

# Towards a Rigorous Definition of Information System Survivability

John C. Knight   Elisabeth A. Strunk   Kevin J. Sullivan  
*Department of Computer Science*  
*University of Virginia*  
*151 Engineer's Way, Charlottesville, VA 22904-4740*  
*{knight|strunk|sullivan}@cs.virginia.edu*

## Abstract

*The computer systems that provide the information underpinnings for critical infrastructure applications, both military and civilian, are essential to the operation of those applications. Failure of the information systems can cause a major loss of service, and so their dependability is a major concern. Current facets of dependability, such as reliability and availability, do not address the needs of critical information systems adequately because they do not include the notion of degraded service as an explicit requirement. What is needed is a precise notion of what forms of degraded service are acceptable to users, under what circumstances each form is most useful, and the fraction of time such degraded service levels are acceptable. This concept is termed survivability. In this paper, we present the basis for a rigorous definition of survivability and an example of its use.*

## 1. Introduction

The technical community uses the term *survivability* in the context of networked information systems. Systems are sometimes described as being *survivable*, technologies are claimed to enhance *survivability*, and so on. Unfortunately, despite the common use of the term, no precise and adequately comprehensive definition of *survivability* exists, and what constitutes a *survivable* system thus is not defined well in an engineering sense.

A narrow view that is sometimes taken is that a system is *survivable* if it can tolerate certain kinds of faults. A server, for example, might be described as *survivable* if it is able to withstand certain types of security attacks. This doesn't necessarily make the server *survivable*, however, because it might still fail if it experiences a hardware fault, is damaged by an explosion, and so on. Similarly, a command-and-control system might be claimed to be *survivable* because it uses intrusion detection, but the system might fail if subjected to battle damage, which is not necessarily what is required. Under these circumstances, a system characterized by its developers as *survivable* might not meet the needs of

its owners and users because it does not have some essential properties that they thought were implied by the term.

What we need is a precise and adequately comprehensive engineering definition of *survivability*, analogous to those that have been framed for the dependability characteristics described by Avizienis et al. [3], such as *reliability*, *availability*, and *security*. *Reliability*, for example, is defined as the probability that a system will meet its (non-reliability) requirements over a given period of time under given operating conditions.

The notion of *survivability* that we need must have three essential characteristics. First, it must be broad enough to encompass various types of damage to the system. Second, it must include alternate forms of service, each achieving an effective tradeoff between the benefits of a given level of function and the cost of providing it, under the range of operating conditions for which it is defined. Third, it should model the probability that each of these services must be available for use, as a function of the conditions that the system is expected to encounter.

Furthermore, the definition must be precise and unambiguous enough to support an engineering approach to the specification, design, and analysis of critical information systems. If we do not state precisely what we mean by the term *survivable*, we cannot determine whether we have made a system that meets its real requirements. This is not merely an academic point. The owners and users of a system need to be able to determine that, with reasonable assurance, the system will perform adequately in its environment.

In a nutshell, then, the problem that we address in this paper is that we currently lack an engineering definition of *survivability* for critical information systems: one that allows us to state precisely what properties are required of a system and to do the kind of design analysis that reveal whether they are present before we come to rely on the system. The chief contributions of this work in this dimension are, first, a case for the proposition that we need such an engineering definition of *survivability*; and second, a proposed basis for a rigorous engineering definition of the term with an example to make the ideas concrete.

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