The Survivable Network Analysis Method:
Assessing Survivability of Critical Systems

Software Engineering Institute
Carnegie Mellon University
Pittsburgh, PA 15213-3890

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**The Survivable Network Analysis Method: Assessing Survivability of Critical Systems**

- **Author(s):** Carnegie Mellon University, Software Engineering Institute, Pittsburgh, PA, 15213

- **Performing Organization:** Carnegie Mellon University, Software Engineering Institute, Pittsburgh, PA, 15213

- **Approved for public release; distribution unlimited**

**Abstract**

- The Survivable Network Analysis Method (SNAM) is a formal analysis method for assessing the survivability of critical systems. SNAM provides a structured framework for analyzing the vulnerabilities and resilience of a system under various threat scenarios. It is designed to help system designers and analysts identify potential weaknesses and make informed decisions to enhance system survivability.

**Subject Terms**

- Network Analysis
- Critical Systems
- Survivability

**Security Classification**

- Report: Unclassified
- Abstract: Unclassified
- This Page: Unclassified

**Limitation of Abstract**

- Same as Report (SAR)

**Number of Pages**

- 42
Agenda

System Survivability Concepts

The Survivable Network Analysis (SNA) Method
System Survivability Concepts
Survivability Motivation

Growing societal dependence on complex, large-scale, networked systems

Serious consequences of system compromises and failures

Traditional security and vulnerability analysis no longer sufficient
Changing Systems Environment

System evolution
- expanding network boundaries
- additional participants with varying levels of trust
- numerous point solutions: Public Key Infrastructure, Virtual Private Networks, firewalls, ...
- blurring of Intranet and Extranet boundaries
- new technologies -- directory services, XML

System security
- No amount of security can guarantee a system will not be penetrated
Impact on Analysis

Lack of complete information
  • unknown physical and logical perimeters
  • unknown participants, untrusted insiders
  • unknown software components -- COTS, Java, etc.

Broader scope
  • Mix of central and local administrative control
  • Critical components more exposed
  • Attacks can impact essential business services
Survivability focus is on the system mission
- assume imperfect defenses
- analyze mission risks and tradeoffs
- identify decision points with survivability impact
- provide recommendations with business justification
- improve survivability to ensure mission capability

**Survivability** is the ability of a system to fulfill its mission, in a timely manner, in the presence of attacks, failures, or accidents.
The “Three Rs” of Survivability

Resistance
  • capability to deter attacks

Recognition
  • capability to recognize attacks and extent of damage

Recovery
  • capability to provide essential services and assets during attack and recover full services after attack
The Survivable Network Analysis (SNA) Method
SNA Objectives

Understand survivability risks to a system
  • What essential services must survive intrusions?
  • What are the effects of intrusions on the mission?

Identify mitigating strategies
  • What process, requirements, or architecture changes can improve survivability?
  • Which changes have the highest payoff?
SNA Characteristics

Tailorable to stage of development -- from initial requirements to deployed systems

Adaptable to variety of development processes

Applies to applications as well as infrastructure
SNA Architecture Focus

Architecture is integrating element of large systems

Capture assumptions on boundaries and users

Support architecture evolution as requirements and technologies change
  • evolving functional requirements
  • trend to loosely coupled systems
  • integration across diverse systems
  • changes in vendor product architectures

Assist selection and integration of rapidly changing security products
The SNA Process

Performed on selected system or system component

Conducted by our team (survivability expertise) working with customer team (system expertise)

Carried out in structured series of working sessions

Findings summarized in report and management briefing
Survivable Network Analysis Method

- **STEP 1** SYSTEM DEFINITION
  - Mission requirements definition
  - Architecture definition and elicitation

- **STEP 2** ESSENTIAL CAPABILITY DEFINITION
  - Essential service/asset selection/scenarios
  - Essential component identification

- **STEP 3** COMPROMISABLE CAPABILITY DEF’N
  - Intrusion selection/scenarios
  - Compromisable component identification

- **STEP 4** SURVIVABILITY ANALYSIS
  - Softspot component (essential & compromisable) identification
  - Resistance, recognition, and recovery analysis
  - Survivability Map development
Joint Planning Meeting/System Documentation
Identify system to be analyzed and documentation
Establish scope of work, teams, and schedules

Off-Site Preparation Task
Review system documentation
Prepare for SNA

Joint Discovery Session
...
SNA Preliminaries - 2

Existing documentation may only partially meet SNA needs

System architecture description may be little more than boxes and arrows

Discovery sessions will continually add new components and functionality to architecture

Critical to have stakeholder involvement and interest
Step 1 and 2 Activities

**Joint Discovery Session**

**SNA Step 1 initiation:**
- Briefings by developers on
  - business mission and life-cycle process
  - functional requirements
  - operating environment
  - architecture
  - evolution plans

**SNA Step 2 initiation:**
- Determination of
  - essential service and asset selection
  - essential service/asset usage scenarios
  - scenario traces and essential components

**Off-site Discovery Integration Task**

**SNA Steps 1 and 2 completion:**
- Analyze system mission, life cycle, requirements, environment,
  - architecture and essential services,
  - assets, and components

**SNA Step 3 initiation:**
- Assess system vulnerabilities
- Define representative set of intrusions
- Define intrusion usage scenarios
Step 1: Mission Definition

Inputs required from diverse stakeholders
  • owners, users, architects, developers, administrators

Identify business mission supported by the system
  • example
    - government agency: review, select, fund, and monitor government contracts
  • example
    - industry: support integration of design teams across internal corporate organization, industry partners, and contractors
Step 1: Architecture Definition

System architecture and operating environment

- evaluation team reviews understanding of architecture from documentation and discussion
- review key system boundaries such as where administrative control changes
  - risks may be with external systems or with systems outside immediate control of the organization
- identify explicit and implicit assumptions such as choice of vendors, operating systems
- identify critical dependencies on other systems
Step 2: Essential Capabilities

