The Design and Application of FEU: Automation Monitoring Unit for 5G base stations

Hong Li\textsuperscript{1,a}, Huazhao Liu\textsuperscript{2,b} and Baiyi Yan\textsuperscript{1,c}

\textsuperscript{1}China Tower Co, Ltd., Beijing, China
\textsuperscript{2}China Communication Service Application and Solution Technology Co, Ltd., Guangzhou, China

E-mail: \textsuperscript{a}lihong@chinatowercom.cn, \textsuperscript{b}liuhuazhao@ccssoft.com.cn, \textsuperscript{c}yanby@chinatowercom.cn

Abstract: In order to realize the co-construction, sharing and intensive management of millions of stations across the network, supporting 5G go into operation efficiently, China Tower Group has developed a new generation of intensive and distributed operation maintenance monitoring platform over the inherited mobile base stations from the three major telecom operators. Based on the development and the application of this platform, FEU (an intelligent Power and Environment Monitoring Unit) is proposed, which uses the dynamic shared library method to embed the edge gateway to realize the edge computing capability of China Tower's intelligent operation and maintenance platform. It effectively solves the normalized monitoring of heterogeneous FSU and massive sites, constructs the intensive operation maintenance capability for China Tower and lays a solid foundation for the tower-based IoT [1,2] expansion business.

1. Introduction
As a vital components of communication system, mobile base stations can provide system interface and wireless function to mobile terminal. In recent years, by the quick development of communication technology, especially the 4G network, there is a great increasing of the mobile base stations. By 2020, 5G network is planning to go into commercial usage, which bring greater demand for constructing more mobile base stations, however, the features of our base stations are decentralization, rugged environment and unstable power supply. For the development of mobile communication, it is even more important to have real time monitoring the power and environment of base stations. It depends on the cooperation of locale FSU, centralized O&M monitoring platform and operation team. Thereinto, centralized O&M monitoring platform is the key to enhance the stability, quality and efficiency of all the base stations.

2. Distributed Architecture Design of Mobile Station Monitoring Platform

2.1. The Current Situation of Power Environment Monitoring Platform
The operators usually use 3-tier-architecture power supply environment system, which is deployed according to the classification of group company, province company and city company. Over 95\% of the base stations access with wire (a few use wireless GPSK), and most of them use the method of central analysis [3]. After CHINA TOWER is established, it took over all the base stations from three Chinese main operator. As the number of base stations reaches 2 million and locates all over 31 provinces of China, CHINA TOWER have built a core R&D team and cooperate with equipment
vendors to quickly achieve production support ability. The power supply monitoring system use centralize architecture and the network management system is deployed in the headquarter with distributed nodes for calculation. The ways of transmission are wireless (mainly 3G and 4G). The signal data performance and remote control of base stations directly access to FSU. It adopts End-Analysis method [4,5] and no longer access to OMC directly.

As the equipment of FSU have a large amount of types, those function interfaces vary considerably. The building of 5G network and the development of IoT accelerate extending the types and number of those equipment, which generate serious requirement for the compatibility of FSU system. Frequent upgrading is necessary for operation and maintenance of base stations. For the vendors vary in their technique, it is complicated to reform, upgrade and combined adjusting their interfaces. The loose relevance between FSU and SC platform cause the complexity to locate problem, which make the platform difficult to control the key functions, like registering FSU, reporting alarm, collecting performance, remote controlling and so on [3].

2.2. The Standardizing Design and Application of Intensive Distributed Platform According to FSU Interface

At the beginning, China Tower integrate the standard of power supply environment monitoring from China Telecom, China Mobile and China Unicom and make a unified monitoring standard and a cross-platform-interface technical proposal [2]. After investigation and communication with 16 domestic main FSU vendor, China Tower reform and upgrade their B Interface of power supply environment monitoring. Then, they formed the architecture of Automatic Intensive and self-adapted monitoring platform [2,6], as shown in Figure 1, after a lot of test on the platform in the experimental network and the typical base stations.

![Architecture of the Tower’s power supply environment intensive monitoring platform base on standard FSU interface](image)

Figure 1. Architecture of the Tower’s power supply environment intensive monitoring platform base on standard FSU interface

This architecture has worked more than 1 year, helping China Tower to take over all the existing base stations from 3 main operators in China. Now, China Tower can collect resource data, like performance, alarm and analysis, and remotely control the base stations, like door opening, camera control and battery measurement, which gives China Tower the Intensive Management Ability.
In this architecture, FSU works as a basic element of the whole monitoring network. By install embedded system and application into terminal-automatic-unit equipment, it can manage and deal with the monitoring data. The main business functions of FSU are controlling the collection of data, interacting with superior monitoring platform and, according to specific hardware, making integrated design with hardware and software. As the types and system software vary in different FSU equipment, although there is unified standard, the monitoring centre is difficult to maintain, analysis and locating the collecting data, especially alarm data due to the process to deal with data vary [7]. If it is necessary to upgrade the FSU software, each type of equipment need to develop its own application, which cause the low flexibility and high cost.

3. The Automatization of FEU Edge Node Calculating

As 5G network incoming, base stations expanding and IoT technique developing [4,8], there are more and more sensors put into monitoring, which cause an explosive growth in the capacity and difficulty of the platform operating. More than ten types of the FSU equipment and millions of them need to upgrade their interfaces. It is quiet a difficult job to update the version depend on different area and vendor, which make system updating a huge amount of work and the software lacks of robustness. Therefore, it is necessary to reform and unified this system. The iTower Core R&D Team of China Tower spent more than three months to analyse the structure of platform software [2], the business process, the function of Edge Node calculation, the core chip of FSU and the algorithm of embedded system [9,10]. Combining the Functional Specification of intensive monitoring platform, this team designed a kind of automatic embedded access unit, FEU, which move the terminal calculating function into FSU operation system and make it possible for each base station to calculate as a distributed unit. Based on this, China Tower plan to reform the access terminal and start the FSU Automatizing Project. The structure after reformed is shown in Figure 2.

