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Design of New-generation Electric Vehicle Terminal

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ABSTRACT

EVT (electric vehicle terminal) has played an important role in EV (electric vehicle) operation. Based on research status of vehicle terminal, EVT brought about in the future should have the following functions: (1) fundamental functions, including real-time monitoring of batteries, guidance in station, position guidance of charging/battery-swap infrastructures, communication with OMS (operation and management system), and so on; (2) advanced functions, including but not limited to multi-media entertainment, subscribing and payment for charging/battery-swap, identification, and safety control during driving. Complete design of new-generation EVT in software structure and hardware architecture is proposed; a new idea of the application of EVT in EV industry is put forward.

Keywords: EV (electric vehicle); Power Battery; EVT (electric vehicle terminal)

1. Introduction

In recent years, with the development of EVs (electric vehicles) industry, OMS (operation and management system) for EVs has been gradually constructed, in order to support the operation of EVs. A number of cities, such as Beijing, Tianjin, Qingdao, Hangzhou, have being launching pilot projects to construct OMS for EVs. All branch companies of SGCC (State Grid Corporation of China) are going to accomplish construction of OMS for EVs in the next two years [1].

In order to realize the functions of revealing real-time information of power batteries as well as location information of EVs in OMS for EVs, real-time information acquisition of power batteries is needed. At the same time, it is necessary for charging/battery-swap infrastructures to take rational and orderly management to coming EVs, which is known as charging guidance. All of these functions demand the EVT (electric vehicle terminal) to acquire real-time information of power batteries, as well as to communicate with OMS and facilities in station.

To EV consumers, the EVT must reveal the real-time SOC (state of capacity) of batteries, like other products whose energy are supplied by battery, such as mobile phones and laptops, and give an alarm under the circumstance of low SOC. At the same time, the construction of charging/battery-swap infrastructures is now in progress, which is small area covered, bringing about inconvenience to consumers to charge or swap batteries. Therefore, the EVT must have the function of navigating to the nearest charging/battery-swap infrastructure.

According to the requirement analysis of EVT, a kind of EVT meeting the needs from OMS, charging/battery-swap infrastructures, as well as consumers is designed.

2. Research Status of Vehicle Terminal

The original design of EVT roots in traditional vehicle terminal [2], 15 member states of EU (European Union) enacted relevant laws and regulations in 1980s, that is, vehicle terminals must be installed and applied on transport vehicles for passengers and goods. Vehicle terminals are applied on 70 million vehicles in Japan; as a result, the death toll due to traffic accident is under 10 thousand per year.

Vehicle terminals are divided into two kinds; one is applying navigation technology recommended and developed by Japan, the other is applying remote information technology widely popularized in Europe and America. In Japan, electronic map navigation function has been standard configuration, and is being developed to austere version navigation along with the reinforcement of graphic function. In Europe and America, sight is focused on value-added services as emergency rescue; in such a system, speech guidance and recognition, individual assistant function is necessary.

For domestic consumers, vehicle navigation and remote information are both urgently needed; therefore, EVT is neither simply following vehicle navigation, nor blindly absorbing remote information technology, but assembling their advantages and referring to development level of domestic EV and individual desire of consumers. On vehicle navigation, in consideration of the status that charging/battery infrastructures are small area covered mentioned above, charging/battery infrastructure navigation function is pressing; on remote information technology, the EVT must provide sufficient data for OMS and receive useful information relative to EV from OMS.

3. Function Summary of New-generation EVT

In OMS for EVs, thermal model for batteries, real-time information, as well as battery voltage model reveal need real-time data of batteries. Power battery has three operating states: in stock, on rack and at work. In stock indicates that the battery is kept in stock; on rack means the power battery is charging on charging rack; at work means the power battery is placed in EV to operate. When the battery is in stock or on rack, information acquisition can be realized by means of wireless network through reconstruction of stocks and charging plants. Nevertheless, when the battery is at work, the EVT is needed as terminal for information acquisition and communication.

When EVs enter charging/battery-swap station to charge or swap battery, workers in station should take rational guidance to them. Its realization needs the stations and EVs to install corresponding wireless sensor modules. Only direction and position information of EVs is acquired and uploaded to management terminals in station, can workers take charging guidance to EVs.

