SAND 2004-2582P

Increasing Regression Test Coverage for the Integrated Tiger Series (ITS–5.0) with Aprobe

By Lisa Cordova

University of New Mexico

August 5, 2003

Simulation Technology Research

Sandia National Laboratories

Leonard Lorence, Manager

Ronald Kensek, Technical Advisor

Sandia is a multiprogramming laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under Contract DE-AC04-94AL85000.

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Outline

- Regression Testing
- Integrated Tiger Series
- ITS Regression Tests
- Coverage with Aprobe
- Problems Encountered
- Benefits of Coverage Analysis
- Summary of Work to Date

Regression Testing

- **What is Regression Testing?**
  - Running a Set of Standard Test Simulations to Verify Code Performance
- **When are Tests Performed?**
  - After Modifications or Setup, to Check for Bugs and System Compatibility
- **What is Regression Test Coverage?**
  - How Much of the Code is Being Executed During the Test Simulations
  - Ideally, this Number Should be 100%
  - 70-80 % Good Practical Coverage

Integrated Tiger Series (ITS - 5.0)

- **Electron-Photon Monte Carlo Transport Code**
- **Development Began in Early 1970's**
- **Applications Include:**
  - **Manufacturing Processes**
  - **Space Radiation**
  - **Medical Physics**
  - **Design and/or Analyze Experiments**
  - **Radiation Effects in Electronics**
- **Written in Fortran-77 with a C++ Interface for CAD**

ITS – Building Executables

- **Geometry**
  - Tiger (1-D)
  - Cyltran (2-D)
  - Accept (3-D: Combinatorial or CAD [ACIS4, ACIS6])
- **Physics**
  - ITS (Continuous Energy Cross Sections)
  - MITS (Multi-group Cross Sections)
  - MCodes (Applied Magnetic and Electric Fields)
  - PCodes (Enhanced Ionization and Relaxation)
- **Processing**
  - Serial
  - MPI (Dynamic or Static Load Balancing)
  - Random Number Generator (1, 2, or 3)

Over 50 Executables (60,000+ Lines of Source Code)!

ITS – Exercising Input Options

- **Source**
  - Electrons, Photons
  - Point, Disk, etc.
  - Energy, Direction
  - Forward, Adjoint
- **Calculation**
  - Histories, Batches
  - Biasing
- **Output**
  - Dose Distribution
  - Charge Deposition
  - Kerma, Pulse Height

Over 50 Keywords!

