Integrated Mobile Management and Control Platform for Electric Power Communication based on Big Data Technology

Hao Yu1*, Lu Zhang1*

1Anhui Electric Power Company, State Grid Corporation of China, He Fei, An Hui, 230000, China
1*Corresponding author’s e-mail: yuh2158@ah.sgcc.com.cn

Abstract. In order to promote the construction of strong smart grid and power communication network, higher requirements are put forward for power communication operation and maintenance management, and the integrated mobile management and control platform for power communication based on big data technology is proposed. The system is divided into full information interaction module, field maintenance module, field defect disposal module, field business opening module and field defect disposal module. Based on the cross-network multi-point remote cooperative interaction technology which conforms to the power field operation and maintenance interaction, an operation and maintenance resource scheduling strategy is proposed. The system has the advantages of efficient interaction and easy expansion, and can be applied in the field of power communication operation and maintenance management.

1. Introduction

Electric power communication network [1-2] is an important basic supporting platform for the construction of strong smart grid. The construction of the mobile operation in the power communication management system could greatly improve the efficiency of enterprise's repair of network dangers, and the quality of operation and maintenance of the power communication network and the level of network operation. For the operators, it can reduce the test work, and improve the efficiency of operation and maintenance. For the users, it can reduce the loss caused by power communication network failure. At present, there are mainly the following problems in the field management of power communication network: The power communication network has many devices in different places. Therefore, it is urgent to quickly locate and query the field resources and understand the situation of field resources. On the other hand, the complexity of power communication network. It is urgent to carry out the research on mobile terminal online data acquisition, transmission and worksheet pushing technology. The key is the safe and reliable interaction technology to improve the intelligent level.

To address the above problems, experts have offered some solutions. Mohapatra S et al. [3] developed that present various challenges that arise in the delivery and exchange of multimedia information to mobile devices. Specifically, the paper focuses on techniques for maintaining QoS to end-user multimedia applications (e.g. video streaming, multimedia conferencing) while maximizing device lifetimes. Ming-Hsiang Tsou et al. [4] provides an overview of a NASA-funded research project that focuses on the development of mobile GIS tools and wireless Internet Map Server (IMS) services to facilitate environmental monitoring and management tasks. By developing and testing wireless web-based map/image servers, mobile GIS applications, and global positional systems (GPS),
this research created an integrated software/hardware infrastructure for a prototype mobile GIS application. Park C et al. [5] proposed that Power line communication (PLC) is an evolving communication network technology using pre-installed power lines, which provides the electricity to the household or the building, in order to provide services such as Internet access, Automatic Meter Reading (AMR) and home networking. In addition, other researchers [6-11] had also done a lot of research in this area, and they made a very remarkable and effective contribution which is meaningful for the present research.

This paper focuses on the integrated mobile management control of power communication. The paper introduces the system architecture in Sect. 2, and the five sub-modules is described in Sect. 3. Section 4 gives the simulations and experiments, and the conclusion is put forward at the end.

2. System Architecture and Overall Process

With the new technologies of the mobile communication, the architecture of the integrated mobile management and control platform for electric power communication based on big data technology is proposed.

2.1. System architecture

The integrated mobile management and control platform for electric power communication consists of four layers: data acquisition layer, platform layer, application layer and mobile visualization layer. The overall architecture shown as figure 1.

![Figure 1. System architecture](image)

**Data acquisition layer:** this layer provides the data which includes field data, personnel, drivers and history data. The field data includes video, audio, picture and text information. The personnel data includes number, type and location. The driver data includes camera, Wi-Fi-driver, flash memory, PC, power management.

**Platform layer:** this layer realizes data integration and data calculation based on big data technology. The data integration includes three modes: data extraction, data conversion and data cleaning. Besides, The data calculation includes two modes: Batch data processing and Stream data processing.
Application layer: this layer consists of five modules and realizes the function of unified service. Activity Manager: managing the life cycle of each application and the usual navigation fallback function. Content Provider: making data accessible or shared between different applications. Notification Manager: making applications to display custom prompts in the status bar. Telephony Manager: managing all mobile device functions. Resource Manager: providing a variety of non-code resources used by applications, such as localized strings, images, layout files, color files, etc. Location Manager: providing Location Services.

Mobile visualization layer: this layer is separated from the other three layers. It is responsible for interaction with SG-TMS system, assisting users in decision-making, and providing visual display services.

2.2. Overall process
In the field of operation and maintenance process of power communication network, multi-point remote cooperative information interaction is the key link to decide whether the operation and maintenance intellectualization can be realized smoothly. Poor data collaboration and interaction will directly result in the waste of communication network operation and maintenance resources, and bring adverse effects to the overall management of units at all levels. The field multi-point remote system interaction of power communication network operation and maintenance is often based on a variety of network environments and terminal devices, and requires interconnected SG-TMS systems for data interaction support.

