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The possibilities of using single-board computers for medical data transmission security

Abstract. *An aim of the MeDiMed project is usage of current information and medical technology possibilities for the quality of medical surgery and medical care enhance, and improvement of conditions for research and medical students' tuition. Current communication technologies level allows expert centers establishing, which provide sophisticated services in radiology, nuclear medicine, etc. In the future, connection of other healthcare facilities is expected, especially outside of Brno hospitals, smaller healthcare organizations and individual offices. Smaller institutions usually do not have a suitable network termination element for the IPSEC tunnel and the connection is usually solved by software on all workstations used for communication with MeDiMed. This solution is sometimes difficult to manage and requires local user response. This article shows an option of shifting network connection configuration from the client station to an external device that will be much easier for central management.*

Streszczenie. *W artykule przedstawiono możliwości wykorzystania współczesnej technologii informatycznej w przychodniach medycznych i jako pomoc w nauczaniu studentów. Przedstawiono możliwości przeniesienia połączeń sieciowych ze stacji klienta na urządzenia mobilne. (**Możliwość wykorzystania miniaturowych komputerów lokalnych do przesyłu danych medycznych**)*

Keywords: MeDiMed, PACS, single-board PC, embedded linux.
Słowa kluczowe: PACS, przesył danych, służba medyczna

Introduction

Increasing need of transferring medical images through internet comes with a various securing techniques. One type of these securing is medical images watermarking. It provides study authenticity and copyright protection [1]. Second technique consists of whole communication channel securing, that provide both authenticity and confidentiality. This is a reason, we use VPN connection. At the present time, the secure network for virtual team consists of a set of IPSEC tunnels completed in two geographically distant locations of the Masaryk University. Pair of firewalls Cisco ASA5520 is configured as a redundant IPSEC concentrator [2]. The device which is focused in this article should be composed of affordable components and provide all services necessary for safe and reliable access to MeDiMed project services [3,4,5]. Moving services like address translation, traffic filtering and building cryptographically secure tunnel in IPSEC, from the client station to a dedicated device greatly facilitate configuration and management of entire solution. Weight and dimensions of used external device has to be such small, that this solution will be the least restricted and harassed, as possible. Also connection of this equipment to the client computer must be as simple as possible.

Recently, on the market appeared a number of miniature computers usually called single-board computer or computer on module. The performance of these computers already enables a traditional operating system operation, particularly embedded Linux [6]. This option gives us the opportunity to use a wide range of software available on these miniature computers. Because this system is very limited by resources - processor power, memory and disk space - is the porting of software packages for this type of machine rather laborious. The effort devoted to this work brings interesting results. We conducted a detailed survey of supply of these elements and we have identified several suitable models.

Miniature computers

We evaluated the following interesting miniature computers, which will be presented in next chapters.

Gumstix Verdex Pro XL6P

Gumstix Verdex Computers are on the market for some time. Model Verdex For XL6P is currently the most powerful of them. Technical parameters of this model are summarized in Table 1. For the model Verdex exists expansion modules, especially module with Ethernet 10/100 Mb/s. The board Verdex XL6P and Ethernet module Netpro-H can be seen in Figure 1.

Table 1. Computer Gumstix Verdex Pro 6LP specifications.

Processor	MarvellTM PXA270 with XScaleTM 600MHz
Memory RAM	128MB
Memory FLASH	32MB
Interfaces	60-pin Hirose, 80-pin Hirose, 24-pin flex ribbon
Size	80mm x 20mm
Price	169.00 USD

Fig. 1. Mainboard Gumstix Verdex Pro 6LP and Ethernet interface board Hetéro-vx.

Gumstix Overo Earth

Overo model series is the successor of Verdex series. It is smaller in size, has a powerful processor, but unfortunately there isn't a sufficiently large range of expansion modules. At the beginning of the project, this model seemed very perspective, development of additional modules, however, did not continue according to our expectations. Technical parameters of this model are summarized in Table 2 and the module is in the Figure 2.

Table 2. Computer Gumstix Overo Earth specifications.

Processor	OMAP 3503 with ARM Cortex-A8 CPU600MHz
Memory RAM	256MB
Memory FLASH	256MB
Interfaces	70-pin AVX 5602 series, 27-pin flex ribbon
Size	58mm x 17mm x 4,2mm
Price	149.00 USD

Fig. 2. Mainboard Gumstix Overo Earth.

Calao Systems USB-A9G20-C01

This model is probably most closely resembles to our original idea at size and shape. The single board computer integrates, Ethernet interface and power from the USB port, which was necessary to develop for computer Verdex. The main disadvantage of this computer is a relatively high weight (30g), which is concentrated in the opposite side of the board than the USB connector, which this computer connects to the host PC. This causes considerable mechanical stress, and breaking. Technical parameters of this model are summarized in the Table 3 and the module is in the Figure 3.

