Chapter 6
Results and Discussions

This chapter presents the results and discussion on each case study. The first case is the base case of the DMS design knowledge. This case is based on the standard consultant practices in DMS design and implementation, and consultant knowledge related to these practices is captured for result comparison's purpose. The second case illustrates the application of the CommonKADS 'Propose and Revise' template as an alternative approach to analyze and construct the DMS design knowledge model. It is to show that this common template can also apply for the design problem. The third case adds the communication plan to further capture and transfer more explicit knowledge within the relevant design team. Finally the last case proposes the knowledge management system for DMS design for the future organization knowledge development.

6.1 Case 1 Base Case

This case shows the general practice for DMS design by the specialist. The procedures begin from questioning, meeting, studying, recommending, training, discussing, and finalizing the DMS specification. At the first step, the initial question topics requested for DMS study with some answer in [ ] are as follows:-

1. Organization
   - Management desire goals for the project [MEA Annual Report]
   - Organization structure [MEA Annual Report]
   - Operation (Control Center) organization structure

2. Power System
   - Transmission/distribution single line diagram and route diagram [autocad files]

- Typical distribution substation [see Feas. Report, 2006]
- Typical distribution system [radial only]
- Typical power flow (result)
- Past outage report (2-3 years) [see report]
- Past power quality report (last year) [voltage dip]
- No. of distribution substation without load tap changer transformer and voltage regulator. [3]
- Criteria for allocation of feeder sectionalizers, reclosers, and tie switches.
  [Capacity of 12/24kV OH switches is 600A]
  [24kV OHs have average 5-8 sections and 5-7 interconnections]
  [12kV OHs have average 4 sections and 4 interconnections]
  [24kV UGs have average 2 sections and 7 interconnections]
  [14kV UGs have average 4 sections and 4 interconnections]
  [Capacity of 12/24kV UG switches is 400A]
- Criteria for reclosing distribution system (overhead only, combination of overhead and underground) [always using autoreclose]
- Planning criteria for substation transformer loading (%) [up to 80%], customer PF, distribution transformer loading (%) [up to 62.5%]
- Number of radial distribution feeder without backup supply [none]
- Theft of energy report (% restitution/sales) [0.026054246%, 2005]
- How many new distribution feeders that are going to construct or upgrade annually? [59, 2005]
- Historic investment in distribution feeder upgrade [254MB for 59 feeders]
- Real feeder loading [see report]
- Historic investment in transmission update due to overload [467MB, 2005]
- Reliability index [see report]
- How much money spends to reduce SAIDI by 1 minute? [247,957 MB, 2005]

3. Operation and Maintenance
   - Labor and time for the procedure:-
     - Monitor distribution system

- Update dispatcher databases
- Scheduling and coordinating the activities of field crews
- Scheduling and perform periodic maintenance
- Detect a fault [5 min]
- Determine fault location [30-60 min]
- Isolate a fault (sectionalizer practice) [30 min]
- Restoration service (on healthy sections) [<30 min]
- Communication with the customers
- Record keeping

▪ Handling of trouble call

- Facilities [call answering center]
- How to keep track of trouble call? [using ESRI TOR-trouble ticket]
- How does the dispatcher learn of the status of trouble call? [TOR screen with trouble ticket and fault location display]
- Is the model of connectivity in trouble call system dynamic? [No]

▪ Information about your load interruption/curtailment program (amount, incentives for customers)
[Interruptible customer 10MWmaximum under conditions:-]
[Once per day, not more than 6 hours]
[Not more than 10 times per month]
[Not more than 20 times per year]

4. Customer Service

▪ What are the main customer complaints?

- Frequent interruption? (sustained/momentaty)
- Length outage?
- Lack of timely information regarding outages?
- Cost of electric service?
- Environmental concerns?

- Power quality?
    - Voltage deviation
    - Voltage sag/swell
    - Voltage imbalance
    - Higher harmonics
    - Flicker

5. Existing SCADA
    - Identify computer system (hardware and software) which are on site, and which are planned
    - Provide hardware configuration for current computer system
    - Indicate SCADA/EMS function
    - Identify what distribution feeder data is monitored at each substation category
    - Description of structure and content of the existing and planned AM/FM/GIS and CIS databases

6. System Economic
    - Methodology and guideline for economic analysis and evaluation
    - Provide the following data:-
    - Incremental cost of energy production at peak
    - Incremental cost of energy production at off-peak
    - Maintenance cost in distribution (B)
    - Cost of new distribution (B/kW)
    - Average customer rate (b/kW)
    - Growth rate of maximum feeder load (% per year)
    - Fault rate per mile of line, per distribution transformer, per switch,..etc.
    - Installation cost
    - Average ration of number of faults on lateral and in secondaries versus number of faults on feeder main
    - Economic life time of DA system for present worth calculation, years
    - Estimated losses due to theft of service (MB/year)

7. Information System Question
    - System peak demand
    - Capacity
    - Spinning reserve
    - Generation
    - Total energy sales
    - Purchase/sales
    - Purchase/sales to other utilities
    - Sales to native customers
    - System load factor
    - System load growth
    - Number of distribution substation with 12kV bus
    - Number of distribution substation with 24kV bus
    - Number of distribution substation with 12/24kV bus
    - Typical number of separate buses per distribution substation
    - Typical number of feeders per distribution substation bus
    - Total number of distribution feeder at 12kV
    - Total number of distribution feeder at 12kV

Then two types of agenda for project meeting are discussed as follows:-

General Topics for Discussion

1. Department responsibility
2. Existing DAS and new DMS
3. DMS project schedule
4. Corporate user
5. DTS training center
6. DMS project cost estimate

Technical Topics for Discussion

1. DMS Control Center and Remote District Office location

2. External system interfaces:-
3. Integrate of GIS data with the DMS
4. CIS
5. SRTU, FRTU, and LB's
6. Trouble Call
7. Meter Reading System
8. Reliability statistic and calculation division
9. Remote district office control room
10. Control center equipment and quantities & sizing
11. System configuration and redundancy
12. Communication
13. MEA database
14. Display
15. Historical database requirements
16. ICCP data exchange with EMS
17. Training

Then more detail questionnaire and DMS sizing table (table 6.1) is request to filled as follows:-

A1. How is the distribution system monitor (in DSC#, DAS, OMS, TOR)?

1. Measurement A, kV, kW, kVar from feeder heads and substation buses
2. Measurement from feeder RTU's
3. Substation feeder CB statuses and tags
4. Feeder load breaker, recloser statuses and tags
5. Statuses and tags of not remotely monitored switching devices
6. Transformer LTC position
7. Feeder capacitor statuses
8. How are the circuit connectivity and measurements presented and updated
   - wall map: paper map, pen & pin
   - display

A2. How is the distribution system controlled? (Who control?, Who permit?, and Who is informed?)

1. Substation feeder CB statuses and tags
2. Feeder load breaker, recloser statuses and tags
3. Statuses and tags of not remotely monitored switching devices
4. V controller setting
5. Feeder capacitor statuses
6. Capacitor controller setting
7. How are switching operation performed, when it involved different jurisdictions?

A3. How is the Force Outage Management coordinated?

1. Are there any fault indication signals from remotely monitored switch?
2. Who receive the trouble call information?
3. Who decide where is the fault?
4. Who decides on fault isolation and restoration of healthy sections? How is the decision made?
5. Who dispatch the crews?
6. To whom the crews report?
7. Are the remotely controlled switch used for fault isolation and service restoration?
8. How is the outage report generated? Where is it stored?
9. Who communicates with the customer regarding the outage?

A4.How is the Planned Outage Management coordinated?

1. Who and when generates the outage request?
2. Who and when analyze the outage request?
3. What analytical tools are used for outage request analyze?

4. Who authorizes the outage request?
5. Who is informed about the decision?
6. Who executes outage requests for different types of equipment?
7. Who can recall an authorized outage?
8. Who (and when) communicates with the customers regarding the outage?
9. How is the outage report generated and sorted?

A5. Control of distribution operation parameters

1. Who selects the setting of voltage controllers?
2. Who selects the setting of feeder capacitor controllers?
3. Who selects the normally open ties between feeders?
4. What software tools are used for operation planning and for future distribution system planning?
5. What are the boundaries of the control areas for different operators?

A6. Support and use of databases

1. What is the role of district and system personnel in updating different databases?
   - AM/FM/GIS
   - Trouble Call
   - Outage management
   - Work management
   - DAS
   - Engineering and planning
   - Customer information system

2. Who are the users of different databases?
   - AM/FM/GIS
   - Trouble Call
   - Outage management

- Work management
- DAS
- Engineering and planning
- Customer information system

Table 6.1: DMS sizing table

Description	**Initial**	**Ultimate**
1. (a) Computer: User Interface		
Dispatch workstation - 3 monitors	8	12
Engineering workstation - 2 monitors	3	6
Report workstation - 1 monitors	2	4
District office workstation - 3 monitors	18	22
(b) Computer: Servers		
Develop & Maint. workstation - 2 monitors	1	1
2. Printers	26	38
3. Maximum name length	40	40
4. Real time database (RTDB)		
Substation: Analog points		
Substation: Status points		
Substation: Pulse accumulation points		
Substation: Digital control points		
Substation: Setpoint control points		
Feeder: Analog points		
Feeder: Status points		
Feeder: Pulse accumulation points		
Feeder: Digital control points		
Feeder: Setpoint control points		
5. Historical data	1,112,400	2,707,200
6. Current size of MEA distribution system		
7. Summaries for 12 month period	25,000	50,000
8. Communication interfaces sizing ports for EMS		
9. Continuous historical storage for 12 months	212,400	506,200
10. Web server system		
No. of simultaneous web access users	200	300
Report workstation - # monitor	1	1

Training to related staff is done for better understanding of DMS. DMS specification is then finished after a number of technical discussions. The results of this base case are summarized in figure 6.1 to 6.10. DMS design task is shown in figure 6.1 which contains 1 implementation plan and 7 inferences; review benefit of DMS, evaluate existing database, recommend upgrade power system, specify DMS applications, integrate the system, specify distribution, and prepare overall specification. The domain GIS knowledge is modeled in figure 6.4. All of them are directly modeled from consult's standard process on DMS without any templates.

Moreover, requirements, function, platform, and project management of DMS project can be summarized from the consult's specification in keywords as follows:-

Requirements

- System
    - Critical, Non-critical
    - Performance
    - Application timing
    - Failover, restart, and startup timing
    - Fail-soft capacity
    - Availability
    - Security
    - Sizing table, upgrade and expansion
- User Interface
    - Language
    - Workstation
    - Display
    - Screen and window feature
    - Data attribute representation
    - Graphical data representation
    - Dispatcher functions
    - Exchange of messages
    - Operation modes

- Management of alarm and event
- DMS Development and test system
- Web server

- Database
  - Real time database
  - Historical database
  - Database generation and maintenance
  - Display generation and maintenance
  - Report generation and maintenance
  - Spreadsheet based data access
- Documentation
  - Content
  - As-built documentation and software
- Quality Assurance and System Testing
  - ISO-9000
  - Configuration control
  - Tracking problems and variances
  - FAT
  - System commissioning
  - Availability test

Function

- SCADA
  - Blocked Load Shedding
  - Switching Management
- DMS
  - Distribution operation analysis
  - Fault location
  - Fault location and service restoration
  - Automatic Feeder Reconfiguration (AFR)
  - Volt and Var Control (VVC)
  - Planned outage request study

- Calculation of reliability statistics (options)
- Interface to external system
    - EMS
    - Metering
    - GIS
    - Corporate link

Platform

- Hardware
- Software
- System resource monitoring
- System process monitoring
- Remote access for maintenance
- Network manager (option)

Project Management

- Responsibility
- Organization
- Schedule
- Procedure
- Acceptance of DMS
- Training
- Participation in system development
- Maintenance support
- Contractor and Original Equipment Manufacturers (OEM) update and information services

Because of the specialized DMS knowledge, utility needs this technical assistance for DMS project as a complete service for the project. The complete report can be used as an explicit guideline for utility; however, it is still difficult for the utility engineers who are not familiar with this computer and communication system. By knowledge engineering model suite in figure 3.3, we identify an inference and domain knowledge of DMS design task from the consult report and specification. It looks the same way as a book, chapter, and topics in the report, but it can be seen much easier.