ITS Regression Tests

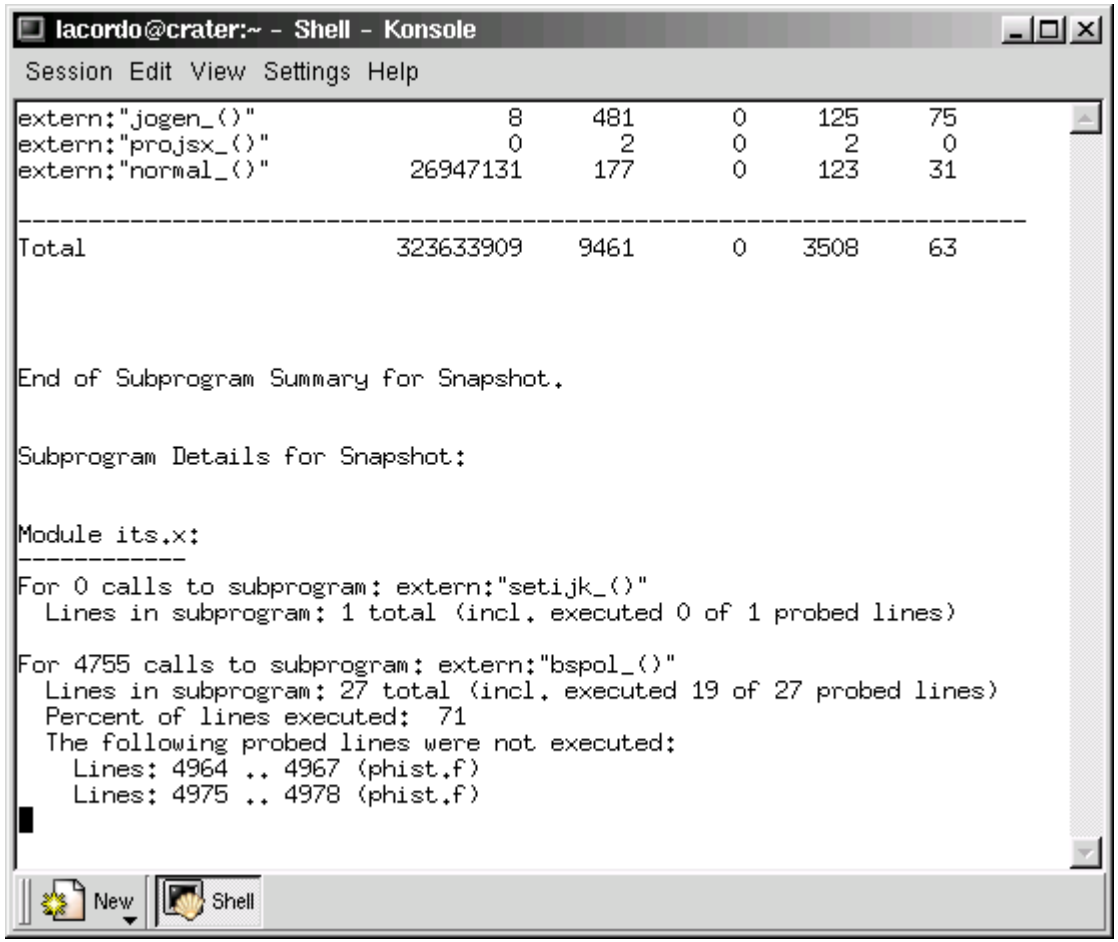
GOALS

- **Execute All Lines of Code**
  - **Build and Test All Executables**
- **Automate Process**
  - **Use Scripts to Run Tests and Determine Coverage**
- **Increase Test Coverage**
  - **Determine Existing Test Coverage**
  - **Create Comprehensive Input Files**
  - **Check for Increase in Coverage**

Aprobe

- Software Development and Testing Tool
- Commercial Product Developed by OC Systems
- Probes with Patches Written in C Language
- Has a Predefined Test Coverage Probe
  - Determines Coverage Percent
  - Specifies Uncovered Lines in Subprograms
  - Writes Data to a Text File

Coverage with Aprobe

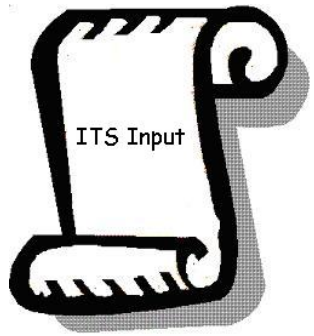


Coverage (Existing)

Executable	Initial Coverage %
its-tig	67%
its-tig-p	69%
mits-tig	41%
its-acc	44%
its-acc-p	47%
its-acc-m	-
mits-acc	32%
its-cyl	63%
its-cyl-p	64%
its-cyl-m	-
its-cad	34%
its-cad-p	35%
mits-cad	50%

LEGEND
its = continuous energy
mits = multi-group
tig = tiger, 1-D
cyl = cyltran, 2-D
acc = accept, 3-D, CG
cad = accept, 3-D, CAD
p = ionization/relaxation
m = magnetic fields

Coverage (Increasing)



COMPREHENSIVE INPUT FILE

- **Objectives**
  - **Include All Keywords**
  - **Deal with Conflicting Input Options**
  - **Trigger Error Messages and Warnings**
- **Approach**
  - **Use NEW-DATA-SET Keyword**
  - **Merge with Error Input File**
  - **Write a Probe to Skip/Trigger Error Messages**

Coverage (Current)

Executable	Initial Coverage %	Current Coverage %
its-tig	67%	79%
its-tig-p	69%	80%
mits-tig	41%	70%
its-acc	44%	76%
its-acc-p	47%	77% *
its-acc-m	-	-
mits-acc	32%	68%
its-cyl	63%	
its-cyl-p	64%	
its-cyl-m	-	
its-cad	34%	
its-cad-p	35%	
mits-cad	50%	

* The remaining 23% is mostly error messages

LEGEND
its = continuous energy
mits = multi-group
tig = tiger, 1-D
cyl = cyltran, 2-D
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Problems Encountered

- **Aprobe DOES NOT PROBE:**
  - All Executables
  - MPI Calculations
  - All Lines of Error Messages

- **Aprobe DOES PROBE:**
  - 3rd Party Code, Shared Libraries and Components

This Reduces Reported Coverage Percent!

Benefits of Coverage Analysis

- **Build Consumer Confidence**
  - Comprehensive Test Suite
  - More Descriptive Error Messages
- **Improve Code**
  - Identify and Fix Bugs
  - Remove Dead Code
- **Identify Compiler Incompatibilities**
- **Teach Me How to Use the Code!**

Summary of Work to Date

- **Completed**
  - ☑ Script to Build All Executables
  - ☑ Some Comprehensive Input Files
  - ☑ Script to Probe All Executables
- **Not Completed**
  - ☐ Need to Finish Input Files
  - ☐ Waiting for Files to Allow Aprobe to Test MCodes

Special Thanks To:

ITS Team

&

Ron Kensek!