KNOWLEDGE SHARING SYSTEM FOR COMPUTER-BASE SUBSTATION CONTROL SYSTEM OF PROVINCIAL ELECTRICITY AUTHORITY, THAILAND

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ABSTRACT

This research applied the concept of knowledge management to develop a system for collecting knowledge about defects and solutions of CSCS in a substation of the Provincial Electricity Authority of Thailand (PEA). This system collects the knowledge systematically using the same format. Users can find the knowledge easily and rapidly. This system represents the statistical data for defects in various formats both tabular and graphic. Moreover, the recorded data in this system can be used with analysis to determine new knowledge by using data mining techniques, i.e. decision trees and the association rule. This knowledge could be further used to help managers plan maintenance in the future. This system was developed on web based technology, PHP and MySQL. The results of an efficiency and effectiveness evaluation showed that this system has benefits that follow the objective of this research.

KEY WORDS: KNOWLEDGE MANAGEMENT / DATA MINING / DECISION TREE / ASSOCIATION RULE

86 pages

ระบบแบ่งปันความรู้สำหรับระบบควบคุมอุปกรณ์ภายในสถานีไฟฟ้าด้วยคอมพิวเตอร์ของการไฟฟ้าส่วนภูมิภาค, ประเทศไทย

KNOWLEDGE SHARING SYSTEM FOR COMPUTER-BASE SUBSTATION CONTROL SYSTEM OF PROVINCIAL ELECTRICITY AUTHORITY, THAILAND

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บทคัดย่อ

งานวิจัยนี้เป็นการประยุกต์ใช้หลักการจัดการความรู้มาพัฒนาระบบ เพื่อใช้สำหรับการจัดเก็บรวบรวมข้อมูลความรู้ในการแก้ไขปัญหาข้อขัดข้องที่เกิดขึ้นกับระบบ CSCS ในสถานีไฟฟ้าของการไฟฟ้าส่วนภูมิภาค ระบบที่สร้างขึ้นมีการจัดเก็บข้อมูลความรู้อย่างเป็นระบบมีรูปแบบเดียวกัน ช่วยให้ผู้ใช้สามารถค้นหาข้อมูลความรู้ได้ง่ายและรวดเร็ว ระบบมีการแสดงผลข้อมูลทางสถิติของปัญหาข้อขัดข้องที่เกิดขึ้นในด้านต่างๆ ทั้งในรูปแบบของตารางและกราฟฟิก นอกจากนั้นข้อมูลที่บันทึกอยู่ในระบบยังสามารถนำมาใช้วิเคราะห์เพื่อหาความรู้ที่ซ่อนอยู่ โดยการทำเหมืองข้อมูล ซึ่งใช้เทคนิคต้นไม้ตัดสินใจและกฎความสัมพันธ์ โดยข้อมูลที่ได้สามารถนำมาช่วยสนับสนุนการตัดสินใจสำหรับผู้บริหารในการวางแผนการดูและระบบต่อไปในอนาคต ระบบที่พัฒนาขึ้นเป็นลักษณะเวบแอพพลิเคชัน ซึ่งพัฒนาโดยใช้ภาษา PHP และฐานข้อมูล MySQL จากผลการวัดประสิทธิภาพและประสิทธิผลของระบบ สรุปได้ว่าระบบมีประโยชน์ตามวัตถุประสงค์ที่ได้ตั้งไว้

86 หน้า

CONTENTS

CONTENTS (cont.)

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (cont.)

LIST OF FIGURES (cont.)

CHAPTER I
INTRODUCTION

1.1 Background and statement of problems

Provincial Electricity Authority (PEA) is a government enterprise under the Ministry of Interior, established on 1960. The responsibility of PEA is to get electricity power from the Electricity Generation Authority of Thailand (EGAT) and distribute it to the end-user, both factories and home users. PEA serves most provinces in Thailand except Bangkok, Pathumtani, Nontaburi and Samutprakran.

PEA is organized into four administrative regions which are Northern (N), North-Eastern (NE), Central (C) and Southern (S). Each region consists of three service areas with its own administrative office, can be called in short as C1, C2 and C3 for Central area 1, Central area 2 and Central area 3 respectively. Therefore, head office covers all 12 responsible areas, and is located in Nontaburi.

Computer-base Substation Control System (CSCS) is a system for operating and controlling equipments in substations (such as close/open circuit breaker, close/open capacitor bank, raise/low transformer tap and etc.). These equipments can be controlled by main computer in substation that more reliability than using control desk and control board. The CSCS can keep record of analog measurement and alarm from devices in substation. The CSCS increasing efficiency of dispatch distributed system and reduces operating time. This corresponds to the government policy that would like to give service to public effectively and rapidly.

Many vendors provide CSCS service to PEA, so there are many different products and models of CSCS that are used in PEA. PEA includes more than 400 substations with circuits operating at 115kV, 69kV, 33kV and 22kV. CSCS is used in those substations over 280 substations. A product of CSCS has many types and models as shown in Table1.1.

No	Product	Model	Area												Total
			N1	N2	N3	NE1	NE2	NE3	C1	C2	C3	S1	S2	S3	
1	ABB	Micro SCADA	-	3	1	2	-	4	12	8	4	-	-	-	34
2	AEG MODICON	-	-	-	-	-	-	-		1	3	-	-	-	4
3	CRUICKSHANK	SAS 2000	2	1	-	-	-	-	3	1	1	-	-	-	8
4	EFACEC	-	-	-	-	4	2	-	-	2	-	2	5	2	17
5	GE MULTILIN	-	8			-	-	-	1	-	1	4	-	-	14
6	GE FANUE	-	-	-	-	-	-	-	1	-		-	-	-	1
7	Ingeteam	PQM	-	-	-	-	-	-	1	-	-	-	-	-	1
8	Ingeteam	PQM 300	-	-	-	-	-	-		-	-	-	1	2	3
9	Ingeteam	TCP-PQM	-	-	-	4	-	-	-		4	2	-	-	10
10	Ingeteam	-	1	-	-	-	1	2	2	5	1	-	-	-	12
11	ISKRA	NEO 1000+	6	-	1	2	5	2	9	15	10	2	8	6	66
12	REMSDAQ	Calisto IES	5	7	3	-	-	1	12	13	6	2	-	1	50
13	REMSDAQ	CALLISTO I	-	3	4	-	3	3	8	9	6	-	-	-	36
14	SAT	-	2	2	2	5	1	4	-	-	-	-	-	-	16
15	SIEMENS	X - MAT	-	-	-	-	-	-	-	-	-	5	4	5	14
Total			23	16	11	17	11	14	49	54	36	17	18	16	282

Table 1.1 List of product and amount of CSCS was used in PEA.*

**Source from: Power System Control and Operation Department, PEA (2008)*

Each branch area has CSCS's administrator that may be 2-4 engineers or technicians who responsible for preventive and corrective maintenance CSCS. When old person had been worked over 7-10 years, they were promoted to higher position and new person will work instead of them. The new person has not enough knowledge and experience as same as the old person. Although before old person were promoted to new position they would teach about CSCS to new person, a lot of experience in old person can not be transfered to new person. This is a cycle that makes a knowledge and experience lost by time.

Moreover, PEA uses various products for CSCS in substation, and each product has more than 1 model. Therefore, this is a problem about CSCS's administrator now. There are many types of products in each area, some area has just 1

substation for some product but some area has many substations. The person who responsibility to maintenance CSCS in difference area will have the different experience about same product.

1.2 Objective

Collect knowledge and experience about CSCS's correct defect as systematic, easy to find benefit data, correct CSCS's defect faster and statistical analyze for CSCS's defect.

1.3 Scope of study

1.3.1 The system will be used only in the PEA through PEA's intranet.

1.3.2 Users are divided into three types which are administrator user, authenticate user and anonymous user.

1.3.3 The system has main four main parts which composes of record data, search data, manage data, and summarize data.

- Record data
  - Authenticated user can record new defects.
  - Authenticated user can add count for same defect and add difference - solution for solve that defect.
  - Authenticated user can edit own defect of created user.
- Search data
  - Search defect by interested product and part.
  - Search defect by keyword.
- Manage data
  - Administrator user can add substation data.
  - Administrator user can add product data.
  - Administrator user can add, modify, and delete user data.
  - Administrator user can reset password of authenticate user.
  - Authenticate user can change own password.

- Summarize data

- Summarize knowledge about solution for solving each defect.

- System can show statistic data of top 10 defects and top 10 substations that found defect present in tabular format.

- System can show statistic data of defect by product, part and area representing in graphic format.

- Supporting un-login user.

1.3.4 The system will have been evaluated after operating for 2 months.

CHAPTER II
LITERATURE REVIEW

2.1 Knowledge and Knowledge Management

2.1.1 Data, Information and Knowledge

Knowledge is commonly distinguished from data and information. Data represent observations or facts and has no directly meaning. Information is data within some meaningful context. Knowledge is that which we come to believe and value based on the meaningfully organized accumulation of information through experience, communication or inference. [1]

2.1.2 Type of Knowledge

Type of knowledge can group by many methods. One concept that was often reference is concept of Michael Polanyi and Ikujiro Nonaka. Concept of Polanyi and Nonaka segments knowledge into 2 types and definition knowledge is analogy to an iceberg.

1) Explicit knowledge is knowledge that can transfer, record and codify in media such as document, book, manual or list. It make other people can access knowledge easy then this knowledge like top part of iceberg that appear above the water, can see clearly.
2) Tacit knowledge is knowledge in people that develop from study, experience, action or talent. This type of knowledge is difficult to transmit to number, formula or writing format. But can develop to share to each other then this knowledge like bottom part of iceberg, can not see. Tacit knowledge was made to have an advantage of competition but difficult to manage.

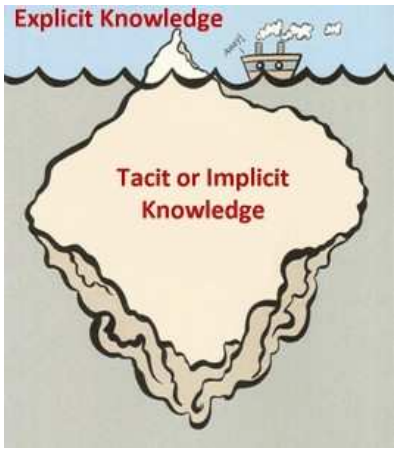


Figure 2.1 Knowledge was analogy to an iceberg. [2]

When consider to explicit knowledge and tacit knowledge in organization found ratio is 20:80 like an iceberg that has top part upon water less than bottom part that under water.

Both of knowledge type can transfer in between through process that calls Knowledge Spiral or SECI Model Conversion process. That process was offered by Ikujiro Nonaka and Takeuchi. Managing the knowledge through this process, it can make a new knowledge.

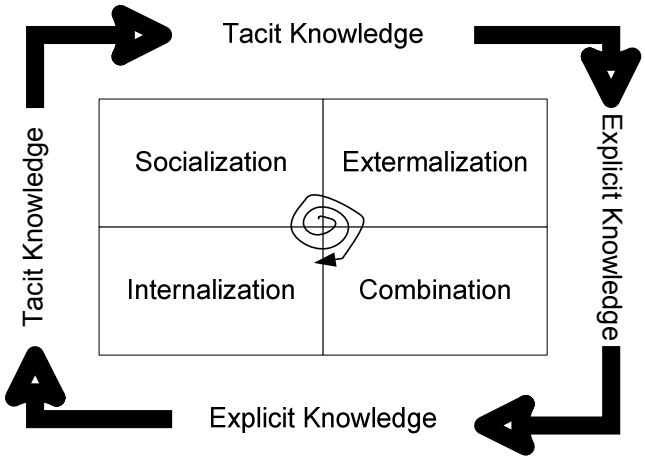


Figure 2.2 SECI Model Conversation Process.

Figure 2.2 shows exchange status of knowledge for make Knowledge Spiral that can separate into 4 parts, i.e. Socialization, Externalization, Combination and Internalization. Each part is explained below.

1) Socialization (Tacit Knowledge -> Tacit Knowledge)

Exchange and create tacit knowledge from tacit knowledge of person from direct experience of each person. For example, sale manager team A had learnt new selling technique from sale manager team B that success in sale by conversation between in. So sale manager team A will get knowledge from sale manager team B.

2) Externalization (Tacit Knowledge -> Explicit Knowledge)

Exchange and create knowledge from tacit knowledge of people and propagate to writing format. It is transfer from tacit knowledge to explicit knowledge. Example, after sale manager team A learn technique then put writing it to document or any report for broadcast to other persons.

3) Combination (Explicit Knowledge -> Explicit Knowledge)

Transfer explicit knowledge to explicit knowledge by collect explicit knowledge that was learned to new explicit knowledge. Such as sale manager team A has learn new sale technique from other source in later then summarize with old knowledge and propagate to new sale technique.

4) Internalization (Explicit Knowledge -> Tacit Knowledge)

Transfer explicit knowledge to tacit knowledge often cause bring knowledge was learned to practice. Such as other sale managers have learned sale technique from document or manual and bring knowledge to tune with their work till make them have skill and experience of sale technique. Then this is a tacit knowledge in them.

2.1.3 Knowledge Management

Knowledge management is different from data management or information management, because data, information, and knowledge are difference so knowledge management is more complex.

There are various definitions of knowledge management such as Ryoko Toyama [3] say “Knowledge Management means management for help to get new

knowledge by old knowledge and experience of people in organization for develops innovation that make an advantage of competitive in business".

Carla O'Dell and Jackson Grayson [3] define about knowledge management that it strategy for make people get knowledge in appropriate time, help to exchange and bring knowledge to practice for develop process in organization. Knowledge management is not tool for managing on knowledge directly but is a method that makes exchangeable knowledge.

So we can conclude that Knowledge management is a process for making the benefit for organization from knowledge through many process such as creation, collection, exchangeable, using, and etc.

2.2 Knowledge Management Process

Badin Wijarn [5] said that knowledge management process consists of 5 stages are.

1) Define

Definition types of intellectual capital or organization knowledge needed. Meet the organization's strategy or operations, or finding that what is the main knowledge of organization (core competency). There must be able to make a difference when compare to competitors clearly.

2) Create

Creation intellectual capital, or take advantage of the already exists. Submit to learn more. Teach internal organization. In case of new knowledge, it may will find from outside organization such as consultants or learn from success of others and benchmarking.

3) Capture

Seek and store knowledge in the organization as a system both of knowledge in various media formats (explicit knowledge) and in the form of experience (tacit knowledge). There is knowledge capital of the organization ready to enhance knowledge, and expand knowledge throughout the organization to easily follow.

4) Share

Exchange, published, share, distributed and transfer knowledge. There has several methods and multi-channel such as seminars to exchange knowledge with each other or teaching work. Other forms of knowledge exchange are meeting with each other, transfer knowledge via computer networks or e-learning system, etc.

5) Use

Using an advantage, applied work and make the benefits and achievement occurs. There is a knowledge practice. Expand the level of knowledge and capabilities in competition in organization higher.

Other researchers have divided knowledge management process into varying sub-processes. Such as Varintorn Supyuenyong and Nazrul Islam [6] collect and summarize into 4 sub processes: knowledge creation and acquisition, knowledge organization and retention, knowledge dissemination, and knowledge utilization. Michael H. Zack [1] divides sub processes of knowledge management process into 5 stages consist of acquisition, refining, storage and retrieval, distribution, and presentation.

2.3 Knowledge Management and Information Technology

Although knowledge management is a process, is not a technology. However information technology is a one of factor that will make knowledge management successful. Information technology infrastructure should provide for support knowledge management process. The technology involved and has role to knowledge management consists of.

1) Communication technology

Help people access knowledge that is easier and easier to connect with experts in various fields. Provide user can find information and knowledge they need through the intranet, internet, mobile networks, and etc.

2) Collaboration technology

Help people in different locations work together to coordinate effectively. Reduce barriers in the distance, such as groupware systems, screen sharing, and etc.

3) Storage technology

Help storage and manage information and knowledge. Such as database systems, search engine, and etc.

4) Multimedia technology

Providing knowledge can offer a variety of characters, such as text, image, animation, sound, and video. People can select to learn from the media that right to own. This will help the learning easier.

Information technology helps processing of knowledge management more effective. Especially internet technology that help searching, gathering and transfer knowledge rapidly and effectively such as the World Wide Web offer a potentially useful environment which to build a multimedia repository for explicit knowledge. Anyhow information technology is just a tool, it can not guarantee successful of knowledge management.

2.4 Knowledge Management System

Knowledge Management System (KMS) is group of various information technology combine together for collaborate support knowledge creation process and using knowledge follow demand of user.

Knowledge management systems are classified based on work flow into two major types: a knowledge repository and a knowledge network. A knowledge repository focuses on transforming knowledge information into explicit knowledge. The explicit knowledge is then stored as database system or file format system in order to be queried. The advantage of this system is that the users can always query information. However, the information would not be up to date since it is stored in file format.

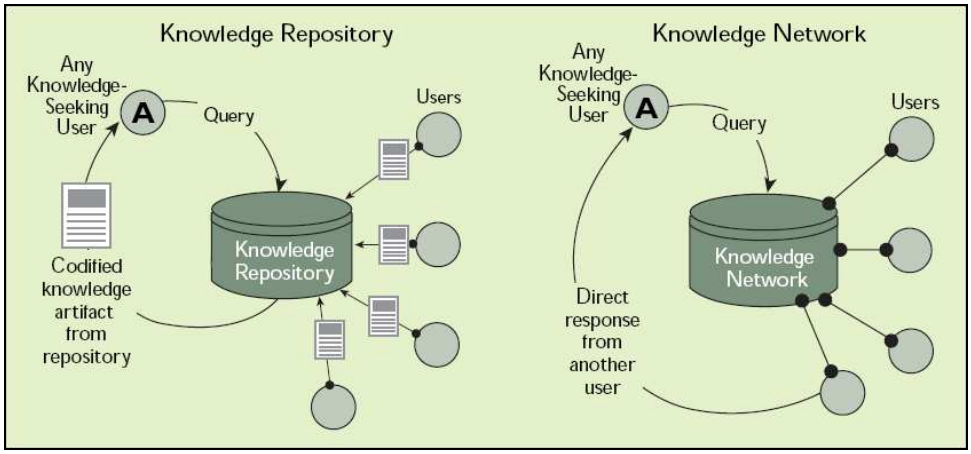


Figure 2.3 Knowledge repository and Knowledge network. [10]

Another type is knowledge network which is not focused on changing knowledge into documents, reports, or manuals, but focuses on connecting users who want knowledge to user who owns the knowledge. Knowledge management for knowledge network is to use the experience and expertise of the user who owns the knowledge for answer to a user who want knowledge. The advantage of the knowledge network is exchangeable of knowledge between individual users can do many ways. Without the knowledge store of knowledge in a document make quite sure that the knowledge gained would be the up to date. However, knowledge network is also has a disadvantage. May be constrained by time especially for users in different locations on a world as if the rest of the user who owns the knowledge may cause the user who want to know the answer behind the need etc.

Michael H. Zack [1] segments knowledge management application into two classes for capacity to support process to make and use knowledge. Integrative applications support repositories for managing explicit knowledge while interaction application supports to integrate tacit knowledge. Define user who gets knowledge from system is consumer, and user who puts knowledge to system is producer.

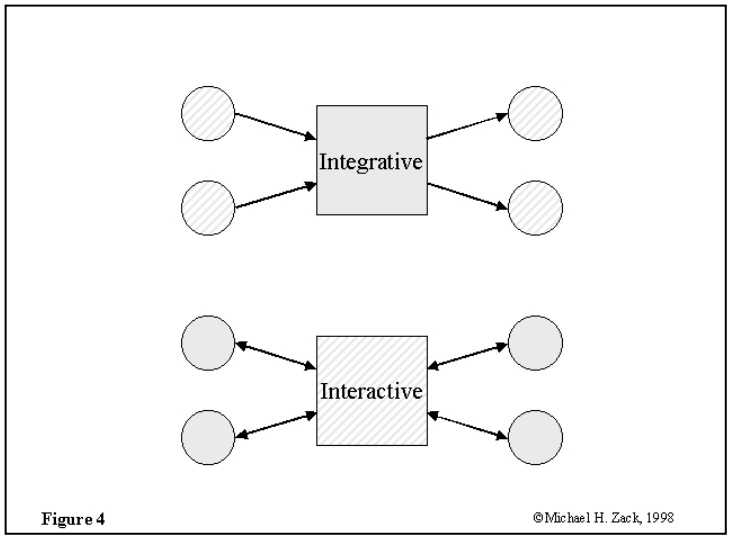


Figure 2.4 Integrative application and Interactive application. [1]

Integrative application primary focus on the repository and explicit knowledge it contains. Producer and consumer interact with the repository rather than with each other directly. The repository is the primary medium for knowledge exchange, providing a place for members of a knowledge community to exchange their knowledge and views. Example is electronic publishing.

Interactive applications are focused primarily on supporting interaction among people holding tacit knowledge. In contrast to integrative applications, the repository is a by-product of interaction and collaboration rather than the primary focus of the application. Its content is dynamic and emergent. Example is a forum that can be linked to an electronic publishing application for discuss between producer and consumer.

Approaches to knowledge management classify knowledge management system into 2 groups are “people-to-document” and “people-to-people” [7]. People-to-document aim to change knowledge to explicit knowledge and keep in database or file system. Users who want to use knowledge must be search from knowledge repository and result is document or knowledge that other user keeps record. Advantage is user can search data always but knowledge in form of document that was recorded so may be it behind the times.

People-to-people aim to focus on tacit knowledge by face-to-face or trough interactive media. Use direct experience and expertness of user that was owner of knowledge for answer problem of user who wants to use knowledge. Advantage is exchangeable between users can do many method such as hyperlink, multimedia or most important method like conversation. This system not needs to keep knowledge in document form so knowledge will be abreast of the times. Anyhow disadvantage of this system is limitation of time in case of users that live so far away and time not match.

Differentiate of advantage and disadvantage of those systems. Therefore, good KMS should be a system that has both advantages of those systems together.

2.5 Data Mining

Data mining [17] is the process of work in filtering information from large databases to get hide information. The information can apply to work. This is important in helping to make business decisions. The steps are as follows.

1. Data Cleaning: edit the data to be completely, such as edit null data to be value 0, or may not apply the row to use in process. Depend on decision of the administrator.

2. Data Transaction Identification: rearrange data into the appropriate format. Which is widely used to make the data into tabular format (Table), there are rows related with columns.

3. Data Integration: gathering all needed data that may be in multiple database, multiple operation system into the same database or single table. May use it as a data warehouses to collect data.

4. Data Transformation: adjust the data to the appropriate for decisions such as product information is "Coke" and "Pepsi" can be change to "soda water" for more appropriate decisions.

5. Pattern Discovery: prescribe format to search to get the results. Compose of path analysis, association rules, sequential patterns, cluster&classification rules and etc.

6. Patten Analysis: analyze search results to help decision making or business planning.

Data mining has various techniques i.e. Association rule Discovery, Classification & Prediction (Decision Tree, Neural Network), Database clustering or Segmentation, Deviation Detection, and Link Analysis. This study selects 2 techniques are Decision Tree and Association rule for find hidden knowledge because both technique appropriate with data and result from both technique can be understand easy.

2.5.1 Decision Tree

Decision Tree [17] is the widely used model in data mining process. It is used to prediction or classification. Chart of decision tree represent result from action or decision on various conditions and then connected to a branch. This technique allows users understand the relationships and properties of data easily than other technical. The structure of the tree consists of decision note, leaf node and branch.

C4.5 algorithm was developed by J. Ross Quinlan (1993), approve from ID3 algorithm for enhancement capability by Information Gain method adding number, missing value, noisy data manage and prune with instead branch that not help decision with leaf node. First step of C4.5 algorithm is finding Info and Gain that likely ID3 algorithm. Select the attribute with the highest information gain

Let *pi* be the probability that an arbitrary tuple in D belongs to class Ci, estimated by |C*i*, D|/|D|

Expected information (entropy) needed to classify a tuple in D:

$$Info(D) = -\sum_{i=1}^{m} p_i \log_2(p_i)$$

Information needed (after using A to split D into v partitions) to classify D:

$$Info_A(D) = \sum_{j=1}^{v} \frac{|D_j|}{|D|} \times I(D_j)$$

Information gained by branching on attribute A:

$$Gain(A) = Info(D) - Info_A(D)$$

Information gain measure is biased towards attributes with a large number of values C4.5 uses gain ratio to normalization to information gain.

$$\text{GainRatio}(A) = \text{Gain}(A)/\text{SplitInfo}(A)$$

$$SplitInfo_A(D) = -\sum_{j=1}^{v} \frac{|D_j|}{|D|} \times \log_2(\frac{|D_j|}{|D|})$$

The attribute with the maximum gain ratio is selected as the splitting attribute

2.5.2 Association rule

Association rule [18] is a tool for discovering interesting relations between variables in large databases. Two values are support and confidence was used to indicate interesting of association rule.

Define $I = \{ i_1, i_2, \ldots, i_n \}$ is a set of items call itemset. D is a set of transactions, where each transaction T is a set of items such that $T \subseteq I$. Let A be a set of itemset I and transaction T is contain A. If $A \subseteq T$, an association rule is an implication of the form $A \Rightarrow B$, where $A \subseteq I$, $B \subseteq I$ and $A \cap B = \phi$.

The association rule $A \Rightarrow B$ holds with support s, where s is the percentage of transaction in D that contains $A \cup B$. This is taken to be the probability, P ($A \cup B$).

The association rule $A \Rightarrow B$ has confidence c in the transaction D, where c is the percentage of transactions in D containing A that contains $A \cup B$. This is taken to be the condition probability, P (B | A).

The association rule that was interested is rule that has support value and confidence value much more than minimum support value and minimum confidence value that was defined.

Apriori algorithm is a famous algorithm for find association rule. Method is finding all frequent itemset that consider from transaction that contain itemset which has minimum support. The process of apriori algorithm is, first round count number of transaction and find support value of all item for know which frequent item in 1-itemset level that has support value much more than minimum support. After that, the next round use frequent itemset in level 1-itemset create candidate itemset in level 2-itemset, find frequent intemset in level 2-itemset that has support value more than

minimum support. Repeat like this until can not find frequent itemset anymore. Result is all frequent itemset that can use to create association rule.

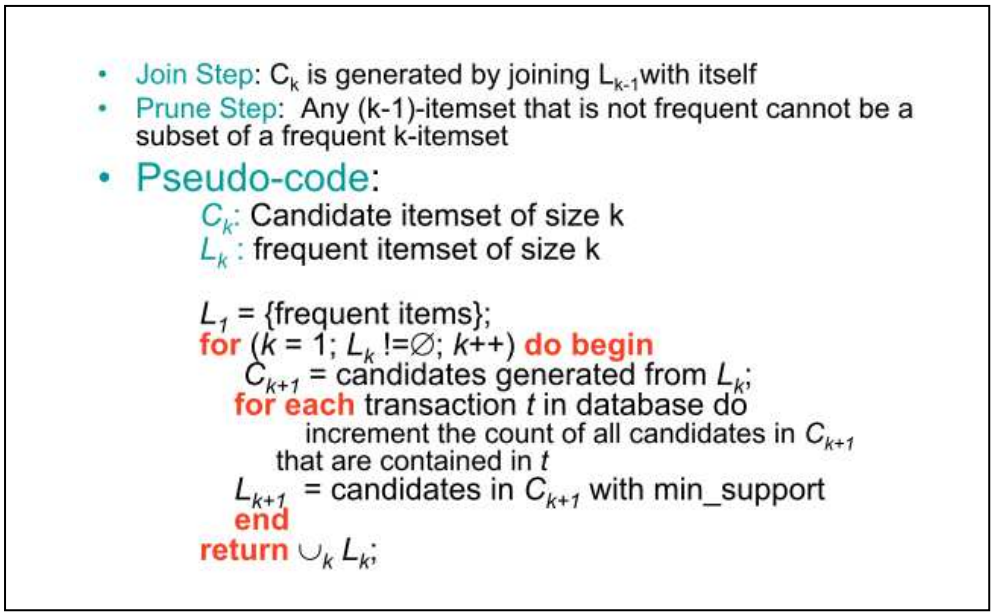


Figure 2.5 Process of apriori algorithm.

