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ScienceDirect

Procedia Computer Science 103 (2017) 384 – 387

Procedia Computer Science

XIIth International Symposium «Intelligent Systems», INTELS'16, 5-7 October 2016, Moscow, Russia

Use of real-time operating systems in the integrated modular avionics

Eugeny Fedosov, Igor Koverninsky*, Anna Kan, Vladimir Volkov, Yuri Solodelov

FSUE GosNIIAS, 7, Viktorenko street, Moscow, 125319, Russia

Abstract

The foreign real-time operating systems were widely used for the last years in Russia-developed aircraft as well as in the Russian Integrated Modular Avionics (IMA) research projects. But presently the question of their substitution with Russian analogues has arisen. This article provides the requirements of the operating system should satisfy in order to be used in the civil aviation, the analysis of existing foreign and domestic RTOS and some aspects of the operating system development process.

Keywords: Real-time operating systems, advanced avionics, IMA.

1. Introduction

Currently one of the high-priority directions for the aviation industry development in Russian Federation is the development of the advanced airborne equipment. Suffice it to say that the percentage of the avionics systems development costs in the total cost of aircraft development can rich 35-40% for civil airplanes and more than 50% for the military projects[1].

Formerly the so-called federative architecture used to be the basic concept of the airborne equipment development. It was not flawless (especially in the integration and certification aspects); to overcome these shortcomings, the alternative concept was contrived. It was designated as "Integrated Modular Avionics" or simply "IMA"[2,3]. It has the following distinctive features:

- Open network architecture, based on the wide usage of standardized and commonly accepted technical solutions and designs.

* Corresponding author. Tel.: +7-499-157-7047; fax: +7-499-943-8605.
E-mail address: ivkoverninsk@2100.gosniias.ru

doi:10.1016/j.procs.2017.01.125

• Unified computing board, embodied as the basic construction (cabinet) with a set of the removable electronic modules (central processor modules, memory modules, network switchboard modules).
• Multifunctional computing system, which means that several user applications (including those with different criticality levels) can be run on the same hardware platform, thus providing the functioning of diverse airborne equipment.

The last item causes two consequences:
• Firstly, the division of hardware and software takes place; it becomes possible to use the functional applications with minor modifications in the projects that feature different hardware platforms.
• Secondly, the real-time operating system (RTOS) obtains the prominent place, because it should provide predictability, safety and workability of several functional applications at once.

Internationally the IMA concept was being developed and widely used in the new aircraft since 1990s. The avionics for Airbus A380, Boeing 787, Sukhoi Superjet and some currently in-development aircraft employ the concept of the first-generation IMA. There are several international projects in EU aimed at the advancement of the second-generation IMA (SCARLETT and ASHLEY), in which some dozens of companies all over the Europe are engaged (including GosNIIAS).

These companies have developed several hardware platforms with the basic software; unfortunately too little attention was given to the RTOS development, because one of the already existing systems was supposed to be used. The experience has shown that it’s not always possible or appropriate; besides, the conducted IMA research allows us to formulate the principal requirements to such systems and emphasize some aspects of its development.

2. Some requirements for the perspective real-time operating system

The requirements that should be met by the RTOS used in the civil avionics field are listed below:

1) Portability amongst several hardware platforms; it is vital to stick to the policy of reducing the number of architecture - and platform-specific code while designing the RTOS kernel; the software architect should always keep in mind that it might be necessary to modify or completely replace this specific code when transferring the OS to another platform.
2) ARINC 653[4] (API for the avionics’ functional applications) support, including:
   a) Part 1 (standard services).
   b) Part 2 (extended services); in particular, file system services and ARINC 429 and ARINC 664 integration.
   c) Part 4 (subset services).
3) Support for the widespread avionics interfaces like ARINC 429, AFDX (ARINC 664), CAN, MIL-STD-1553.
4) Advanced tools: Integrated Development Environment (IDE) with debug and verification tools; the possibility to use the simulator (e.g. open-source QEMU project).
5) Transparent RTOS adaptation to a specific hardware platform (availability of infrastructure required to develop a board support package and drivers).
6) Support of graphical programming interfaces (OpenGL SC/ES and ARINC 661 standards).
7) High performance (compared to the modern foreign RTOS’).
8) Safety standards compliance.
9) Multi-core CPUs support.
10) The Possibility of certification according to DO-178C5, including:
   a) High-level requirements development.
   b) Development of low-level specifications’, that should be traceable to the high-level requirements.
   c) Documentation development for the software components.
   d) Development of certification kits’ for the RTOS and also for the network stack, drivers, the graphical components and the file system.
   e) Software components verification (including formal methods).

Certification support is a key requirement because it affects not only the final product but also the entire life cycle. Certification requires correct development processes, the use of qualified tools, interaction with certification bodies; it also has a significant impact on the conduct of the processes of modernization and refinement of the RTOS.

When the RTOS is created it is necessary to consider prospects of development of the concept of IMA, in particular, make the ground for the network RTOS, enabling the sharing and interaction of several modules, the use of distributed file systems, etc.