

Research on the Power Information Collector of Optical Fiber Based on EPON Technology

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Abstract— EPON (Ethernet Passive Optical Network) technology is a new kind of fiber optical broadband access network technology. The EPON system mainly includes OLT, ONU and ODN. It inherited the low cost of Ethernet and the high bandwidth of light network, so it has broad prospects of application in the Residential electricity information collection field. Based on above, this paper combines the characteristics of EPON technology and the requirement of information collection system in the Residential electricity, developed the design and application methods of Optical Fiber collection terminal equipment for the power consumption data acquisition system based on EPON technology, which is an important application part of EPON system. This paper mainly studies the hardware and software design of Optical Fiber collector, and its application in the L.X.Y Community in Beijing.

Keywords— EPON, ONU, Optical Fiber Collector, eCos, Smart community

I. INTRODUCTION

EPON (Ethernet Passive Optical Network) is a new technology that adopts one-to-multi-points topology, realizes data transmission on the physical layer by optical fiber and optical passive devices, and provides various internet accesses by Ethernet. It is comprised of OLT (Optical Line Terminal), ONU (Optical Network Unit) on consumer side, and ODN (Optical Distribution Network), and can be flexibly organized into tree topology, star topology, bus topology, etc (e.g. [1]).

EPON technology combines the advantages of both passive network and Ethernet technologies, with a transmission rate of both upstream and downstream reaching 1.25Gbps. It is featured with high-reliability, low maintenance cost, high compatibility with multiple topologies and interfaces, hence an ideal communication solution for the power system, which satisfies the unique requirements of network structure, security, maintainability and interface types for utilities.

Power consumption data collectors of traditional communication mode are well developed and widely applied. Collectors, concentrators and meters are integral parts of traditional power consumption data acquisition system. Differences between various solutions lie in the adoption of communication methods, such as GPRS, CDMA, RS485, carriers, and other integrated methods. The main problem regarding PLC is the rapid attenuation of high-frequency

signal in low-voltage grids, while the GPRS and CDMA are affected by package loss, limited maximum rate, long switching delay, operation instability, uncertainty of fault processing time (e.g. [2]). The communication architecture of the system consists of two layers: one is communication between master station system and concentrators, called remote communication; the other is the communication between concentrators and meters, called local communication. Since the collecting points are numerous and collecting intervals short, large amount of data will come out. Thus it is ideal to adopt EPON optical fiber technology with broad bandwidth, low cost, and high scalability in the remote communication between master station system and concentrators to collect real-time, accurate and reliable power consumption data. In addition, EPON is compatible with current Ethernet technology, and can be easily maintained and managed. This paper focuses on the design and development of ONU, which is the key part of power consumption data acquisition system. By means of joint debugging of OLT and master station system, ONU has met its design requirements and SGCC (State Grid Corporation of China) standards.

II. OPERATING PRINCIPLE AND APPLICATION SOLUTIONS OF EPON SYSTEM

The EPON is the primary type of PON technology that reduces Optical fiber deployment dramatically while preserving the merits of Ethernet networks.

A. Operating Principle of EPON

In this paper, ONU refers to the equipment integrating traditional ONU and power consumption data collector, which is called optical fiber collector. Through single-mode bi-directional optical fiber, the upstream and downstream data of EPON has realized full-duplex communication by WDM (Wavelength Division Multiplexing) with a data rate of 1.25 G b/s. The downstream communication (from OLT to ONU) adopts TDM (Time Division Multiplex) broadcasting mode. The data is broadcasted from OLT down to all ONU by variable length information packet, and the maximum length of information packet can be 1518 bytes. Based on LLID (Logical Link Identifier), ONU receives packets that belongs to it and abandons other packets (e.g. [3]). The wave length of downstream communication is 1490 nm. The upstream communication shares the system by TDMA (Time Division

Multiple Access). For each ONU upstream data, a private timeslot is allocated to ensure that only one ONU is sending upstream data at a time. The procedure is as follows: all data is marked with a unique LLID tag at ONU, then the OLT will allocate each registered ONU with a LLID tag, and finally the data is sent to OLT according to its timeslot. More details about the registration phase can be found in the current version of the IEEE 802.3ah standard as well as in [4]. The wave length of upstream communication is 1310nm.

