Distribution Automation

What ?

How ?

Why ?

D A

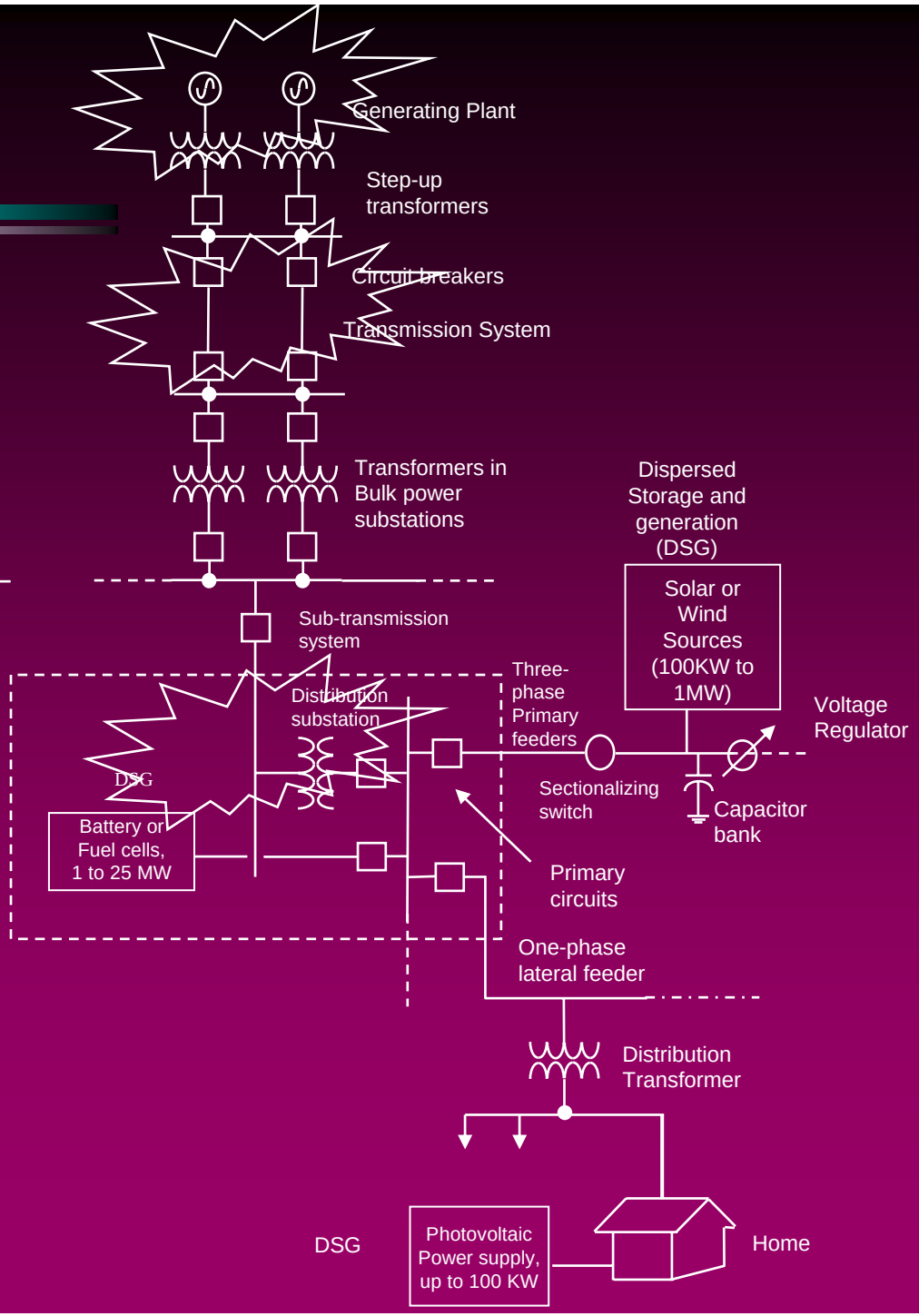
Typical Power System

Generation System

Transmission System

Distribution System

- substations
- transformers
- circuit breakers
- feeders
- sectionalizing switches
- capacitor banks
- voltage regulators
- DSGs
- customers
  - HT customers
  - LT customers



Function of Distribution Automation System

Remotely monitors the distribution system, facilitates supervisory control of devices and provides decision support tools to improve the system performance

- SCADA

  (**S**upervisory **C**ontrol **A**nd **D**ata **A**cquisition)

- Application Functions

Levels of Automation

Substation Level Automation

Feeder Level Automation

Customer Level Automation

Operational problems and Potential Applications of DAS

- Fault location, isolation and Service Restoration
- Maintaining good voltage profile
- Load Balancing
- Load Control
- Metering
- Maintaining Maps
- Fuse-off call operations
- Energy accounting