![Figure 2](image-url)

**Figure 2.** Architecture of the Tower’s power supply environment intensive monitoring platform base on automatic FEU

3.1. Design of FEU Software Architecture

FEU includes all the functions of B interface. After FSU collects and delivers data from the equipment by A interface to FEU, FEU deal with the data depending on the kind and then update performance,
report alarm, store the data as history and so on. Wireless Network is connected by FSU. When the connecting status (online/offline) of VPN has changed, FSU need to notify FEU with all the registering information, like the VPN address, IMSI, network standard and so on. As soon as FEU judge it is Heartbeat Timeout, it will inform FSU and FSU will deal with it following the Triple-Reboot standard. The process is shown in Figure 3.

**Figure 3.** The scheme design of automatic monitoring unit

FEU is provided as Dynamically Shared Lib to the FSU vendor. As each vendor varies in its CPU chip, FEU need to compile according to the Cross Link Compilation Environment of each vendor. The FSU software can load the dynamic lib by the feu.h and libfeu.so, and then it can interact with monitoring platform after start-up FEU function by the operation process.

FEU API consist of 4 parts:
- Configuring management, which set the parameter for SDK running by Configuration File, including the storing space offer to SDK, the space for IPC picture, the base information of FSU and equipment, the information of collecting point and so on.
- Call-back function, which includes modifying FTP service parameter and control orders, reporting for Heartbeat Timeout, getting version of FSU, getting the status of VPN, correcting clock, obtaining the resource of system and so on.
- Control of SDK running, which can start or stop the SDK function, distribute initial memory for FSU, load the configure parameter, create instant and so on.
- Business Interaction Managing Function, which is the core model of FEU receiving the business monitoring function from FSU, including the real-time-remote-measurement data, the real-time data of remote signal related to remote measurement, the real-time data of remote signal, the real-time data of remote control and submit function, the informing about the status of VPN, getting the register status of FEU and so on.

After the platform issues a remote controlling order, FEU distributes it to FSU by Call-back function and FSU operates the controller and returns the result to FEU, and then FEU feed it back to the platform.
3.2. The Applying Effects of Automatic FEU

The applying of automatic FEU has 6 main benefits:

- Unified management of B interface, which makes the monitoring data more accurate and reliable.
- High expansibility of function, which can fast upgrade and deploy in any environment.
- Accuracy of the monitoring data, which help to locate the problem quickly.
- Compatibility to most FSU equipment, suitable for old and new equipment.
- Self-development, which reduce the cost to purchase FSU.
- Automation of monitoring.

China Tower first apply automatic unit FEU into the power supply environment monitoring system of far-away base stations. By now, there are over 300,000 base stations which have installed FEU. As upper interface is uniform, the version of software is the same and format of reported data is totally unified, it is simple to install, upgrade to support the new function of base stations and the operation, maintenance and management is standard, which make the system stable and reliable. This project archive the goal of base stations unified management, automatic deployment and simple expansion. FEU design the model depending on the demand, dividing the software highly related to hardware and interface of equipment into independent part. Designing the applications which interacts with monitoring centre and manage the data as individual components, FEU can unify the process of delivering monitoring data and ensure the data is complete and reliable.

4. Conclusion

This paper presents a new system architecture for automatic monitoring unit. It packages the interaction with platform and business deal as a function model FEU for FSU to interact with platform. It is independent of the application dependent on hardware and highly compatible. It is benefit to use model design for the development of power supply environment monitoring standard. As the incoming of NB-IoT and 5G network, in the future, the standard scene of FEU will be more detailed and, focusing on different access signal, FEU will put more calculating function into the edge layer, which can make the business service of platform more and more automatic.

References

[1] Bo Chen, Zhihui Gan 2016 The research of the commercial value and networking scheme of NB-IoT Mobile Communication.07-15
[2] Huazhao Liu 2016 The design and application of big data platform for IDC internet behaving analysis Telecom Technique.Jan
[3] Xin Gong, Zhiju Wang 2017 The technical proposal to reform power-supply environment monitoring unit of stock base stations Telecom Technique.01-25
[4] Huoming Cheng, Linsu Shi, Shan Gao, Meng Jin, Luda Miao 2016 The Summary of D2D Technology for 5G communication network Communication Journal.07-25
[5] SCUT.Wenjian Xu 01/16/2015 The design and realization of monitoring digital base stations base on SNMP
[6] Yin Ling, Yun Qiu 2017 The method to monitor the network behaviour of IoT Terminal base on internet data Telecom Science.12-20
[7] Huoming Cheng, Linsu Shi, Shan Gao, Meng Jin, Luda Miao 2017 The Expectation of China Tower’s Big Data Application Communication Journal.07-20
[8] 3GPP TR 23.720. Study on architecture enhancements for Cellular Internet of Things (Release 13)[S]. 2016
[9] Wei Liu, Jun Liu 2017 The research of distributed and dynamic resource management in the network of time-delay-sensitive sensors Communication Journal.07-25
[10] Hong Zhang, Yufeng Wang 2017 The frame, key technique and application of NB-IoT base on Fog Calculation ZTE Communication Technique.01-05