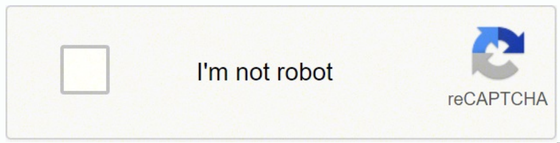

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100486922310 14019490144 105735782928 797071455 6408642.4848485 33295435200 3944321175 13202831.5 27842672.584906 49967523459 12931621.59375

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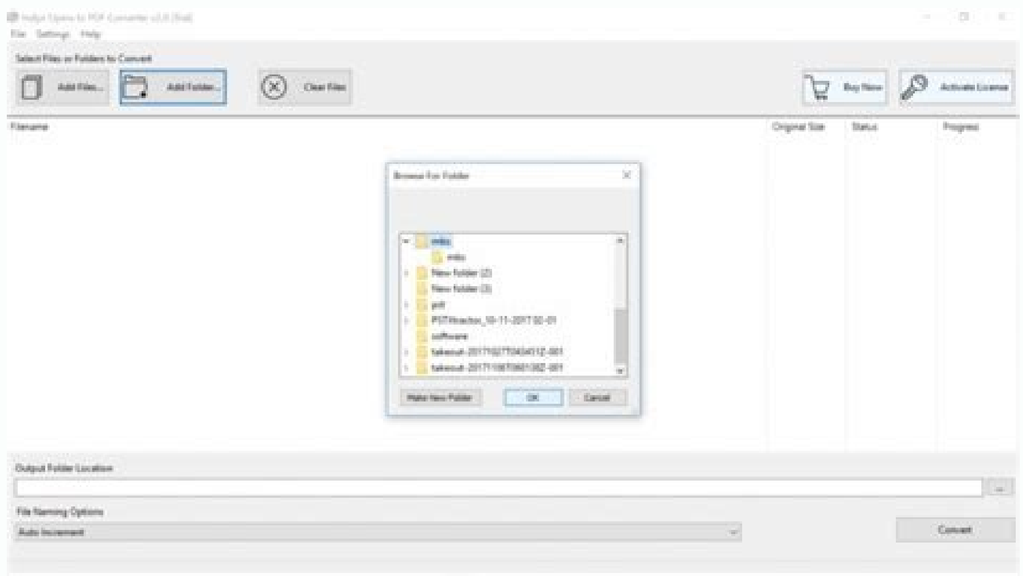

Cantata github.

Isolation / Integration Cantata++ V5 can be used for Isolation and Integration testing and the flexibility of Stubs and Wrappers supports the requirements of those techniques. 1625 44+ Shows what code has been exercised by a set of tests Informs decision on when to stop testing Option to add more test cases / remove unwanted code Identifies un-reachable code needing re-design Coverage Metrics Function/method entry-point Call-returns Statements Basic Blocks of Statements Decisions (branches) Conditions (including MC/DC) 25 Why use code coverage? Cantata++ Rule Sets make the selection (they are also user configurable) very easy. Integrated code-coverage analysis with checks on coverage requirements. Variations on CHECK() and CHECK_RANGE() directives: CHECK_NAMED(description, actual, expected) CHECK_RANGE_NAMED(description, actual, lower, upper) CHECK_WARN(actual, expected) CHECK_NAMED_WARN(description, actual, expected) CHECK_RANGE_NAMED_WARN(description, actual, lower, upper) as CHECK() but if comparison fails then a warning is logged, instead of an error Examples: CHECK_MEMORY(Input buffer, &input_data_buf, &expected_input_data_buf, sizeof(struct comms_buffer); CHECK_OBSERVATION("did the motor start?, Y); Record pass if answer is Y, fail otherwise CHECK_OBSERVATION("is the robot moving?, 'N'); Record pass if answer is N, fail otherwise (60 All examples described in exercise handouts This example will show you how to create a test project with Cantata++ v5.0 Compiler configuration for MS2005 or GCC If your test fails, check your source code for obvious mistakes/ bugs (note: this is debugging, different to testing) Build, Run, Extend the test suite until full coverage has been achieved Generate Cantata++ Results in XML & HTML file formats 60 See the exercise handout for full instructions and screenshots. The options file needs to be in the current directory when make is running, so that an existing user-defined makefile can know whether to use Cantata++ or not. REPLACE functions are discussed in detail in the advanced Cantata++ course. The structured use of directives allows re-use from test case to test case.14 Flexible Test Build / Run Code Verification Build and run test projects from inside Eclipse Build and run with users own IDE Automated regression tests from command line scripts Checks for expected and unexpected exceptions, standard and user-defined data types, global data. The demonstration also covers advanced functionality such as wrapping, and the Eclipse user interface to efficiently add in extra test cases. A standalone C/C++ test executable is generated. To solve this, manually copy the file after running the Install MSVC++ addin program Target Compilers (custom ports) Please speak to your course instructor if your intention is to use Cantata++ in a Non Standard environment. This banner also includes the name of the results file. We will use wrapping where necessary to complete code coverage and execute difficult to test conditions If your test fails, check your source code for obvious mistakes/ bugs (note: this is debugging, different to testing) Build, Run, Extend the test suite until full coverage has been achieved Generate Cantata++ Results in XML & HTML file formats 7576 $ %$ 8 Generated Cantata++ Results in XML & HTML file formats showing the tests passed to 100% boolean coverage, and the blood pressure function correctly meets its specification 7677 09:15 Introduction to IPL and Emenda 09:20 Introduction to Unit & Integration Testing 09:30 Cantata++ v5.0 Overview 10:15 Demonstration of Cantata++ v5 10:30 break 10:45 Installation of Cantata++ v5 11:00 Example 1 Reverse String (Dynamic Testing) 12:15 Lunch 13:15 Example 2a Blood Pressure (Integration Testing) 14:00 Example 2b Blood Pressure with Advanced Coverage 14:45 break 15:00 Example 3 List Class (White Box Testing) 15:30 Design for Testability 16:00 Testing on Target 7778 09:15 Introduction to IPL and Emenda 09:20 Introduction to Unit & Integration Testing 09:30 Cantata++ v5.0 Overview 10:15 Demonstration of Cantata++ v5 10:30 break 10:45 Installation of Cantata++ v5 11:00 Example 1 Reverse String (Dynamic Testing) 12:15 Lunch 13:15 Example 2a Blood Pressure (Integration Testing) 14:00 Example 2b Blood Pressure with Advanced Coverage 14:45 break 15:00 Example 3 List Class (White Box Testing C++) 15:30 Design for Testability 16:00 Testing on Target 78 #79 White Box Testing 79 (80 /$ %90 If you test a car, you can do this in two ways Driving it (left, right, reverse, brakes, etc) Checking it in a garage Driving is black box Garage check is white box Only the white box tester would find the small hole in the petrol tank Same in software - white box testing finds the obscure implementation problems 80 We recommend a mixture of black box (functional) and white box (implementation) testing when testing C++ classes. Check-in of passing tests tied to check-in of source code Set up automated regression runs Integration Testing Phase Some objects may be better tested at integration stages (e.g. hardware interaction layer) Wrapping can be used with a test script or completed standalone Overlay code coverage from different stages of