Designation of Green Computer Terminal Supported by Cloud Computing

Guohua Xiong(✉)

GuangDong Construction Vocational Technology Institute, Baiyun District, Guangzhou, Guangdong, China
xiongguohua2005@126.com

Abstract. Due to the rapid development of cloud computing and information technologies, traditional computer is replaced by novel terminal gradually. This paper conducts a full research on the design of computer terminal equipment accessing the cloud server. On the basis of the analysis of a large number of existing terminal equipment performance and presenting an effective solution, we design the device by hardware and software integration method, by selecting the appropriate hardware to optimize the communication protocol. The test results of our scheme is a feasible method to solve some problems of traditional solution, which is a kind of green energy-saving product with stable performance and cheap price.

Keywords: Cloud computing · Energy-saving · Green computer · Cloud terminal

1 Introduction

Cloud computing is a method to provide the shared software and hardware resource information to computers and other equipment for computation as needed via internet [1-3]. Users can acquire the service provided by "Cloud" simply via internet with no need to know details of cloud computing environment. "Cloud" here is a graphic metaphor, actually, it is to provide service for users with many distributed interconnected computers to form cloud service platform through unified resource management and scheduling and then by virtue of the internet[4-5]. Users use it on demand just as water, electricity and other public services and it is charged based on the amount of usage. Cloud computing provides virtualization services mainly at three levels [6], namely: (Infrastructure as a Service, IaaS), services such as storage, hardware, server, network components, etc. are available for users via internet. Service providers possess these hardware resources and distribute them according to the demands of different users, and users pay for each application. Main products include Amazon EC2 and Sun Grid. (Platform as a Service, PaaS), at the same time service providers will provide a basic computation platform for users instead of a specific application. Users can construct their own application through this computation platform, besides, cooperation among many users is also allowed in this platform, such as Google App Engine. (Software as a Service, SaaS), it is a new delivery software mode. Software service providers deploy application software uniformly to their own servers, and provide paid online

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application service via internet to customers. Only by logging in the website of SaaS service providers, customers can place and order for even use the needed application software service according to their own actual needs. Such as mail server which is a natural SaaS-mode system. Cloud computing is mainly fulfilled by relaying on virtualization technology [7-8].

Cloud server virtualization mainly refers to the optimization of "Computation" while desktop virtualization is the combination of "Computation" optimization and "Communication" optimization, which shows the essence of "Centralization" computing mode to a greater extent. Generally speaking: foreground virtualization and background centralization are to place the foreground terminal operation system and the applied physical computation into background data center so as to achieve the centralization of actual computation and relevant data at the background; the foreground is only used for displaying and user's operation interface, and all data, applications, etc. are presented in virtual forms before end-users. With such foreground and background relationship, communication technology between foreground and background is necessarily needed to offer support so as to form complete technology system. Cloud computing represents a kind of new computing and service providing method, and only a simple terminal device is needed for future users to enable "Cloud" to fulfill any needed service. Cloud computing integrates computing resources and storage resources to provide huge computing and storage capabilities for end users; according to the philosophy of cloud computing, as long as there is network, high-quality services will be available for users. As for how to utilize network band width effectively, compressing communication data is a relatively effective method. Terminal equipment with rapid compression and decompression technologies is in critical shortage in current market, therefore, it is extremely urgent to launch computer terminal equipment with extraordinary performance and green energy-saving features [9-11].

2 Key Technologies

To meet the above customer demands, surveys are made on three global cloud computing service providers; there are two ways to access cloud server: one is to access through practical network application program of browser, such as Google Apps, and the other is to access through remote desktop protocol, thereby customers can use the cloud server just as local computer. With user demand and actual situation of cloud computing server, the system shall be up to the three points: to realize green energy saving and cheap price, it is a must to abandon traditional PC mode and adopt the current system-on-chip with low power consumption. PC mode needs to be installed with operation system and other software; software licensing fee is required; PC is relatively not green and will consume a large amount of electricity, which go against low-carbon requirement; besides, the utilization rate of PC is less than 20% and they are left to be used at most of time according to the statistics of the concerned authority. While SOC adopts embedded Linux operation system which saves the software licensing fee and consumes low power; generally, the power consumption of the entire machine is less