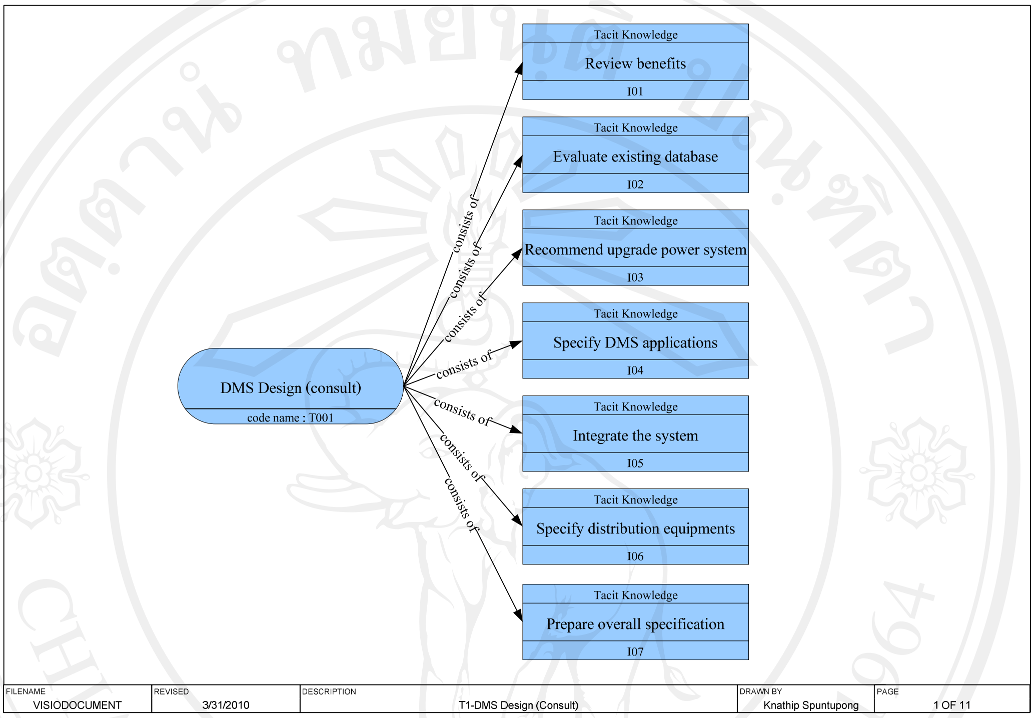

Figure 6.1: T1-DMS Design Task Model

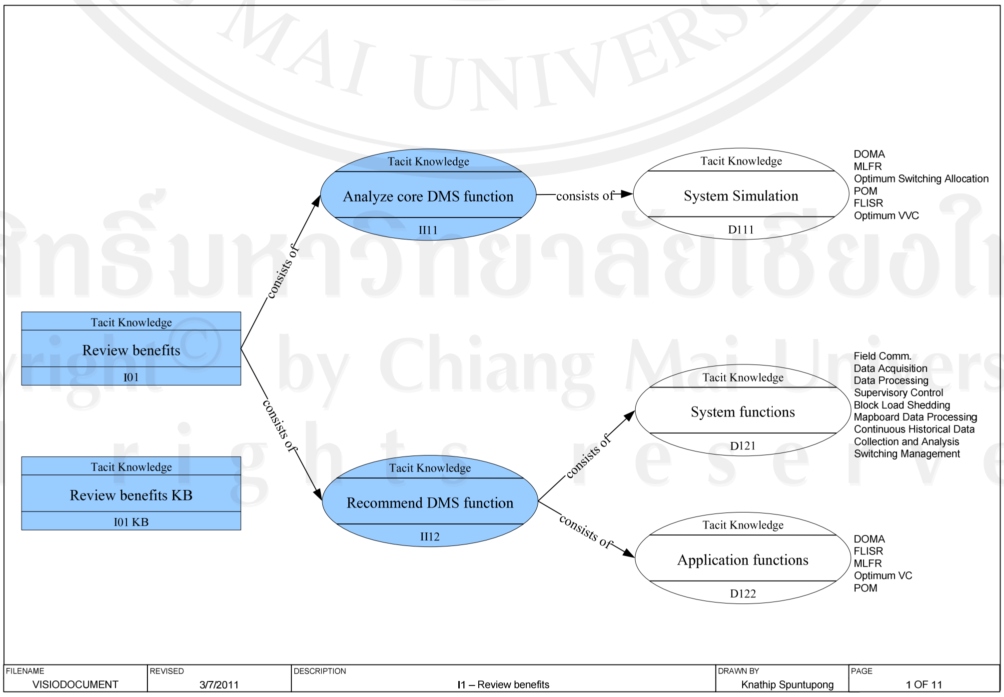

Figure 6.2: I01-Review Benefit

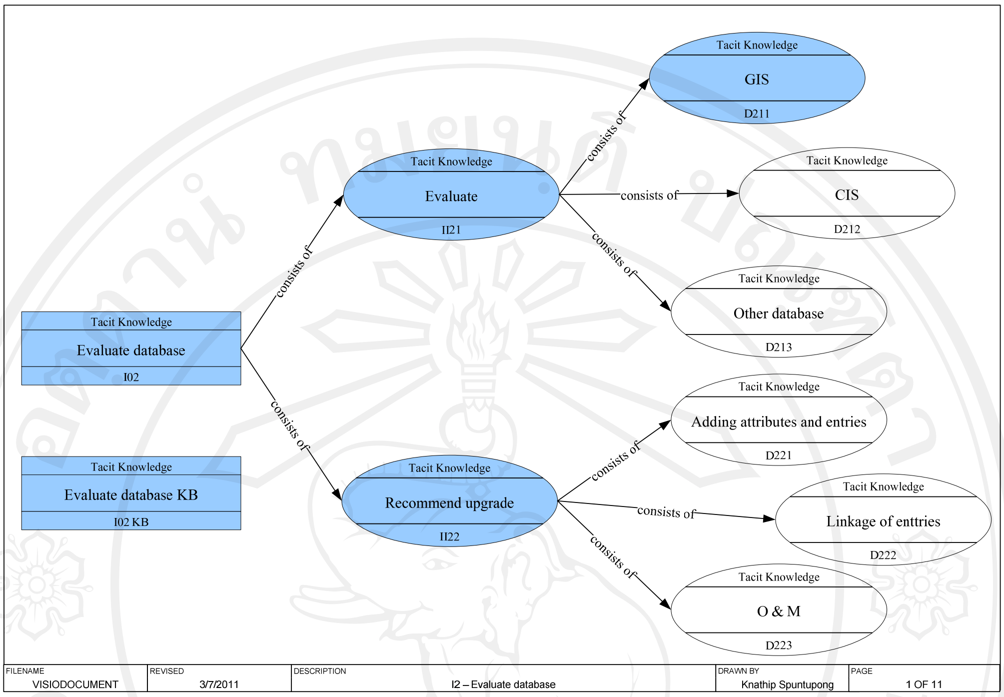

Figure 6.3: I02-Evaluate Database

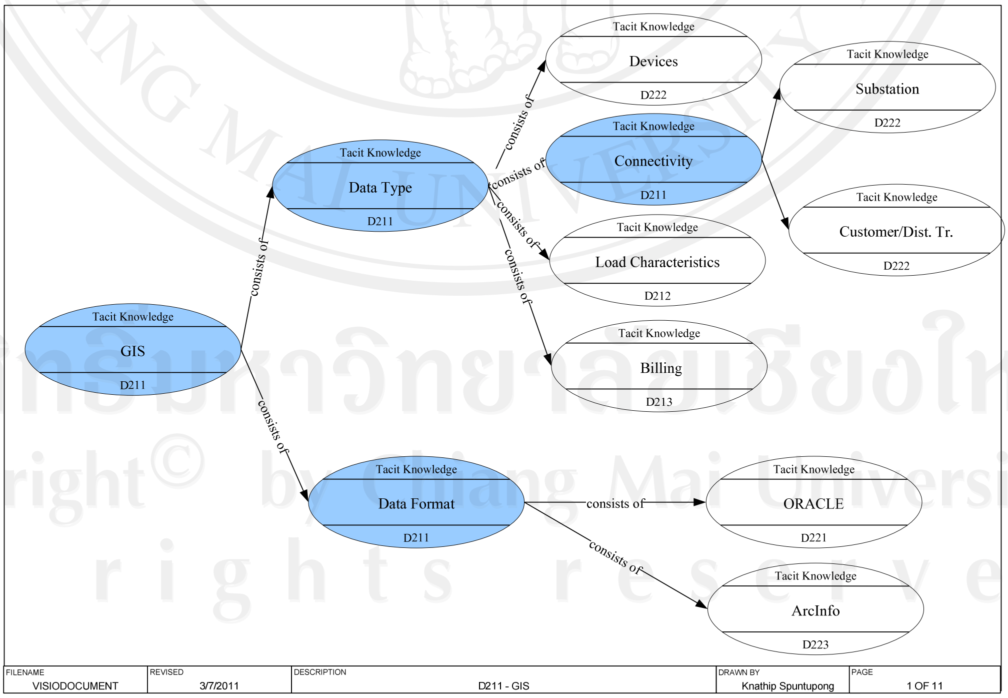

Figure 6.4: D211-GIS Domain Knowledge

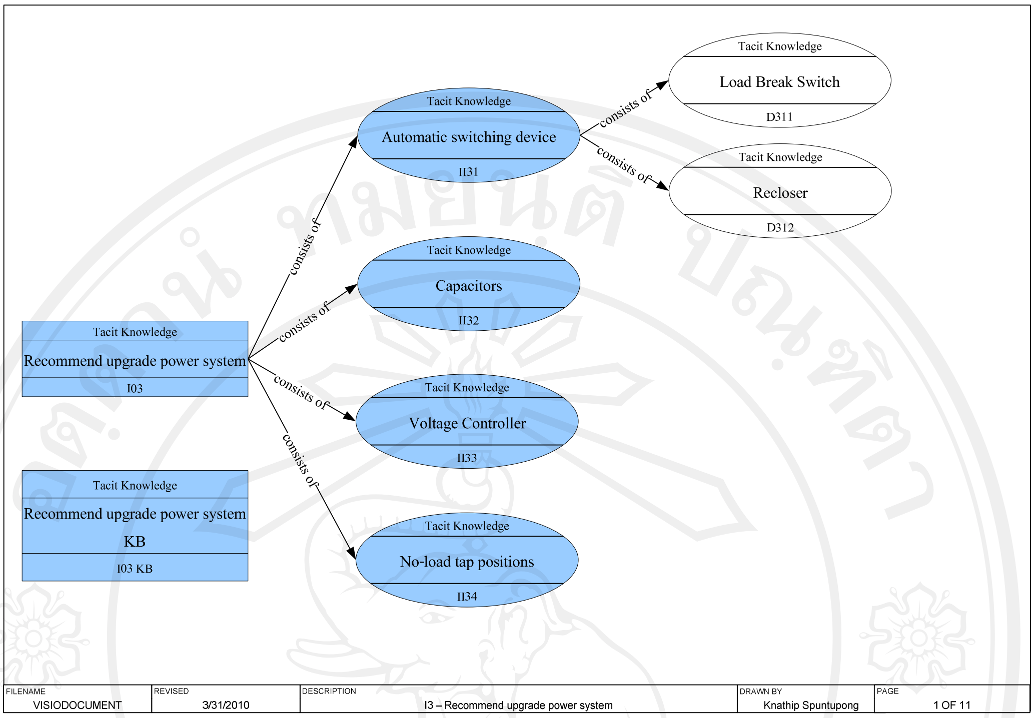

Figure 6.5: I03-Recommend Upgrade Power System

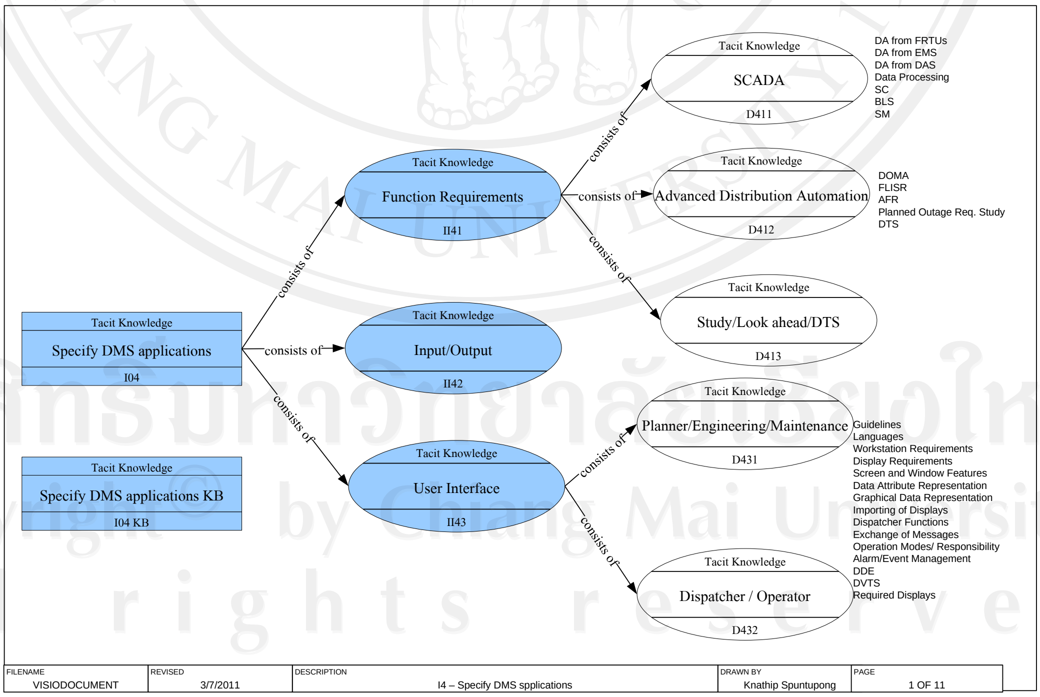

Figure 6.6: I04-Specify DMS Application

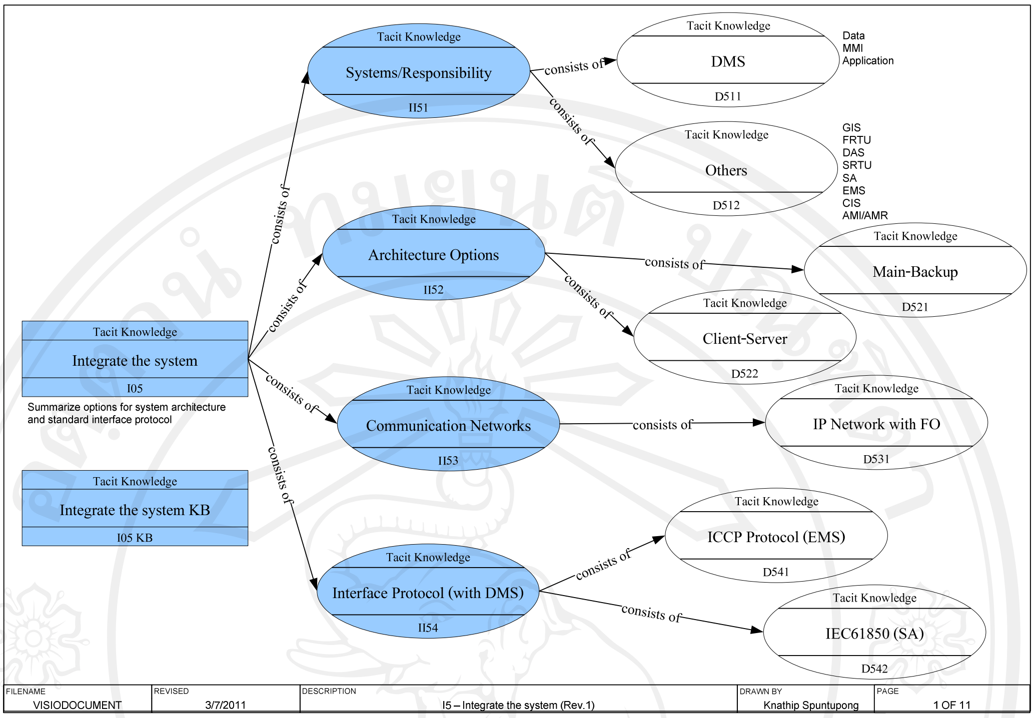

Figure 6.7: I05-Integrate the System

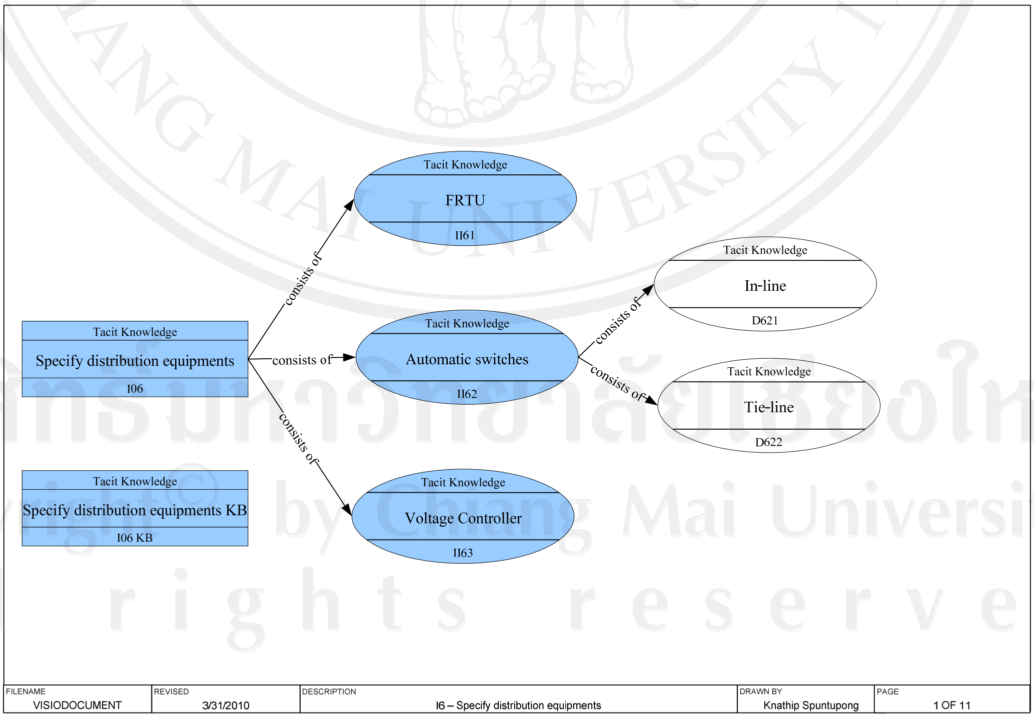

Figure 6.8: I06- Specify Distribution Equipments

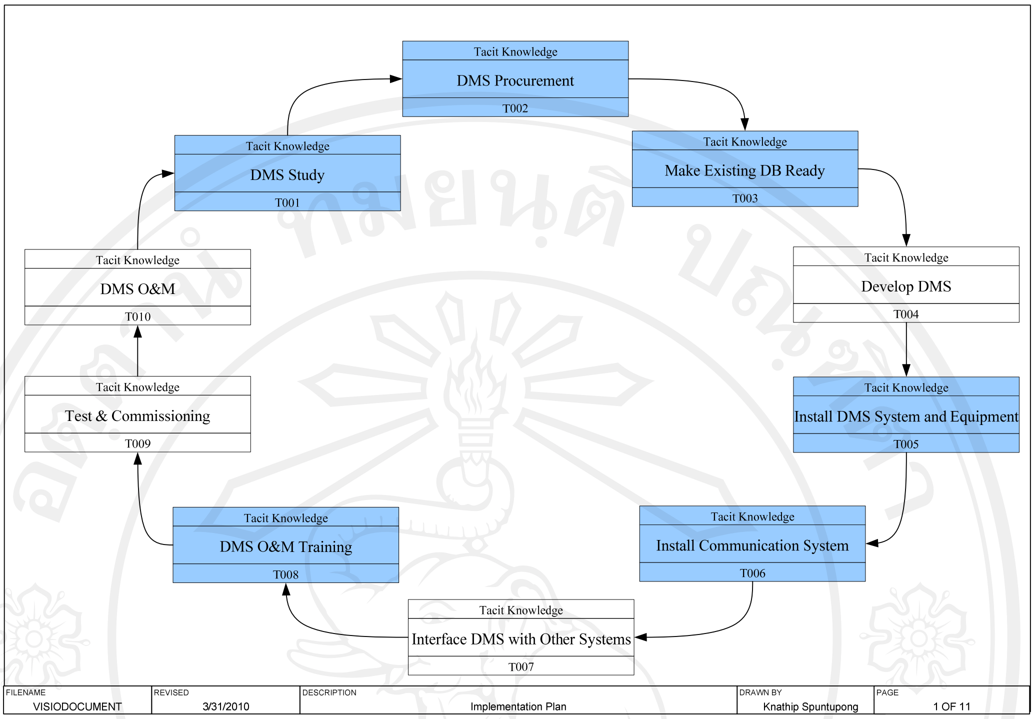

Figure 6.9: Implementation Plan

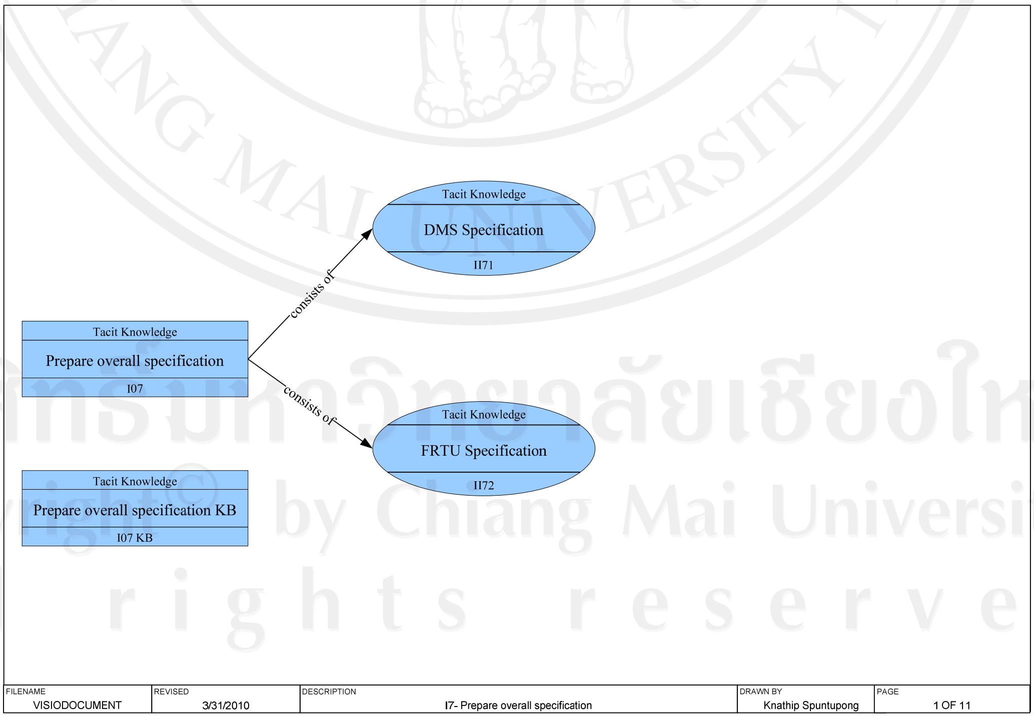

Figure 6.10: I07-Prepare Overall Specification

The DMS configuration hardware consists on DMS control center (main and backup), district control center, engineering center, training simulation, and DMS workstation, All of these must communicate with feeder remote terminal units (FRTU's) in the distribution feeder. The DMS configuration in the base case is shown in figure 6.11.

