An approach to Creation of Terminal Clients in CNC System

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To facilitate the maintenance of large machines with working area of several meters, one equips them with additional terminals, as well as a supplementary remote handler. A practical approach to develop operator terminals, specialized panels and remote handlers, implemented as CNC kernel clients, is suggested. The control transfer mechanism is implemented. Examples of creating a multi-terminal solution for turning-milling machine and a web client for performing remote monitoring and controlling of a CNC machine are provided.

Keywords — CNC system; web – terminal, terminal clients; turning-milling machine;

I. INTRODUCTION

The use of CNC systems in modern technological systems has long gone beyond stereotypes, according to which there is a machine tool with a CNC system, an operator terminal and a manual control panel (which is optional) [1].

Complex machine tools, like machines with a working zone of several meters, require additional operator terminals [2,3]. Depending on the method of implementation, additional operator terminals can be:

- Full-featured, which are completely identical to the main terminals;
- Simplified, in which only key information is displayed, such as the status of the control system and the PLC (Programmable Logic Controller), the current values of the axes, process state parameters, etc.;
- Combined, which use a mixed solution, for example, several full-featured and several simplified terminals.

Regardless of the scheme used, at any time only one of the terminals can be active, i.e. only one of them can transfer control commands to the kernel of CNC system, the remaining terminals are passive and only display information about the state of the control system and the machining process.

Unique and technically sophisticated machine tools require specialized panels and additional manual handlers for maintaining the main and auxiliary mechanisms [4]. The development of such panels and manual handlers, as well as the appropriate interfaces and connection schemes, is a laborious process.

In recent years, simplified web terminals have been increasingly used for diagnostics of machine tools and their units and for remote monitoring of the technological process [5]. This involves integration into the control system a web-browser and a script generator for creating pages.

In spite of the variety of described problems, all of them can be solved on the basis of a common mechanism. The paper proposes an approach to create operator terminals for specialized panels and remote manual handlers, implemented as CNC system kernel terminal clients.

II. STRUCTURE OF THE CONTROL SYSTEM WITH TERMINAL CLIENTS

Formally, in the CNC system, depending on the purpose, the following control tasks are distinguished: geometric, logical, technological, diagnostic and terminal. Recently, with the expansion of the functions of the control system, additional tasks have been identified, such as the communication task [6].

The geometric control task is responsible for the process of shaping the workpiece, the logical control task is connected with the control of the cycle logic of the machine tool. The technological task is present if special control of the technological process is required [7], for example, control of laser beam power [8,9] during laser cutting. The diagnostic control task is connected, first of all, with diagnostic functions of geometrical and logical control tasks [10]. The communication control task implements general network communications, including communications with MES and ERP systems. The terminal control task is responsible for interaction with the operator, in the framework of this task the terminal clients are implemented.

A. Client-Server Architecture

In the kernel of the CNC system, the dedicated interfaces implement the abstraction at the level of the drives and cycle logic (Fig. 1). The proposed solution allows one, according to customer demands, to build the CNC systems with servo drives and PLC I/O operating on high-speed field buses (SERCOS, EtherCAT, etc.) [11,12]. The interpolation algorithms do not need to be changed.

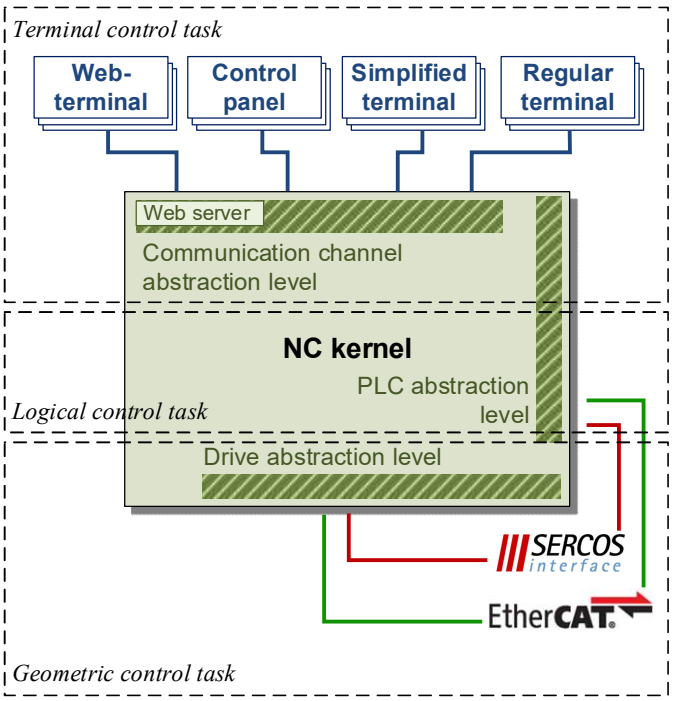

Fig. 1. The structure of the control system with terminal clients organized on the "client-server" principle