2.6 Related Technology

2.6.1 Apache Webserver

Apache HTTP Server is an open source software purpose to provide service data by HTTP protocol that available on multi platform.

Apache was developed from HTTP Daemon that created by Rob McCool at NCSA (National Center for Supercomputing Applications) University of Illinois at Urbana–Champaign.After McCool has quitted from NCSA ,HTTPD Web Server was left without any Development. Due to Software is license reserved to GNU that mean everyone has authenticate to develop this software, cause one user group to edit the code for fixing some old bugs (Call patching) .But these patching data has scattered in many place .Finally Brian Behlendorf has created a mail list group for assemble the data to be unite and conform to edit source code.

Since April 1996 Apache has been the most popular HTTP server software. As of February 2010 Apache served over 54.46% of all website and over 66% of the million famous website.[9]

2.6.2 PHP

PHP was original developed by Rasmus Lerdorf in 1995 by use basic of Perl programming and uses C++ for develop. PHP stand for Hypertext Preprocessor or as know Personal Home Page is an Open Source programming language with server-side script characteristic. PHP was used for website construction then show in HTML format. PHP commands base on C language, Java and Pearl these make it is easily to learn by users who had used other programming language before. PHP also supports object oriented programming and interpreter (translates and line to line operating without compiling entire the program) that more flexible development for coding dynamic web pages increasingly.[10]

2.6.3 MySQL

MySQL is a database management system created by both Swedish David Axmark and Allan Larsson and Finland nationality Michael Monty Widenius under Swedish's Company MySQL AB.

MySQL can be divides to three versions as follow

- Community version
- Commercial version
- SAP supportive version

Community version is free to use, but not permit to any support from the company. Commercial version is opposites from Community version, however because of MySQL is use by massive users which mean users can also solve most problems by searching from internet.

MySQL is most use to create database for web applications and integrated with PHP translators on web server called "Apache". Unless PHP it have more programming languages to use with MySQL database through ODBC including C language, C++, Pascal, C#, Java, Pearl etc or through another database connector for example ASP which can connect to MySQL database through MyODBC, ADO or ADO.NET.[11]

2.7 Related Research

Wilairat Peedharakorn (2003) [12] developed knowledge Management system for Networking Administration at Thailand Post Co., Ltd. System was developed by ASP.NET, Visual Studio.NET, and use Microsoft SQL server 2000 for relational database. System was developed to support daily tasks of network operators and administrators, and base on web-based technology. User can access information via intranet network. The new solutions/procedures can be added to the system by network operators. When problems had been solved by an expert, operator will records problems and solutions into the system, and then reports to network supervisors for decision making. The system allows network operators can comment or suggest to solutions of a problem. The procedures were approved by network administration case by case in order to create a set of problem-solution pairs that are often used. Another feature of the system is function to export the solutions/procedures into an XML format for exchange data with other system if required. After developing the system completed Wilirarat set test case for test the accuracy of the system. After that, the system was tested by user for evaluate performance and satisfaction.

Suksit Sripitchayaphan (2008) [13] developed Knowledge Management System for Administrating SCADA/DMS of Proviencial Electricity Authority. Aims to improve work process and correct problems arising with SCADA/DMS administrator team. Suksit used SWOT Analysis to analyzing strength, weakness, opportunity and treat to occasion as a guide in developing the system. Results from analysis found that administrator understand SCADA/DMS system can solve the discussed property occur, but lack of knowledge storage systematically. Therefore, they can not search knowledge easy, or sometime has no data. Knowledge has no distributed when problems occur each administrator can not work instead. Also, the system is nearly out of warranty period if administrator cans fix the problem by own; this will reduce expense of organization. Suksit selected CMS (drupal) for develop system by compared test results of CMS open source software by IMB. Suksit listed the problems occur, concept of correct problem, related knowledge management process and information technology related. After that, determine various module of drupal for select suitable to use in system, and develop some custom module to meet the most demanding. After developing completed test system is divided into 2 steps is

to test the accuracy of the complete system by him and test systems evaluate following the objectives of development. Evaluate performance and satisfaction by open system for administrator actual use and assessment using questionnaires.

Chirachai Chittikun (2008) [14] developed Knowledge Management for Project Management (KMPM): Case Study of Real Integrity Company. System is developed by Microsoft Visual Studio and use Microsoft SQL server. Chirachai study and found that the majority of project management often uses personal skills from experience primary. Therefore the necessary knowledge in project management such as process of project management, method to solve problem, experience and knowledge from project management are no reuse, broadcast for benefits. Chirachai brought project management principles from the Project Management body of Knowledge adoption to create repository of knowledge that will be applied in management of projects effective. Components of the system are Project Management body of Knowledge, Knowledge Creation, KnowledgeMapping and Communities of Practices. After testing and use prototype of the system found that the system can provide project manager management project as systematic. Project manager can distribution and tracking order closely. Employees are sharing knowledge and help resolve the problem effectively. The system can reduce errors caused by carelessness and lack of team focus. Creation new knowledge and practices for management. It also allows to sharing of knowledge regardless of time or place, and reduces operating time.

Nattamon Siriwattananan (2008) [15] studied Transportation Suitability Detection Using Decision Tree. The objective of the study was to find out the suitable vehicle transportation rules. Because of vehicles transportation operation at the lowest cost was very important, it will directly impact on reducing goods costs. This directly affects sales and increases the chances of competing with other competitors in the market. Nattamon use algorithms C4.5 decision tree modeling to detection the Transportation suitability decision tree. Use data of Bangkok and urban transportation management transaction of 2008 for training ‘8316’ records and testing ‘2773’ records. Transportation decision tree accuracy was ‘97.23’ percentage. After develop a model, application program of transportation decision was developed base on Window application by Visual Studio.Net 2003 and use VB as a tool. Application

program was tested by ten experienced users. Evaluation found that the overall satisfaction of user average was equal to '4.67', which indicated that Transportation suitability detection using decision tree had a good performance.

Kanjana Haruehansapong (2006) [16] studied Extracting knowledge from student database using data mining techniques: A case study of Walailak University. This research applied data mining techniques including association rule, data classification and a new sequential pattern mining algorithm to extract knowledge for give advice to students. Kanjana divided knowledge in this research into three parts. The first part is knowledge for high school students by create models for selecting appropriate program to study and model for predicting the student's cumulative grade point average (GPAX). The second part is the knowledge for bachelor students, association among sets of course and grade and association among sets of course and GPAX. The third part is also the knowledge for bachelor degree student, sequences of course registration which help improve student's GPAX. Kanjana process an approach called Adaptive Candidate Apriori algorithm for finding the sequences of course registration that affect the GPAX and process the enhancement version of the applying FP-growth algorithm to reduce the computational time. Data to analysis knowledge are personal's data, high school's grade data and bachelor's grade data. The knowledge can be used to advice students for have more study efficiency. And provide useful information to educational institute on how to improve the quality of education program.

CHAPTER III
METHODOLOGY

This chapter describes step of work, materials, and project schedules.

3.1 Step of works

This section will explain each step of works in research. This research has 6 steps as the following.

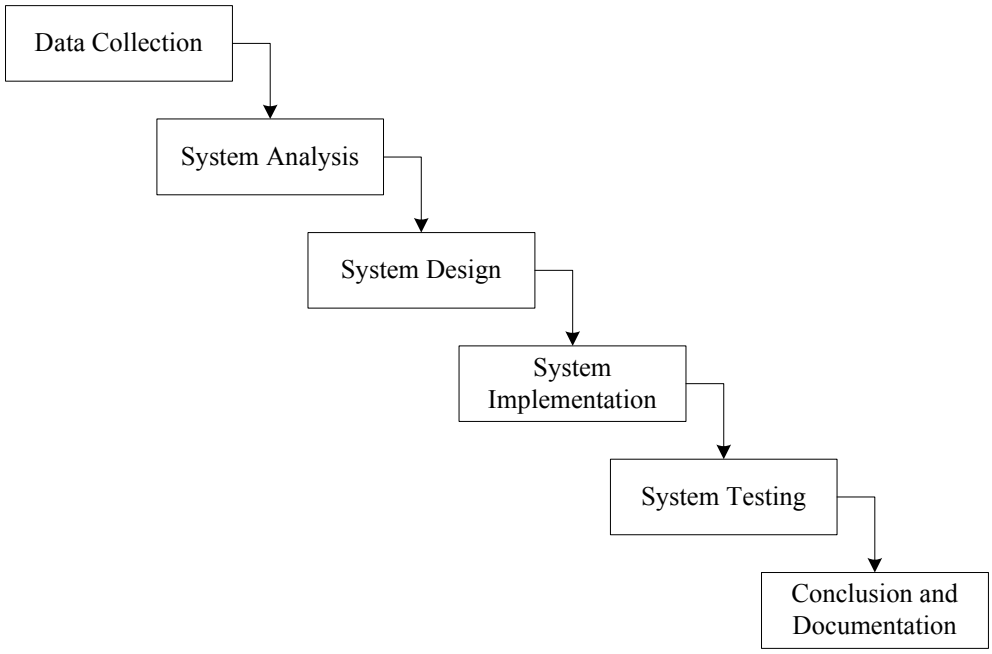


Figure 3.1 Steps of work in this research.

3.1.1 Data Collection

Collect data and study the related research as the following:

1. Study about concept of KM and technology that related.
2. Study about problem of CSCS's administrator from current process.

Current system

Current system has collect information and transfer knowledge of the CSCS corrective maintenance already but not systematic

- Each area, CSCS's administrator has create own log book for record defect and solution. Could not form in the same format, information is scattered and difficult to find.
- If the problem can not be corrected manually. CSCS's administrator will use the telephone to ask the experts in other areas.
- The process to transfer knowledge is trained or teaches directly.

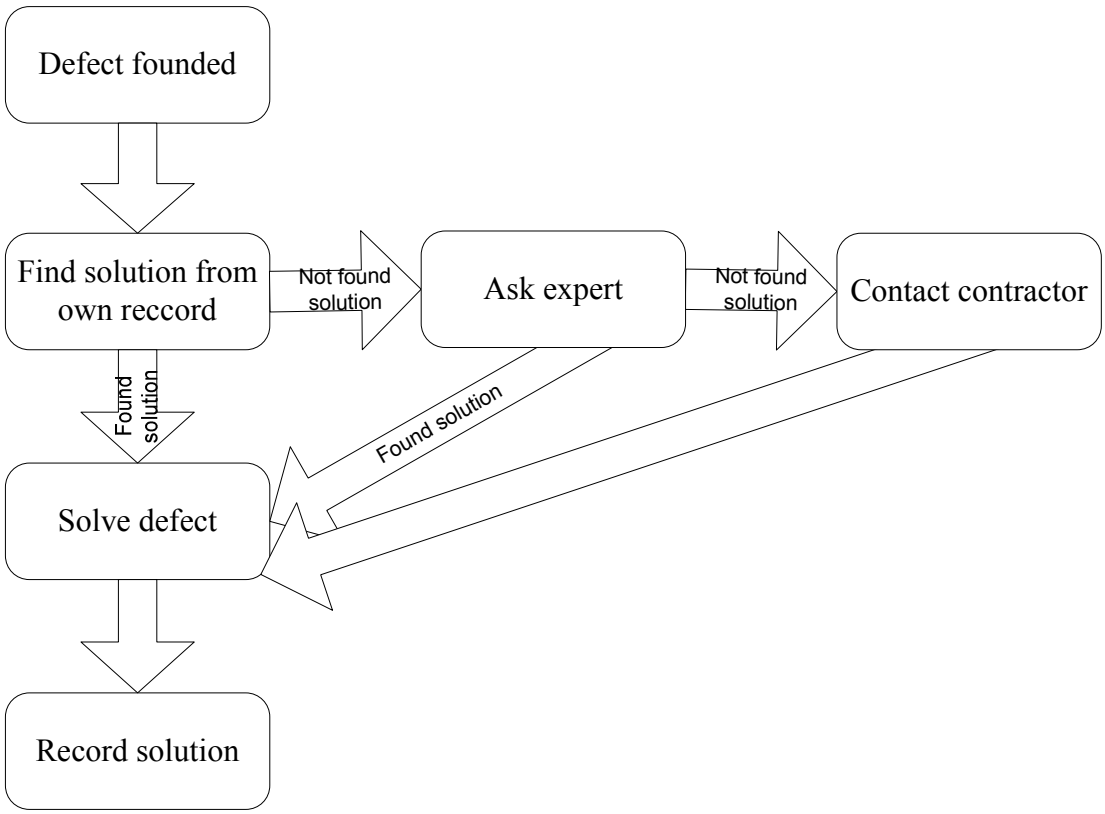


Figure 3.2 Current process of CSCS's administrator solves defect process.

Problem from current process will be seen are

- Record's knowledge are scattered and it cannot find easy.

- Difficult to get information about other knowledge that occurred outside responsible area. If has problem that can not correct by own may be must call phone to

expert, that sometimes they has mission or can not contact. Then it has to wait or delays time to transfer knowledge to employees.

- The method to transfer knowledge to all of employee like training, teaching job teaching may not cover all issues. And can not be broadcast all experience. When old employees have moved or changed position. It's make old employee's experience will be lost.

- Each CSCS's administrator can not work instead. Sometime if once of them absent, other may be can not solve defect because of have not record about solution of solve defect in own log book.

- If some member of CSCS's administrator team resigned or missing log book. Organizational knowledge will be lost, both the explicit knowledge (in the book) and tacit knowledge (the knowledge in people of CSCS's administrator). Then transfer knowledge to new CSCS's administrator is difficult and may be incomplete.

3. Explore requirements and suggestion from CSCS administrator and office's director.

- Centralize system that member in CSCS's administrator team from 12 areas of PEA and head office can access and collaborate use.

- System has login system for authenticate user and administrator user can access the system.

- User has 2 groups is login and un-login group.

- System has defect and solution record system.

- User can correct data of own defect.

- User can find knowledge by group of product and model of CSCS and part of defect.

- User can find knowledge by keyword.

- Administrator user can add substation data and product data of CSCS.

- Administrator user can add, modify and delete data of authenticate user.

- System has summarized knowledge of solution for CSCS's defect.

- System has summarized statistic data represent such as top 10 CSCS' defect, top 10 substations that has defect, etc.

4. Collect data of substation that use CSCS in each area of PEA. Data of substation compose of

- Substation code is unique 3 English alphabets that use instead substation name. For example BAL it mean BANGPLA substation.

- Substation name is name of each substation.

- Area means responsible area of each substation such as AYA is AYUTHAYA 1 substation is located in area C1.

- Product and model of CSCS that use in each substation.

- Start assurance date and end assurance date of CSCS's in substation.

5. Collect data of product and model of CSCS. Products of CSCS that is used in PEA's substation are 11 products, and some product has more than one model. Therefore, there are 15 types of difference product and model is used in PEA's substation.

- ABB model Micro SCADA
- AEG MODICON
- CRUICKSHANK model SAS 2000
- EFACEC
- GE MULTILIN
- GE FANUE
- Ingeteam model PQM
- Ingeteam model PQM300
- Ingeteam model TCP-PQM
- Ingeteam
- ISKRA model NEO 1000+
- REMSDAQ model Calisto IES
- REMSDAQ model CALISTO I
- SAT
- SEIMENS model X-MAT

6. Collect data about part of problem that found in CSCS corrective maintenance process. Part of problem that found in CSCS corrective defect process can divide to 7 parts as the following:

- CPM
- DIM
- LUI

- Network
- Power Supply
- SCADA Interface
- Time Reference

3.1.2 System Analysis

Analysis problem and requirement about CSCS from data collected step to identify knowledge sharing system for CSCS.

3.1.3 System Design

This step will design system for implementation from analyze data in previous step. Database design will use ER diagram to present designing details, and data dictionary for describe the data model components. Design users interface to define how the users will interact with the system.

3.1.4 System Implementation

Implement system following data from design and analyze in previous steps. All of information in the system analysis and system design will used to develop webpage by use PHP coding to retrieve information from database. Create relational database on MySQL, and when system implementation complete move system from develops computer to web server.

3.1.5 System Testing

The system will be tested to ensure that can work following objective of research. This step can be divided into 2 parts.

1. Programmer testing: programmer testing by self between development times. If the system has bugs or errors, it will be corrected in this process.

2. User testing: user testing after implementation complete for 2 months. The system will be keep record of user access knowledge etc. After certain period, the system is evaluated against user’s requirement and objective of research for conclusion of the system.

3.1.6 Conclusion and Documentation

After step of implementation and testing, the conclusion will be made. For suggestion further study will also be directed.

3.2 Research Tools

3.2.1 Hardware Tools and Configuration

- Computer for develop and test system.
- Computer for work as web server.

3.2.2 Software Tools

- Operation System: Microsoft Windows XP
- Programming Language: PHP
- Database Management System: MySQL
- Text Editor Software

3.3 Research Schedules

Task	Time (weeks)	Year 2010								
		01	02	03	04	05	06	07	08	09
Data Collection										
- KM and related	4									
- CSCS problem	4									
- Requirement	4									
System Analysis	4									
System Design	4									
System Implementation	6									
System Testing										
- Programmer testing	4									
- User testing	8									
Conclusion and Documentation	8									

Table 3.1 Research schedules.

CHAPTER IV
KNOWLEDGE SHARING SYSTEM FOR COMPUTER-BASE SUBSTATION CONTROL SYSTEM OF PROVINCIAL ELECTRICITY AUTHORITY, THAILAND

4.1 Overview System Design

Overview structure of Knowledge Sharing System for Computer-base Substation Control System of Provincial Electricity Authority is Web base technology. Web servers connected to a database server. Users can access information through the intranet of the organization.

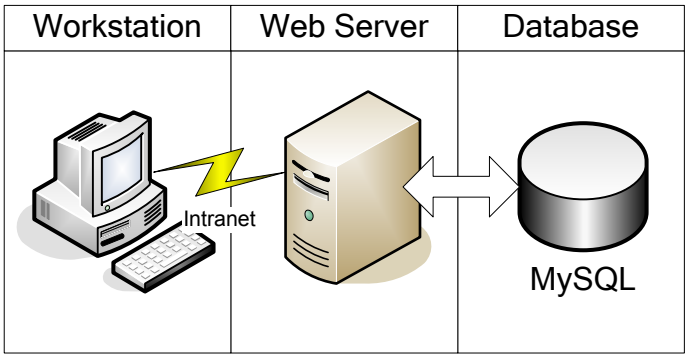


Figure 4.1 Overview of system design.

System consists of three user groups. Each group has difference right to access as below.

Administrator User

Administrator user is required to confirm the identity through login with user name and password. These users responsible for manage base data of the system to accurate and up to date as always. Base data of the system consist of substation data, product data and user data. Also administrator user can access other parts of the system as different users.

Authenticated User

Authenticated user is required to confirm the identity through login with user name and password. Authenticated user will has accessible more than anonymous user by able to record knowledge, search knowledge or add comment into the system.

Anonymous User

Anonymous user can access the system without login required but this user can access only summarize data part of the system, other part has no right to access.

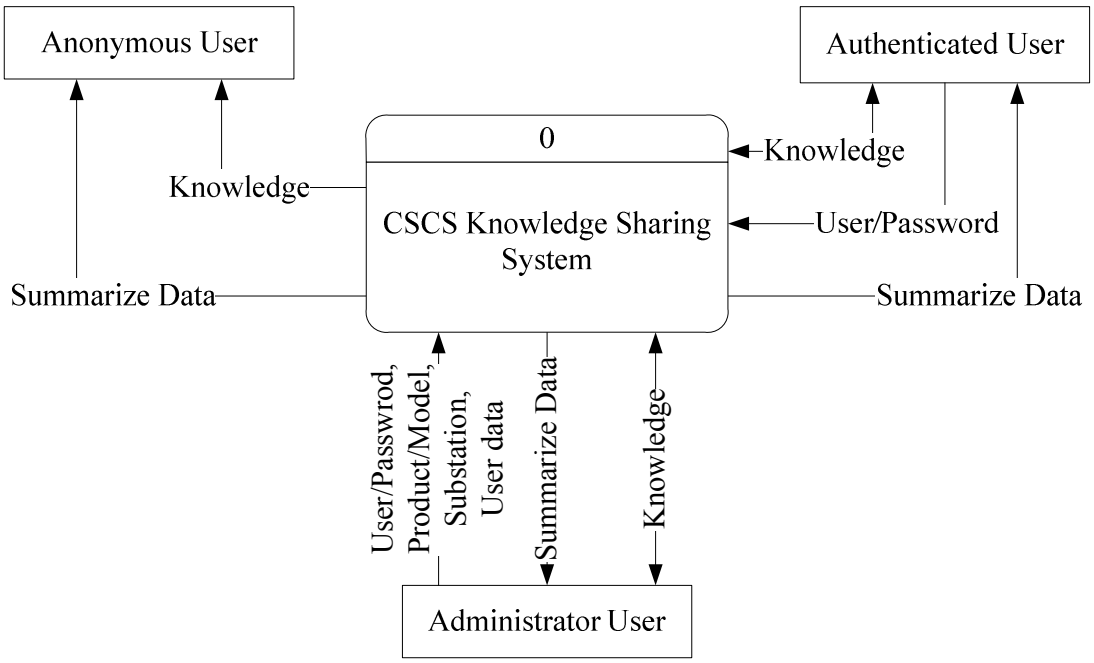


Figure 4.2 Context diagram.

The system consists of five processes as below.

Login

Administrator user and authenticated user are required to confirm the identity through a login process with user name and password.

Record data

Record data process categorize by the types of products and part of defect in CSCS system. Authenticated user can add new issues defect or add count number of the same defect that was recorded in the system. User can edit data of own defect record but does not for defect of other user. And also user can add additional

comments on each defect record.

Search data

Search data process can do two types; first by providing data are product and part of defect. Another one is user input keyword of interest to the system. The system will show list of defects that are stored in database according user want.

Summarize data

Administration user, authenticated user and anonymous user can access summarize data following below.

-- Summarize knowledge about CSCS's defect and solution.

-- Top 10 CSCS's defect.

-- Top 10 substations that has defect

-- Summarize defect data by product of CSCS.

-- Summarize defect data by part of defect.

-- Summarize defect data by area of substation.

Manage data

Manage data for manage base data of the system to accurate and up to date as always. Base data of the system consist of substation data, product data and user data. Administrator user has right to manage data following below.

-- Add new substation data.

-- Add new product data of CSCS.

-- Add, modify and delete user data.

Authenticated user can change own password.

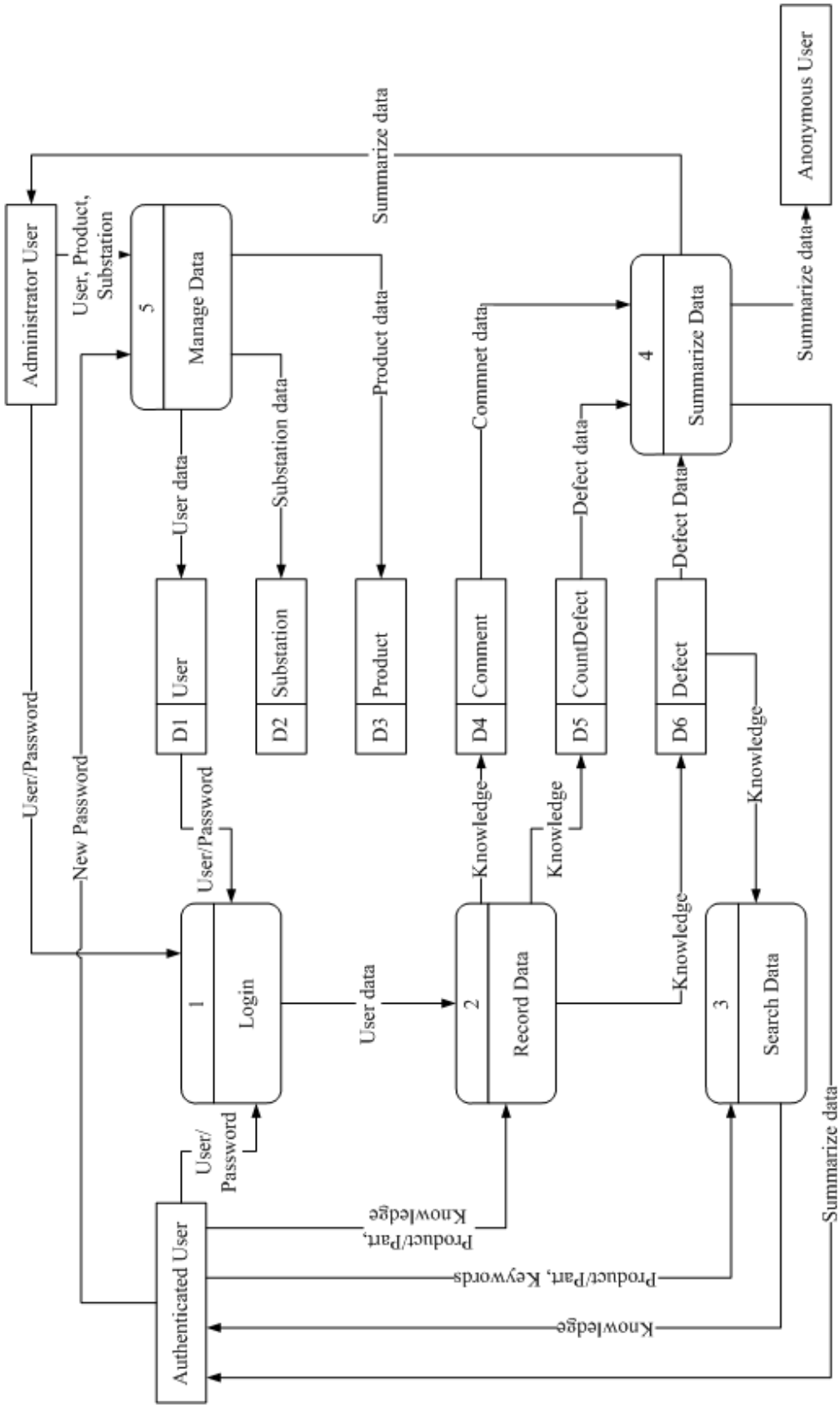


Figure 4.3 Data flow diagram level 0.

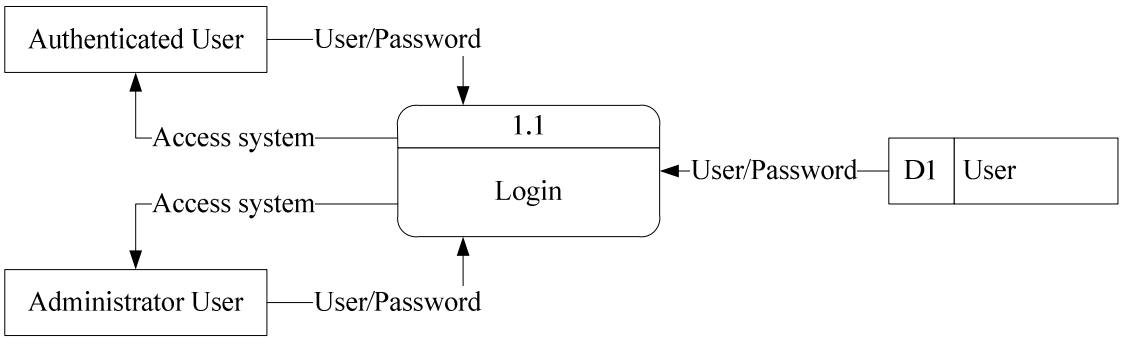


Figure 4.4 Data flow diagram level 1 (Login).

