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Future Power Systems

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Introduction

- Traditional power systems
  - » Centralized large-scale interconnected systems
  - » Fossil fuels are the primary sources
- Challenges
  - » Power industry restructuring
  - » Energy crisis (depletion of fossil fuels)
  - » CO_2 and SO_2 emissions

Introduction

- Global warming has raised the issues of reducing greenhouse gas and pollutant emissions, of which fossil fuel power plant is a major source.
- Renewable, nuclear and hydrogen will be the future energy sources.
- Power industry is responsible for renovating the structure of power generation, and providing a clean, safe and reliable electric energy supply.

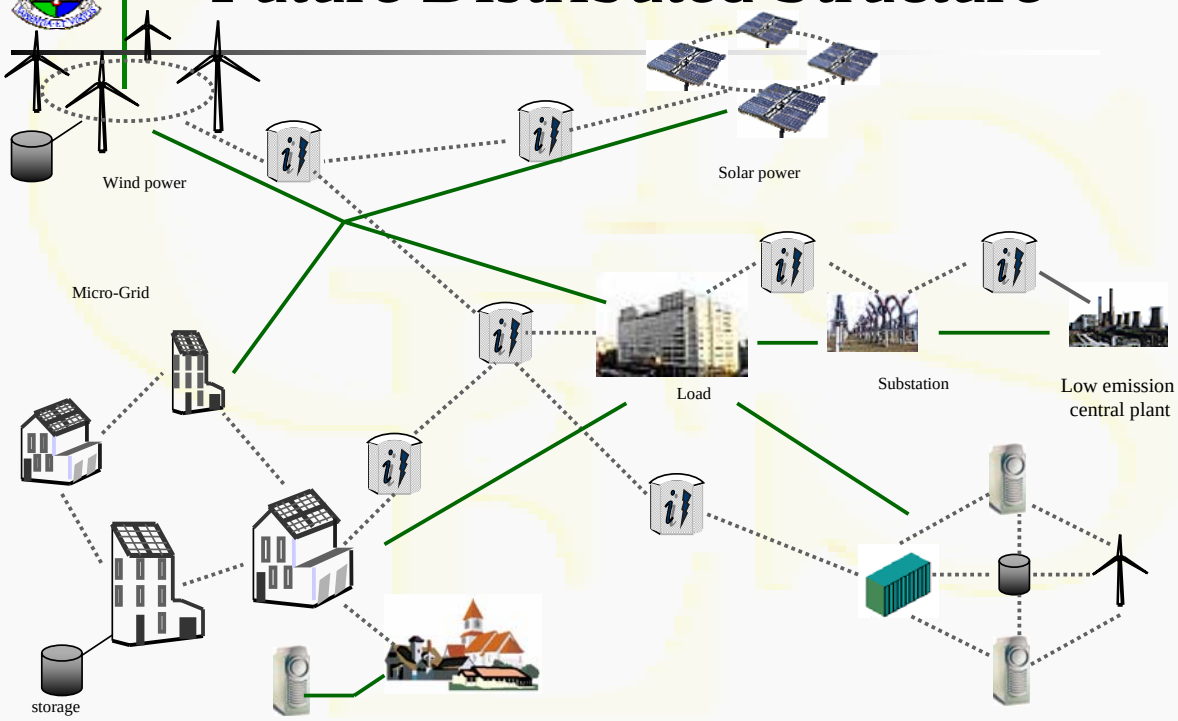
Introduction

- Development of DG and DRE technologies.
  - » It is possible to apply small scale distributed clean energy sources in the future power systems.
  - » Future power systems combine central power plants and DG, DRE. → micro grid.
- Development of information technology and power electronic technology
  - » It is possible to control the power flow intelligently.
  - » Smart power grid, standard modular, “plug and play”.

Future Power Systems

- Generation: a combination of traditionally centralized generation with the DG and renewable generation.
- Power grid:
  - » renovation of the current distribution system to accommodate DGs.
  - » Integrating micro grids with the existing power grid.
- Customer will no longer be the passive load. A customer can own a microgrid.

Future Distributed Structure



Intelligence in Future Power Systems

- The most significant change for the future power system is that it will be an intelligent system.
  - » Intelligent in various aspects: data acquisition and processing, assets and demand-side management, system operation and control, etc.
  - » It will integrate the renewable and DG with smart system architectures.
- Supporting technologies include ICT, sensor, electricity storage, power electronics, visualization, etc.

Information and Communication (ICT) infrastructure

- Future power system have a high requirement of monitoring and control.
- The new ICT infrastructure
  - » All-optical network: long distance DWDM transmission coupled with intelligent optical switching
  - » Wireless communication
  - » Quality of service (QoS) based packet network.

