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Advanced Metering Infrastructure

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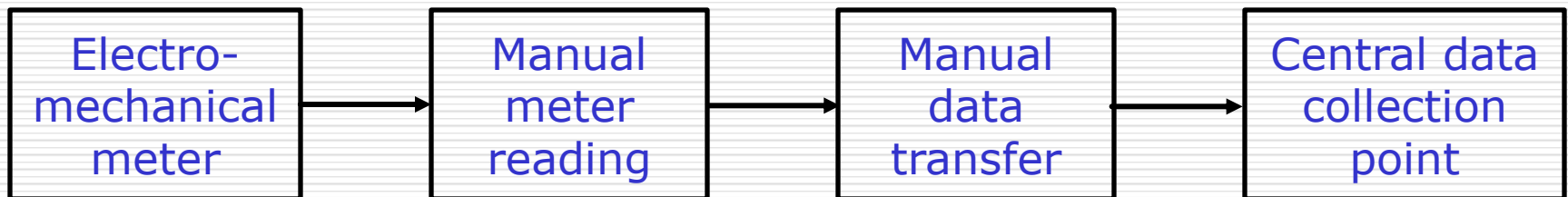
- ❑ Evolution of Electricity Metering
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Evolution of Electricity Metering

- ❑ First Generation (G-1) : **Electromechanical Metering**
 - Electromechanical energy meter + manual meter reading
 - Since beginning of electricity metering
- ❑ Second Generation (G-2) : **Electronic Metering**
 - Electronic energy meter without communication interface + manual meter reading
 - 1970 onwards
- ❑ Third Generation (G-3) : **Remote Meter Reading**
 - Smart energy meter with one-way communication interface + remote meter reading
 - 1985 onwards
- ❑ Fourth Generation (G-4) : **Automatic Meter Reading : Advanced Metering Infrastructure (AMI)**
 - Smart multi-function meter with two-way communication interface + automatic meter reading
 - 2000 onwards

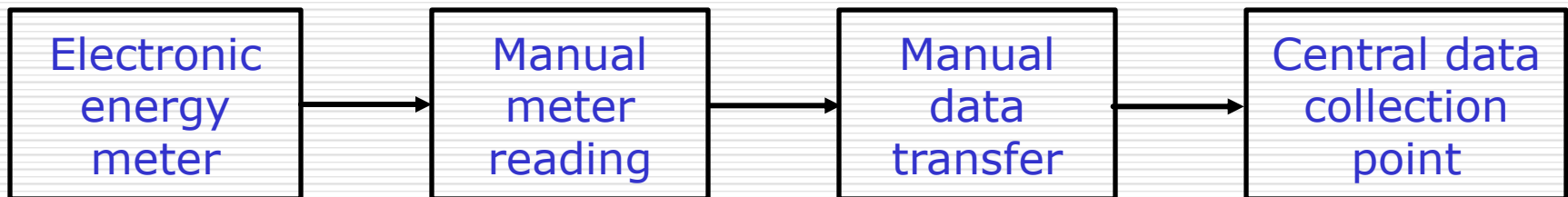
G-1 : Electromechanical Metering

- ❑ **Meter Type:** Electromechanical energy meter
 - Works on principle of electromagnetic induction
 - Meter has short life and needs regular maintenance because of the moving parts in it
- ❑ **Meter Reading Technique:** Manual meter reading
 - Meter reader has to go to every meter and note down its energy reading
 - Readings/meter data are finally collected in a central data collection (CDC) point
- ❑ **Data transfer to CDC Point:** Manual process
- ❑ **Since:** Beginning of electricity metering