DMS specification can be vary from utility to utility and depend on information and communication technology. It is usually difficult for utility to do their own design at the beginning. The technologies come from suppliers and change so fast. It is quite difficult for utility themselves to do exact long term planning and design. Because utility who owns the requirement (but not product and technology); Manufacturers know their product and system. The consultant is the expert who knows technology and can guide utility the direction by asking their requirement from vision, action plan, organization, operation, and technical details to specify the appropriated solution and system. Then summarize it and propose an appropriated solution. Their methodology and guideline is easy to manage the DMS implementation project.

This base case was analysed and transcripted from the consultant report for DMS design. The consideration and methodology is precisely reasonable and easy for utility to manage and implement the project. In order to understand and transfer right information for the design, the understanding of power system operation requirement and DMS technology is very important. The meeting was done to confirm the understanding between utility and consult. However, the different view of understanding may be possibly occurred because of many related technical area and experience. If there are some misunderstandings of the requirement in the transfer stage, the expected system may not be appropriate. The next two cases will try to visualize the knowledge and communication model for every related party which may help better understanding and get right information, right person, and right time for the DMS design and implementation project.

In this case utility have a complete service package of DMS solution. Although the utility can successfully design and implement the DMS, the knowledge on how to design and why it is done is not transferred. Apparently, in this base case, utility only involves in the project management of the consultant's complete services.

This also results in the not very efficient project management since the utility has no sufficient knowledge to communicate with the consultant. According to questionnaire, utility own their system knowledge and operational requirement. It should be fruitful if they continue to have their own DMS design knowledge in order to achieve long run DMS operation and maintenance. The result from this can be used in the next case with can infer the key knowledge for DMS design.

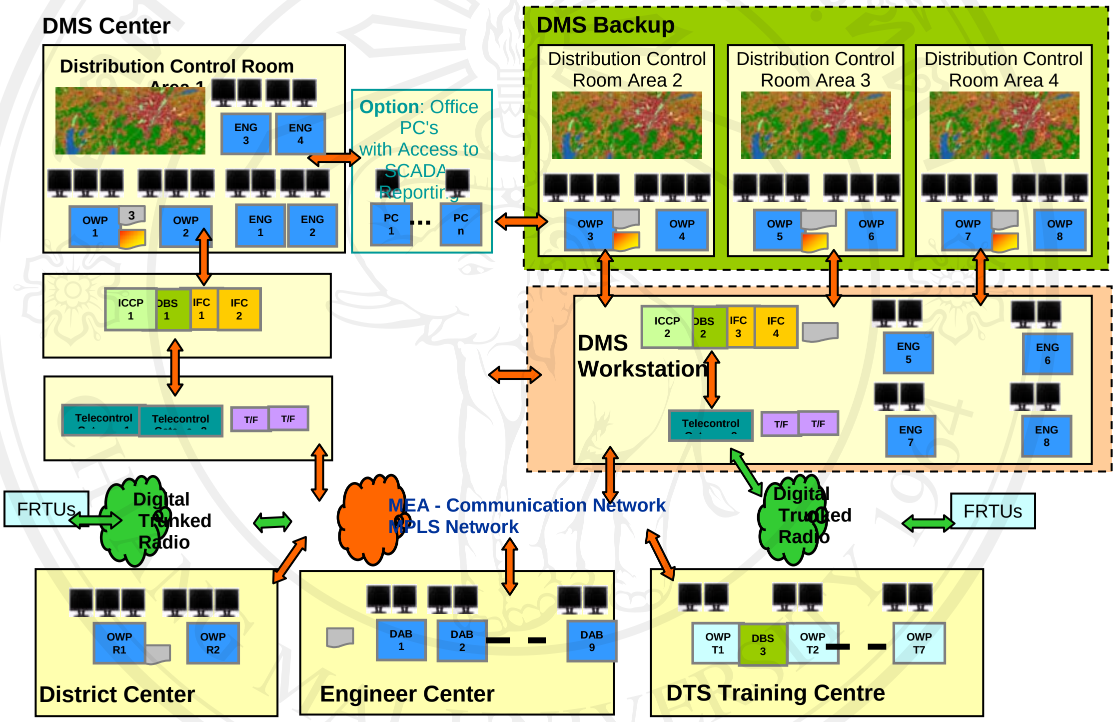

Figure 6.11: DMS Configuration

Source: UCI-MEA Specification, 2008

6.2 Case 2 Propose DMS Design Knowledge Model

This case begins with doing the context analysis at the first level of the CommonKADS model suite (Table 6.2 to 6.7) which consists of Organization Model, Task Model, and Agent Model for MEA DMS design. These first templates will analyze and provide knowledge engineer to understand the problem, process, and key persons who are necessary for the DMS design knowledge model.

Context level

1. Agent Model:- Kernel Team
2. Organization Model
   - 2.1. OM-1 Problems and Opportunities Worksheet
   - 2.2. OM-2 Variant Aspects Worksheet
   - 2.3. OM-3 Process Breakdown Worksheet
   - 2.4. OM-4 Knowledge Assets Worksheet
   - 2.5. OM-5 Feasibilities Decision Worksheet
3. Task Model
   - 3.1. TM-1 Task Analysis Worksheet
   - 3.2. TM-2 Knowledge Item Worksheet

Table 6.2: OM-1 Problem and Opportunities Worksheet

Organization Model	**Problems and Opportunities Worksheet OM-1**
Problems and Opportunities	<u>Problems</u> 1. Reliability of distribution system operation 2. Risk in distribution business 3. High cost-efficiency ratio <u>Opportunities</u> 1. Leader in power distribution service 2. Center for distribution operation training 3. Role model of modern utility with smarter grid
Organizational Context	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) 5. Key Drivers ▪ Human development by training ▪ Apply new control system technology ▪ Implement new management system ▪ Employ business ICT

Solutions	1. Distribution Management System for the problem of reliability and efficiency ratio 2. Knowledge Management System

Table 6.3: OM-2 Variant Aspects Worksheet

Organization Model	**Variant Aspects Worksheet OM-2**
Structure	1. Utility 2. Consultant 3. Supplier
Process	First Phase 1. Review benefit 2. Evaluate existing database 3. Recommend upgrade power system **4. Specify DMS application** 5. Integrate the system 6. Specify distribution equipments 7. Prepare overall specification Second Phase 1. DMS Implementation Third Phase 1. DMS Operation and Maintenance
People	1. Utility 2. Consultant 3. Supplier
Resources	1. Study Report 2. Operation Manual 3. Guideline 4. Handbook 5. Standard 6. Website 7. Expert Agents
Knowledge	Primary Distribution Protection Control and Operation Service Regulation DMS application DMS interface Data Communication System Integration
Culture & Power	1. Organization Structure 2. Trust 3. Sharing

Table 6.4: OM-3 Process Breakdown Worksheet

Organization Model		**Process Breakdown Worksheet OM-3**				
No .	Task	Performed by	Where	Knowledge Asset	Intensive	Significant
1	Review benefit	Utility Consultant Supplier	Utility	Primary Distribution Protection Control and Operation Service Regulation DMS application	Yes	Yes
2	Evaluate existing database	Utility Consultant Supplier	Utility	Primary Distribution Protection Control and Operation Service Regulation Data Communication System Integration	Yes	Yes
3	Recommend upgrade power system	Utility Consultant Supplier	Utility	Primary Distribution Protection Control and Operation	Yes	Yes
4	**Specify DMS application**	**Utility** **Consultant** **Supplier**	**Utility**	**Primary Distribution** **Protection** **Control and Operation** **Service Regulation** **DMS application** **DMS interface** **Data Communication** **System Integration**	**Yes**	**Yes**
5	Integrate the system	Utility Consultant Supplier	Utility	Primary Distribution Protection Control and Operation Service Regulation DMS application DMS interface Data Communication System Integration	Yes	Yes
6	Specify distribution equipments	Utility Consultant Supplier	Utility	Primary Distribution Protection Control and Operation	Yes	Yes
7	Prepare overall specification	Utility Consultant Supplier	Utility	Primary Distribution Protection Control and Operation Service Regulation DMS application DMS interface Data Communication System Integration	Yes	Yes

8	DMS Implementation	Utility Consultant Supplier	Utility	Primary Distribution Protection Control and Operation Service Regulation DMS application DMS interface Data Communication System Integration	Yes	Yes
9	DMS Operation and Maintenance	Utility Consultant Supplier	Utility	Primary Distribution Protection Control and Operation Service Regulation DMS application DMS interface Data Communication System Integration	Yes	Yes

Table 6.5: OM-4 Knowledge Assets Worksheet

Organization Model		**Knowledge Assets Worksheet OM-4**				
Knowledge Asset	Possessed by	Used in process	Right Form?	Right Place?	Right Time?	Right Quality?
Primary Distribution	Utility Consultant Supplier	1-9	✓	✓		
Protection	Utility Consultant Supplier	1-9	✓	✓		
Control and Operation	Utility Consultant Supplier	1-9	✓	✓		
Service Regulation	Utility	1,2,4,5,7,8,9	✓	✓		
DMS application	Utility Consultant Supplier	1,4,5,7,8,9	✓			
DMS interface	Utility Consultant Supplier	4,5,7,8,9	✓			
Data Communication	Utility Consultant Supplier	2,4,5,7,8,9	✓			
System Integration	Utility Consultant Supplier	2,4,5,7,8,9	✓			

Table 6.6: OM-5 Feasibility Decision Document Worksheet

Organization Model	**Checklist for Feasibility Decision Document Worksheet OM-5**
Business feasibility	KMS will improve the quality of knowledge sharing of DMS design.
Technical feasibility	KMS can provide virtual communication among utility, consult, and supplier which is not required advanced technology and specification.
Project feasibility	Project requires low budget and resource to achieve the objective but need the commitment from the participant. The risk is the participant cooperation.
Proposed actions	The project should have the following criteria; Focus: Knowledge Sharing Target Solutions: 1. Exchange information/knowledge 2. Support DMS design Expected Results: better quality communication and better DMS project management Risk: the participant cooperation

Table 6.7: Task Model Worksheet

Task Model	**Task Analysis Worksheet TM-1**
Task	**Specify DMS application**
Organization	Utility Consultant Supplier
Goals and Value	Specify an adequate DMS application for MEA
Dependency and Flow	Input:- Review benefit, Evaluate exisitng system and database Output:- Integrate and Implement the system
Objects Handled	DMS Specification
Timing and Control	Discussion at least twice a month
Agents	Utility Consultant Supplier
Knowledge and Competence	Distribution Operation Technology SCADA application Service Regulation ICT and Primary System Planning
Resources	Study Report Operation Manual Guideline Handbook Standard Website Expert Agents
Quality and Performance	

Task Model	**Knowledge Item Worksheet TM-2**	
Name	Specify DMS Application	
Possessed by	Consultant	
Used in	DMS Design	
Domain	DMS	
Nature of the knowledge		**Bottleneck/ to be improved?**
Formal, rigorous		
Empirical, quantitative		
Heuristic, rules of thumb	✓	Operation manual, Work description
Highly specialized, domain specific	✓	Supplier technology and may be vendor specific
Experience-based	✓	
Action-based		
Incomplete	✓	
Uncertain, may be incorrect		
Quickly changing	✓	Highly depend on ICT technology
Hard to verify	✓	
Tacit, hard to transfer		
Form of the knowledge		
Mind		
Paper	✓	incomplete
Electronic	✓	incomplete
Action skill		
Other		
Availability of knowledge		
Limitations in time	✓	Depend on project schedule (contract)
Limitations in space		
Limitations in access	✓	
Limitations in quality	✓	
Limitations in form	✓	

The results from context level analysis show agents who relate to DMS design project. By the use case diagram, the cooperation among utility (various department), consult, and vendors is identified. And by the result of the first case, this case uses CommonKADS 'Propose and Revise' template in figure 6.12 as a common tool to capture the requirement and the different type of knowledge from utility, consult, suppliers, and literatures. DMS design information may also come from all relevant resource within the organization such as consult' s report, supplier's manual and training materials, utility operation guidelines, distribution automation book, technical paper, and so on. The results of this case are taxonomies considering from the component in 'Propose and Revise' template. These can be modeled in requirement, specify, skeleton design, operationalize, soft requirement, hard requirement, propose, and extension taxonomy in figure 6.13 to 6.20 which can validate and further model during DMS project implementation. In the first phase of the DMS project, this template can use to capture and construct the knowledge map so that we can understand the basic design concept and learn more in the future.

Some of application software that is necessary for distribution system operation is shown in term of domain knowledge in figure 6.21 to 6.28. These are SCADA, Operation Load Flow, Fault Calculation, Loss Minimization, Var Control, Volt Control, Fault Location Isolation and Service Restoration.