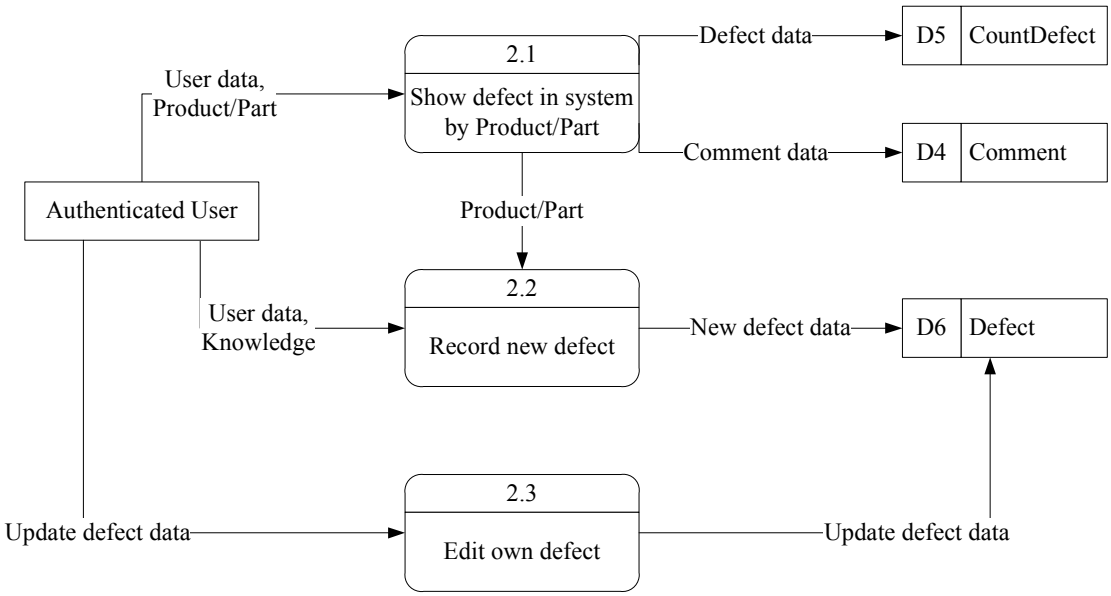


Figure 4.5 Data flow diagram level 1 (Record data).

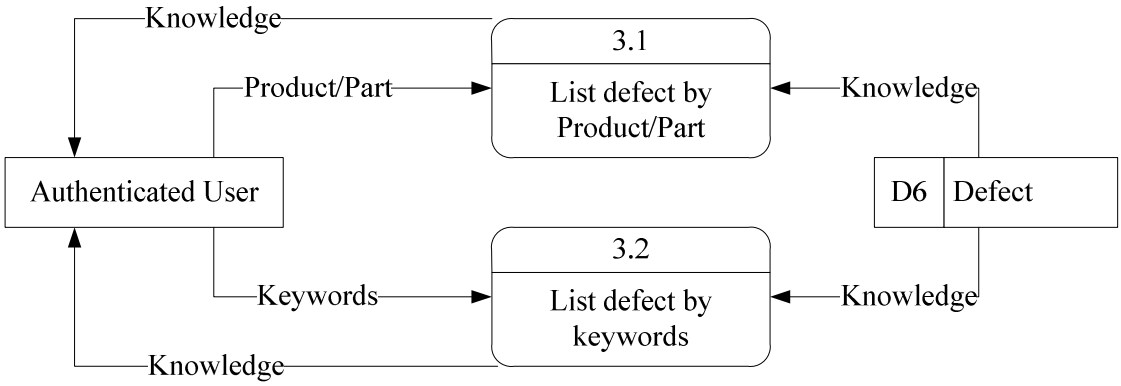


Figure 4.6 Data flow diagram level 1 (Search data).

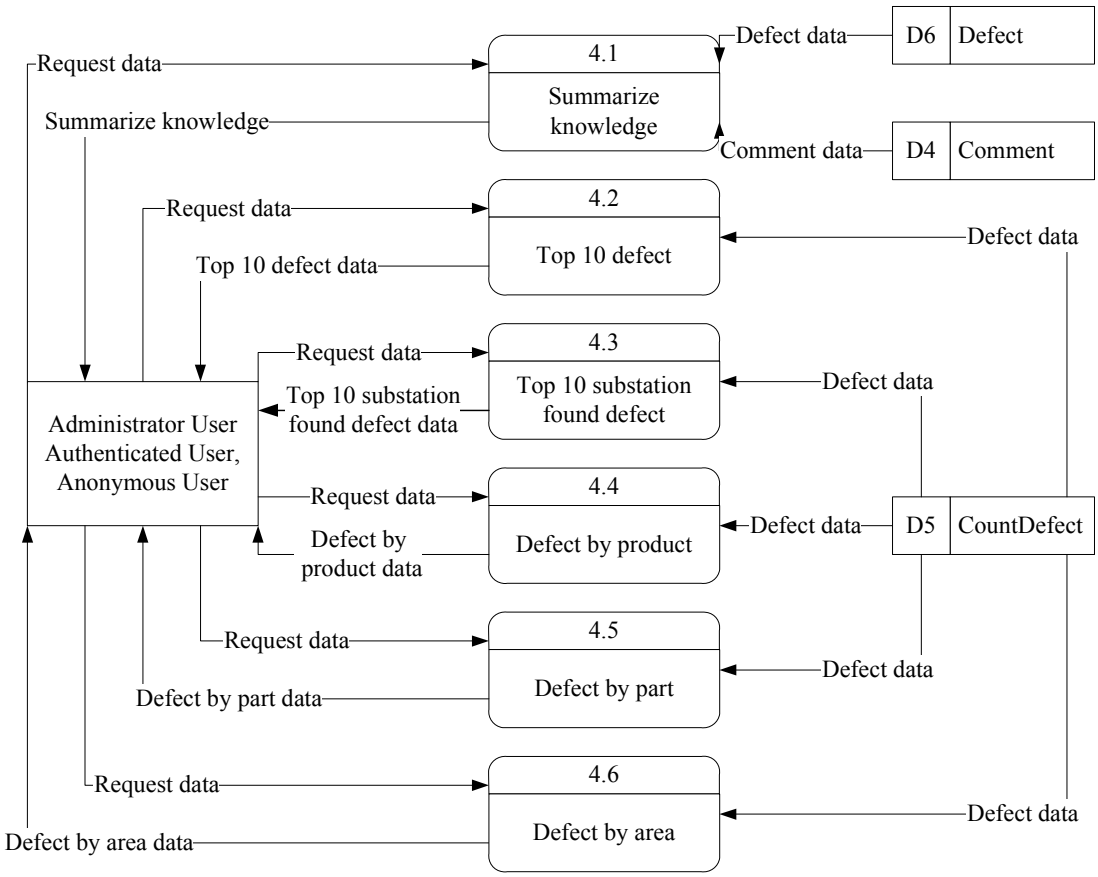


Figure 4.7 Data flow diagram level 1 (Summarize data).

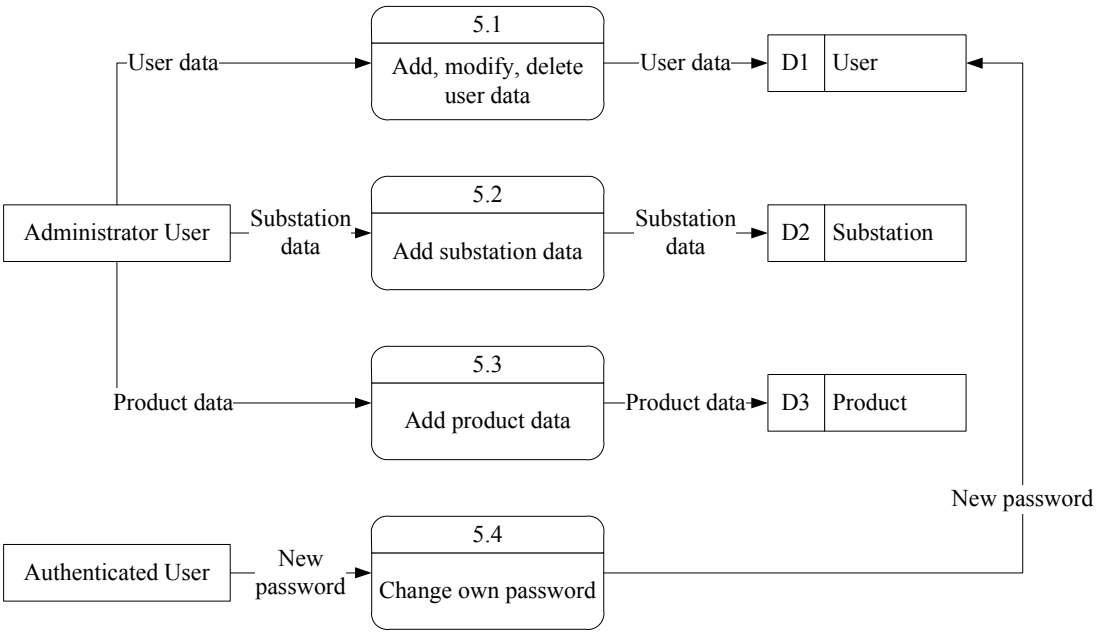


Figure 4.8 Data flow diagram level 1 (Manage data).

4.2 Database Design

Designing relational database system for Knowledge Sharing System for Computer-base Substation Control System of Provincial Electricity Authority, the details are as follows.

4.2.1 ER-Diagram

ER –Diagram can show as follows.

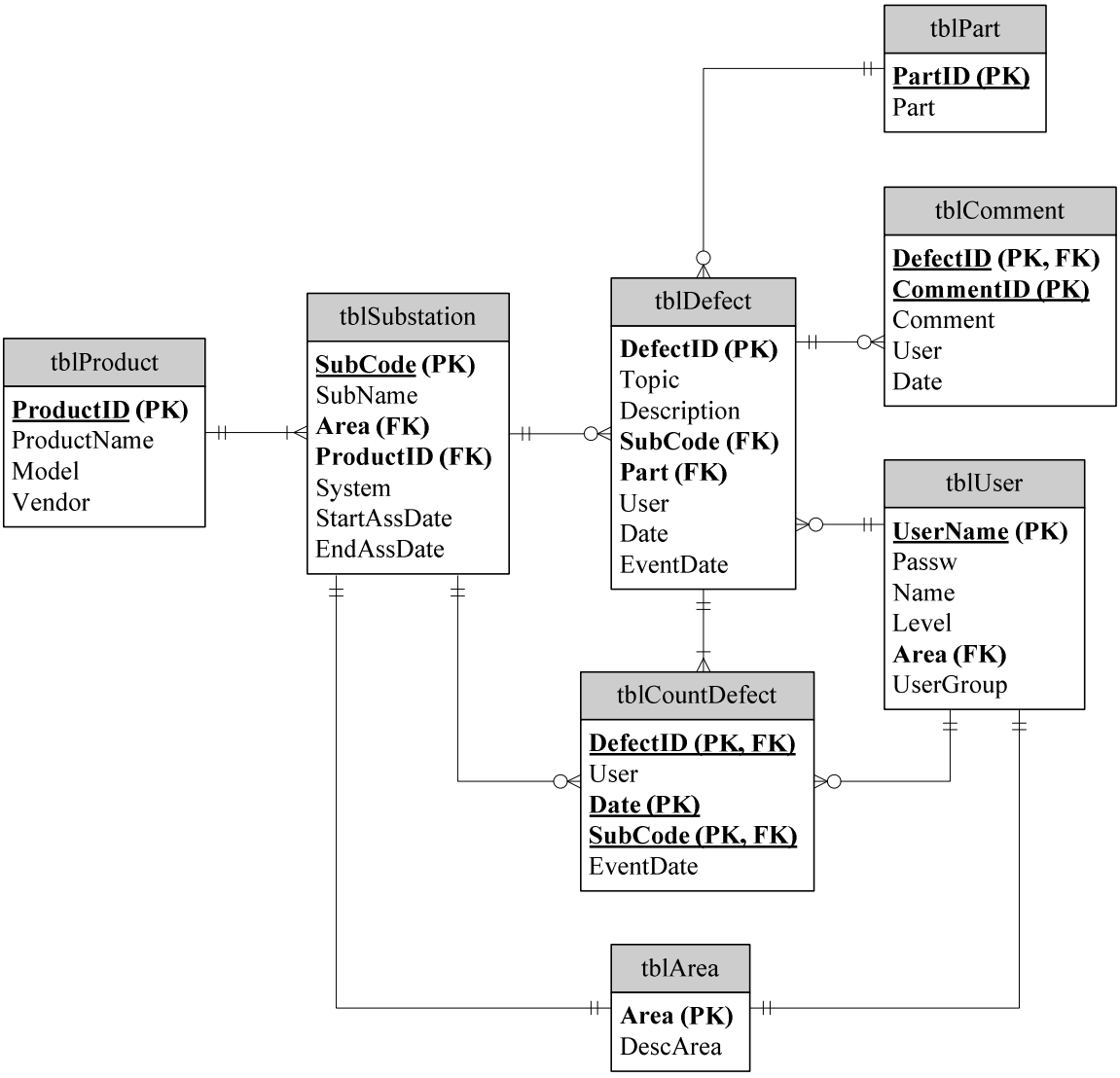


Figure 4.9 ER Diagram.

4.2.2 Data Dictionary

4.2.2.1 tblComment

Attribute Name	Type	Key	FK Referenced Table	Description
DefectID	int(11)	PK		Defect ID
CommentID	varchar(2)	PK		Comment ID
Comment	longtext			Comment Detail
User	varchar(10)			User
Date	date			Date

Table 4.1 Data dictionary of tblComment.

4.2.2.2 tblDefect

Attribute Name	Type	Key	FK Referenced Table	Description
DefectID	int(11)	PK		Defect ID
Topic	varchar(100)			Defect Topic
Description	longtext			Defect Description
SubCode	varchar(3)	FK	tblSubstaion	Substation Code
Part	varchar(1)	FK	tblPart	Part of CSCS's defect
User	varchar(10)			User
Date	date			Date
EventDate	date			Date occur defect

Table 4.2 Data dictionary of tblDefect.

4.2.2.3 tblCountDefect

Attribute Name	Type	Key	FK Referenced Table	Description
DefectID	int(11)	PK, FK	tblDefect	Defect ID
User	varchar(10)			User
Date	date	PK		Date
SubCode	varchar(3)	PK, FK	tblSubstation	Substation Code
EventDate	Date			Date occur defect

Table 4.3 Data dictionary of tblCountDefect.

4.2.2.4 tblPart

Attribute Name	Type	Key	FK Referenced Table	Description
PartID	varchar(1)	PK		Part ID
Part	varchar(20)			Part Description

Table 4.4 Data dictionary of tblPart.

4.2.2.5 tblSubstation

Attribute Name	Type	Key	FK Referenced Table	Description
SubCode	varchar(3)	PK		Substation Code
SubName	varchar(25)			Substation Name
Area	varchar(3)			Area of substation
ProductID	varchar(2)	FK	tblProduct	Product ID
System	varchar(15)			Electricity system
StartAssDate	date			Start Assurance Date
EndAssDate	date			End Assurance Date

Table 4.5 Data dictionary of tblSubstation.

4.2.2.6 tblProduct

Attribute Name	Type	Key	FK Referenced Table	Description
ProductID	varchar(2)	PK		Product ID
ProductName	varchar(20)			Product Name
Model	varchar(20)			Model
Vendor	varchar(20)			Vendor Name

Table 4.6 Data dictionary of tblProduct.

4.2.2.7 tblUser

Attribute Name	Type	Key	FK Referenced Table	Description
UserName	varchar(10)	PK		User name
Passw	varchar(10)			Password
Name	varchar(50)			Firstname and Lastname of user
Level	varchar(5)			Position of user in organization
Area	varchar(3)			Area of user
UserGroup	varchar(1)			Group of user

Table 4.7 Data dictionary of tblUser.

4.2.2.8 tblArea

Attribute Name	Type	Key	FK Referenced Table	Description
Area	varchar(3)	PK		Area code in English
DescArea	varchar(5)			Area code in Thai

Table 4.8 Data dictionary of tblArea.

4.3 User Interface Design

The system is a web application. The main page and related link show as follows.

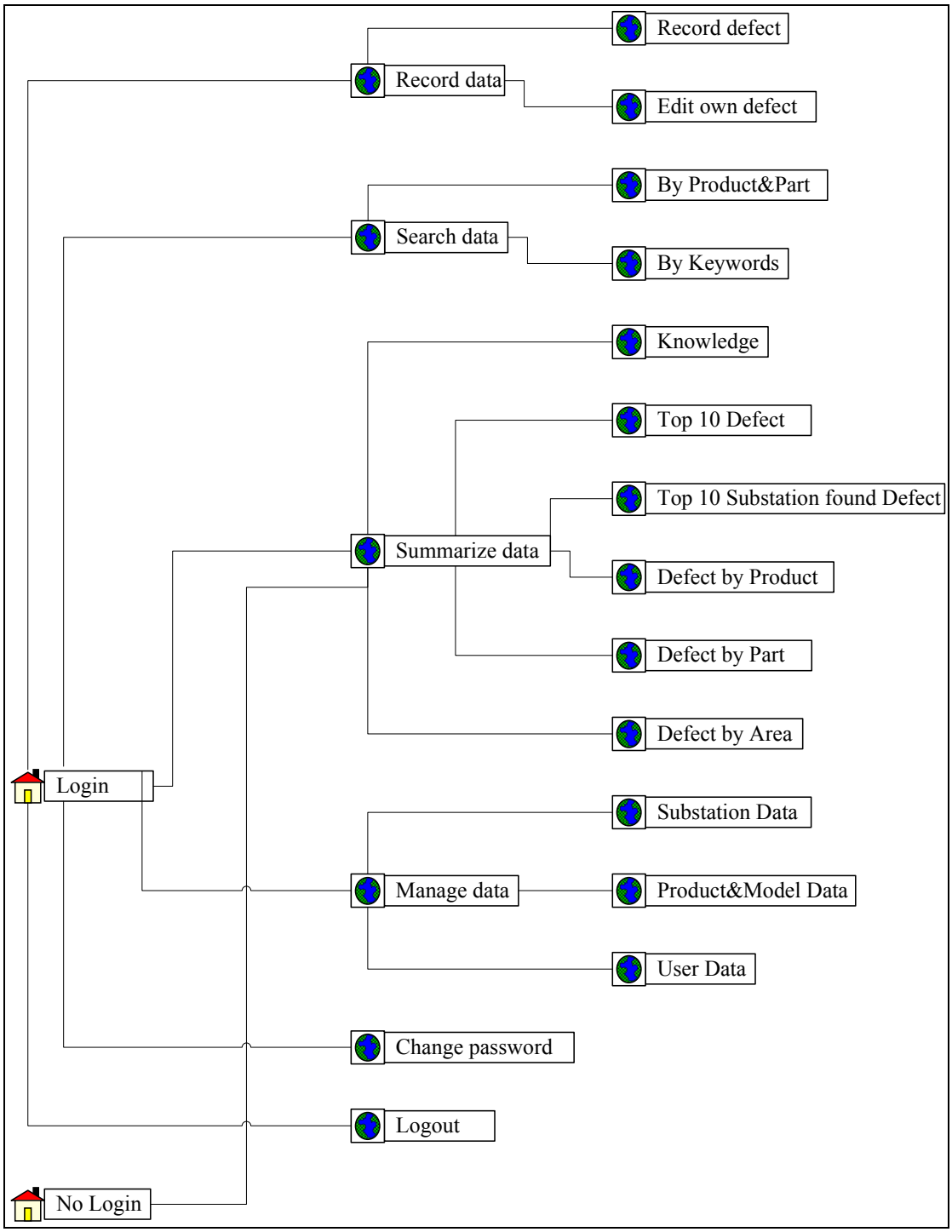


Figure 4.10 Main structure of webpage.

4.3.1 Login

First page or index page has login part for administrator user and authenticated user. Anonymous user no need to login can access by click “Access the system for view report (No Login) (เข้าระบบเพื่อดูข้อมูลรายงาน (ไม่ต้อง Login))”.

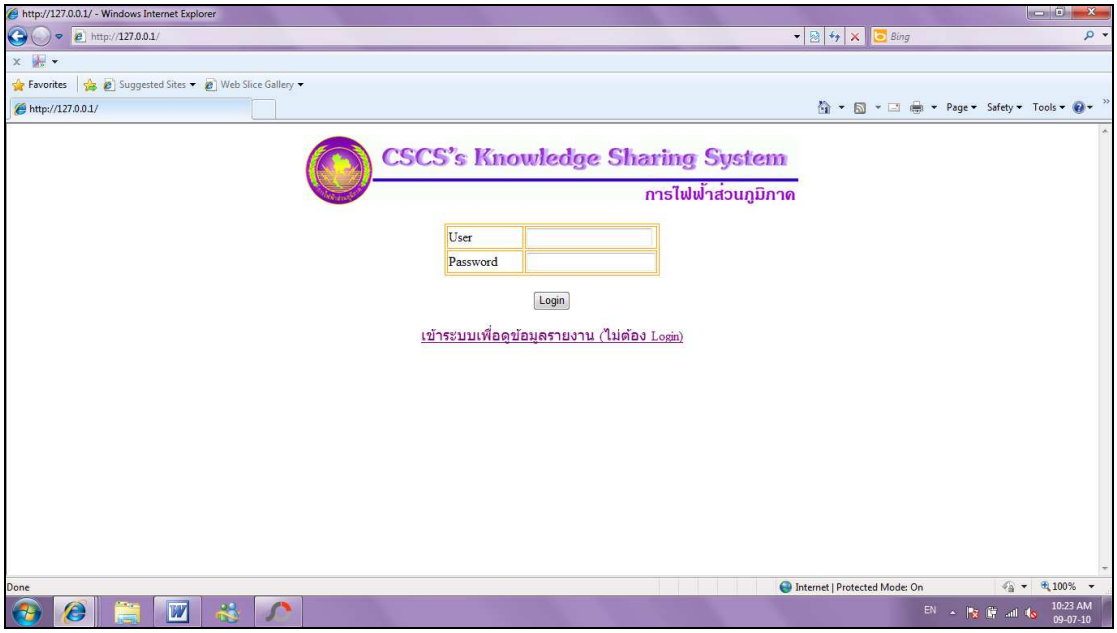


Figure 4.11 Index page of the system.

When user login was completed (User name and Password correct) the system will go to page record data as default. If user login was uncompleted the system will return to login page for user login again.

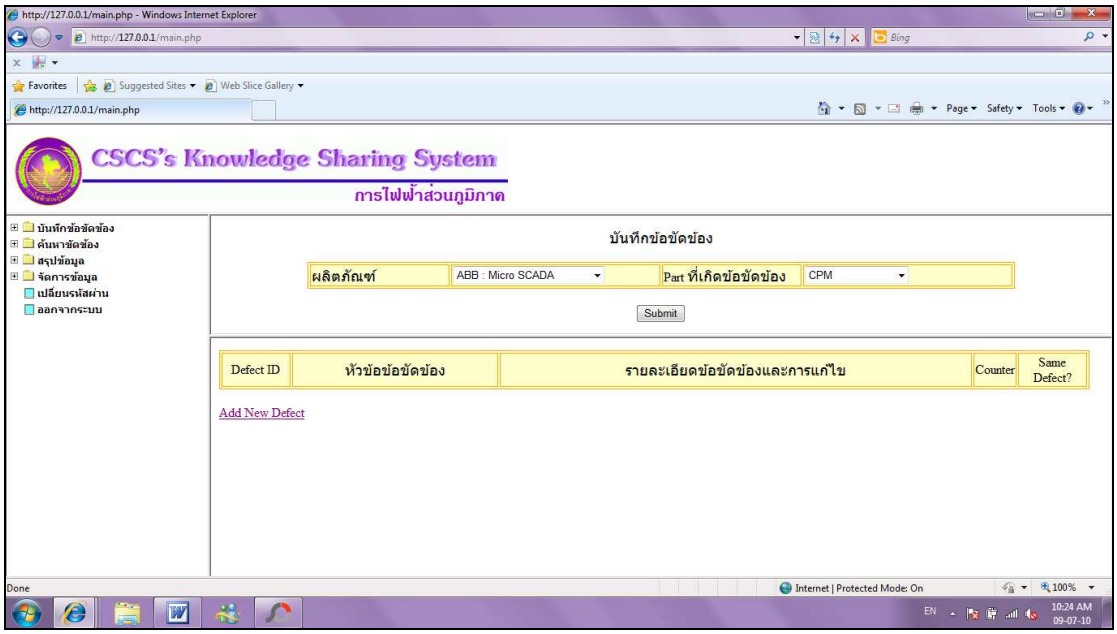


Figure 4.12 Default page after login completely.

If anonymous user access the system for see summarize data, the system will go to page summarize data.

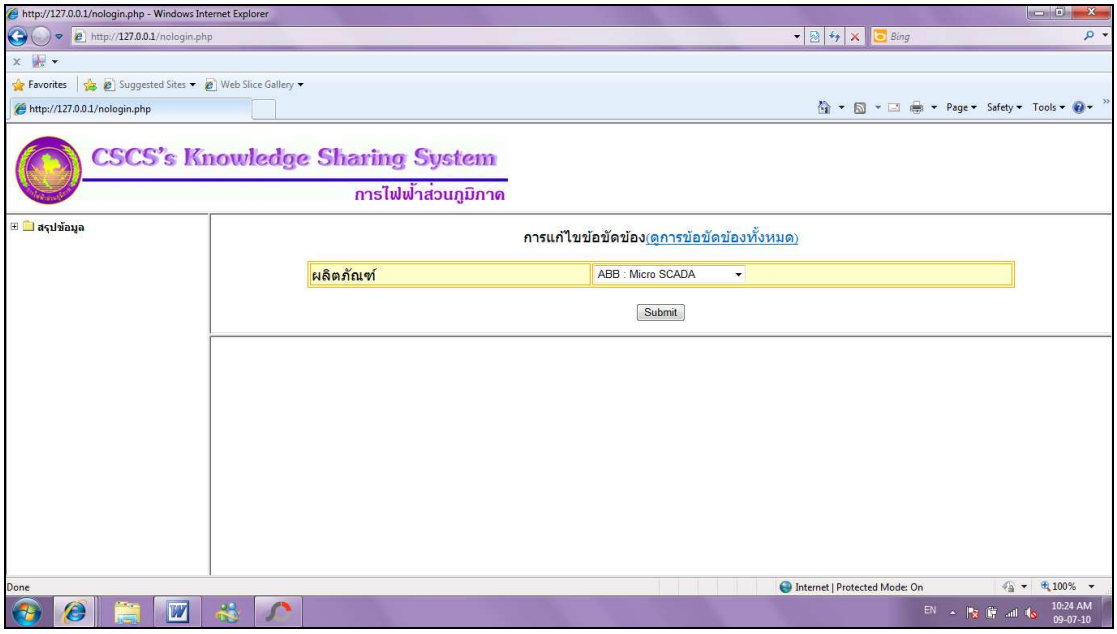


Figure 4.13 Default page for anonymous access the system.

4.3.2 Record data

After login, the system will go to page record data as default, or user can select record data from dropdown list menu on left side of page. Record data consist of two part are

- Record Defect (บันทึกข้อขัดข้อง)
- Edit Defect (แก้ไขข้อขัดข้อง)

Record defect page has dropdown list of product/model of CSCS and part of defect. When user selected and click “Submit” the system will show list of defect that recorded in database by product/model of substation and part of defect according user select.

