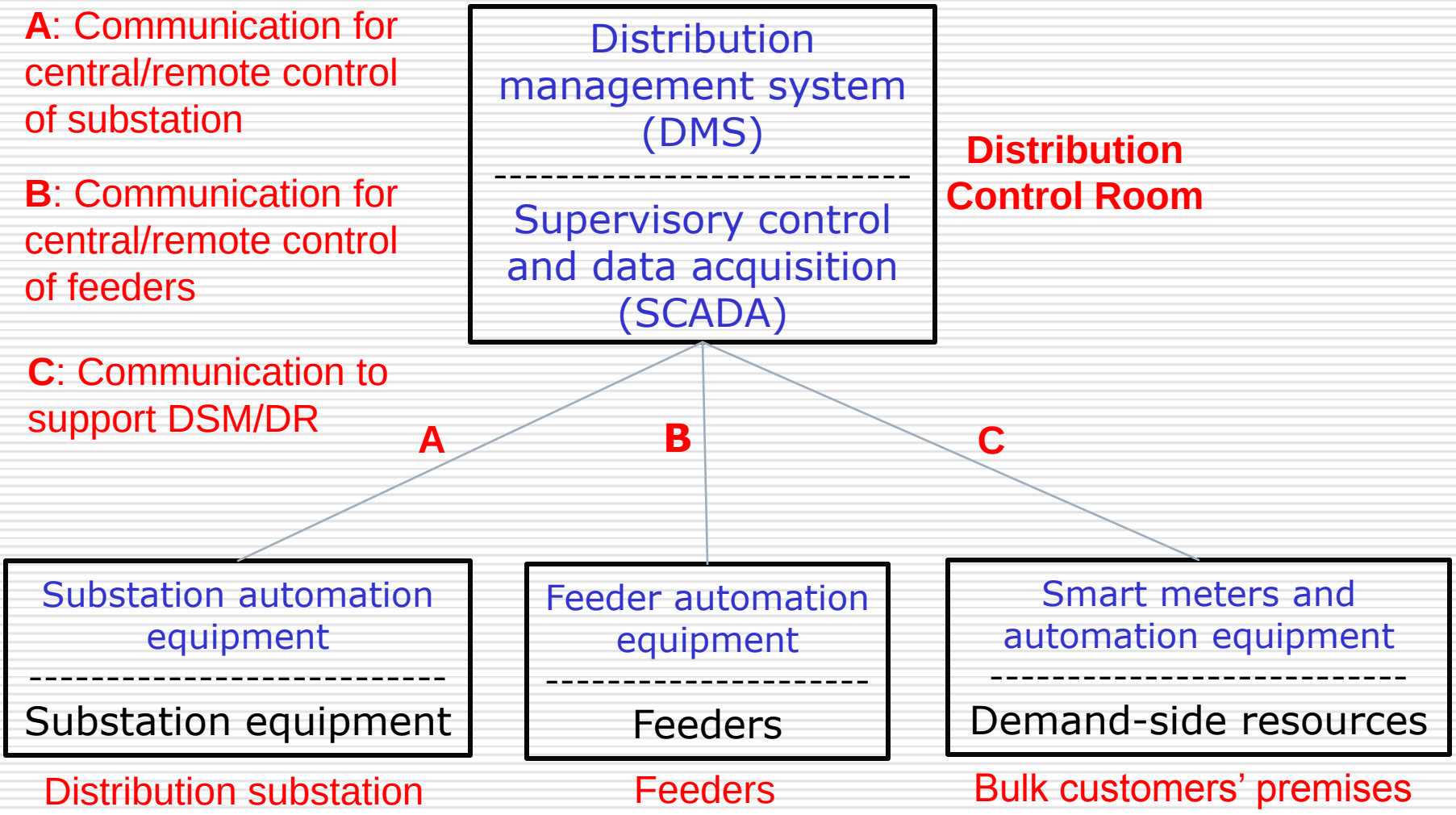
[Shown in next slide]