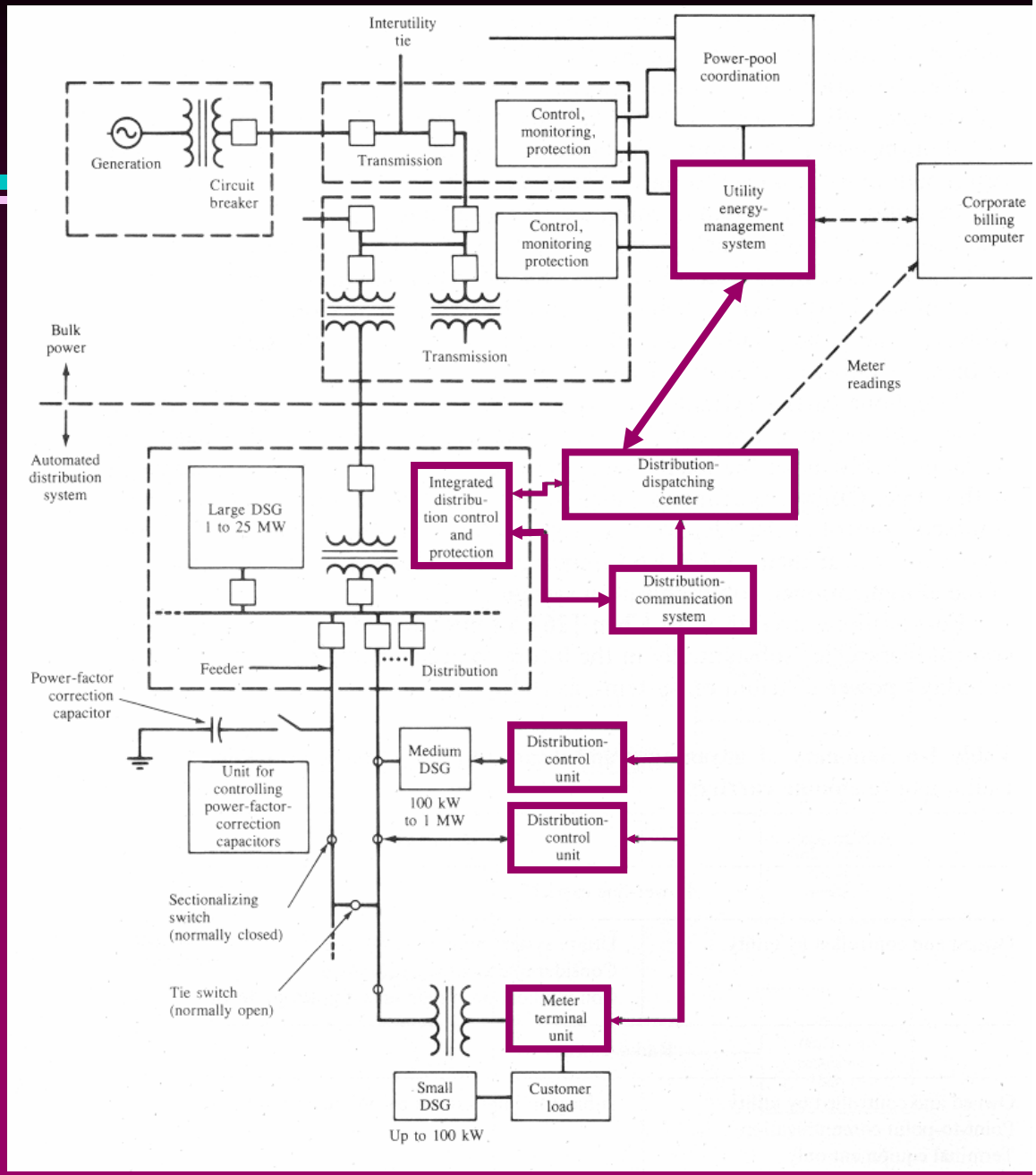
Recent Buzz words !!