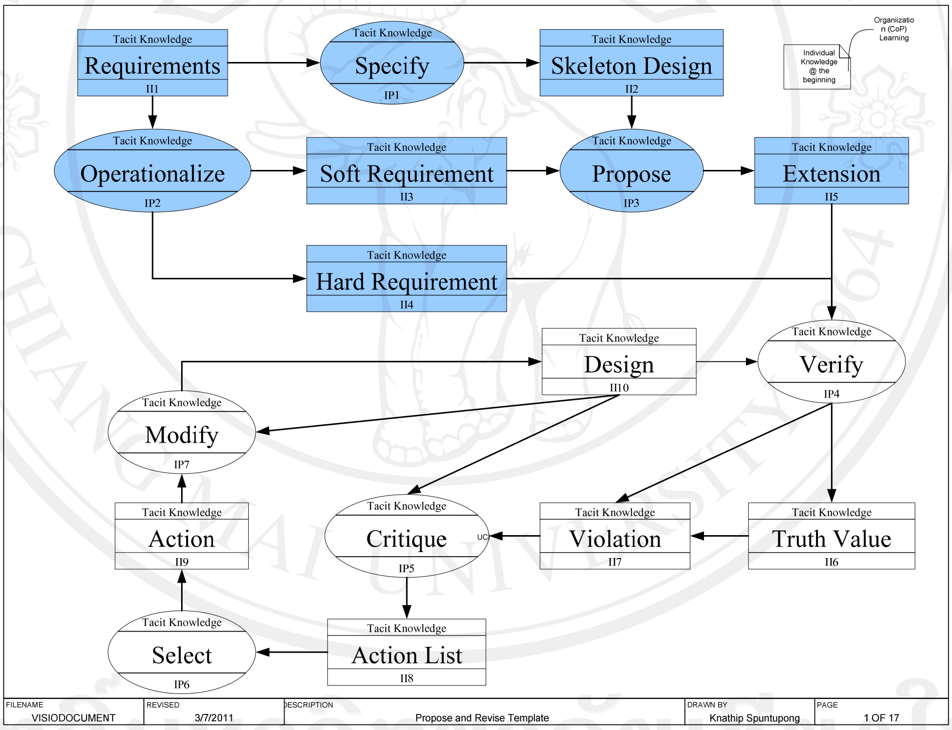

Figure 6.12: Propose and Revise Template

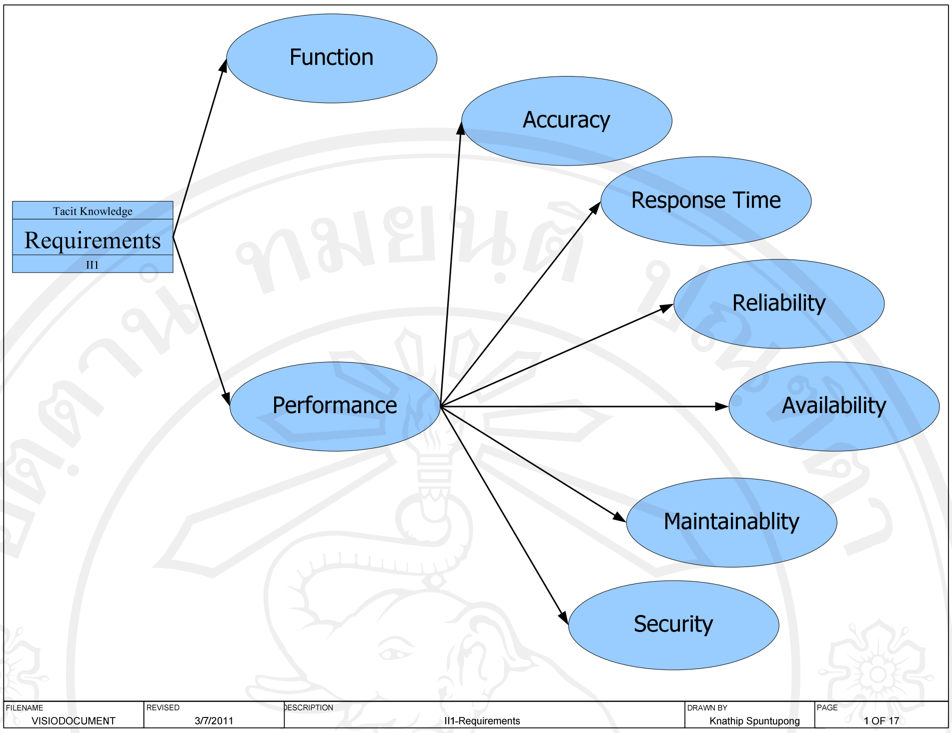

Figure 6.13: II1-Requirements

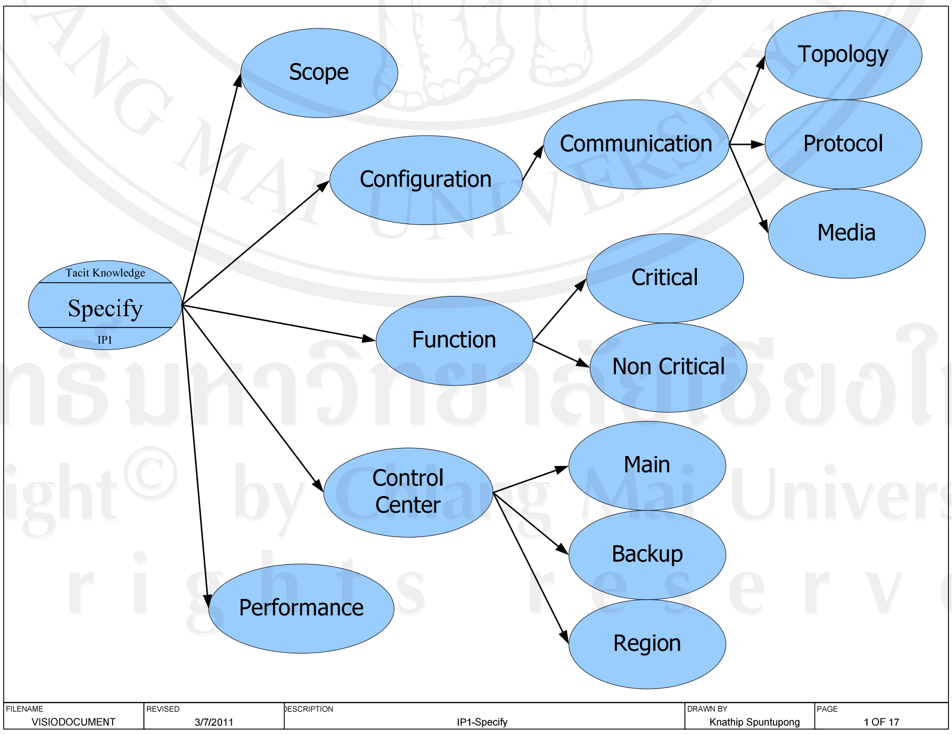

Figure 6.14: IP1-Specify

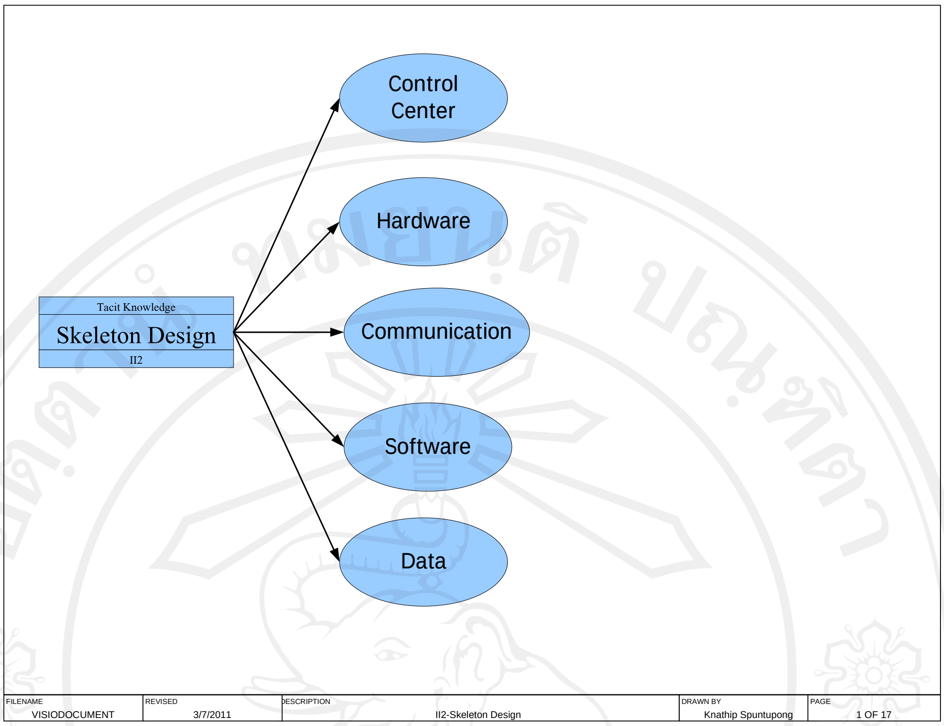

Figure 6.15: II2-Skeleton Design

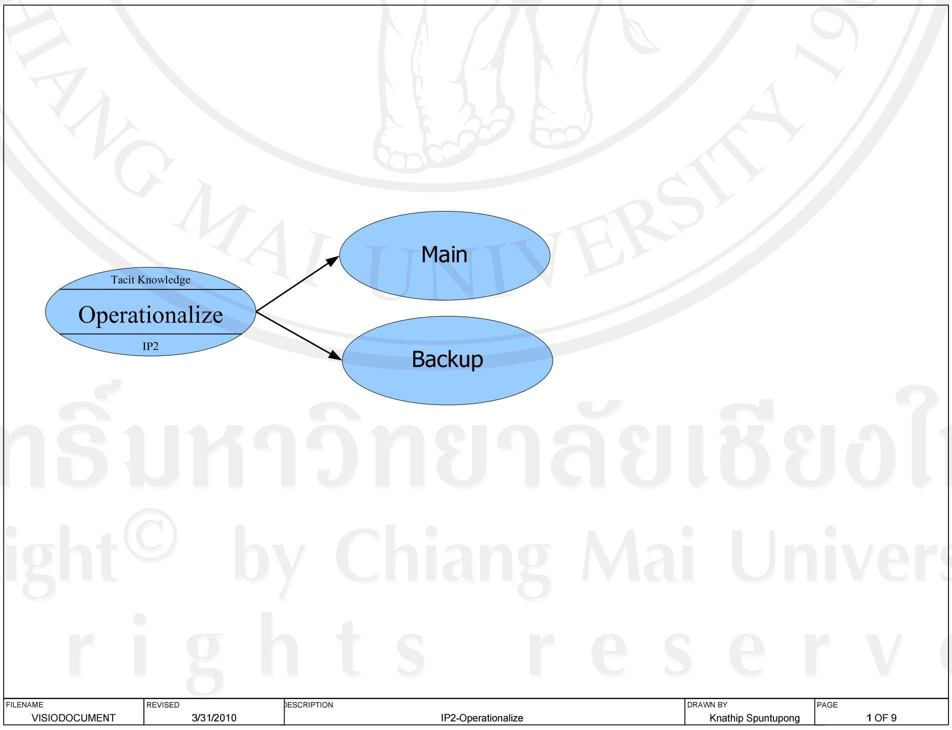

Figure 6.16: IP2-Operationalize

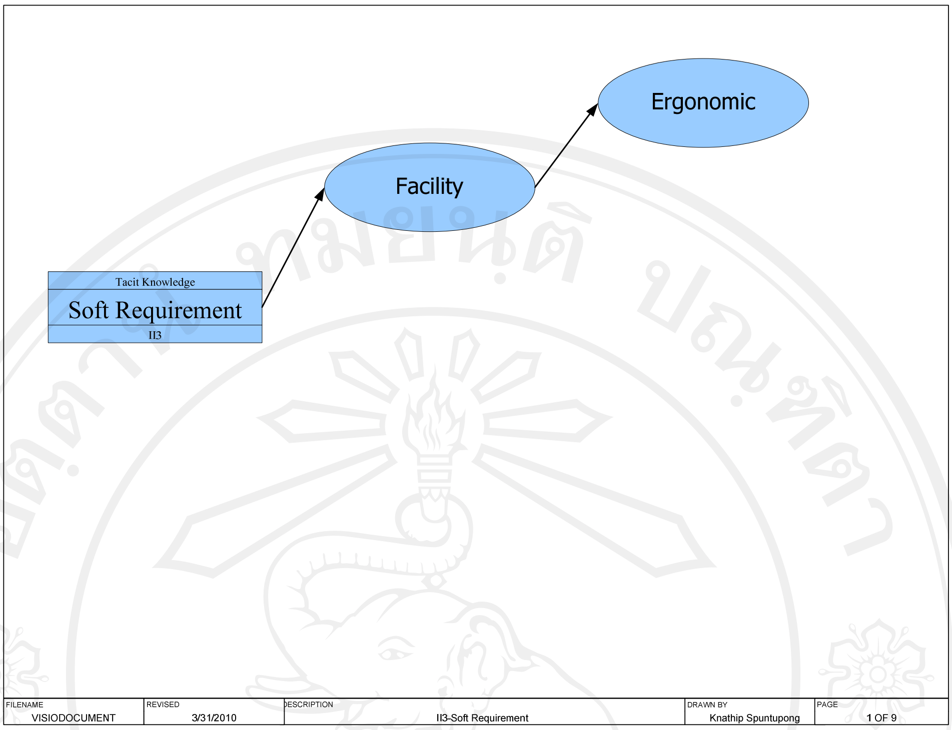

Figure 6.17: II3-Soft Requirement

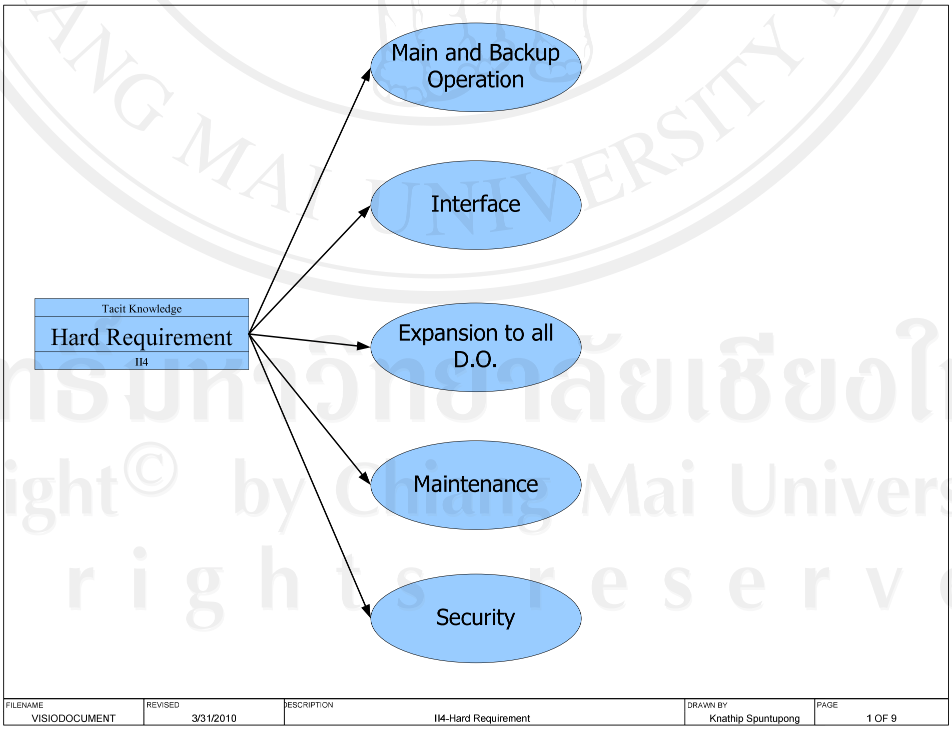

Figure 6.18: II4-Hard Requirement

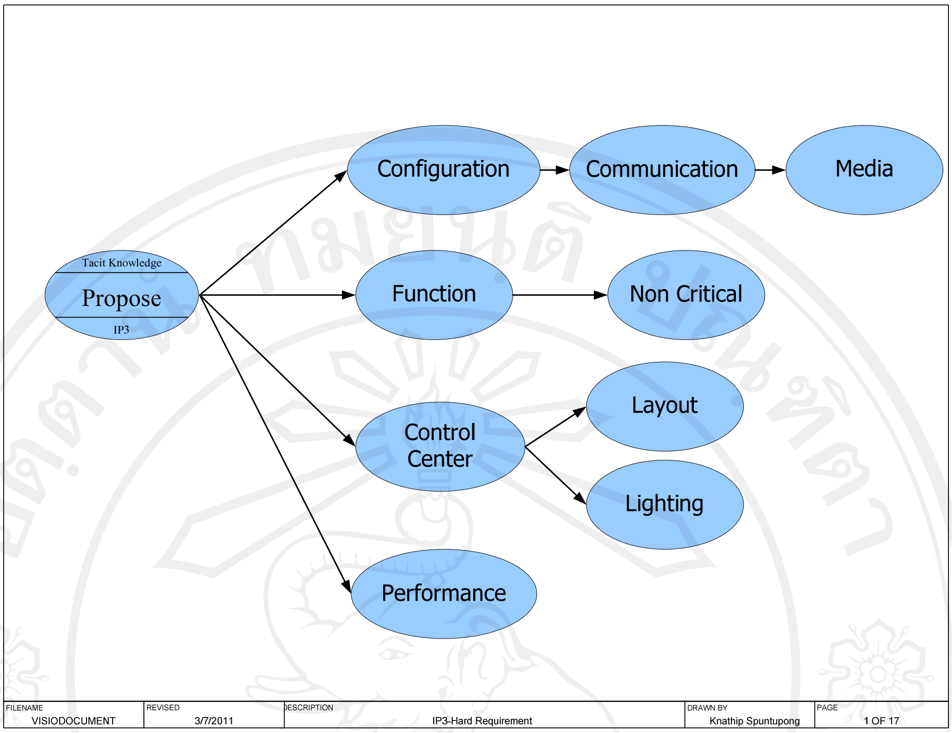

Figure 6.19: IP3-Propose

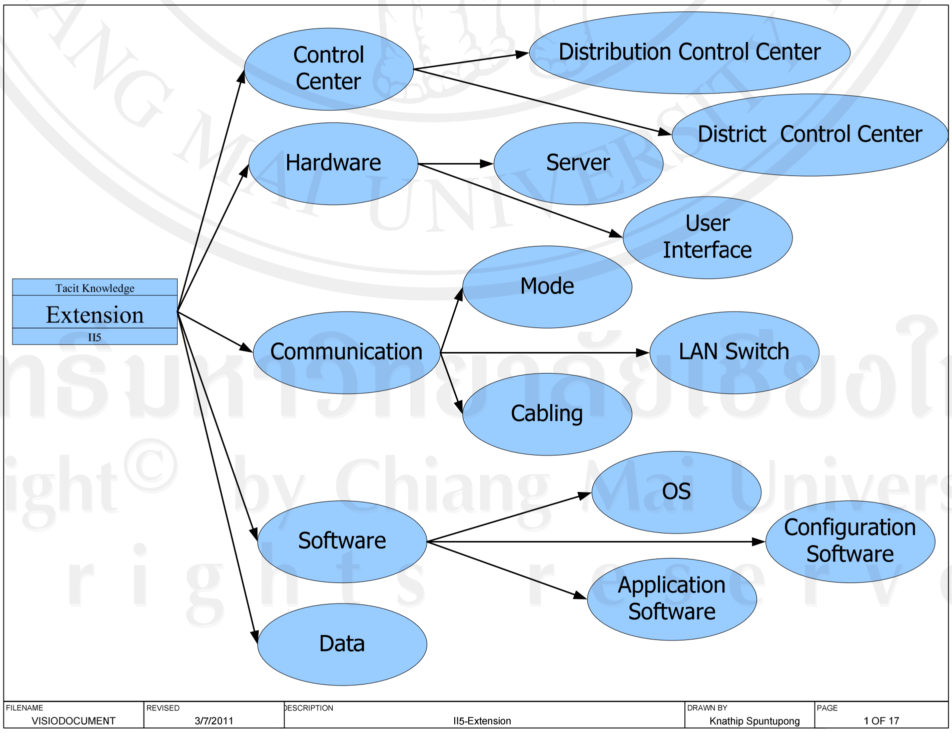

Figure 6.20: II5-Extension

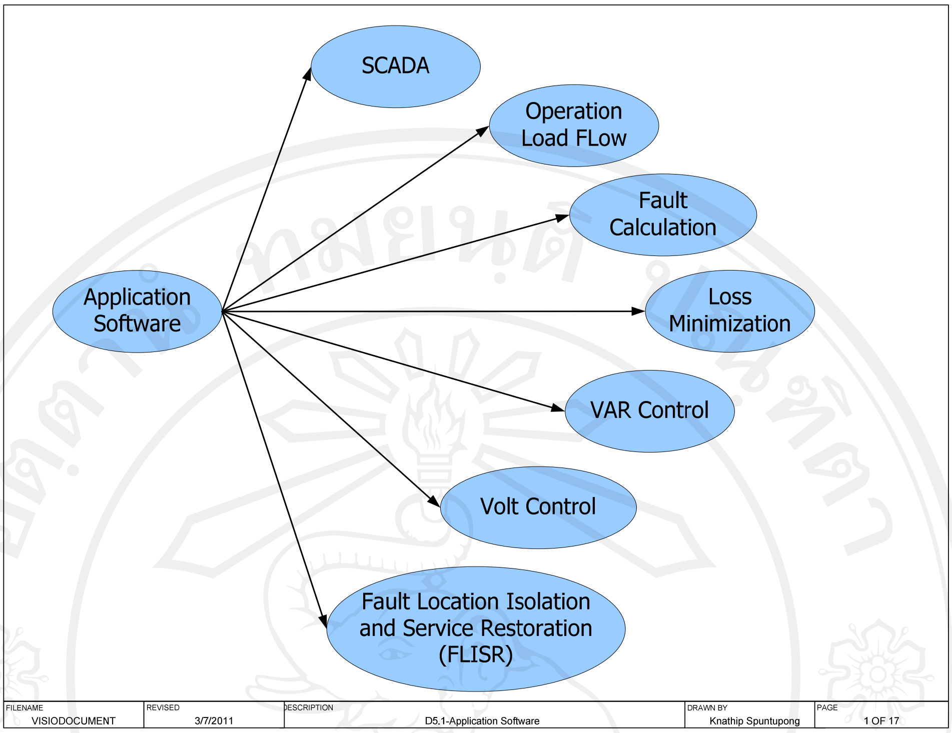

Figure 6.21: D5.1 Application Software

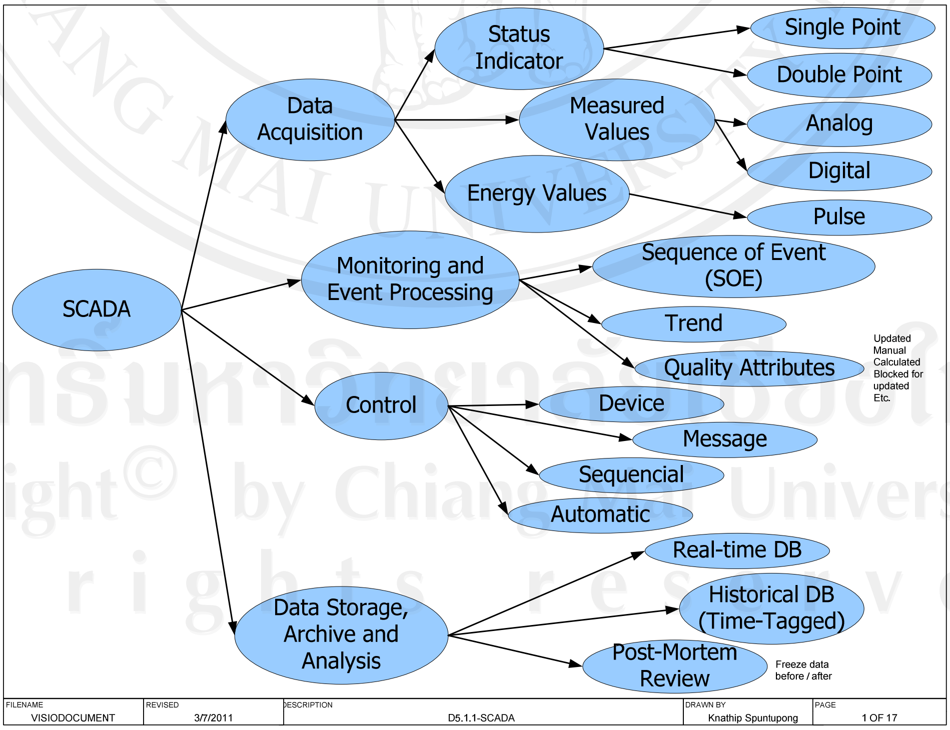

Figure 6.22: D5.1.1 SCADA

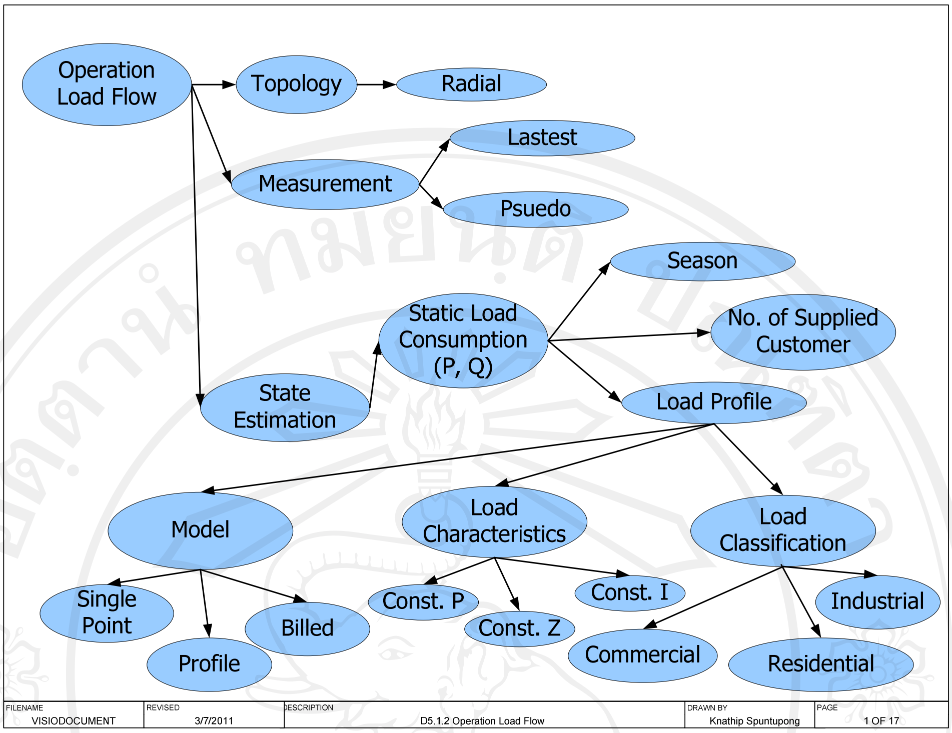

Figure 6.23: D5.1.2 Operation Load Flow

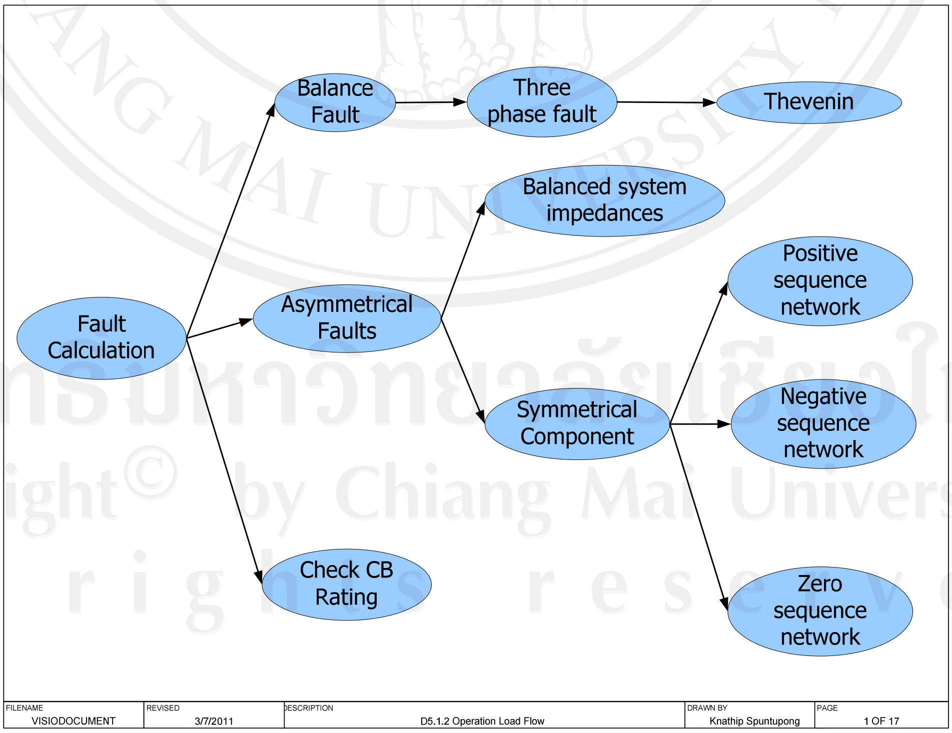

Figure 6.24: D5.1.3 Fault Calculation

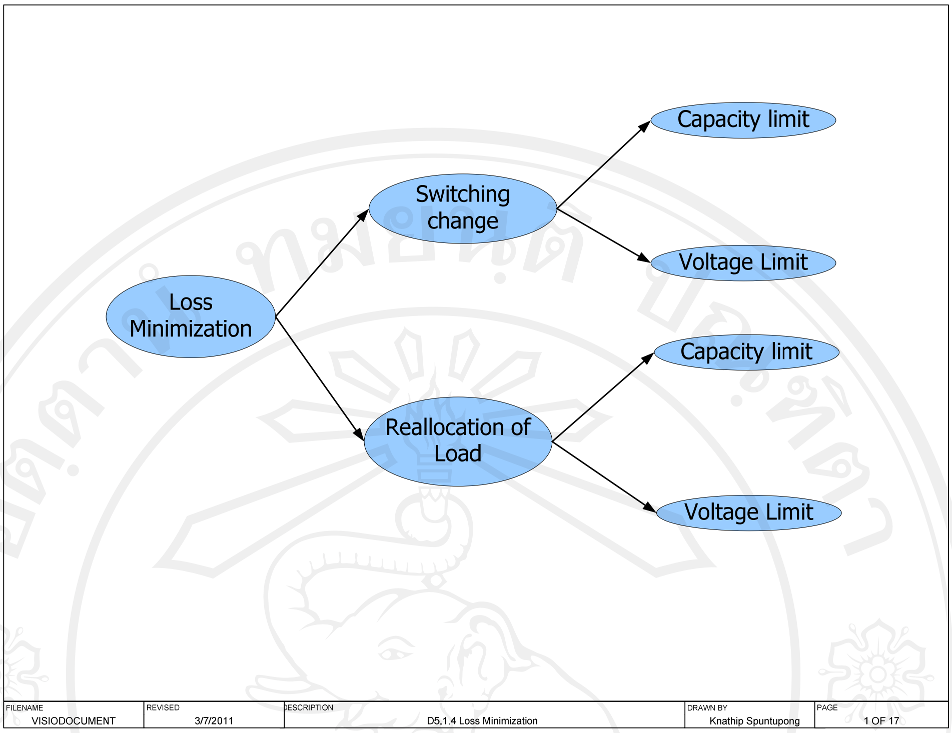

Figure 6.25: D5.1.4 Loss Minimization

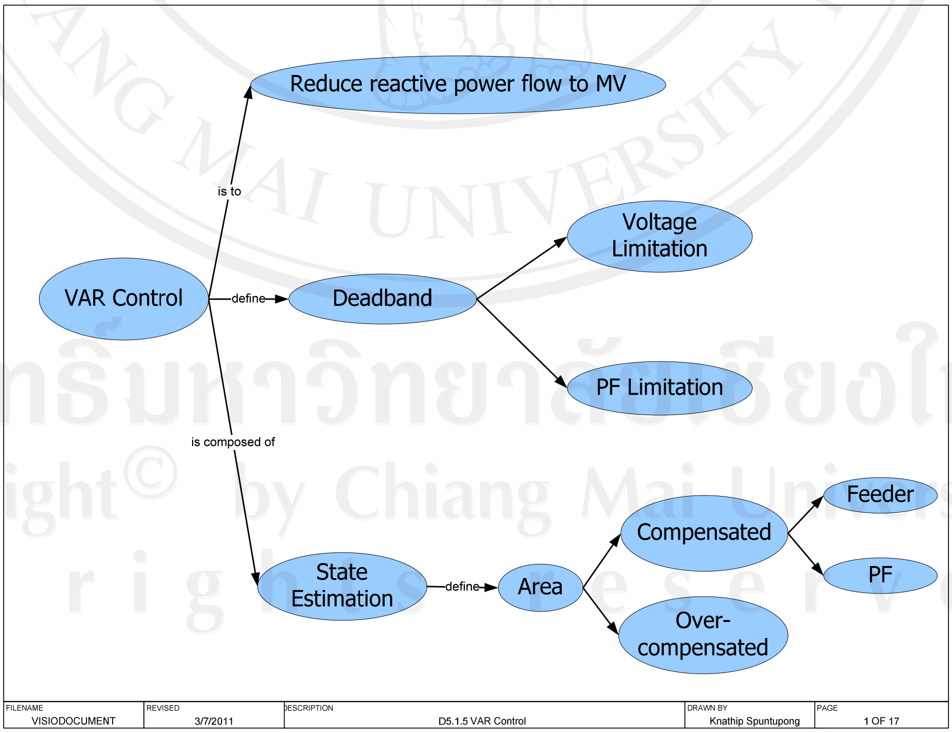

Figure 6.26: D5.1.5 VAR Control

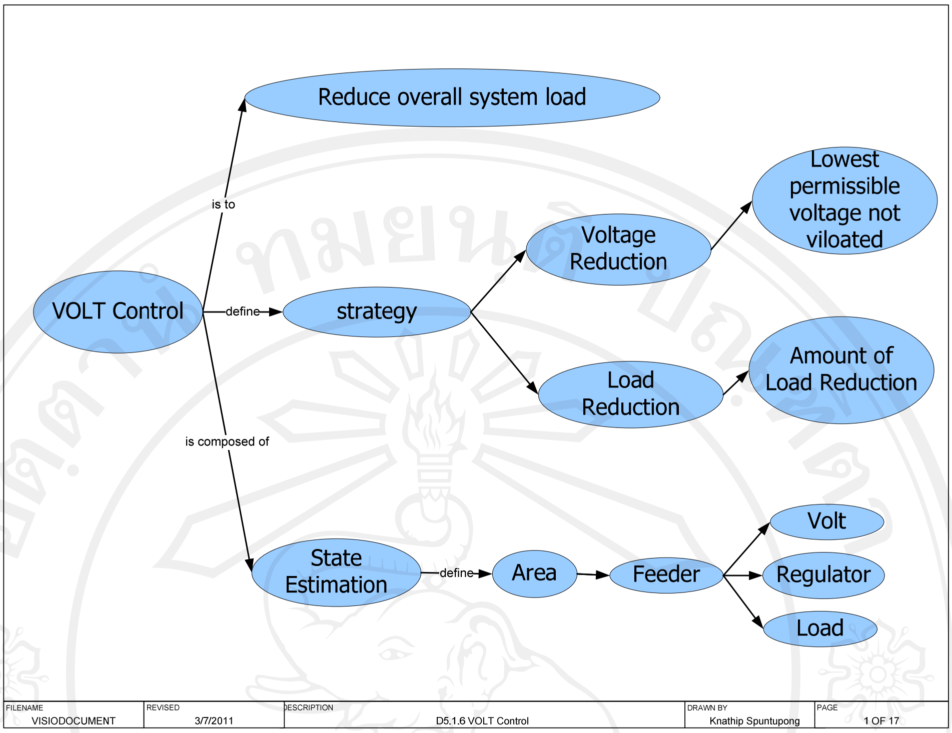