than 20W, which saves a large amount of electricity and protects the environment. Second, according to the analysis and test on current remote desktop protocol, accessing cloud server with the improved remote desktop access technology can hardly meet the current user demands; while the remote desktop protocol with image compression technology can reduce the network data transmission amount, improve transmission efficiency, and avoid time delay, as if the computing was made locally. At the same time, with Web2.0 technology browser, users can use and give full play to the performance of cloud server; in addition, it keeps traditional entertainment functions, such as movie playing, etc. With the above discussion combined, the integrated design of hardware and software is performed [12].

A. Hardware Design

In this solution, S5PV210 chip of ARM CortexTM-A8 core is used as main control chip and also ARM V7 instruction set is adopted, frequency is 1GHZ, 64/32-bit internal bus structure, 32/32KB data/instruction first-level cache, 512KB second-level cache, and 2000DMIPS (operating 0.2 billion instruction sets per second) high-performance computing capability. With low power consumption, it supports Linux and android operation systems, and it has built-in MFC (Multi Format Codec) , supports the encoding and decoding of videos with MPEG-1/2/4, H.263, H.264 and other formats, and supports simulated/digital TV output. With JPEG hardware encoding and decoding, the supported resolution ratio can be up to 8000x8000; it is inbuilt with high-performance PowerVR SGX540 3Dgraphics engine and 2D graphics engine, supports 2D/3D graphics acceleration, and is the fifth generation of PowerVR product. Its polygon formation rate is 28 million polygons/s, pixel fill rate can be up to 0.25 billion/s, and it supports PC level display technologies such as DX9, SM3.0, OpenGL2.0, etc.. It is the equipment with IVA3 hardware accelerator, with excellent graphics decoding performance, supports full-definition and multi-standard video encoding, can play , record smoothly video documents of 1920×1080 pixel (1080p) at 30 frame/s, and encode high-quality graphics and videos more rapidly. At the same time, it is inbuilt with HDMIv1.3 so that high-definition videos can be transmitted to external display. It has great multi-media performance capability, supports hard decoding of many graphic formats such as JPEG; video encoding supports MPEG1, MPEG2, MPEG4, H.264, VC-1 and RV, and audio encoding supports MP3, WMA, EAAC+ and AC3; with the cooperative work of software and hardware, FULL HD (1080P) high-definition video movies are clearly and vividly brought to people's daily entertainment through the HDMI output of digital TV to meet the entertainment function of users, apart from which, S5PV210 also provides 3D accelerator which can enrich the design of the next generation of GUI or other graphic application. Hardware system provides various video input, HDMI and LVDS interfaces, and even the function enabling users to get "cloud computing" service by directly connecting traditional TVs. To meet the storage need of users, the system provides USB2.0/SD/CF interface, to which, users can connect various portable storage devices; it also supports SATA hard disk interface and has infinite storage expansion capability. Overall hardware design frame is shown in Figure 1:

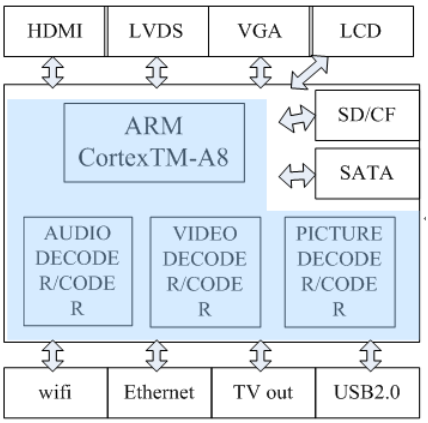

Fig. 1. Hardware System Frame

B. Software Design

Traditional remote desktop transmission protocols are diversified, such as VNC and RDP. In VNC system, it is divided into Client and Server. The design of VNC Viewer is very simple, i.e. it is purely responsible for receiving the keyboard or mouse signal input by users, then pack it into TCP packet, and transmit to far-end server through network; the communication protocol used between VNC Server and Client is named as Remote Frame Buffer Protocol (RFB Protocol) which regards Server as a virtual display card at far end; the produced screen images (FrameBuffer) can not only be displayed on native computer but also can be transmitted to far-end Client. This transmission protocol is pretty perfect in theory, however, in actual use, the transmission speed is relatively low and it falls behind RDP to some extent.

