Chapter 4
DMS Design Methodology

Expert system, called *'Artificial Intelligence'* or AI, had begun to use to solve the problem of nuclear power plant design problem in 1970. Then it was used in other application. However, today the system is change into 'Knowledge management' because it has to be related not only with computer machine but human expert. According to fast technology development especially in software industry, many users have to position themselves as super-user, who know their requirement, understand how to operate the software, and even maintain the system life-cycle. So SCADA/DMS needs some something to cope with this problem. Normally utility ask for technical assistance to get the system. However, they still need some *'know how'* and *'how to'* operate and maintain the system.

This research introduces an alternative DMS design approach using knowledge engineer to get the DMS design knowledge within the organization. Eventhough, utility need to get consultant service to specify and verify what the system they really need, the approach is still valuable for communicating and modifying the system in the future. Knowledge model can represent the specific knowledge picture to communicate among the related task groups such as utility officer, consult agent, and suppliers to work better together on the same objectives. This research uses knowledge management and knowledge engineering technique that mention in the previous chapter to cope with the problem in the research theme (figure 1.8).

The organization knowledge of DMS design task can be modeled in 3 levels which are task, inference, and domain knowledge. This model can be done by knowledge engineer. With the CommonKADS model suite; context level, concept level and artifact; the knowledge management system for DMS design can be further developed to support knowledge user within the organization.

4.1 Standard DMS Design

Because DMS is complicated and technology-oriented, an existing DMS design is a complete package from consultant agency. An example of the procedure is described as follows:-

1. Consult experts give the training on the following topics:-

   Overview
   - What are the components of DMS?
   - What are the advanced DMS applications?
   - What does DMS with advanced applications provide additional benefit?
   - What is the role of the dispatcher when a DMS application operates in a close-loop mode?

   Distribution Operation Model and Analysis (DOMA)
   - What are the output data of distribution operation model and analysis?
   - How will the losses in distribution change if the voltage is reduced?
   - What is changed if the voltage in distribution is changed?

   Coordinated Voltage and Var Control
   - What are the objective of Coordinated Voltage and Var Control?
   - What are the constraints of Volt/Var Control?
   - What will Volt/Var function do, if the objective is “Super Quality”?
   - What will Volt/Var function do, if the objective is “Conservation”?
   - What will Volt/Var function do, if the objective is “Economic” and the cost of generation is higher than the customer rate?
   - What will Volt/Var function do, if the objective is “Conservation” and the voltage in the secondaries is below the lower limit?

   Fault Location Isolation and Service Restoration (FLISR)
   - What are the objectives of FLISR?

- FLISR takes into account the following real-time conditions
- What will FLISR recommend in case of an outage, if the adjacent backup feeder becomes overloaded?
- Two feeders are connected to the same substation bus. There was a fault in the beginning of one feeder. The fault section is disconnected. The healthy sections of the feeder are transferred to the second feeder. What will Volt/Var function most likely do?

Multi-level Feeder Reconfiguration

- What are the objectives of multi-level feeder reconfiguration?
- What are the benefits of multi-level feeder reconfiguration for service restoration?
- Why is the reliability improved by multi-level feeder reconfiguration?

2. Consult then requests for information by using questionnaire. The questions are about:-
   - Organization
   - Power System
     a) Transmission and Distribution one line diagram
     b) Typical distribution substations
     c) Distribution configuration
     d) Typical power flow
     e) Outage report
     f) Criteria for allocation of feeder sectionalizer/recloser switches
     g) Requirement for reclosing distribution system
     h) Typical feeder and substation transformer loading
     i) Theft of energy
     j) Annually new distribution feeder
     k) Investment in new distribution feeder upgrade
     l) Real feeder loading distribution
     m) Investment in transmission upgrade due to expected overload
     n) How much money spend to reduce SAIDI by 1 minute

- Operation and Maintenance Procedures
    a) Describe labor and time for monitor, update database, schedule and coordinate, detect a fault, locate the fault, isolate the fault, restore service, communicate with customers, record keeping
    b) Handling of trouble calls
    c) Load interruption/curtailment program
- Customer Service
    a) Main customer complaint on
- Existing SCADA and Other system
- System Economic and Other Characteristics
- Quantitative Information on System Operation