The interfaces implementing the abstraction at the level of the communication channel [13], on the one hand, separate the data stored in the CNC system kernel from their visualization on the terminals. On the other hand, they separate the commands coming from the specialized panels and remote handler from their execution in the CNC system kernel. Web-terminals are connected through web-servers, implemented at this level of abstraction.

B. *Control transfer mechanism*

The mechanism of control transfer is based on the notion of "active client" and "exclusive ownership of the right to control". When the control system is started, there is in the kernel an active client by default. The address of the active client is defined in the machine parameters of the control system.

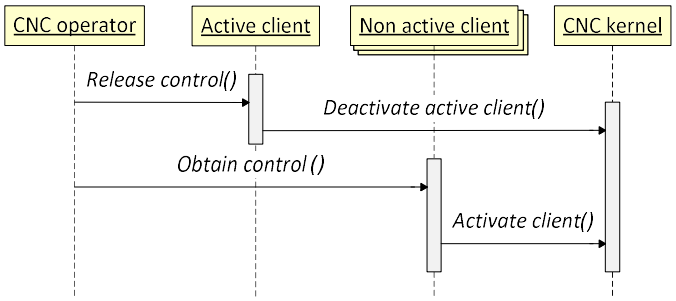

Fig. 2. Sequence diagram of mechanism for changing the active terminal client

If there is a need to transfer control (Fig. 2), the active client refuses to hold the right to control (Deactivate_control ()). After that, any of the terminal clients connected to the kernel is able to take over the control right (Obtain_control ()) and become an active client.

III. EXAMPLES OF PRACTICAL IMPLEMENTATION

Consider two examples that illustrate the implementation of a mechanism for the transfer of control on turning-milling machine that is designed to process large workpieces and the web terminal for remote monitoring and controlling the kernel of CNC system.

A. *Multi-terminal solution for turning-milling machine*

The machine tool is designed to handle large parts weighing up to 125 tons, has a round table with a diameter of 5 m and a milling table with a length of 9 m. The height of the workpiece can be up to 5 m. The machine tool is equipped with 14 servo drives controlled by the SERCOS interface, 8 of which are organized into 3 gantry groups (Fig. 3) [14]. The machine tool implements turning and milling processing and is equipped with technology 5-axis machining [15].

To control such a complex machine tool with a large area of working space, it is impossible to use the CNC system of standard equipment. To solve this problem, two regular terminals and a specialized remote control panel were used (Fig. 4).

The kernel of the CNC system is implemented on the x86 platform and operates under Linux RT OS. Terminal clients are connected to it through industrial hab.

Terminal_1 and Terminal_2 are implemented as full-featured regular terminals, and each of them includes: an operator panel operating under Windows OS with the .NET platform, a machine panel based on the ARM platform and the Linux OS and an industrial PC keyboard.

