DESIGN OF APPLICATION COMMON MODEL FOR NETWORK ANALYSIS IN SMART DISTRIBUTION MANAGEMENT SYSTEM

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ABSTRACT

This paper presents the design of real-time data-base for Smart Distribution Management System(SDMS). The design of real time database is important for stable operation of the management system which conduct the analysis of large scale power system, because the efficiency of system resource and stable operation should be considered. In SDMS, there are some applications for monitoring and operating the power distribution system, and these applications should be continuously and stably conducted. For this reason, the real time database is designed for considering the performance.

INTRODUCTION

Recently, the intelligence of management system is very interest study part due to efficient operation of power distribution system on the consideration of a connection with the distributed generation. For this reason, the Smart Distribution Management System(SDMS) has to smoothly perform a function, such a monitoring, operating and controlling the power distribution system, by periodically supplying the results of variable application programs for analysis of the system to the system operator. Therefore, the rapid computing speed and the reliable result of the application programs are essential. For those terms, the data modelling and the design of database on the system topology is very important. However, the typical file based computation and the way interconnected with relational database is unable to meet the requirement for the rapid computing speed and the stable performance.

This paper presents the design of real time database using the linking structure, commonly used on the analysis of large scale system. For considering a continuous analysis of the application and the efficient allocation of DB resources, the database presented in this paper, called 'Application Common Model(ACM)', is designed.

The ACM is designed to extract common model depending on the computing characteristic on each application, and the most of the common models are designed according to equipment model and topological structure. The ACM Model is separated out as the hierarchical and the non-hierarchical structure, and those structures are directly or indirectly associated with each other. Also, to consider the introduction of new equipment and the change of topology on power distribution system, the ACM is designed for general-purposes.

APPLICATION COMMONMODEL

The ACM is designed to extract the I/O data on the computing requirement of the application and the characteristic of the system equipment as following Fig.1. As the Fig.1, the ACM is comprised of three models. The network common model is designed with the static data for system topology and equipment, and the dynamic data is for the output data on the applications and the measurement data. The application information data is for the adjusted data by the user or the specific data using at the individual application.

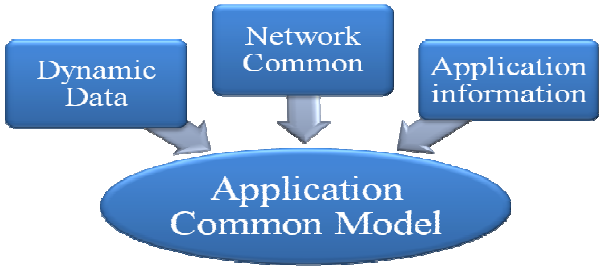

Fig1. Conceptual Structure of ACM Concept

ACM is classified according to the hierarchical and non-hierarchical model, and those models are designed to consider the factor for expression of the application result. For the set of relation between each tables, the linked list model is used. The relation of each data table in ACM is set to use the following three links.

1) The identifier on the each data records : Generally, the continuous integer is used.
2) The value of record : name(table, field), name of upper layer, specific value(such a impedance, thermal limits, rated voltage and so on)
3) The link with other tables(or other records) : There are three indices, such a Head Index(HI), Sibling Index(SI), Indirect Index. The HI and SI are the pointers which respectively indicate the first record in the liked table and the next record associated with HI. The II is also a pointer which indicate the one-on-one link.

The Fig.2 shows the example of the liked data structure on ACM. If the injection power by the connected generator in any bus is calculated, the injection power(active and reactive power) can be calculated using the HI and SI.

As the Fig.2, the HI of Bus_1 indicates the first generator, and the SI of the first generator for Bus_1 indicates the next layer(2). According to tracking of SI, it is possible to know that the generator connected on Bus_1 is three generators(first, second and third generator), so the injection power in Bus_1 is the sum of the three generators. If SI of the record is not zero, the next record is included in the sum and tracked until finding 'zero' record.

