4. Smart Transmission System

Transmission system:
- PMU (Phasor measurement unit)
- EMS (Energy Management System)
- WAMS (Wide Area Monitoring System)

→ Transmission system is the bulk power delivery system of electric utilities. They carry millions of megawatt of energy each day.

→ There will be an increased focus on the transmission level of the smart grid. As transmission system become more complex and more interconnected as the power delivery system for more renewable energy sources.

→ There are several monitoring and control technologies that ensure efficient operation & reliability at the transmission level of the grid.

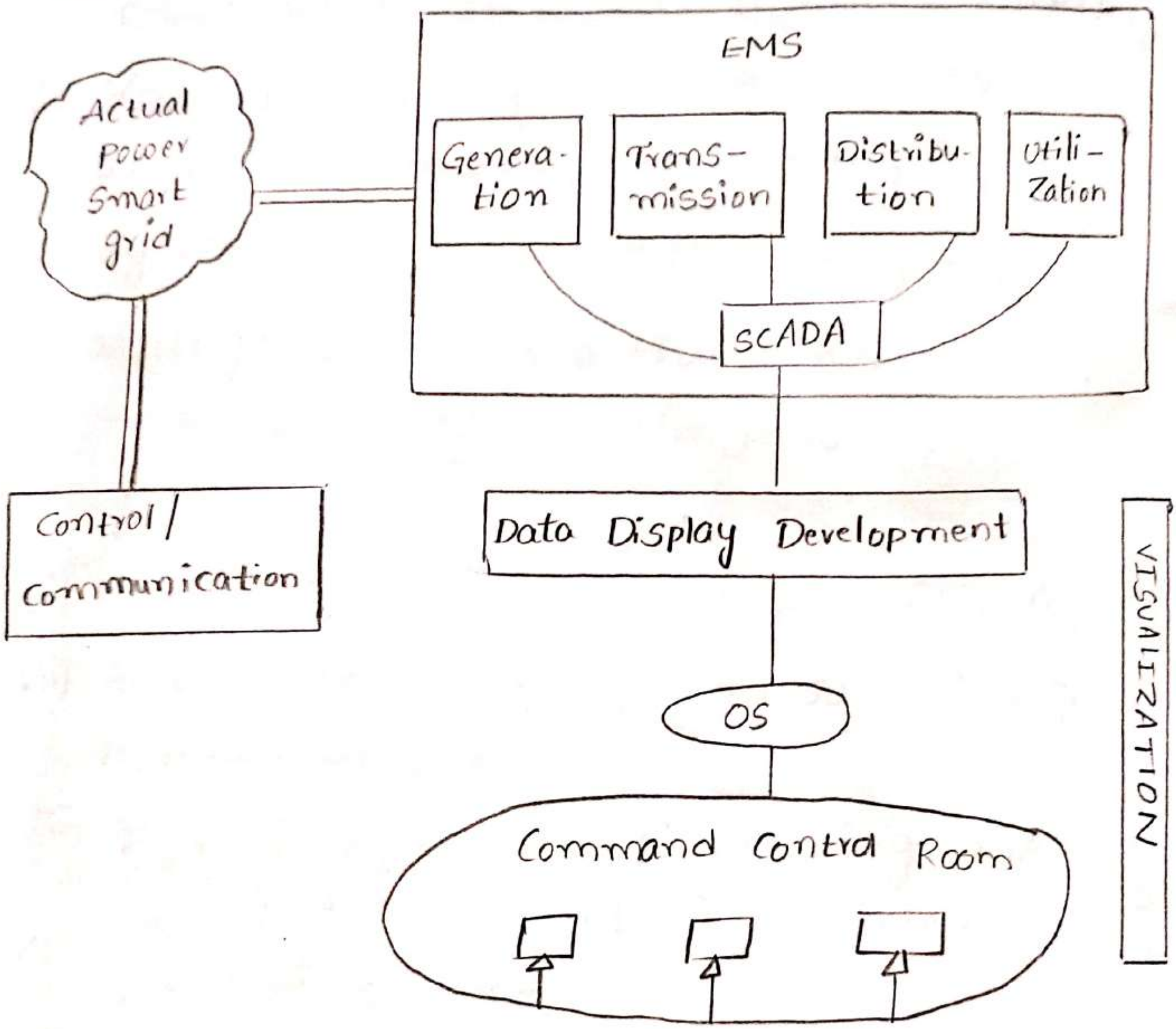
→ While some smart grid technologies for the transmission system may take pro-active action to automatically control the network.

⇐ Energy Management System

→ An EMS monitors and manage flows in the higher voltage transmission network.

→ A DMS (Distribution Management System) monitor and manage flows in the lower voltage distribution n/w (reduce the harmonics) in

Energy Management System



→ Control centre uses a s/w and h/w system called an energy management system. Based on Centralized Command and control paradigm, the EMS has evolved over the past six decades into much larger and more complex system through computer paradigm.

→ energy management systems consist of:

1. Real time monitoring of grid connections
2. Maintaining system frequency
3. Sharing electricity with neighbors
4. Modern Control Centers.

(1) Real time monitoring of grid connections:

→ The first EMS application placed in Control centers across the country was known as the Supervisory control and data aquisition (SCADA) system.

→ SCADA allows electric system operators to visually monitor grid connections from a center location and to take control & remedial actions remotely via the SCADA system if adverse Conditions are detected.

→ The initial SCADA systems were hardwired to analog systems.

(2) Maintaining system frequency

→ The next function implemented at control centers was Load Frequency Control (LFC).

→ The objective of LFC is automatically maintain system frequency as load changes by changing generation output accordingly.