testing and test runs to get complete picture.36 36 9 Product Managers Long term product reliability Code base maintainability Development Managers Deliver on time Deliver within budget Deliver to agreed quality standard Quality Managers Independent visibility of quality Engineers Powerful, flexible easy to use tools Fits with their way of working To Product Managers Long term product reliability. This is called robustness testing.34 $ %,11' We implemented the two tests, as per the test plan. Specialisations of the templates are written by the compiler when the template is instantiated, e.g. List mylist; mylist.push(10); So what should you test? The ASCII Text results file (.CTR) is written out to the project directory and is viewable in a highlighted form within a Cantata++ view and corresponding Outline view. This should be seen as two IDE views on the same project code. 104 End. They contain the correct function prototype and declare a function return, but this is not initialised. Checks Checks Download Test Exe Application Layer Target Interface Layer RTOS / Kernel Target Hardware Upload Results Why do it When to do it How does it Deployment issues EC++ 96 This slide introduces the topics covered in the remaining slides. The testing of advanced C++ concepts such as these is covered by Emenda s Testing Advanced C++ follow on course, or can be covered in our advanced workshops. The structured use of directives allows re-use from test case to test case.12 The Professional s C and C++ testing tool 12 Cantata++ is a professionals unit and integration testing tool for C/C++. A one-time change to the compile and link commands in a user defined makefile is all it takes to set Unit Tester ready for use. All those enabled will have stubs auto-generated into the test script. In addition to this training course, Emenda also provides consultancy, and an advanced training course covering C++ Testing (Templates, Polymorphism, etc) and Embedded Software. (40 " PC Windows UNIX Run the installer program cantpp.exe Make sure your compiler is already installed (MSVC++.NET 2003, 2005 or GCC 3.4.2) Make sure you have administrator privileges Have your license.dat file to hand Choose evaluation option, and all defaults where possible Run the installer program cantpp.bin Make sure your compiler is installed (e.g. GCC 3.4.3) Have your license.dat file to hand Custom Port Install for Custom Port Speak to us regarding compiler libraries and target issues 40 Installation Issues No known problems in v5 on English language computers On German machines, sometimes the addin gets copied to My Documents instead of eigene Dateien. Existing tests What test suite investment do I already have? Automated wrapping is unique to Cantata++ Integrated coverage (not just reporting coverage like other tools, but checks on coverage requirements causing tests to pass/fail) Using Cantata++ is not rocket science. Should we test boundary values such as 60, 120? View in Cantata++ and determine whether and how to plug the gaps: Extend existing test suite with more test cases Zoom in Cantata++ reaches the parts other tests fail to reach! Overlay all stages / tests runs to get the complete picture Incremental Testing of new functionality What test strategy is going to work for my additional functionality. Example of Use selectively - some calls you want to intervene (to check or change) others you do not. Note that any C/C++ code can be inserted into an instance of a stub. (95 Testing on Target 95 Introductory title slide (96 Testing on target is building tests using the crosscompilation environment and running the tests on a simulator or on the actual processor. When generating a test script Cantata++ presents the list of calls with suggestions for what to stub or wrap. There is code completion within the editor for all Cantata++ directives. The demonstration starts from having a source file to test, and going on to create a Cantata++ project, change compiler and test tool settings, generate a template test script, link and run the test, and examine results. If it is false, the contents of the file will be overwritten. This example extends the previous test to show that boolean coverage is an even more rigorous metric than we have currently used.75 9"/ All examples described in exercise handouts Extend the previous test to obtain 100% boolean coverage Compiler configuration for MS2005 or GCC This is an integration test. #(90 D-! When Cantata++ is being used, the macro CANTPP_ is always defined (automatically). Could be bubble sort, quick sort, merge sort Call private member functions of class Set the private data of class Check the private data of class Requires some form of implementation specification An algorithmic check rather than a functional check 81 #82 +8:3% Make the test script a friend of the class under test maintains encapsulation and data hiding from other classes only one test script has access (enforces independence of test scripts) The Instrumentation for Testability tool does this automatically 82 Notes on C++: Private members of a class are not accessible from outside the class. - Stubs must always be linked in so must always be used - Wrappers by default pass straight through, so you only need to add an instance to check/modify behaviour if needed.))101 %"! Build HOST Test Exe Download to target Test Exe TARGET Run Stdout Results Summary Compiler IDE Pass/Fail Return Upload from target via USB, LAN or Serial.CTR ASCII Text.CTG Studio tests.cov Studio coverage 101 This slide animates, show the flow of files from host to target and back. They allow engineers to write tests in C/C++. It is the code coverage quality bar. More on this later! 