As the branch-side equipment of EPON network, OLT aggregates data from ONU, which provides internet ports and other interfaces on consumer side. ODN is a 100% optical network of different topologies enabled by splitters of various split number and split ratio. It connects OLT and ONU, as illustrated in Figure 1 (e.g. [5]).

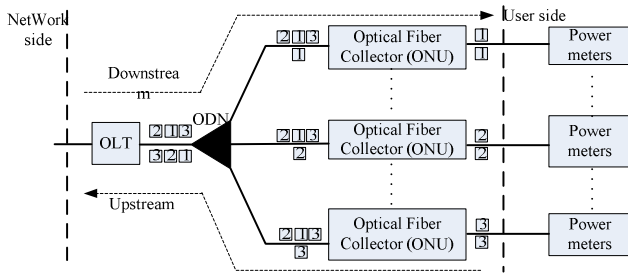


Figure 1. Typical network diagram of EPON

B. Application Solution

With optical fiber communication, the dedicated network of power system can be divided into two parts: the optical fiber backbone network and the optical fiber access network. The backbone network is comprised of SDH (Synchronous Digital Hierarchy) equipment, while the access network is comprised of EPON equipment. This article mainly focuses on the access network, which is directly applied in the local communication of power consumption data acquisition system. In communities, as a network-side equipment, OLT directly gets access to the acquisition server (master station system) by Ethernet in engine room, and works as a data bridge between master station system and ONU, providing PON interfaces for ONU. ODN connects OLT and ONU, and provides optical transmission channel between the two sides. It allocates the optical signal power. And the optical ratio can be 1:8, 1:16, and 1:32. As the core part of power consumption data acquisition system, ONU reaches meters through RS485 BUS, and collects power consumption data of end users. At present, each ONU can collect data from 32 meters, and its basic functions are in line with the specifications of SGCC. In a power consumption data acquisition program based on EPON (e.g. Figure 2), ONU collector is the power optical fiber collecting equipment.

III. H&S DESIGN OF ONU

ONU adopts the idea of embedded and modular design. Compared with upstream GPRS, CDMA and 230MHz dedicated network of traditional concentrators, ONU takes optical fiber as its communication medium. This has greatly improved the timeliness, stability and security of meter

reading, hence an essential difference from traditional concentrators in terms of hardware structure.

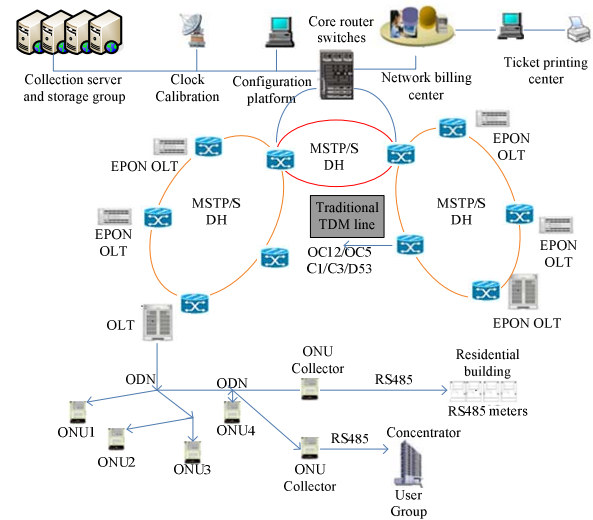


Figure 2. Diagram for power information collection based on EPON

A. Hardware Design of the System

The hardware of ONU mainly consists of 4 parts: EPON processor module, optical transceiver module, power supply module, FE interface module, bus and storage module (e.g. Figure 3).

The core part of ONU is EPON processor module, which adopts the PCC8016 chip solution of CORTINA. This kind of chip is a single-chip solution functioned with traffic management and dispatching. It has built-in frame buffer, Gigabit PON interface, serials port, JTAG debugging interface, FLASH and SRAM interfaces, and 5 volts power supply. And a built-in ARM-9 processor is responsible for management and control. As a standard IEEE 802.3ah compatible chip, it supports EPON Technological Specifications of China Telecom and MPCP (one-to-multi-points control protocol). The entire EPON system realizes the discovery and registration of ONU by means of MPCP Protocol (e.g. [6]). The operation principle of the MPCP mechanism can be explained as follows: the whole available upstream channel bandwidth is divided into transmission units (typically termed slots) using the Time Division Multiplexing (TDM) technique, which can be assigned to the active ONU (more specifically to the respective LLID) based on the DBA mechanism under operation in the OLT central packet schedule (e.g. [7], [8]). On consumer side, PCCS8016 also provides wide range of QoS (quality of service) and traffic management functions to guarantee that the bandwidth, delay, and jitter of each ONU are satisfied when the traffic is allocated by SLA. The optical module of this system adopts LTB34D2 and Optical transceiver provided by Hisense. The optical transmission distance of this module can reach 20 kilometers. The FE interface module for consumer business is a high speed Ethernet interface, which provides operation control platform for consumers and work as the debugging supporting interface for maintainers in the operation of ONU.