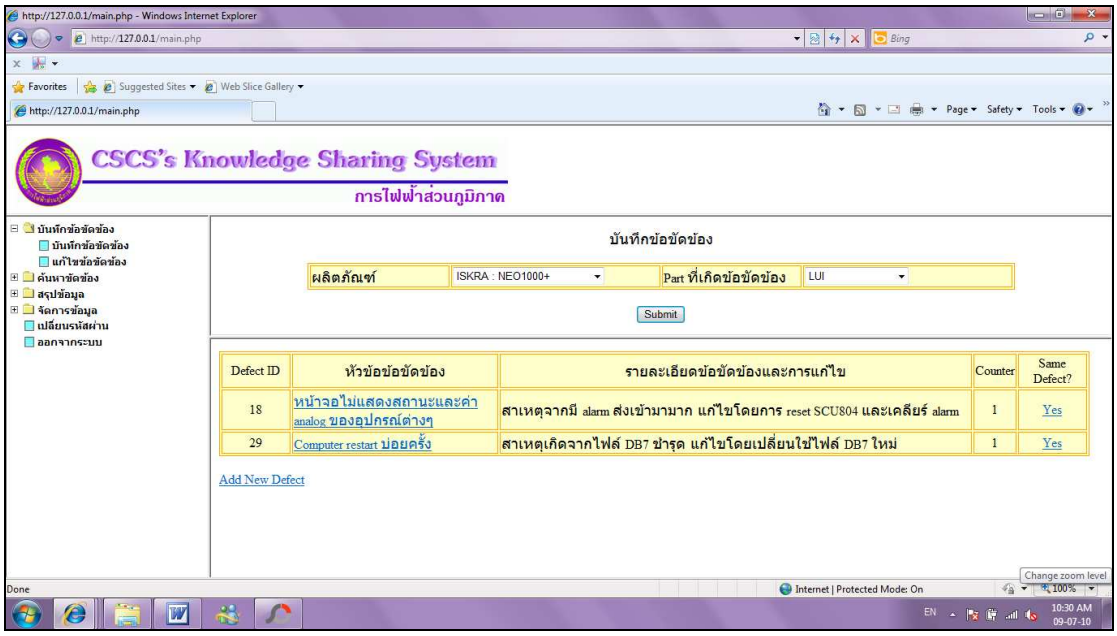


Figure 4.14 Page of record defect.

From list of defect, if defect that user want to record does not show in list. User click “Add New Defect” the system will go to page add new defect.

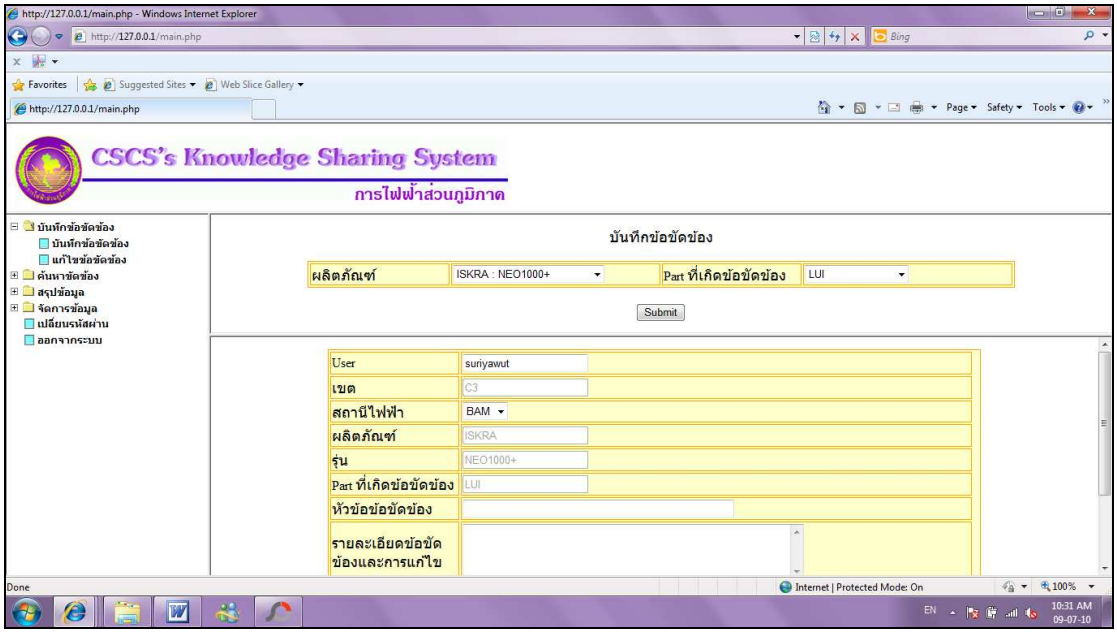


Figure 4.15 Page of add new defect.

When user record detail of defect complete and click “Submit”, data will be recorded to the system. The system will show message “Complete, Thank you”

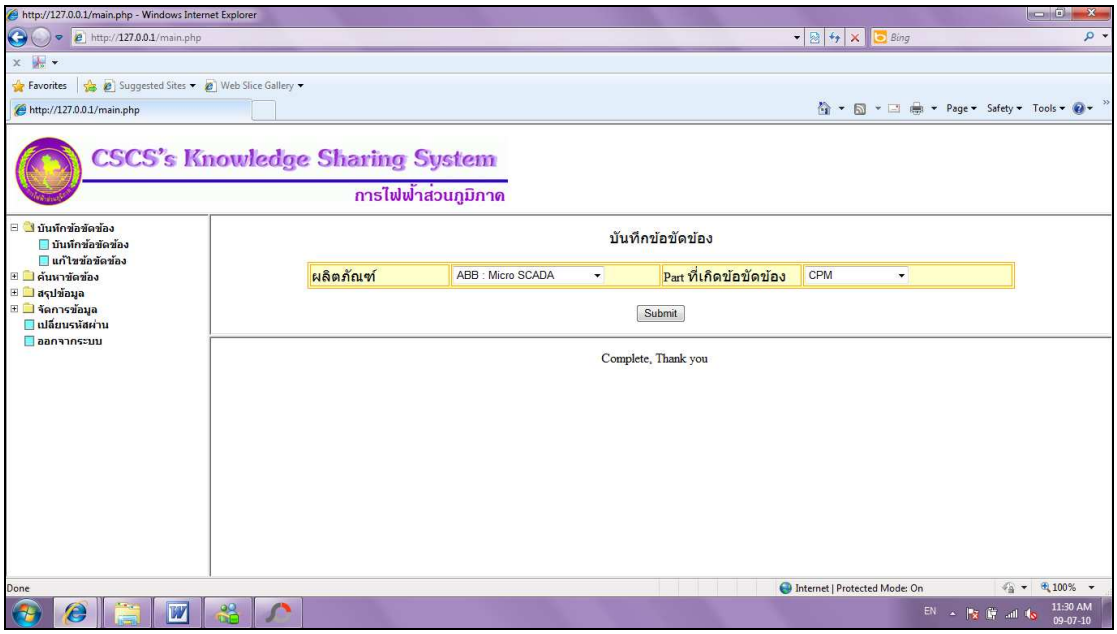


Figure 4.16 Message show when record new defect was completed.

From list of defect, if defect that user want to record has shown in list. User just clicks “Yes” at “Same Defect” column. The system will get input substation name and defect occur date from user.

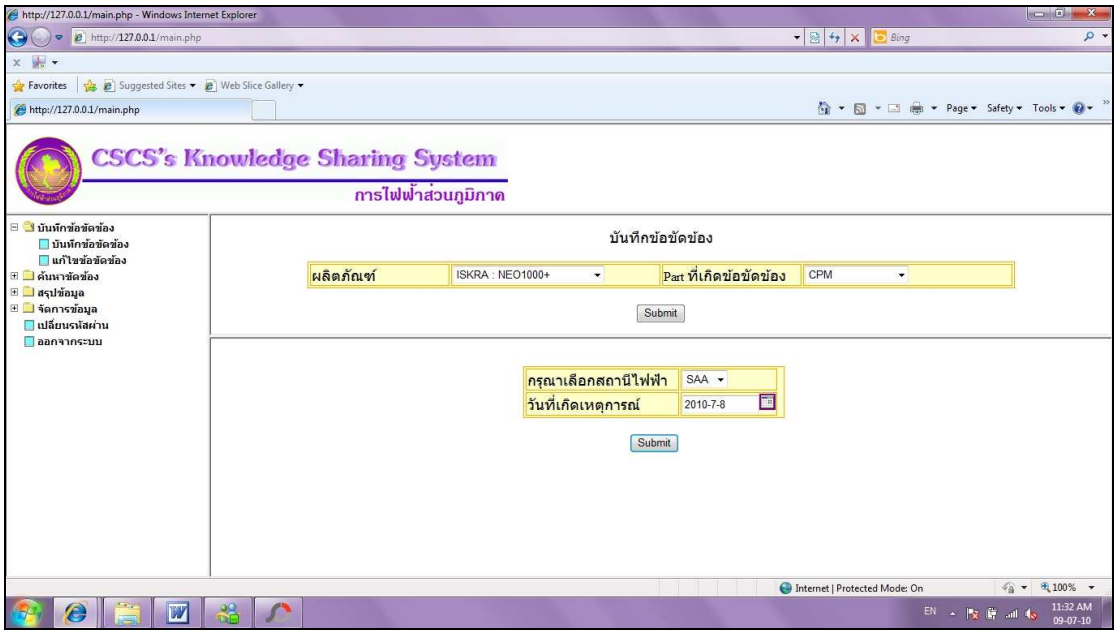


Figure 4.17 Page of add same defect.

After user click “Submit” the system will record data and show detail of thus defect.

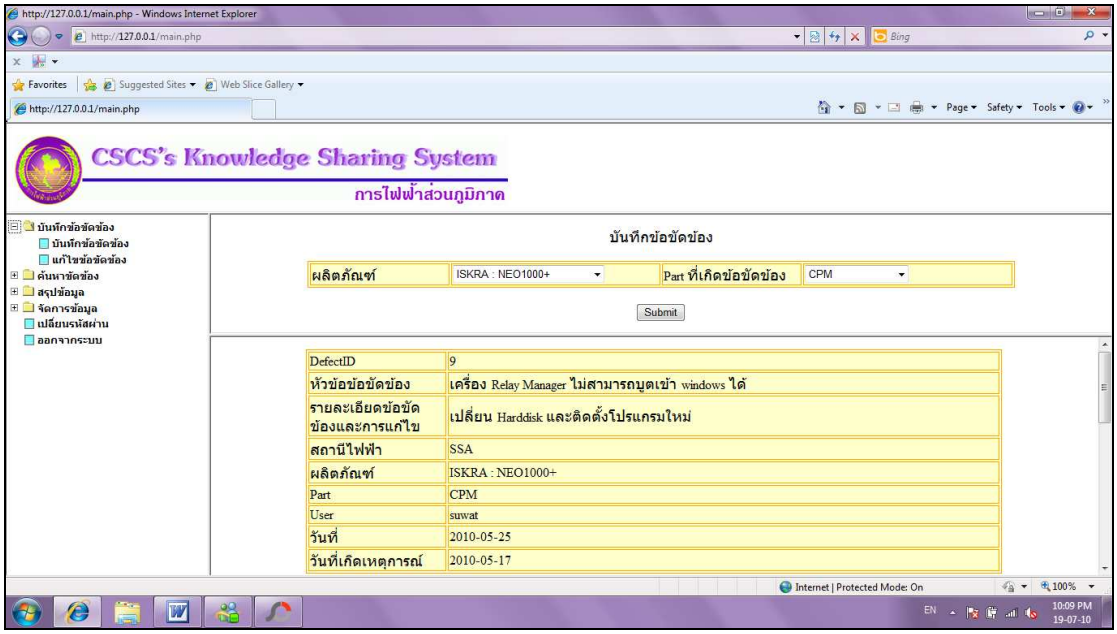
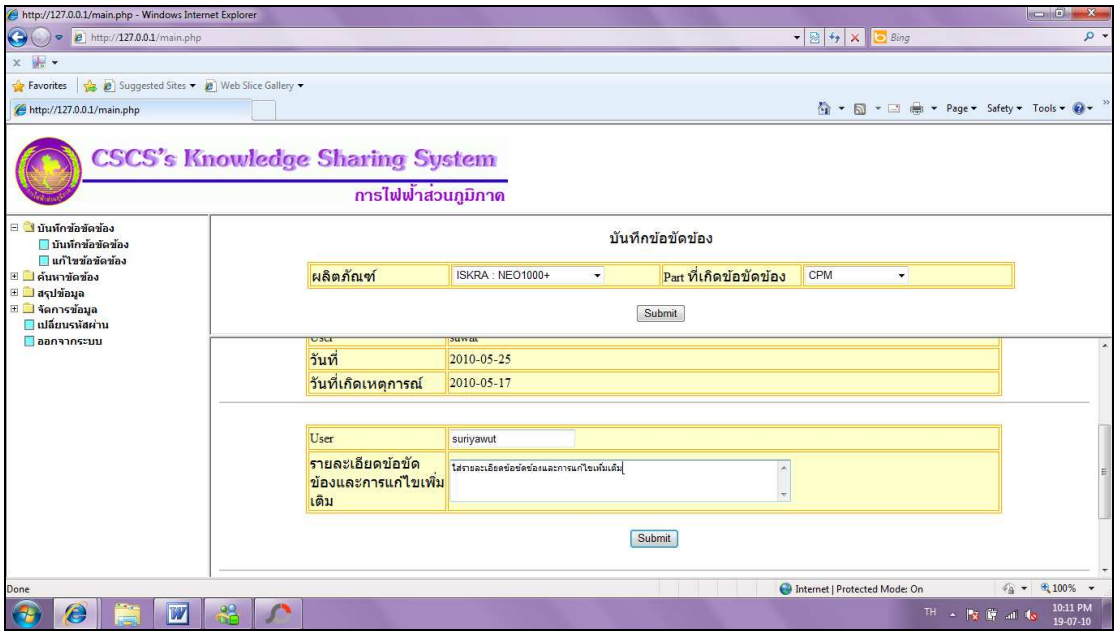


Figure 4.18 Page show detail of defect when user add same defect completely.

When user read detail of defect already and want to add comment or another data of defect and solution, user can add data to “other detail of defect and solution (รายละเอียดข้อขัดข้องและการแก้ไขเพิ่มเติม)”.



4.19 Page of add other detail of defect and solution.

When user record data completely and click “Submit”, data will be recorded to the system. The system will show message “Complete, Thank you”.

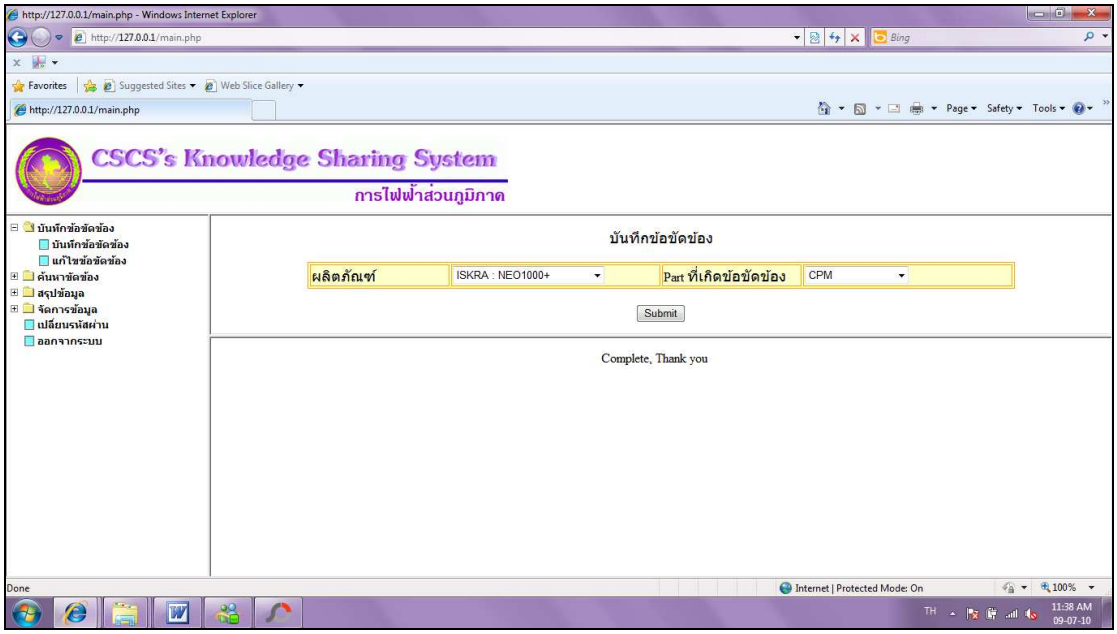


Figure 4.20 Message show when record comment was completed.

User can edit own defect by select “Edit Defect (แก้ไขข้อขัดข้อง)” from dropdown list menu from left side of page.

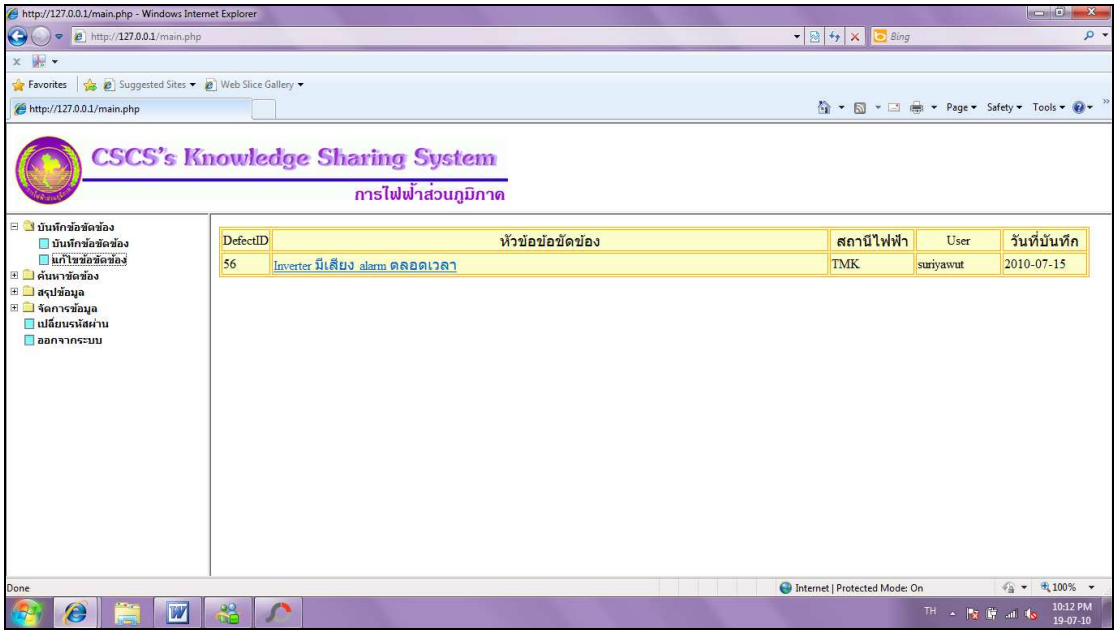


Figure 4.21 List of defect of user login.

User can edit description of defect and solution only. Another part of data can not editing.

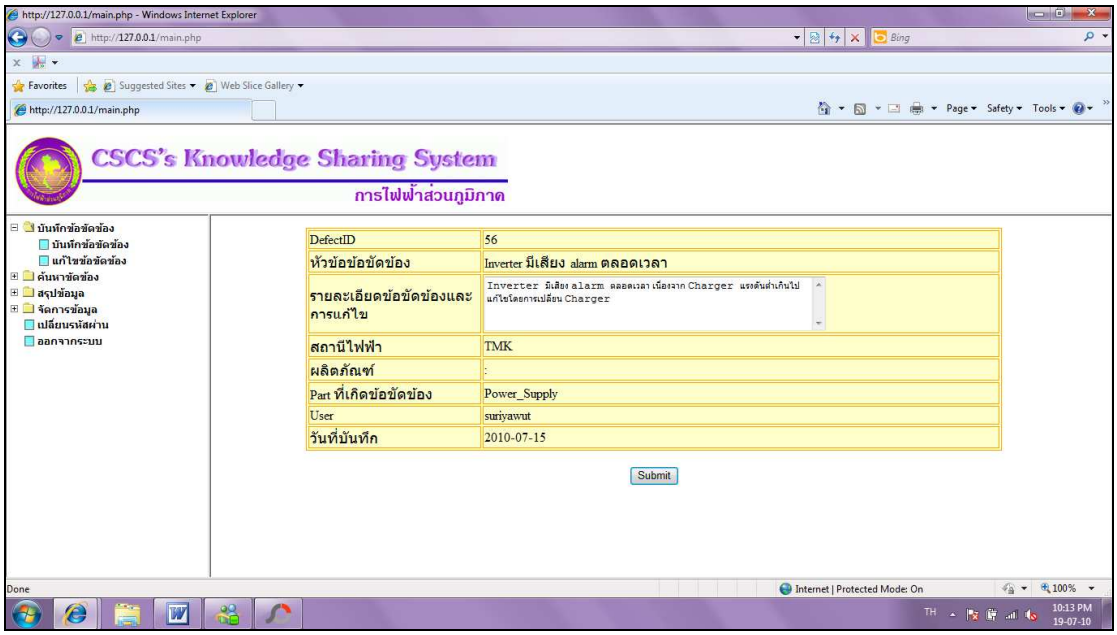


Figure 4.22 User edit description of own defect.

After user edit data was completed and click “Submit” data will be recorded to the system. The system will show message “Complete, Thank you”.

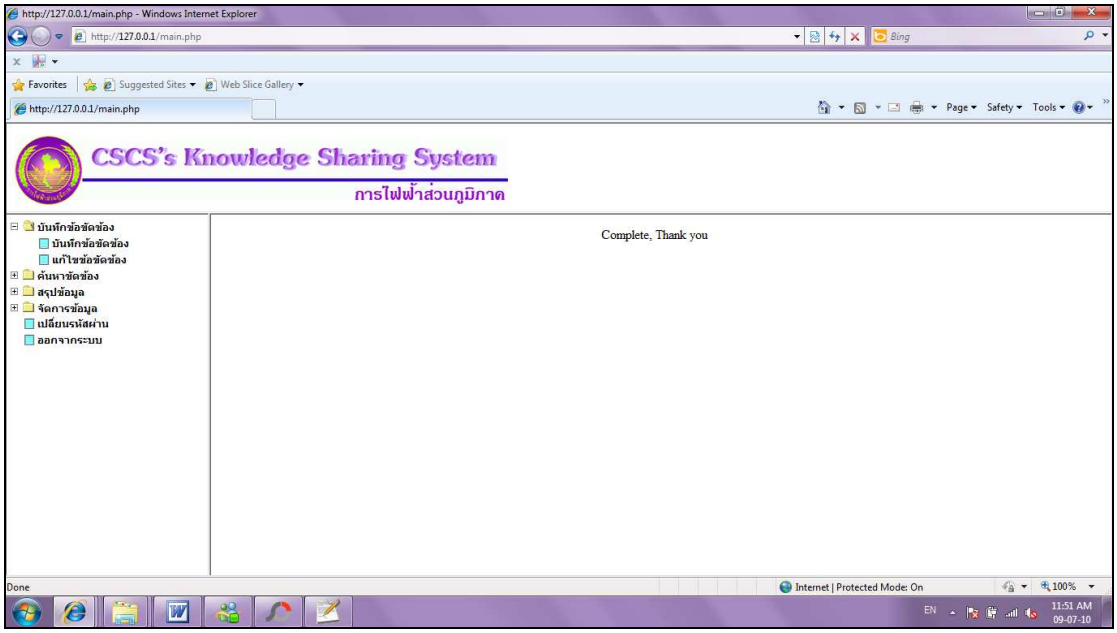


Figure 4.23 Message show when edit defect was completed.

4.3.3 Search data

User can access search data by select from dropdown list menu on left side of page. Record data consist of two part are

- Search by Product&Part (ค้นหาตาม Product&Part)
- Search by keyword (ค้นหาตาม keyword)

When user selects “Search by Product&Part” the system will show dropdown list of Product/Model and Part of defect for user select by interest. Otherwise user can click “See all defects (ดูข้อขัดข้องทั้งหมด)” for all defects.

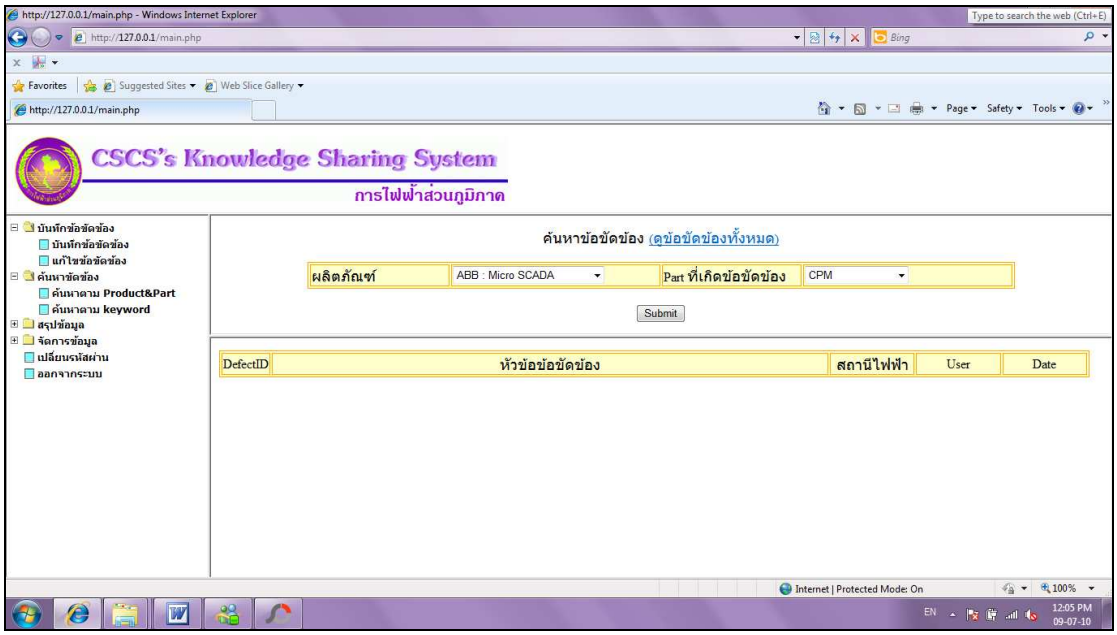


Figure 4.24 Search by Product&Part.

If user clicks “See all defects” all of defects are recorded in the system will show in list order by DefectID.

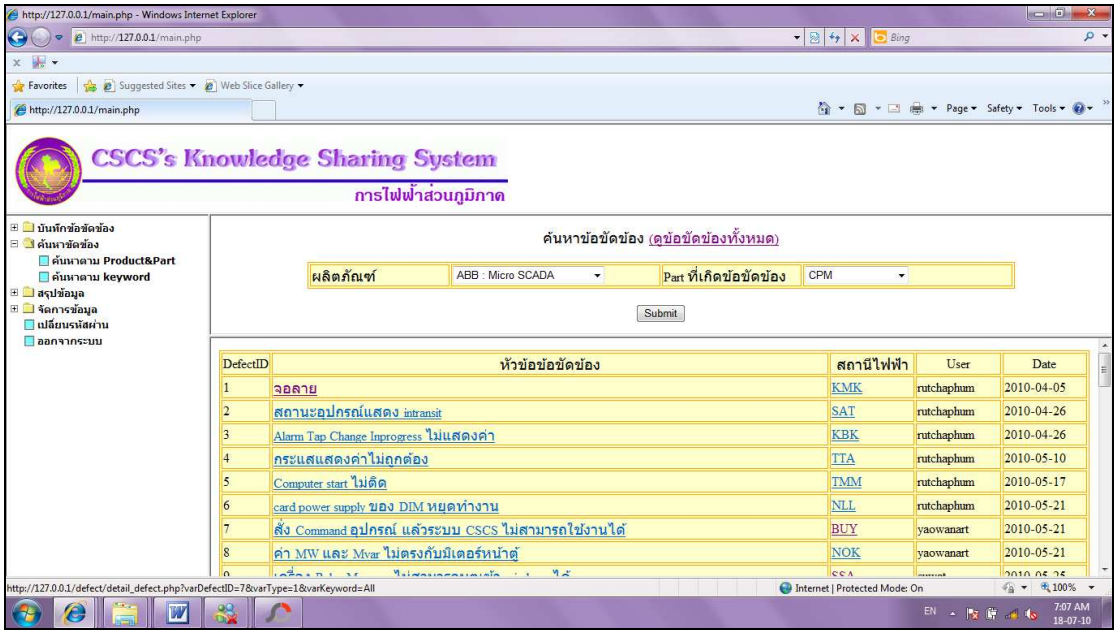


Figure 4.25 List of all defect.