Distribution Automation Layout

A: Communication for central/remote control of substation

B: Communication for central/remote control of feeders

C: Communication to support DSM/DR



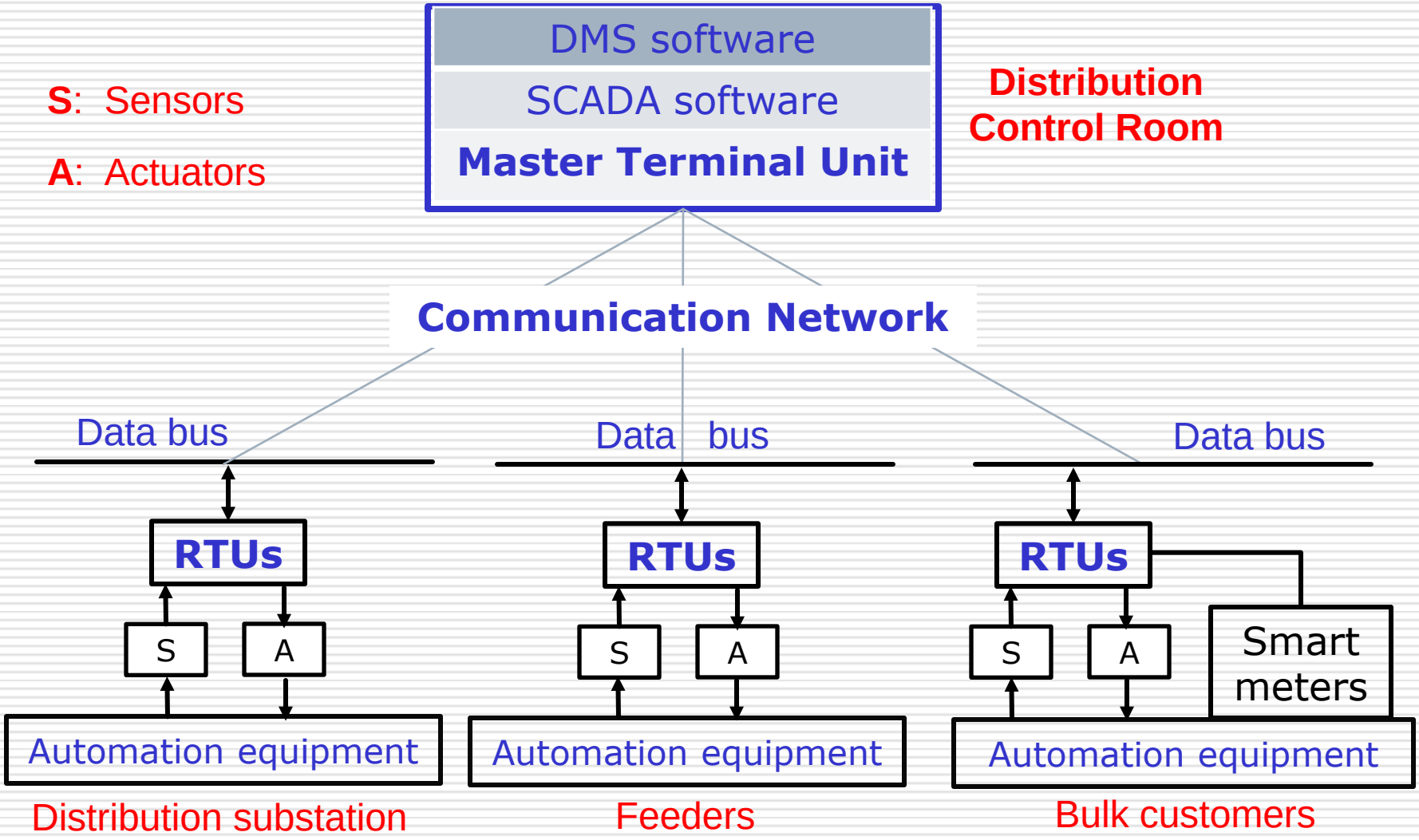
SCADA System for Distribution Automation

- A simplified layout of the SCADA system is shown in the next slide.
- The slide also illustrates its relationship with DMS via MTU located in DCR.
- SCADA system is comprised of hardware plus software.
- SCADA system has five major components, as shown in the next slide:
  1. Master Terminal Unit (MTU) or Master station (MS)
  2. Remote Terminal Units (RTUs)
  3. MTU-RTU communication network
  4. Sensors and actuators
  5. SCADA software

For details of SCADA components:

Refer to "Monograph on SCADA" at www.profhkverma.info

SCADA System Layout



Functions of SCADA System (1)

- SCADA system performs six major functions:

1. Data acquisition and transmission
   - Data are acquired and processed by RTUs and transmitted to MTU on the MTU-RTU communication network.
   - Two types of data are continuously acquired by RTU:

     (a) **Analog Values:** Values of the uncontrolled as well as controlled variables, which are almost always analog in nature, are acquired continuously using suitable **analog sensors**.

