Learning by Doing: A Laboratory Based Training Course on Dispatching Communication System

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Abstract. Communication technology plays a critical role in modern power grids. Electric utility personnel need to upgrade their professional skills on communication technology through training. Dispatching communication system is an important integral part of electric power communication systems. This paper presents a laboratory based training course on the topic of dispatching communication system in State Grid Technology College (SGTC). The paper describes the objective of developing the laboratory based training course, the equipments and components of the laboratory, and training projects based on the laboratory environment. The proposed laboratory consists of IP-based soft-switch and TDM-based private branch exchange (PBX) in a hybrid TDM/IP network. Hierarchical training programs have been developed by using the laboratory scenario as real work place. Hands-on laboratory projects have been developed to help the trainees experience configuration and maintenance of equipment and software that is the same as in industrial fields. The proposed training course has provided trainings and evaluations to novice employees of State Grid Corporation of China (SGCC) for 5 years and the feedback is good. Continuous revision of the laboratory and projects will be made according to the evolvement of the technical field in electric power communications.

1. Introduction

Reliable voice communication is an essential tool for power system operators. An investigation has been conducted about the actual voice communication equipments in State Grid, and it is found that there are two telephone networks in use, administrative telephone network and production dispatching telephone network. They are deployed respectively and conducted independently. The dispatching telephone systems adopt redundant structure, which use traditional circuit switch as primary equipment and soft-switch as standby equipment, while administrative telephones are going to use IMS (IP Multimedia System). Dispatching telephone is an important means for power grid command and control. The dispatching communication system is upgrading from TDM voice communication to multimedia communication which contain voice, data, or video content. In a relatively long term, there are soft-switch and traditional circuit switch working simultaneously[1-4].

Command and control centers play a pivotal role in power system. A voice communication system is important for dispatching operation in the command and control center of power system. The communication system must offer flexible and reliable voice communication to meet all command requirements for scalability, availability, reliability and safety of the power grid. If the actual operation of power grid communication equipment fails, it will cause a series of disasters and incalculable losses to the power grid. Significant blackout events, such as the Northeastern Blackout of 2003 and the
Florida Blackout of 2008, have communication issues listed among the top contributors to loss of load and generation[5]. In order to ensure the reliability of the power grid, more practitioners with quality skills about the operation and maintenance of communication system are needed. SGCC recruits many college graduates, but there exist a discrepancy in needed skill perception between industry and education, novice employees are lack of practice skills[6].

Professional career training for novice employees at elementary levels to help them master necessary working skills is critical for both achieving employees' professional success and enhancing the enterprise growth[7]. SGTC offers induction training to novice employees and upgrade training for current staff of SGCC. Novice employees can’t acquire technical skills through having tries on actual equipments in power grid. We need to build a laboratory to simulate the actual workplace of dispatching voice communication system, and offer training program to help the trainees have a general knowledge in voice communication system, have practical skills of operation and maintenance about voice communication system, improving their competencies and confidence in work place. Through training, trainees get the knowledge and skills needed in the workplace and the certification approved by SGCC.

The proposed course is an integral part of employees training program. Emphasis of the course is on improving employees’ configuration and maintenance capability of the dispatching telephone system.

2. Outline of the laboratory based course

The laboratory consists of a hardware-based hybrid structure voice communication network and interactive training simulation software. Based on the laboratory, a series of theoretical lectures, hands-on laboratory practice projects, guide books and evaluation methods are developed and provided to the personnel training of SGCC.

2.1. Basics of telephony and private switched telephone network

We developed a theoretical lecture introducing basics of telephony and private switched telephone network, which include contents about telephone equipments, switching systems, infrastructure of telephone network and numbering plans, the classification and working principle of signaling, the construction elements and functions of telecommunication network, the basic telephone call procedures and signaling network.

The other subject of the lecture is about the private switched telephone network in electric utility especially the overall structure of dispatching telephone network and the special function of dispatching terminal.

The above contents are described and explained by using texts, images, animations and lecture videos as an on-line course supplied on the platform of the on-line university of SGCC. Employees register at the on-line university of SGCC freely, and learn anytime anywhere as their convenient.

The SGCC organizes centralized induction training on SGTC campus for new employees. Trainees should finish the online learning of relevant theoretical knowledge and then take part in laboratory practice.

2.2. The hardware equipment in laboratory

The first period in laboratory is equipment cognition; the trainees will be informed of safety precautions first and led by instructor to recognize the equipments such as telephone, PBX, dispatching terminal, recording system, interface cards, main distribution frame (MDF), and digital distribution frame (DDF), soft-switch equipment, trunk gate (TG), analogue gate (AG) etc. They will observe the overall structure of the telephone system in the laboratory. The instructor will show the learners all the equipments in laboratory and demonstrate the communication between different types of terminals.

The architecture of system in laboratory is similar to real field dispatching telephone network in power grid. At present, it is in the stage of evolution from the existing TDM-based circuit switching
network to the next generation IP-based soft-switching network, the two types of telephone system coexist in power dispatching communication network. Most existing dispatching telephone networks are primarily PBX switched and IP based telephone network are used as standby and they are backed up with each other[1-4]. To help learners master practical skills suitable for their jobs, the laboratory is equipped with PBXs and soft-switch equipments which are connected in a hybrid TDM/IP network.

The schematic diagram of equipment connection in laboratory is illustrated in figure 1. This is an integrated training platform that provides attendees a truly interactive experience on dispatching telephone network.

