CNC ARCHITECTURE

IT IS NECESSARY TO DESIGN THE ARCHITECTURE OF HARDWARE AND SOFTWARE MODULES IN ORDER TO IMPLEMENT A CNC SYSTEM CONSISTING OF A VARIETY OF MODULES SUCH AS NCK, MMI, AND PLC. SYSTEM PROGRAMMING FOR OPERATING THESE MODULES IN REAL TIME IS ALSO REQUIRED. IN THIS CHAPTER, THE MAIN FUNCTIONALITIES AND COMMANDS OF REAL TIME OPERATING SYSTEMS (OS) FOR REAL-TIME PROGRAMMING SYSTEMS WILL BE DESCRIBED. THROUGH INVESTIGATION OF MULTI-PROCESSING HARDWARE ARCHITECTURE, THE USER WILL LEARN THE BASIC APPROACH FOR DESIGNING THE ARCHITECTURE OF A CNC SYSTEM THAT REQUIRES THE GUARANTEE OF REAL-TIME OPERATION. 9.1 INTRODUCTION A CNC SYSTEM CONSISTS OF THE NCK UNIT THAT IS COMPOSED OF THE INTERPRETER MODULE THAT INTERPRETS THE PART PROGRAM, THE INTERPOLATOR MODULE THAT CREATES THE MOVING PATH OF THE TOOL, THE ACCELERATION/DECELERATION MODULE THAT SOOTHES THE AXIS MOVEMENT, AND THE POSITION CONTROL UNIT THAT CONTROLS THE SERVO MOTOR BASED ON THE FEEDBACK SIGNAL AND INTERPOLATION RESULT. IN ADDITION TO THE NCK UNIT, A CNC SYSTEM CONTAINS AN MMI UNIT THAT ENABLES A USER TO OPERATE THE CNC, MONITOR THE OPERATION STATUS AND MESSAGES, AND MAKE A PART PROGRAM. FINALLY THERE IS THE PLC UNIT THAT LOGICALLY CONTROLS THE MACHINE EXCEPT FOR THE SERVO MOTORS. IN THE CNC SYSTEM, VARIOUS TASKS FROM THE NCK, MMI, AND PLC UNITS ARE EXECUTED SIMULTANEOUSLY AND EACH TASK REQUIRES REAL-TIME OPERATION. THEREFORE, IT IS ESSENTIAL TO USE A REAL-TIME OS IN ORDER TO OPERATE VARIOUS REAL-TIME TASKS IN A MULTIPROCESSING ENVIRONMENT. IN ADDITION, THE DESIGN OF THE ARCHITECTURE OF HARDWARE AND SOFTWARE TASKS TO REALIZE CNC SYSTEM IS REQUIRED. IN CONCLUSION, THE FOLLOWING MUST BE CONSIDERED IN ORDER TO DESIGN A CNC SYSTEM: 1. REAL-TIME OPERATING SYSTEM (THE KIND OF SYSTEM CALL AND USABLE HARDWARE) 2. THE ARCHITECTURE OF HARDWARE (THE NUMBER OF CPUS AND THE WAY OF CONNECTING BETWEEN MODULES) 315 316 9 CNC ARCHITECTURE DESIGN 3. THE ARCHITECTURE OF THE SOFTWARE (THE DESIGN OF TASK MODULES AND THE SYSTEM KERNEL) A REAL-TIME OS PROVIDES VARIOUS FUNCTIONS SUCH AS TASK SCHEDULING, INTER-TASK COMMUNICATION RESOURCE SHARING, AND TASK SYNCHRONIZATION IN ORDER TO USE THE HARDWARE RESOURCES EFFECTIVELY. ACCORDINGLY, THE CNC DESIGNER SHOULD CONSIDER SIMULTANEOUSLY THE HARDWARE RESOURCE TO BE MANAGED AND THE FUNCTIONALITY (OR PERFORMANCE INDEX) OF THE OS. RECENTLY, DESKTOP PCS HAVE BEEN USED AS THE BASIC HARDWARE FOR INDUSTRIAL CONTROL SYSTEMS. HOWEVER, A NOVEL IDEA IS REQUIRED TO BUILD A CNC SYSTEM UTILIZING A DESKTOP