The integrated mobile management process of electric power communication is shown as figure 2. The whole process involves three parts: Power communication control center, SG-TMS system and several workspaces. The power communication control center is the overall decision-making unit, responsible for the decision-making, analysis and panoramic display of all information. SG-TMS system is an electric power communication management information system. It is not only responsible for the information exchange between the electric power communication control center and each workspace, but also assists the electric power communication control center in analysis and decision-making based on the functions of overhaul, defect disposal, business opening and intelligent inspection management, and provides services for each working point. The workspace is the basic operation and maintenance site, receiving the guidance of power communication control center and the service of SG-TMS system.

![Figure 2. Integrated mobile management process](image)

3. System Application Modules
The integrated mobile management and control platform for electric power communication based on big data includes the following application modules: full information interaction module, field
maintenance module, field defect disposal module, field business opening module and field defect
disposal module.

3.1. Full information interaction module
After checking and repairing power communication equipment and power lines with mobile terminals
in power communication operation site, and the emergence of unexpected situations, operators of
power communication field need to report to the control center in real time, and then the control center
will give corresponding instructions according to the situation. Both sides need to communicate and
real-time audio-visual. Full information interaction module is responsible for the information
exchange between the electric power communication control center and each workspace based on SG-
TMS system.

3.2. Field maintenance module
The module supports bidirectional flow of maintenance ticket information between mobile terminal
and SG-TMS; provides on-site application for completion, completes remote real-time judgment of
operation and maintenance on-site work content, realizes intelligent maintenance; provides
maintenance object-related operation and maintenance data push function, and provides on-site image
and video data return function.

The module is divided into twelve functional sub-modules: to-do maintenance module, on-site
maintenance module, archived maintenance module, revocation maintenance module, basic
information module of on-site maintenance, on-site maintenance equipment and line module, impact
business module, work unit module, cooperation work unit module, completion of maintenance with
SG-TMS interaction module, flow module, process footprint module and process processing module.

Based on the cross-network multi-point remote cooperative interaction technology which conforms
to the power field operation and maintenance interaction, an operation and maintenance resource
scheduling strategy is proposed.

\[
\begin{align*}
\text{n} (i, \text{max}) &= \left[ M (i) \ast S (i) \ast P (i, \text{max}) \right] \\
\text{n} (i, \text{min}) &= \left[ M (i) \ast S (i) \ast P (i, \text{min}) \right]
\end{align*}
\]

\[
\text{[n (i, min), n (i, max)] represents the number of operations and maintenance resources (including personnel and materials) required in the i-th workspace. M refers to the size of the workspace, s refers to the overall complexity of the workspace, P refers to the probability of accidents.}
\]

Deploy \text{n} (i, min) operations and maintenance resources in each workspace, and the other resources
is shared by multiple workspaces. For example, if the distance between the i-th and the j-th workspace
is relatively close, a resource sharing site can be built between these workspaces. The number of
shared resources can be be calculated by equation 2-3:

\[
\text{n} (i, j) = \left[ \alpha \sum_{k=i}^{j} \text{N}_k + (1 - \alpha) \max (\text{N}_i, \text{N}_{i+1} \ldots \text{N}_j) \right]
\]

\[
\text{N}_k = \left[ \text{n (k, max)} - \text{n (k, max)} \right]
\]

\[
\text{N}_k \text{ represents the maximum amount of resources needed further on the basis of meeting the minimum resource requirements on the k-th workplace. } \alpha \text{ is a number between 0 and 0.5, which can be set by the users.}
\]

According to the above methods, the most reasonable scheduling of operation and maintenance
resources can be achieved for the construction of electric power communication.

3.3. Field defect disposal module
The module supports bidirectional flow of single defect information between mobile terminal and SG-
TMS; provides recording feedback of field defect disposal process; provides remote expert diagnosis
and consultation functions based on video, image, voice, text and other interactive modes; supports multi-party remote multimedia interaction, and provides the function of image and video data return. The module is divided into ten functional sub-modules: completed defect module, filing defect module, cancel defect module, basic information module of on-site defect sheet, on-site defect equipment and circuit module, impact business module, impact channel module, defect disposal defect elimination with SG-TMS interaction module, process footprint module, flow module, and processing link module.

3.4. Field business opening module
The module supports the bidirectional flow of single information between the field mobile terminal and SG-TMS mode; after the implementation of the mode, the feedback can be carried out in the mobile terminal, and the uploading function of information such as field photos (label marking, etc.) can be provided, and the remote expert guidance based on video, image, voice, text and other interactive modes can be provided. The module is divided into ten functional sub-modules: established mode module, archiving mode module, revocation mode module, on-site mode single basic information module, application business content module, application optical path module, application other business module, mode opening feedback with SG-TMS interactive module, process footprint module and process module, and processing link module.

