Consideration of the reconfigurable aspect in evaluating predictive reliability of mechatronic system

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Abstract:

More than a multi-technology fusion, mechatronic systems are becoming more and more complex, these systems can be reconfigured with changes in the environment and states of the functional units, evaluating and improving the reliability of mechatronic system requires to take into account the reconfigurable aspect. This point has become a major challenge for reliability engineers during the design phase. Therefore their dysfunctional modeling is very difficult. This communication presents an original proposed methodology for evaluating the reliability of mechatronic system with taking account the reconfigurable aspect. This reliability model integrates the change of the configuration related to the external and internal conditions.

Résumé:

Plus qu'une fusion multi-technologique, les systèmes mécatroniques deviennent de plus en plus complexes, ces systèmes peuvent être reconfigurés avec des changements dans l'environnement et les états des unités fonctionnelles. Evaluer et améliorer la fiabilité d'un système mécatronique en prenant en compte cet aspect reconfigurable est devenu un défi majeur pour les fiabilistes lors de phase de conception. Dans cette communications, nous proposons une méthodologie originale, d'évaluation de fiabilité des systèmes mécatroniques avec la prise en compte l'aspect reconfigurable, nous abordons un modèle fiabiliste qui intègre le changement de la configuration liée à la fois aux conditions externes et internes d'un système mécatronique.

Keywords: Predictive Reliability, Mechatronics, Modeling, Reconfiguration, Functional Analysis, Dysfunctional Analysis, Petri Networks.

Mots clés: Fiabilité Prévisionnelle, Modélisation, Mécatronique, Reconfiguration, Analyse fonctionnelle, Analyse dysfonctionnelle, Réseaux de Pétri.

1 Introduction

Mechatronics is a concept of merger and integration in permanent evolution, Fusion means that it involves associating disciplines [1] (mechanical, electronic, computer, ...). It's a synergistic combination of precision mechanical engineering, electronic control and systems thinking in the design of products and manufacturing processes. in order to improve and/or optimize its functionality. Reconfigurable mechatronic systems are developed to perform a given function, in a specific environment, hence the need to adapt and react dynamically to the variation of the parameters related to its operation[3], these systems consist of many intelligent interconnected units, and from this strong adaptability to changes in the external environment and to the system states itself. According to bibloigraphy [1, 2, 3], to allow a better control of the reliability of the mechatronic systems, one must take into account its aspects: dynamic, hybrid, interactive and reconfigurable. We focus mainly in this communication on taking account the reconfigurable aspect during evaluating the predective reliability of mechatronic systems.

Reconfigurable systems [7] are gaining an increasing interest, previously systems were traditionally designed to keep the same structure and behavior throughout their existence. In case of failure or change of objectives, a significant external intervention was required to continue the mission. So, a reconfigurable system has the ability to adapt to changes according to an internal and/or external factors, and to make changes to the configuration and fit of the structure in order to maintain its functionality with adequate quality of service, despite the presence of disturbances.

A reconfiguration can be static or dynamic. In the first case called Static, the systems have little flexibility. System configuration occurs before the execution of the task. Throughout this task, the system remains frozen.

In the second case, called dynamic, His goal is to dynamically adapt to specifications. It allows to change the con-

figuration, and therefore the functionality of a part of the circuit, without having even to stop the operation of whole system.

2 Reconfigurable Mechatronic system

In this part, In order to formalize a reliability model for the concept of reconfigurable mechatronic systems, we first propose to treat the notion of reconfigurable aspect for each domain (electronic, mechanical, automatic, etc.) as proposed in Figure 1, and to conclude a representation for reconfiguration of mechatronics.

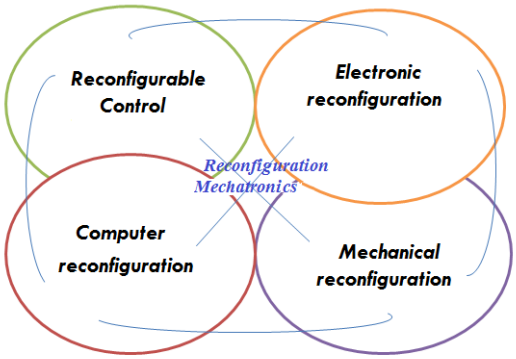

Figure1: Presentation of multi-domain reconfiguration

2.1 Electronic Reconfiguration

Reconfiguration within electronic systems has been made possible by the appearance of reprogrammable circuits which are the FPGA (Field Programmable Gate Array). An FPGA can be composed of several million cells. It provides logical functions and memory. These cells are interconnected by a programmable interconnection network forming a grid. The use of these FPGAs makes it possible to have calculation units whose functionalities can change as needed during the operation of the system.

2.2 Computer Reconfiguration

The notion of reconfiguration is commonly used in complex computer systems. Both aspects of a computer system (software or hardware) are reconfigurable. The concept of configuration is indeed found at the software level, when it is built in a modular way. The complete computer system itself is a reconfigurable system in which hardware and software reconfiguration aspects are entangled.