Figure 6.27: D5.1.6 VOLT Control

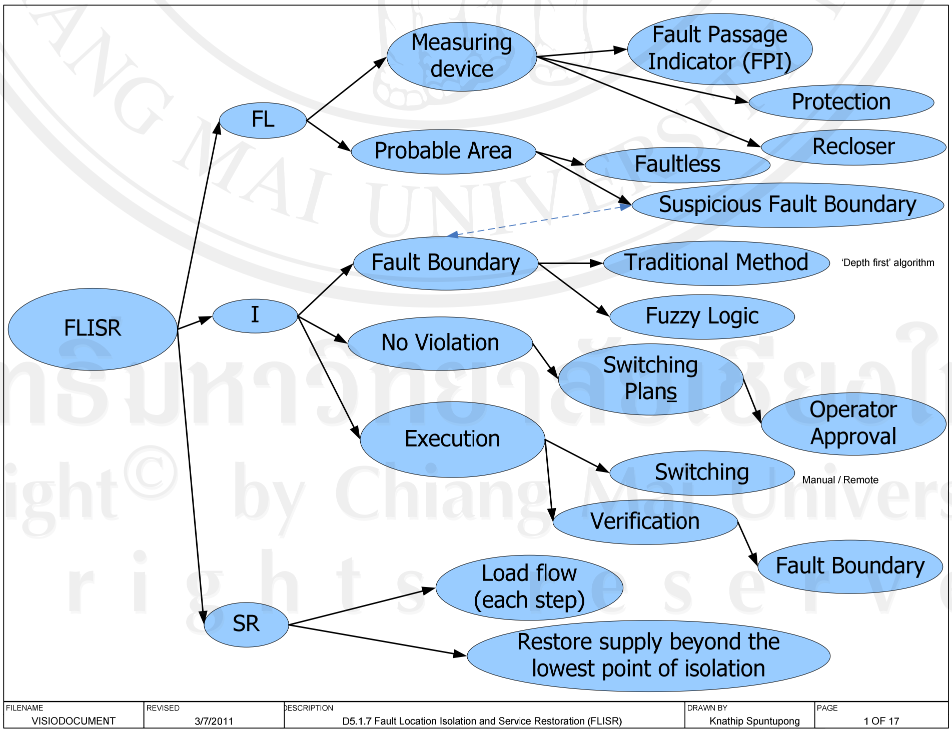

Figure 6.28: D5.1.7 Fault Location Isolation and Service Restoration

The inference DMS design knowledge can be captured from CommonKADS 'Propose and Revise' template, transcript into an information item, and model DMS design taxonomy. This inference DMS design knowledge is static and may not be completed as the first case but knowledge engineer can use this template as a powerful tool to repeat capturing more complete design knowledge. However, the example of DMS design in figure 6.29 can be used to prove the understanding of basic DMS design components with consult and supplier. Knowledge can be modeled, read and understood the model like the simple tense; for example, *"DMS design is required critical operating functions"*. *'Task'* is *'DMS Design'*. *'Inference'* is *'requirement'*. *'Domain'* are *'Critical operating functions'*. For this case we have three inference knowledge for DMS design. These are requirement, specify, and verify. And we can capture the domain knowledge which are hard requirement, soft requirement and propose DMS design at this time because the DMS is still in the procurement phase.