6162 09:15 Introduction to IPL and Emenda 09:20 Introduction to Unit & Integration Testing 09:30 Cantata++ v5.0 Overview 10:15 Demonstration of Cantata++ v5 10:30 break 10:45 Installation of Cantata++ v5 11:00 Example 1 Reverse String (Dynamic Testing) 12:15 Lunch 13:15 Example 2a Blood Pressure (Integration Testing) 14:00 Example 2b Blood Pressure with Advanced Coverage 14:45 break 15:00 Example 3 List Class (White Box Testing) 15:30 Design for Testability 16:00 Testing on Target 62 Lunch the most important part of the day!63 09:15 Introduction to IPL and Emenda 09:20 Introduction to Unit & Integration Testing 09:30 Cantata++ v5.0 Overview 10:15 Demonstration of Cantata++ v5 10:30 break 10:45 Installation of Cantata++ v5 11:00 Example 1 Reverse String (Dynamic Testing) 12:15 Lunch 13:15 Example 2a Blood Pressure (Integration Testing) 14:00 Example 2b Blood Pressure with Advanced Coverage 14:45 break 15:00 Example 3 List Class (White Box Testing) 15:30 Design for Testability 16:00 Testing on Target 63 This example is an integration test because it is testing the interaction of one function (check_blood_pressure) with two other subroutines (for low and high blood pressure respectively). For example, ABC should return CBA And string should return gnirts If a NULL string is passed, NULL should be returned In this demonstration, we will: Define a Test Plan for this Function Implement the tests in Cantata++ v5 Measure Coverage Obtained Complete Coverage by Adding More Test Cases 32 Check the Exercise Handouts for more information.33 Reverse String Test Plan Every dynamic test has 3 stages: Initialisation of the software under test Execution of the software under the initial conditions Verifying that the results as as expected Test 1: Pass in ABC, expected return is CBA Test 2: Pass in xyzab expected return is bazyx We wish to test to 100% Decision Coverage DEMONSTRATION 33 Unit Test Planning This is perhaps the hardest phase of testing. Examples of when simulation may not be wanted: Testing using the real hardware / firmware rather than a dummy implementation which might be incorrect! Simulation is too complex / costly Simulation of system calls The C++ stubbing problem: Functionality implemented in C contains less function calls than the equivalent functionality implemented in C++. By returning this state from main() we can easily write makefiles (or shell scripts or batch files) which depend on the pass/fail result of the test.45 4 // Each method of the test class implements a single test case (this can test more than one method/feature of the class under test) void test_case_name() { } START_TEST("test_case_name", "test case description"); // initialise input data // call software under test // check return, params and global data END_TEST(); 45 Cantata++ functions rather like a state machine, with everything happening between START and END_TEST. How can you test template code? However, sometimes it is convenient for two closely linked classes to have direct access to each others private data, whilst retaining the protection afforded by privacy from all other classes A class can declare another class or function to be its friend. The default instance for a stub will always need to be edited to set the return value, but the default instance for a wrapper will simply call the original object and pass through the return and parameters unaltered. Cantata++ supports both variants of this metric (Masking, and Unique Cause).28 ,44+5 Copy of the source code is instrumented for Coverage Other Libraries Results Summary Source Code Copy of Source Code Build Test Exe Run Test Results Coverage Explorer Test Script Libraries Coverage Viewer Select a Coverage Rule Set when generating a Test Script 28 Again, this is just what we have seen before. In C, this is usually an isolated function or subroutine. Please contact us for more information about our other courses.3 09:15 Introduction to Emenda and IPL 09:20 Introduction to Unit & Integration Testing 09:30 Cantata++ v5.0 Overview 10:15 Demonstration of Cantata++ v5 10:30 break 10:45 Installation of Cantata++ v5 11:00 Example 1 Reverse String (Dynamic Testing) 12:15 Lunch 13:15 Example 2a Blood Pressure (Integration Testing) 14:00 Example 2b Blood Pressure with Advanced Coverage 14:45 break 15:00 Example 3 List Class (White Box Testing) 15:30 Design for Testability 16:00 Testing on Target 34 Emenda Software Limited Independent UK & Germany based Company Offices in Cheshire, UK & Munich, Germany Activities: Software Training Software Tools Support Software Consultancy Software Standards, e.g. D0178B, FDA Cantata++ and Klocwork Support in DACH Small & technically focused company Sectors: Communications Aerospace Defence Transport Emergency Services 45 Independent UK Software House since 1979 Based in Bath, UK Activities: Software Implementation Software Products Software Consultancy Employs over 230 Software Engineers Certified to ISO 9001:2000 and TickIT Sectors: Communications Aerospace Defence Transport Emergency Services 56 09:15 Introduction to IPL and Emenda 09:20 Introduction to Unit & Integration Testing 09:30 Cantata++ v5.0 Overview 10:15 Demonstration of Cantata++ v5 10:30 break 10:45 Installation of Cantata++ v5 11:00 Example 1 Reverse String (Isolation Testing) 12:15 Lunch 13:15 Example 2a Blood Pressure (Integration Testing) 14:00 