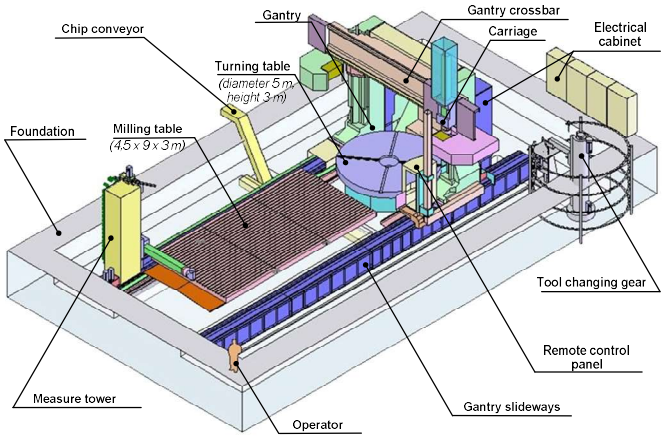

Fig. 3. The sketch of the machine tool and operator are shown in the scale model

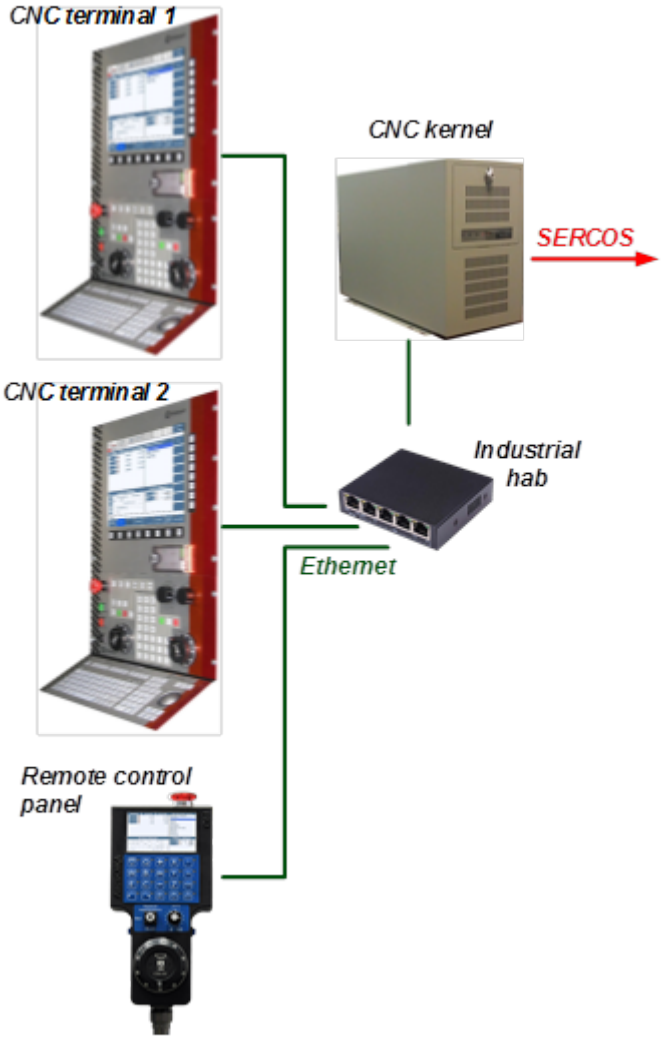

Fig. 4. The organization of terminal clients on turning and milling machine tool

A specialized remote control panel is implemented on the ARM platform with Linux OS. There is a small screen, which displays the current coordinates of the axes, the current mode and the status of the CNC system. More than 20 physical buttons on the remote control panel are used to control the machine in Jog mode, either bound to the cycle logic functions machine tool via the PLC program.

Terminal_1 is located in the service area of turning. Through the configuration of the machine parameters, it is assigned as the "active client" in the kernel of CNC system. While it is active, only it can submit commands to the kernel of the control system for changing modes, starting the part program, stopping it, changing the feed and spindle speed, moving with handwheels, etc. All other terminal clients are passive. All commands coming from inactive terminal clients are ignored by the CNC kernel.

Terminal_2 is located in the service area of milling. To transfer control to it, the operator has first to deactivate Terminal_1, by means of the activation button on the machine panel, then to activate Terminal_2 by means of the similar buttons on its machine panel.

Similarly, the control is transferred to the remote control panel. The difference from regular terminals is that side lock buttons are available. The remote control panel operates as long as the operator's hand holds these buttons. If the remote control panel is dropped, it is blocked. The activation button is located on the remote control very panel.

B. An example of building terminal clients based on a web browser

The advantage of using web browsers is that they can be used available everywhere, including mobile devices. Solutions based on a web browser do not require special hardware solutions, such as the presence of physical buttons of machine- and function-keys located around the screen of the regular operator terminal. It should be borne in mind that applications based on a web browser have limited functionality. They cannot substitute the regular operator terminals, web browser terminals are focused on narrowly specialized tasks and have limited functionality.

Terminal web clients are used as auxiliary operator terminals, process monitoring terminals [16] or as a part of the control system configuration and diagnostics tools.