→ In the early implementations of LFC, the control center operator visually monitored the system frequency measurement & periodically sent incremental change signals to generators via analog wired connections or by placing phone class to generate plant operators to keep generation output close to system load demand

3. Sharing electricity with neighbors

The next progression in system monitoring & Control was interconnecting one power utility with neighboring utilities to increase overall grid reliability by allowing power sharing during emergencies & to exchange cheaper power during normal operations.

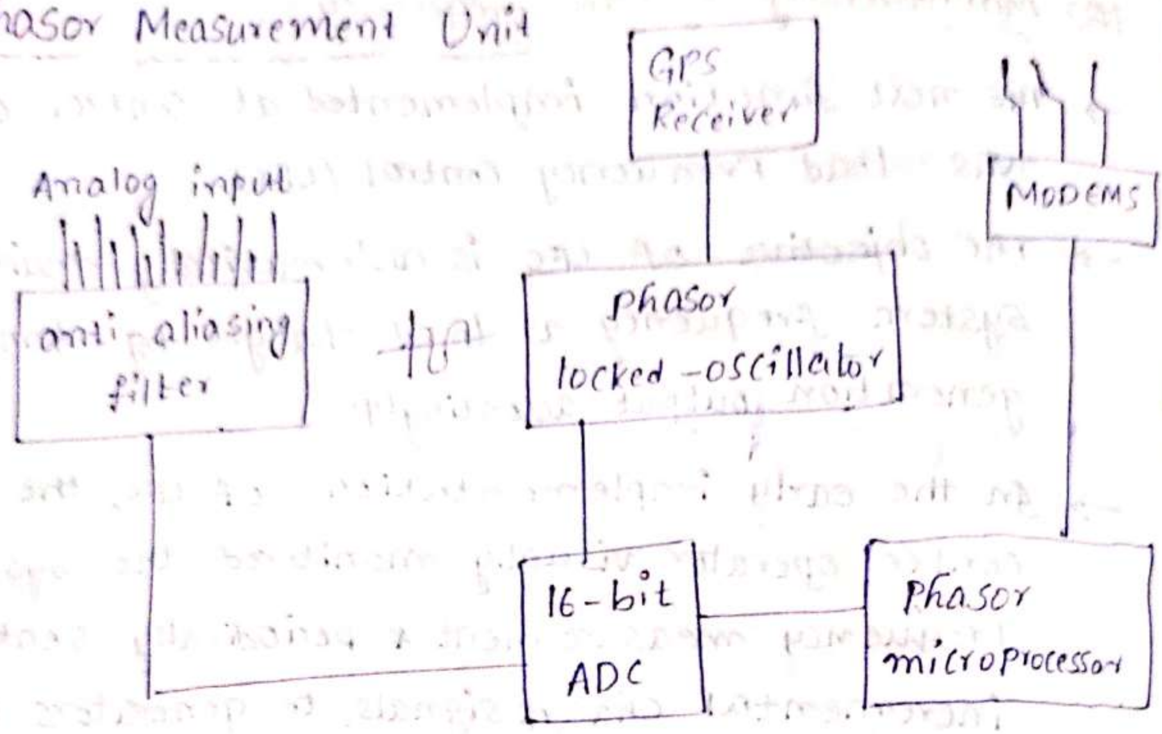
(4) Modern Control Centers

The Suite of real time & off-line functions that comprise a modern control Center.

ion

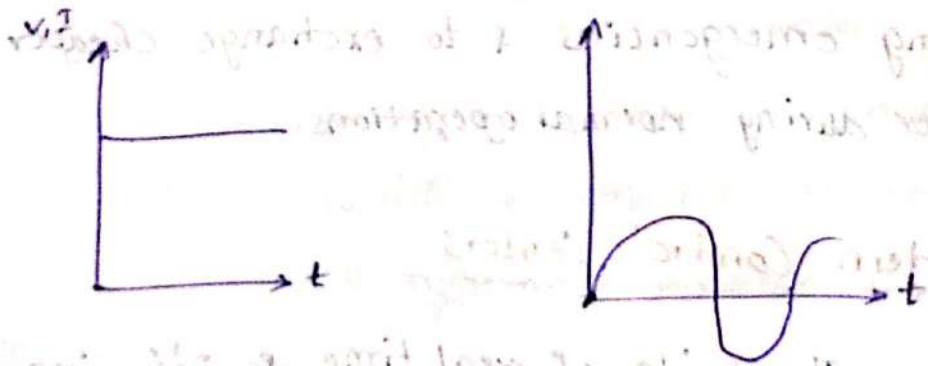
V.V.Imp

Phasor Measurement Unit



1) PMU (Phasor Measurement Unit) or electronic device that use digital signal processing components to measure AC wave form and convert them into phasor according to the system frequency.

2) The analog signal / sample is compiled & processed by a receiver, phasor algorithm to generate voltage and current.



(DC wave-form) (AC wave form)

IED:-

Intelligent electronic device describes a range of device that perform One Or more functions of

1) protection
2) measurement
3) fault recording and control

⇒ An IED Consists of a Signal processing unit, a microprocessor with input and output device and a communication interface.

① IED Configuration Consists of analog | digital input from power equipment and Sensors
② Analog to Digital convertor (or) Digital to Analog converter
③ DSP (Digital Signal processing)
④ Flex logic unit
⑤ Display
⑥ virtual input/output
⑦ Internal RAM/ROM.