Example 2b Blood Pressure with Advanced Coverage 14:45 break 15:00 Example 3 List Class (White Box Testing) 15:30 Design for Testability 16:00 Testing on Target 6 Automated Test Script Generation Parse of source code and dependencies (uses the EDG C/C++ parser) The complete test harness allows the code be tested without the remainder of the system or a GUI to drive data into it.)61 $ %$ 8 Created our first test project for Cantata++ Configured the build with our chosen compiler Implemented the tests as according to the specification Discovered a bug! The end condition was not implemented correctly Fixed the bug, re-ran all the tests Generate Cantata++ Results in XML & HTML file formats showing the tests passed, and coverage had been achieved However: Is there more we can test here? Verification Flow NB - the verification flow is from test to appropriate de-composed design level. In C++, unit testing usually occurs at the class level. See test script for an example.52 A+ The DECLARE_EXPECTED directive can be used for the negative testing of classes It takes a copy of the object which is then automatically checked at the end of the test START_TEST( ); // initialise input data DECLARE_EXPECTED(object); // take copy here // call software under test // check return, params and object state END_TEST(); // automatic check is done here 5253 A+ The expected object can be referenced using EXPECTED(object) START_TEST(string to list conversion); // initialise input data string a_string(an arbitrary input string); DECLARE_EXPECTED(a_string); // call software under test List a_list = convert_to_list(a_string); // check return, params and object state CHECK(a_list.length(), EXPECTED(a_string).len()); END_TEST(); 5354 01 can be used to verify that exceptions are thrown by the software under test when expected Check that no exceptions have been thrown Check that a specific exception has been thrown The macros have implicit bracketing and C++ exception coding rules must be taken into account 54 99% of the time, we are checking that no exceptions have been thrownthis is the usual case. The Rule-Sets available are also configurable via Workspace Preferences. Cantata++ V5 has the highest level of Eclipse integration (UI) where Tools and their user interfaces are dynamically integrated at runtime including window panes, menus, toolbars, properties, preferences, etc. 65 Yes it can!66 $ 11$ % allows us to perform such integration testing through the use of wrapping Wrapping allows the test script to Verify the order in which wrapped calls are made Verify the parameters passed in each wrapped call Change the return value to force coverage of particular paths All controlled on a call by call basis from the test script It allows tests to be designed which cover those difficult to reach cases (e.g. hardware errors, etc.) 6667 $ 11*++ Calls are wrapped, not functions Can elect to wrap some calls to a function but not others Original function call is still made Calls to wrapper functions are inserted BEFORE and AFTER the original function call Can be thought of as call instrumentation 67 Wrapper functions can check parameters passed to, or change return values passed back from, the original function68 $ 115/ Conceptually, wrapper functions sit between the software under test and any external routines Call Original Software Under Test Return External Routine Call BEFORE Call Modified Software Under Test External Routine Return AFTER Return 68 #69 95*.5.5/ BEFORE function can: Check that the call is in the correct sequence Check parameters are correct Modify parameters to be passed to the original function AFTER function can Modify the return value passed back to the original function Only user-selected calls are wrapped Selected on a call by call basis 69 Actually, the wrapper is three functions, but we will not cover REPLACE functions in this training course. What test cases should I design and implement? Cantata++ supports both variants of this metric (Masking, and Unique Cause).26 %4+= Improved Efficiency Efficiency Acceptable level of confidence Coverage ROI More efficient testing Training: Design for testability Testing techniques Test Automation Tool Test effort / cost Stop Stop Testing Testing Coverage also helps measure efficiency of given test effort 26 An acceptable level of confidence is how thorough the testing needs to be. Also think about unexpected events, such as hardware failures, out of memory, or boundary values (such as min/max numbers in your system). The test case per function style test case includes a call sequence entry (with a default instance) for each wrapper if the object wrapped is called by that function. Note that the raw ASCII text results file is what should be considered definitive for any certification requirements.16 5"06"%7/ 16 Isolation / Integration Isolation unit testing Top-down or Bottom-up integration testing Flexible Stub or Wrapper use for testing interfaces Procedural / Object Oriented / Multi-threaded Procedural Black-box or White-Box Automated negative testing for global data Full support for OO paradigm (re-use, templates, polymorphism) Fully thread-safe Multiple Environments On host: Windows / Linux / Solaris On target: Simulator / Device All tests can run unchanged on different platforms This is a summary slide introducing the flexible techniques available to Cantata++ V5 users. Test 1: Passed Test 2: Passed Both tests pass because the return value was equal to the expected return value But Coverage failed, because