As an example of a terminal web client, let us consider an application for monitoring and controlling the machining, which is as close as possible to the standard operator HMI (Human Machine Interface) (Fig. 5). The application is developed in HTML 5 with the use of the JavaScript and it is destined to work with the touch-screen. Most often it is used on a tablet with a web browser. The F-keys (function keys) to navigate between the HMI screens and the M-keys (machine keys) to control the auxiliary equipment via the PLC are implemented. The status bar displays information about the active control channel, the current operating mode, the state of the NC system, the executing time of the part program.

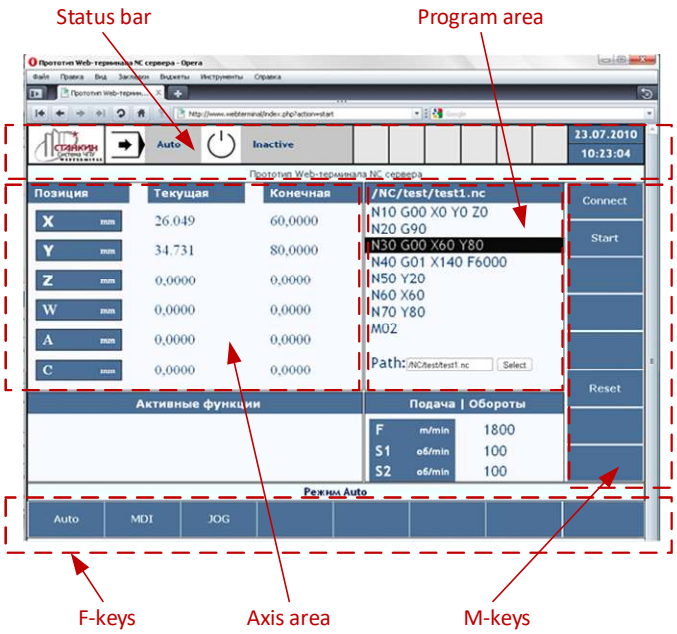

Fig. 5. Web application for monitoring and controlling of the machining

The status bar also displays information messages, warnings and errors when they arise. The configuration file determines the PLC information displayed on the right of the status bar, for example, the supply of spindle lubrication is on or off, the motion along the axes is permitted or blocked, etc.

In the area of the part program, the name and contents of the executable file are displayed, the current NC block is highlighted. The user can select and activate the file of the part program.

In the axis information area, the axis names, the units, the current axes position, the programed end position in the NC block and the rest of the path are displayed.

The web terminal also displays information about the current feed and spindle speed, active G and M functions, and the number of the selected cutting tool.

IV. CONCLUSION

The proposed approach to create of terminal clients in the CNC system allows one to solve the task of multi-terminal control of the CNC machine. The problem is extremely relevant for complex machine tools with a large working area, equipped with several operator terminals, specialized panels and remote controls panels [17,18].

The implemented algorithm for transferring control between terminal clients, based on the notions of "active client" and " exclusive ownership of the right to control ", provides a simple and reliable mechanism for switching the active terminal.

Terminal applications based on a web browser have limited functionality and are focused on narrowly specialized tasks [19,20]. They cannot completely replace the regular HMI terminals of the operator. Terminal web clients are used as auxiliary operator terminals, process monitoring terminals or as a part of the configuration and diagnostics tools of control system.

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REFERENCES

[1] Martinov G.M., Martinova L.I. Trends in the numerical control of machine-tool systems. Russian Engineering Research. 2010. T.30. №10. P. 1041-1045.

[2] Sergej N. Grigoriev, Georgi M. Martinov Research and Development of a Cross-platform CNC Kernel for Multi-axis Machine Tool. Procedia CIRP Volume 14, 2014, p. 517-522.

[3] G. M. Martinov, N. V. Kozak Numerical control of large precision machining centers by the AxiOMA contol system. Russian Engineering Research. July 2015, Volume 35, Issue 7, pp 534-538.

[4] Sergej N. Grigoriev, Georgi M. Martinov Scalable open cross-platform kernel of PCNC system for multi-axis machine tool. Procedia CIRP 1 (2012) p.p. 238 – 243.