Essential services/assets
• Capabilities that must be available despite intrusions

Essential service/asset scenarios
• Steps in essential service/asset usage

Essential components
• Architecture parts required by essential services/assets
• Determined by tracing scenarios through architecture
Essential Service Scenario Trace

Diagram showing the flow of essential services and components with annotations for architecture nodes, communication links, and essential service traces.
Step 2: Essential Services

Ask user communities to describe their system use
• government agency: file system was essential component but users employed email servers as an alternative file system with extensive storage of attachments

Identify future changes in function and usage
• government agency: electronic submission of grant proposals and financial reports

Identify small number of essential services
• government agency: grant administration, internal administration, dissemination of public information
Step 3 and 4 Activities

Joint Analysis Session
SNA Step 3 completion:
  Briefing by SEI on
    system vulnerabilities
    selected intrusions and their usage scenarios
  Validation of intrusions by customer team
  Determination of
    scenario traces/compromisable components
SNA Step 4 initiation:
  Determination of
    softspot components
  current resistance, recognition, and recovery

Off-site Analysis Integration Task
SNA Step 4 completion:
  Define recommended mitigation strategies for
    resistance, recognition, and recovery
  Assess architecture modifications and impacts
  Document findings in the Survivability Map
  Prepare customer briefing

Briefing
Step 3: Intrusion Capabilities

Treat intruders as users

Select representative intrusions based on environment and risk

Intrusion scenarios
- steps in attacker usage

Compromisable components
- architecture parts accessible by intrusion scenarios
- determined by tracing scenarios through architecture
Intrusion Scenario Trace
Step 3: Vulnerabilities

Review initial analysis of probable attacks and impacts with stakeholders and users
- often significant variation in stakeholder view of intruder impact
- script-kiddie attackers generate most attention but may draw focus away from skilled attackers with specific objectives
- generate stakeholder consensus on probable attackers and impacts
Step 3: Model Attacker Profiles - 1

“Target of opportunity” profile -- general objectives
- readily available tools
- defense: increased resistance, system configurations, file-integrity checks

“Intermediate” profile -- specific objectives
- use of trusted resources, greater patience
- higher impact on essential services
- defense: increased recognition and recovery

“Sophisticated” profile -- very focused objectives
- customized tools, compromise internal staff
- defense: high probability of success; recognition and recovery essential
### Step 3: Model Attacker Profiles - 2

Generate table of probable attackers and impacts

For each class of attacker consider:
- **resources:** personnel, skill, finances
- **time:** patience and persistence
- **tools:** access to tools, ability to customize
- **risk:** level of risk aversion
- **access:** internal, Internet
- **objectives:** personnel, financial, moral

**Example:** Government agencies may have attackers who have strong political or moral positions. These attackers are not risk averse and can be very patient.
Step 3: Current Strategies

Identify current survivability strategies
  • normal operations for backup
  • configuration management
  • resistance, recognition, recovery (usually weak)

Get input from users, management, and system administrators
Step 4: Survivability Analysis

Steps 1-3 provide information for extensive, in-depth analysis to develop recommendations for

- architecture modifications
- requirements changes
- policy revisions
- operational improvements
Step 4: Softspot Identification

Softspot components

- architecture components that are both essential and compromisable

- members of essential service scenario traces that must be available despite intrusion effects
Architecture Softspots

Essential Service Scenario

Intrusion Scenario

Softspot Component: both essential and compromisable
Step 4: Survivability Analysis

Evaluate system in terms of response to scenarios

Make recommendations for survivability improvements
  • requirements: propose response to intrusions
  • architecture: evaluate system and operational behavior

Identify decision and tradeoff points
  • areas of high risk
  • tradeoffs with safety, reliability, performance, usability
Step 4: Survivability Map

Defines survivability strategies for the three Rs based on intrusion softspots

Relates survivability strategies to the system, its environment, and identified intrusions

Provides basis for risk analysis, cost-benefit tradeoffs
# SNA Survivability Map

<table>
<thead>
<tr>
<th>Intrusion Scenario</th>
<th>Softspots</th>
<th>Architecture Strategies for</th>
<th>Resistance</th>
<th>Recognition</th>
<th>Recovery</th>
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</thead>
<tbody>
<tr>
<td>Scenario 1</td>
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<td>Current</td>
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<td>Recommended</td>
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</table>
Step 4: Recommendations - 1

Case Study A: large distributed organization, large number of legacy systems, currently involved in redesign of most major systems

- establish security architecture -- directory services, support for a mix of central and distributed administration, develop common application interface to security infrastructure, architectural support for managing active content (Javascript, email attachments)

- support architecture evolution -- accommodate product changes, interoperability among security vendors, and changes in vendor architecture
Step 4: Recommendations - 2

Case Study B: administrative unit inside a large, diverse organization. Very heterogeneous user environment (university-like) including significant research component

- revise security/survivability policies
- improve separation between internal systems and those accessed by general public and employees outside the administrative unit
- add internal firewalls to better manage diverse user community
- extend attacker analysis beyond script-kiddies
- improve system recovery
SNA Benefits

Clarified requirements

Basis to evaluate changes in architecture

Early problem identification

Increased stakeholder communication

Improved system survivability
Future Work

Define survivability architecture patterns

Develop improved methods for system and intrusion definition

Create automation support for SNA
Additional Information

SNA Case Study: The Vigilant Healthcare System
  • IEEE Software: July/August 1999

Survivability: Protecting Your Critical Systems
  • IEEE Internet Computing: November/December 1999

Web site: IEEE article and other reports
On www.sei.cmu.edu
/organization/programs/nss/surv-net-tech.html