we failed to execute the false branch of the if decision, i.e. the case when the input parameter is NULL Coverage showed us our testing was not sufficient We then added another test case, using V5.0 s copy test case functionality We need to keep our testing specification-based 34 Always keep in mind the software specification, which should preferably be independent of the source code, and available in written form (e.g. Word document).35 $ %/ Unit Testing Phase Code / Review / Test / Debug cycle Structured developer unit testing Prior to use of debuggers Integrated with configuration management system Regression runs Each time code changes Nightly builds Integration Testing Phase Objects not unit tested Selective use of wrapping and coverage analysis Slots into integration build cycle 35 Unit Testing Phase After code is written and reviewed decide what is to be unit tested: - Isolation / bottom-up / top-down / bolt-on approach - Single C file with multiple functions - Single class or tightly coupled cluster of classes Do not add Cantata++ on-top of existing ad-hoc developer testing - replace it! Builds can be run under the de-bugger, but de-bugging should be used to aid finding the exact cause of a test failure. For isolation testing C++ this may mean writing a much larger number of stubs than for the equivalent functionality in C which can often make isolation testing C++ financially impractical. (#99 E,' for target environment Simulator Emulator Actual processor Custom built and validated by Integrated with your compiler, processor and RTOS 99 Cantata++ target ports are done for any combination of simulator/emulator and actual processor. All those enabled will have wrapper functions auto-generated into the test script. Intuitive Test Directives Easy to understand for programmers, directives are simply calls to Cantata++ library functions or executables. 8 For C the most common unit test will actually be a.c file containing one or more functions For C++ either a single class or cluster of tightly coupled smaller classes. Stubbing for isolation tests, wrapping for integration tests even if it s a single class integrating with the rest of the system. (30 09:15 Introduction to IPL and Emenda 09:20 Introduction to Unit & Integration Testing 09:30 Cantata++ v5.0 Overview 10:15 Demonstration of Cantata++ v5 10:30 break 10:45 Installation of Cantata++ v5 11:00 Example 1 Reverse String (Isolation Testing) 12:15 Lunch 13:15 Example 2a Blood Pressure (Integration Testing) 14:00 Example 2b Blood Pressure with Advanced Coverage 14:45 break 15:00 Example 3 List Class (White Box Testing) 15:30 Design for Testability 16:00 Testing on Target 30 Demonstration of V5 This assists greatly with the training, as all users see the product in action before trying it for themselves. 7 Introduce Unit and Integration Testing in relation to traditional Waterfall development lifecycle.)41 09:15 Introduction to IPL and Emenda 09:20 Introduction to Unit & Integration Testing 09:30 Cantata++ v5.0 Overview 10:15 Demonstration of Cantata++ v5 10:30 break 10:45 Installation of Cantata++ v5 11:00 Example 1 Reverse String (Dynamic Testing) 12:15 Lunch 13:15 Example 2a Blood Pressure (Integration Testing) 14:00 Example 2b Blood Pressure with Advanced Coverage 14:45 break 15:00 Example 3 List Class (White Box Testing) 15:30 Design for Testability 16:00 Testing on Target 4142 Dynamic Testing 4243 The dynamic tests should check the behaviour of the software against a requirements specification The test script drives the dynamic test Set up input data Invoke the software under test Check the return value and any output parameters or global data Check the order of external function calls Check the execution time of the software 4344 1 // Test cases are implemented as independent methods (makes maintenance/debugging easier) The test script has a main() routine to open the results file and run the test cases int main() { OPEN_LOG(results file, false); START_SCRIPT(class under test, true); TEST_CLASS(class under test) test_object; test_object.run_tests(); return!end_script(true); } 44 END_SCRIPT() returns true or false to indicate the overall pass or failure state of the test. Even so, it is still a simple class with no inheritance, no external dependencies (apart from operator new), no polymorphism or other objects, templates etc. Clear and Flexible Reporting Drill-down provides results at each level, and is available through to individual test checks/directives or source code lines. If A grants friendship to B, it does not get access to B s private members in exchange Friendship is not transitive - if A grants friendship to B and B grants friendship to C, C does not automatically get access to A s private members Friendship is not inherited - if A grants friendship to B and D derives from B then D does not automatically get access to A s private members #83 +8:3% 83 #84 +*$ %90 Do not need to use the public interface to check correct behaviour Better at finding obscure implementation faults (e.g. pointers left corrupted) Makes achieving coverage easier Can call private methods directly Can set private data directly to test particular cases 84 #85 4" All examples described in exercise handouts Test the List class functionality, against its specification Obtain 100% decision coverage for this class White box test the private methods and data in this class Wrap call to operator new to obtain full coverage and test the difficult out of memory condition If your test fails, check your