- Outage Management
- Customer Information Management

Candidate Distribution Automation Functions

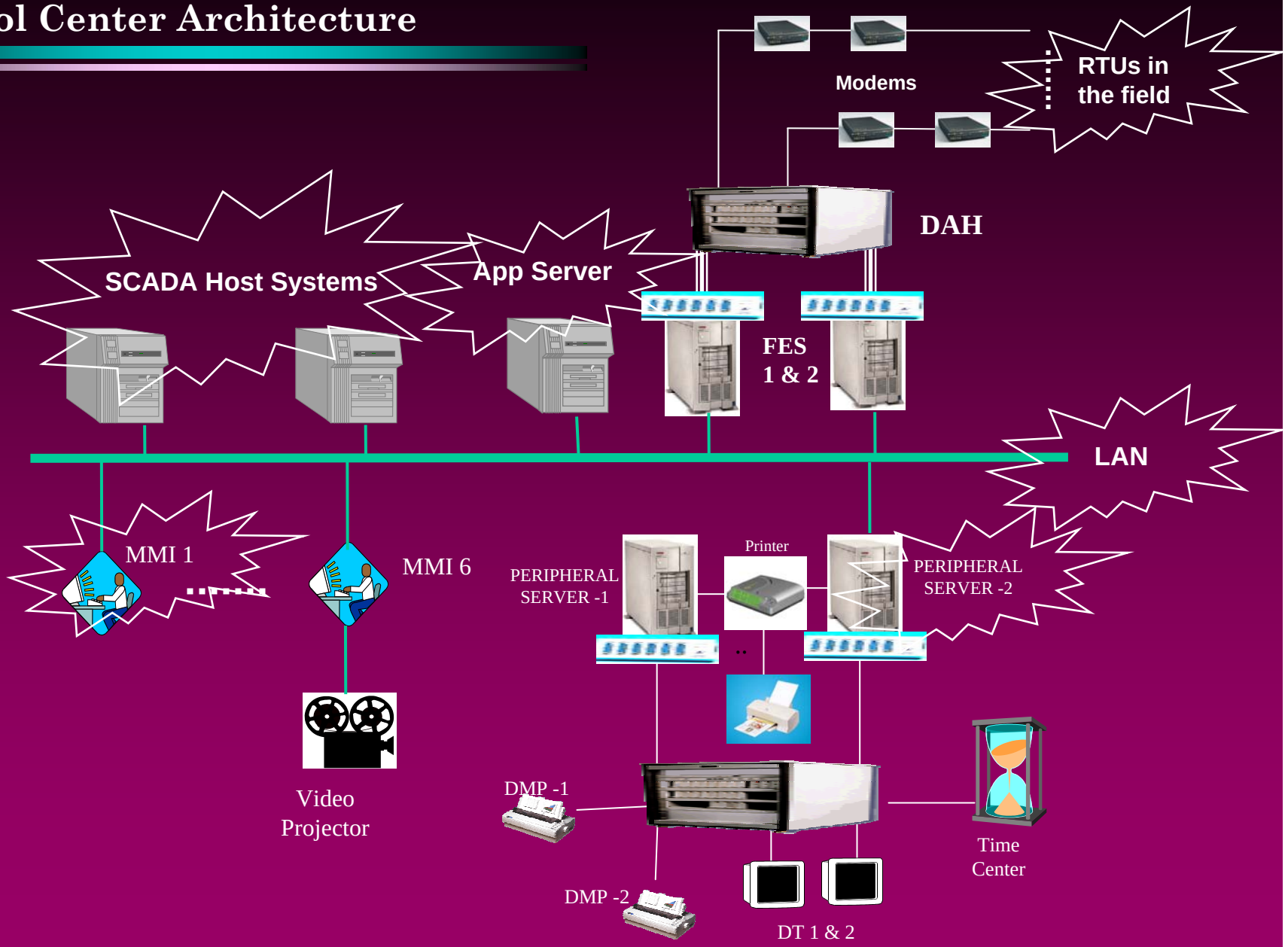
Substation Automation Functions	Feeder Automation Functions	Customer Interface Automation Functions
▪ **Data Acquisition From:** - Circuit Breakers - Load Tap Changers - Capacitor Banks - Transformers ▪ **Supervisory Control of:** - Circuit Breakers - Load Tap Changers - Capacitor banks ▪ **Fault Location** ▪ **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**	▪ **Automatic Meter Reading** ▪ **Remote Reprogramming of Time-of-Use (TOU) Meters** ▪ **Remote Service Connect/Disconnect** ▪ **Automated Customer Claims Analysis**

Control Hierarchy



(From: Turan Gonen, “Electric Power Distribution System Engineering”, McGraw-Hill Book Company)

Control Center Architecture



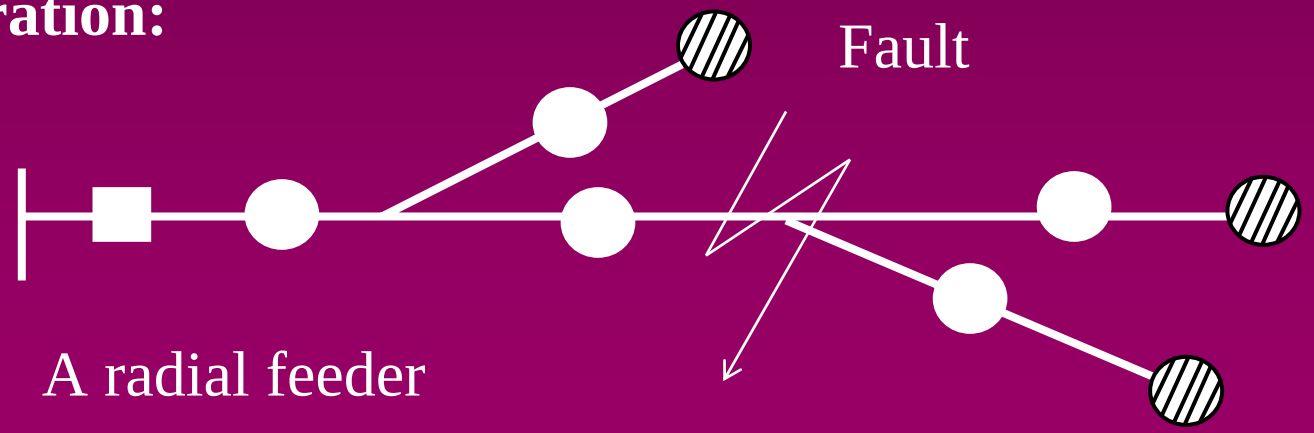
Application Functions

- Network Reconfiguration
  - a) Fault localization
  - b) Service Restoration
  - c) Load Balancing
- Integrated Volt-Var Control
- Remote Metering
- Automatic Load Shedding
- Load Management
- Automated Mapping and Facilities Management (AM/FM)
- Trouble Call Management System (TCMS)
- Load Survey and Energy Accounting