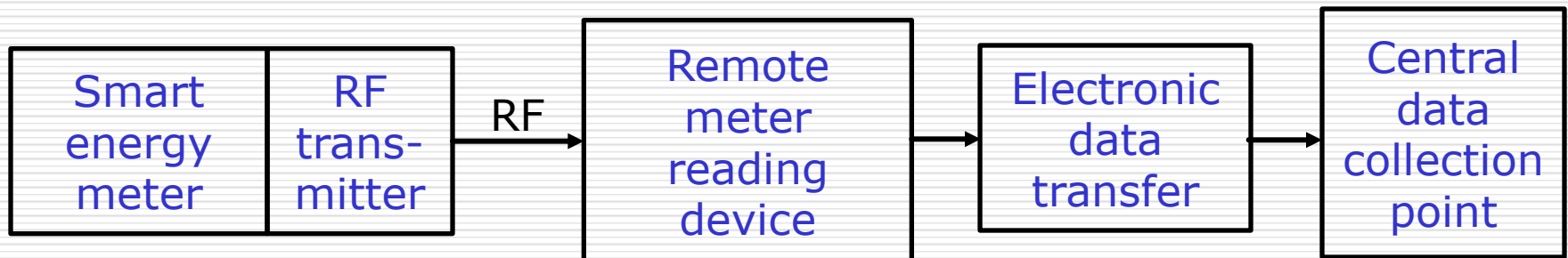
G-2 : Electronic Metering

- ❑ **Meter Type:** Electronic energy meter
 - Uses an ASIC (application specific integrated circuit)
 - Meter has a long life and needs no maintenance because of its static nature (i.e. no moving parts)
- ❑ **Meter Reading Technique:** Manual meter reading
 - Meter reader has to go to every meter and note down its energy reading
 - Readings/meter data are finally collected in a central data collection (CDC) point
- ❑ **Data transfer to CDC Point:** Manual process
- ❑ **Since:** Around 1970



G-3 : Remote Meter Reading (RMR)

- ❑ **Meter Type:** Smart electronic energy meter
 - Uses an ASIC (application specific integrated circuit)
 - Incorporates a one-way wireless communication interface /RF (radio-frequency) transmitter
- ❑ **Meter Reading Technique:** Remote meter reading
 - The meter reader, carrying a remote meter reading device, either walks-by on foot or drives-by in a vehicle along the meter reading route
 - The device gets energy readings from the meters via their wireless transmitters
- ❑ **Data transfer to CDC Point:** Electronic data transfer
- ❑ **Since:** Around 1985



G-4 : Automatic Meter Reading (AMR)

- ❑ **Meter Type:** Smart multi-function meter (SMFM)
 - Meter uses a microprocessor or DSP (digital signal processor)
 - It incorporates a two-way communication interface (wired or wireless transceiver)
- ❑ **Meter Reading Technique:** Automatic meter reading (AMR)
 - Meter data is read automatically from the meters to a central data collection station
 - The data communication may take place either on a single data network or multiple data networks.
 - The infrastructure used is called Advanced Metering Infrastructure (AMI).
- ❑ **Since:** Around 2000



Advanced Metering Infrastructure (AMI)

- ❑ A generic structure of AMI is given in last slide.
- ❑ **Communication Options:**
 - a) Single communication network: For smaller systems
 - b) Multiple communication networks or hierarchical communication : For larger systems
- ❑ **Options in Single Communication Network:**
 - a) Wireless data network
 - b) Wired data network
 - c) Mobile-phone network
- ❑ **Options in Multiple communication networks or Hierarchical communication**
 - e) PAN and LAN
 - f) NAN and WAN/Internet

A- AMI using Wireless Data Network

❑ Wireless Data Network that may be used:

- WiFi network, or
- Zigbee network

❑ Advantages:

- Simplicity of network
- Low cost
- Fast deployment

❑ Limitations:

- Low range
- Small number of meters can be connected.



B- AMI using Wired Data Network

- ❑ **Wire (or wired) data network that may be used:**
 - RS-485/ ModBus,
 - Foundation FieldBus,
 - ProfiBus, or
 - Power line communication.
- ❑ **Advantages:**
 - Simplicity of network
 - Low cost
 - High security of data
- ❑ **Limitations:**
 - Low range
 - Small number of meters can be connected.