At the same time, the EVT should show the current SOC to consumers and give an alarm under the circumstance of low SOC or abnormity. When charging or battery-swap is needed, the EVT should point out the location of the nearest infrastructure.

As the EVs are ridden instead of walking, EVT should have advanced functions. Comprehensively considering various aspects for EVT and progressiveness, their functions can be divided into fundamental ones and advanced ones.

3.1. Fundamental Functions

The fundamental functions of EVT are composed by the four aspects bellow: real-time monitoring of batteries, guidance in station, position guidance of charging/battery-swap infrastructures, communication with OMS, as is show in **Figure 1**.

1) Real-time monitoring of batteries

Real-time monitoring of batteries is mainly meeting requirement from two aspects: one is remote data acquisition from relative applications of OMS to batteries; the other is basis of real-time show of SOC, low SOC alarm and abnormity alarm to consumers. Real-time data of batteries are acquired through the CAN transceiver from BMS (battery management system), uploaded through GPRS (general packet radio service) to the front end server of the OMS, and displayed on terminal screen. When abnormity or low SOC occurs, the EVT can carry out audible and visual alarms [3].

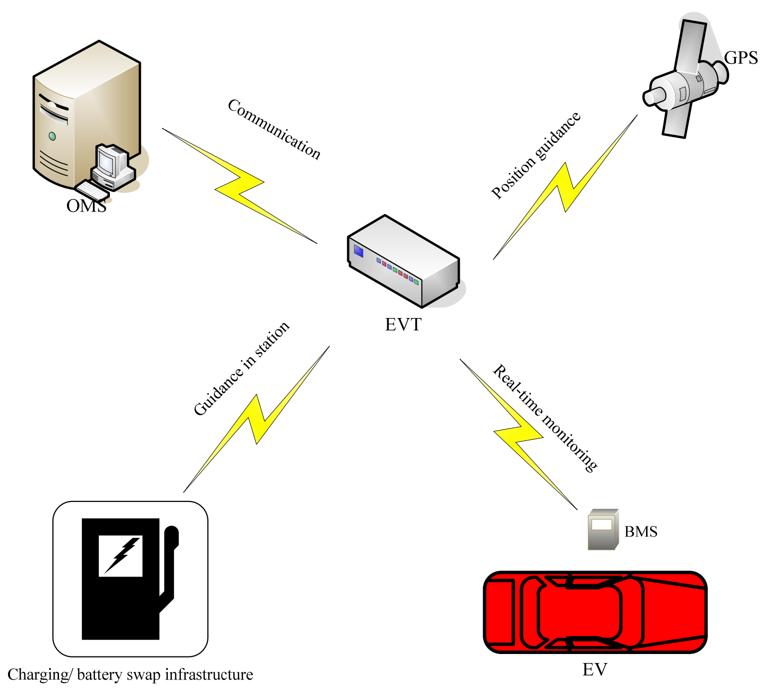

Figure 1. Fundamental function of EVT.

2) Guidance in station

Guidance in station is mainly for the convenience of the workers to manage EVs, bringing about effective charging or battery-swap. The EVT communicates with the infrastructures in station and PDA (personal digital assistant) through ZigBee, computers in station show the azimuth information and sequence information. The drivers only need to cooperate with the workers and screen in station to easily find out free charger or battery-swap equipment. Disputes from jumping a queue can be avoided due to the sequence information [4].

3) Position guidance of charging/battery-swap infrastructures

As the construction of charging/battery-swap station isn't completed at present, compared with petrol filling stations for traditional vehicles, coverage area of charging/battery-swap stations is badly limited; all of this brings about inconvenience to charging and battery-swap. In addition, as a result of bottleneck effect from battery technology, the range of EV is short; consumers must charge or swap batteries frequently. Consequently, for the convenience of usage, the EVT should have the function of position guidance of charging/battery-swap infrastructures, with the help of which value-added services, such as long-distance rescue, can also be launched.

4) Communication with OMS

Compared to traditional vehicles, the greatest advantage of EV is their energy supply depends on comprehensively constructed smart grid. In recent years, all branch companies of SGCC are constructing OMS for EVs as well as information management towards EVs. Through OMS for EVs, batteries and charging/battery-swap equipments are managed, operating state of batteries is monitored, trajectory of EVs is reappeared, relative services are provided and short messages about tariff are sent. The EVT is essential to information management for EVs, which is not only supplier of real-time data for OMS, but also service window between OMS and consumers. Through EVT consumers can obtain the latest tariff information about charging and battery-swap, ask for long-distance rescue and remind subscribe of charging and battery-swap. Providing comprehensive services through communication between EVT and OMS is one of the most fundamental and important functions.