Intelligent Electronic devic or microprocessor based device with the capability to exchange the date and contrcl the Signals with another devices. [IED, electronic device, controllers, SCADA, etc...] Over a communication link

IED performs protection, monitoring, controlling and Data Aquisition functions in generating Stations, Substations, analog feeders.

IED'S are widely used in Substation for different purpose. In Some cases, they are Separately used to achieve individual functions Such as:

→ differential protection
→ distance protection
→ Over Current protection and
→ monitoring.

IED receives measurements and status information from Substation equipment and pass it into the process bus of the SCADA.

IED are a key component of substation integration and automation technology, a substation integration involve protection and Controlling.

Main Components of PMU:-

(1) Analog Inputs
(2) Gps receiver.
(3) phase locked Oscillator
(4) A/D Converter
(5) Anti - aliasing filters
(6) phasor micro - processor
(7) Modem

(1) Analog Inputs:-

→ Current & potential transformers are employed at substation for measurement of voltage & current.

→ The analog inputs to the PMU are the voltages and currents obtained from the secondary winding of potential & current transformers.

(2) Anti-aliasing filters

→ Anti-aliasing feature/ filter is an analog low pass filter which is used to filter out those components from the actual signal whose frequencies are greater than or equal to half of Nyquist rate to get the sampled waveforms

→ Nyquist rate is equal to twice the highest frequency component of input analog signal.

→ If anti aliasing filters are not used, error will be introduced in the estimated phasor.

(3) A/D Converter

→ Quantization of the input involves in ADC that introduces a small amount of error.

→ The output of ADC is a sequence of digital values that convert a continuous time and amplitude analog signal to a discrete time and discrete amplitude signal.

→ It is therefore required to define the rate at which new digital values are sampled from the analog signal.

→ The rate of new values at which digital values are sampled is called the sampling rate of the converter.

4) Global positioning system

→ The synchronized time is given by GPS uses the high accuracy clock from satellite technology.

→ without GPS, py providing the synchronized time, it is hard to monitor whole grid al the same time.

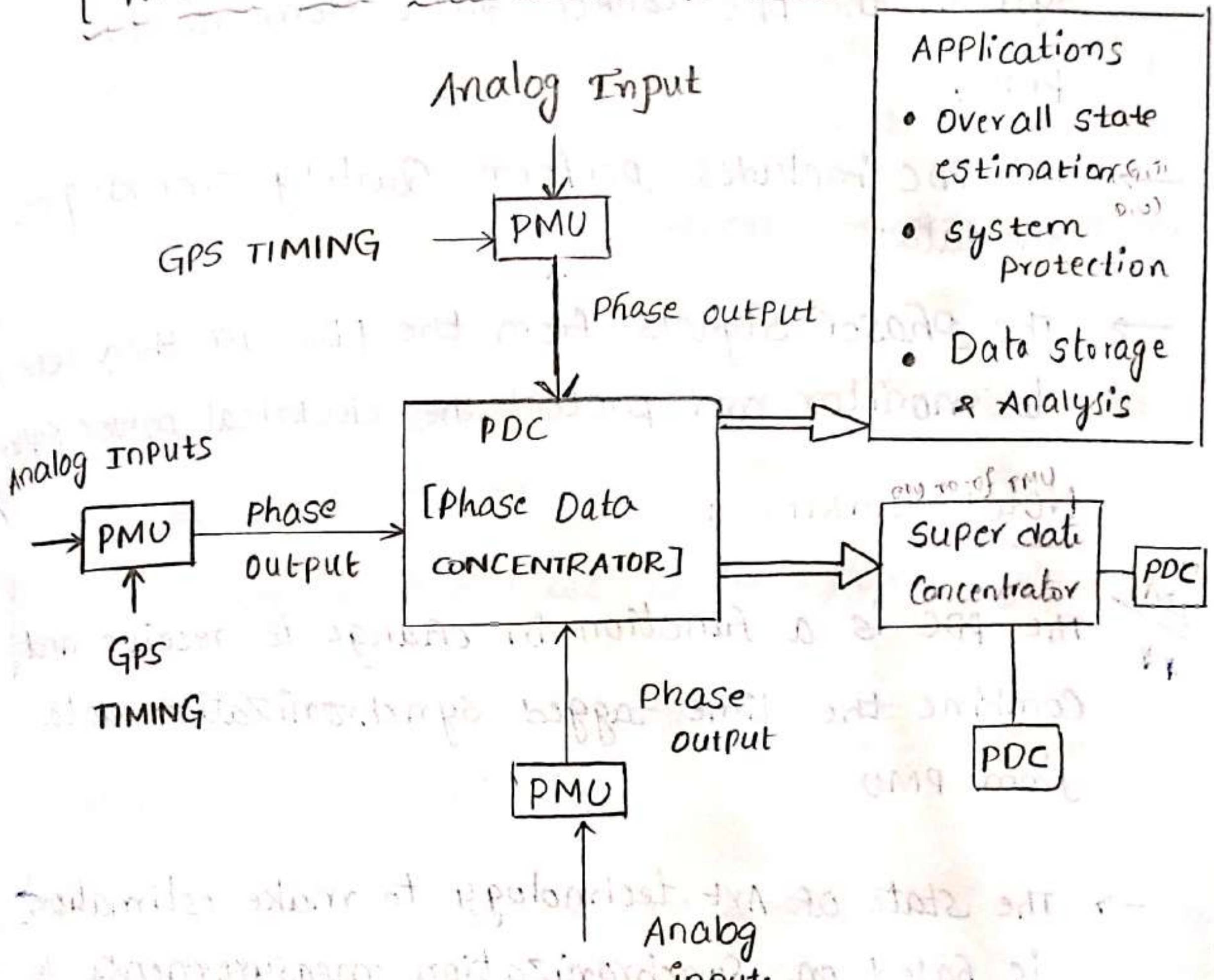
→ The GPS satellite provide a very accurate time synchronization signal available, via an an antenna input through out the power system. This means that the voltage & current recordings from different substations can be directly displayed on the same time axis and in the same phasor diagram.