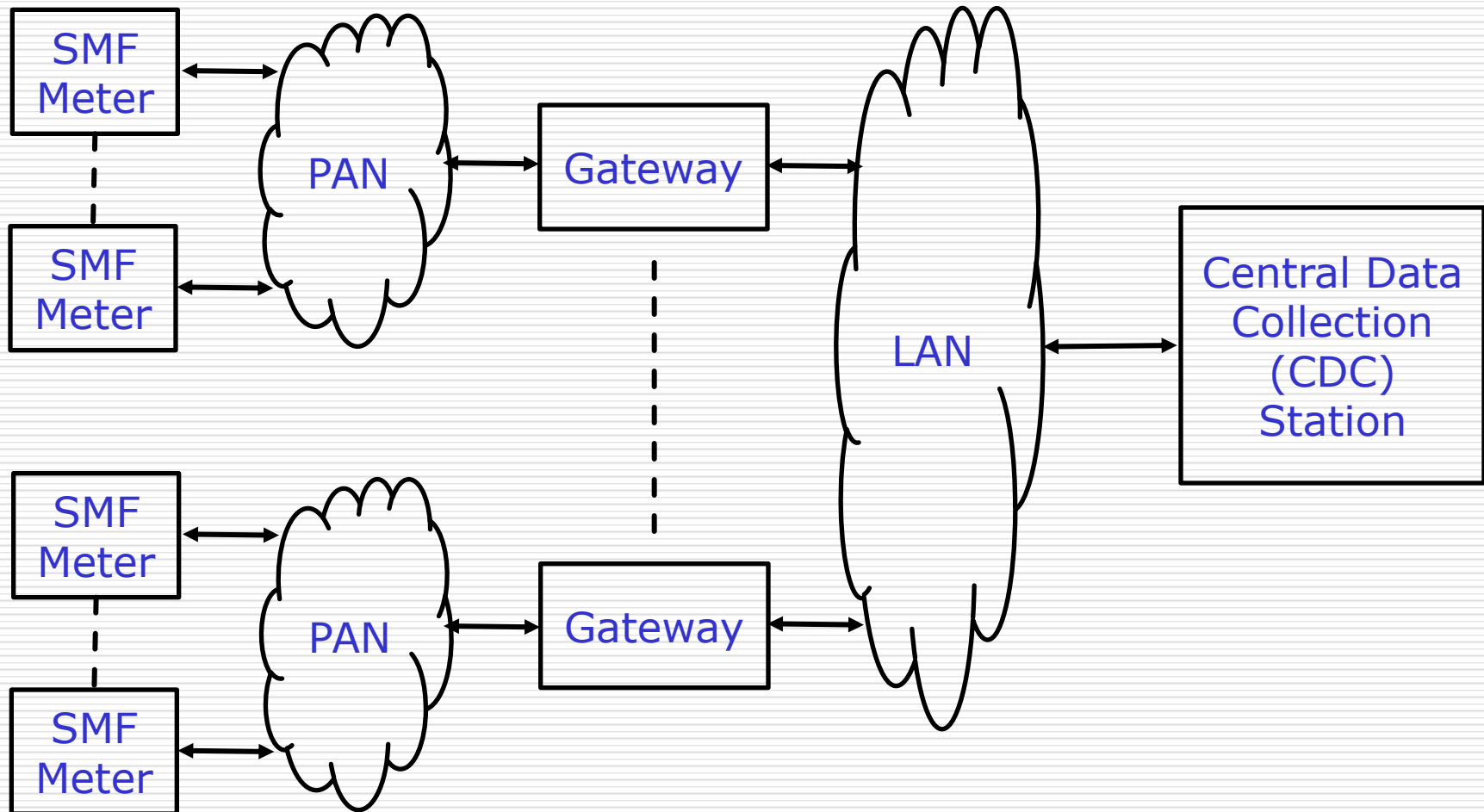


C- AMI using Mobile Phone Network

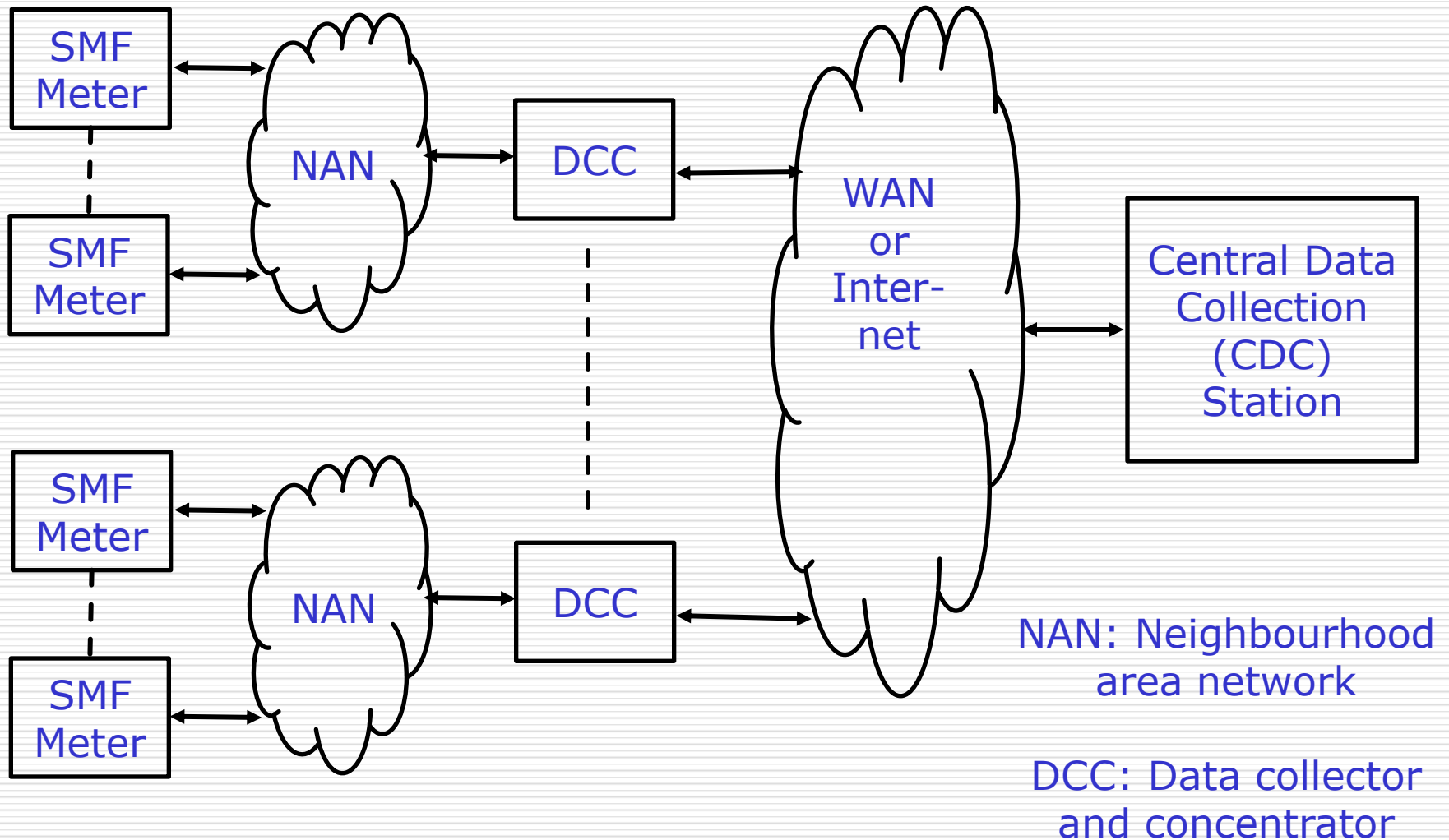
- ❑ **Mobile phone network that may be used:**
 - GSM,
 - GPRS, or
 - Any other available mobile phone network
- ❑ **Advantages:**
 - Minimal effort
 - Mobile phone networks can serve large areas
 - Large number of meters can be connected
- ❑ **Limitations:**
 - Data security may be an issue