Table 3. Calao Systems USB-A9G20-C01 computer specifications.

Processor	ATMEL AT91SAM9G20 400MHz
Memory RAM	64MB
Memory FLASH	256MB
Interfaces	50-pin
Size	85mm x 36mm
Price	149.00 EUR

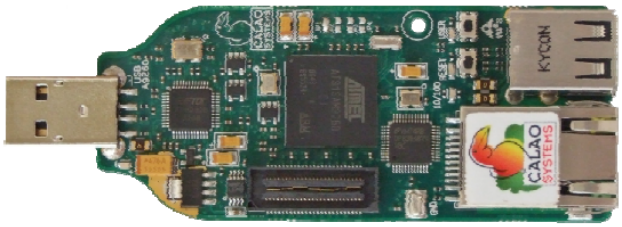

Fig. 3. One-board computer CALAO USB-A9G20-C01.

PlugPC LXP2310

This computer is intended as thin client. It is equipped with an Ethernet interface, four USB ports, among other things intended for connecting a keyboard and mouse and video card with DVI-D and a resolution of 1600x1200 pixels. This computer is designed for access to remote server that runs applications. Here is calculated with the operation of rdesktop, Citrix, and so on. Technical parameters are in Table 4 and the computer is in the Figure 4. Although it is an interesting idea, the computer is not powerful enough even in environments where the computer and the server have full 100Mb/s network capacity is the movement of pictures, such as moving windows on the desktop, noticeably slow. This computer has the widest range of Linux applications. But, to control the sensors installed on a person has too much weight.

Table 4. PlugPC LXP2310 computer specifications.

Processor	32-bit ARM 7 Netsilicon NS 55MHz
Memory RAM	8MB
Memory FLASH	4MB
Interfaces	5-pin TTL
Size	38mm x 19mm x 19mm
Price	109.00 EUR

Fig. 4. Computer PlugPC LXP2310.

DIL/NetPC DNP/9200

The computer is primarily intended for development and laboratory environments. Its great advantage is pulling all the external interface onto socket DIL-64. This greatly facilitates the development of prototypes of other devices, because it is possible to use the Universal PCB. In the course of development, we can easily change the connection without requiring any need to develop a new PCB. This model provides all the basic types of interface and is very suitable for sensor management. Technical parameters are given in Table 5 and the computer is in the Figure 5.

Table 5. DNP/9200 computer specifications.

Processor	Atmel AT91RM9200 32-bit ARM9 180 MHz
Memory RAM	32MB
Memory FLASH	16MB
Interfaces	DIL-64
Size	82mm x 28mm
Price	169.00 EUR

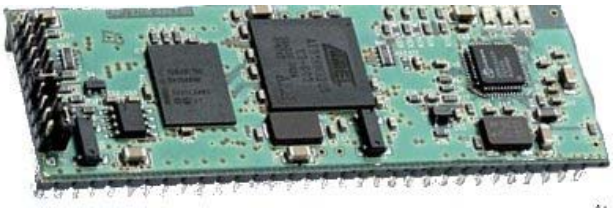

Fig. 5. Computer DNP/9200.

Yoggie Firestick Pico

Firewall Pico Firestick (designed USB stick) is commercially offered by the company Yoggie, as a finished product. It uses a hardware solution that is attractive for sensor management, too. This solution is not open, is conceived as a Firewall, antivirus and anti-spam protection for PC and requires installation of special drivers into the operating system of host computer. Most models are not equipped with external interfaces and connections to the Internet network. They use physical interface of the host computer. Manufacturer unfortunately interrupted its activities during the project. By testing of this microcomputers we find out the fact that we need to understand better to microcomputer design and need certain versatility of our solution. Technical parameters of this model are summarized in Table 6 and module is shown in Figure 6.

Table 6. Computer Firestick Pico specifications.

Processor	Intel XScale PXA270 321MHz
Memory RAM	32MB
Memory FLASH	4MB
Interfaces	USB
Size	12mm x 16mm x 23mm
Price	77.00 EUR

Fig. 6 Computer Firestick Pico.

PicoTux

This is the smallest model with the Linux operating system, which we found. It does not provide sufficient power for our application and it is designed for installation to the PCB, which could be developed. In a survey of interesting mini-computer will are just for completeness. The computer is in Figure 7 and its technical parameters are summarized in Table 7.

Table 7. PicoTux computer specifications.

Processor	32-bit ARM 7 55MHz Netsilicon NS7520
Memory RAM	8MB
Memory FLASH	4MB
Interfaces	5-pin TTL
Size	38mm x 19mm x 19mm
Price	109.00 EUR

Fig. 7. Computer PicoTux.

Table 8. BeagleBoard computer specifications.