     (b) Status Information: Information about the states of remotely as well as locally controlled objects, which is essentially discrete or binary in nature, is also acquired continuously. This is done using suitable **status sensors**.
   - The data acquired as above is processed in the RTU to extract the information desired by the MTU.
   - The extracted information is transmitted by RTU to MTU.

(continued)

Functions of SCADA System (2)

2. Data collection, storage and retrieval
   - Data so received by the MTU from RTUs is collected and stored in the mass-storage media of the MTU.
   - The SCADA operator can later on retrieve a block of data of his interest from the storage and use it .
3. Monitoring
   - It is a common practice to monitor

     (a) status,

     (b) events,

     (c) limits, and

     (d) trends.
   - This function is carried out jointly by RTU and MTU.

(continued)

Functions of SCADA System (3)

4. Control
   - MTU analyzes the data received from RTUs.
   - It sends control messages to RTUs as necessary for the proper operation of the distribution system.
   - Each RTU that receives control messages, decodes them and converts into control signals.
   - These control signals are applied to relevant actuators.
   - Finally, these actuators convert the control signals into actions.

(continued)

Functions of SCADA System (4)

5. Human-machine interfacing (HMI)
   - The SCADA system is designed to monitor and control the process/ plant automatically most of the time.
   - But provisions are made for human operators to continuously **watch** the operation and to **intervene** as and when felt necessary by them.
   - This requires an interface between human operators and computers of the MTU, commonly known as human-machine interface (HMI).
   - HMI enables the operator to 'watch' and 'intervene' as and when considered necessary by him.
   - HMI comprises computer peripherals (keyboard, video monitor, computer mouse and speaker etc. on each operator's console) and their software drivers.

(continued)

Functions of SCADA System (5)

6. Report Generation
   - The SCADA software in the MTU is designed to produce periodic reports.
   - The reports may be on working-shift basis or on daily basis for routine management.
   - Additional reports may be generated on monthly, quarterly and/or annual basis as needed for planning purposes.

Distribution Management System (DMS)

- **What is DMS?:** DMS is the software responsible for the operation and control of a distribution system with the support of:

  (a) supervisory control and data acquisition (SCADA) system, and

  (b) some enterprise-level systems.

- DMS carries out operation and control activities from the distribution control room (DCR).