source code for obvious mistakes/ bugs (note: this is debugging, different to testing) Build, Run, Extend the test suite until full coverage has been achieved Generate Cantata++ Results in XML & HTML file formats 85 List is a class containing several different classes of bugs. The Results summary will be piped out to the compiler console (either in Eclipse if using a CDT managed build, or to the external compiler IDE or command line shell). Training staff in good testing techniques improves the efficiency curve, e.g. Boundary value analysis, Error seeding, State based testing, OO test case re-use Test Automation Tool Cantata++ V5! The improvement in the testing efficiency curve means you spend less test effort / cost achieving the same level of acceptance, and hence realise the ROI from purchasing Cantata++.27 44+ Coverage metrics chosen have direct impact on how many test cases are needed, and how much effort needs to be spent on testing bool foo(bool a, bool b) { a = a-1; if (a && b) { ; /* do something */ } else { ; /* do something else */ } } How many test cases are needed: (1) For entry point coverage? Test the instantiations used in real execution of the software.

Cantata++ V5 supports use with other compiler IDEs (for managing projects, building and running test exes), although the test script, stub & wrapper generation and editing facilities are only available through the Eclipse IDE.13 *++ Automated Test Script Generation Parse of source code A complete test harness environment Test driver script with test case per function Black-Box (public) / White-Box (private) modes Test script containing all necessary stubs and wrappers Full interface control Simulation of interface to external objects (Stubs) Control of interface to external objects (Wrappers) Call sequence validation Intuitive Test Directives Quickly develop structured, repeatable tests in C/C++ Allows for easy test-case re-use 13 Automated Test Script Generation Parse of source code and dependencies (uses the EDG C/C++ parser) The complete test harness allows the code be tested without the remainder of the system or a GUI to drive data into it. (92 1" Template Class List { List(); T pop(); sort(); }; Template code in the above form is not executable code. Cantata++ V5 is built on Eclipse 3.2 (including the C development Tools CDT). NB Bolt-on is neither top-down or bottom-up but all-over interfaces, and perfect for wrapping. Understand if changes to common code modules will affect current or other projects.) Our support line is open from 08:30 until 17:00 every working day, or you can us using the details below Support (in Germany): +49 (0) Website: #88 Design For Testability 88 ##89 /856"! It is good to plan testing in advance of software development, to make life easier during the testing phase Certain C++ constructs and keywords can cause problems in testing: static const template For example: How can you test statically declared functions that can, by definition only be seen at file scope? (2) For statement coverage? Note that as with a stub, any C/C++ code can be inserted into an instance in any of the wrapper sections.23 ,$ 115 Copy of the source code is instrumented to call wrappers Other Libraries External Objects Source Code Copy of Source Code Build Test Exe Run Results Summary Test Results Wrappers Coverage Results Test Script Libraries Wrappers auto-generated into Test Script 23 Again this is just what we have seen before. The structured use of directives allows re-use from test case to test case.7 !" System Requirements Validation Acceptance Test Architectural Design Verification System Test Phase Exit Criteria Detailed Design Verification Integration Test Phase Exit Criteria Component Design Verification Unit Test Phase Exit Criteria Code Implementation Flow Dynamic Testing Are design requirements met?)11 09:15 Introduction to IPL and Emenda 09:20 Introduction to Unit & Integration Testing 09:30 Cantata++ v5.0 Overview 10:15 Demonstration of Cantata++ v5 10:30 break 10:45 Installation of Cantata++ v5 11:00 Example 1 Reverse String (Dynamic Testing) 12:15 Lunch 13:15 Example 2a Blood Pressure (Integration Testing) 14:00 Example 2b Blood Pressure with Advanced Coverage 14:45 break 15:00 Example 3 List Class (White Box Testing) 15:30 Design for Testability 16:00 Testing on Target 17 Automated Test Script Generation Parse of source code and dependencies (uses the EDG C/C++ parser) The complete test harness allows the code be tested without the remainder of the system or a GUI to drive data into it. To Development Managers Consistent test case structure and generation. Every instantiation? The "Built on Eclipse" trademark is used to identify a product that includes the core Eclipse Platform, specifically the runtime, SWT, JFace, and Generic Workbench components. What about making sure that the software works with values such as 59, 61, 0, infinity74 09:15 Introduction to IPL and Emenda 09:20 Introduction to Unit & Integration Testing 09:30 Cantata++ v5.0 Overview 10:15 Demonstration of Cantata++ v5 10:30 break 10:45 Installation of Cantata++ v5 11:00 Example 1 Reverse String (Dynamic Testing) 12:15 Lunch 13:15 Example 2a Blood Pressure (Integration Testing) 14:00 Example 2b Blood Pressure with Advanced Coverage 14:45 break 15:00 Example 3 List Class (White Box Testing C++) 15:30 Design for Testability 16:00 Testing on Target 74 Advanced Coverage Metrics Sometimes, simple statement or decision coverage is not enough, particularly when we are working towards rigorous standards such as FDA or D0178-B. Note that if you are stubbing a function or class in your project then this should be deleted to avoid build errors when including the stub.22 $ 11 A function/method in test script with programmable instances Intercepts call to external software, firmware or hardware Wrapper for External Object Check Out Parameters Check Call sequences Before Wrapper Modify Out Parameters Source Code Replace like a Stub Replace Wrapper External Object Modify In Parameters and Return After Wrapper Check In Parameters and Return 22 As with Stubs, programmable instances allow the Wrapper sections to perform different actions depending on the call being wrapped. (3) For decision coverage? #9 !