Processor	OMAP3530DCBB72 720MHz
Memory RAM	256 MB
Memory FLASH	256 MB
Interfaces	28-pin
Size	78 mm x 76 mm x 16 mm
Price	113 EUR

BeagleBoard

BeagleBoard is, with its OMAP3530DCBB72 720MHz processor, the most powerful board in our considerations. As not so common in this segmet we can mention DVI-D and S-video connectors on one board for video output or 6 in 1 SD/MMC/SDIO connector. BeagleBoard has also the biggest dimensions and the most varied input and output connectors. It has huge possibilities of implementation and relatively new linux kernel can be used as operation system. These specifications encourage to usage as a basic computer. The board uses 2 W of power and can be powered from the USB connector or power adapter. This and dimensions are main disadvantage for our purpose. The computer is in Figure 8 and its technical parameters are summarized in Table 8.

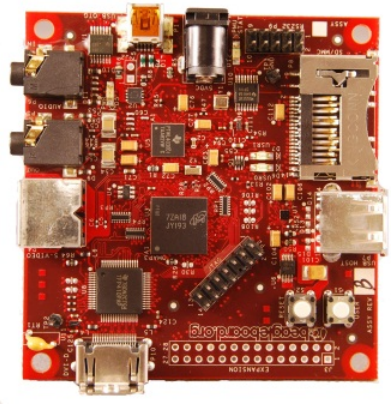

Fig.8. Computer BeagleBoard

TinCan Tools

TinCan Tools uses as CPU module based upon Samsung's S3C2410A ARM920T processor called Hammer CPU module. It has the power of an ARM9 processor in an easy to use modular package. The Hammer CPU module fits into a standard 40 pin DIP socket. This is big advantage for developers. But there are not suitable expansion modules for our purpose at present. For example Hammer Carrier prototyping board is with its dimension 121x103mm. The processor is in Figure 9 and its technical parameters are summarized in Table 9.

Table 9. Hammer CPU module specifications

Processor	S3C2410A – Samsung 200 MHz
Memory RAM	32 MB
Memory FLASH	16 MB
Interfaces	40-pin DIP
Size	19mm x 57mm x 16mm
Price	118 EUR

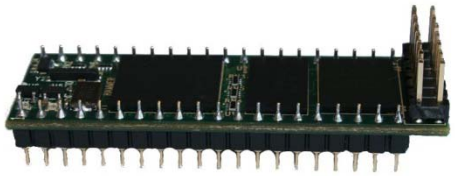

Fig.9. Hammer CPU module

DIL/NetPC DNP/9265

The DIL/NetPC DNP/9265 processor is Atmel AT91SAM9263. It is 32-bit ARM9-based low power embedded controller with TCP/IP stack and SDRAM/Flash memory. The DNP/9265 offers the footprint of a standard 40-pin DIL socket with 2.54 mm centers. It was developed specifically for embedded HTTP(S) client and server gateway applications with connection up to 100 Mbps. The computer is in Figure 10 and its technical parameters are summarized in Table 10.

Table 10 . DIL/NetPC DNP/9265 computer specifications.

Processor	Atmel AT91SAM9263 32-bit ARM9 192 MHz
Memory RAM	32 MB
Memory FLASH	32 MB
Interfaces	40-pin JEDEC DIL-40
Size	55 x 23 mm
Price	59 EUR

Fig.10. DIL/NetPC DNP/9265

Solution method

As an external device that will provide client access to service stations MeDiMed project, we used a small single board computer equipped with embedded Linux operating system. After a thorough survey of available computers, we chose the most suitable type the Gumstix Verdex XL6P. This model has dimensions 80x20x6.3mm. The computer must connect the network interface board with dimensions of 93x20mm. This board can optionally connect interface board WiFi 802.11b/g. We physically involved a WIFI interface, but the software is not yet revived. Since the beginning of the project, we also consider the use of newer and smaller PC series Overo. These computers have dimensions only 58x17mm. Until completion of this article, there was not for this model range available with network interface board suitable dimensions unfortunately. Using of this computer so remains a topic for another article, including possible development board with Ethernet interface. Gumstix Computers Verdex offers among others the type of interface USB OTG [7]. This interface is using for connecting user to the system. USB OTG is only available on the connector for expansion modules type 60pin Hirose [8].

The computer may have brought the same power connector. External power supply is ready to board interface such as Ethernet. For our purposes, however, external power input is not suitable. We solved the computer's power via USB [9] connection to the user station. For these reasons it was necessary to develop and produce hardware module, which removes the USB OTG standard connector and bring power from an external USB port on the PC bus power. This provides basic circuits protection. Power Development and production of this module has been dealt with suppliers. Given that we ultimately used only one type of computer instead of the originally planned two (Verdex and Overo, which unfortunately has no usable network interface card), so we could use more funds for the development of the computer chassis. The device also gained against the plan and an external antenna to connect to a Wi-Fi network. Dump the black part of the antenna in Figure 8 and the real housing is shown on the Figure 9.