RDP transmission protocol is relatively sophisticated among remote desktop transmission protocols and its performance is more excellent. The purpose of RDP is to transmit the display and other data information on the Windows terminal server to clients smoothly. The client here can be PC or Non-PC equipment with different systems and in different structures, such as computers operating various different OS platforms such as UNIX and Linux and so on. Through RDP protocol, the computer at client can interact with the operating service program in remote server to acquire corresponding service.

Except connection and synchronization functions of RDP, the most important is the updating of the displayed images. Compared with other systems in which screen images are all transmitted in graphics, RDP uses rectangle, polygon and texts to strengthen display effect, therefore, it is also faster than other transmission protocols. With Cache technology, most of the used texts and graphics of RDP will remain in the Cache of the internal memory for within a period of time for future re-use, in this way, there is no need for Server to transmit the same materials to client the next time and will reduce transmission amount. The following technologies are also used in RDP to improve transmission performance.

Memory blt is to display the cache graphics stored in internal memory onto the designated position of the screen. The same graphic can be displayed at different positions but

only one-time transmission is needed so as to reduce the amount of data. In general Windows, the most commonly-seen one is all-white window background, and it is to display white 64*64 graphics after respective Memory blt at different positions of the image.

Pattern blt instruction is to transmit 1 bit pattern and display it at the designated position on the screen after specifying its foreground and background colors. The most commonly-seen pattern is the window frame displayed when we drag the window, and it is formed by single pattern through Pattern blt at different positions.

The method of Screen blt is common when window content is dragged. As images are completely the same and only their positions on the screen are changed, it is only needed for the Sever to change the position of content through this instruction.

The maximum function of Rectangle/Line/Polygon to reduce data amount in RDP is to display basic shapes, such as rectangles, line blocks, polygons, etc. which can form various different window elements even though they seem simple. Rectangles are often used to compose window itself, and line blocks are mainly used to add bottom lines for word serials, while polygons can be found in Cache patterns added into Powerpoint.

Text: texts are ubiquitous in windows, covering function table, title list, webpage content, Command Line, etc.; in other previous systems, all texts are transformed into graphics for representation; as most texts are tall and thin and classified as high-frequency area in graphics, therefore, if distortion compression is used together, the texts will become illegible. So RDP Server allows texts with pure background to be shown in the form of dot matrix font while texts with complicated environment remain to be shown in the form of graphics. As for the word serial shown in the form of dot matrix graphic words, RDP Server will designate the font, id and index of word serial word Cache, its displaying position on the screen, etc..

The above transmission mechanisms make advantages for RDP among numerous remote desktop transmission protocols but the current demand can not be satisfied, mainly reflected in two aspects: 1. The playing of movies is awfully unsatisfactory, and the refreshing speed is very low when the window is in full screen; 2. Serious motion trailing occurs when browsing more than one pictures. According to the display of network monitoring results, there is huge amount of data transmitted in network under the above two situations. Based on the analysis of the data, there are the following reasons:

When movies are played in RDP, RDP Server has no idea about whether users are playing movies but only those frames are changing, therefore, all of them are transmitted to the connected Client end, which greatly increases the transmission amount for several times.

Movie playing or multi-picture previewing generally includes many graphics of various colors and with complicated structures, therefore, non-distortion compression inbuilt in RDP can not reduce effectively data amount, instead, it can increase it. Sometimes, RDP Server can even determine the uncompressed graphics directly transmitted, as low compression rate of graphics will produce additional burden to network.