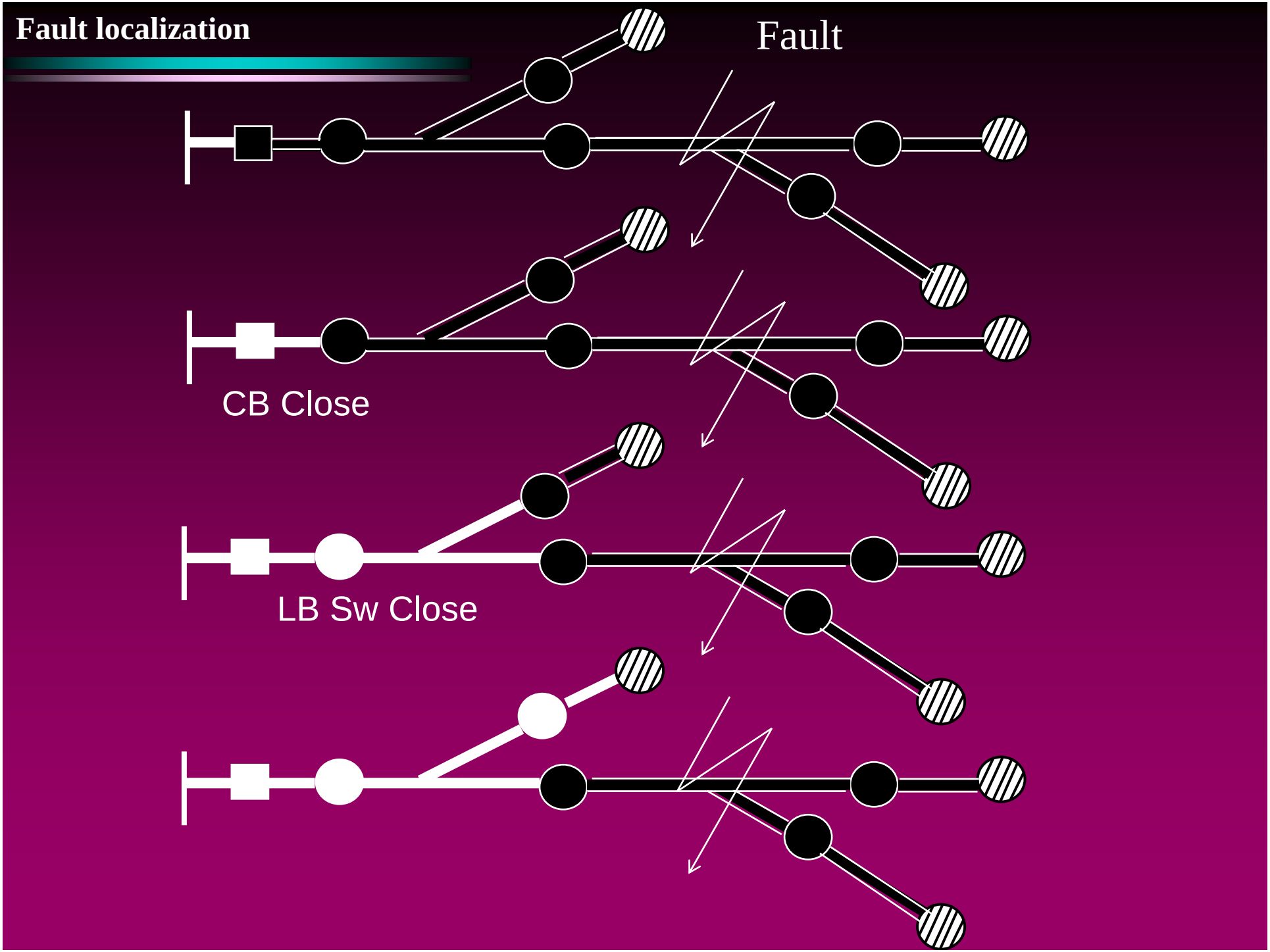
Network Reconfiguration - Fault Localization

- Locates faulty section in a radial distribution feeder by operating “Load Break Switches” on a feeder
- Localization is faster compared to manual determination of faulty section

Illustration:



Fault localization



Network Reconfiguration - Service Restoration

- Restores service to non-faulty feeder sections by reconfiguration

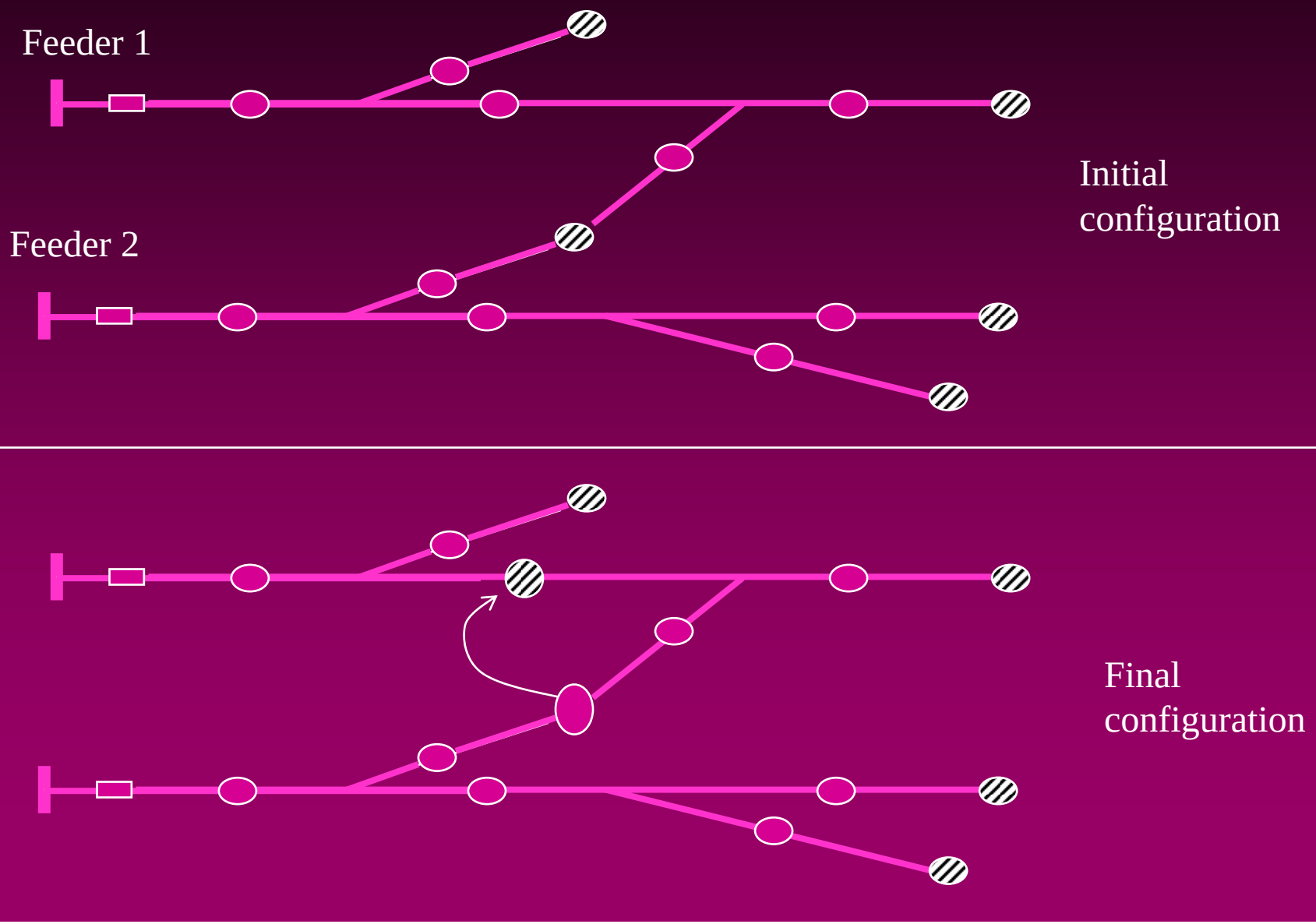
- Considerations

    * Presence of alternate paths
    * Operation of LB switches
    * Need to have remotely controllable switches
    * Restoration based on
        - satisfaction of current and voltage constraints
        - minimum switches
        - minimum losses

Network Reconfiguration - Load Balancing

- Composition and hence consumption patterns of loads on different feeders are different
- To distribute loads among transformers/feeders
- Remote control of switches for reconfiguration

Load Balancing - Illustration



Integrated Volt-Var Control

- Applied on feeders with capacitors and voltage regulators
- Control of capacitor banks and voltage regulators
- Schedule for switching and tap control
- To meet reactive power requirements and reduce losses

Remote Metering

- Uses of electro-static meters
- Customer meter reading
- Facilitates Multiple tariff
- Detection of Meter tampering
- More justifiable at HT (high value) Customers

Automatic Load Shedding

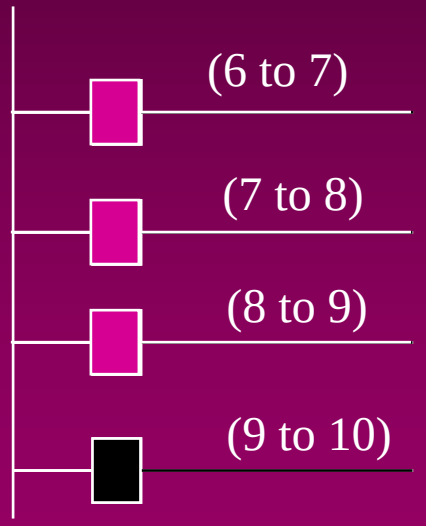
- Under Frequency based load shedding
- Sensing Frequency through transducers
- Load shedding based on the frequency drop, current loading conditions and priority of the load
- Closed loop function at RTU level

Load Management - Scheduled power cuts

- Gap between generation and demand
- Schedule power cuts on rotation
- Automatic load shedding based on schedules
- Facility to change the schedules

Illustration

Schedules for Power cut on Feeders



Load Management - Emergency based load shedding

- Gap between power generation and load demand due to sudden contingencies
- To shed the loads based on the relief required
- Identification of loads to be shed based on
  - current load magnitudes
  - priority of the load
  - time when last shed
- Shed the load based on the above factors