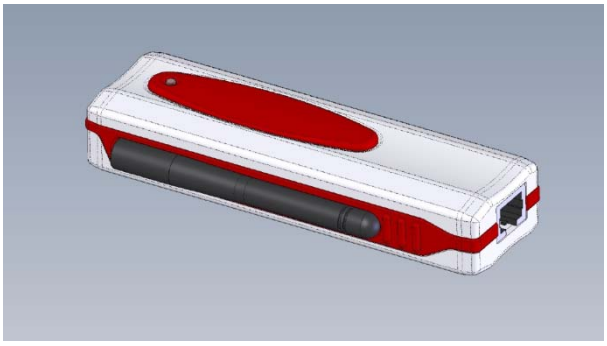

Fig. 8.Housing Gumstix computer Verdex developed custom solutions for the needs of the project – design

Fig. 9.Housing Gumstix computer Verdex developed custom solutions for the needs of the project – reality

Our prototype device is ultimately about 12 mm longer than the board Ethernet interface. The reason for this extension is both necessary tools to attach the computer chassis and the need to gain space for anchoring the WiFi antenna, see Figure 10.

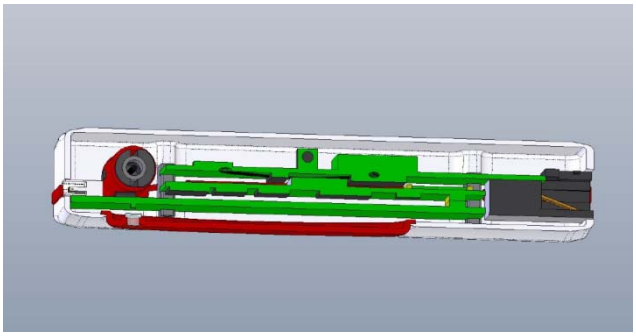

Fig. 10. A proposal of the computer components storage in the chassis.

The real picture of the open computer components in the case is shown on the Figure 11.

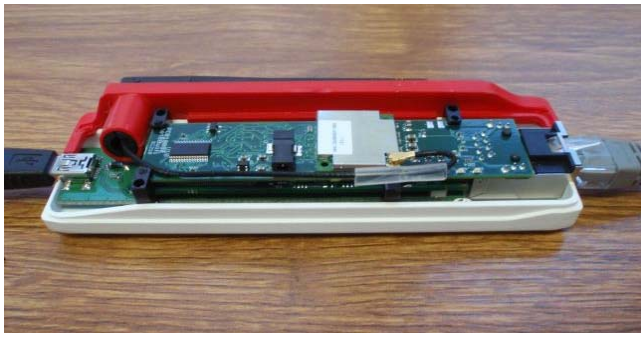

Fig. 11. A real storage of the computer components in the chassis.

The original intention was connection to the USB port on the user station type A-male connector on the PCB. This would allow develop to connect devices to the computer without using a USB cable. Due to the mechanical stress of these connectors we had to abandon this plan. Our device uses miniB female connector and computer cable is connected.

The developed device serves as a safe repository of private PKI keys that could possibly be used for authentication or encryption operation [10,11]. Extending our solution in this direction is possible in the future. Besides this open solution for comparison, we purchased commercially offered by the company firewall and Yoggie Pico's firewall model (designed USB stick). The advantage of this solution is very small dimension. Firewall Pico served as one of the inspirations for this project. This solution is not open, is designed as a Firewall, antivirus and anti-spam protection for your PC and requires installation of special drivers into the operating system of your computer. Most

models not equipped with an external interface and connect to the "outside", i.e., an internet network physical interface uses the host computer. In the project we have planned to purchase and testing firm Yoggie other models, especially GatekeeperPro model, which is equipped with an external Ethernet interface. Manufacturer unfortunately interrupted his work before we were able to realize this purchase.

Conclusion

The main objective of the project, a prototype development of affordable small-sized device that will plague for secure user access to medical data archives MeDiMed project have been met. Prototype developed within the project consists of affordable components and provides all services necessary for safe and reliable access to services project MeDiMed.

The project verified the possibility of single-use computers for cryptographic security of data transmission. He created a prototype device dimensions acceptable to potential users of this service can easily carry in your pocket. The primary application area of this project results is to provide mobile medical communications for MeDiMed project users. The results of this project can facilitate the involvement of other doctors in the group MeDiMed projects. The device developed and described in this article is easily transferable and will made unsecured computers available to access the medical image data. It can significantly enhance the mobility of medical professionals who use the system MeDiMed. The results of this project are allowed to further development, both in the improvement of existing solutions and expanding its functional properties in the area of application.

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