3. Review the benefits of DMS Application functions for the grantee
    - Analyze core DMS function (simulation)
    - Recommend functions based on simulation (at least 3 interconnected substations)

4. Evaluate the grantee's databases
    - Evaluate GIS, CIS database (available to support DMS requirements)
    - Recommend for upgrade database (adding attributes and entries, linkage of entries from different databases, database O&M)

5. Recommend feasible upgrade of power distribution system
    - Installation of automated switching devices
    - Installation of additional capacitors
    - Replacement of voltage controllers
    - Change of no-load tap positions

6. Specify DMS applications (cover functional requirements, input/output data, user interface, performance of the functions)
    - SCADA
    - Real time

- Look-ahead
- Study modeling
- Optimization function

7. Integration of systems (seamless, secure, timely information exchange)
   - ADA (Advance Distribution Automation)
   - OMS (Outage Management System)
   - WMS (Work Management System)
   - AM/FM (Automated Mapping/ Facility Management)
   - GIS (Geological Information System)
   - CIS (Customer Information System)
   - EMS (Energy Management System)

8. Identify and specify distribution equipment
   - Study the characteristic of the utility power system to identify and specify
     a) automated switched
     b) voltage controllers
     c) other power system equipment
   - Specify the optimum number and location of pole-top RTU suitable for DMS

9. Develop implementation plan for DMS
   - Activities
   - Allocation of manpower resources
   - Setting the budget
   - Documentation

10. Prepare overall specification and bid documents

This information is finally reported to utility who own the technical assistance contract. However, there is no knowledge retention within the organization. So this

research proposes an alternative solution for DMS design that mention in the next section.

4.2 Propose Methodology

According to DMS design task, the CommonKADS model suite that is proposed in this research which is expressed into 4 model in figure 4.1 which are organization model, agent model, communication model and knowledge model

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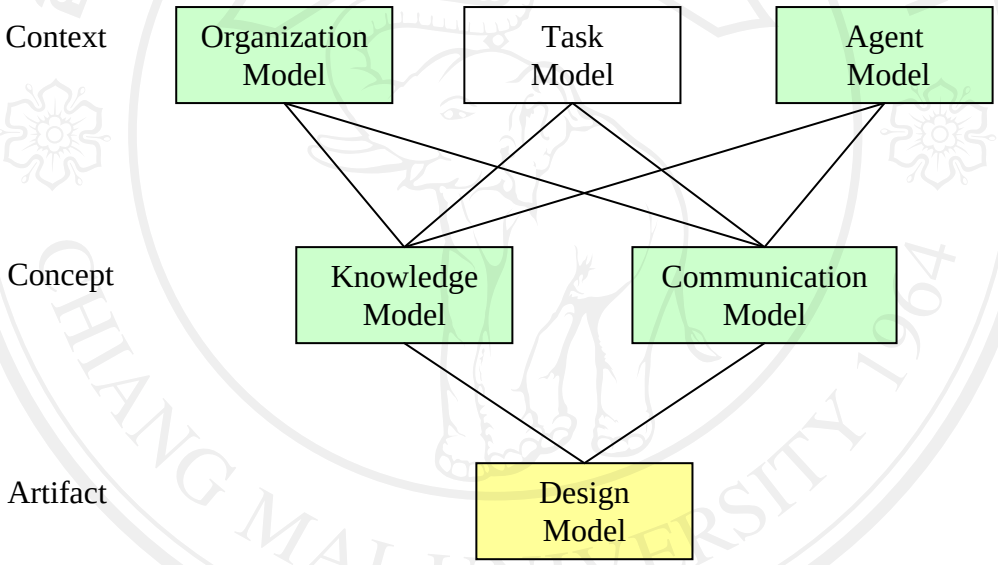

Figure 4.1: CommonKADS Model Suites

The organization context analysis should be done for DMS design in order to identify problems and opportunities, variant aspect, process breakdown in table 4.1 to table 4.3.