[5] Martinov G.M., Ljubimov A.B., Martinova L.I., Grigoriev A.S. Remote machine tool control and diagnostic based on web technologies. Proc. of COMA 13, International Conference on Competitive Manufacturing, Stellenbosch (South Africa), 2013: ISBN: 978-0-7972-1405-7, pp. 351-356.

[6] Georgi M. Martinov, Aleksandr I. Obuhov, Lilija I. Martinova, Anton S. Grigoriev An Approach to Building Specialized CNC Systems for Non-traditional Processes. Procedia CIRP Volume 14, 2014, p. 511-516.

[7] Martinov G.M., Grigor'ev A.S. Diagnostics of cutting tools and prediction of their life in numerically controlled systems. Russian Engineering Research. 2013. T. 33. № 7. C. 433-437.

[8] Georgi M. Martinov Aleksandr B. Ljubimov, Anton S. Grigoriev, Lilija I. Martinova Multifunction numerical control solution for hybrid mechanic and laser machine tool. Procedia CIRP 1 (2012) p.p. 277 – 281.

[9] Georgi M. Martinov, Aleksandr I. Obuhov, Lilija I. Martinova, Anton S. Grigoriev An Approach to Building a Specialized CNC System for Laser Engraving Machining // Procedia CIRP, Volume 41, 2016, Pages 998-1003.

[10] Georgi M. Martinov, Anton S. Grigoryev, and Petr A. Nikishechkin Real-Time Diagnosis and Forecasting Algorithms of the Tool Wear in the CNC Systems. Advances in Swarm and Computational Intelligence. Volume 9142, 2015, pp 115-126.

[11] Grigoriev S.N., Martinov G.M. Decentralized CNC automation system for large machine tools. Proc. of COMA 13, International Conference on Competitive Manufacturing, Stellenbosch (South Africa), 2013: ISBN: 978-0-7972-1405-7, pp. 295-300.

[12] Martinov G. M., Lyubimov A. B., Bondarenko A. I., Sorokoumov A. E., Kovalev I. A. An Approach to Building a Multiprotocol CNC System. Automation and Remote Control. 2015, Vol. 76, No. 1, pp. 172-178.

[13] Sergej N. Grigoriev, Georgi M. Martinov The Control Platform for Decomposition and Synthesis of Specialized CNC Systems. Procedia CIRP, Volume 41, 2016, Pages 858-863.

[14] V.V.Bushuev, S.V.Evstafieva, V.V.Molodtsov Control loops of a supply servo drive // Russian Engineering Research, 2016, Vol. 36, No. 9, pp. 774–780.

[15] G.M. Martinov, N.V. Kozak, R.A. Nezhmetdinov, A.S. Grigoriev, A.I. Obukhov, L.I. Martinova Method of decomposition and synthesis of the custom CNC systems. Automation and Remote Control. March 2017, Volume 78, Issue 3, pp 525–536.

[16] Lilija I. Martinova, Sergey S. Sokolov, Petr A. Nikishechkin Tools for Monitoring and Parameter Visualization in Computer Control Systems of Industrial Robots // Advances in Swarm and Computational Intelligence. 6th International Conference, ICSI 2015 held in conjunction with the Second BRICS Congress, CCI 2015, Beijing, June 25-28, 2015, Proceedings, Part II, p.200-207.

[17] L. I. Martinova, N. V. Kozak, R. A. Nezhmetdinov, R. L. Pushkov, A. I. Obukhov The Russian multi-functional CNC system AxiOMA control: Practical aspects of application // Automation and Remote Control. 2015, Volume 76, Issue 1, pp 179-186.

[18] R. A. Nezhmetdinov, S. V. Sokolov, A. I. Obukhov, A. S. Grigor'ev Extending the functional capabilities of NC systems for control over mechano-laser processing // Automation and Remote Control, May 2014, Volume 75, Issue 5, pp 945-952.

[19] L.I. Martinova, R.L. Pushkov, N.V. Kozak, E.S. Trofimov Solution to the problems of axle synchronization and exact positioning in a numerical control system. Automation and Remote Control. January 2014, Volume 75, Issue 1, pp 129-138.

[20] Martinova L.I., Grigoryev A.S., Sokolov S.V. Diagnostics and forecasting of cutting tool wear at CNC machines. Automation and Remote Control. 2012. T. 73. № 4. p. 742-749.