The Scheduling of Real-Time tasks using Performance Evaluation through fuzzy-random in Real-Time Systems

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Abstract

The scheduling of real-time tasks needs both correctness and timeliness. But it is not easy to schedule real-time tasks having different characteristics in a single system. In this paper we solve the problem through an approach using the performance evaluation of real-time tasks through fuzzy-random variables. Using the performance evaluation through fuzzy-random variable, we can achieve flexible and efficient scheduling for real-time systems.

1.Introduction

Real-time control systems, intrinsically characterized by stringent timing constraints, fails catastrophically if its control input is not updated by its digital controller computer within a certain timing constraints formally specified by the hard deadline. Since the fail of a real-time control system can cause an economical disaster or a loss of lives, the reliability that guarantees the safety of the system is crucial. Along with safety, optimality is also an essential factor in the control system. To control the real-time system optimally, the evaluation of performance of the real time system is imperative. Estimating the performance produced, we can assign and schedule tasks optimally by maximizing the performance or minimizing the cost. Conventionally, a few performance measures were developed in non real-time system merely by focusing on systems logical states. However, the evaluating method of the performance and/or reliability of the real-time system has been less intensively treated than the description and computation techniques due to its increased complexity and intrinsic subjectivity in the context of applications. The states which change stochastically in a real-time system are too difficult to be described and to be analyzed using conventional models or tools. Especially in the gracefully degradable system, computational time delay and its effect should be considered. For flexible and efficient evaluation, we define a new definition of a fuzzy-random variable and address its properties to derive the probability of the fuzzy-random event. We then schedule real-time tasks using the produced performance.

2.Fuzzy-random variable

As mentioned above, we introduce the concept of fuzzy-random variables to capture the uncertainty of the deadline information and then describe how those fuzzy-random variables are used for performance evaluation and scheduling for dynamic system events. In [8], the notions of fuzzy-random variables under different conditions were discussed. It is reasonable that we describe uncertain information especially existing in the generic and dynamic aspects of the real-time system by merging with each other through fuzzy-random variables. The fuzzy-random variable is defined as follows:

Definition: Let (Ω, A, P) be a probability measure space. A mapping $\tilde{X}: \Omega \to F_0(R)$ is called a fuzzy-random variable on (Ω, A, P), if for $\alpha \in (0,1]$ $(\omega \in \Omega)$:

$$\tilde{X}_\alpha(\omega) = \{x \mid x \in R,\ \tilde{X}(\omega)(x) \geq \alpha\} = [X_\alpha^-,\ X_\alpha^+] \qquad (2.1)$$

where $\tilde{X}_\alpha$ is a random interval, namely, X_α^- and X_α^+ are two random variables on (Ω, A, P) which is redefined by $FR(\Omega)$ being the set of all fuzzy-random variables on (Ω, A, P).

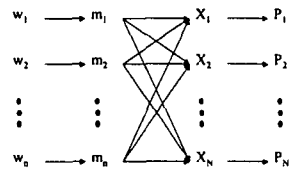

Fig 1. Relationships among discrete fuzzy-random variables, the elements, the membership functions, and the probabilities

The fuzzy-random variable is explicitly distinguished from a simple random variable primarily in the aspect of the presence of the real interval for the element of Ω denoting ω. Therefore, the relationship between the fuzzy-random variable $\tilde{X}(\omega)$ and ω does not match uniquely, so that the interval of the real line, which shares with different element ω, does exist with certain membership value. We turn to define the probability of the fuzzy-random variable in two ways. (i) discrete ω and discrete X. (ii) discrete ω and