Table 4.1: Problem and Opportunity Worksheet for DMS design

Organization Model	Problems and Opportunities
Problems and Opportunities	Problems 1) Reliability of distribution system operation 2) Risk in distribution business

	3) High cost-efficiency ratio Opportunities 1) Leader in power distribution service 2) Center for distribution operation training 3) Role model of modern utility with smarter grid
Organization Context	Manner Keys 1) Vision: Modern Utility with smarter grid 2) External Factors ▪ MEA Policy ▪ Government policy ▪ Connection with other utility in the region ▪ Budget 3) Strategy ▪ Privatization ▪ Human-technology development ▪ Asset management ▪ Risk management ▪ Enhance efficiency by employ utility automation 4) Value Chain (Planning, Operation, Maintenance, and distribute power from substation to customer) Key Drivers ▪ Human development by training ▪ Apply new control system technology ▪ Implement new management system ▪ employ business ICT
Solutions	Knowledge Management 1) Distribution Management System for the problem of reliability and efficiency ratio

Table 4.2: Variant Aspect Worksheet for DMS design

Organization Model	**Variant Aspect**
STRUCTURE	1) 14 District offices 2) Power system control department 3) Planning department 4) ICT planning department 5) Communication department
PROCESS	1) Control power system 2) Reliability, economic and quality planning for system operation 3) System expansion planning 4) Communication system planning
PEOPLE	1) Knowledge manager:- Department Director 2) Knowledge provider:- Chief of Section 3) Knowledge User:- Engineer, Technician
RESOURCES	ICT system

	▪ Communication:- network management, transmission, PSTN, PSDN ▪ Remote control:- SCADA/EMS, SCADA/DMS ▪ Substation Automation ▪ Planning software ▪ ERP Equipment and material ▪ Switch ▪ Distribution feeder ▪ Substation ▪ Remote Terminal Unit ▪ Communication system Technology License Copyright Memberสัมปทาน ▪ EPRI IEEE IEC DNP
KNOWLEDGE	1) Substation Operation and Maintenance Power System Planning and Control 2) Insulation Monitoring, Relay Protection Setting and Maintenance, Distribution Line Inspection and Maintenance, Maintenance Planning 3) Telecommunication, Data communication, SCADA Planning and Maintenance
CULTURE & POWER	Engineer is the core in technical knowledge. Manager makes a decision.

Table 4.3: Process Breakdown for DMS design

Organization Model		**Process Breakdown Worksheet OM-3**				
No	Task	Performed by	Where?	Knowledge Asset	Intensive ?	Significant
T1	Review DMS Benefit	consult	Engineering dept.	reliability	Y	
T2	Evaluate database	consult	ICT dept.	Interface, format	Y	
T3	Recommend feasible upgrade	consult	Engineering dept.	Equipment ability	Y	
T4	Specify DMS application	consult	Operation dept.	function	Y	
T5	Define integration of system	consult	Engineering dept.	Interface	Y	
T6	Specify distribution equipment	consult	Engineering dept.	Equipment ability	Y	
T7	Develop implementation plan	consult	Planning dept.	Timing estimation	Y	
T8	Prepare bid document	consult	Procurement dept.	Regulation and procedure	Y	

Then the task worksheet should be filled to indicate the agent and knowledge involved in the task. Moreover, the task worksheet will identify where the domain knowledge is, what the nature knowledge is, and if it is bottleneck (or need to be improved). The agent model should also be filled to describe the agent who executes the specific task. For agent model in DMS design, there are at least 3 parties which are utility, consult and supplier.