Structure of AMI using PAN and LAN



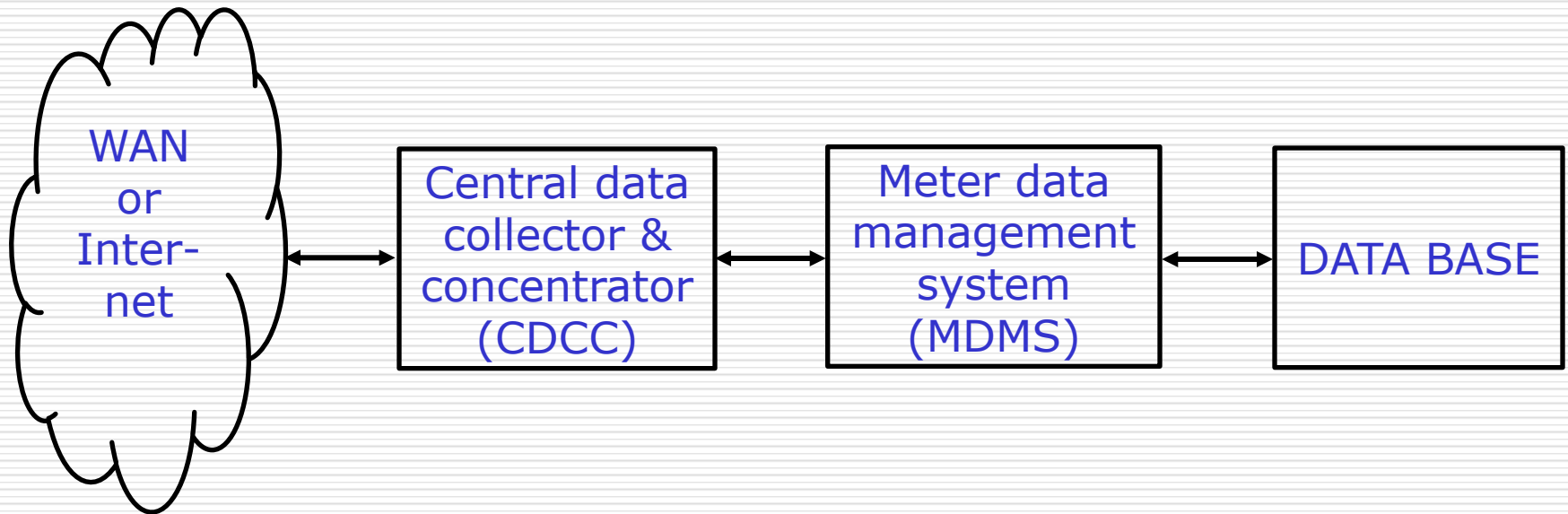
Structure of AMI using NAN and WAN/Internet



Central Data Collection (CDC) Station

❑ CDC Station of AMI has 3 parts:

1. Central data collector & concentrator (CDCC): Responsible for collecting data from all DCCs and presenting to MDMS after concentrating the same
2. Meter data management system (MDMS): Responsible for analyzing and storing data in data base
3. Data base



Meter Data Management System (MDMS)