- **Objective of DMS:**

  a) To provide high quality power supply to customers

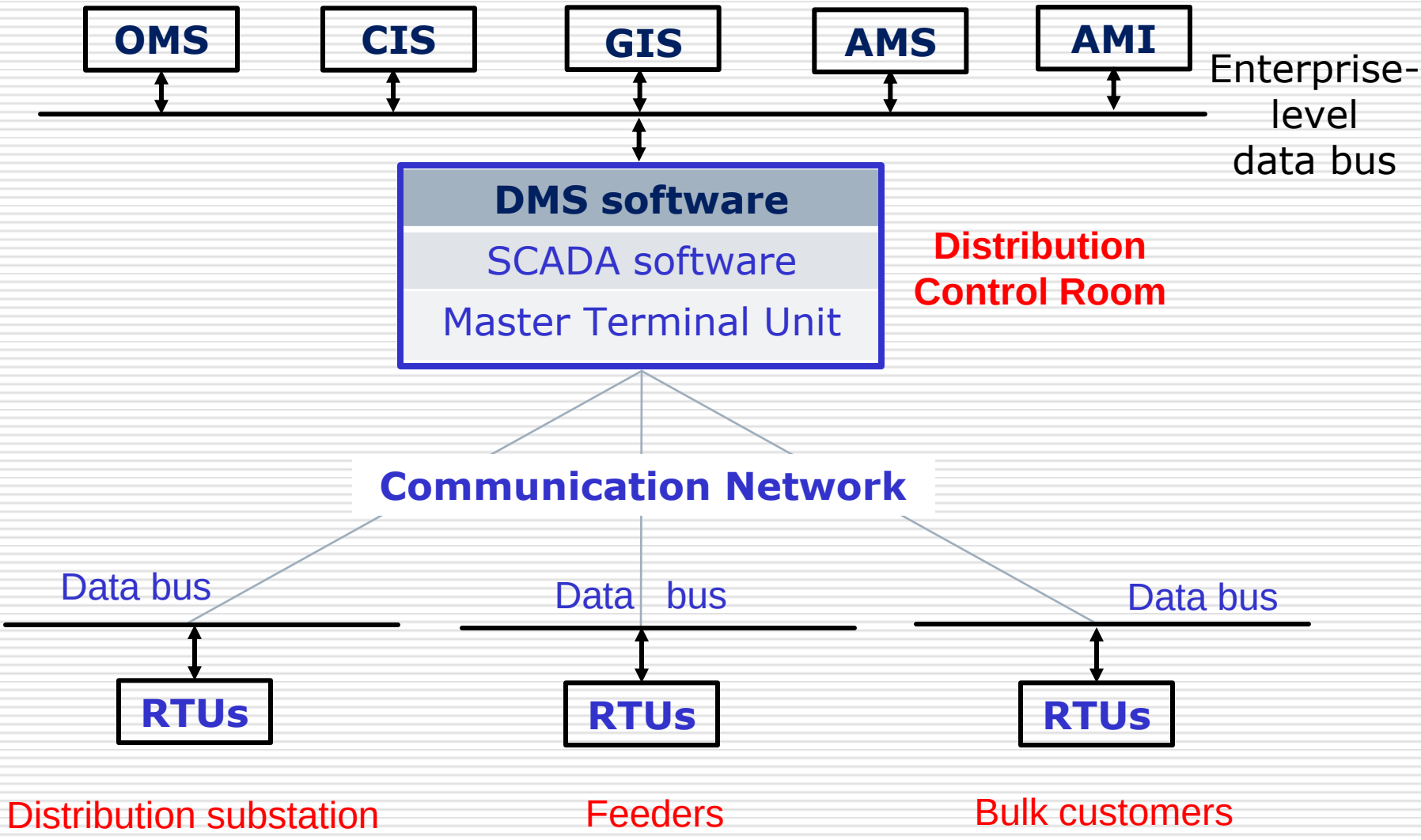
  b) To ensure high reliability of power supply

  c) To ensure good profits to the utility.

Subsystems of DMS

- As mentioned earlier, the DMS software along with the SCADA software run on the computer(s) of the master terminal unit of SCADA system.
- DMS is supported by the following enterprise-level systems:
  1. Outage Management System (OMS)
  2. Customer Information System (CIS)
  3. Geographical Information System (GIS)
  4. Asset Management system (AMS)
  5. Advanced Metering Infrastructure (AMI)
- These systems act as **subsystems of DMS** in managing the power distribution.
- The DMS and its subsystems are integrated through **enterprise-level data bus,** as shown in next slide.

Integration of DMS with its Subsystems



1- Outage Management System (OMS)

- **What is outage?**: Outage or power outage is a sustained interruption in power supply to customers.
- **What is OMS?:** OMS is a subsystem of DMS which, in the event of a power outage, is responsible to bring the distribution system back from a contingency state to the normal state

  in a minimum time frame

  and confining the power outage to a minimum number of customers.
- **Types of outage:**

  a) Unplanned outages

  b) Planned outages.

Unplanned Outages

- **Reasons or causes:**
  a) Fault
  b) Failure of equipment
- **Sources of information** about an unplanned outage:
  a) Trouble calls from affected customers
  b) Status information from SACDA
  c) Data from smart meters installed at customers' premises
  d) Maintenance crew may sometimes detect a fault or outage.
- **OMS actions** (steps to be taken by OMS):
  I. Analyze the received information to (a) locate the fault or failure, and (b) determine the affected area or customers.
  II. Take action to narrow down the affected area or the number of affected customers.
  III. Assess the time required to clear the contingency.
  IV. Inform the affected customers accordingly.
  V. Manage the repair work.
  VI. Restore the power supply to customers.
  VII. Call back the customers to verify power restoration.

Planned Outages

- **Reasons or causes:**
  a) Routine maintenance
  b) Replacement of equipment
  c) Load shedding necessitated by shortage of available power.