To solve the above problems, the solution proposed the improvement method, which makes full use of original advantages of RDP and reduces data transmission amount by improving RDP image compression rate. There are many compression technologies; the hardware system of the solution is installed with JPEG hard decoding chip, therefore, images processed by JPEG compression at RDP Server end can be decoded easily without adding burden to embedded CPU so as to reduce data transmission amount without

adding time delay caused by image decoding. The processing method is: RDP Server end adopts JPEG encoding when transmitting images, and sends the compressed images to Client after encoding; then the Client end adopts JPEG Decoder hard decoding chip to decode and display them on the screen. Therefore, the key of this system is to transform the originally transmitted documents in BMP format at the RDP Sever end into JPEG format through encoding, as shown in Figure 2.

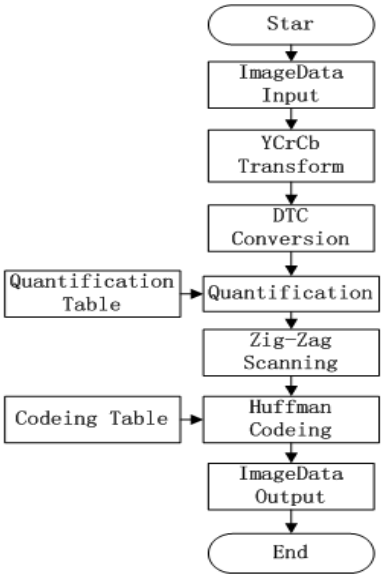

Fig. 2. JPEG Encoding Processing Procedure

3 Key Algorithms

A. Color Space Conversion

It is regulated in JPEG standard that information source image can be colored or black and white; if it is colored image, it is usually composed of luminance component Y and chrominance component Cr and Cb; it is shown in research results that the visual system of human beings has strongest resolution capability in the luminance of light, and the resolution rate of chrominance is approximately 1/4 of that of the luminance; then RDP signals are encoded after transforming luminance and color difference signal relying on the perception of human visual system on colors. The conversion formula is as Formula (1).

$$\begin{aligned} Y &= 0.299R + 0.587G + 0.144B - 128 \\ Cr &= 0.500 - 0.4187G - 0.0813B \\ Cb &= -0.1687R - 0.3133G + 0.500B \end{aligned} \tag{1}$$

B. 2D forward discrete cosine transform

With 2D forward discrete cosine transform, the input images are first decomposed into 8*8 blocks, and then transform each block for 2D DCT; the transformation formula is shown as Formula (2); then the coefficient of DCT transform is encoded and

transmited; perform 2D DCT inverse transformation for each 8*8 image block when decoding, finally, the inverse transform of data blocks are combined into a pair of images. For common images, the values of most DCT coefficients are close to zero. If these DCT coefficient values close to zero are discarded, the image quality will not decline significantly when image is reconstructed. Therefore, compressing and coding images with DCT will save large storage space. The compression should be done with minimum quantity of coefficients under the most reasonable situation similar to the original image. The number of the used coefficients determines the compression rate.

$$\begin{aligned} G(u,v) &= C(u)C(v)\sum_{y=1}^{8}\sum_{x=1}^{8}\{\frac{1}{2}\cos[\frac{\pi}{16}(u-1)(2x-1)]\} \\ &\quad F(x,y)\{\frac{1}{2}\cos[\frac{\pi}{16}(2y-1)(v-1)]\} \\ F(x,y) &= \sum_{u=1}^{8}\sum_{v=1}^{8}C(u)C(v)\{\frac{1}{2}\cos[\frac{\pi}{16}(u-1)(2x-1)]\} \\ &\quad G(u,v)\{\frac{1}{2}\cos[\frac{\pi}{16}(2y-1)(v-1)]\} \\ while, C(u), C(v) &= \begin{Bmatrix} \frac{1}{\sqrt{2}} .....if(u,v=0) \\ 1.....if(u,v\neq 0) \end{Bmatrix} \end{aligned} \tag{2}$$

C. Uniform quantification based on quantification table:
In JPEG standard, linear uniform quantizer is employed. The definition of uniform quantification is that 64 DCT conversion coefficients are divided by corresponding quantification step to take the round number by rounding off, as is shown in Formula (3).

$$Q(u,v) = IntegerRound(Y(u,v)/S(u,v)) \tag{3}$$

S(u, v) in the formula refers to quantification step pitch. Quantification is to quantify DCT coefficients through quantification table, i.e. to perform mod operation for 8*8 blocks of DCT coefficients with 8*8 quantification tables as templates in turn, and the result will be the quantified coefficient.