Processor

→ The microprocessor calculates positive sequence estimates of all the current and voltage signals using the DFT techniques.

→ Certain other estimates of the interest are frequency & rate of change of frequency measured locally and these also are included in the output of the PMU.

WAMS
[Wide Area Monitoring System]/
[Wide Area Measurement System]



- Global positioning system [GPS]
- Phase Data Concentrator [PDC]
- Phasor Measurment Unit [PMU]

→ The WAMS, normally the PMU are installed at the substation across the power grid where it is relatively easy for installation & maintenance.

→ For wide Area, Measurement system, the PMU measures voltage & current phasors and send

them to PDC [Phase Data Concentrator]
where the time stamped data & Current are processed.

→ As the Core Component of the measurement system, the PDC collect data from no. of PMU,

→ The PDC includes perform Quality checking on the data.

→ The phasor Signals from the PDC are then used to monitor and protect the electrical power system

Note:

2M ** The PDC is a function in change to receive and Combine the time tagged synchronization data from PMU

→ The state of Art technology to make estimation, is based on Synchronization measurements to Solve a non-linear equation. [maintainig Stability of voltage, courrent, frequency].

→ The real time Synchro phasor data make the dynamic ~~sta~~ system state reasonable.

→ The measurement techniques for voltage and Current phasors was first proposed as a part of Symmetrical Components (V, I)

2M Benifits of WAMS

1) The operator are additionally provided with online information at the right time for improved power system Operation.

2) With real-time information on angular Separation b/w bus voltage & normal Voltage.

3) Early detection of Critical Condition in the grid.

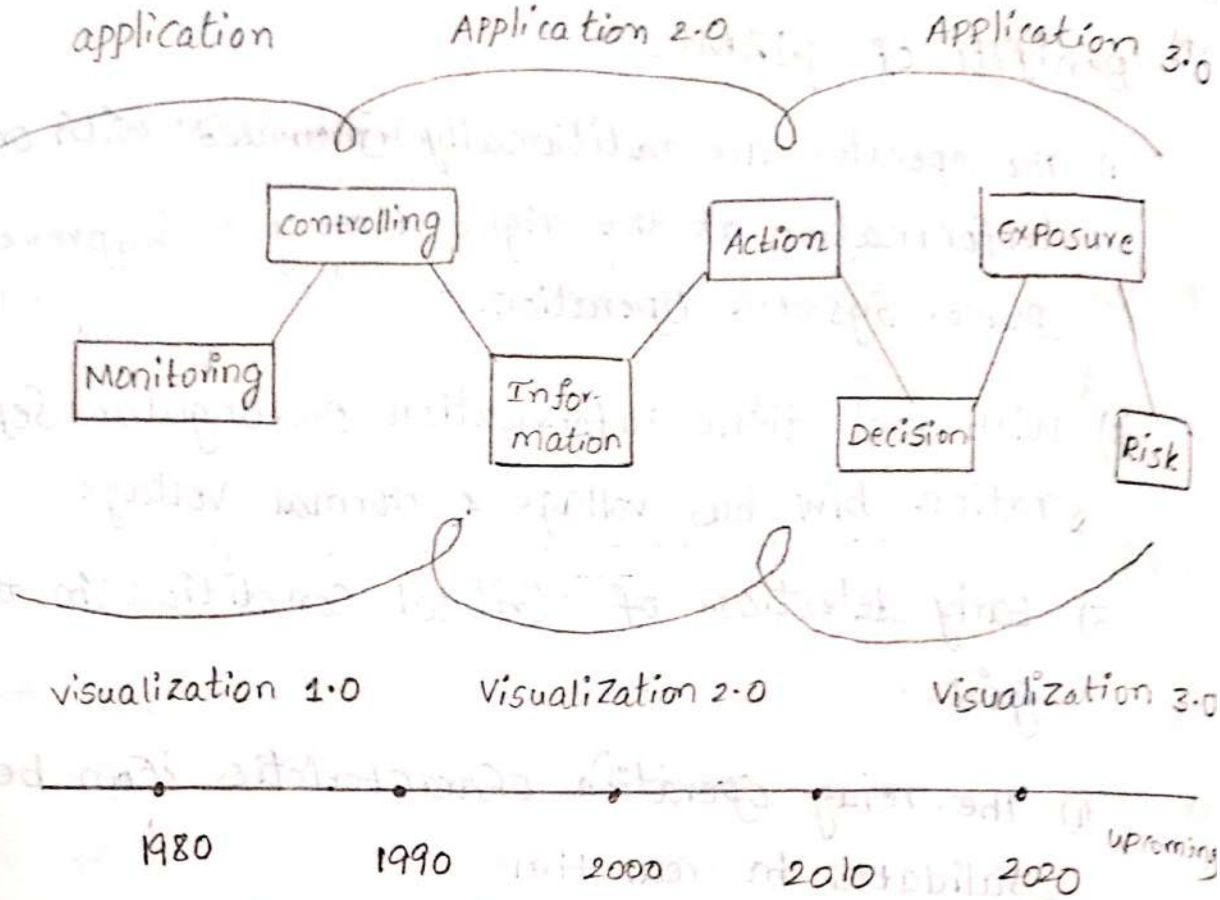
4) The relay operation characteristics Can be Validated in real time.