If user select interest product/model and part of defect from dropdown list after click “Submit” the system will show list of defect that has product/model and part of defect according user select.

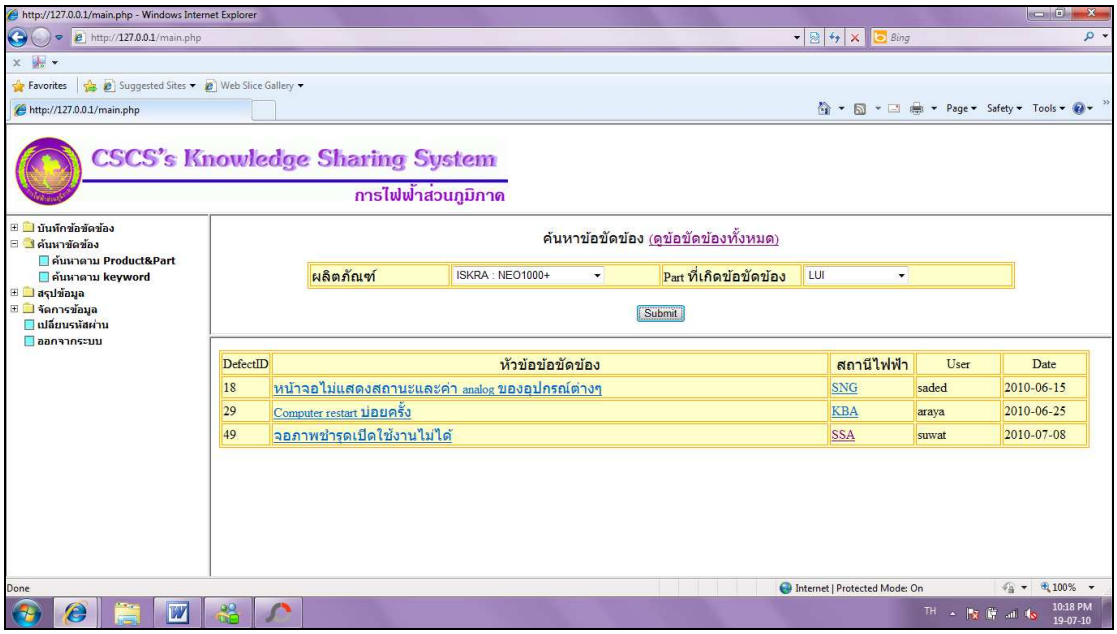


Figure 4.26 List of defect by user select Product/Model and Part.

User can search defect by interest keyword, select “search by keyword” from dropdown list menu on left side of page. When open page default is show all list of defect.

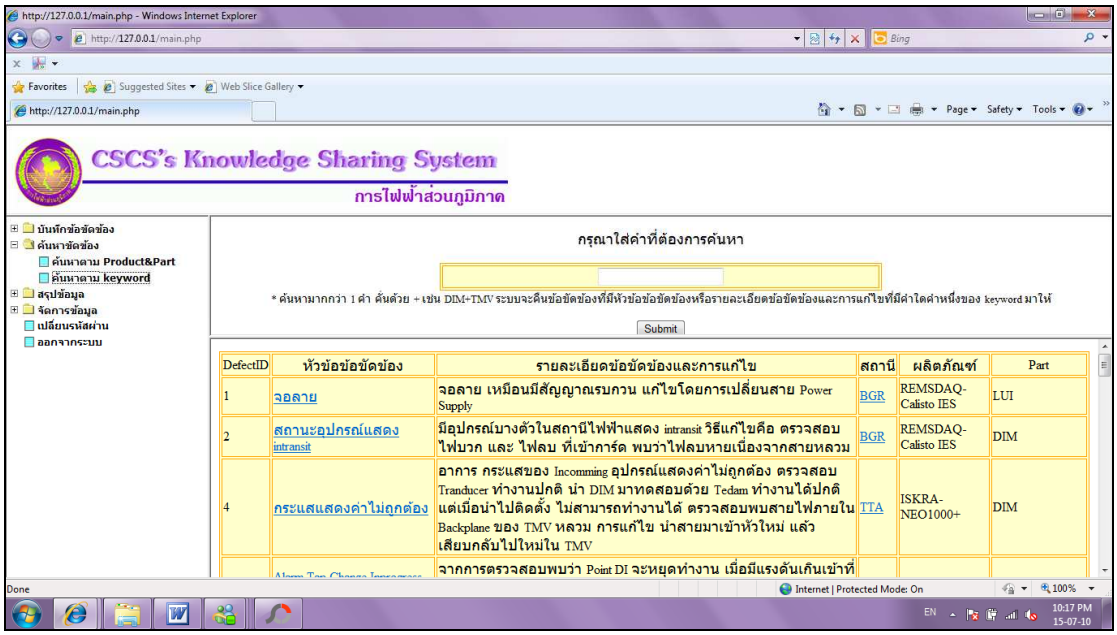


Figure 4.27 Default page of search by keyword.

User input interest keyword and click “Submit” the system will show list of defect that has keyword in topic or description of defect according user want.

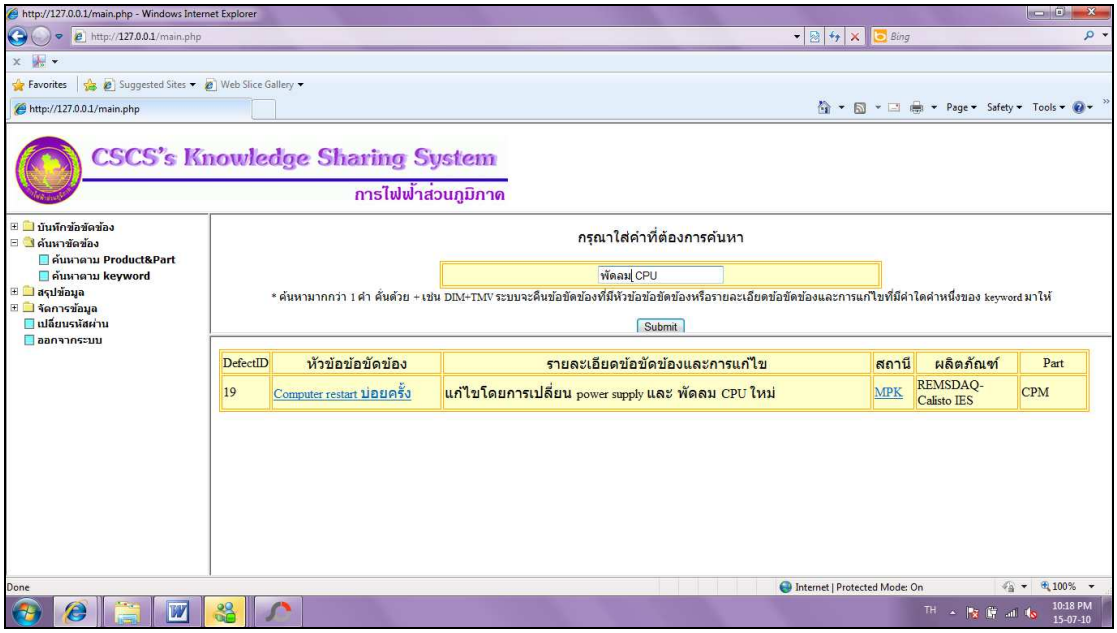


Figure 4.28 List of defect by user input keyword.

User can see detail of interest defect by click topic of defect. The system will open new window that show detail of defect.

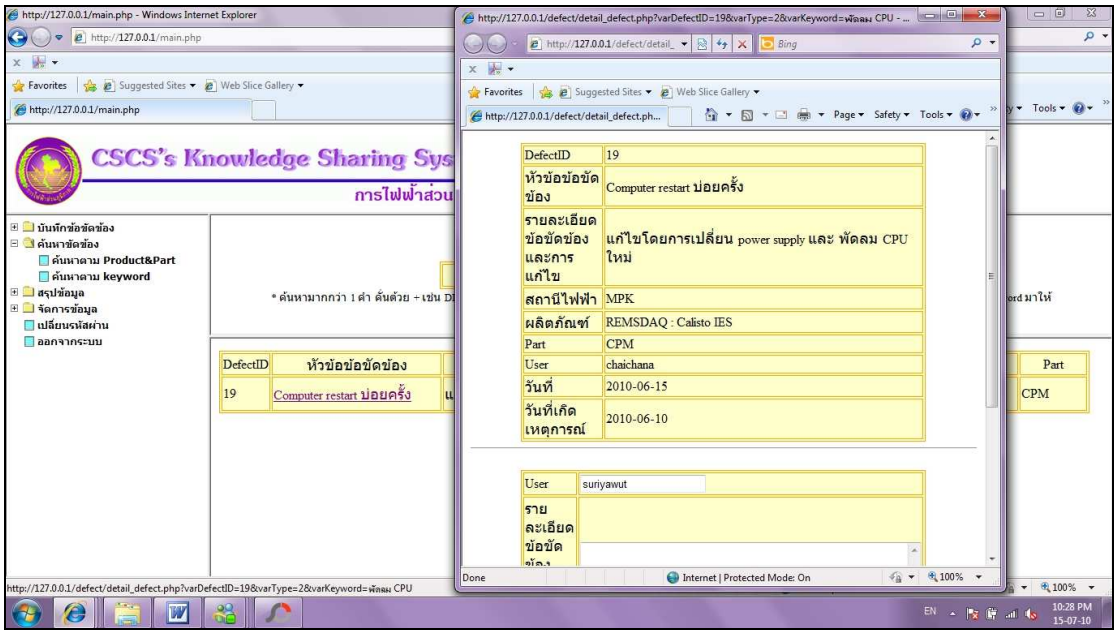


Figure 4.29 New window show detail of defect.

User can see detail of interest substation by click substation code. The system will open new window that show detail of substation.

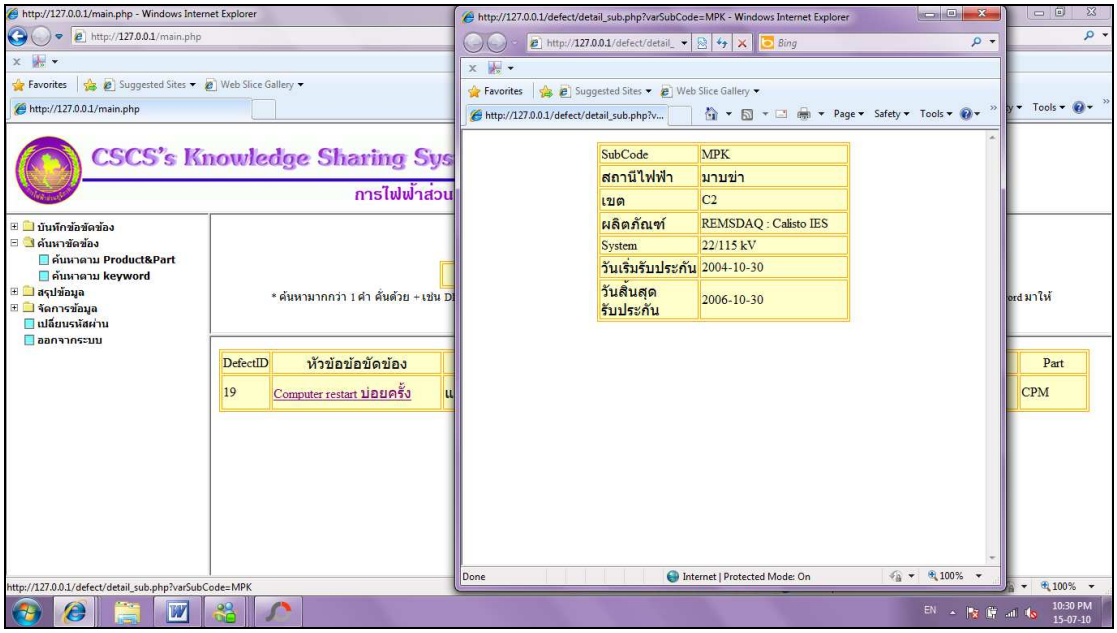


Figure 4.30 New window show detail of substation.

4.3.4 Summarize data

User can access summarize data by select from dropdown list menu on left side of page. Summarize data consist of six part are

- Summarize knowledge (สรุปความรู้การแก้ไขข้อขัดข้อง)
- Top 10 defect (10 ข้อขัดข้องที่พบมากที่สุด)
- Top 10 substation that found defect (10 สถานีที่พบข้อขัดข้องที่พบมากที่สุด)
- Defect by product (ข้อขัดข้องตามผลิตภัณฑ์)
- Defect by part (ข้อขัดข้องตาม Part)
- Defect by area (ข้อขัดข้องตาม Area)

When user select “Summarize knowledge” the system will has dropdown list of product of CSCS or user click “See all defects (ดูรายการปัญหาข้อขัดข้องทั้งหมด)”.

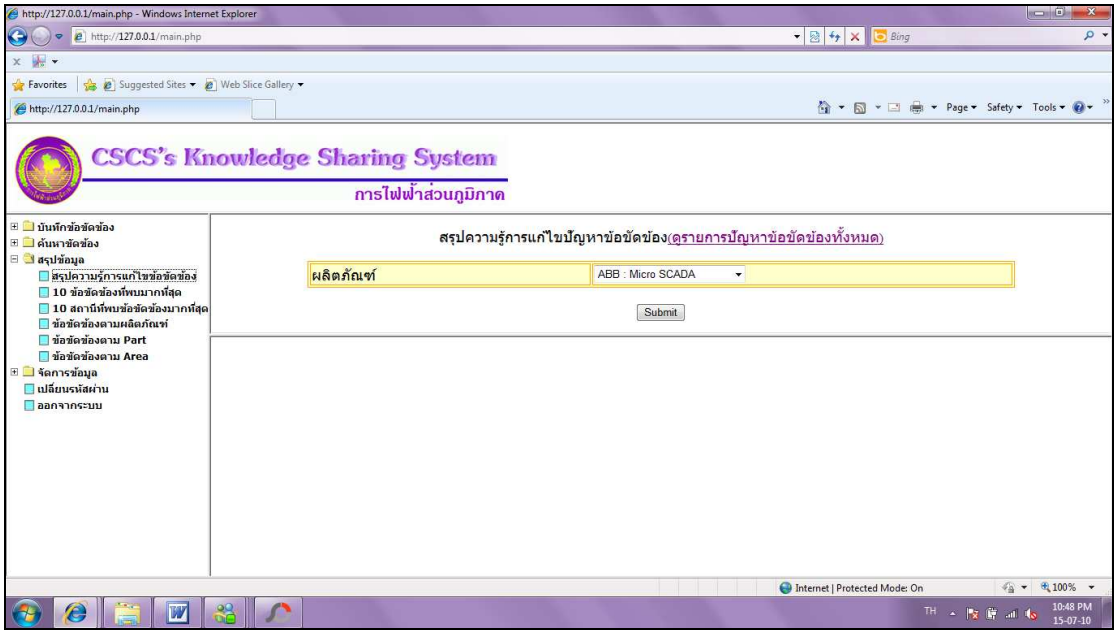


Figure 4.31 Default page of summarize knowledge.

If user clicks “See all defects” the system will show list of all defect data order by product of CSCS.

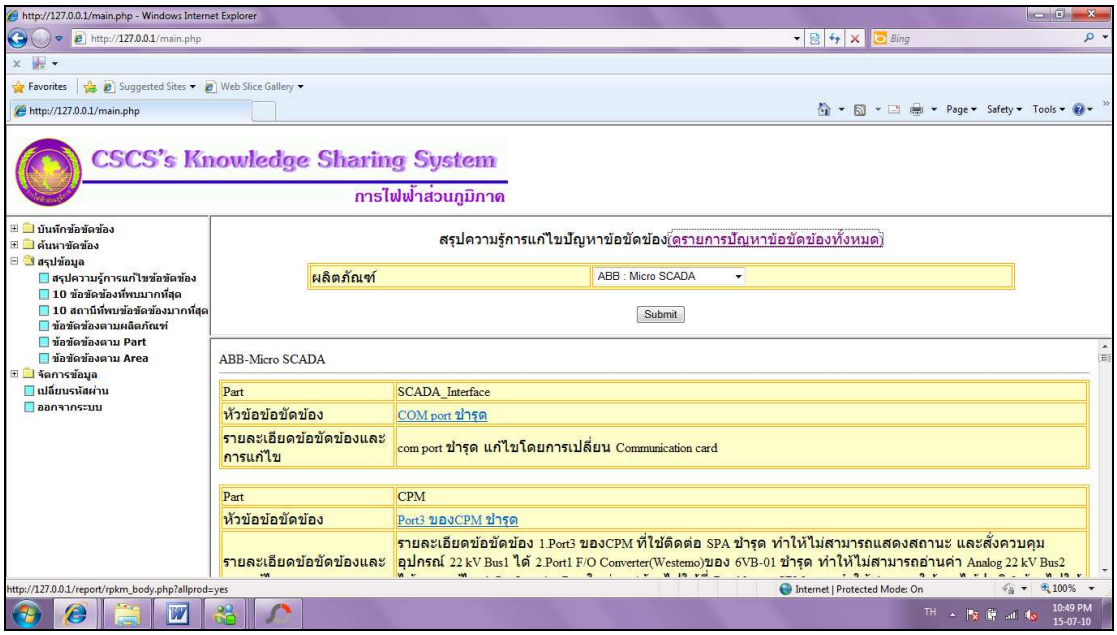


Figure 4.32 List all defect of summarize knowledge.

If user select interest product by dropdown list and click “Submit” the system will list defect data by product that user select.

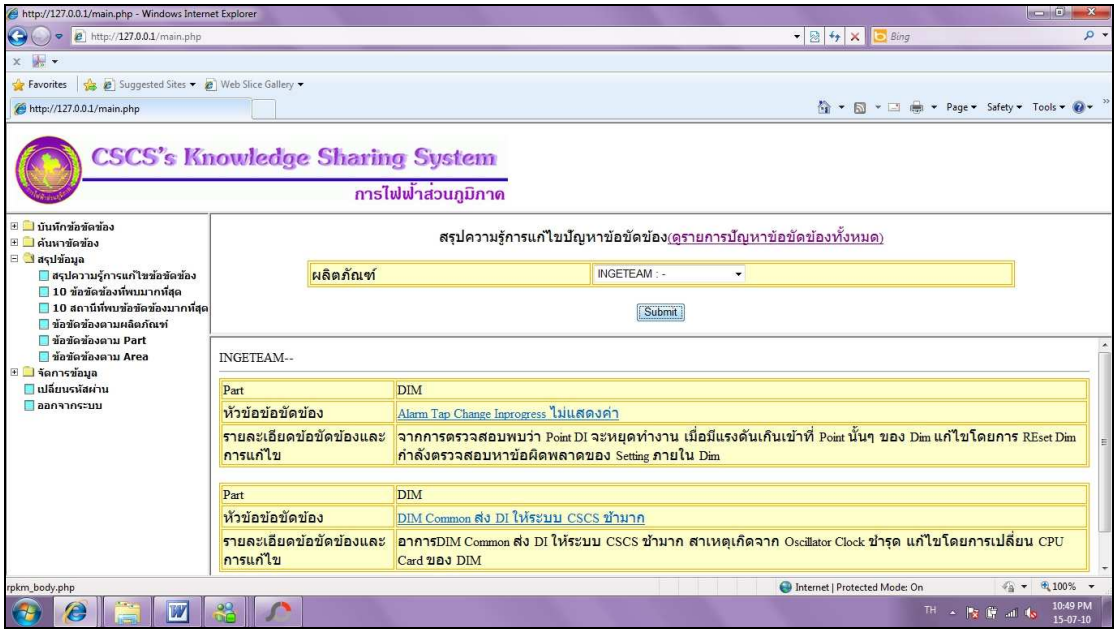


Figure 4.33 List defect by product of summarize knowledge.

User can see detail of interest defect by click defect topic. The system will open new window that show detail of defect.

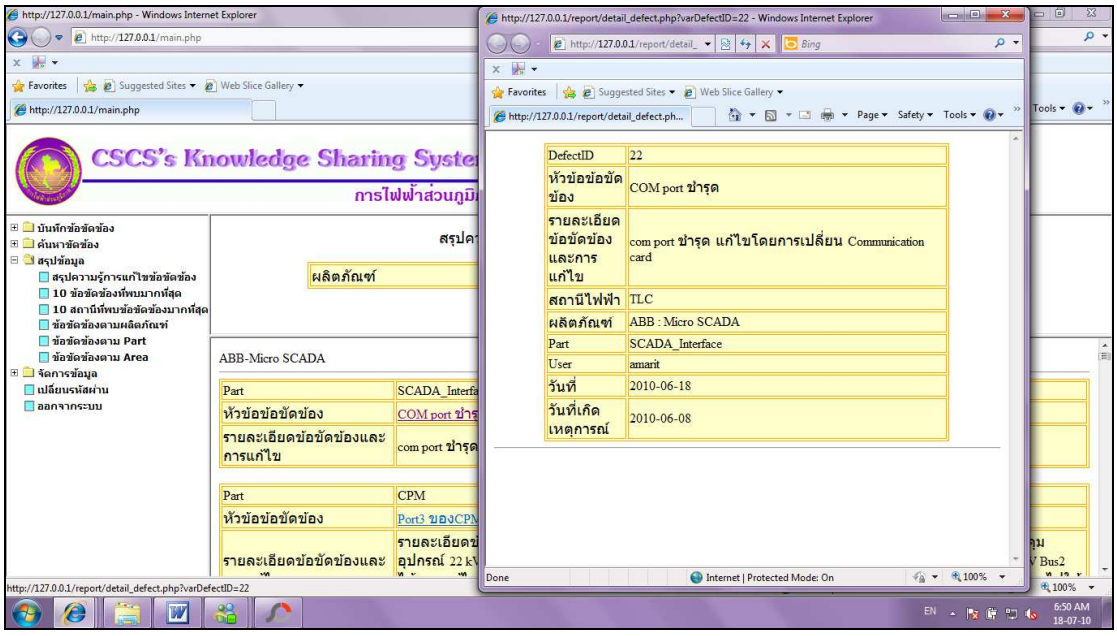
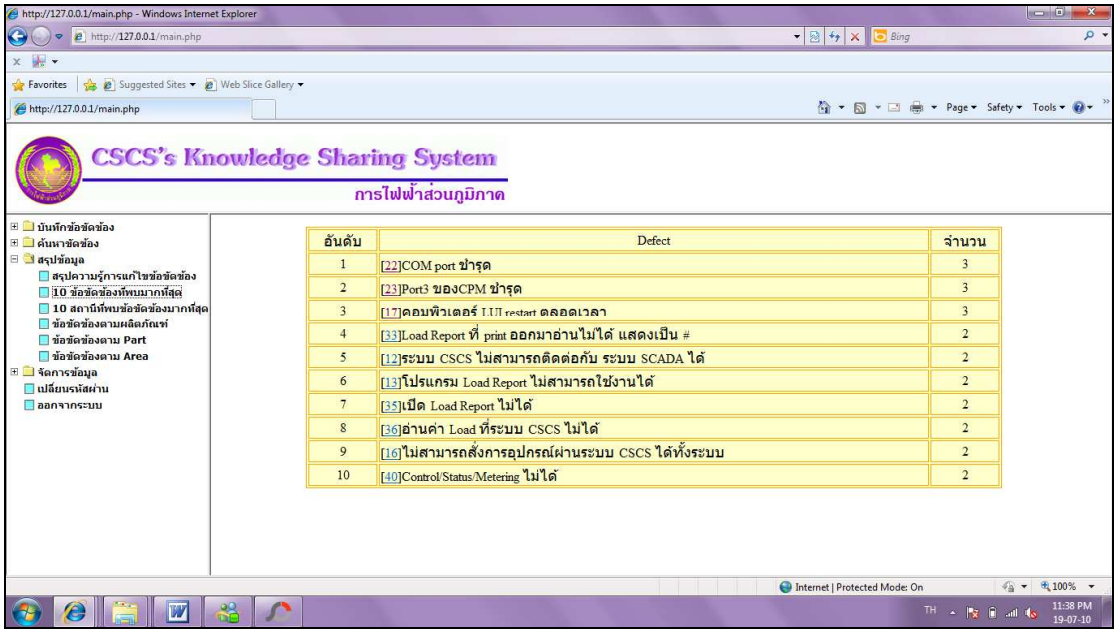


Figure 4.34 New window show detail of defect.

If user select “Top 10 defect” the system will show list of top 10 defect order by number of time that defect occur.



อันดับ	Defect	จำนวน
1	[22]COM port ชำรุด	3
2	[23]Port3 ของCPM ชำรุด	3
3	[17]คอมพิวเตอร์ LUI restart ตลอดเวลา	3
4	[33]Load Report ที่ print ออกมาอ่านไม่ได้ แสดงเป็น #	2
5	[12]ระบบ CSCS ไม่สามารถติดต่อกับ ระบบ SCADA ได้	2
6	[13]โปรแกรม Load Report ไม่สามารถใช้งานได้	2
7	[35]เปิด Load Report ไม่ได้	2
8	[36]อ่านค่า Load ที่ระบบ CSCS ไม่ได้	2
9	[16]ไม่สามารถสั่งการอุปกรณ์ผ่านระบบ CSCS ได้ทั้งระบบ	2
10	[40]Control/Status/Metering ไม่ได้	2

Figure 4.35 List of top 10 defects.

User can see detail of interest defect by click defect number. The system will open new window that show detail of defect.