Sensors

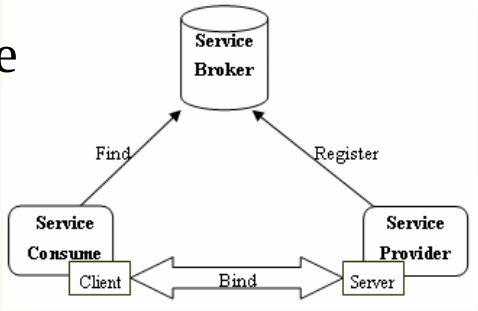
- Traditionally, RTUs are equipped for collecting real-time data.
- Recent technologies of sensor nodes consist of sensing, data processing and communication components.
- A sensor network is composed of a large number of sensor nodes with the support of a high-speed communication network.

Future Distributed Control System

- Future distributed control system will be flexible, modular and “plug and play”.
- Standards for data formats, interfaces, transport protocols are required to support “plug and play” for both software and hardware.
- Multi-agent technology for intelligent control.

Enabling technologies

- Grid service: a combination of Web services and Grid computing technologies.
  - » It uses open standard data formats and transport protocols, offers access to resources from different locations.
- Service-oriented architecture (SOA)
  - » Three roles: service provider, service consumer and service broker.



Enabling Technologies (cont.)

- Grid computing provides seamless access to the distributed resources, applications and data, and also provides security interaction among them
- Grid service is a evolution of grid computing adopting a standard SOA.
- Grid service technology provides an open, flexible and scalable solution for future power system management and control on large number of dispersed sensors and distributed generators.

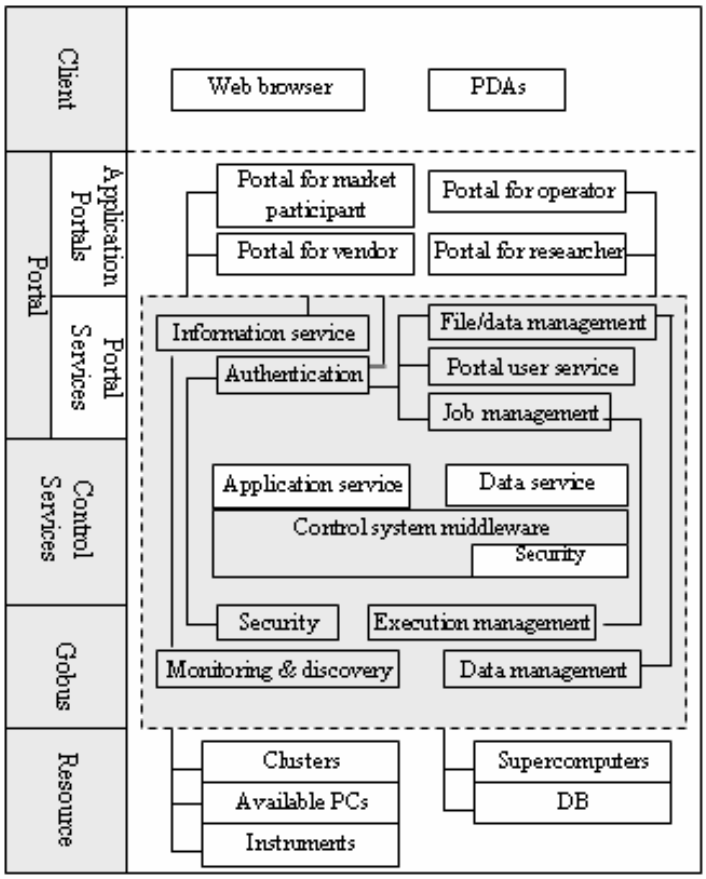
Grid service based power control system

- The future power systems will have more applications in both system operation and business operation.
- In a Grid service environment, everything is service. For example,
  - Data service is provided throughout the power system
  - Data acquisition service collect, timestamp and normalize the data.
  - Data processing service process data from various sources.
  - Applications will call data services.
  - Various functions of power system control are carried out as application services.

Grid service based power system control

- The designer of power system control system develops data and application services, and no longer consider the details of implementation.
- Power companies focus on information consumption and software vendors focus on software manufacturing, maintenance and upgrading.
- ICT professionals will take care of computer and communication infrastructures.

- Multi-layered architecture of control system design



Multi-layered architecture of control system design

- Client layer: clients can access the system by PC or PDA
- Portal layer: identify client and provide private portals
- Control center layer: data proceeding, requirement response, monitor and control equipment management
  - » Application service and data service
- Gobus Layer: transmit data from the resource layer to the control center layer and transmit commands from the control center layer to the resource layer
- Resource Layer: monitor equipment, control equipment, data storages, communication backbone.

Conclusions

- Energy deficiency, environmental issues, deregulation, etc. and technology development are shaping the future power systems.
- Large centralized structure → future distributed structure.
- Grid service technology provides an solution for power industry to develop the distributed control system for the future power systems.