5) Improved knowledge of the power system Condition.

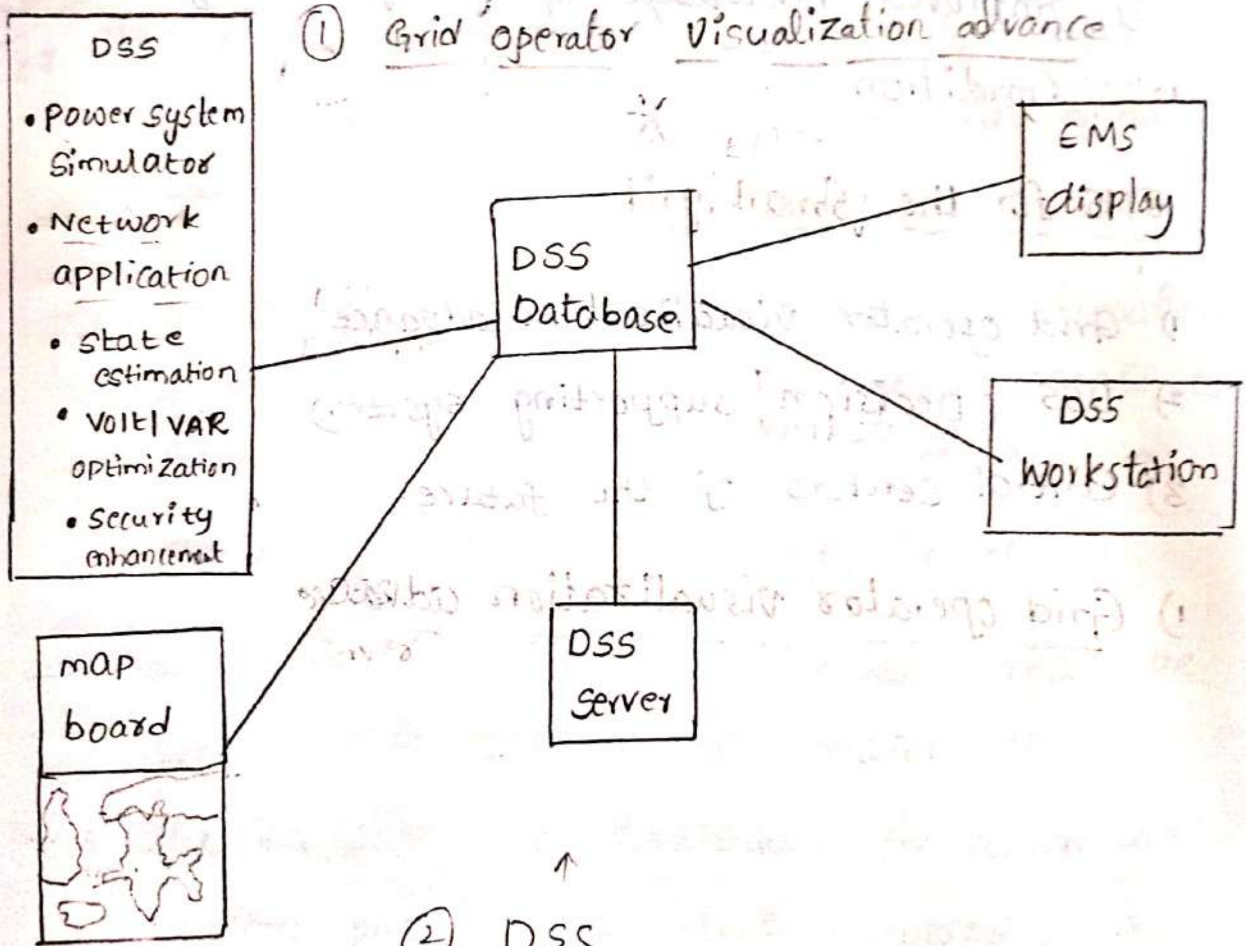
EMS for the Smart grid

1) Grid operator visualization advance
2) DSS (Decision supporting system)
3) Control centers of the future.

