Design and implementation of graphical interface of vehicle display and control system based on SylixOS

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Abstract: To satisfy the design requirements of the current vehicle display and control system, and in consideration of the independent controllable requirements of the current software and hardware platforms, this paper proposed a set of nationalized solution. The Loongson 2K1000 was selected as the main control chip, and the interface design and development of vehicle display control system was completed based on the SylixOS autonomous real-time operating system. This paper elaborated on the development process of the open source graphics library Qt, and proposed solutions to the screen flicker problem encountered during the development process.

1. Introduction
As an interface between the vehicle and the operator, the vehicle display and control system takes a prominent position in armored vehicles. Early vehicle information was displayed through pointer instruments and operated through rotary switches, with low integration, large space, and high failure rate. As the development of technology, the display of vehicle parameters and information gradually appeared through the display screen, and the operation was completed through the side keys. After using the display screen as the main way of displaying information, a solution using VxWorks as the operating system and x86, PowerPC, and ARM as the main control chip appeared to realize the construction of the display and control system. Comprehensive comparison of these several CPUs, x86 is Intel’s first microprocessor architecture developed and manufactured. This architecture has been introduced for more than 30 years, but the variable instruction length has caused the x86 CPU’s decoding work to be extremely complicated. The x86 instruction set architecture consists of 8 general-purpose registers, and only 6 can be used, resulting in a shortage of registers. Therefore, the x86 instruction set limits the further improvement of CPU performance. ARM chip is small in size, low power consumption, low cost, high performance, a large number of registers are used, so that the instruction execution speed is fast, the addressing mode is flexible and simple, the execution efficiency is high, and the price is low, and the energy consumption is low. Compared with ARM devices, PowerPC is slightly more expensive, but has high integration. Now Freescale PowerPC processor
integrates USB, PCI, DDR controller, SATA controller, Gigabit Ethernet port controller, CAN controller, RapidIO and PCI Express controller, IEEE1588 communication protocol, supports various communication protocols CPM coprocessor like DMA, SPI, I2C, UART, etc., It does not need to design complex peripheral circuits, which is not available in ARM\textsuperscript{[1]}.

The above list operating systems, whether it is the embedded real-time operating system VxWorks or the main control chip, are all non-domestic processors and non-domestic operating systems. These non-domestic chips and systems have some problems such as unaffordable prices, technology monopoly, export restrictions, etc. Therefore, an excellent domestic microprocessor chip and operating system are urgently needed to solve these problems. With the development of Chinese domestic embedded industry, a large number of high-quality chips and operating systems have emerged.

In view of the design requirements of the display and control system, the development of the graphical interface of the display and control system should not only have good portability, but also support graphical development tools such as QT, be flexible and reconfigurable between different interface components, and the graphical display and data logic should be managed hierarchically. Therefore, in the construction of the display and control system, this article uses the Loongson 2K1000 as the main control chip, and the embedded operating system uses the SylixOS real-time operating system, which can effectively support the compilation and development of the graphics tool QT.

2. Hardware design of vehicle display control system

2.1 Overall composition

The hardware environment of the vehicle display and control system is realized by the means of Loongson 2K1000 main processor + FPGA + interface. Loongson 2K1000 is a medium-sized CPU with low power consumption and advanced performance newly launched by Loongson Zhongke Technology Co., Ltd. in 2017, which can replace 200MHz~1.5GHz ARM and PowerPC embedded CPUs. It has Firmware BIOS, and can realize hardware initialization and detection, boot operating system kernel: in terms of operating system software, SylixOS real-time operating system is taken as the basic software platform to provide support in device driver layer, to provide develop and support environment layer to integrate common compilation tools and various supporting environments, and basic software layer, which can provide support for subsequent application deployment.

2.2 Hardware design

2.2.1. Power supply circuit design

This motherboard adopts 5V input, and to realize the function of the board, other voltages need to be converted to power the chips on the board.

2.2.2. Processor

We used Loongson 2K1000 as the main processor, which integrates two GS264 processor cores. The main frequency is 1GHz, 64-bit DDR3 controller, 2 GMAC controllers, 2 x4 PCIe controllers, 2 CAN controllers, 4 UARTs Controller and various other interfaces. With the Loongson processor as the core, the CPU and other core processing units are integrated on the single board, and the rich external interfaces are expanded through FPGA to meet the interface requirements for 1553B, GPIO and other interfaces.