3.5. Field defect disposal module
The module assists the communication patrol personnel through the field mobile terminal, and improves the standardization, intelligence and work safety of the communication patrol. Provide patrol task dispatch, spare core test records, patrol operation instructions solidified in mobile terminals, patrol personnel according to mobile terminal APP patrol work order prompts and requirements for patrol, inspection, image archiving, patrol process through APP to record, and automatically generate patrol reports. The module is divided into eleven functional sub-modules: to-do inspection module, to-file inspection module, to cancel inspection module, basic information module of field inspection list, inspection content module, inspection card module, inspection execution module, standby core test record, inspection report module, process footprint module, trace and processing module.

4. Simulations and Experiments
The integrated mobile management and control platform for power communication has been deployed in East China based on SG-TMS system. And the proposed operation and maintenance resource scheduling strategy also has been verified in Zhejiang Electric Power Company, Jiangsu Electric Power Company and Shanghai Electric Power Company. The result is shown in the following table:

|            | Number of resource (before) | Number of resources (after) | Resource saving rate |
|------------|-----------------------------|-----------------------------|----------------------|
| Zhejiang   | 1357                        | 1029                        | 24.17%               |
| Jiangsu    | 1544                        | 1247                        | 19.24%               |
| Shanghai   | 573                         | 396                         | 30.89%               |
| **Total**  | **3474**                    | **2672**                    | **23.09%**           |

Above all, with the popularization and application of the integrated mobile management and control platform, the use of resources has been greatly reduced by 23.09%. Therefore, the system will play a greater role in promoting various business applications of power communication network, greatly improving the operation and maintenance quality of power communication network and network operation level.
5. Conclusions
Based on the current situation of field operation and maintenance management of power communication network, an integrated mobile management and control platform for power communication based on big data technology is proposed. The system realizes intelligent on-site multi-point remote cooperative interaction. With the popularization and application of the system in the power industry, the efficiency of multi-point interaction and resource utilization has been greatly improved.

Acknowledgment
This research is supported by the research “Customization and Implementation of Field Work Flow of Communication Mobile Transportation and Inspection Intelligent Terminal Based on TMS”. The author wishes to thank the team of Anhui Electric Power Company for their guidance and their previous research results. Thank you also to the members of SG-TMS project team for their careful proofreading of this paper and many useful suggestions for the improvement.

References
[1] He Y J, He Y, Peng P, et al. Electric Power Communication Network Alarm Data Acquisition System Based on CORBA Northbound Interface[J]. Advanced Materials Research, 2014, 989-994:4175-4178.
[2] Huang Z, Yu P F, Chen W, et al. Application of Network Experimental Platform in Evaluation of Electric Power Communication Network[J]. Applied Mechanics and Materials, 2014, 556-562:5201-5204.
[3] Mohapatra S, Cornea R, Dutt N, et al. Integrated power management for video streaming to mobile handheld devices[C]// 2003.
[4] Ming-Hsiang Tsou. Integrated Mobile GIS and Wireless Internet Map Servers for Environmental Monitoring and Management[J]. The American Cartographer, 2004, 31(3):13.
[5] Park C K P C K, Kang J M K J M, Choi M J C M J, et al. An Integrated Network Management System for Multi-Vendor Power Line Communication Networks[C]// International Conference on Information Networking. IEEE, 2008.
[6] Yang Y, Lv J X, Sheng L, et al. The Researches on the Construction of the Management in Integrated Electric Power Communication Network System[J]. Applied Mechanics and Materials, 2014, 644-650:3671-3674.
[7] Zhao W M, Zhu C Y, Yu Z. Development and Research of an Integrated Platform System for Management and Control[J]. Applied Mechanics and Materials, 2015, 719-720:5.
[8] Adewole A C, Tzoneva R. Co-simulation platform for integrated real-time power system emulation and wide area communication[J]. IET Generation, Transmission & Distribution, 2017, 11(12):3019-3029.
[9] Yao H, Peng Q, He W, et al. Integrated Communication Technology for Supervisory Control and Data Acquisition System of PV Power Station[C]// International Conference on Intelligent System Design & Engineering Applications. 2012.
[10] Kansal A, Hsu J, Zahedi S, et al. Power management in energy harvesting sensor networks[J]. ACM Transactions on Embedded Computing Systems, 2007, 6(4):32-es.
[11] Hong-Chun Y. Integrated Communication Technologies for Supervisory Control and Data Acquisition System of Multi-type PV Station[J]. Telecommunications for Electric Power System, 2012.