& Project C / C++ Source File int strlen (char *str) { int len = 0; // Do calculation here return len; } Unit Function (or Class) 9 A test project is still required i.e. the object(s) to test and any dependent header files need to be located in a project to build. EC++ and ETC++ subsets of ISO C++ standard reducing code bloat improving execution times Scaleable EC++ Standard EC++ is scaleable up towards full ISO C++ Include / Exclude selected language features Templates Exceptions Namespaces 103 Scaleable All compiler switches for scalability are supported Pre-Built compatibility modes as standard e.g. GreenHills MULTI EC++ For more info see C++ Target Testing paper C++ is a scaleable language, and Cantata++ is an equally scalable testing tool for it. Cantata++ coverage will report for which types the template has been instantiated 92 It would make sense to put this #ifdef code in a header file. Standalone or mirroring a project in a compiler IDE Build Libraries Test Exe Run./"01" 23.1 Select source code file to generate Test Script 4 0./" 15 This slide animates on-click to show the various stages. Is code sufficiently tested? Note that if you use stubs for hardware you may want to optionally remove them when migrating tests from a host to the target.17 9"-:$ %;"< Public 4%- Private 4%- 17 Black-Box testing is purely through the public interface. Fault injection, where errors are deliberately injected into the software under test, also comes into this category. (197 97 E $ %!' Process requirement Cost effectiveness Certification Contractual acceptance criteria Dangers in Host / Target environment differences Cross-compiler bugs Supposedly standard library functions (printf, scanf, etc) Correct interface operation to target input/output devices Interaction with the RTOS or real time kernel Ordering of bytes within words Word length Structuring, packing of compound data (arrays,records) Data representation Memory constraints Timing errors Why test on target falls into two categories: Commercial process requirements Technical advantages in testing the code running on the real target environment not just on the development host. Data manipulation sequence verification checking global data set and read in the correct order by multiple units Cantata++ is fully thread-safe. It is worth asking what proportions of a customers code falls into the various layers in the graphic. NB the default call sequence validation generated by Cantata++ for each test case, is based on the calls made by that function/method only and is of the format: {{call_a#default}{call_b#default}} Which checks that the calls to the external objects occur in any order and any number of times, providing a default instance for the call. How much of the code have we tested code coverage requirements. ((100 81"! Target environment Any 8-bit, 16-bit, 32-bit or 64-bit processor Sufficient addressable memory IDE or CLI integration with compiler simulator/emulator Building and Validation Access to full target environment Building library source code Configuration settings Validation Suite Host-Target communication Printf and capture of Stdout 100 The full details of the customers target environment are captured using the Cantata++ Non-Standard Platform Porting questions (PPIQ) document. (50 A+ Each test case should initialise all data to which the software has access to a known random value glb_1 = 0x55; glb_2 = 0x55; glb_3 = 0x55; Specific values that are required by the software can then be set glb_1 = 10; 50 This initialisation is done automatically in Cantata++ 5.0, via the helper functions for global data. Stubs which are a dummy replacement for hardware are always subject to the risk that the stub incorrectly mimics the behaviour of the hardware. Inputs Inter-process communication, interfaces between functions, external software or hardware Checks Checks Checks Checks Memory allocation and de-allocation between units Call sequence and data manipulation sequence verification Multi-threaded application behavior 10 Explanation of the detailed points: This is testing parameter values and returns passed between objects Memory allocation/de-allocation between units and total utilization of memory Call sequence validation checking the order that calls are made, and determining actions (via stubs or wrappers) or specific instances. Call sequence validation allows control over both the call order and any programmable stub/wrapper instance being used. Should we test min/max conditions also? Cantata++ is tightly integrated with Eclipse, (but can still be used with non-eclipse compiler IDEs). If the parameter to END_SCRIPT() is true, the summary is also written to stdout.58 9,8+ SET_LOG_LEVEL(cppth_log_level) RESET_TIMER() START_TIMER() STOP_TIMER() GET_TIMER(cppth_timer_type, false) 58 The