PC AND PC OPERATING SYSTEM BECAUSE THE DOS OR WINDOWS USED WIDELY AS THE OS OF A DESKTOP PC CANNOT SUPPORT THE REAL-TIME REQUIREMENTS OF A CNC SYSTEM. ONE IDEA TO MEET THE REAL-TIME CRITERIA OF PC-BASED CNC SYSTEMS IS TO UTILIZE A REAL-TIME OS AND NON-REAL-TIME PC OS SIMULTANEOUSLY. WHEN THE HARDWARE ARCHITECTURE OF A CNC SYSTEM IS DESIGNED, THE NUMBER OF PROCESSORS NEEDED TO SATISFY THE REAL-TIME PROCESSING REQUIREMENTS OF NCK, PLC, AND MMI SHOULD BE CONSIDERED. IF AN ARCHITECTURE BASED ON MULTI-PROCESSORS IS DESIGNED, THE COMMUNICATION METHOD BETWEEN PROCESSORS SHOULD BE CONSIDERED. IN TERMS OF SOFTWARE, IT IS NECESSARY TO DIVIDE ALL THE FUNCTIONS OF THE CNC SYSTEM INTO APPROPRIATE MODULES FROM A FUNCTIONAL POINT OF VIEW. FURTHERMORE, THE DESIGN OF THE SYSTEM KERNEL, WHICH PLAYS THE ROLE OF BOOTING UP THE CNC SYSTEM, TERMINATING THE CNC SYSTEM, COMMUNICATING DATA AND EVENTS TO THE TASKS, AND SWITCHING TASKS IS ALSO REQUIRED. WHILE THE CNC SYSTEM IS BEING IMPLEMENTED, AN ADEQUATE DEVELOPMENT LANGUAGE SHOULD BE SELECTED AND HOW TO DEBUG SHOULD ALSO BE CONSIDERED. BECAUSE TYPICAL DEBUGGING TOOLS FOR TRADITIONAL PROCEDURAL SYSTEMS ARE NOT EFFICIENT AND APPROPRIATE AS DEBUGGING TOOLS FOR REAL-TIME SYSTEMS, A COMPILER IN WHICH AN APPROPRIATE DEBUGGING TOOL IS SUPPORTED SHOULD BE SELECTED. IN ADDITION, IT IS NECESSARY TO CONSIDER HOW TO INCREASE THE RELIABILITY OF THE SYSTEM AND HOW TO PROGRAM FOR THE REAL TIME NATURE OF THE TASK. FOR EXAMPLE, HOW TO HANDLE THE EXCEPTIONS THAT OCCUR DURING SYSTEM EXECUTION SHOULD BE CONSIDERED AND THE USE OF ASSEMBLY CODE FOR THE HARD REAL-TIME TASKS THAT MUST BE CARRIED OUT WITHIN EXTREMELY SHORT TIMES MAY ALSO BE NECESSARY. IN THIS CHAPTER, REAL-TIME OS AND HARDWARE ARCHITECTURE FOR DESIGNING CNC SYSTEMS WILL BE DESCRIBED. THE SYSTEM PROGRAMMING METHOD UNDER REAL-TIME OS, THE BASIC STRUCTURE OF REAL-TIME OS, AND THE CONCEPT OF RESOURCE HANDLING WILL ALSO BE ADDRESSED. MOREOVER, WITH PROGRAMMING EXAMPLES USING THE FUNCTIONALITIES OF REAL-TIME OS, THE READER WILL LEARN THE SYSTEM PROGRAMMING METHOD FOR IMPLEMENTING REAL-TIME CNC SYSTEMS. BY INTRODUCING THE ADVANTAGES AND DISADVANTAGES OF VARIOUS HARDWARE ARCHITECTURES WHICH CAN BE CONSIDERED AS THE BASIS HARDWARE FOR CNC SYSTEM TO THE READER, THE READER WILL GAIN THE KNOWLEDGE TO DESIGN ARCHITECTURE THAT IS APPROPRIATE FOR THE DEVELOPMENT GOAL.

DEFINITION AND STRENGTHS OF THE CNC ARCHITECTURE

ACCORDING TO THE JD EDWARDS DOCUMENT, CONFIGURABLE NETWORK COMPUTING IMPLEMENTATION, THE CNC ARCHITECTURE IS DEFINED AS FOLLOWS:

"CNC IS THE TECHNICAL ARCHITECTURE FOR JD EDWARDS ONEWORLD AND ENTERPRISEONE SOFTWARE. CNC ENABLES HIGHLY CONFIGURABLE, DISTRIBUTED APPLICATIONS TO RUN ON A VARIETY OF PLATFORMS WITHOUT USERS OR ANALYSTS NEEDING TO KNOW WHICH PLATFORMS OR WHICH DATABASES ARE INVOLVED IN ANY GIVEN TASK. CNC INSULATES THE BUSINESS SOLUTION FROM THE UNDERLYING TECHNOLOGY. ENTERPRISES CAN GROW AND ADOPT NEW TECHNOLOGIES WITHOUT REWRITING APPLICATIONS....(IT IS) AN APPLICATION ARCHITECTURE THAT ENABLES INTERACTIVE AND BATCH APPLICATIONS, COMPOSED OF A SINGLE CODE BASE, TO RUN ACROSS A TCP/IP NETWORK OF MULTIPLE SERVER PLATFORMS AND SQL DATABASES.