In the process of power consumption data acquisition, as the core equipment, ONU receives meter-reading order from master station and handles it. The upstream communication uses optical fiber, while the downstream communication with meters uses RS485 BUS.

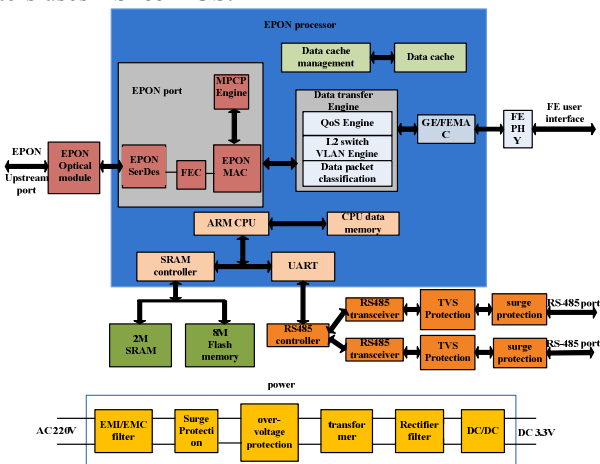


Figure 3. Hardware schematic of Optical Fiber collector

Tailored to the meter-reading system, a RS485 controller chip MAX3082 is added to the PCCS8016 processing chip to facilitate the switch from serial port to RS485 interface. For the bi-path RS485 interface, one path is used to connect RS485 BUS of meters; the other is used as engineering maintenance interface as well as meter connection. The extended FLASH is used to solidify the bootstrap and store data document of automatic meter reading. It is also functioned with data freezing, historical and curve data storage. The JS28F128 FLASH has a capacity of 16M, which basically meets application requirement. The SDRAM (HY57V1601 by HYNIX, 16M) is mainly used for operating system document copy from FLASH and caching of applications. The power supply module is also a key part of the system. It not only supports EMC, but also provides surge protection. With filter and transformer, it can provide a service voltage of 3.3 volts for the chip. In addition, the system has the function of hard clock. It uses the SD2405, high-accurate and real-time clock chip of built-in battery to realize the clock synchronization of the master station and collecting terminals of power consumption data acquisition system.

B. Software Design of the System

The software of ONU adopts embedded design idea. This article will skip protocols relating the upper layer OLT and focus on applications. Considering the real-time requirement of power consumption data acquisition system, the operating platform of ONU adopts the eCos (embedded Configurable operating system) by RedHat. This open source system is a configurable, portable, royalty-free, and real-time operating system for deeply embedded applications. Compared with Linux, the advantages of eCos lie in its flexible configurability, and less occupied kernel space, which makes it suitable for the cost-sensitive terminals of power consumption data acquisition. Figure 4 illustrates the software framework of the

system. Similar to other embedded equipment, the bottom layer of the system as BSP (Board Support Package) are device drivers such as serial port, internet port, clock, FLASH, etc., enabling upper layer applications to access the hardware. The eCos realizes thread management, thread dispatch, interrupt and anomaly handling, and synchronization of the system on the platform layer.

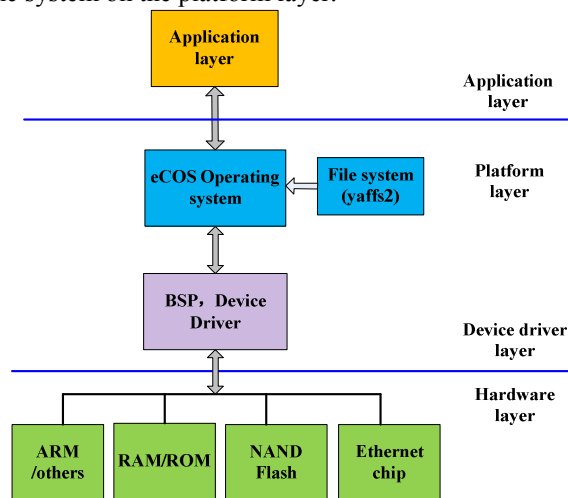


Figure 4. Software diagram of Optical Fiber Collector

According to the requirements of power consumption data acquisition system, the software adopts modular design. All the modules are independent threads, and communicate by message mechanism such as mailbox, queue and shared data structure. Cys_user_start(), the main function of applications, is responsible for creating main threads regarding to specific tasks, including:

- 1) **ONU_heart_thread and Task_thread:** Responsible for Freeze data of day, Freeze data of month and Freeze curve of meters for one month.
- 2) **Read_meter_rs485_thread:** Responsible for meter reading by collector at fixed intervals.
- 3) **Rx_thread and term_sever_rx_thread:** Responsible for sending data to RS485 meters from collectors and finish relevant protocol conversion.
- 4) **Protocol_Comm_thread:** Responsible for the protocol data analysis and processing for the master station and meters.
- 5) **Term_client_thread:** Responsible for the interaction between data and the master station.

All the threads are interdependent and compose the software of entire meter reading system.

IV. APPLICATION OF OPTICAL FIBER COLLECTORS IN SMART COMMUNITY

Pilot deployment of optical fiber collectors as the key of smart power consumption has been finished in L.X.Y Community, the first smart community of commercial operation in Beijing. Figure 5 illustrates the distribution of

optical fiber collectors in 2 buildings of L.X.Y Community. About 20 collectors were installed; each of them covers 2 floors (about 20 meters). Data from up to 400 meters is then time multiplexed by the splitter and transmitted to OLT and the master servers system in the basement. The master system can read meters at real time and store these data into local database, and the master station system can be connected to the public network. Figure 6 shows an on-site installation of Optical Fiber Collector in L.X.Y smart community. With a smart home gateway, consumers can gain access to the database and check their daily or monthly power consumption information.

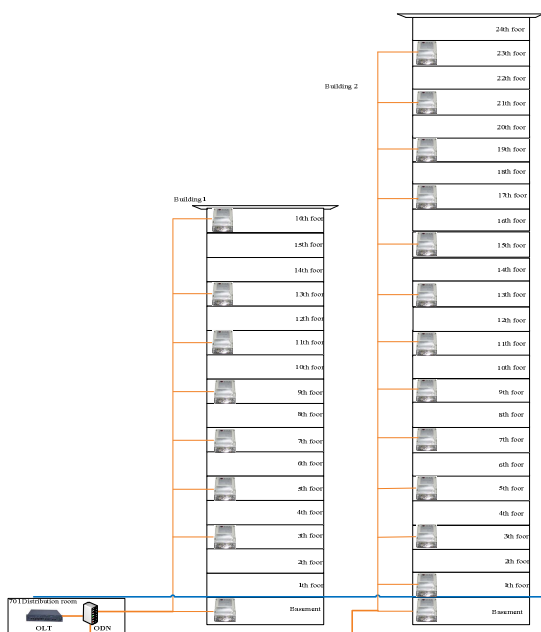


Figure 5. Deployment diagram of Optical Fiber collector in the L.X.Y Community

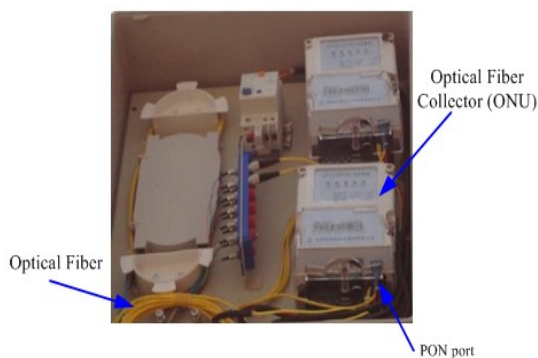


Figure 6. On-site installation diagram in smart community

V. CONCLUSIONS

The implementation of power consumption information acquisition system is a vital part of smart grid construction, and is in line with the development of international grid

technology. As a representative smart grid technology, power fiber to the home has been widely supported by the government and State Grid. Power fiber communication network has covered more and more communities, providing residents with power consumption information acquisition services. Optical fiber collectors based on EPON technology will be the mainstream of future power consumption information acquisition system.

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