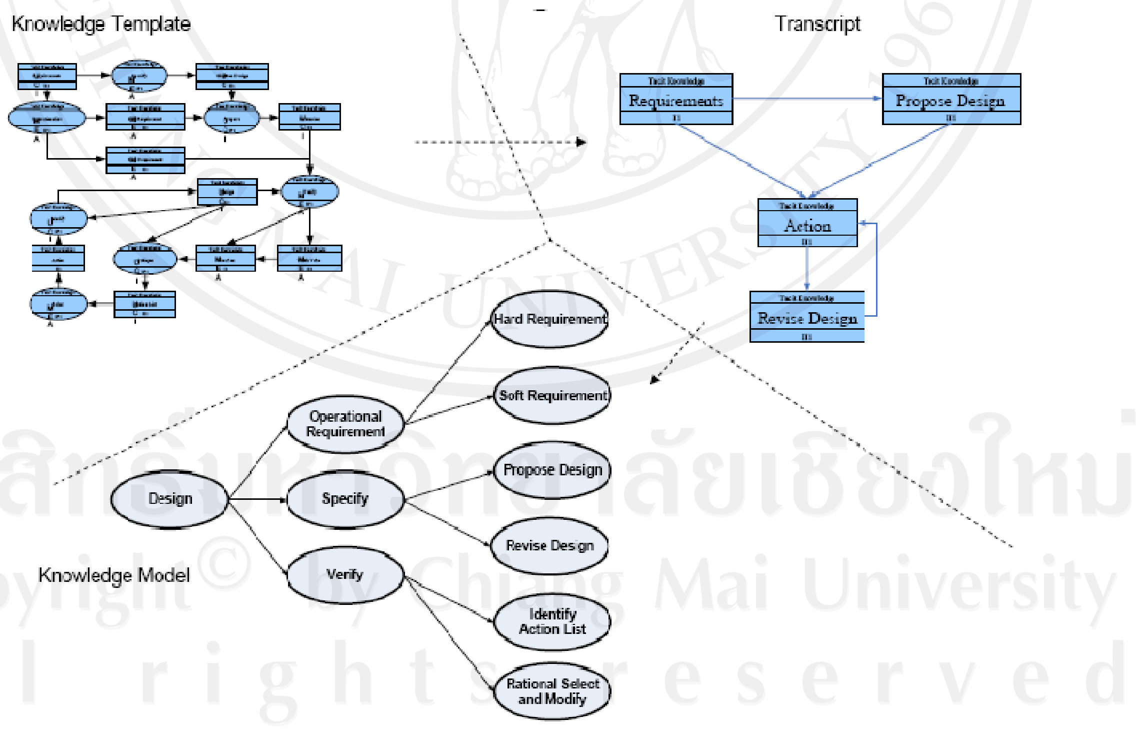

Figure 6.29: Knowledge Modeling Process

The requirement such as organization requirement, function requirement, facility requirement, and performance requirements of the DMS are shown in table 6.8. Then the skeleton design specification domain topics is identified in table 6.9 which are distribution feeder, control center, hardware, communication architecture, software, data, and document in order to get the required DMS.

Table 6.8: Requirement

Requirement	Description
Organization	Main and Backup control center
Function	To improve the overall technical and economical management of distribution system Right information at Right time Easy to operate and understand (Quality of control interface) Allow the network maintenance engineers to analyze a faulty part of network Control level of Voltage and frequency (Stability) Integrate Load Shedding Control systems have same time reference
Facility	Ergonomic Lighting Printing
Performance	IEC60870-4: Telecontrol equipment and system - Accuracy - Reliability (MTBF= MTTF+MTTR) - Availability (%) = (Total operating time – Cumulative downtime)*100/Total operating time Availability (Ability to perform its required function at given moment) ▪ Display call-up response time ▪ Display update time ▪ Operator request completion time ▪ Alarm and event response time ▪ Application completion time ▪ Application save case and retrieval time - Maintainability (Ability of the system or equipment under given condition) ▪ Steady state ▪ High activity state ▪ Overload state - Security and Safety (Ability to avoid placing the system in dangerous or unstable situation) ▪ Failover time

Table 6.9 Skeleton Design

Skeleton Design	Description
Typical Distribution Feeder	Primary Equipment (CB ,CT, PT, Recloser,Distribution transformer) RTU (Feeder, Substation) Communication system (Fiber Optic)

Control Center	Distribution Control Center District Control Center
Hardware	Server - SCADA - Display and Database (primary and backup at different location) - DMS Application (primary and secondary at different location) - Workstation - Communication - ICCP (may be included in other server) - Web - Develop and Test User Interface - Monitor (at least 3) - Wall Display (necessary at Distribution Control Center)
Communication Network Architecture	Mode (Master/Slave, Client and Server) LAN Switch (Managed, Unmanaged) Cabling (type and connection)
Software	OS (Unix, Linux, X-Window) Configuration Software Application Software - SCADA (Suprvisory Control, Data Acquisition, Block Load Shedding) - Dynamic Network Coloring, Navigation, Connectivity and Violation Resolution (State estimation, generate and update data from existing GIS) - Fault Location - Fault Isolation - Automatic Feeder Reconfiguration (Switching order management) - Volt and Var Control - Loss Reduction - Planned Outage - Off-line Network Analysis (Load Flow, Fault Analysis) - Off-line Training Simulator
Data	Model (CIM) static or dynamic Acquisition (Real-time, Historical) Generation Process Storage and Archive Modification and Update Backup and Recovery Exchange (XML, JAVA, 'ESRI' GIS data format)
Document	Scope of Work (include update and extension) Single Line Diagram System Architecture (open architecture) Equipment Layout Equipment and System Specification

DMS requirement in table 6.8 is used to develop DMS skeleton design in table 6.9. Utility will begin to understand and visualize their own DMS architecture, function and data management as illustrated in figure 6.30. This skeleton design consists of the control center and hardware as follows:

1. Main Control Center
2. Backup Control Center
3. Data Center
4. Region Control Centers

In each center the hardware configuration can be identified such as Data and Application Servers, Man Machine Interfaces (MMIs), Wall Displays, Ehernet switches, Firewall, and Printers.

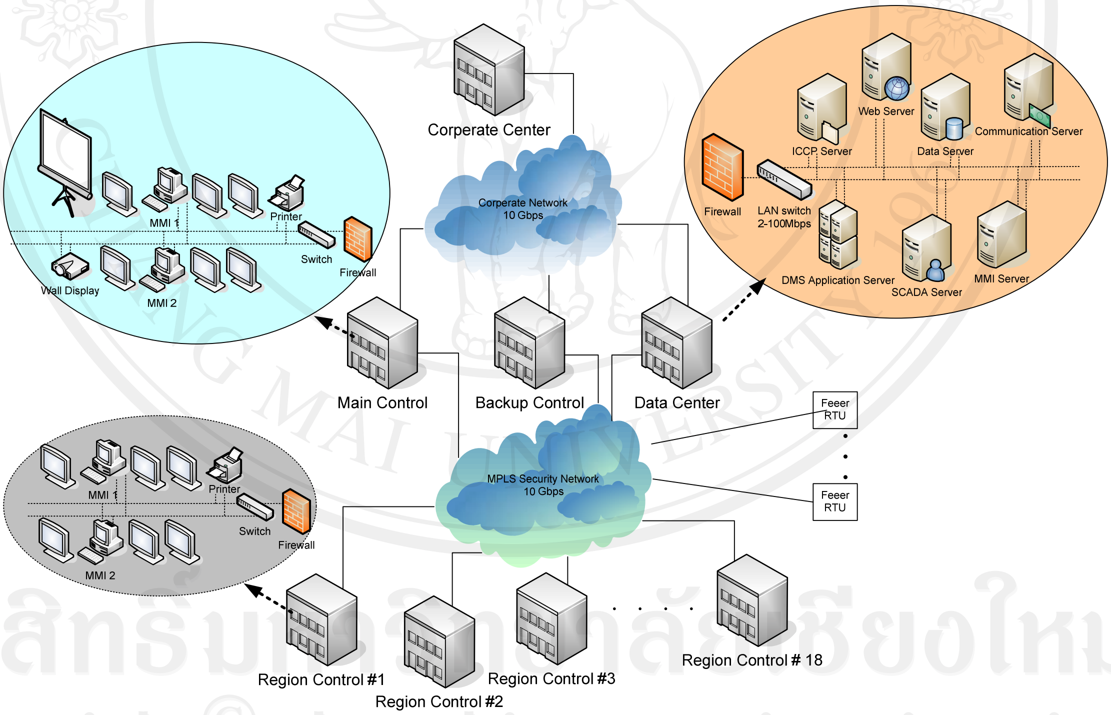

Figure 6.30: An example of DMS design

In normal operation, control functions are typically done at main control center. If main control center is down, backup control center will take its action suddenly. However, remote switching can be delegated to regional center in emergency operation. Its function can be simplified into critical and non critical. Critical functions such as data, application, configuration diagnostic, and switchover are allocated at data center.

The most important DMS application can be categorized into 4 main functions which are:-

- *Power Flow*: to compare with measurement and to see the power flow in each simulation
- *Short Circuit*: to prevent operation that exceeds the short circuit capacity of the equipment
- *Connectivity*: to see the overall connection routing and identify the feeder and switch
- *Switching Management*: to generate and guide switching sequences for operator
- *Training Simulator*: to train new operator how to use the system

Moreover, these applications must be interfaced and shared data with other applications. For example, from the protection and control view, autoreclose function is necessary for overhead system because temporary faults frequently happen. And the first primary feeder tapping position should be carefully identified in order to coordinate the operation times between fuse, earthfault relay and autoreclose function. However, these schemes must be switched 'off' when the disconnector switch (of the overhead distribution feeder or distribution transformer fuse) is switched manually to prevent the misoperation of earthfault relay and autoreclose function from this switch operation (single phase). DMS must know when to switch the feeder earth fault and autoreclose scheme 'on' or 'off'. So Data sharing between applications is essential.

Although Common Information Model (CIM) can be used to create central database which all applications are linked, this is not a solution. Generally there are different data structures existing in various applications both in data center such as SCADA, DMS application, GIS, and external such as CIS and ERP. The communication link between each enterprize applications should be well clearly visualized, understanded, and planned for the fully integration among those applications. Data interface between these applications can be done via messaging middleware where common interfaces or wrappers attach each application to message bus as shown in Figure 6.31.

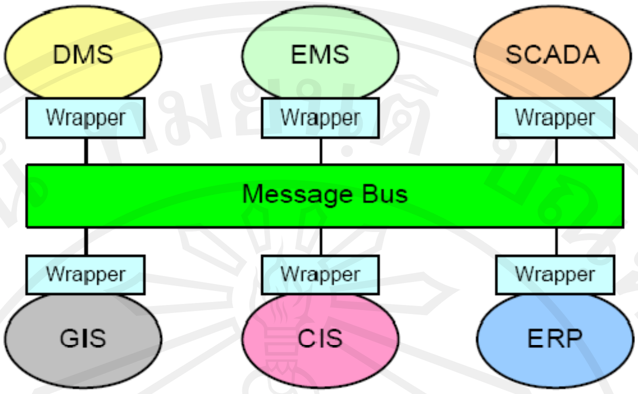

Figure 6.31: Message bus and Wrapper

In order to verify the DMS, the UML notation can also use to visualize the DMS control center in figure 6.32 and to model the DMS component in figure 6.33. There are many components in DMS which can be divided mainly into control center view, hardware view, and software view. So we can picture DMS for all of related person. When we know what is DMS, we can go on 'know how' and 'how to' design it. Figure 6.34 shows the reliability calculation domain schema for hardware component that compose to the DMS system. We can know the reason of the hardware selection and the hardware configuration from this domain knowledge with related to the DMS system requirement. Other domain schema such as system performance can be modeled in the same way in figure 6.35.

One master control station can control more than three area control station. And one area control station can monitor and control more than five feeder RTUs. The DMS hardware system may compose of use interface, application server, data server, and communication server. User interface or Man Machine Interface is used for operator to monitor and control the distribution system. Application servers may consist of Distribution Operation Analysis server, SCADA server, DMS server, and Fault Location server. Data server may be divided into real time and historical. And lastly the DMS hardware must be composed of communication server.

Performance requirement such as reliability and transfer time can be calculated as the domain schema showing. Calculation formulas and details are given in appendix C.

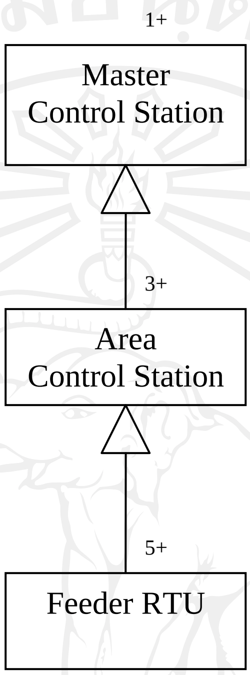

Figure 6.32: DMS Control Center

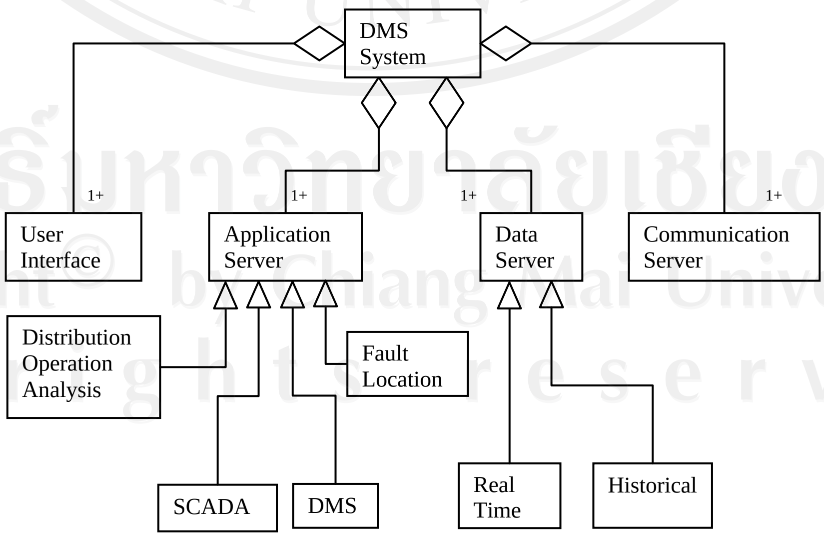

Figure 6.33: DMS Composition

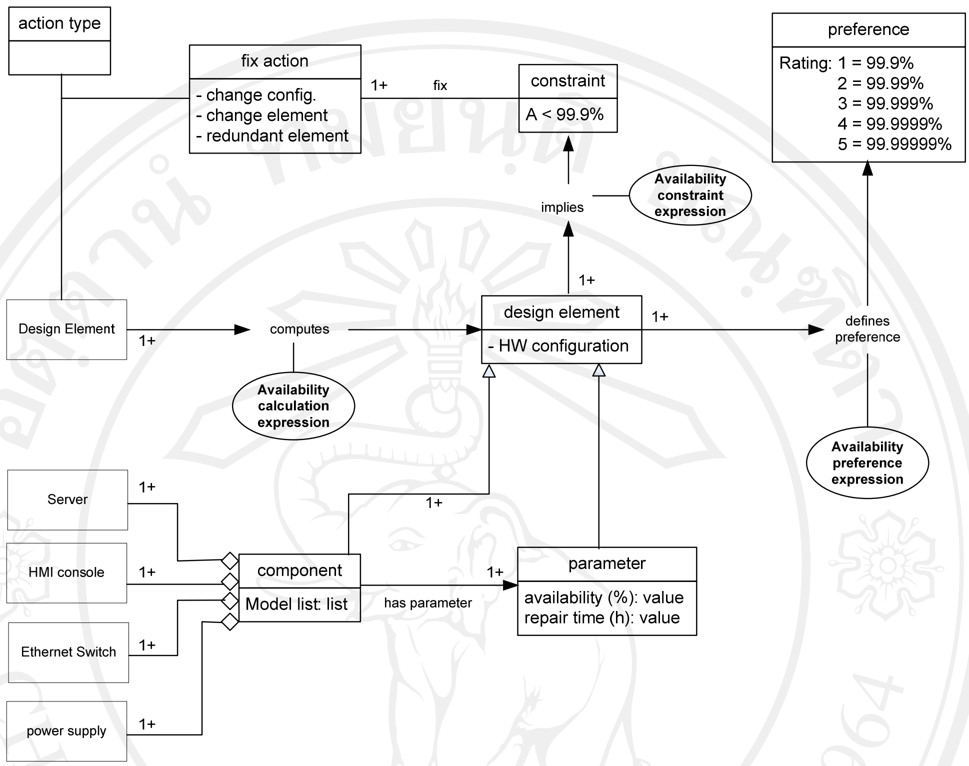

Figure 6.34: Domain Schema for Reliability Calculation

The DMS design procedure in this study is structure, simple, and reasonable. The process is not subjective to only consultant. Because of using CommonKADS template, this design knowledge can be systematically made explicit, extended, and reused rather than strictly reading from a consultant guideline to find and identify design knowledge from book to chapter and from chapter to theory or concept. Even though CommonKADS provides a standard tool such as 'blackboard' to search and model 'knowledge', this research uses knowledge engineer as a worker for this modeling job. Another hugh advantage of the above DMS knowledge model is that in short-term basis it gives the utility more capability to better manage the DMS project with the consultant. More specifically, in each project or progress meeting between utility and consultant, important issues can be brought up for discussion and evaluation.

At the beginning, this design may be not complete and perfect like consultant work because of many difficulties such as knowledge gap between expert and interviewer, and communication environment. However, the next case will try to model communication among utility, consult, and supplier.