The 'Propose and Revise' template in figure 4.2 is used to transcript and model the knowledge and requirement in the concept level. This transcript in this research is basically done from the consult report or other knowledge provider if there are any in the organization. Then it can be modeled into DMS design knowledge model in figure 4.3 with have 8 mainly inference tasks (same as consult):-

I01 Review benefit of DMS
I02 Evaluate an existing database
I03 Recommend feasible upgrade for distribution power system
I04 Specify DMS application
I05 Integrate the system
I06 Specify distribution equipment
I07 Develop an implementation plan
I08 Prepare specification and bid document

Then communication worksheet is used as a channel to capture knowledge from consult and requirement from user. Knowledge model together with communication model can help utility to create the DMS design knowledge along with consult experts. Although utility has no technical knowledge on DMS design at first, this knowledge and communication model can help utility to manage DMS project better and it will be ever better for long run learning and knowing.

For more knowledge capture, communication plan in figure 4.4 and activity diagram among each other should be identified in order to capture, analyze, validate and model further useful knowledge.

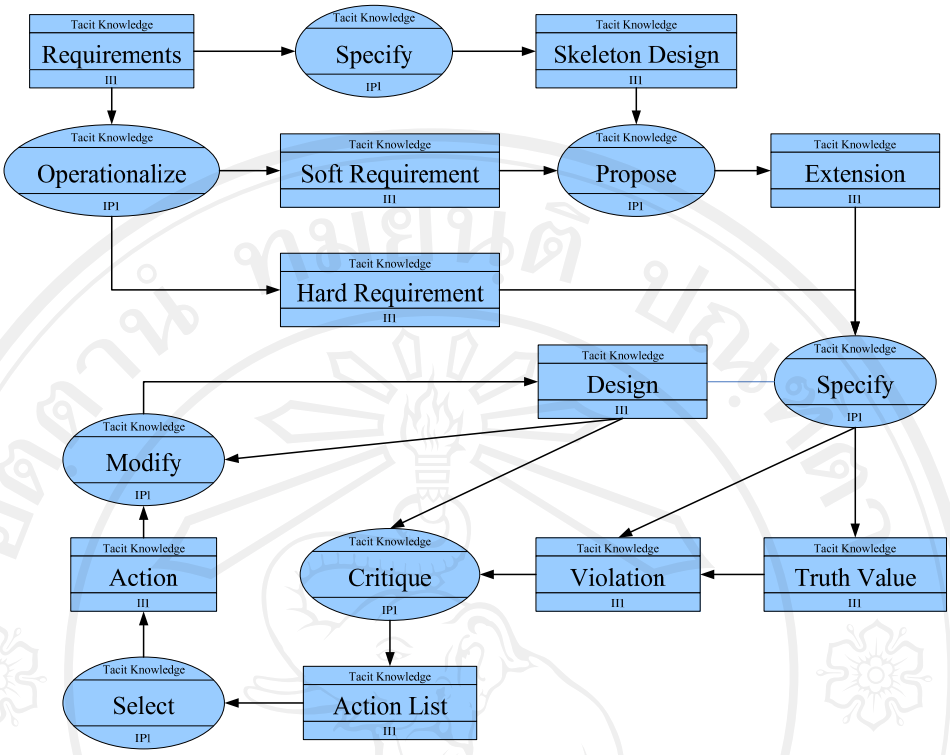

Figure 4.2: CommonKADS 'Propose and Revise' Template