3.2. Advanced Functions

Compared to traditional vehicles, EV is in its elementary period, not only for production scale, but also for the functions and types of its auxiliaries. However, the appearance of vehicle comprehensive service platforms, such as iDrive of BMW and G-Star of GM, offers valuable experiences to the EVT's development. Besides fundamental functions mentioned above, future EVT should provide more comprehensive and abundant advanced functions for consumers. Taking consumers, electric power corporations and charging/battery-swap infrastructures into consideration, EVT should have the following four advanced functions: multi-media entertainment, subscribing and payment for charging and battery-swap, identification and safety control during driving.

1) Multi-media entertainment

Multi-media entertainment has been indispensable part for traditional vehicle. From inchoate radio to cassette, till multi-media player nowadays, consumers are enjoying the driving pleasure as well as multi-media entertainment inside the car as the result of the development of vehicle terminal. Future EVT should not only play audio and video, but also bring about VOD (video on demand) and surf the Internet with the help of wireless communication networks. By self-organizing wireless networks, mobile office and mobile meeting in car can easily accomplished.

2) Subscribing and payment for charging and battery-swap

In the near future, disperse AC (alternating current) charging spots will be important infrastructures in communities, rest areas on super highway, and parking areas. Taking convenience of customers into consideration, the EVT should have the function of subscribing and payment for charging and battery-swap. By the EVT, consumers can find out the nearest disperse AC charging spot available, subscribe the spot through OMS, write their own ticket to determine the time to proceed to the spot after they are informed the subscribed time. When the consumer is to charge after arriving at the spot, it will confirm the subscribing information through communication with the EVT. As long as the subscribing information is confirmed, the spot starts charging according to consumer's operation. When charging is finished, the spot will confirm the charging information through the communication with the EVT, as long as the charging information is confirmed, the consumer can pay not only by swing card, but also by account presorted in the EVT. After payment, the EVT will communicate with OMS, updating account information and uploading charging information.

3) Identification

Identification is the extending of the existing intelligent electricity card. The EVT will identify the card and upload the consumer's essential information to OMS, displaying consumer's information after confirmation. After that, using information of batteries, charging/battery-swap information and payment information will be uploaded and updated to OMS by EVT. Moreover, identification can take precautions against theft, that is, the card is corresponding to EV and EVT, any inconformity will trigger alarm, OMS will send message to cell-phone obligated by the consumer.

4) Safety control during driving

Guaranteeing driver's safety is one of research areas in traditional vehicle fields, which is equal problem to EV. The future EVT will be redesigned on safety control during driving. The EVT will play two main roles on safety control: one is taking precautions against potential safety hazard, the other is giving an alarm and controlling in case of accident. Locations where potential safety hazard probably appears, such as the tire pressure and environmental conditions of battery boxes will be monitored, magnanimous sensors of varied function are installed, monitoring results are transmitted to the driver to check the corresponding location. In case of malfunction or accident, the EVT will transmit the alarm information to OMS, cut off power supply and open the door. The consumer can escape, avoiding misoperation from nervousness.

4. Architecture Design of EVT

In EVT design, fundamental functions are nucleus; design and lecto type of corresponding functional units meet the requirement of fundamental functions at least. Inconsideration of advanced functions, bus interfaces are reserved for corresponding modules [5]. As designs of main control unit and memory cell needs continuity, their lectotype depends on performance indices for prospective advanced functions.

Application programs for fundamental functions are designed to realize the fundamental functions mentioned above. Hardware architecture is shown in **Figure 2**; the EVT consists of the following main units: main control unit, power supply unit, vehicle interface unit, memory cell, communication unit, human computer interaction unit.

4.1. Main Control Unit

Main control unit is the processing core of EVT, which integrates various peripheral control units and bus control units, assembling the EVT into an entirety. ARM9 cored SoC control chip is selected.