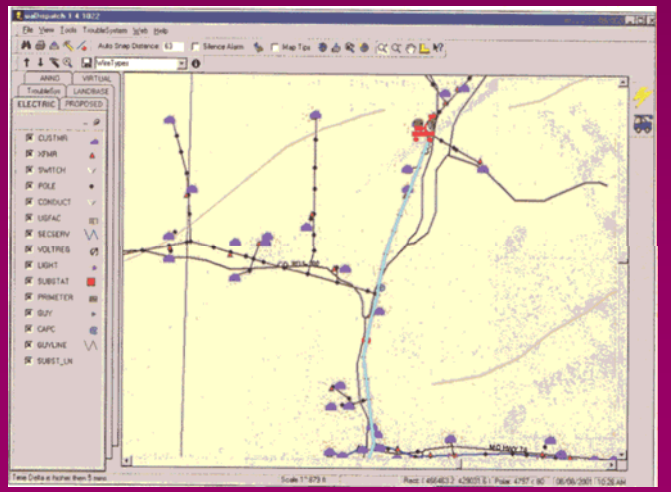
Load Management - Agricultural load control

- Importance of Agricultural load
- Separate schedule for Agricultural loads
- Ag. Loads categorized into groups
- Schedule for each group
- Shed the load based on the schedule
- Use of one-way radio switch
  - Accepts a command to shed
  - Restores automatically

Automated Mapping and Facilities Management (AM/FM)

- Display of geographical Maps
- Dynamic info on Maps
- Layering, Zooming, Scrolling and Panning
- Historical data on Devices

(From T&D World, Oct 2001)



(From T&D World, Oct 2001)

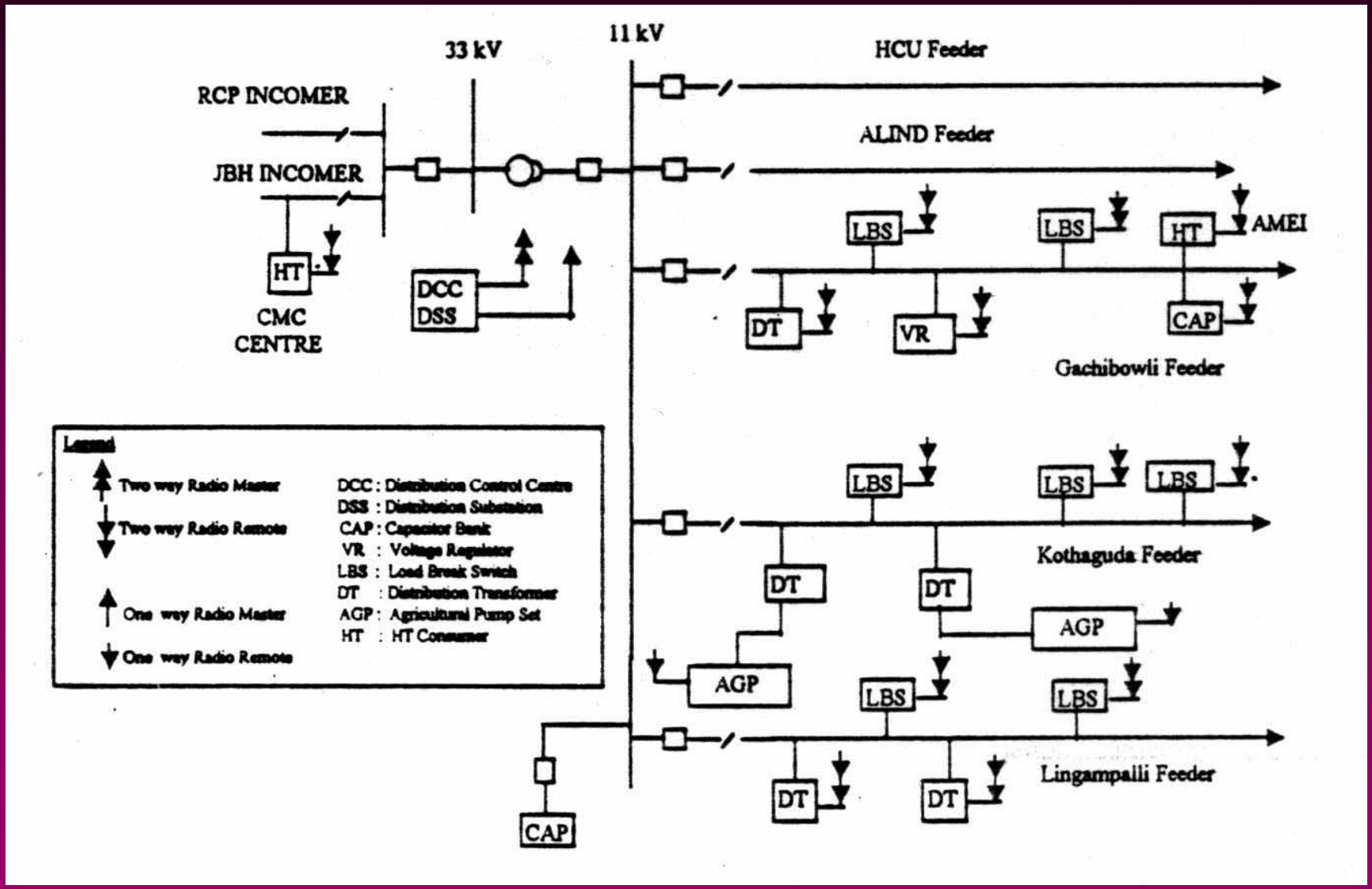
Trouble Call Management System (TCMS)