2.2.3. BIOS circuit design

BIOS (Basic Input Output System) is particularly important in the system, which is the bridge between the hardware layer and the operating system layer. In this design, FLASH uses 16MB SPI flash memory.
2.2.4. Network interface design
Loongson 2K1000 integrates 2 GMAC controllers, two 10/100/1000Mbps adaptive Ethernet MAC, and both two network cards are compatible with IEEE 802.3 half duplex/full duplex adaptive. When half-duplex, it supports collision detection and retransmission (CSMA/CD) protocol, can automatically generate and verify CRC check codes, supports generation and deletion of preambles, and supports network startup.

3. Software environment of vehicle display control system

3.1 SylixOS
SylixOS autonomous real-time operating system is selected for the vehicle display control system. SylixOS is a hard real-time operating system that supports SMP scheduling. The kernel autonomy rate reaches 100%, and it has completely independent and controllable technical capabilities. SylixOS supports a symmetric multi-processor (SMP) platform, and has a real-time process and dynamic loading mechanism to meet the needs of multi-departmental distributed software development and support the integration of application software in various departments on the operating system. At the same time, the SylixOS operating system has processor cross-platform support capabilities, supports ARM, MIPS, PowerPC, x86, SPARC, DSP, RISC-V, C-SKY and other architecture processors, and supports mainstream domestic general-purpose processors, such as the full range of Feiteng, Loongson's full series, Zhongtian Micro CK810, Zhaoxin's full series, etc., so that when the hardware is upgraded, the software migration workload of the display and control system is very small.

3.2 SylixOS operating system features

3.2.1 Network communication
SylixOS supports complete network functions and rich network tools:
- Support 10M/100M/1G/10G Ethernet;
- Support wireless net framework;
- Support Mesh network and MAODV self-organizing network protocol;
- Support mainstream WIFI, 3G/4G/5G modules, network card redundancy, virtual network card, network bridge;
- Support IPv4/IPv6 dual network protocol stack and provide standard socket interface;
- Support AF_UNIX, AF_PACKET, AF_INET, AF_INET6, AF_ROUTE protocol domain;
- Support many network tools, such as FTP, TFTP, NAT, PING, TELENT, NFS, PPP, KidVPN, VLAN, etc.;
- Support mainstream industrial real-time Ethernet, such as EtherCAT;
- Support rich network middleware, such as SNTP, libxemail, libcurl, GoAhead-WebSever, DHCP-Server, ACE, TAO, OpenDDS, LCM, pcap, Tcpdump, NeFTP Client, SNTP Server, noPoll, Boa, etc.;
- Support built-in rule security system, external network security system.
3.2.2 Graphic display

One of the most important features of the SylixOS operating system is the provision of RealEvo-QtSylixOS software, which enables Qt Creator to develop Qt applications on SylixOS with almost zero configuration, and deploys Qt shared libraries to SylixOS devices with one click, making the Qt application environment configuration extremely simple, and one-click deployment, operation, debugging, and analysis of Qt applications greatly improves the efficiency of development.

Qt is the industry’s leading cross-platform graphical user interface application development framework. Qt has a good encapsulation mechanism, which makes Qt highly modular and reusable. In this way, the program code of the interface can be easily reorganized and called during the development of the graphic interface of the display control system. At the same time, Qt provides a safe type of signal/slot instead of callback, which makes the collaboration between various components very convenient and simple. Qt also has an extraordinarily rich API, supports 2D/3D graphics rendering, and supports OpenGL. The SylixOS operating system's support for Qt enables the interface software to have an operator-friendly integrated development environment (IDE) during the development process, which is quick and easy to use and powerful. The SylixOS operating system's support for Qt on the other hand makes the process of cross-platform porting of the display and control system interface software quite easy and fast. We only need to modify some simple configurations and the cross-platform porting work can be completed by compiling.

The SylixOS operating system has the following functions in terms of graphics display:

- Support multi-screen display, OpenGL, VNC remote display;
- Supports graphical user interfaces (GUI) such as Qt4, Qt5, uGFX, uC/GUI, MiniGUI, etc., and supports third-party Qt control libraries such as Qwt;
- Support touch screen, keyboard, mouse, and hot swap of input devices.
3.2.3 File storage

- Support many standard file systems: FAT, YAFFS, ROOTFS, PROCFS, NFS, ROMFS, etc.
- Support SylixOS patent file system: TpsFs (Power-down Safe File System), completely solve the power-off safety problem of file storage in the embedded industry;
- Support file record lock and database;
- The file system supports POSIX standard I/O operations;
- File storage media supports NOR FLASH, NAND FLASH, eMMC, SD, CF, IDE hard disk, SATA hard disk, U disk, NVMe solid state storage.

