Chapter 1.1

FAULT INJECTION TECHNIQUES
A Perspective on the State of Research

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1. INTRODUCTION

The low-cost high-performance microprocessors are easily obtained due to the current state of technology, but these processors usually cannot satisfy the requirements of the dependable computing. It is not easy to forget that the recent America Online blackout affecting six million users for two and half hours, which was caused by a component malfunction in the electrical system, and the maiden flight tragedy of the European Space Agency’s Ariane 5 launcher, which was caused by a software problem. The failures of critical computer-driven systems have serious consequences, in terms of monetary loss and/or human sufferings. However, for decades it has been obvious that the Reliability, Availability, and Safety of computer systems cannot be obtained solely by the careful design, the quality assurance, or other fault avoidance techniques. Proper testing mechanisms must be applied to these systems in order to achieve certain dependability requirements.

To achieve the dependability of a system, three major concerns should be posed by the procedure of the computer system design:

1. Specifying the system dependability requirements: selecting the dependability requirements that have to be pursued in building the computer system, based on the known or assumed goals for the part of the world that is directly affected by the computer system;

2. Designing and implementing the computing system so as to achieve the dependability required. However, this step is hard to implement since the
system dependability cannot be satisfied simply from the careful design. Therefore, the third concern becomes the one that cannot be skipped.

3. Validating the system: gaining confidence that a certain dependability requirement has been attained. Some techniques, such as using the fault injection technique to test the designed product, can be used to help to achieve this goal.

Dependability is a term used for the general description of a system characteristic but not an attribute that can be expressed using a single metric. There are several metrics, which form the foundation of dependability, such as Reliability, Availability, Safety, MTTF, Coverage, and Fault Latency. These dependability-related metrics are often measured through the life testing. However, the time needed to obtain a statistically significant number of failures makes the life testing impractical for most dependable computers. In this chapter, fault injection techniques are thoroughly studied as a new and effective approach to testing and evaluating the systems with high dependability requirements.

1.1 The Metrics of Dependability

Several concerns of the dependability analysis have been defined to measure the different attributes of the dependable systems.

- **Definition 1: Dependability**, the property of a computer system such that reliance can justifiably be placed on the service it delivers [LAPR_92], which is a qualitative system attribute that is quantified through the following terminologies.

- **Definition 2: Reliability**, a conditional probability that the system will perform correctly throughout the interval [t0, t], given that the system was performing correctly at time t0 [JOHN_89], which concerns the continuity of service.

- **Definition 3: Availability**, a probability that a system is operating correctly and is available to perform its functions at the instant time t [JOHN_89], which concerns the system readiness for the usage.

- **Definition 4: Safety**, a probability that a system will either perform its functions correctly or will discontinue its functions in a manner that does not disrupt the operation of other system or compromise the safety of any people associated with the system [JOHN_89], which concerns the non-occurrence of the catastrophic consequences on the environment.