- Responds to customer complaints
- Acceptance of interruption/restoration data from the operator
- Distribution Transformer trip/close info from SCADA
- Determination of source of interruption
- Improvement of response time to customer complaints

Load Survey and Energy Accounting

- Availability of continuous data on loads etc.,
- Determination of Load Patterns
- Data for planning
- Detection of abnormal energy consumption pattern
- Identification of high loss areas

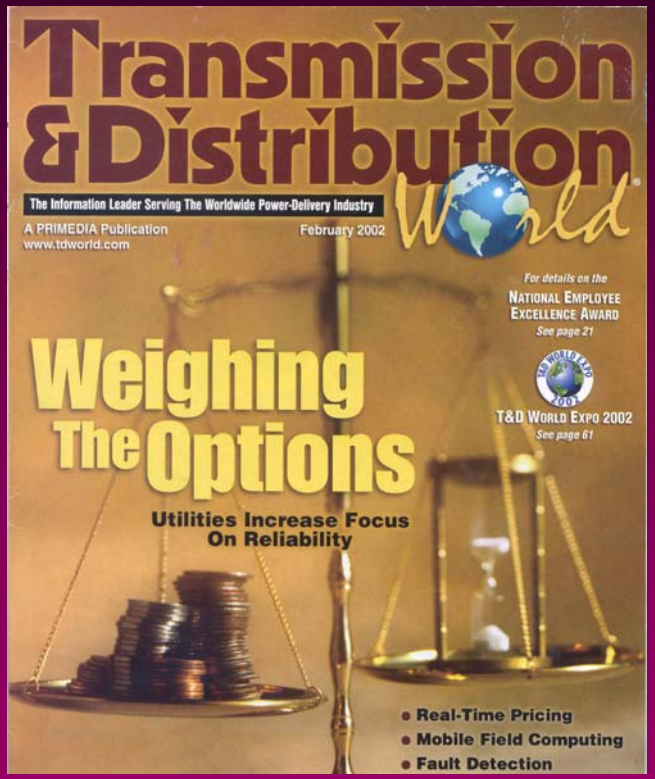
Overall Schematic Diagram of Gachibowli DA Project



Why Distribution Automation ?

Benefits

- Tangible
- In-tangible



Tangible Benefits

Substation Automation	Feeder Automation	Customer interface Automation
Reduction in Capital Expenditure due to: • Deferment of additional substation facilities • Effective utilization of substation facilities	**Reduction in Capital Expenditure due to:** • Deferment of additional feeders • Effective utilization of existing feeders	**Reduction in O&M Costs of:** • Regular Meter Reading • Reprogramming of Meters • Service Connect/Disconnect • Processing of Customer Claims
Reduction in O&M Costs of Breaker switching for: • Routine Operations • Non-Routine Operations	**Reduction in O&M Costs of:** • Fault Location and Isolation • Service Restoration • Routine Switching Operations • Recloser Setting • Recloser Testing • Data Collection • Data Analysis • Feeder Reconfiguration • Capacitor Banks Inspection	**Increased Revenue Due to:** • Reduction of System Peak Load • Tamper Detection to Reduce Electricity Theft • Reduced Payments for Customer Claims
Reduction in O&M Costs of LTC Operation for: • Routine LTC Operations • Non-Routine Operations		
Reduction in O&M Costs for: • Routine Relay Testing • Relay Setting		
Reduction in O&M Costs of: • Routine Data Collection • Non-Routine Data Collection • Data Analysis • Testing of Data Logging Devices • Repair of Data Logging Devices	**Increased Revenue Due to:** • Loss Reduction due to Feeder Reconfiguration • Loss Reduction due to Capacitor Banks Automation • Faster Service Restoration	

Summary of cost/benefit Analysis Results (done in 1991) based on tangible benefits

Function Category	Substation Automation	Feeder Automation	Customer interface Automation
Present Value of benefits ($)	177,393	423,260	2,913,258
Present Value of costs ($)	166,764	555,000	10,934,353
Benefit/Cost Ratio	1.06	0.76	0.27

Details of the area : 32,000 customers with electric and gas meters with a mix of 53 % residential, 8 % commercial 37% industrial and 2% agricultural.
Peak demand : 124 MW
Area served by three major substations (230/21 kV, 115/12 kV, 60/12 kV) with 13 primary feeders circuits (eleven 12kV and two 21kV) in the area

David L. Brown, et al., “Prospects For Distribution Automation at Pacific Gas & Electric Company”, IEEE Transactions on Power Delivery, Vol. 6, No. 4, October 1991, pp 1946-1954.

Intangible Benefits

Benefit Category	Substation Automation	Feeder Automation	Customer interface Automation
Improved Service Reliability	Applicable	Applicable	Not Applicable
Improved Customer Satisfaction	Applicable	Applicable	Applicable
Improved Public Safety	Applicable	Applicable	Not Applicable
Better Information for Engineering and Planning	Applicable	Applicable	Applicable
Strategic or Marketing Advantages	Applicable	Applicable	Applicable
Improved Public Image	Not Applicable	Not Applicable	Applicable

Summary

- What is Distribution Automation ?