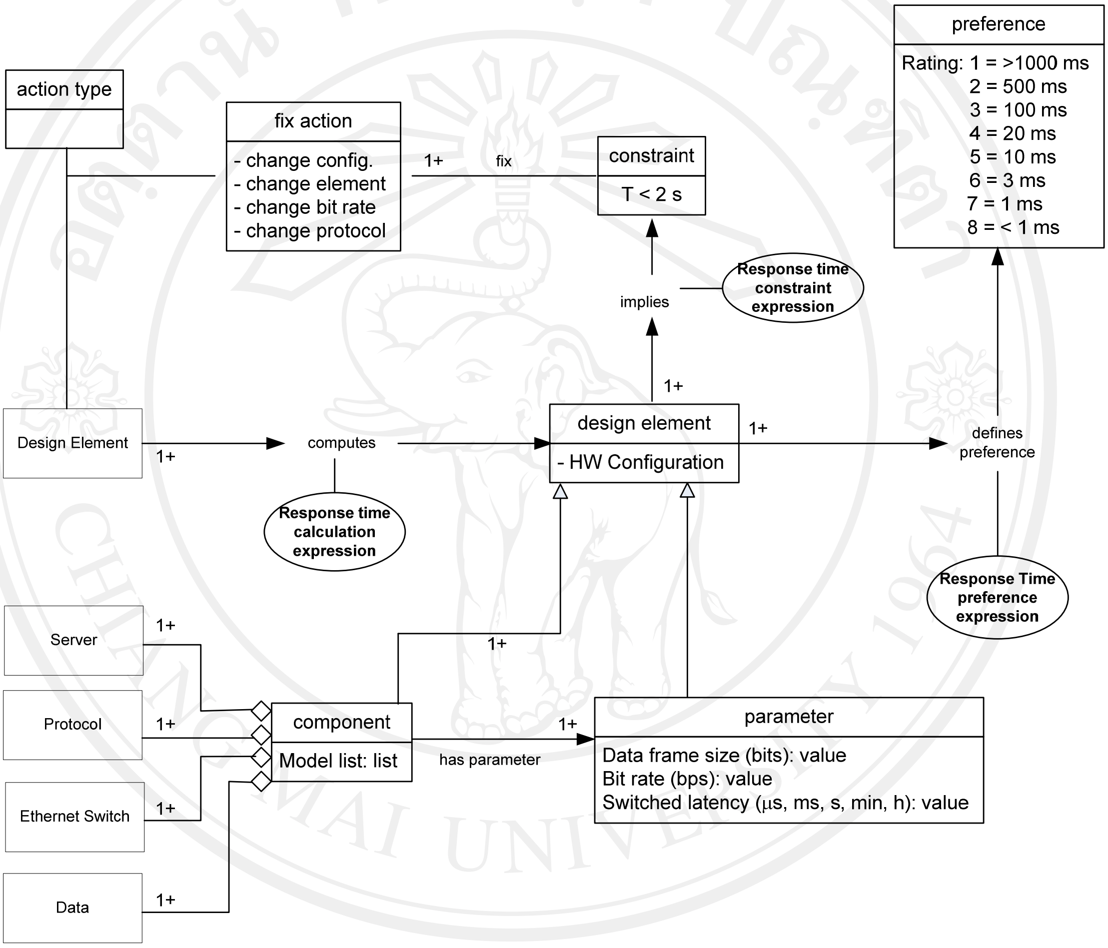

Figure 6.35: Domain Schema for Response Time

6.3 Case 3 Proposed DMS Design Communication Model

This case uses communication model to create the process and tool to identify the necessary information for DMS design and plan the transaction and worksheet to collect it. In the previous case, this research shows the constructed DMS knowledge model which provides the platform for the utility to retain and reuse the DMS design knowledge, and to become better project management in short-term basis. In this case study, this research proposes additional model by which the knowledge of the consultant can be systematically captured during the project. It is seen that with this DMS communication model the utility can capture the knowledge from the consultant, retain the knowledge within the organization and reuse when required. This eventually results in more DMS capability in the long-term basis. This can be done next from the inference knowledge in the second case and from context analysis which we know task model, agent model, and organization model for DMS design. Figure 6.36 shows the communication plan for DMS design which has the transaction to communicate among utility, consult, and supplier. With the first phase of DMS design, the communication plan is only between utility and consult on the left side. Each transaction plan is for exchange an information object between agent (consult and utility). Utility has requirements, technical and system knowledge while consult has both technical and solution knowledge.

From the communication plan for DMS design in this case, there are seven transactions between utility and consult and five transactions between consult and suppliers which should be done later. The transaction between consult and supplier will be done after getting the DMS procurement phase. In this phase seven transactions between utility and consult which are:

Transaction no. 1: 'Hard Requirement' from utility to consult

Transaction no. 2: 'Soft Requirement' from utility to consult

Transaction no. 3: 'Design Extension' from consult to utility

Transaction no. 4: 'Design Verification' from utility to consult

Transaction no. 5: 'Design Choice' from consult to utility

Transaction no. 6: 'Design Selection' from utility to consult

Transaction no. 7: 'Configuration Design' from consult to utility

The information exchange specification in each transaction can be shared and exchanged in order to collaborate among the related design team. It should be sincerely win-win solution. Utility must tell exactly what they need as well as consult really explains the criteria of selecting an appropriate technology and system.

This knowledge from both sides can be shared by using transaction description and information exchange specification worksheet in table 6.10 and 6.16. Operation hard requirement for DMS can be identified and put into DMS knowledge model. The objective of this comunication model is the sharing and exhanging channel for related design team to accomplish the demanding design.

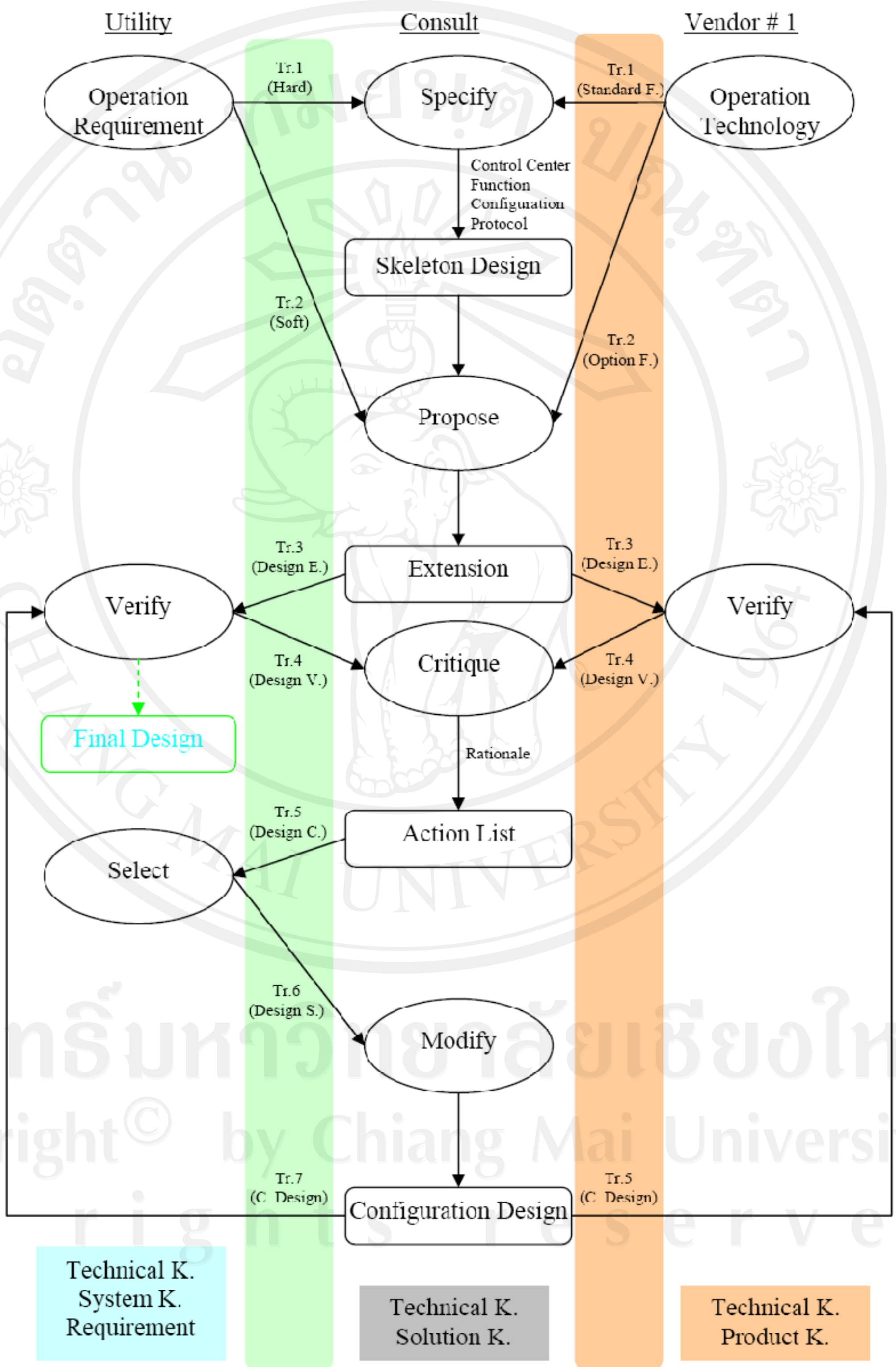

Figure 6.36: Communication Plan

This should be sincerely win-win solution for every party in the project. With this communication, better project management for DMS implementation can be achieved in short term and DMS design knowledge model can be more supportive and may complete in the future. Nevertheless, the communication security should be considered in order to keep some secret information only in the relevant organization.

Table 6.10: Transaction no.1 'Hard Requirement'

Communication Model	**Transaction Description Worksheet CM-1**
Transaction	'Hard Requirement'
Information Object	Operational hard requirement (1) Functions e.g. on-offline mode (2) Performance e.g. resolution time (3) Safety (4) Guideline (5) Interface
Agent Involved	Utility ▪ Manager ▪ Planner ▪ Dispatcher (control center) ▪ Operator (district office) ▪ Analyzer (Engineer) ▪ Maintenance personnel Consult
Communication Plan	DMS Design (Utility-Consult)
Constraints	transaction period VS project schedule
Information Exchange Specification	See CM-2

Communication Model	**Information Exchange Specification Worksheet CM-2**
Transaction	'Hard Requirement'
Agents Involved	Sender: Utility Receiver: Consult
Information Items	(1) Role: all 5 items are *core*, no *support* items (2) Form: map (area, route), diagram (switching), documents (instruction, questionnaire), (3) Medium: meeting room, email
Message Specifications Operation hard requirement	 Communication Type: INFORM Content: ▪ Function (online, offline) ▪ Performance (Resolution time) ▪ Safety issue ▪ Guideline needs

	▪ Interface Reference: all utility agents (manager, dispatcher,…) From: Utility To: Consult
Control over Messages	

Table 6.11: Transaction no. 2 'Soft Requirement'

Communication Model	**Transaction Description Worksheet CM-1**
Transaction	'Soft Requirement'
Information Object	Operational soft requirement (1) Facility
Agent Involved	Utility ▪ Manager ▪ Planner ▪ Dispatcher (control center) ▪ Operator (district office) ▪ Analyzer (Engineer) ▪ Maintenance personnel Consult
Communication Plan	DMS Design (Utility-Consult)
Constraints	transaction period VS project schedule
Information Exchange Specification	See CM-2

Communication Model	**Information Exchange Specification Worksheet CM-2**
Transaction	'Soft Requirement'
Agents Involved	Sender: Utility Receiver: Consult
Information Items	(1) Role: *support* items (2) Form: drawing, documents (instruction, questionaire), (3) Medium: meeting room, email
Message Specifications Operation soft requirement	Communication Type: INFORM Content: ▪ Function (online, offline) ▪ Performance (Resolution time) ▪ Safety issue ▪ Guideline needs ▪ Interface Reference: all utility agents (manager, dispatcher,…) From: Utility To: Consult
Control over Messages	

Table 6.12: Transaction no. 3 'Design Extension'

Communication Model	**Transaction Description Worksheet CM-1**
Transaction	'Design Extension'
Information Object	Conceptual Design, Scope, and Budget on (1) Control Center (2) Hardware (3) Communication (4) Software (5) Data
Agent Involved	Utility ▪ Manager ▪ Planner ▪ Dispatcher (control center) ▪ Operator (district office) ▪ Analyzer (Engineer) ▪ Maintenance personnel Consult
Communication Plan	DMS Design (Utility-Consult)
Constraints	transaction period VS project schedule
Information Exchange Specification	See CM-2

Communication Model	**Information Exchange Specification Worksheet CM-2**
Transaction	'Design Extension'
Agents Involved	1. Sender: Consult 2. Receiver: Utility
Information Items	(1) Role: all 5 items are core, no support items (2) Form: map (area, route), diagram (switching), drawing, design calculation (3) Medium: meeting room, email
Message Specifications Design Extension	 Communication Type: ASK Content: ▪ Scope ▪ Specification ▪ Budget Reference: all utility agents (manager, dispatcher,…) From: Consult To: Utility
Control over Messages	

Table 6.13: Transaction no. 4 'Design Verification'

Communication Model	**Transaction Description Worksheet CM-1**
Transaction	'Design Verification'
Information Object	Comment on (1) Control Center (2) Hardware

	(3) Communication (4) Software (5) Data
Agent Involved	Utility ▪ Manager ▪ Planner ▪ Dispatcher (control center) ▪ Operator (district office) ▪ Analyzer (Engineer) ▪ Maintenance personnel Consult
Communication Plan	DMS Design (Utility-Consult)
Constraints	transaction period VS project schedule
Information Exchange Specification	See CM-2

Communication Model	**Information Exchange Specification Worksheet CM-2**
Transaction	'Design Verification'
Agents Involved	Sender: Utility Receiver: Consult
Information Items	(1) Role: all 5 items are *core*, no *support* items (2) Form: documents, drawing (3) Medium: meeting room, email
Message Specifications Design Verification	 Communication Type: REPLY Content: ▪ Availability ▪ Performance (Resolution time) ▪ Dimension, layout and location ▪ System interface ▪ System extension ▪ Safety issue Reference: all utility agents (manager, dispatcher,…) From: Utility To: Consult
Control over Messages	

Table 6.14: Transaction no. 5 'Design Choice'

Communication Model	**Transaction Description Worksheet CM-1**
Transaction	'Design Choice'
Information Object	Alternative # ▪ Advantages ▪ Disadvantages
Agent Involved	Utility ▪ Manager ▪ Planner ▪ Dispatcher (control center)

	▪ Operator (district office) ▪ Analyzer (Engineer) ▪ Maintenance personnel Consult
Communication Plan	DMS Design (Utility-Consult)
Constraints	transaction period VS project schedule
Information Exchange Specification	See CM-2

Communication Model	**Information Exchange Specification Worksheet CM-2**
Transaction	'Design Choice'
Agents Involved	(4) Sender: Consult (5) Receiver: Utility
Information Items	(4) Role: all items are *core*, no *support* items (5) Form: drawings, documents, calculation (6) Medium: meeting room, email
Message Specifications Design Choice	 Communication Type: OFFER Content: ▪ Function (online, offline) ▪ Performance (Resolution time) ▪ Safety issue ▪ Guideline needs ▪ Interface Reference: all utility agents (manager, dispatcher,…) From: Consult To: Utility
Control over Messages	

Table 6.15: Transaction no. 6 'Design Selection'

Communication Model	**Transaction Description Worksheet CM-1**
Transaction	'Design Selection'
Information Object	Selected Design (based on reason) ▪ Performance ▪ Budget ▪ etc.
Agent Involved	Utility ▪ Manager ▪ Planner ▪ Dispatcher (control center) ▪ Operator (district office) ▪ Analyzer (Engineer) ▪ Maintenance personnel Consult
Communication Plan	DMS Design (Utility-Consult)
Constraints	transaction period VS project schedule
Information Exchange Specification	See CM-2

Communication Model	Information Exchange Specification Worksheet CM-2
Transaction	'Design Selection'
Agents Involved	(1) Sender: Utility (2) Receiver: Consult
Information Items	(1) Role: all items are *core*, no *support* items (2) Form: documents (checklist) (3) Medium: meeting room, email
Message Specifications Design Selection	Communication Type: INFORM Content: ▪ Function (online, offline) ▪ Performance (Resolution time) ▪ Safety issue ▪ Guideline needs ▪ Interface Reference: all utility agents (manager, dispatcher,…) From: Utility To: Consult
Control over Messages	

Table 6.16: Transaction no. 7 'Configuration Design'

Communication Model	Transaction Description Worksheet CM-1
Transaction	'Configuration Design'
Information Object	Design, Scope, and Budget on (1) Control Center (2) Hardware (3) Communication (4) Software (5) Data
Agent Involved	Utility ▪ Manager ▪ Planner ▪ Dispatcher (control center) ▪ Operator (district office) ▪ Analyzer (Engineer) ▪ Maintenance personnel Consult
Communication Plan	DMS Design (Utility-Consult)
Constraints	transaction period VS project schedule
Information Exchange Specification	See CM-2

Communication Model	Information Exchange Specification Worksheet CM-2
Transaction	'Configuration Design'
Agents Involved	(6) Sender: Consult

	(7) Receiver: Utility
Information Items	(4) Role: all items are *core*, no *support* items (5) Form: map (area, route), diagram (switching), documents (instruction, questionnaire) (6) Medium: meeting room, email
Message Specifications Configuration Design	Communication Type: OFFER Content: ▪ Function (online, offline) ▪ Performance (Resolution time) ▪ Safety issue ▪ Guideline needs ▪ Interface Reference: all utility agents (manager, dispatcher,…) From: Consult To: Utility
Control over Messages	

From the content in transaction no. 3, 5, 7 which are ‘Design Extension’, Design Choice’, and ‘Configuration Design’, we add the table to help utility to understand the reason from consult according to table 6.17 to 6.19. This will help utility to know each decision making for DMS design and it will be transparent for both utility and supplier. In the future DMS supplier will share this information and get the benefit of selecting an appropriate solution.