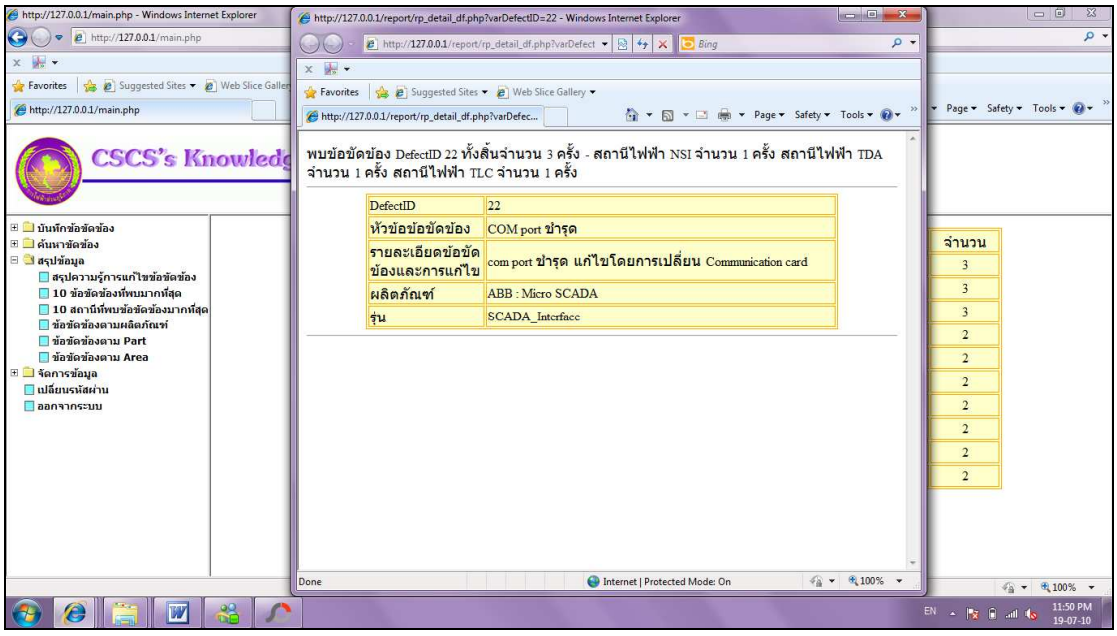
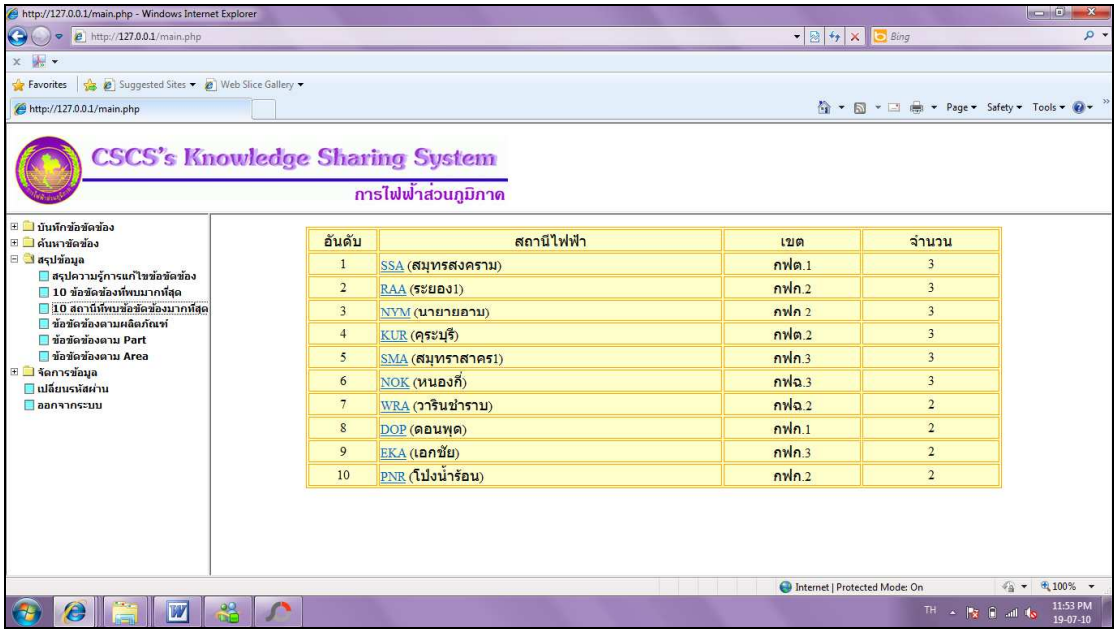


Figure 4.36 New window show detail of defect.

If user select “Top 10 substation that found defect” the system will show list of top 10 substation that has defect order by number of time that defect occur.



อันดับ	สถานีไฟฟ้า	เขต	จำนวน
1	SSA (สมุทรสงคราม)	กฟต.1	3
2	RAA (ระยอง1)	กฟก.2	3
3	NYM (นายายอาม)	กฟก.2	3
4	KUR (คุระบุรี)	กฟต.2	3
5	SMA (สมุทราสาคร1)	กฟก.3	3
6	NOK (หนองกี่)	กฟฉ.3	3
7	WRA (วารินชำราบ)	กฟฉ.2	2
8	DOP (ดอนพุด)	กฟก.1	2
9	EKA (เอกชัย)	กฟก.3	2
10	PNR (โป่งน้ำร้อน)	กฟก.2	2

Figure 4.37 List of top 10 substations that found defect.

User can see detail of defect that occur each substation by click substation. The system will open new window that show detail of defect that occur each substation.

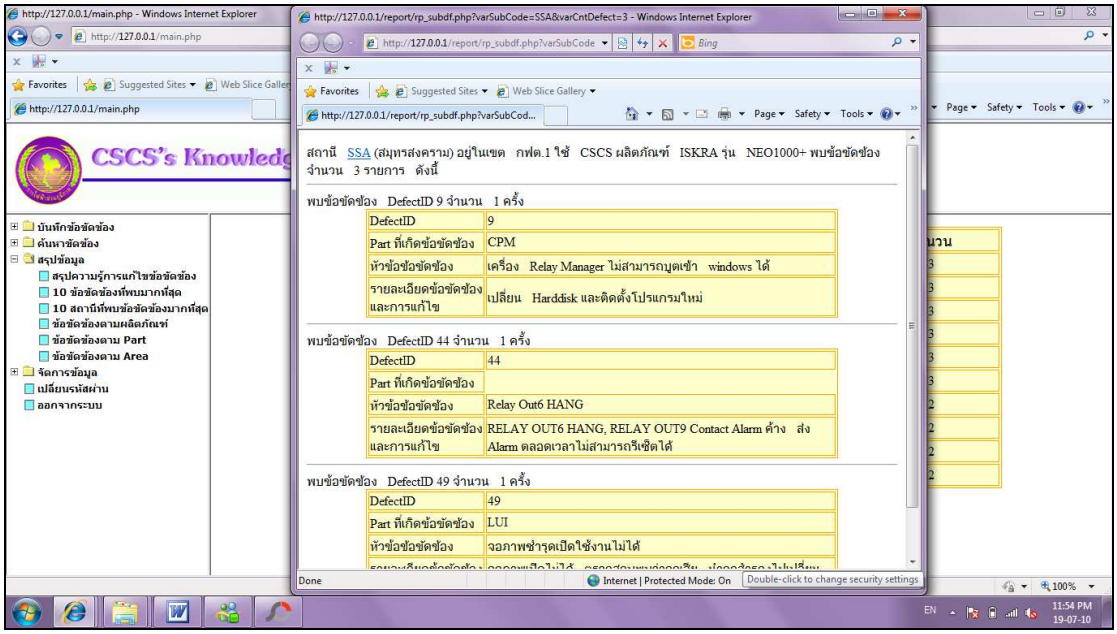


Figure 4.38 New window show detail of defect in each substation.

If user selects “Defect by product” the system will show pie graph of percentage of defect for each product.

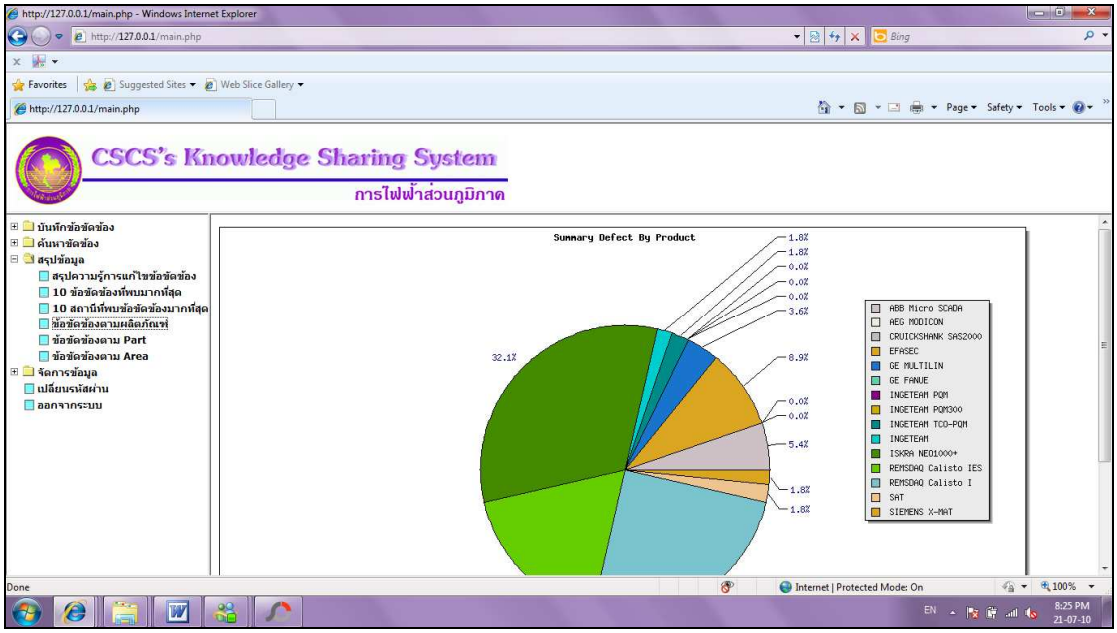


Figure 4.39 Page of defect by product.

If user selects “Defect by part” the system will show pie graph of percentage of defect for each part.

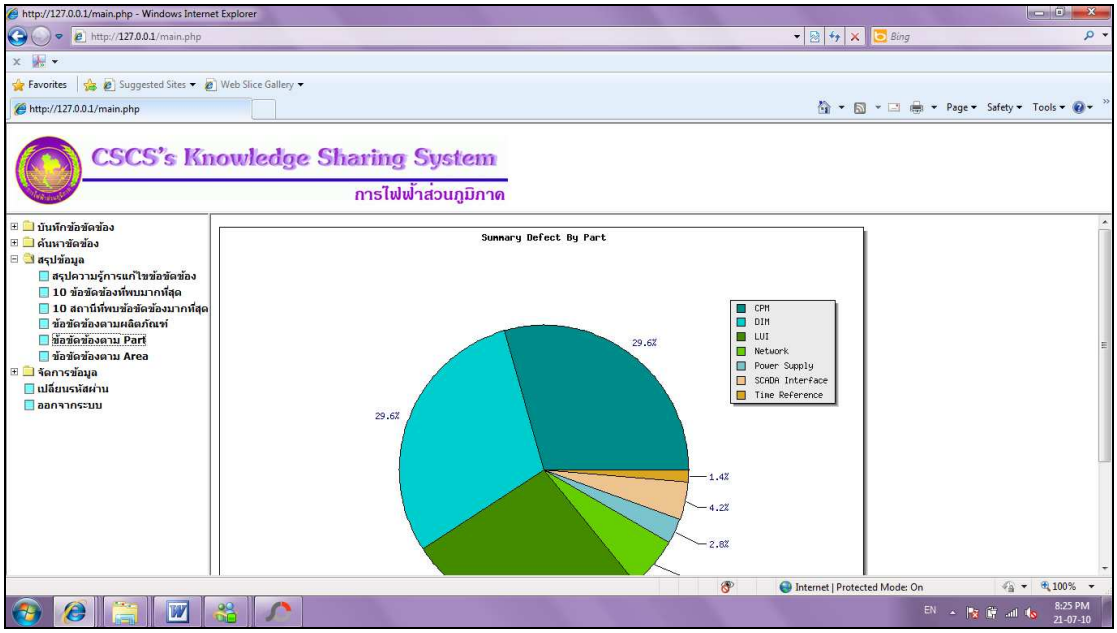


Figure 4.40 Page of defect by part.

If user selects “Defect by area” the system will show pie graph of percentage of defect for each area.

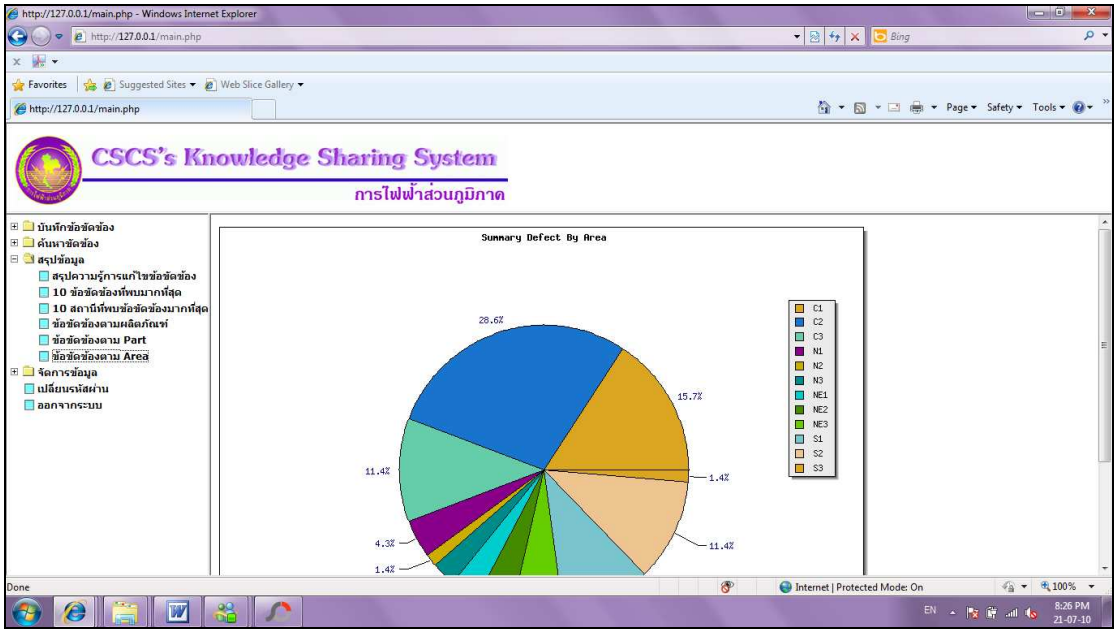


Figure 4.41 Page of defect by area.

4.3.5 Manage data

Only administrator user can access manage data part from dropdown list menu on left side of page. Manage data consist of three part are

- Manage substation data (จัดการข้อมูลสถานีไฟฟ้า)
- Manage product data (จัดการข้อมูลผลิตภัณฑ์)
- Manage user data (จัดการข้อมูลสมาชิก)

If authenticates user click some link of manage data part the system will show message “Sorry!! You’ve not Authorized to Access This Page”.

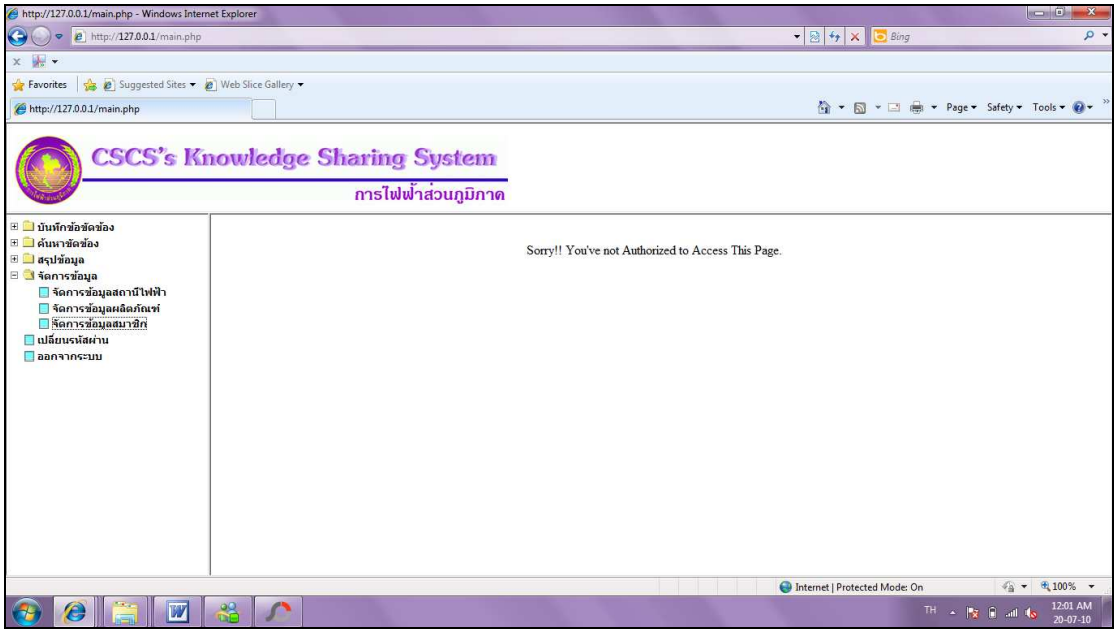


Figure 4.42 Error message show when authenticated user access manage data.

When user selects “Manage substation data” the system will show list of all substations and user can select “Add new substation (เพิ่มข้อมูลสถานีไฟฟ้าใหม่)” or “List all substation (รายชื่อสถานีทั้งหมด)”.

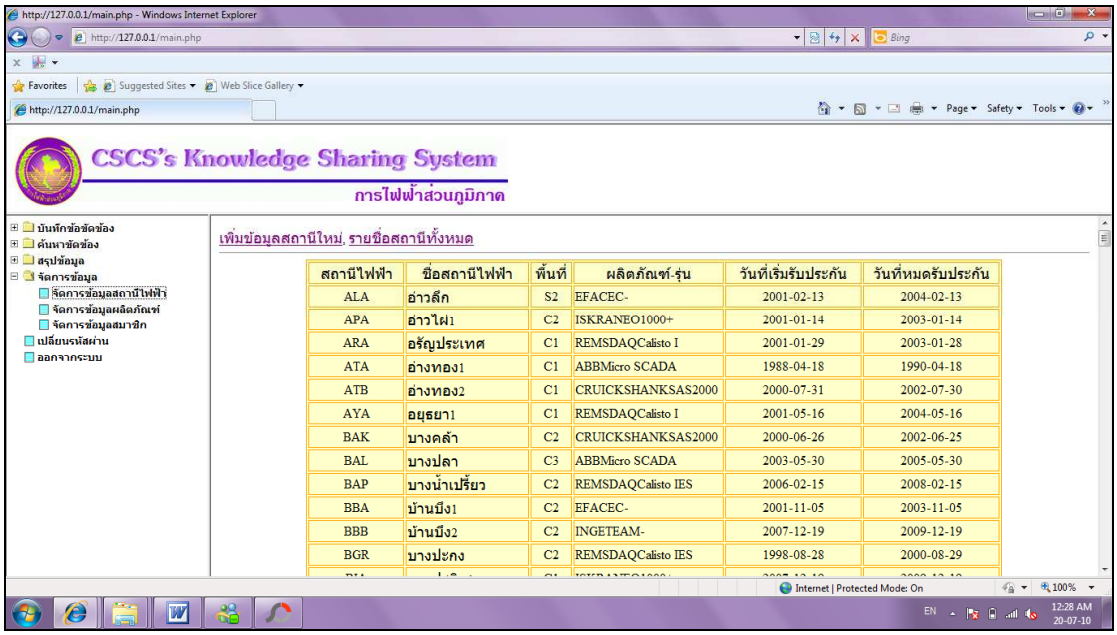


Figure 4.43 List of all substations.

When user selects “Add new substation” , then input data completely after that click “Add New Substation” for record new substation data to database.

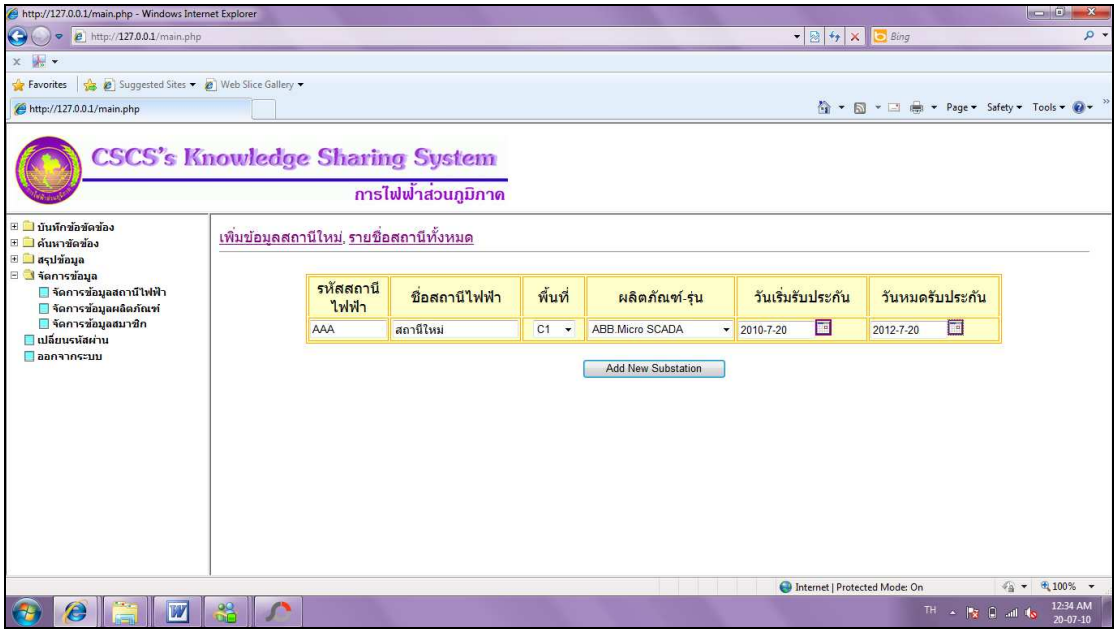


Figure 4.44 Page of add new substations.

The system will show message “Add new substation data completely (เพิ่มข้อมูลสถานีใหม่ เรียบร้อยแล้ว)”.

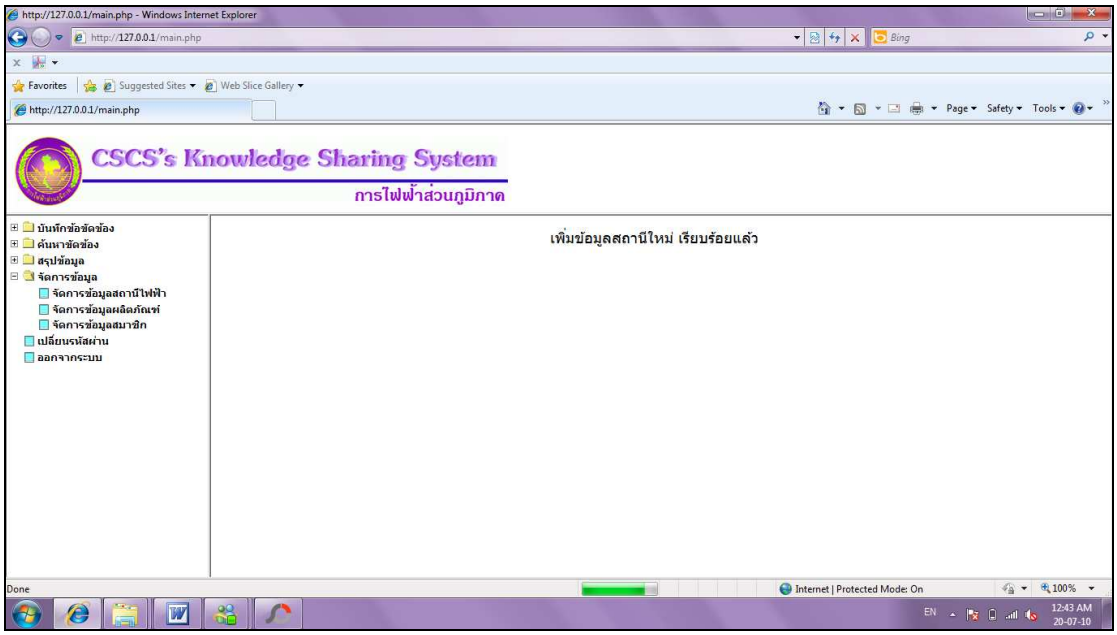
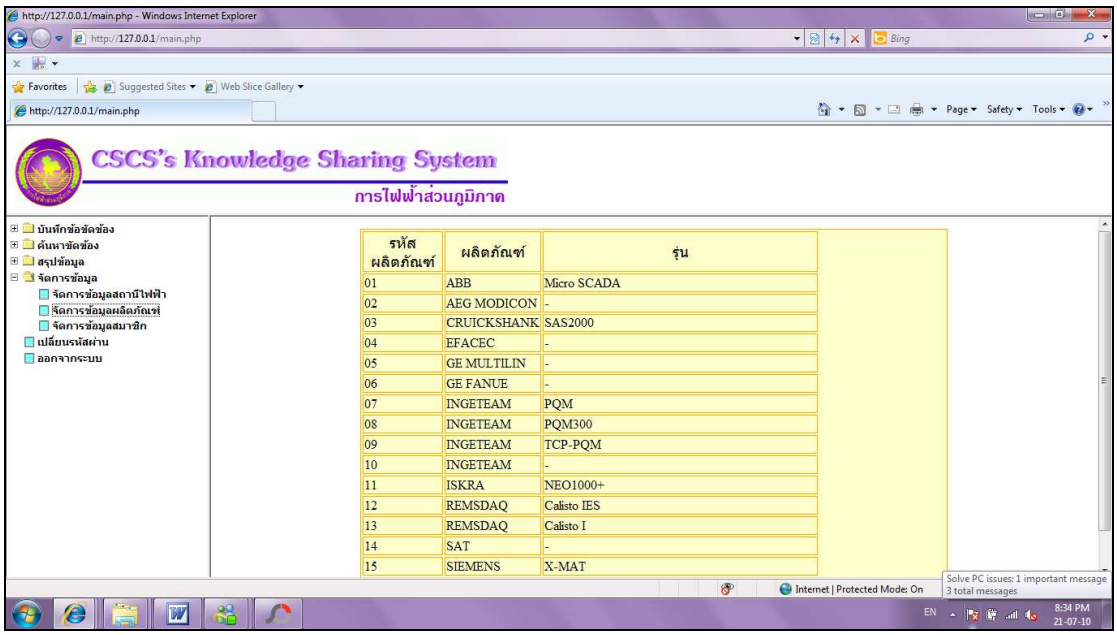


Figure 4.45 Message show when add substation data was completed.

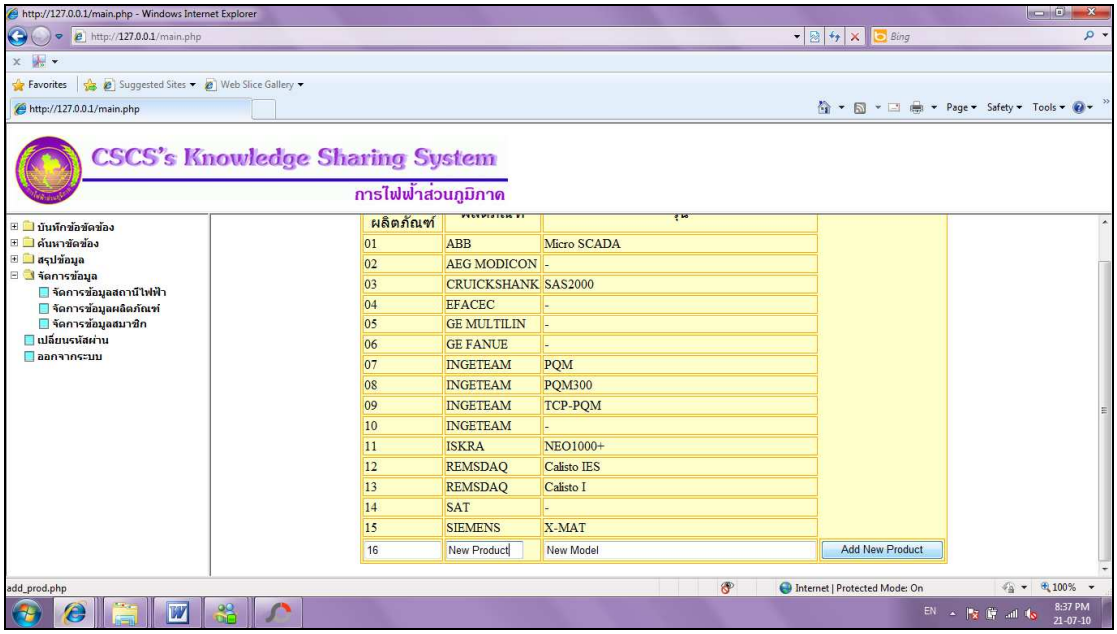
When user selects “Manage product data” the system will show list of product.



รหัสผลิตภัณฑ์	ผลิตภัณฑ์	รุ่น
01	ABB	Micro SCADA
02	AEG MODICON	-
03	CRUICKSHANK	SAS2000
04	EFACEC	-
05	GE MULTILIN	-
06	GE FANUE	-
07	INGETEAM	PQM
08	INGETEAM	PQM300
09	INGETEAM	TCP-PQM
10	INGETEAM	-
11	ISKRA	NEO1000+
12	REMSDAQ	Calisto IES
13	REMSDAQ	Calisto I
14	SAT	-
15	SIEMENS	X-MAT

Figure 4.46 List of all products.