- **OMS actions** (steps to be taken by OMS):
  I. Assess in advance the time required to restore power supply.
  II. Inform in advance the affected customers accordingly.
  III. Manage the repair / replacement work.
  IV. Restore power supply to customers.
  V. Call back the customers to verify power restoration.

2- Customer Information System (CIS)

- CIS is an integral part of every business company.
- It provides an interface between the utility and its customers.
- CIS collects and store the following information:
  1. **Customer Data:** Name, Type and demographic details.
  2. **Meter Data:** Type of the meter installed at customer's premises, serial number of the meter.
  3. **Energy Consumption Data:** Current value of energy, history of energy consumption, pattern of consumption of energy over the day/ month/ season.
  4. **Tariff Data:** Type of the tariff applicable, actual tariff.
  5. **Bill & Bill-Payment Data:** Current bill details, payment details, payment history, and payment dues, if any.
- The data can be accessed by the customers as well as by the utility.
- CIS is a useful tool for ***custom relations management*** (CRM) and interaction with customers.

3- Geographical Information System (GIS)

- **What is GIS?:** It is a subsystem of DMS that
  a) captures,
  b) stores,
  c) manipulates,
  d) analyzes, and
  e) uses

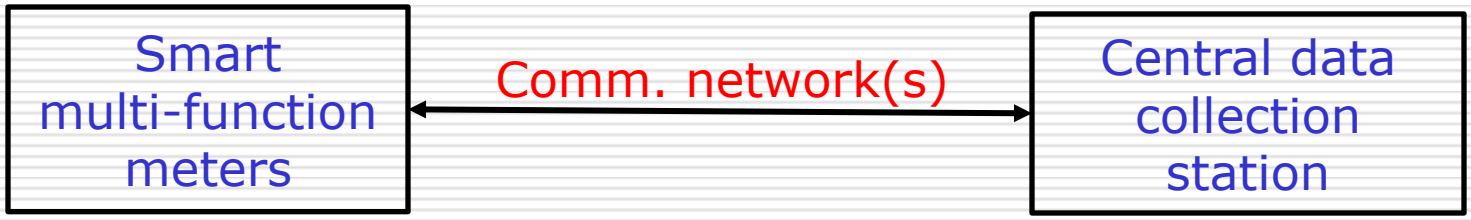
  all types of geographical information.
- **Purpose of GIS:** It maps the resources of the utility and bulk customers on a geographical plane.
- **Vector-based map:** Sometimes, a vector-based map is prepare by over-laying the entire distribution system and energy resources of bulk customers over a satellite image of the area.

4- Asset Management System (AMS)

- **Assets:** The assets of a distribution company are the equipment installed in its substations and field. Transformers are the most expensive assets. Other assets include switchgear, protection gear. CTs and VTs, bushings, feeders, etc.
- **Asset Management:** Asset management may be defined as the process of maximizing the performance and minimizing the life-cycle cost of the equipments.
- **Asset Management System:** AMS is the software designed to meet the above objective.

5- Advanced Metering Infrastructure

- Uses smart multi-function meters incorporating two-way communication interface (wired or wireless transceiver).
- Uses automatic meter reading (AMR) technique, wherein meter data is read automatically and regularly from the smart multi-function meters to a central data collection station.
- The data communication between smart multi-function meters and the central data collection (CDC) station may take place either on a single data network or multiple data networks, as shown below:



Basic functions of AMI

1. **Measures** energy usage and power quality using smart meters.
2. **Collects** energy usage and power quality data from smart meters using an advanced communication infrastructure.
3. **Analyzes** the data to extract information on usage of energy by individual and groups of customers and the quality of power (QoP) delivered to them.
4. **Shares** this information with OMS, CIS and the customers.

Advanced Purposes of AMI

The two-way communication infrastructure created as an essential element of AMI to carry out its basic functions, can be used to serve the following additional purposes:

1. For disseminating the information on energy usage and power quality to customers for their information.
2. For sending tariff structures to customers to help them manage their demand or to support tariff-driven DR by them.
3. For intimating daily and dynamic prices to customers to support market-driven DR.
4. For intimating generation-shortage conditions in the grid, as and when they arise, to support grid-status-driven DR.
5. As future smart meters are expected to be equipped with some switching functions as well, the two-way communication will be useful in executing some control functionalities on the demand side from utility side (as a part of DSM).