Table 6.17: Design Extension Explanation

Extension Item	Causes	Advantages	Disadvantages	Remarks
Distribution Contingency Analysis	Faults in switchable section	- Maximum customer restoration - Minimum switching operation - No overload in backup feeder - Minimum losses - Acceptable voltage	-	Pre and post-fault power flow calculation
FLISR	Faults in switchable section	- Maximum restoration - No overload - Acceptable voltage - Minimize switching operation - Minimum losses	-	Find optimum switching order in advisory mode
Multi-level feeder reconfiguration	- Hundreds of interconnected	- Service restoration - Overload elimination	-	Optimization of nomally open points in

	feeders - Thousand of switches	- Loss minimization - Voltage balancing - Reliability improvement		multiple feeders

Table 6.18: Design Choice Explanation

Topics: 'Control Center Architecture'				
Alternative name	**Description**	**Advantages**	**Disadvantages**	**Ranking (1-5)**
1. Centralized	All databases and servers are in control center	- Database and Display maintenance is minimized - No time skew	- Single point of failure - Require circuit router	3 (Fair)
2. Client/Server	Peer to Peer	- Database and Display maintenance is minimized - No time skew - Separate backup center not required	- Require circuit router	5 (Best)
Topics: 'Master Station Computer'				
Alternative name	**Description**	**Advantages**	**Disadvantages**	**Ranking (1-5)**
1. Workstation	High-end computer	Higher performance esp. graphics, processing power and multi-tasking	Expensive	-
2. PC-based hardware	Personal Computer	Economical	-	-

Table 6.19: Configuration Design Explanation

Configuration Item	Specification	References or Rationale
Control Center Architecture	Client/Server	Ranking in Table 6.9
Master Station Computer	Workstation or PC-based hardware	Depend on vendor standard product or utility corperate preference

Together with communication model propose in this case, the dynamic procedure to capture, store, and reuse the design knowledge is possible. Utility can begin to 'know how' and 'how to' design DMS in order to operate and maintain the system properly. The last case will show the knowledge management system for DMS design which can support all related agents in the design organization.

6.4 Case 4 Proposed DMS Knowledge Management System

This case uses all DMS design model of knowledge engineering methodology (context model, knowledge model, and communication model) from the previous three cases to propose the IT-based Knowledge Management System for DMS design in MEA. This is the transition phase between the knowledge engineer who perform the context and concept level of the DMS design knowledge (case 2 and case 3), and the knowledge system developer who will implement the IT-based knowledge management system for DMS design (this case). The system specification will be consisted of the Requirement Specification (RS), the Function Specification (FS), the Design Specification (DS), the System Specification (SS), and the Function Test Specification (FT) as follows:

1. Requirement

RS-1 Support knowledge creation

- RS-1.1 Provide opportunity (Refer to FS-1.2, FS-4.3)
- RS-1.2 Create knowledge card (Refer to FS-2)
- RS-1.3 Add contact (Refer to FS-1.1)

RS-2 Support knowledge sharing

- RS-2.1 Push/Pull news system (Refer to FS-3)
- RS-2.2 Calender system (Refer to FS-4.1, FS-4.2)
- RS-2.3 Display knowledge card (Refer to FS-2)
- RS-2.4 Display users (Refer to FS-1.1)

RS-3 Support knowledge reuse

- RS-3.1 Search opportunity (Refer to FS-3, FS-4)
- RS-3.2 Search knowledge card (Refer to FS-2.2, FS-8)
- RS-3.3 Search contact (Refer to FS-1.1)

RS-4 Support information storage (Refer to FS-1)

RS-5 Support communication

- RS-5.1 Text communication (Refer to FS-5)
- RS-5.2 Voice and video communication (Refer to FS-6)

RS-6 Support Users' Personalization (Refer to FS-7)

RS-7 Support Users's Visualization (Refer to FS-1)

RS-7 Support Knowledge System Management (Refer to FS-1)

2. Function Specification

FS-1 Administrative Functions

FS-1.1 Manage User

FS-1.2 Manage News: Push/ Pull information

FS-1.3 Manage Opportunity: Cooperative Calendar

FS-2 Knowledge Card Functions

FS2.1 Knowledge Card

FS2.1 Knowledge Map Search

FS-3 Push/ Pull News Functions

FS-4 Cooperative Calendar Functions

FS-4.1 Display Week Calendar

FS-4.2 Display Month Calendar

FS-4.3 Add New Event to Calendar

FS-5 Live Chat Functions

FS-6 Video Conference Functions

FS-6.1 Broadcast video to online users

FS-6.2 Display online users in the conference room

FS-7 Widget Functions: *Allow user to personalize information from KMS*

FS-7.1 Customizable knowledge map search

FS-7.2 Customizable news view

FS-7.3 Customizable calendar view

FS-7.4 Customizable users' view

FS-8 Advanced Search functions

FS-8.1 Knowledge card search

FS-8.2 Content search

FS-8.3 Forward inference search

FS-8.4 Backward inference search

3. Design Specification

DS-1 View Only Level

DS-1.1 Top Menu Frame

- Home, Users' map, Calendar

DS-1.2 Main Content Frame

- Portal (Refer to RS-2: FS-3)
- Users' map (Refer to RS-2: FS-1)
- Calender (Refer to RS-2: FS-4)

DS-2 Knowledge Provider

DS-2.1 Top Menu Frame

- Home, Users' map, Calendar, Knowledge Card, Advanced Search

DS-2.2 Main Content Frame (Extended from DS-1.2)

- Knowledge Card (Refer to RS-1.2: FS-2)
- Advanced Search (Refer to RS-3.2: FS-8)

DS-3 User Level

DS-3.1 Top Menu Frame

- Home, Users' map, Calendar, Knowledge Card, Advanced Search

DS-3.2 Main Content Frame (same as DS-2.2)

DS-3.2 Widget

- Search (Refer to RS-6, RS-7: FS-7.1)
- News (Refer to RS-6: FS-7.2)
- Events (Refer to RS-6: FS-7.3)
- Users (Refer to RS-5: FS-4)

DS-4 Administrator Level

DS-4.1 Top Menu Frame

- Home, Users' map, Calendar, Knowledge Card, Advanced Search, Administrator Control Panel

DS-4.2 Main Content Frame (Extended from DS-3.2)

- News Management (Refer to RS-1.1: FS-1.2)
- Subscriber Management (Refer to RS1.1: FS-1.2)
- Community Management (Refer to RS-1.3: FS-1.1)

4. System Specification

SS-1 Hardware Specification

SS-1.1 Server Specification

- Processor: Intel Pentium4 3.0 GHz minimum
- Memory (RAM): 2048 MB recommended
- Etc.

SS-1.2 Client Specification

- Processor: Intel Pentium4 3.0 GHz minimum
- Memory (RAM): 2048 MB recommended
- Etc.

SS-2 Software Specification

SS-2.1 Server Specification

KMS Server (Linux)

- Apache Web Server
- MySQL
- Red5 flash server

SS-2.2 Client Specification

- Microsoft Internet Explorer 6.0
- Adobe Flash Player 9.0 plug-in
- Adobe AIR Installer

5. Function Test Specification

FT-1 Administrative Functions

FT-2 Knowledge Card Functions

FT-3 Push/ Pull News Functions

FT-4 Cooperative Functions

FT-5 Live Chats Functions

FT-6 Video Conference Functions

FT-7 Widget Functions

FT-8 Advanced Search Functions

Then knowledge management system from agent model, knowledge model, and communication model can be architected for *Users, Services, Technology, and Knowledge Taxonomy* in order to facilitate (create, communicate, storage, share, and reuse) the DMS design knowledge among agents who involved in DMS project. This DMS knowledge management system is shown in figure 6.37. New knowledge should be carefully added to the system by the process in figure 6.37 in order to maintain the reliability of the IT-based Knowledge Management System.

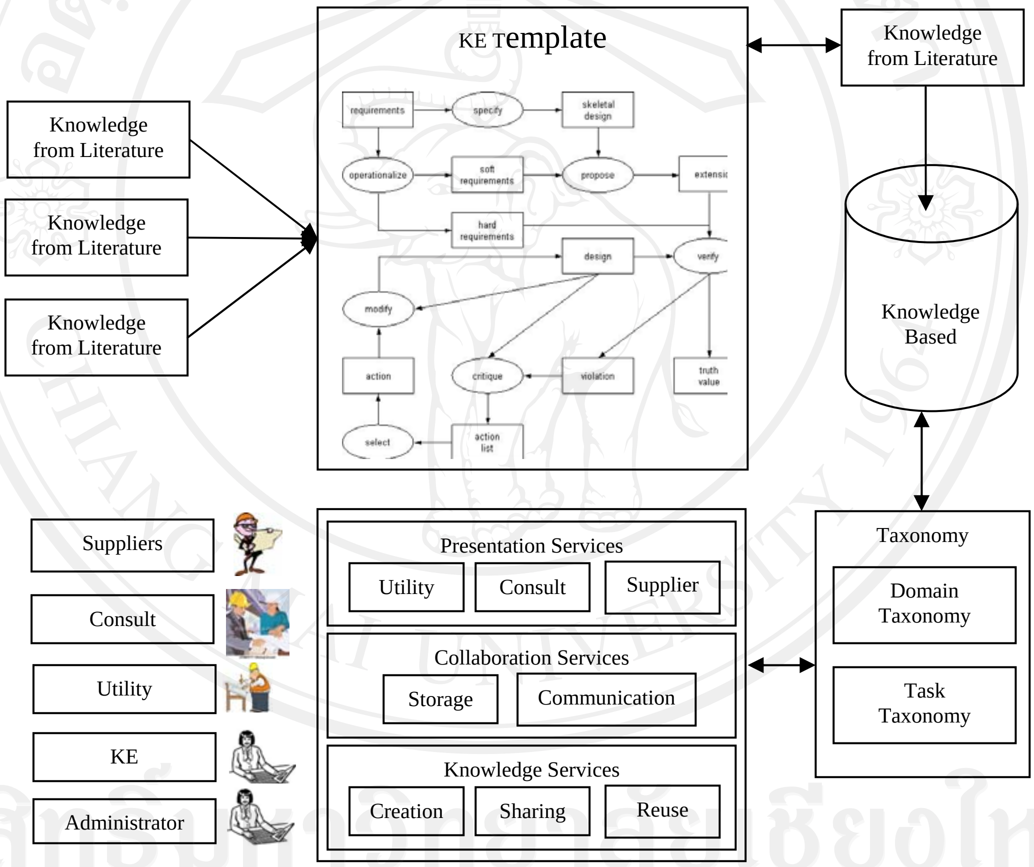

Figure 6.37: DMS Knowledge Management System

Then the knowledge in DMS project life cycle can be created, stored, shared, and reused; however, the knowledge management system itself must be managed in spiral way in figure 6.38. By attempting the good feature of the classic 'waterfall' life cycle for software engineering and prototyping approach of IT-base KMS. The four quadrants indicate recurring and structured step of project management activity. The aim is to achieve progress by means of subsequence cycles that may be adapted on the basis experience from previous cycle. By this way, the model aims to balance between structure control and flexibility by review process, identify risk, plan the cycle task, and monitor results in each cycle.

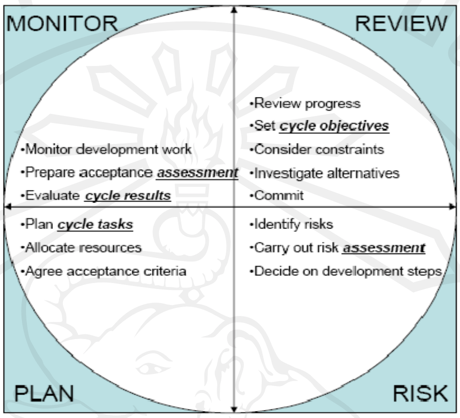

Figure 6.38: Project Management (States and Activities)

It should be repeated and revised in the different steps. For example, the objective and criteria should be set in each cycle. The risk should be assessed and monitored. Table 6.20 shows risk assessment worksheet for knowledge management system. Table 6.21 shows model state planning for knowledge management system.

Table 6.20: Risk Assessment

Project Management		**Risk Assessment Worksheet PM-1**			
Risk	**Affected Quality Feature**	**Likelihood of Occurrence**	**Severity of Effect on Project**	**Rank of Risk**	**Counter-Measure**
Risk idetifier and nature	Quality Feature at stake due to risk	Very low, Low, Medium, High, Very High	Very low, Low, Medium, High, Very High	Ranking number based on product of likihood and effect	Action to taken against risk

Table 6.21: Model State Planning

Project Management	**Model State Planning Worksheet PM-2**
Attribute	**Description**
Model Name	One of CommonKADS models: OM, TM, AM, Knowledge M., Communication M., Design M.
State Variable	A part of component of selected model (e.g. the inference layer of the knowledge model)
State Value	An indicator of the degree of completion to be achieved (5 point range):- 1. Empty:- Starting state 2. Identified:- Basic feature 3. Described:- Complete first version or draft 4. Validated:- Tested 5. Completed:- Finished and Accepted
Quality Metrics	To measure whether the desired model state has indeed achieved
Role	To indicate that a model state plays a specific role in the project (option)
Dependencies	To indicate that achievement of the model state critically depend on certain external input (option)

Moreover, the quality of DMS design knowledge and KMS should be measured in each cycle in order to adapt the IT-base KMS. The quality attributes relevant to knowledge system project are presented in figure 6.39.

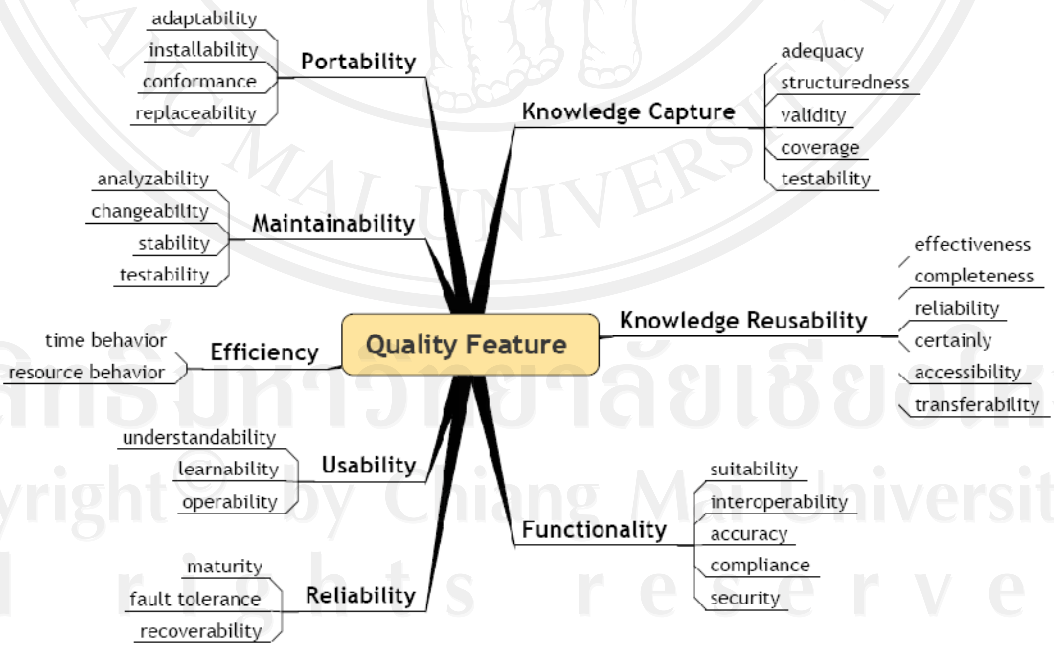

Figure 6.39: Quality Feature

6.5 Discussion

In this research, the four case studies were done in order to clarify the concept of knowledge management system in the field of DMS design. The first case, Base Case, is the general case for DMS design which captured from the consultant report. The second case, Knowledge Model, uses CommonKADS knowledge engineering template, 'Propose and Revise', to capture DMS requirement and DMS skeleton design for the IT-base Knowledge Management System. The third case, Communicaton Model, makes the communication plan among related parties for IT-based Knowledge Management System to get more reasoning knowledge. And the last case, IT-based Knowledge Management System, will identify the IT-based knowledge management system requirement, function, and system specification for MEA DMS design in the future.

The result from base case was splendid because it was captured from report of very reputation specialist. However, MEA may still not understand and can not do by themselve. The DMS implement project in future will be needed a lot of effort from the specialist. The second case was tried to model knowledge with standard methodology The 'Propose and Revise' template seemed to be common sense of the simple understanding. However, to put in the real DMS design knowledge was still difficult and required both DMS specialists who providing and verifying 'the practical knowledge' and knowledge engineer who capturing and modeling that knowledge. This knowledge model can help better understand each other objective by visualizing explicit knowledge and may bring out some tacit knowledge among this DMS community of practice. The third case was communication model to create the pattern of sharing information among the design community for the DMS project. Every party can understand each other better. The last case was the IT-based knowledge management system specification which provided the environment like virtual 'Ba' for every related party to create, verify, share, and reuse the specific DMS design knowledge. The IT-based knowledge management system in this research is not complete, only specification and plan for the future because the MEA DMS project is just in the procurement stage. However, with the cooperation of related parties, we ensure that IT-based knowledge management system can be useful for better project management and create organization knowledge.