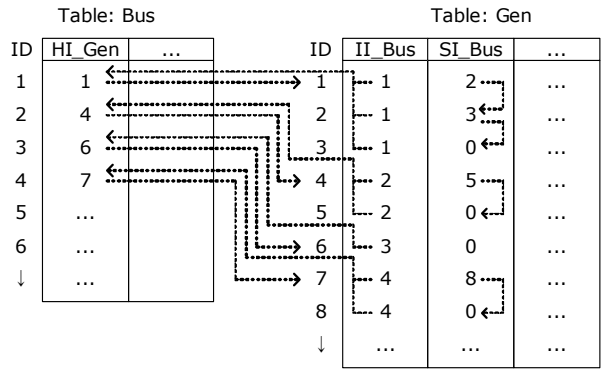

Fig.2 The example of linked data structure on ACM

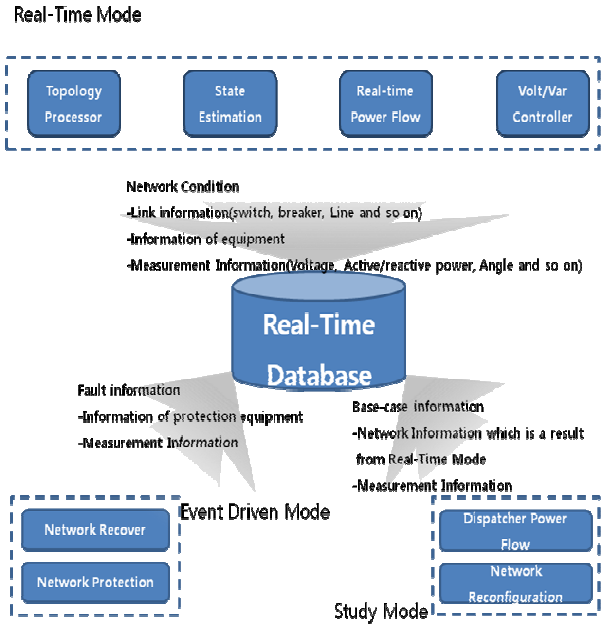

Fig.3 Summery of I/O data in each application

REQIREMENT OF APPLICATION

The data modeling in ACM has the purpose to supply the mathematical model for the system analysis on the equipment and the hierarchical/non hierarchical structure of power distribution system. The applications for the system analysis are the following Table 1.

Table 1. Applications of SDMS

Application	Function	Model
Network Connectivity Processor	Computing the system topology	NCP
State Estimator	Estimating the system state	SE
Real time(Dispatcher) Power Flow(DPF)	Calculating the power flow	PF
Voltage/Var Controller(VVC)	Controlling the voltage	
Network Reconfiguration(NR)	Computing the system reconfiguration	
System Recovery(SR)	Computing the system recovery	
Short Circuit Analysis(SCA)	Calculating the fault analysis	SCA
Protective Coordination(PC)	Estimating Protective Coordination	
Load Forecasting & Management(LFM)	Calculating the amount of load	-

And, the I/O data used to the applications in Table.1 is summarized in Fig.3.

However, the four base applications as following are necessary in viewpoint of the data modeling.

1) Network Connectivity Processor(NCP) : This application performs the function changing the state of system topology, presented to node state on the kind of breaker or switch, into the form of 'Bus' using the open or close state of those kinds. Also, the topological island and the equipment state(Live or Dead) are classified
2) State Estimation(SE) : This application revise the error and asynchronous measurement data getting from the bus created by NCP. For power flow, the initial values are calculated.
3) Power flow(PF) : This application calculates the voltage, angle and an amount of the power flow between buses using the result of SE as an initial value. Among the applications in Table 1, the VVC, DPF, NR and SR are performed the calculation based on the PF model.
4) Short circuit analysis(SCA) : Based on positive, negative and zero sequence impedance, the fault current for the each section of the power distribution system is calculated in case of the fault occurrence.

Therefore, the requirement of the modeling on those applications are following table.

Modelling of power distribution system

The important consideration for the design of ACM is to reflect the characteristic of power system equipment. Of course, the application's own algorithm should be considered first of all, but the characteristic of equipment is more difficult to get the information because of the limitation o

f data on the real system.

Table 2. The result of requirement on the application

Model	Input data	Output data
NCP	-Rated voltage - Link information between nodes	-Link information -Elements on the Y matrix
SE	-The value and quality of the measurement -The result of NCP	-The estimated value for the measurement - Elements on the Y matrix
PF	-The result of SE -Information on the control of each equipment -The result of NCP	- The value for voltage and angle on buses -The recommended value for control factor
SCA	-The result of PF -The connectivity for transformer -The fault contribution by generator	-voltage and current on each bus and branch in case of fault occurrence -The violence of the rated value on protection coordination

The ACM is designed for analyzing the DB for the established Distribution Automation System with the consideration on the part of extension and available supplies. The design concept of the system equipment is as in following.

1) The mathematical model on power system equipments is designed to modify the model of PSS/E which is globally used as the power system analysis tool.

2) The similar characteristics of the equipment are reflected to make a common model. For example, the transformer is designed to consider the 2/3 winding transformer with the step voltage regulator(SVR).

3) In case of the tie switch which connects the substation with the other, the switch is designed as zero impedance line depending on the switch status(open or close).

HIERARCHICAL DB STRUCTURE

Above mentioned on the requirement of application and the modelling of power system equipments, the real time database of SDMS is designed as Fig.4. In the Fig.4, each box represents the data table group. The table group has the parallel table structure involving a number of static and dynamic data table as Fig.5.
The characteristic of hierarchical structure illustrated in Fig.4 is as follows.