4.2. Power Supply Unit

Compared with other hand-held flush-type products, the power supply unit of EVT should allow wider input

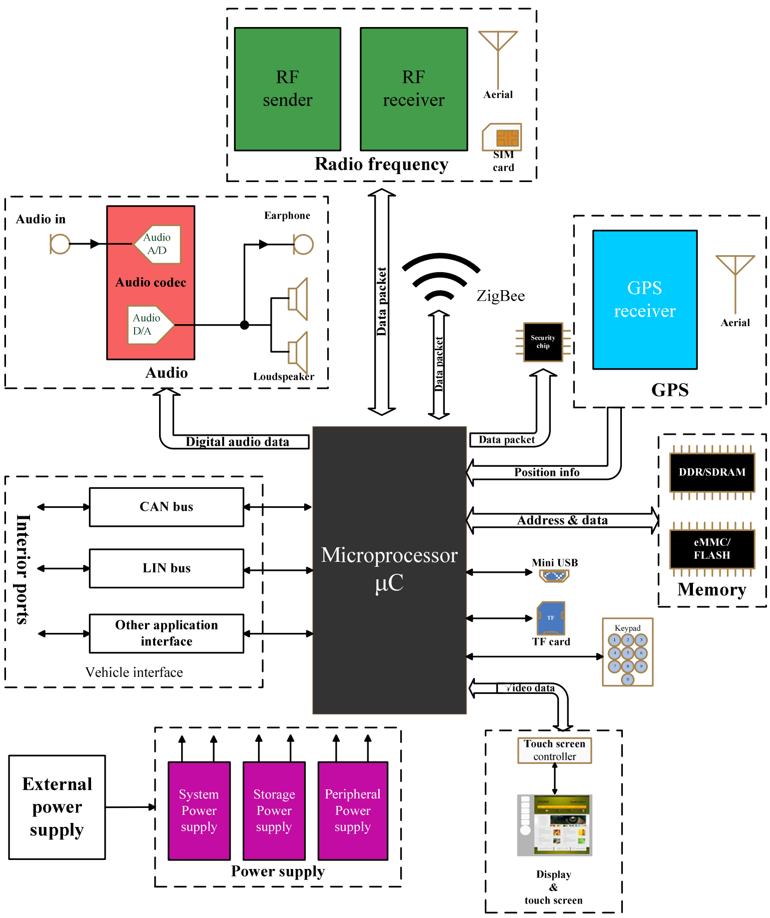

Figure 2. Hardware architecture of EVT.

voltage scale and better stability. Power supply of EVT is from 12 V lead-acid cells on board. Output voltage of lead- acid cell ties up with driving status: when the vehicle is running, it is 10 to 12 volts; when the vehicle is pulsing on, it is 14 to 16 volts. In order to prevent abnormality from sudden change of input voltage, the power supply unit is designed according to standards in automotive industry.

4.3. Vehicle Interface Unit

Vehicle interface unit is communication interface between EVT and EV. In automotive industry, CAN (controller area network) bus have been used proverbially as another appellation of interior bus? EVT needs to acquire the batteries' status information and condition information on the interior bus, which makes this unit one of the most important fundamental units, as well as main source of communication data.

4.4. Memory Cell

Memory cell consists of two parts: internal storage and external storage. The former drives at storage components integrated in EVT, such as SDRAM and FLASH; the latter indicates external extended storage components, such as SD cards and TF cards. Memory cell mainly stores Bootloader, embedded system, user parameter, application program, user data, etc. At the same time, in order to prevent valuable experimental data from missing, historical information can also be stored in external extended storage.

4.5. Communication Unit

Communication unit includes GPRS, GPS (global positioning system) and ZigBee. Through GPRS module, EVT uploads battery information to OMS at regular time, and receives relative service information from OMS. Through GPS module, location information of vehicle is positioned, which will help navigation software to compute the shortest path to charging/battery-swap infrastructure. ZigBee module is designed to realize guidance in station. Through communication with short distance wireless devices in station, EVs are guided to the target spot. Besides, out of communication security, security chip is integrated to encrypt sensitivity data.

4.6. Human Computer Interaction Unit

Human computer interaction unit consists of display, I/O and audio, by means of which EVT communicate with consumer. Moreover, this unit makes control to EVT come true.

5. Conclusions

EVT is significant device for OMS to lay on correlative services. Through EVT can consumers enjoy convenient value-added services? Besides, EVT provides valuable experimental data for research on EV and power battery.

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