THE APPLICATIONS CONSIST OF REUSABLE BUSINESS FUNCTIONS AND ASSOCIATED DATA THAT CAN BE CONFIGURED ACROSS THE NETWORK DYNAMICALLY. THE OVERALL OBJECTIVE FOR BUSINESSES TO PROVIDE A FUTURE-PROOF ENVIRONMENT THAT ENABLES THEM TO CHANGE ORGANIZATIONAL STRUCTURES, BUSINESS PROCESSES AND TECHNOLOGIES INDEPENDENTLY OF EACH OTHER."[2]

EXAMPLES

THIS STONE VAULT PROTOTYPE CREATES ALMOST NO MATERIAL WASTE

AA SUMMER DLAB PROGRAM APPLIES COMPUTATIONAL DESIGN TO CONCRETE

SINUOUS SCREEN WALL FROM CONCRETE BLOCKS

WEAKNESSES IN THE CNC ARCHITECTURE

SPECIFICATIONS FILE CORRUPTION WITH JDE APPLICATIONS

UNTIL THE ADVENT OF ENTERPRISEONE APPLICATIONS VERSION 8.12 RUNNING ON TOOLS RELEASE/SERVICE PACK 8.96, BY FAR THE MOST VULNERABLE ASPECT OF THE CNC TECHNOLOGY WAS THAT PROPRIETARY OBJECT SPECIFICATIONS HAD TO BE COPIED FROM FULL CLIENT UP TO THE APPLICATIONS SERVER IN ORDER FOR A JDE USER'S DATA SELECTION AND PROCESSING OPTIONS TO BE RUN AS REQUESTED ON THE SERVER. IF THOSE PROPRIETARY SPECIFICATIONS BECAME CORRUPTED, THE BATCH APPLICATION OBJECT, IN TURN, ON THE APPLICATIONS SERVER COULD BECOME CORRUPTED. A REBUILD AND REDEPLOY OF THE OBJECT WAS THE ONLY FIX. LIKEWISE, IF THERE IS SOME INTERVENING PROCESS THAT CORRUPTS OBJECT SPECIFICATIONS AS THEY COME DOWN TO THE CLIENT PC, THE RELATED OBJECT COULD BECOME CORRUPTED AND NO LONGER FUNCTION CORRECTLY. SINCE APPLICATIONS UPGRADE E812 AND TOOLS RELEASE OR SYSTEMS OR FOUNDATIONAL SERVICE PACK, THE PROPRIETARY SPECIFICATIONS HAVE BEEN REPLACED WITH XML-BASED OBJECT PROPERTIES WHICH HAS PROVEN TO BE MORE STABLE AND LESS PRONE TO CORRUPTION. IN THE FALL OF 2008, ORACLE BROUGHT OUT THE E900 APPLICATIONS RELEASE AND BY THE FALL OF 2010, THE TOOLS RELEASE WAS UP TO 8.98.3.3. E900 UPDATE 1, OR E901 IS THE LATEST RELEASE AS OF FALL 2010.

SPECIFICATIONS PORTABILITY

WHILE COPYING THE OBJECT SPECIFICATIONS BETWEEN THE DIFFERENT ENVIRONMENTS WITHIN THE SAME SYSTEM IS EASY, THE CODE, ONCE DEVELOPED IN ANY GIVEN SYSTEM, IS NOT EASILY PORTABLE TO OTHER SYSTEMS. JD EDWARDS HAS DEVELOPED A BUILT-IN PROCESS NAMED "PRODUCT PACKAGING" TO ADDRESS THIS ISSUE, BUT IT'S SLOW, NOT EASY TO USE AND IS LIMITED IN A NUMBER OF WAYS. BECAUSE OF THIS, IT'S MAINLY USED TO DELIVER SOFTWARE UPDATES BY ORACLE ITSELF, WHILE INDEPENDENT SOFTWARE VENDORS ARE MOSTLY USING THIRD-PARTY TOOLS LIKE BOOMERANG. PRODUCT PACKAGING SUPPORTS THE EXPORT OF SPECIFICATIONS AND E812 AND BEYOND ALLOW FOR VERSIONS TO BE EXPORTED AS ZIP FILES THROUGH THE ACTIONS COLUMN IN OBJECT MANAGEMENT WORKBENCH [3]

SPECIFICATIONS READABILITY

OBJECT SPECIFICATIONS ARE NOT EASILY ACCESSIBLE TO RETRIEVE THE DATA FROM, BECAUSE THEY ARE IN A PROPRIETARY FORMAT. A VARIETY OF INTERESTING INFORMATION IS THEREFORE HIDDEN FROM THE VIEW. SOME OF THIS DATA CAN BE RETRIEVED, INTERPRETED AND DISPLAYED BY THE STANDARD JDE SOFTWARE, BUT IN MANY CASES THIS MAY NOT BE ENOUGH, NOR FAST ENOUGH, NOR IN THE DESIRABLE FORMAT. MANY THIRD-PARTY SOFTWARE SOLUTIONS HAVE BEEN DEVELOPED TO FILL THIS GAP.[4]