1) Mixture of the congregative topology elements(Ex: Branch Office(BOF), Substation(SS), Main Transformer(MTR), Feeder(DL)) with electrical topology elements(Ex: Switch & Breaker(CBSW), Generator(GEN), Load(LD) and so on).

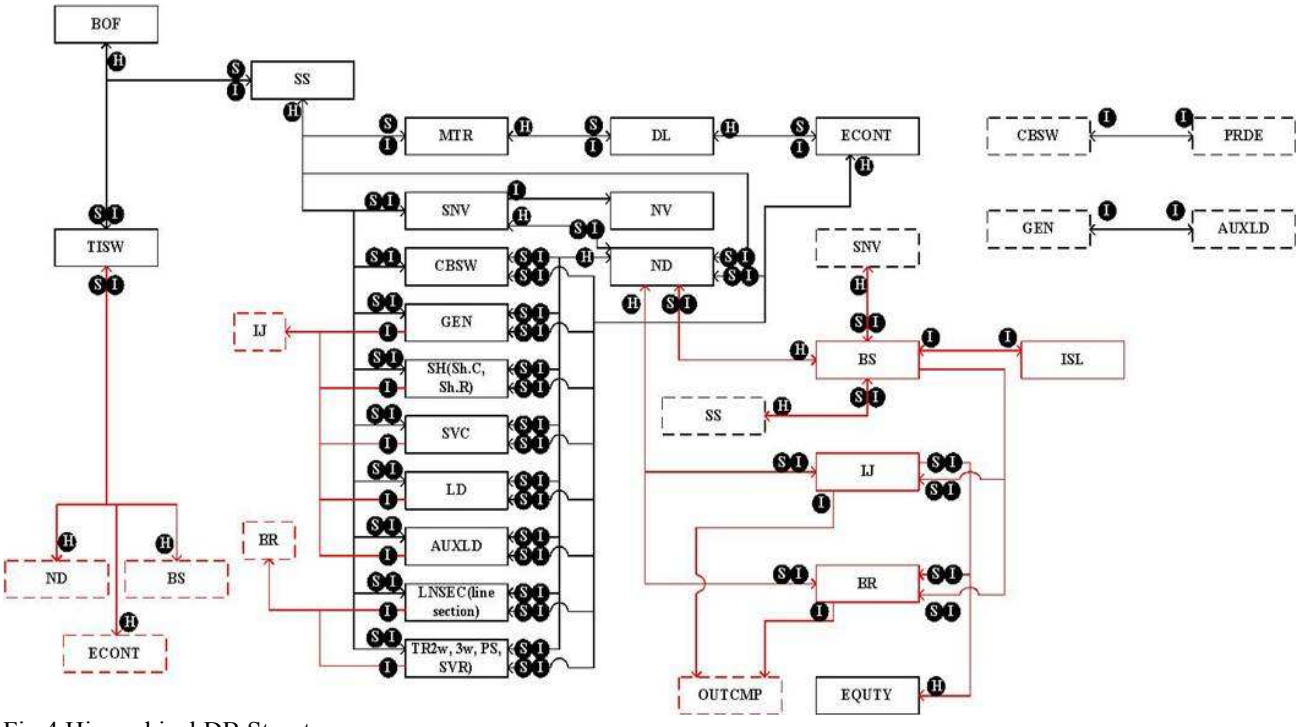

Fig.4 Hierarchical DB Structure

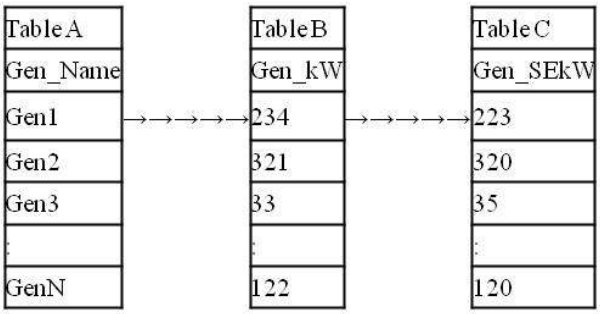

Fig.5 The structure of parallel table

2) Unit of NCP process : Basically, the substation is the unit of NCP process. It means that all of the applications in SDMS perform the analysis with a substation as a unit, even if there are many individual island in the substation due to a switch status.

3) Table structure for rapidly computing the application : For reducing the time of the computation and developing the programme conveniently, the model(Ex : branch model(BR), injection(IJ)) and link of the power system equipment in the database is designed.

CONCLUSION

In the SDMS, the application for the system analysis has been developed with the object of monitoring, operating, and controlling the power distribution system in real time. Therefore, the efficient design of the real time database is required. The ACM presented in this paper have been applied directly in the application software for the analysis, and designed to consider the fast computing speed and the stable operation of the application. Also, the ACM is designed to accept the additional requirement of the application as far as possible. From now on, we have a plan progressively to supplement the ACM while the application will be developed.

Acknowledgments

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