User can add new product by slide to bottom of page and input data after that click “Add New Product” for record new product data to database.



ผลิตภัณฑ์		
01	ABB	Micro SCADA
02	AEG MODICON	-
03	CRUICKSHANK	SAS2000
04	EFACEC	-
05	GE MULTILIN	-
06	GE FANUE	-
07	INGETEAM	PQM
08	INGETEAM	PQM300
09	INGETEAM	TCP-PQM
10	INGETEAM	-
11	ISKRA	NEO1000+
12	REMSDAQ	Calisto IES
13	REMSDAQ	Calisto I
14	SAT	-
15	SIEMENS	X-MAT
16	New Product	New Model

Figure 4.47 Page of add new product.

The system will show message “Add new product data completely (เพิ่มข้อมูลผลิตภัณฑ์ใหม่ เรียบร้อยแล้ว)”.

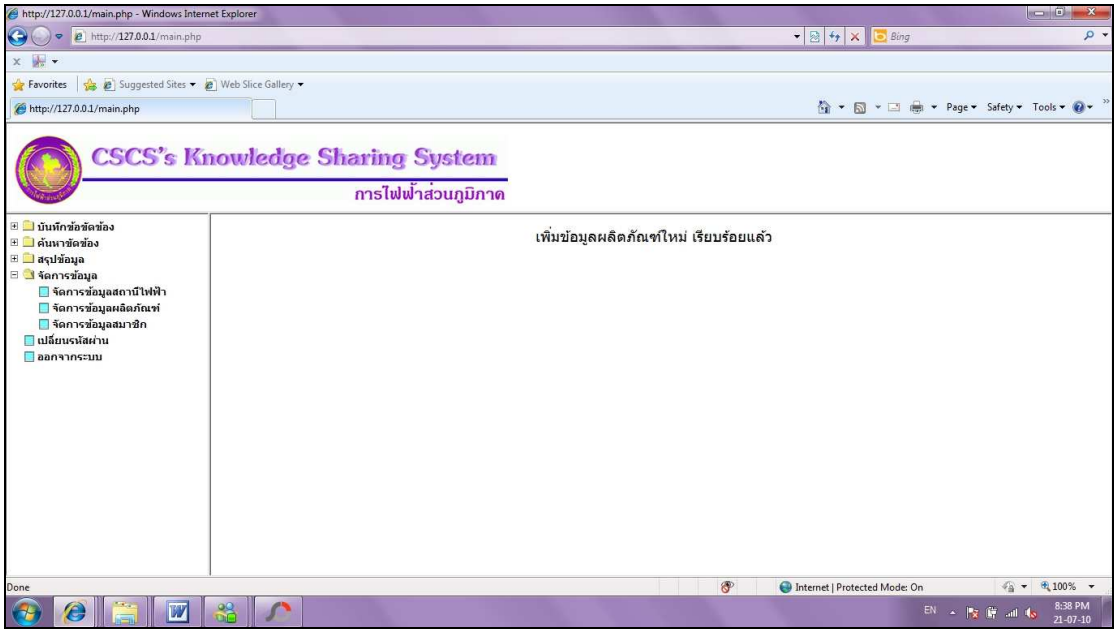


Figure 4.48 Message show when add product data was completed.

When user selects “Manage user data” the system will show list of all users.

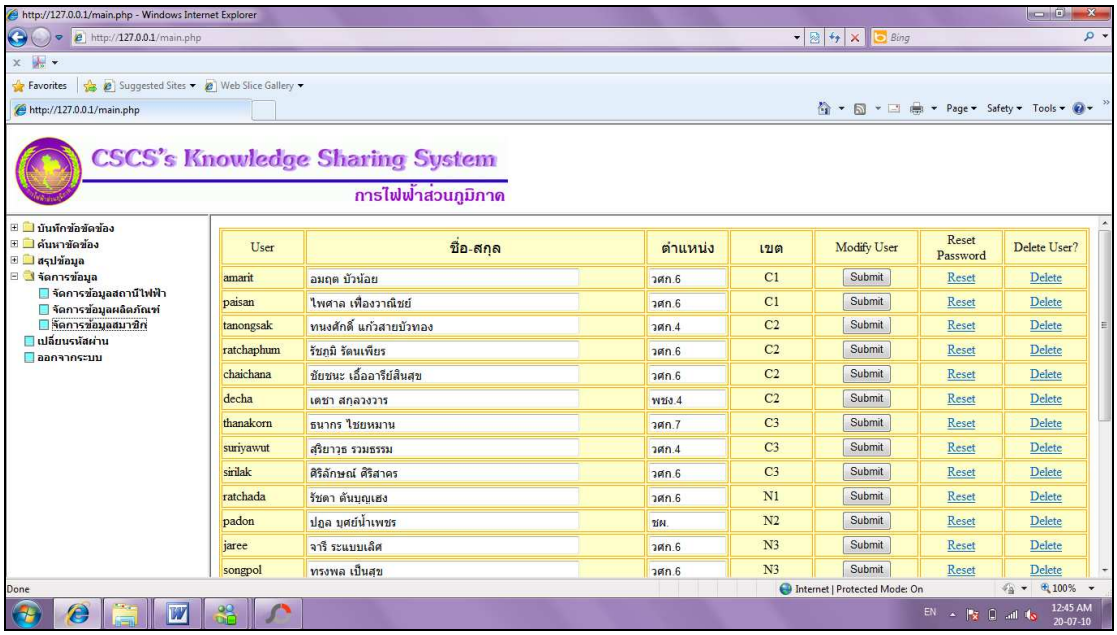


Figure 4.49 List of all products.

Administrator user can add new authenticated user by input data of user and then click “Add New User” for record new user data to database.

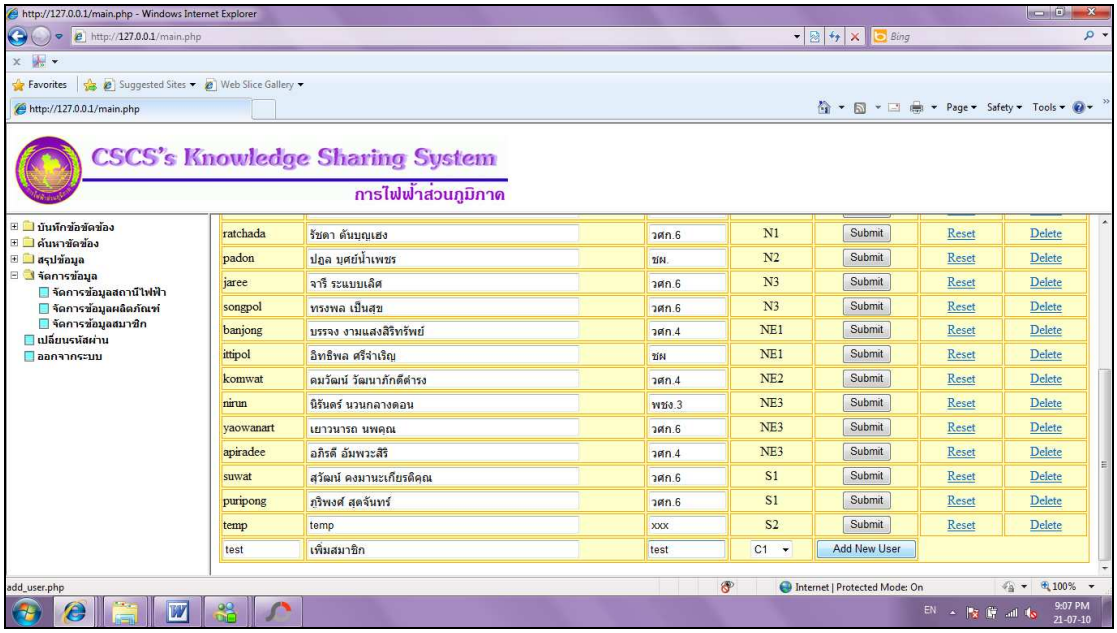


Figure 4.50 Page of add new user data.

The system will show message “Add new user data completely (เพิ่ม User ใหม่ เรียบร้อยแล้ว)”.

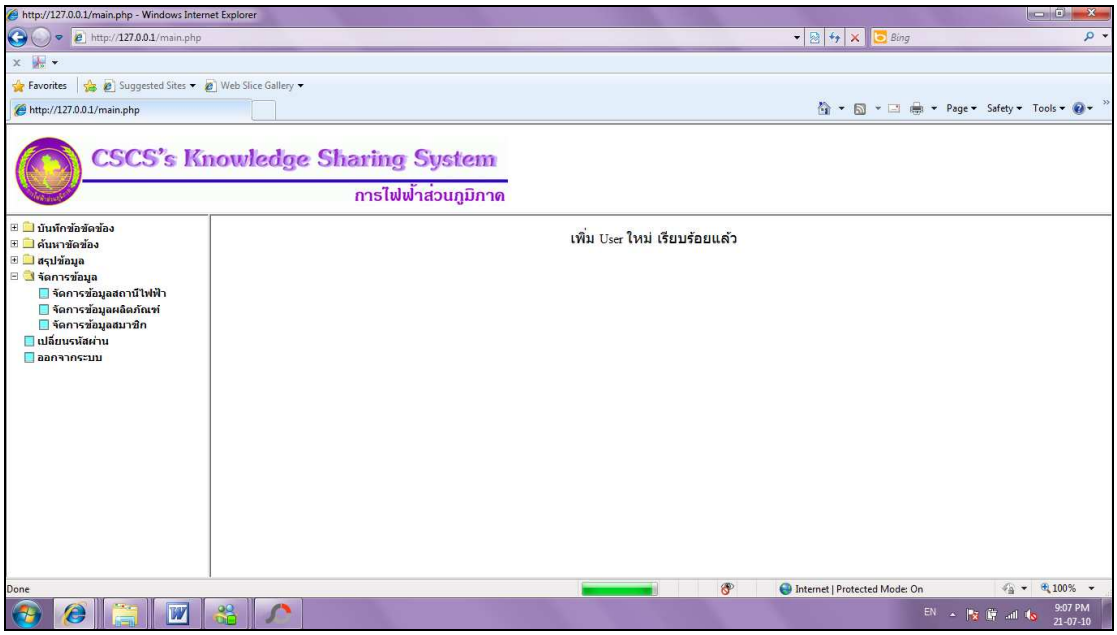


Figure 4.51 Message show when add user data was completed.

Administrator user can edit name and level of authenticated user, after click “Submit” in “Modify User” column for update data in database. The system will show message “Modify user data completely (ปรับปรุงข้อมูล User เรียบร้อยแล้ว)”.

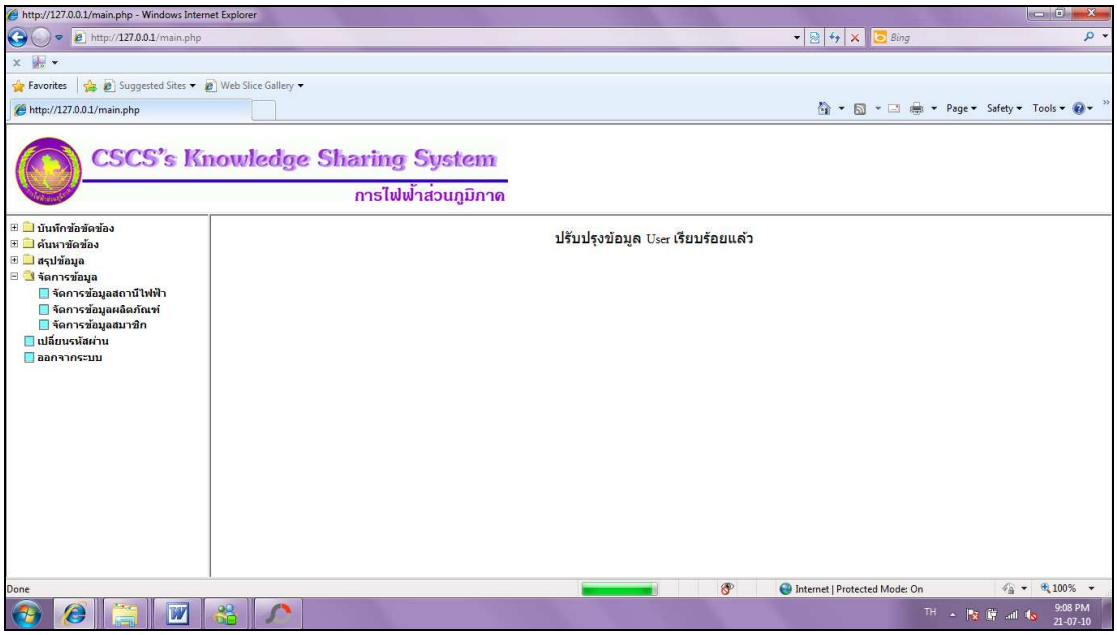


Figure 4.52 Message show when add user data was completed.

Administrator user can reset password of authenticated user by click “Reset” in “Reset Password” column after that the system will show message “Reset password completely (Reset Password เรียบร้อยแล้ว)”.

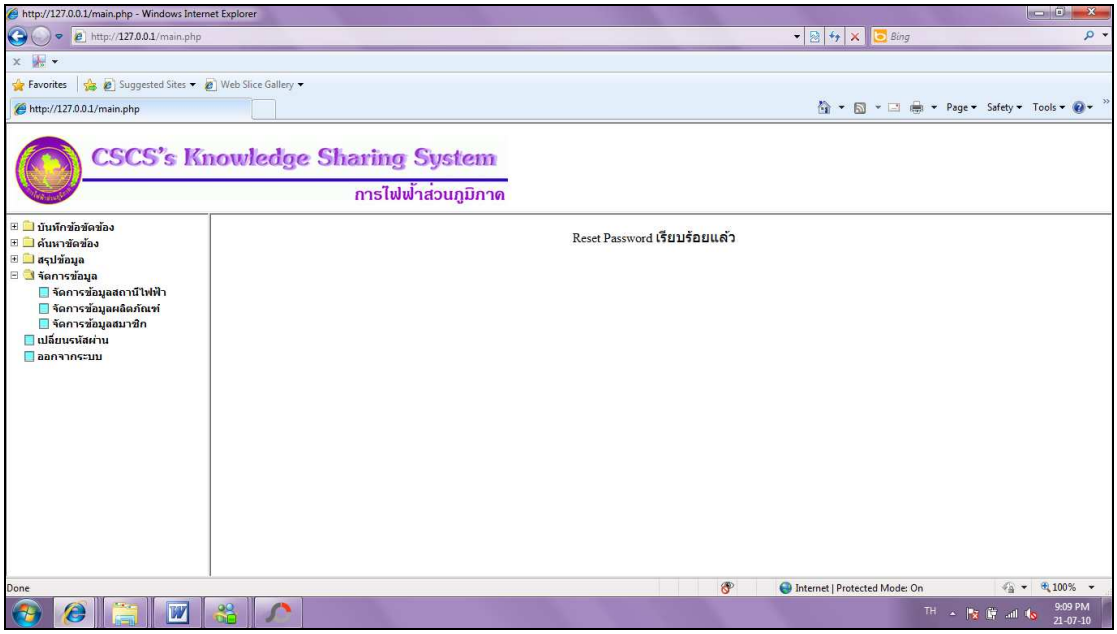


Figure 4.53 Message show when reset user password was completed.

Administrator user can delete authenticated user by click “Delete” in “Delete User” column after that the system will show message “Delete user data completely (ลบข้อมูล User เรียบร้อยแล้ว)”.

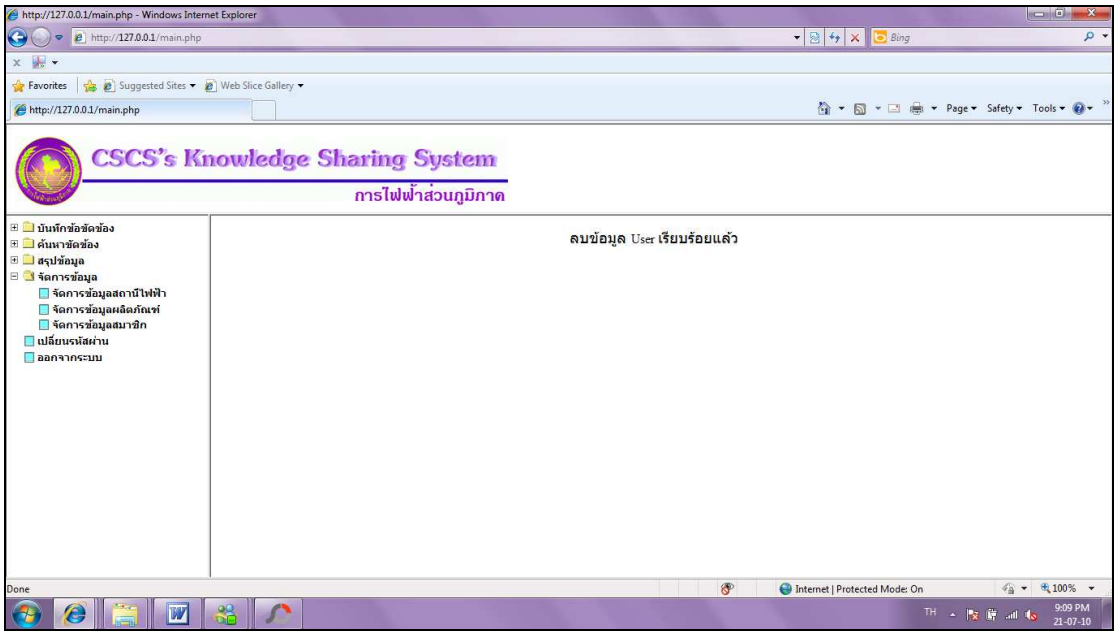


Figure 4.54 Message show when delete user data was completed.

User can change own password by select “Change password (เปลี่ยนรหัสผ่าน)” from dropdown list on left side of page.

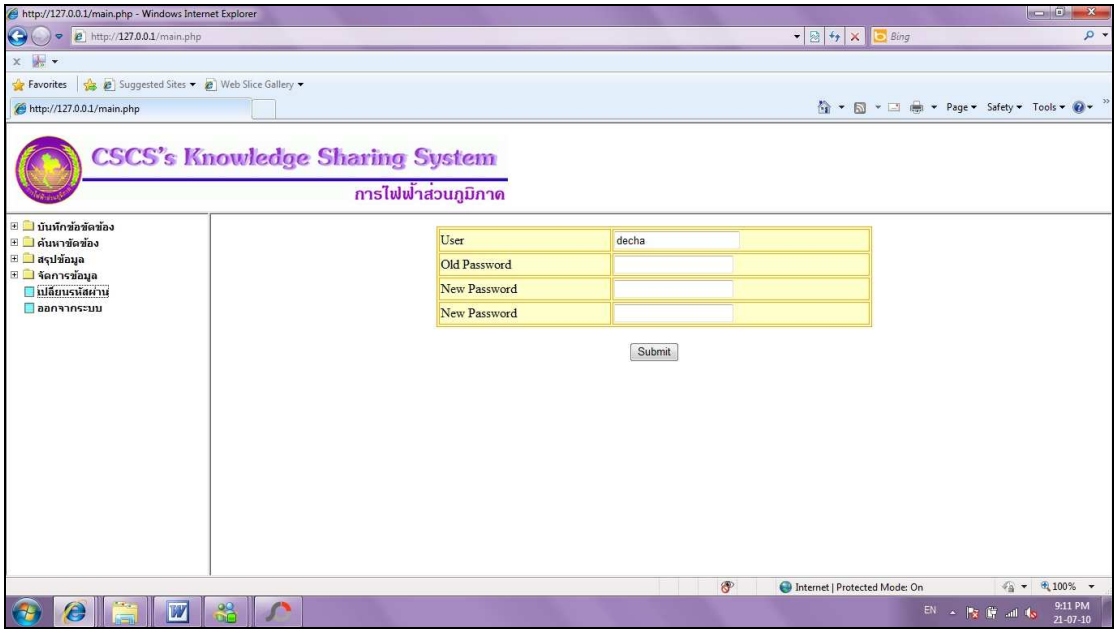


Figure 4.55 Page of change password.

After user input data add click “Submit”. The system will show message “Change password completely (แก้ไข Password เรียบร้อยแล้ว)”.

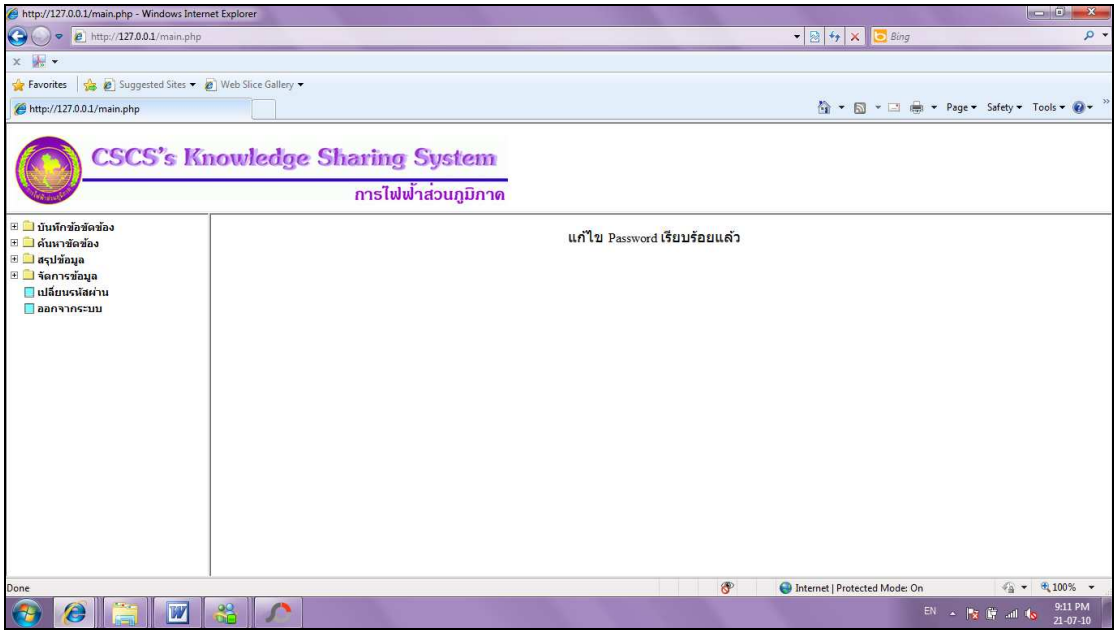


Figure 4.56 Message show when change password was completed.

When user want to exit the system can select “Logout (ออกจากระบบ)” from dropdown list on left side of page. This is logout from the system and page return to first page.

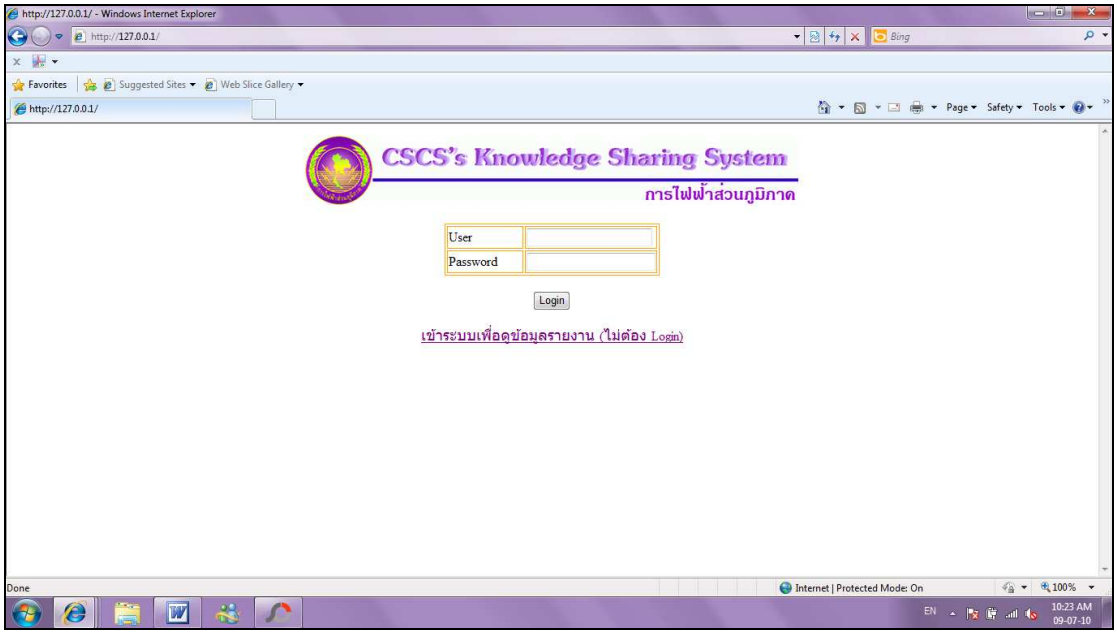


Figure 4.57 Logout the system.

CHAPTER V
SYSTEM TEST

After implementation, the system will be tested to ensure that it can work following objective of research. Testing and evaluation system for Knowledge Sharing System for Computer-base Substation Control System of Provincial Electricity Authority is divided into two parts, 1) Developer tests to verify the error. The system should be work properly as designed. Another part, users test to evaluate efficiency and effectiveness of the system.

5.1 System Testing

This part is an evaluation to verify that the system can work correct by developer. Between system implementation period, there are testing each module of the system and correct before user testing. Developer uses checklist in Table 5.1 to test the system.

Topic of Testing	Yes	No
1. Login		
- User can access the system by right username or password.	/	
- User can not access the system by wrong username or password.	/	
2. Record data		
- User must be logon before access this part.	/	
- User can record new data.	/	
- User can record same data as old data and the system count defect and show amount of same defect in database.	/	
- User can edit own record defect.	/	
- User can record enhancement of solution for each defect record data.	/	
3. Search data		
- User must be logon before access this part.	/	
- User can search defect by interested product and part.	/	
- User can search defect by keyword.	/	
4. Summarize data		
- Anonymous user can access summarize data part.	/	
- User can access summarize knowledge.	/	
- The system can show statistic data of top 10 defects.	/	
- The system can show statistic data of top 10 substations that found defect.	/	
- The system can show statistic data of defect by product.	/	
- The system can show statistic data of defect by part.	/	
- The system can show statistic data of defect by area.	/	
5. Manage data		
- User must be logon before access this part.	/	
- Authenticated user can not access this part.	/	
- Administrator user can add substation data.	/	
- Administrator user can add product data.	/	
- Administrator user can add, modify and delete user data.	/	
- Administrator user can reset password of authenticate user.	/	
- Authenticate user can change own password.	/	

Table 5.1 Check list for testing system and test result.

5.2 System Evaluation

System is operated for over 2 months (1 June 2010 – 6 August 2010) there was evaluated by user. The evaluation has two types for evaluate of efficiency and effectiveness of the system.

5.2.1 Efficiency Evaluation

- Reduce time to find knowledge from old system.
- Two groups of user (work > 3 years and work < 3 years).
- Two test groups.
- Compare time between find knowledge in book/manual (old system) and find in the system.
- Ask user about CSCS's defect that was recorded in the system 3 defect for each time test.

Test Group	**Time for search data (minute)**	
Group1	**Book/manual**	**The new system**
Work >3 years	3.5	<1
Work <3 years	8	<1
Group2		
Work >3 years	3	<1
Work <3 years	9	<1
Average time	**5.87**	**<1**

Table 5.2 Average times of find knowledge about CSCS's defect compare between find in book/manual and in the system.

From result, CSCS's administrator who have work experience over three years can find answers to solve defect or knowledge from book/manual faster than CSCS's administrator with work experience less than three years but still take time over to find knowledge in the system. Because of the system have tools to support users to find knowledge quickly. Whether they can find by product/part time, or search by keywords.