![Figure 1. Hardware components of the training platform.](image)

The platform owes 2 sets of PBX and 2 sets of soft-switch equipments and there are 2 sets of recording device and 4 sets of dispatch terminal. All the equipments are manufactured by Harris which is a relatively popular brand in electric dispatching network. There are also 48 sets of personal computer with simulation software installed. All the equipments are connected through local area IP network. This training platform mainly provides the training for novice employees engaged in electric power communication, and it provides senior technology training as well as other projects such as grade assessment and skills competition, etc. The equipments and devices can form various training scenes through different combinations.

3. Modular Training Projects

The aim of the training process is to help trainees develop their competencies to carry out maintenances and operations of dispatching communication system effectively and competently. We adopt scenarios based learning approach and project based learning approach to our current training courses to achieve the aim.

We have developed laboratory projects that focus on enhancing professional practice skills. The projects are developed according to the modularization idea combining with the actual operation and maintenance of dispatching communication system in power system.

The modules are classified into 4 levels according to competence proficiency. Learners are trained in every level one by one and at last they conduct a comprehensive project to cultivate their systemic thinking and problem solving ability. Modules and projects are listed from simple to complex as follows:

3.1. Level 1: essential skills on inner subscriber phone

The level 1 is for novice; at this level learners should understand the composition of the telephone switching network, the composition of the PBX and the functions of each part, focusing on the functions of the line interface cards. Trainees learn to use tools for voice distribution frame (VDF) wiring, learn to install and replace interface card, learn to connect and configure the dispatching
console. They connect computer to the PBX as maintenance terminal and log in to the PBX for setting up software data and perform data backup and recovery.

Trainees use the simulation software for database configuration practice individually first, then they are divided into groups to implement inner subscriber line connection and software configuration for PBX. They set the subscriber telephone with call processing features such as distinctive ringing, call hold, call forwarding, call pickup, call transfer, call waiting (CW), calling line identification (CLI), hunting and etc.

They operate the dispatching equipment and recording system in circuit switching mode. The dispatch terminal has special features such as push-to-talk, multi-level precedence, force-disconnect call and force-insert call etc. The recording system records all voice conversations that occur on the dispatch instruction communication equipment. The recordings may be used to audit the dispatch instruction, and to verify the response of the participant concerned to the dispatch instruction.

The training scenario for level 1 is shown in figure 2.

3.2. Level 2: trunk line and inter-office communication
Level 2 is for junior, at this level learners should implement 2M digital trunk line connection adopting signaling mode Q.SIG between PBXs and configure relevant software data settings of PBXs, and implement DDF wiring, configure the dataset and test inter-office telephone calling, view alarm information and carry out fault handling.

Learners need to choose board cards correctly, in this scenario, IP configurable functions unit (ICFU) board is used to connect to IP network, basic rate interface (BRI) board is used to connect to dispatch terminal, analogue line unit (ALU) board is used to connect to extension, digital trunk unit (DTU) board is used to interconnect between two PBXs. Every board needs to be installed correctly and the corresponding software data such as signaling and circuit location needs to be configured correctly.

The training scenario for level 2 is shown in figure 3.

3.3. Level 3: soft-switch equipments and IP-terminals
Level 3 is for senior, at this level learners will learn about soft-switch networking and relevant settings.

They get ideas of the layer architecture of soft-switch network and protocols and equipments in every layer especially TG, AG, IP phone in access layer; carry out hardware connection and software configuration of soft-switch equipments.

The training scenario for level 3 is shown in figure 4.
In the process of each project, at first instructors give demonstrations on operating real equipment, and then learners conduct operation following a prescribed procedure over a set time with a training guide book which gives step by step instructions. The actions are conducted under the supervising of trainers.

Each project is based on previous projects, and learners improve their practical ability by completing projects one by one. After completing the above individual projects, learners will begin their level 4 stage.

3.4. A comprehensive project

Level 4 is for supervisor, and at this level learners should conduct a comprehensive project that integrate all parts in a TDM/IP hybrid network as figure 1 shows and let all type of the terminals communicate each other. Learners will connect the hardware equipment and setup software and database as required. The emphasis is on interconnection between circuit switch and soft-switch.

The trainees were divided into small groups and given a pre-determined outcome. The groups develop their own procedure with the knowledge and skill they have learned in previous projects under the supervise of instructor in the context of an overall problem solving scenario to get the outcome. In their work process trainees were assigned contextualized problems that show the applications of PBX and soft-switch and some intentional faults made by instructor for enhancing their complex problem solving and fault handling ability.

At the end of each project, students give a presentation on their laboratory work and are asked questions about the project after the presentation. They also submit a short individual experimental report summarizing what they learned from the project, including any benefits and any difficulties. They will be given a score on their laboratory work by the instructor assessing.

The training scenario for level 4 is the same as in figure 1.

All the lab exercises are assigned to use 10 work days. After completing all the training programs, the learners have improved from beginner's level to proficient level.

Through these laboratory experiences, the trainees will have an overall cognition of power system dispatching telephone communication network, and master relevant operation and maintenance skills.

4. Conclusion

We have developed laboratory based course and projects suitable for training employees. The laboratory environment is consistent with the current power dispatching telephone network and can be used for training operation and maintenance skills of dispatching telephone system involve TDM-based PBXs and IP-based soft-switches, telephone equipments and dispatching terminals. It is applicable to the post skill training, technical grade assessment and skill contest of the electric power communication professionals. Through laboratory practice hands-on projects, trainees have been able to obtain real-life operation experience in the operation and maintenance of communication system of command and dispatch center. The laboratory based course can be used to train employees engaged in
operation and maintenance of communication system in power grid, and it can be used to train employees for other organization as public safety, train, potreliom, and so on. In our own studies at the SGTC we have used the course and projects for 5 years and about 2000 new employees have been trained. Course evaluations by trainees indicate that it is very useful and it upgrades the effectiveness of training.

The lab setup will be updated according to the technique development of industry.

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