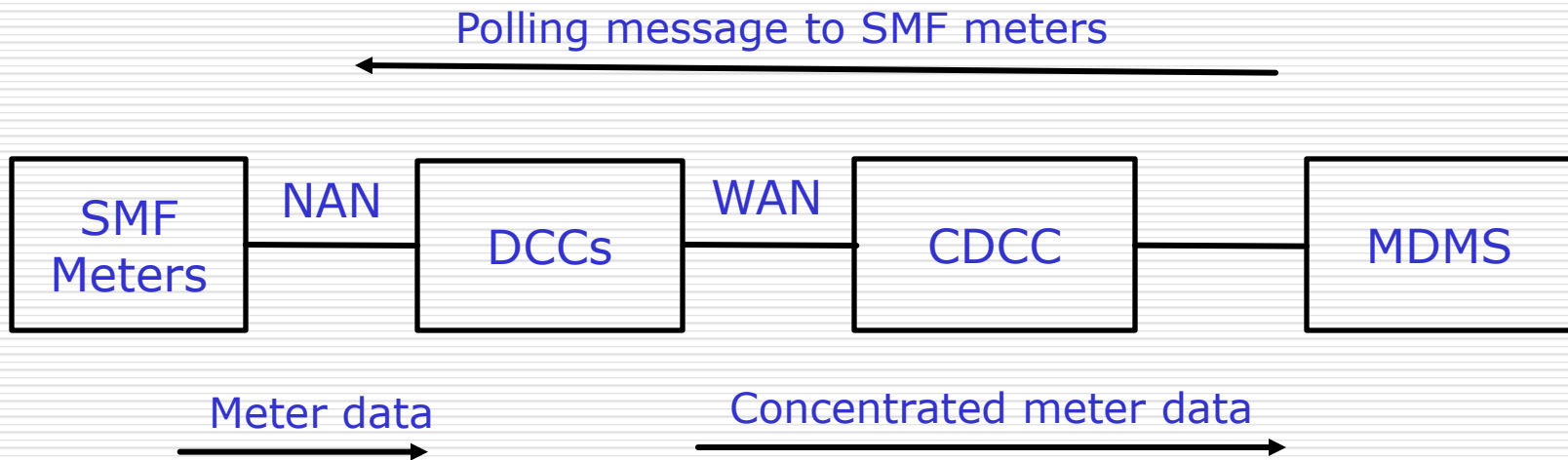
❑ **Functions of MDMS:**

1. Receives meter data (normal as well as outage plus restoration data)
2. Validates the data
3. Analyzes and classifies the data
4. Stores the analyzed & classified data in data base

❑ **Data classes:**

- a) Normal data
- b) Outage data
- c) Restoration data

Automatic Meter Reading (AMR) Process



Comparison between RMR System and AMR-AMI System (1)

Feature	RMR System	AMR-AMI System
1. Electricity Meter	<ul style="list-style-type: none">• Electronic• Has one-way communication facility• Non-programmable• Based on ASIC	<ul style="list-style-type: none">• Electronic• Has two-way communication facility• Programmable• Based on micro-processor or DSP
2. Meter Reading Process	<ul style="list-style-type: none">• Remote meter reading device used	<ul style="list-style-type: none">• Automatic and interactive meter reading
3. Data Collection from Meters	<ul style="list-style-type: none">• Monthly• Only energy consumption over the month	<ul style="list-style-type: none">• On-demand• Energy plus lots of other data (up to 100 quantities)

Contd...

Comparison between RMR System and AMR-AMI System (2)

Feature	RMR System	AMR-AMI System
4. Communication type	<ul style="list-style-type: none">• One way Communication	<ul style="list-style-type: none">• Two way communication
5. Load-pattern monitoring?	<ul style="list-style-type: none">• No	<ul style="list-style-type: none">• Yes
6. Power quality monitoring?	<ul style="list-style-type: none">• No	<ul style="list-style-type: none">• Yes
7. Market prices and tariff information from utility to customers?	<ul style="list-style-type: none">• No	<ul style="list-style-type: none">• Yes
6. Outage information from meters to MDMS?	<ul style="list-style-type: none">• No	<ul style="list-style-type: none">• Yes

Smart Multi-Function Meter (SMFM)

❑ In what way is it Smart?

- Because it has built in communication/ networking port.