COMPLEXITY OF THE ARCHITECTURE

WHILE POWERFUL, THE CNC ARCHITECTURE CAN BE ENORMOUSLY COMPLEX MAKING IT DIFFICULT TO MAINTAIN BY ANYONE EXCEPT QUITE SENIOR CNC ANALYSTS. IT IS NOT UNCOMMON TO SEE 50 SERVERS IN SOME OF THE LARGER IMPLEMENTATIONS AND ALL THESE HAVE TO BE MAINTAINED. WHILE VIRTUALIZATION HAS HELPED IN SOME AREAS, A LOT OF TIME HAS TO BE INVESTED INTO KEEPING ALL THESE SERVERS UP AND OPERATIONAL.

THIRD PARTY APPLICATIONS SCHEDULER ENHANCEMENTS

THERE ARE A NUMBER OF THIRD PARTY APPLICATIONS THAT ADD FUNCTIONALITY AND PROGRAMABILITY TO THE JDE SCHEDULER. THEY INCLUDE CISCO TIDAL ENTERPRISE SCHEDULER WHICH IS A JDE CLIENT-BASED PRODUCT AND APPWORX, A THIRD PARTY SERVER-BASED SCHEDULER IN WHICH SCRIPTING AND WORK-FLOW PRODUCT HAVE BEEN CUSTOMIZED FOR JDE SUPPORT ADDRESSING ADDING TO THE VANILLA SCHEDULER THAT COMES WITH JDE. AUTODEPLOY, A THIRD PARTY BOLT ON, FULLY AUTOMATES THE PACKAGE BUILD AND DEPLOY PROCESS FOR JD EDWARDS ENTERPRISEONE REDUCING THE COMPLEXITY OF PRE PROJECT, IN PROJECT AND POST PROJECT CODE BASE MAINTENANCE.

CONCLUSION

THE USE OF OPEN ARCHITECTURE CNC IS CONSIDERED OF GREAT IMPORTANCE SINCE IT IS A PROMISING TECHNOLOGY THAT ACTS IN THE AREA OF INDUSTRIAL AUTOMATION, ALLOWING THE INTEGRATION OF THE EQUIPMENT, A MORE FRIENDLYR INTERFACE IN THE CONFIGURATION, MACHINE TOOL COMMUNICATION AND MODERNIZATION.

THE LOW COST OF THE ELECTRONIC COMPONENTS HAS BEEN MOTIVATING THE DEVELOPMENT OF NEW CONTROLLERS.

THERE ARE SEVERAL TYPES OF OPEN ARCHITECTURE BEING DEVELOPED IN THE USA, EUROPE AND ASIA, WHICH USE THE STANDARD IBM-PC COMPUTER FOR CONTROL. THE OSACA ARCHITECTURE IS USED MOSTYIN THE SOFTWARE AREA, THE ARCHITECTURE OMAC ACTS MOSTLY IN INDUSTRIAL APPLICATIONS AND THE OSEC ARCHITECTURE ACTS IN AUTOMATION IN EVERY INDUSTRIAL AREA, LOGISTICS AND SUPPORT. THE HOAM-CNC ARCHITECTURE ACTS IN THE HARDWARE AREA IN TERMS OF NEW SENSORS AND SPECIAL MODULE IMPLEMENTATION.

ALL THESE ARCHITECTURES HAVE INTEGRATED EQUIPMENT OF SEVERAL DIFFERENT MANUFACTURERS AND TO OBTAIN CONTROL SOLUTIONS AT A LOWER COST, MAINTAINING THE SAME PERFORMANCE.

SOME BENEFITS OF THE OPEN ARCHITECTURE CONTROLLER ARE:

• THE USE OF THE C + + PROGRAMMING IN THE DESIGN OF THE CONTROL SOFTWARE. SOFTWARE ROUTINES CAN CONFIGURE AND IMPLEMENT NEW FUNCTIONS TO INCREASE THE MACHINE TOOL PERFORMANCE.

• THE APPLICATION POSSIBILITY OF ALGORITHM DEVELOPMENT OF ADAPTABLE CONTROL FOR NEW APPLICATIONS, WHICH USES FORCE SENSOR, VIBRATION SENSOR, ACOUSTIC SENSOR, ETC.

• THE ALGORITHM EXECUTION OF SPECIAL SERVO-CONTROL, INCREASING THE MACHINE TOOL PRECISION.

• THE USE OF THE SAME OPERATOR INTERFACE FOR DIFFERENT MACHINES, SIMPLIFYING USER'S TRAINING AND REDUCING THE COSTS.

REFERENCES

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