1) Grid operator visualization advance



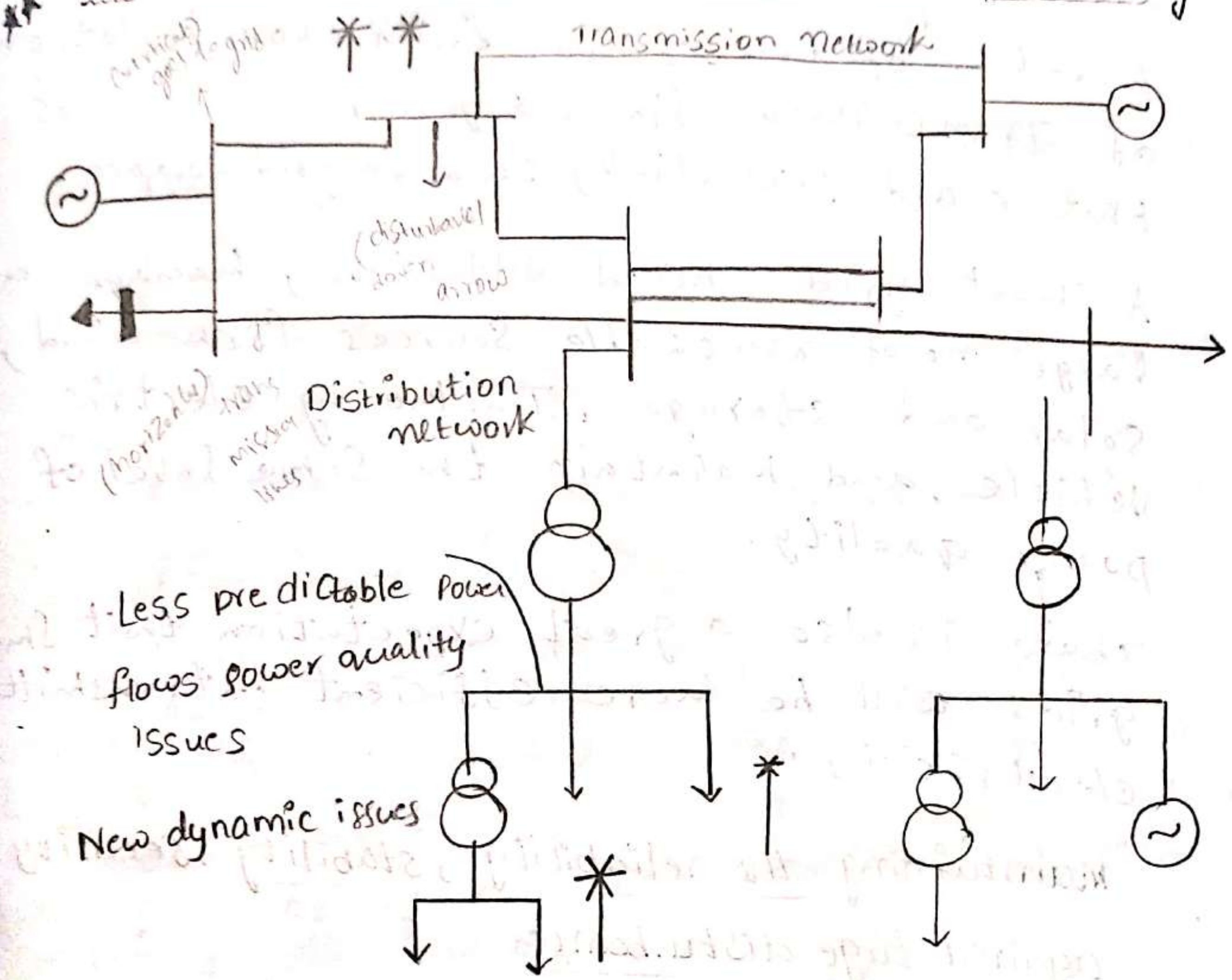
① Grid operator Visualization advance



② DSS

③ Control center of the future

** Wide Area Monitoring, Protection and Controlling (or) (WAMPAC) needs in smart grid



1) Maintaining the reliability, stability & security against large disturbance.

2) Management of large number of intermittent generation

3) Power quality

4) Increase in transmission efficiency.

A smart grid should be Self healing from power disturbance events.

Events of ten causes failure (or) isolation of Transmission lines & generation sources that could potentially lead to grid collapse.

A smart grid should effectively manage a large no. of renewable sources from wind, solar and storage. Including electric vehicle, and maintain the same level of power quality.

There is also a great expectation that smart grids will be more efficient in transmitting electricity.

Maintaining the reliability, stability, security against large disturbances

→ smart transmission grids should exhibit self healing capabilities from power disturbance events. They are expected to endure disturbance and outage with zero (or) minimal impact to the grid ability to supply and distribute power.

→ while grids have been designed to survive large events, the integration of renewable generation will probably push these designs to limits.

→ Renewable generation will be Integrated into both the bulk transmission level and in the distribution level.

→ power system events often cause failures (or) Isolation of transmission.

② Management of large number of intermittent generation:

→ smart grids will need to support a higher penetration of Intermittent generation and storage.

→ managing such large no.s and varieties of generation sources could exceed the processing limits of existing EMS(or) DMS.

→ large no. of Intermittent generator will result in highly transient power flows that can push the limit of transmission lines be their current carrying capabilities and cause transmissions grid congestion. This co-ordination will need to occur in much faster time frame than what can be realised.

In current grid management system.

Maintaining power quality:

→ A potential issued in smart grid is the degration of power quality as large no. of Intermittent generation and power electronics loads becomes Integrated into the transmission and distribution system

→ It will be challenging to maintain

nominal frequency and the quality of power with highly variable generation in the grid.

→ frequency and voltage quality issues could be resolved with Improved regulations from the grids active power source.

→ Improved frequency regulation could come from using energy storage.

→ A key requirement to addressing these power qualities issues is the ability to monitor, store and communicate data for processing and analysis in control. So that operator actions may be intiated.

Increasing Transmission efficiency:

→ smart grid, are expected to increase utilization of existing grid assets, such as lines and transform.

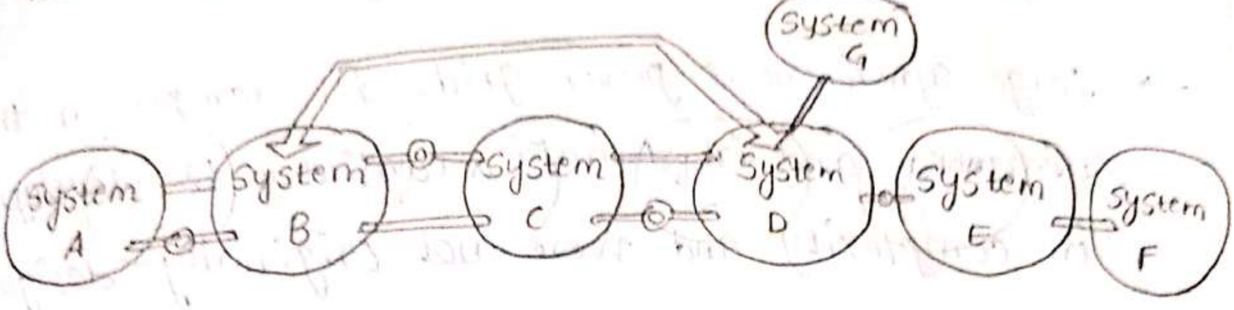
In this way, the grid can be more efficient.

