A Novel Efficient Method for Conflicts Set Generation for Model-Based Diagnosis

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Abstract—In this paper we present a new efficient algorithmic method for generating the conflicts set for model-based diagnosis. Much of the effort in ground-based mission operations, Earth orbiters, and deep space probes is directed toward fault detection and diagnosis. In the current state of practice, the most disciplined approach to diagnosis is the "model-based" approach, employing knowledge of devices operation and their connectivity in the form of models. However, current approaches cannot provide the required efficiency for diagnosis of time critical faults. Our new method is indeed motivated for achieving such a desired efficiency.

Research in model-based diagnosis, over the past three decades, has been based on two different disciplines: one, the Fault Detection and Isolation (FDI), which is based on automatic control theory and statistical decision theory, and the other one, known as DX, which is based on artificial intelligence techniques, and is best represented by General Diagnosis Engine (GDE). For many years, each discipline has used different tools to approach the diagnosis problem. But recently a unifying framework has been developed that shows that the techniques used in both disciplines are actually equivalent to each other. This equivalence is based on the relation between the *residuals,* used by FDI, and the *conflicts*, used by DX. The basic principle of the model-based diagnosis approach is to compare the expected (or nominal) behavior of the system, provided by the model of the system, with the actual behavior which is presented by the measurements. An *analytical redundancy relation* (or residual) is a relation among the *measured* parameters of the system, and on the other hand a *conflict* is a set of assumptions on the modes of some components that is not consistent with the model of the system and measurements. The link between these two concepts is that the *support* of an ARR, i.e., the set of components involved in that ARR, which is a *possible conflict*, i.e., there is a possible scenario of measurements for the system which produces that set as a conflict. However, both approaches run into computational problems, making them inefficient for many applications of interest. For the ARR-based approach, all the current algorithms for generation of the complete set of ARRs have an exponential complexity, thus making generation and hence application of ARRs rather impossible. The GDE approach requires performing many *consistency checks*, which might not even be required, and most often leads to an exponential complexity.

In this paper, we present and demonstrate a new method which combines the strength of both the ARR-based and GDE approaches while avoiding their weaknesses to achieve maximum efficiency. We first present a new efficient method (with a polynomial complexity) for generation of the complete set of ARRs for the system in an implicit form. Such an implicit form of an ARR establishes a logical relation between the set of measurements, involved in its evaluation, and its support components. Such a derivation is performed only once for each system of interest prior to its diagnosis. For the diagnosis, our method first performs (similar to GDE) a system simulation to calculate the expected values of the measurements. Any discrepancy, i.e., the difference between expected and actual value of measurement, would trigger our diagnosis process. To this end, only those ARRs which involve the measurement with discrepancy are checked for consistency which lead a to a significant reduction in the number of consistency checks usually performed by GDE. We demonstrate the efficiency of our new method by its application to several synthetic systems and compare it with that of GDE.

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