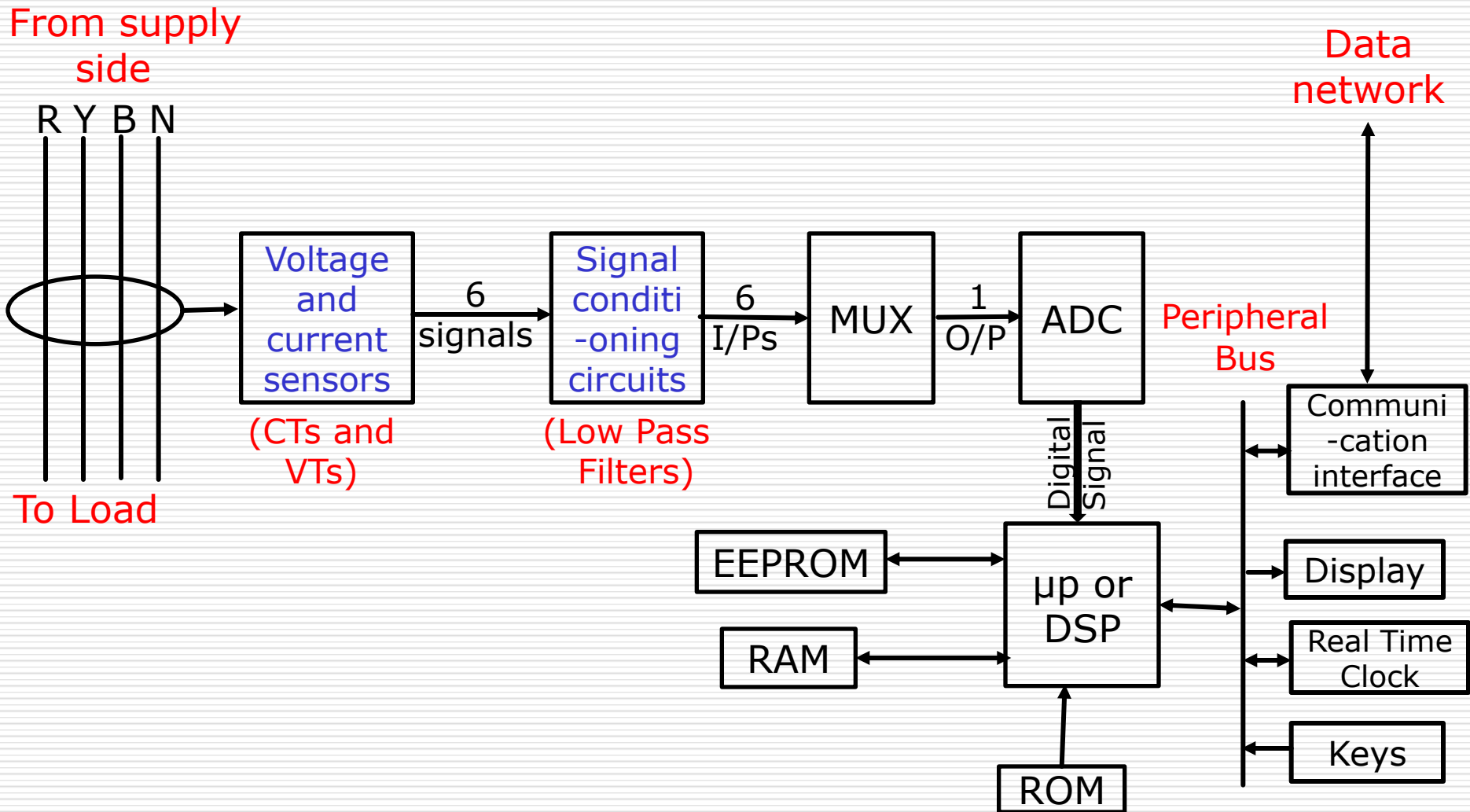
❑ How is it a Multi-Function Meter?

- Because it has several functions and can measure several electrical quantities.
- SMF meters, now commercially available at economic prices, can measure around 100 electrical quantities.

❑ Principle:

- Three phase (or line) voltages and three line currents are sensed using voltage and current transformers, then conditioned as 6 analog voltage signals, which are sampled synchronously and converted into digital values (data) and then fed to a MP or DSP.
- The MP/DSP processes this data in real time to extract values of various electrical quantities.

Block Diagram of Smart Multi-Function Meter



Typical Functions and Features of SMFM

1. Measurement of some basic electrical quantities
2. Calculation of other electrical quantities
3. Integration of electrical quantities
4. Measurement of certain time durations
5. Counting certain events
6. Two-way communication
7. Programmability
8. Data security
9. Reset function.

Basic Measured Quantities (Typical)

1. Three line currents
2. Three phase (or line) voltages
3. Frequency

Calculated Quantities (Typical)

1. Neutral wire current
2. Three line (or phase) voltages
3. Average line current
4. Average phase voltage
5. Average line voltage
6. Unbalance in line currents
7. Unbalance in phase voltages
8. Unbalance in line voltages
9. Active power in kW
10. Reactive power in kVAr
11. Apparent power in kVA
12. Total harmonic distortion (THD)

Integrated Quantities (Typical)

1. Active energy in kWh
2. Reactive energy in kVArh
3. Apparent energy in kVAh
4. "On" hours
5. "Load" hours
6. Number of interruptions

Programmability (Typical)

1. Selection of metering circuit (e.g. 3-phase 3-wire, 3-phase 4wire, 1-phase 2-wire etc.)
2. CT ratio, if connected through CT
3. VT ratio, if connected through VT
4. Selection of communication parameters (e.g. data rate, parity etc.)
5. Set real-time clock