  Monitor, Control, Decision support tools

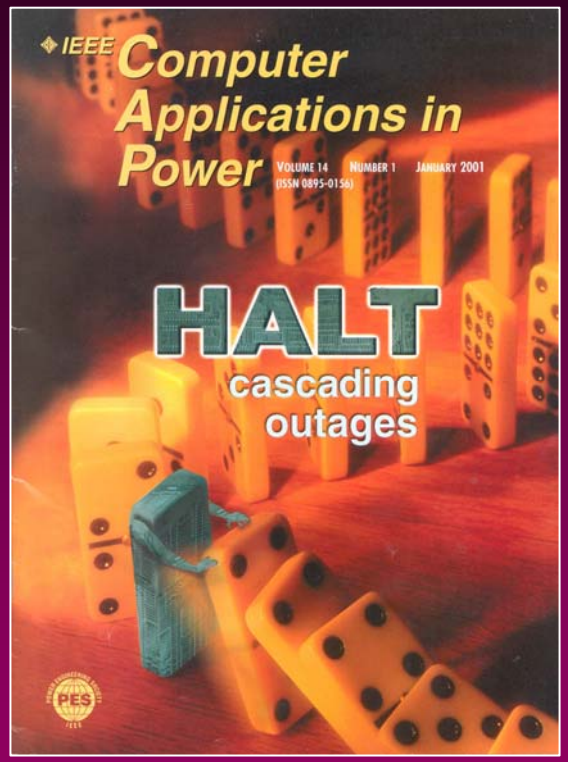
- How do you do Distribution Automation ?

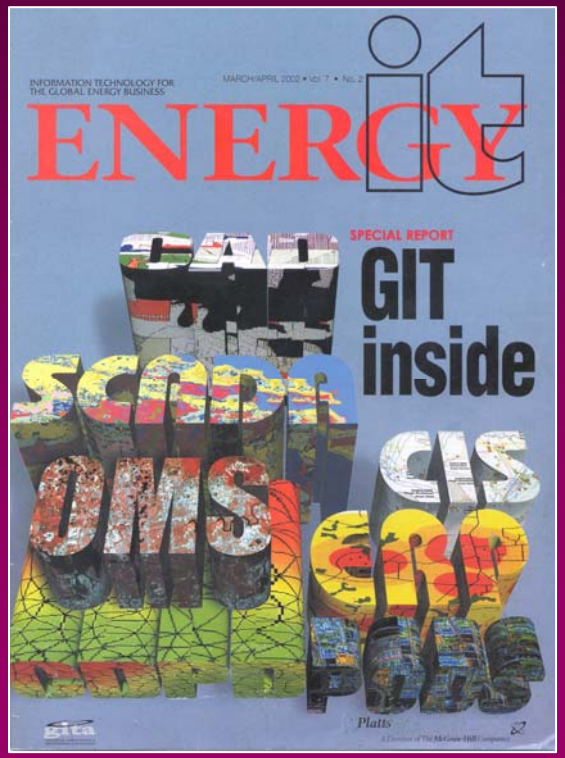
  SCADA and Application Functions

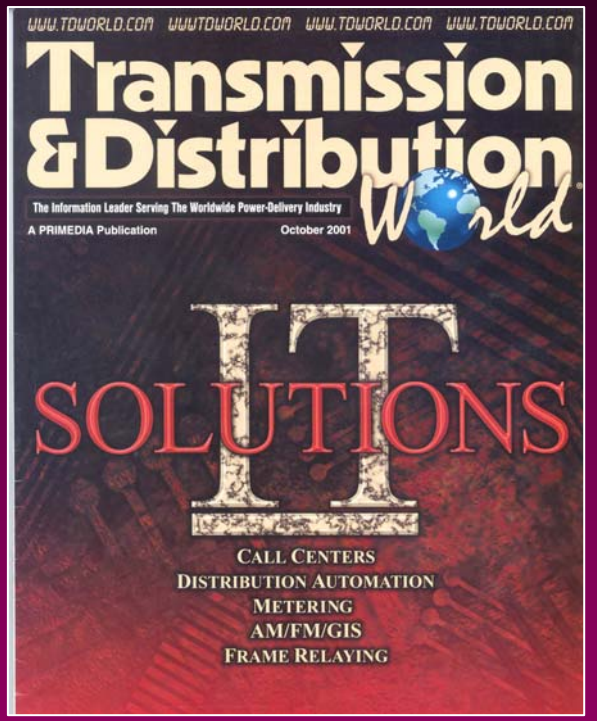
- Why Distribution Automation ?

  Tangible and Intangible benefits

Further Reading…….







References

1. Turan Gönen, “Electric Power Distribution System Engineering”, McGraw-Hill Book Company, 1986, Chapter 1, pp 1-36.

2. David L. Brown, James W. Skeen, Parkash Daryani, Farrokh A Rahimi, “Prospects For Distribution Automation at Pacific Gas & Electric Company”, IEEE Transactions on Power Delivery, Vol. 6, No. 4, October 1991, pp 1946-1954.

3. NDR Sarma, “ Rapid Growth Leads to System Automation Efforts”, Transmission and Distribution World, Sept, 1997.
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QUESTIONS

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Thank U !!

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