2.3 Mechanical Reconfiguration

The case of mechanical systems, the use of reconfiguration appear so that the systems are designed in a modular way, the modules can be modified or reorganized. The example of a mechanical system illustrating the reconfiguration is the auto-configurable robot. This robot consists of an arrangement of identical modules interconnected by a system of electromagnets. This robot shows several steps leading to a configuration "walker robot".

2.4 Reconfigurable Control

The reconfigurable control consists in using the redundancies at the level of the control or measurement means to compensate for the failure or use under sub-optimal conditions of one of them. reconfiguration improves the efficiency of an architecture by allowing the allocation and reuse of its resources for several tasks and the reorganization of the constituent elements of the system.

2.5 Example of reconfigurable system:

In reconfigurable Photovoltaic system, the reconfigurable architecture allows rearranging the PV modules or groups of cells in order to regulate the overall voltage output of the PV generator according to the states of various illumination and production potential energy. these systems chagnes its configuration according to externals and Internals factors [14]; these parameters trigger a dynamically reconfigure our system. Firstly, there as example of externals factors we have : The shading, irradiation, temperature, geographic location. Secondly, the internal factors for reconfiguration of PV system, we means direcly the failure of PV or DC modules. This reconfiguration has several interests as the Optimization of the power in case of shading. Increase in voltage gain. Also Flexibility of the architecture (Serie/Parallel Structure, Cross Link Structure, Bridge Structure), and improving Reliability (degraded mode).

3 Predictive Reliability of Reconfigurable Mechatronics System

From the perspective of reliability analysis system[3, 6, 7], if the system can be reconfigured for a function, the architecture of the execution of this function will be modified, while the redundancy of the system increases and implicitly the reliability of the system will also be improved. Evidently, increases in system reconfiguration functions produce positive or negative effects for system reliability. Therefore, the reliability of the system directly influenced its reconfiguration.

The traditional tools of reliability prediction such as FT, FMEA, etc., do not allow to take into account changing reconfiguration of the system. [2, 4, 6]. the specificity for a mechatronic system, since the system has multi-technology solutions, so in each reconfiguration, the system brought back into operation different domain components. In the work of Demri [3], the evaluating reliability for ABS braking system with two configurations

separately (normal braking, braking mode ABS), but they don't consider it as reconfigurable system, the comparison of the results shows the influence of the aspect reconfigurable on the total reliability of the system, Until now, we do not know of an approach to assess the reliability of the entire system which takes account of the alternation between deferential configuration. The mains of this work attempts to build the framework and to give the methodology for system reliability with reconfiguration characteristics, by taking into account externals and internals multi-domain factors for reconfiguration.

4 Proposed Methodology

To meet the challenges of consideration of reconfigurable aspect during the predictive reliability assesement, a new approach for system design is necessary to enable a system reliability modeling with reconfiguration, by constructing of quantitative relationship between the characteristic parameters of reconfiguration and its impact for system reliability. This approach should definitely consider the goals of reliability from the design phase of the system

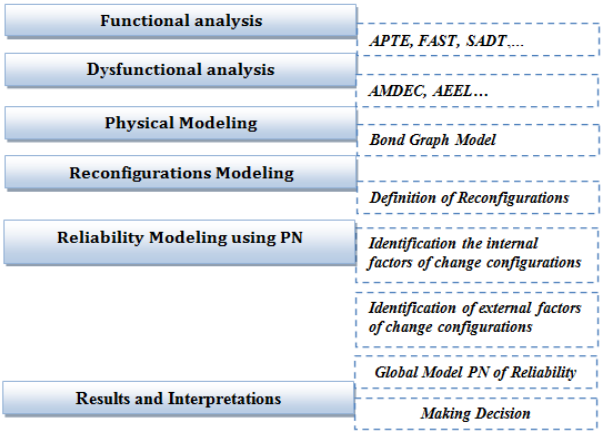

Figure 2: Proposed Methodology for Predective Reliability of reconfigurables mechatronics systems

The reliability models of system function level and system basic mission will be built under the reconfiguration caused by system state changes. The system reliability mathematical models will be built under the phase tasks time-varying and system.

We consider that the reconfiguration of the system can be carried out according to several possibilities:

- Replace the failed subsystem with a new subsystem (multi-domain subsystem).
- Use the failed subsystem in degraded mode and ensure the lack of its function by other subsystems (functional redundancy).
- Disconnect the failed subsystem and continue the mission with the remaining subsystems

5 Conclusion

The reconfiguration of the system has a very important influence on the reliability of the system, in particular for a very complex mechatronics system, we can say that the evaluating of reliability in reconfigurable systems is a line of research still in its early stage. The methodology proposed in this paper presents a reliability model that allows to take into account the reconfigurable aspect namely the internal and external multi-domains factors of the configuration change, using the Petri nets. This work requires an industrial application to illustrate the interest of the proposed methodology

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