In delivering power from the source to the loads.

One approach to incrase transmission utilization is to dispatch generators to maximize power flow through the grid requires sufficient system-wide Asurements to support system optimization applications.

→ The efficient utilization of grid assets is also limited by the requirement for operating margins to account for potential grid instability

Role of Transmission system in a Smart grid :



Step 3	HVDC – long distance DC transmission
Step 2	HVDC B2B – via AC lines
Step 1	High voltage AC transmission & Facts

DC is a stability booster & firewall against Black out.

" Counter measures" against large blackouts.

fig: "Hybrid System interconnections – Super Grid" with HVDC and FACTS.

→ Renewable energy generation is a key topic of today's power systems in all countries. Drives by the need to reduce CO_2 emissions to stop or atleast reduce the global warming effect, new "CO_2 – free" technologies are investigated to fulfill the energy requirements of the future.

→ Based on the kyoto protocol and its subsequent Conferences, most Countries have committed to specific CO_2 reduction and renewable energy targets within the next 10-20 years.

→ Large synchronous power grids for example in the America and in Europe, continue to develop in complexity and were not originally designed to serve the purpose they are expected to carry out. Now a days and this progression will continue into future.

→ Originally the conventional power plants which are very easy to control were mostly built in the vicinity of cities and local centers and the grid around them was designed to provide the required capacity.

→ The power demand was growing over the years and the ever-increasing amount of power capacity had to be brought from the adjacent grids over large distances.

→ In addition to this, in the course of deregulation and privatization a great number of power plants had to change their location, in the mean-time plenty of volatile wind power has been installed in many countries, causing parts of the grid which may already be overloaded to become even more overloaded

→ The deteriorates voltage quality; the Corresponding grid code can no longer be adhered to, and the adjacent loads as well as the grid itself are affected determinally. Moreover, in the event of grid faults, large power Outages referred to as voltage Collapse can easily Occur due to Cascading tripping of wind or Solar generators at low voltage level.

→ Due to this, in a large number of countries, the grid Codes have been significantly tightened in-order to fix the voltage within the exact time-dependent ranges of tolerance and to protect the grid.

→ The Security of power Supply in-terms of reliability and blackout prevention has the utmost priority when planning and extending power grids.

→ The availability of electric powder is the Crucial prerequisite for the Survivability of a modern Society and power grids are virtually lifelines

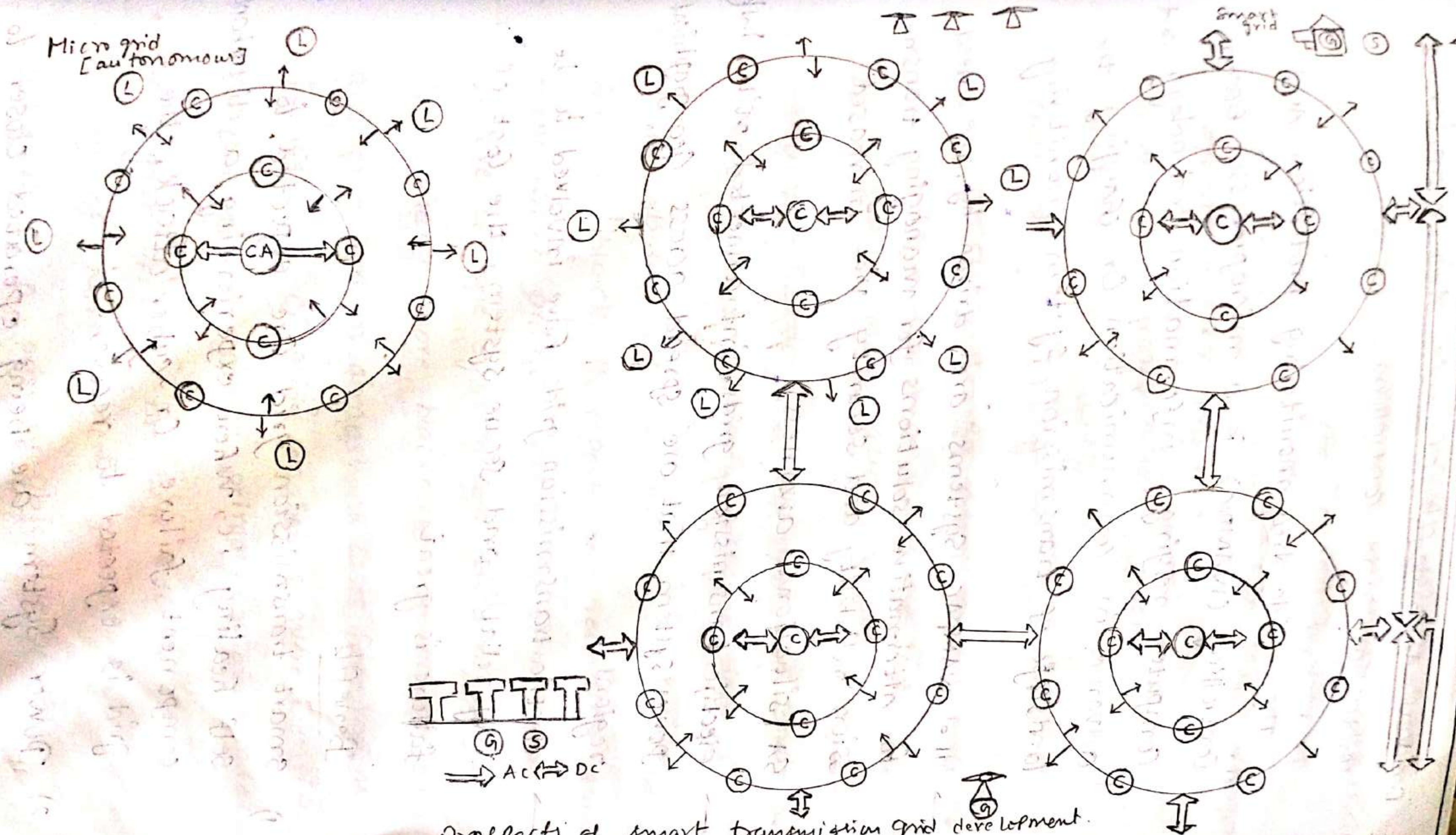
→ DC Current transmission constitutes the best Solution when it comes to loss reduction for transmitting power over long distances. The HVDC technology also helps Control the load flow in an optimal way.