Good quantification table can improve compression rate and reduce image distortion. Quantizer step is the key of quantification while the best value of quantification step is determined by the characteristics of input image and image display equipment, for which, quantification table provides quantification steps. It makes use of the feature so that it is difficult for human vision to sense high space frequency distortion and the quantification step increases with the improvement of space frequency. As human eyes are sensitive to luminance but not to color difference, different quantification steps are used for luminance and color difference. The quantification step of luminance is divided more specifically while that of chrominance is more generally; the step of the low-frequency part at the upper left corner of quantification table is slightly small while that of the high-frequency part at the lower right corner is much larger. As the energy of most images is gathered at the upper left corner after DCT conversion, their quantification step is also small. High-frequency part will show some 0 after 8*8 DCT coefficients are quantified, which fulfills compression, and distortion also mainly occurs at this moment. As human

eyes are not sensitive to high-frequency component, the distortion at high-frequency can not be easily found by human eyes. JPEG compression of images is mainly finished at the quantification part. For image compression, such spatial filtering with the lower right corner eliminated and the upper left corner remained is equivalent to a low-pass filter of space. The result after quantification is still 64 coefficients of 8*8 Q(u, v); the quantification does not change the nature of coefficients, and similarly, Q(0,0) is DC coefficient and other 63 coefficients Q(u, v) are AC coefficients.

D. Huffman Coding [13,14]

The code length of Huffman coding is changing. For information with high-frequency occurrence, the length of coding is short; while for information with low-frequency occurrence, the coding length is long. Thus, the overall code length to process all information is surely less than the symbol length of actual information. Compared with general coding method, Huffman coding seems a little complicated, mainly including Huffman coding part and preorder traversal Huffman tree function. Main procedures of Huffman coding mainly include initialization of original data, making statistics for the probability of message occurrence, sequencing message according to the occurrence probability, and finally combining two messages with the lowest occurrence probability into one, to construct the leaf nodes of Huffman tree; then, repeat the above processes till all coding work is finished, i.e. Huffman tree is completely built. Traversal of Huffman tree function is mainly used to fulfill Huffman compression coding. The processing flow chart is shown in Figure 3.

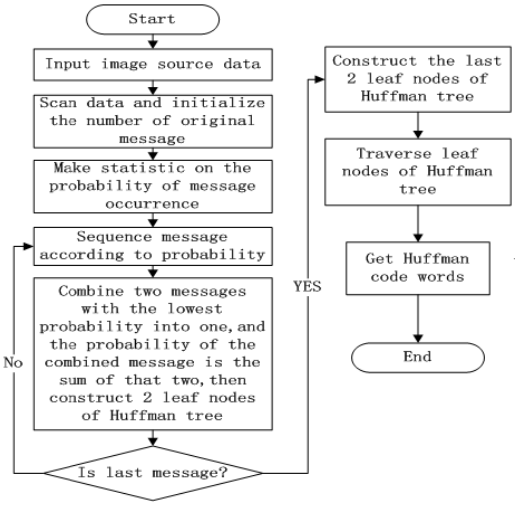

Fig. 3. Huffman Coding Processing Procedure

4 Conclusion

The solution is realized through embedded technology, and it has the following specific advantages: 1. Low power consumption, low heat productivity, simple maintenance, low maintenance cost; 2. Adopt the browser with Webkit core and it is flexible

to use network application programs, such as Google Apps; 3. Support 1080p high-definition playing, and meet the multi--media entertainment function for users; 4. The remote desktop protocol is improved; the network transmitted data amount and time delay is decreased greatly; and end users are more significantly satisfied. But there are also still many aspects needing improvement, such as 3D application, about which, it does not support 3D desktop effect and large network game which are yet to be improved in the future.

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