5.2.2 Effectiveness Evaluation

- For evaluate benefit of knowledge in the system.
- Evaluating occurs between running system period.
- Consideration about benefit of knowledge in the system by user.
- Each knowledge in the system should be has benefit more than 60% and knowledge should be has benefit more than 80% of all knowledge

Consideration by user	Amount	Percentage
All knowledge in the system	75	100%
Knowledge has benefit score>60%	61	81.3%
Knowledge has benefit score<60%	0	0%
Knowledge has no benefit score	14	18.7%

Table 5.3 Present percentage of benefit knowledge in the system.

From result, CSCS's administrator rate the knowledge more than 60% of the knowledge stored more than 80% of all knowledge that was recorded in the system.

CHAPTER VI
DATA MINING RESULT

Data that stored in database of the system can bring to analyze for support decision making by data mining, it is finding knowledge of fact that hidden in the data (knowledge discovery). Data mining is process of mining interesting data that we have had which is difference from database system in case of we no need to set a command (i.e. SQL) to find the needed data. Developer invent data mining by using decision tree technique and association rule technique, also using software weka as a tool for data mining.

Data that are stored in database compose of base data are substation data, CSCS's product/model, part of CSCS's defect and user's. The another one is data that record from user when user login and record data about defect and solution compose of topic of defect, description and detail of defect, defect's date and defect's record date. For each defect's record compose of data about defect that come from user record, the other data that come from user select from list are substation, part and user who record.

Example of data in database about defect after join process can be show following in Figure 6.1.

Substation	Area	ProductID	Vendor	System	StartAssDate	DefectID	Part	Topic	Description	EventDate	User	Level
NOK	NE3	13	REMSDAQ	22/115kV	2001-04-10	30	1	PSU หยุดทำงาน	แก้ไขโดยการเปลี่ยน converter จาก 35 Watt เป็น 50 Watt	2010-06-22	yaowanart	วศก.6
CCI	NE3	14	SAT	22/115kV	1999-04-10	NULL	NULL	NULL	NULL	NULL	NULL	NULL
HTL	NE3	14	SAT	22/115kV	2000-07-10	NULL	NULL	NULL	NULL	NULL	NULL	NULL
KKR	NE3	14	SAT	22/115kV	1999-07-02	NULL	NULL	NULL	NULL	NULL	NULL	NULL
TTU	NE3	14	SAT	22/115kV	2000-06-11	NULL	NULL	NULL	NULL	NULL	NULL	NULL
CPA	S1	1	ABB	22kV	2010-01-22	NULL	NULL	NULL	NULL	NULL	NULL	NULL
PDA	S1	1	ABB	22kV	2010-01-22	NULL	NULL	NULL	NULL	NULL	NULL	NULL
TSE	S1	4	EFASEC	22/115kV	2001-02-13	31	2	out1 เวลาที่สถานีไฟฟ้าและศูนย์ต่างกันประมาณ 2 นาที	card GPS Hang หยุดทำงาน แก้ไขโดยการ reset card gps	2010-07-19	rapeesak	นรค.5
BSP	S1	4	EFASEC	22/115kV	2001-02-13	71	2	อุปกรณ์แสดงสถานี Intransit ไม่สามารถ control ได้	C2 ติด F Step 1,2,3 สถานะเป็นสีเทา Intransit ไม่สามารถ control ได้ ตรวจสอบพบว่า CPU Card ของ URR C2 ชำรุด 1 Card แก้ไขโดยการเปลี่ยน Card	2010-07-29	rapeesak	นรค.5
PTR	S1	5	GE	22/115kV	2000-10-31	NULL	NULL	NULL	NULL	NULL	NULL	NULL
RBB	S1	5	GE	22/115kV	2001-02-02	NULL	NULL	NULL	NULL	NULL	NULL	NULL
DNA	S1	5	GE	22/115kV	2000-10-31	51	3	จอภาพชำรุดเปิดใช้งานไม่ได้	ตรวจสอบแล้วพบว่าจอภาพชำรุดไม่สามารถใช้งานได้แก้ไขโดยนำจอสำรองมาใช้แทนจอที่ชำรุด	2010-07-01	rapeesak	นรค.5

Figure 6.1 Example data in database about defect after join process.

To do data mining in this study can separate two parts, first is an overview to see how relation about defect and other attribute. Attributes that was used includes area, vendor, electrical system, duration of use and data about defect YES or NO.

From data above can preprocess to new format that contain only the data required following below.

Area	Vendor	System	Duration	Fail
C1	ABB	22/115kV	OLD	NO
C1	ABB	22/115kV	HALF-WORN	NO
C1	ABB	22/115kV	OLD	NO
C1	ABB	22/115kV	OLD	NO
C1	ABB	22/115kV	HALF-WORN	NO
C1	ABB	22/115kV	OLD	YES
C1	ABB	22/115kV	HALF-WORN	YES
C1	ABB	115kV	HALF-WORN	YES
C1	ABB	22kV	OLD	YES
C1	ABB	115kV	HALF-WORN	YES
C1	ABB	22/115kV	HALF-WORN	YES
C1	ABB	22/115kV	OLD	YES
C1	CRUICKSHANK	22/115kV	OLD	NO
C1	CRUICKSHANK	22/115kV	OLD	NO
C1	CRUICKSHANK	22/115kV	OLD	NO
C1	GE	115kV	OLD	NO
C1	GE	22/115kV	OLD	NO
C1	INGETEAM	22/115kV	NEW	YES
C1	INGETEAM	22/115kV	HALF-WORN	NO
C1	INGETEAM	22/115kV	NEW	NO
C1	ISKRA	22kV	HALF-WORN	NO

Table 6.1 Example of preprocess data for data mining. (Overview)

Duration of use (in case of record that has no defect duration is since start guaranteed to now, in case of record that has defect duration is since start guaranteed to EventDate) can be separate in to three durations are NEW (duration of use < 2 years), HALF-WORN (duration of use > 2 years and < 5 years) and OLD (duration of use > 5 years)

Result from weka by decision tree technique is as follow.

```
J48 pruned tree
------------------

Vendor = ABB: NO (37.0/14.0)
Vendor = CRUICKSHANK: NO (7.0)
Vendor = AEG: NO (4.0)
Vendor = EFASEC: YES (17.0/6.0)
Vendor = INGETEAM: NO (30.0/5.0)
Vendor = GE: NO (14.0/3.0)
Vendor = ISKRA: YES (59.0/25.0)
Vendor = REMSDAQ
|   Duration = NEW: NO (5.0)
|   Duration = HALF-WORN
|   |   Area = C1: NO (10.0/2.0)
|   |   Area = C2: YES (11.0/4.0)
|   |   Area = C3: YES (4.0/2.0)
|   |   Area = N1: YES (4.0/1.0)
|   |   Area = N2
|   |   |   System = 22kV: NO (2.0)
|   |   |   System = 33kV: NO (0.0)
|   |   |   System = 115kV: NO (0.0)
|   |   |   System = 22/115kV: YES (5.0/2.0)
|   |   |   System = 33/115kV: NO (0.0)
|   |   Area = N3: NO (3.0/1.0)
|   |   Area = NE1: NO (0.0)
|   |   Area = NE2: NO (0.0)
|   |   Area = NE3: NO (1.0)
|   |   Area = S1: YES (2.0)
|   |   Area = S2: NO (0.0)
|   |   Area = S3: YES (1.0)
|   Duration = OLD: YES (47.0/8.0)
Vendor = SAT: NO (16.0/2.0)
Vendor = SIEMENS: NO (14.0/4.0)
```

Figure 6.2 Result from weka by decision tree technique. (Overview)

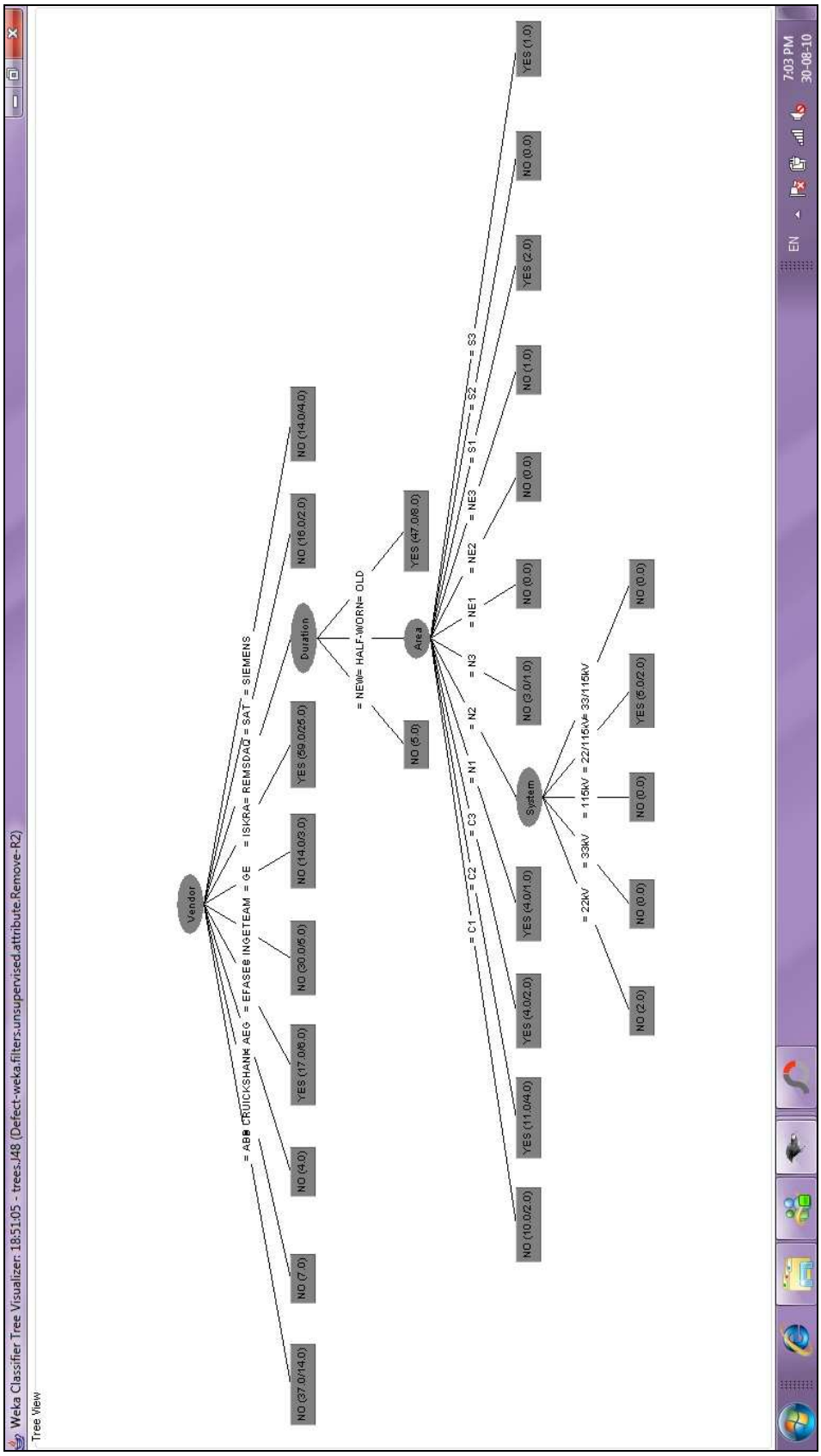


Figure 6.3 Result from weka by decision tree technique represent in format of decision tree. (Overview)

Result from weka by association rule technique is as follow.

```
Best rules found:

 1. Vendor=REMSDAQ Fail=YES 60 ==> System=22/115kV 57    conf:(0.95)
 2. Vendor=REMSDAQ Duration=OLD Fail=YES 39 ==> System=22/115kV 37    conf:(0.95)
 3. Vendor=REMSDAQ Duration=OLD 47 ==> System=22/115kV 44    conf:(0.94)
 4. Vendor=REMSDAQ 95 ==> System=22/115kV 83    conf:(0.87)
 5. Duration=HALF-WORN Fail=YES 38 ==> System=22/115kV 32    conf:(0.84)
 6. Vendor=REMSDAQ System=22/115kV Duration=OLD 44 ==> Fail=YES 37    conf:(0.84)
 7. Vendor=REMSDAQ Duration=HALF-WORN 43 ==> System=22/115kV 36    conf:(0.84)
 8. Vendor=REMSDAQ Duration=OLD 47 ==> Fail=YES 39    conf:(0.83)
```

Figure 6.4 Result from weka by association rule technique. (Overview)

Result from decision tree found substation that use product of vendor EFASEC, ISKRA and REMSDAQ will has defect. Data of vendor REMSDAQ enough to have seen more detailed that if duration of use is HALF-WORN and OLD will has defect. In HALF-WORN duration, found that the area will has defect is C2, C3, N1, S1 and S3. Area N2 and electrical system is 22/115kv will has defect. Result from association rule (confidence 0.8) when consideration on the relationship of the results, found information that direct relate with defect two rules. First rule is substation that use product of vendor REMSDAQ and has duration of use is OLD will has defect. The second is substation that use product of vendor REMSDAQ, has electricity system is 22/115kV and has duration of use is OLD will has defect. Which result is consistent in terms of vendor REMSDAQ, which is duration of use is OLD will has defect.

Other rule such as substation that has duration of use is HALF-WORN and has defect will has electricity system 22/115kV, or substation that use product of vendor REMSDAQ and has defect will has electricity system 22/115kV. Both rules may be indirect relating with defect but the information can represent other benefit information such as we will know most of substation that use product of vendor REMSDAQ in PEA has electrical system 22/115kV and etc.

The second data mining is focus to detail of defect to see how relation about part of defect and other attribute. Attributes that was used includes area, vendor, electrical system, duration of use and data about part of defect.

From data that show in Table 6.1 can preprocess to new format that contain only the data required following below.

Area	Vendor	System	Duration	Part
C1	ABB	22/115kV	OLD	SCADA_Interface
C1	ABB	22/115kV	HALF-WORN	SCADA_Interface
C1	ABB	115kV	HALF-WORN	SCADA_Interface
C1	ABB	22kV	OLD	CPM
C1	ABB	115kV	HALF-WORN	CPM
C1	ABB	22/115kV	HALF-WORN	CPM
C1	ABB	22/115kV	OLD	DIM
C1	INGETEAM	22/115kV	NEW	Network
C1	ISKRA	22kV	HALF-WORN	DIM
Area	Vendor	System	Duration	Part
C1	REMSDAQ	22/115kV	HALF-WORN	LUI
C1	REMSDAQ	22/115kV	HALF-WORN	DIM
C1	REMSDAQ	22/115kV	OLD	Power_Supply
C1	REMSDAQ	22/115kV	OLD	DIM
C1	REMSDAQ	22/115kV	OLD	CPM
C1	REMSDAQ	22kV	OLD	DIM
C1	REMSDAQ	22/115kV	OLD	DIM
C1	REMSDAQ	22/115kV	OLD	DIM
C1	REMSDAQ	22/115kV	OLD	LUI
C1	REMSDAQ	22/115kV	OLD	DIM
C2	ABB	22/115kV	HALF-WORN	Time_Reference

Table 6.2 Example of preprocess data for data mining. (Detail part of defect)

Result from weka by decision tree technique is as follow.

```
J48 pruned tree
------------------

Vendor = ABB
|   Area = C1: CPM (7.0/4.0)
|   Area = C2: Time_Reference (1.0)
|   Area = C3: Power_Supply (2.0)
|   Area = N1: CPM (0.0)
|   Area = N2: DIM (1.0)
|   Area = N3: CPM (0.0)
|   Area = NE1: SCADA_Interface (1.0)
|   Area = NE2: CPM (0.0)
|   Area = NE3: CPM (2.0/1.0)
|   Area = S1: CPM (0.0)
|   Area = S2: CPM (0.0)
|   Area = S3: CPM (0.0)
Vendor = CRUICKSHANK: DIM (0.0)
Vendor = AEG: DIM (0.0)
Vendor = EFASEC: DIM (11.0/3.0)
Vendor = INGETEAM: DIM (5.0/1.0)
Vendor = GE: LUI (3.0)
Vendor = ISKRA: CPM (34.0/15.0)
Vendor = REMSDAQ: DIM (60.0/33.0)
Vendor = SAT: DIM (2.0)
Vendor = SIEMENS: SCADA_Interface (4.0/2.0)
```

Figure 6.5 Result from weka by decision tree technique.

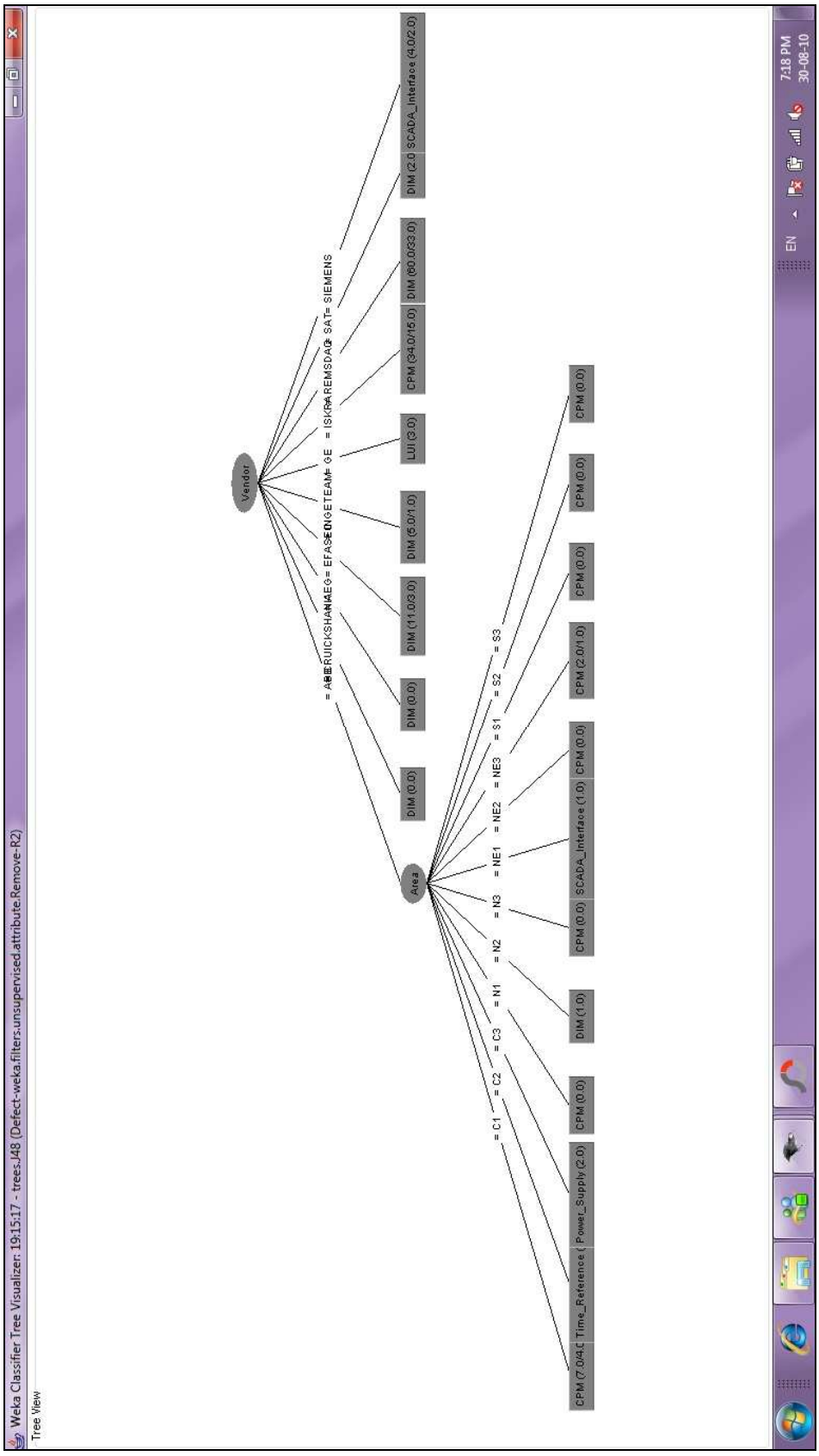


Figure 6.6 Result from weka by decision tree technique represent in format of decision tree.

Result from weka by association rule technique is as follow.

```
Best rules found:

 1. Vendor=REMSDAQ Duration=HALF-WORN 21 ==> System=22/115kV 20    conf:(0.95)
 2. Vendor=REMSDAQ 60 ==> System=22/115kV 57    conf:(0.95)
 3. Vendor=REMSDAQ Duration=OLD 39 ==> System=22/115kV 37    conf:(0.95)
 4. Area=C2 Vendor=REMSDAQ 16 ==> System=22/115kV 15    conf:(0.94)
 5. Vendor=REMSDAQ Part=LUI 16 ==> System=22/115kV 15    conf:(0.94)
 6. Vendor=REMSDAQ Part=DIM 27 ==> System=22/115kV 25    conf:(0.93)
 7. System=22kV 22 ==> Duration=OLD 20    conf:(0.91)
 8. Vendor=REMSDAQ Duration=OLD Part=DIM 22 ==> System=22/115kV 20    conf:(0.91)
 9. Vendor=ISKRA System=22kV 17 ==> Duration=OLD 15    conf:(0.88)
10. Duration=HALF-WORN 38 ==> System=22/115kV 32    conf:(0.84)
11. System=22/115kV Part=LUI 18 ==> Vendor=REMSDAQ 15    conf:(0.83)
12. Vendor=REMSDAQ Part=DIM 27 ==> Duration=OLD 22    conf:(0.81)
13. Vendor=REMSDAQ System=22/115kV Part=DIM 25 ==> Duration=OLD 20    conf:(0.8)
```

Figure 6.7 Result from weka by association rule technique.

Result from decision tree found substation that use product of vendor EFASEC, INGETEAM, REMSDAQ and SAT will has defect in part of DIM. Substation that use product of vendor GE will has defect in part of LUI, ISKRA will has defect in part of CPM and SAT will has defect in part of SCADA_Interface. Data of vendor ABB enough to have seen more detailed that if substation locates in C1 or NE3 will has defect in part of CPM. Area C2 will has defect in part of Time_Reference, area C3 will has defect in part of Power_Supply, area N2 will has defect in part of DIM and area NE1 will has defect in part of SCADA_Interface. Result from association rule (confidence 0.8) when consideration on the relationship of the results, can not found information that direct relate with part defect.

However, rule such as substation that has duration of use is HALF-WORN will has electricity system 22/115kV, or substation that use product of vendor REMSDAQ and has duration of use is OLD will has electricity system 22/115kV. The information can represent other benefit information such as we will know most of substation that use product of vendor REMSDAQ in PEA has electrical system 22/115kV, most of substation that has duration of use is HALF-WORN in PEA has electrical system 22/115kV and etc.

Result from association rule can represent relationship about each attribute and defect less than decision tree because those two techniques has difference algorithm. Another one is when run weka with association rule the confidence value was assigned is 0.8, which accuracy of decision tree result less than that. First time mining accuracy is 67.23% and second time is 48.87%. However both two techniques have inconsistency result and other rule from association rule technique although not direct related with needed information but has other benefit.

The results from decision tree and association rule represent the relationship between area, vendor, duration of use, part of defect and defect data. Data in the database when bring processing with data mining. It will useful for implementation of maintenance plan and provide spare part of maintenance work. In the future, when data stored in the system enough, result from data mining will be has more benefit information.

CHAPTER VII
DISCUSSIONS

This study was design and develops the information system to improve efficiency of the defect record process and the sharing knowledge process of the CSCS's administrator team in Provincial Electricity Authority. The system will be help to record CSCS's defect and solution more easily and in the same format. The system also help user access knowledge about solution to solve CSCS's defect rapidly and has statistic data about CSCS's defect for use to analyze in the future.

System development consists of study requirement, data gathering, analysis, system design, system implementation, and test. System is base on web base technology. Tools for develop system is php and relational database is MySQL. The system was used in PEA through intranet.

The system compose of 5 main part i.e. Login, Record data, Search data, Manage data and Summarize data. Anonymous user can access the system only summarize data part by not need to login. Authenticated user and administrator user must be login before access the system, and both of users have difference right. User interface of the system was designed to easy to understand and use. It is likely old record system when user record in book. Authenticated users are CSCS's administrator responsible to record defect. User can select almost of data that necessary to record such as substation name, part of defect by dropdown list. Just few data that user must be type by own are topic of defect, description and detail of defect, defect's date user can select date by popup window. User can add new record of defect, or add count defect in case of same as old defect. So the system will keep both data of defect and solution and statistic data about defect. Administrator user can manage base data as add substation data, add product data and add, delete or modify user data. All user can access summarize data part that compose of statistic data about defect in various both tabular and graphic formats.

Testing and evaluation system for Sharing Knowledge System for Computer-base Substation Control System of Electricity Authority is divided into two, First is test by developer to verify the error by use check list to check that the system can conform to function. If some part of system has error developer will fix and test again. Finally, the system can be used properly as design function. Another one is test by users to evaluation efficiency and effectiveness of the system. Results from efficiency evaluation prove that the system help user reduce time to find knowledge, user can find knowledge easy and rapidly than old system. And results from effectiveness evaluation prove that knowledge in the system has benefit.

Data stored in database of the system has useful when bring to data mining, result from data mining represent hidden information about relationship about area, vendor, electrical system, part of defect and defect data. This study use two techniques are decision tree and association rule for data mining. Results from both techniques represent relationship between attributes in the same way. It will useful for implementation of maintenance plan and provide spare part of maintenance work. In the future, when data stored in the system enough, result from data mining will be has more benefit information.

7.1 System Strengths

7.1.1 The system increase efficiency for work of CSCS's administrator team. The system can collect knowledge and experience about CSCS's correct defect as systematic, easy to find benefit data and user can self learning or find knowledge to correct CSCS's defect faster.

7.1.2 The system can help in managing, planning of back up spare part of equipments and budget for solving the problem of CSCS's defect that happen with CSCS system in substation.

7.1.3 User can be using web application online on intranet every place that in PEA network.

7.1.4 Supporting policy of organization for make a learning organization the system can be developing to knowledge management in future.

7.1.5 The system can be apply to other workgroup that has work process similar CSCS's administrator team.

7.2 System Limitations

7.2.1 The system is sharing knowledge system, now has no process to investigate or confirm data that be recorded in system is knowledge, or not. Every time that found defect and CSCS's administrator can be correct and record data in system is knowledge.

7.2.2 The system does not connected with other involves system such as system for reporting CSCS's defect from other section of organization.

CHAPTER VIII
CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

This project, “Knowledge Sharing System for Computer-base Substation Control System of Provincial Electricity Authority, Thailand” is the system development following with the analysis results and the system design based on user requirements and problem of old process which should help to increase efficiency for work process of CSCS’s administrator team by collecting knowledge and experience about CSCS’s defect as systematic. User can find benefit data easily and find knowledge to correct CSCS’s defect faster.

The result of this information system is for CSCS’s administrator workgroup of Provincial Electricity Authority. This system was developed by PHP and the database used in this information system is MySQL. This system is designed to be used by many right to access the system, there are authenticated users, administrator user and anonymous user. The defect data which is used in the system is the data of CSCS’s defect that was found in substation of Provincial Electricity Authority. This system has 5 sub-systems consisting of login, record data, search data, summarize data, and manage data. Result from this system proved to be reduce times to find benefit knowledge less than old system. Data that are stored in database can be used for data mining to find hidden data that has useful for decision making.

8.2 Recommendations

Results of this study should be applied with further development in the following aspects:

8.2.1 Connect with other involves system such as system for reporting CSCS’s defect from other section of organization.

8.2.2 Knowledge sharing system should be developed to knowledge management system by adding other function.

8.2.3 The system should be verified by user process to verify or confirm that recorded data in system is really knowledge such as user can give point to solution that correct.

8.3.4 Results from data mining should be feedbacked into the system for using their benefit.

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