→ HVDC technology allows for grid access of generation facilities on the basis of availability dependent regenerative energy sources, including large on-and off shore wind forms and compared with conventional AC transmission, it suffers a significantaly lower level of transmission losses on the way to the loads.

→ Based on these evaluations, the above figure shows the stepwise interconnection of a number of grids by using AC lines, DC B2B systems, DC long-distance transmissions, and FACTS for strengthening the AC lines.

→ These integrated hybrid AC/DC systems provide significant advantages in terms of technology economics as well as system security. They reduce transmission costs and help bypass heavily loaded AC systems.

→ This approach is an important step in the direction of environmental sustainability of power supply. Transmission technologies with HVDC and FACTS can effectively help reduce transmission losses and CO_2 emissions.



Prospects of smart transmission grid development.

* Drivers & benefits of wide Area monitoring, Protection and controlling

The wide Area monitoring protection And Controlling (WAMPAC) is a microprocessor based computer relying, information technology and advance in communication Or changing the landscape of transmission system monitoring.

→ The WAMPAC Systems are driven by the need for alternative solutions for managing transmission reliability and security via increased

· SA (situational awarness)

→ electric transmission grids interconnected with bulk power system that are spread across Geo graphical regions

→ electric transmission grids have involved to be very reliable and secure system, the Cost of failure is great.

Benefits:

1) smart transmission grid Are expected to self healing i.e., when experiencing a disturbance component failure Or cyber attack, the grid is expected to recover.

2) Power System are being operated closer to

their thermal, and stability limits

3) Transmission operators need to increase their situational awarness of the grid.

4) EMS and SCADA system need more advanced WAMPAC applications

5) New and unconventional generating Sources from renewable energy introduce operational challenge.

Continuation for "EMS for Smart grid"

1) Grid operator visualization advance

- Timely visualization of Real time grid condition, is essential for Successful grid operation.
- In 1965, Blackout of US and canada, the finding from the blackout report and recording equipment which provides operators with clear picture of the system conditions as possible. Since, many more blackouts have occured, small and large an in almost all cases improvements in visibility of grid conditions were identified as one of the power primary recommendations.
- On August 14, 2003 the large blackout in the history of North America power grid occured. Subsequently a primary objective of this team

was to perform more importantly to make the recommendations on what could be done to prevent future of such events.

- The report identified for root causes:

  understanding, situational awarness, reliability and support

(2) Decision Supporting System.

- Most Control Center Operator decisions today are essential reactive, Correct information as well as Some recent history.

- The industry trend next possess predictive decision making in future decision will be proactive.

- This type of decision making actions are: the foundation of decision support system.

- The DSS will use more accurate forecast information and more advanced analytical to be able to confidently predict Conditions

- The components of DSS:

  * Geographical views of grid
  * Dynamic Dashboard generated on demand
  * Advance past ~~electrte~~ alert system
  * Look ahead analysis to predict system analysis

3) Control Center of future:

- Automation of the grid will evolve towards more decentralized, intelligent and localized control. This is the vision of smart grid at the transmission level.

- Evolution toward a "smarter" transmission system grid is imminent and will take many forms of predictive and corrective actions: from avoiding system congestion while maximizing efficiency and minimizing supply costs to reacting quickly to system faults while maintaining power to as many customers as possible.

- These are goals not only at the transmission level but also at the distribution level of the electric grid.

- The future will likely see some more generation resources closer to the load centers. Residential sub divisions could have their own local fuel cells supporting power to 20 or 30 households, this will result in the creation of local micro grids that will attempt to optimize benefits for that local area.

- This would reduce dependence on the transmission grid to transfer power from remote locations to populated load centers.

- As renewable energy costs become more competitive, there will be growth in generation sources such as wind power, solar cells and possibly geothermal and tidal and ocean power. Customers will be able to monitor the current price of electricity and decide to turn on the dishwasher or not using a "smart metering" scheme.

→ This will flatten the utility's load demand profile and make generation dispatch more predictable

1) Define transmission system and explain it briefly EMS, DMS, WA, PMU

2) Define PMU and explain the block diagram of PMU

3) Write a short notes on EMS and benefits of EMS

4) Explain the block diagram of wide Area monitoring system.

5) explain the role of Transmission system in smart grid.

6) write a short notes on drivers and benefits of wide Area monitoring.