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Design of Embedded Architecture for Integrated Diagnostics in Avionics Domain

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Abstract

The resent paper introduces a multi-level decision-making approach for design of optimal embedded integrated diagnostic architecture that combines maintenance decisions at the k-levels of system architecture and integration with health and usage monitoring systems (HUMS) mechanisms for achieving efficient system for level maintenance and lowering life-cycle cost of Integrated Modular Avionics (IMA). HUMS can be implemented in software or directly on an integrated circuit. The effectiveness of such an approach is investigated through the optimization of embedded HUMS architecture for known reliability and economic dependence during life cycle of IMA.

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Keywords: Embedded architecture, health and usage monitoring systems, integrated modular avionics

1. Introduction

Embedded systems are an essential component of safety-critical applications, such as avionics of airplanes and air traffic management systems (ATM). The future ATM system infrastructure will consist of a mix of access technologies, each with its own avionics elements at the aircraft side (airborne embedded cloud) and its own ground infrastructure (ground embedded clouds). The high level of system integration in avionics is made possible through

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the use of integrated avionics architectures or Integrated Modular Avionics (IMA) (Garside and Pighetti, 2007). The IMA employs extensive use of Surface Mount Technology, Very Large Scale Integrated Circuits, and Application Specific Integrated Circuits. IMA has been developed to create a modular, open, and highly-flexible architecture for digital avionics.

IMA may also have some special advantages for space applications, where power, weight, and volume are of particular concern. By hosting many applications on the same platform, some of which run at different times than others, the total amount of hardware needed can be reduced and consequently there will be cost, weight and volume savings and perhaps some power savings as well (Butler, 2008).

One of the important attribute of the embedded systems for such safety-critical applications as IMA is diagnosability – ability of system to support the identification of information related to its real or potential faults (Rajan and Wahl, 2013).

Traditional maintenance decisions in the framework of condition-based maintenance applied to multi-component systems are performed either at the system level or at the component level. These decisions however cannot always assure the best maintenance performance for IMA. Use of health and usage monitoring systems (HUMS) is new approach to activities that utilize data collection and analysis techniques to help ensure availability, reliability and safety of vehicles (Spitzer, 2006).

The present paper introduces a multi-level decision-making approach for design of optimal embedded integrated diagnostic architecture that combines maintenance decisions at the k-levels of system and integration with HUMS mechanisms for achieving efficient system level maintenance and lowering life-cycle cost of IMA. HUMS can be implemented in software or directly on an integrated circuit. The effectiveness of such an approach is investigated through the optimization of embedded HUMS architecture for known reliability and economic dependence during life cycle of IMA.

The rest of this paper is organized as follows. In Section II some important works in the area of Built-in-Test embedded system are reviewed. In Section III the main definitions and assumptions are presented. In Section IV a models of multi-level decision-making approach for design of optimal embedded integrated diagnostic architecture are proposed and optimal solution is designed. In Section V the conclusions are presented.

2. Related works

Integrated avionics architectures or Integrated Modular Avionics have been developed to create a modular, open, and highly-flexible architecture for digital avionics. Built-in-Test (BIT) is an invaluable component of modular, embedded systems that are used for critical applications such as avionics, mission systems, sensors, and others. BIT provides a level of confidence in the correct operation of each module at both power-up and during normal operation. As more of these critical embedded systems are assembled from off-the-shelf hardware and software components, it is increasingly important to evaluate BIT's performance and its potential for interaction with software.

The avionics systems in commercial aircraft are organized into sub-systems for functional areas such as flight control, engine control, navigation, communication etc. Typical avionics bay consists of specials cabinets with avionics modules (Itier, 2007).

The paper (Ott, 2007) has discussed the limitations of the current avionic architectures when dealing with the high level of functionality required by advanced civil aircraft and has formulated the main tasks for avionics designers:

- a reduction in overall cost of ownership through reduced spares requirement and equipment removal rate;
- a reduction in weight and volume of wiring leading to increased range and payload;
- improved built-in-test coverage to provide better maintenance diagnostics, improved fault detection, and reduced unconfirmed removals;
- maintenance-free dispatch to achieve quick turnaround times;
- resource sharing to reduce line replaceable units count;
- standardization at the functional interface to provide hardware and software interoperability (that is, vendor/product independence).