4. Graphical interface software design

4.1 Qt-based interface graphics drawing
The Qt drawing system is composed of three parts, namely QPainter class, QPaintDevice class, and QPaintEngine class. The QPainter class is used to perform drawing operations. It is equivalent to a painter and provides various drawing commands such as drawPixmap and drawImage. The QPaintDevice class is equivalent to a canvas and provides canvas interfaces such as QImage, QPixmap, QBitmap, and QPicture. The QPaintEngine class provides the QPainter class for the interface for drawing to several types of devices is the concrete realization of the basic QPainter drawing commands.[2]

4.2 Keyboard operation and data acquisition
In the graphical interface software of the vehicle display control system, the operation of the interface is completed by the keyboard information sent by the keyboard acquisition software via the RS422 serial port. Here, a thread QUartComp is started: QTThread uses Qt's thread mechanism to complete the collection and reception of keyboard information. The interface data is collected and received through the CAN bus and placed in the buffer area. Here, a thread QCanComp: QThread is started to complete
the receiving and sending of bus data[3].

Qt thread is composed of thread class and thread synchronization class. QThread is a thread class interface, which provides a platform-independent method to manage threads. Thread synchronization classes include QMutex, QSemaphore, QWaitCondition, QReadWriteLock, etc., which provide thread synchronization interfaces. In Qt graphical user interface applications, the GUI thread is the main thread of the graphical user interface. It is the only thread in Qt that can perform GUI-related operations, but it can have one or more non-GUI threads as worker threads at the same time to facilitate process other time-consuming operations in the application.

4.3 Qt signal and slot mechanism
The signal and slot mechanism is the core mechanism of Qt, which is mainly used for communication between objects. It can bind objects that do not understand each other through existing signals and slots or custom signals and slots. The connection modes of signals and slots include automatic connection, direct connection, queue connection, queue blocking connection, etc. After a signal and a slot are connected, each time an object emits the signal, the slot function is automatically called, especially the signal and slot mechanism can support cross-thread connections, and objects in different threads can also use signals and slots to connect, which can realize the communication between threads[4].

In the process of collecting and receiving keyboard information, the keyboard value sent by the keyboard via the serial port is cyclically received in the QUartComp thread. When a button is pressed, a signal is sent to pass the button parameter. In this case, the slot function in the processing interface information thread responds to complete the corresponding operation. The signal and slot mechanism is very convenient to complete the communication of data between threads.

![Figure 4](image-url)

Figure 4  key value Receiving process

4.4 Double buffer technology
In the process of program design, it was discovered that the screen will flicker and jitter. The reason for this phenomenon is that the window needs to perform complex graphics processing when responding to drawing messages. Firstly, the refresh of the window must erase the original image.
this process, it uses the background color to fill the form, and then calls the new drawing code to redraw, so that the image color contrast is caused by the erasure. When the refresh response is very frequent, this contrast becomes more obvious, so there is a flicker phenomenon[5].

To eliminate the flicker phenomenon, this article uses double buffering technology to solve this problem. As the image displayed on the screen is the content of a specific area in the video memory, only when the image is displayed, a video memory area with the same size as the screen is used as a buffer screen in the video memory, and the image to be displayed in the next frame is written into the buffer screen. When this image needs to be displayed, it can directly display the buffer screen. This avoids the switching between the background color and the displayed image, and effectively eliminates the flickering and shaking of the screen.

5. Conclusion
Today, when international trade disputes continue, there are excessively high risks and uncertainties in the use of non-domestic processors and non-domestic operating systems. The independent controllability of software and hardware platforms has become our most concern nowadays. In the field of vehicle display control system interface development, this paper proposes a solution based on the national production platform. It selects Loongson 2K1000 as the main control chip and based on the SylixOS autonomous real-time operating system to complete the design and development of the vehicle display control system interface. This article elaborates on the selection of hardware and software, platform construction, and the development process of the open source graphics library Qt, and proposes the application method of double buffering technology for the screen flicker encountered in the development process. Finally, we realized the human-machine graphical interface for vehicle display and control system, which is a friendly interface, and has stable operation and fast response speed.

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