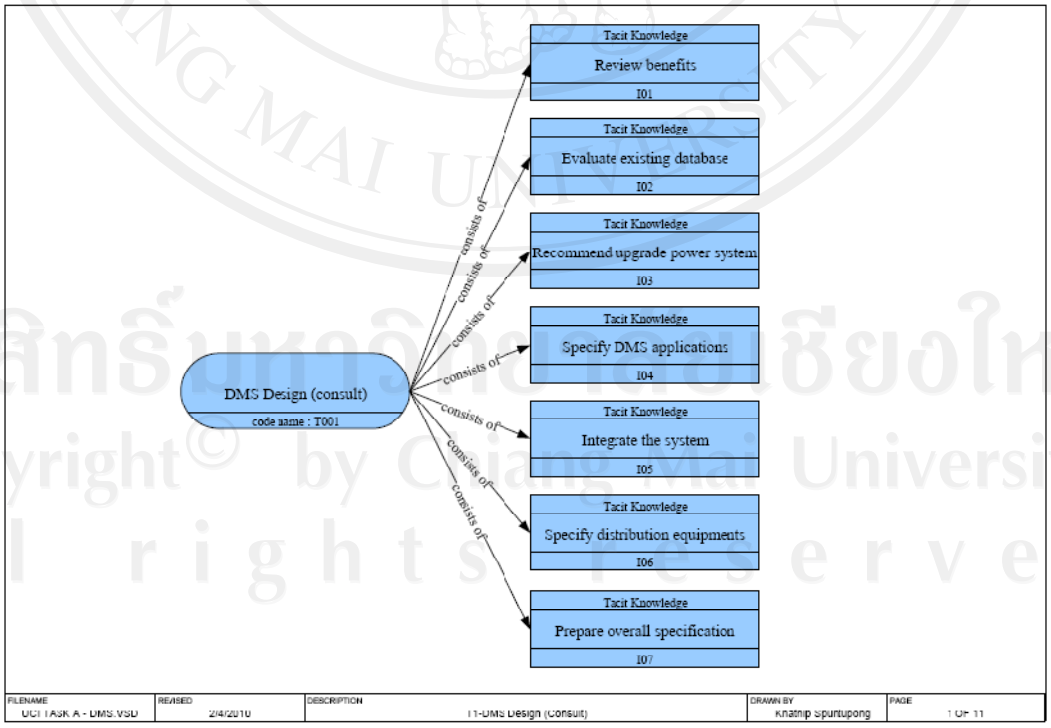

Figure 4.3: DMS Design Knowledge Model

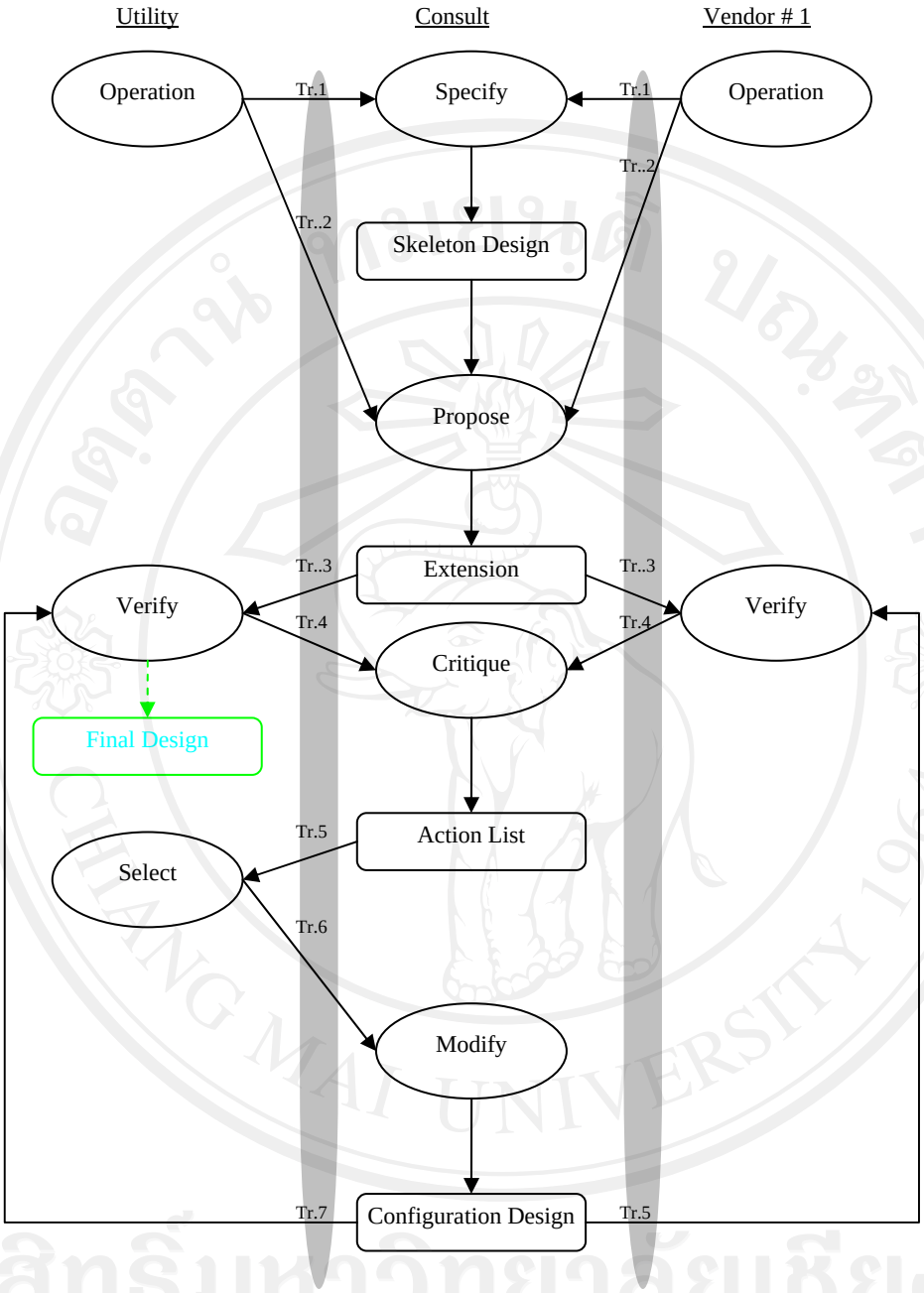

Figure 4.4: Communication Plan

Finally knowledge system in figure 4.5 should be implemented during DMS project implementation in order to get the benefit of organization knowledge model. UML/XML is used to visualize in some parts of this research. This knowledge can be visualize by all knowledge worker and better for DMS operation life-cycle. This

research provides the models for knowledge system implementation for system developer to create it within the organization.

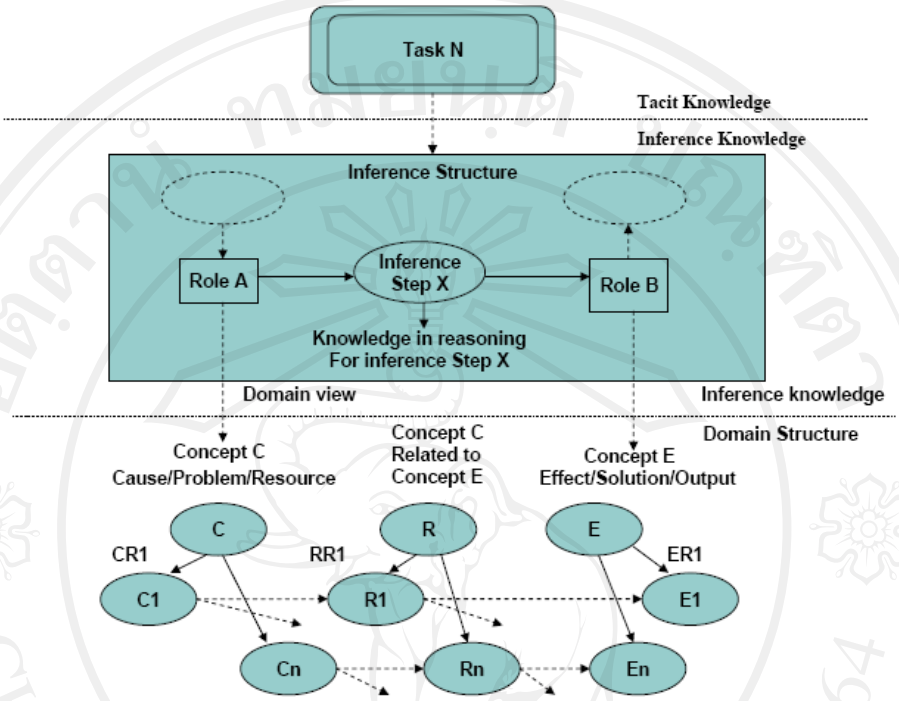

Figure 4.5: Knowledge System for DMS Design