cppth_log_level can be one of: cppth_ll_none cppth_ll_minimal cppth_ll_concise cppth_ll_normal cppth_ll_detailed The cppth_timer_type can be: cppth_tt_cpu cppth_tt_elapsed If the second parameter to GET_TIMER() is true, then time spent in test harness directives is included in the times returned. Aim to exercise all branches of your software (100% decision coverage) and every testable line of the specification (preferably in a separate test case). Tests can unambiguously pass/fail on the code coverage requirement (specified in a RuleSet) i.e. thoroughness of the test as well as functional correctness of the code. A de-bugger is not a test tool: not structured and repeatable You want systematic farming of bugs not random grazing for them. The Test Results Explorer is a Cantata++ view in Eclipse, displaying a node for each check / directive with Actual and Expected values for the selected node. 90 It would make sense to put this #ifdef code in a header file. (20 /6 A function/method in test script with programmable instances Replaces call to external software, firmware or hardware Source Code Check Parameters Check Call Sequences Replace Return Parameters Stub for External Object Stub is a dummy function replacing interface to the External Object External Object 20 Programmable instances allow the stub to perform different actions depending on the call being stubbed. NB The project itself needs to be analysed (to obtain information about the code through a parse) with Cantata++, before test scripts can be generated NB This slide is not to show test script generation, but the process of identifying units (source files) to test and then identifying test cases for the individual functions or classes therein (10 $ %' Software testing that involves taking several units together and testing their interaction as a group. Target port validation can be done either at IPL or remotely by the customer using the Cantata++ Target Validation Suite. These next slides deal with the most common issues arising when testing C or C++ code. Cantata++ V5 parses the source code to provide all the parameters and global data information required to set data values for test cases, but it does not use this parse to set the data values for test cases as that would be just testing the code does what the code does (which it will if it compiles), not what it should do according to the design requirement/specification.8 $ %&' Unit testing is the lowest level of testing performed during software development, where individual units of software are tested in isolation from other parts of a program. This type of product is able to run standalone with no prerequisites of other Eclipse components. Tests written for direct to target execution only Direct to target execution using wrapping provides full test control over the real interfaces 98 Development stages You can do Target Testing with Cantata++ at all stages of the lifecycle Application layer code Stubbing more viable for application layer external calls, then for hardware. Full Interface Control Users can choose to use Stubs or Wrappers for calls, depending on what they want to do. Wrapping (and cluster level testing) thereby using the real external objects is the solution to this C++ stubbing problem. Automated regression tests are essential to retaining the value of unit testing. ()91 D-!;/< Again, use the define CANTPP to conditionally control the definition of const: #ifdef CANTPP #define CONST /* only defined for testing */ #else #define CONST const /* normal release build */ #endif Then declare data with the keyword CONST. When generating a test script Cantata++ presents the list of calls with suggestions for what to wrap. The advantages of having integrated checks in the test script on the % code coverage achieved for each metric are: The user does not have to separately do coverage analysis visually. 27 Why use code coverage? How can you modify const data? (Do first click) then explain except that this time the source code calls external objects. Life can be made much simpler with a bit of forward planning. 1 Steve Howard Siemens PTD (China) 12 09:15 Introduction to IPL and Emenda 09:20 Introduction to Unit & Integration Testing 09:30 Cantata++ v5.0 Overview 10:15 Demonstration of Cantata++ v5 10:30 break 10:45 Installation of Cantata++ v5 11:00 Example 1 Reverse String (Dynamic Testing) 12:15 Lunch 13:15 Example 2a Blood Pressure (Integration Testing) 14:00 Example 2b Blood Pressure with Advanced Coverage 14:45 break 15:00 Example 3 List Class (White Box Testing) 15:30 Design for Testability 16:00 Testing on Target 2 This training course covers the use of Cantata++ for both C and C++ developers. This is the essence of negative testing, also sometimes called robustness testing. Boolean coverage proves that we have tested each operand in a true and false condition. Automated regression tests can pass/fail on coverage requirements without manual checking of code coverage obtained. Coverage Metrics MC/DC is Modified Condition Decision Coverage and is a metric required by the Civil Avionics software testing standards. It is a one day course, with hands on examples and presentations by a Cantata++ expert. Cantata++ is most useful at these stages (dark-blue).)21 , /665 Other Libraries External Objects Source Code Results Summary Build Test Exe Run Test Results Stubs Test Script Libraries UnitTester Libraries Coverage Results Stubs auto-generated into Test Script 21 This is the diagram we have seen before. NB Cantata++ V5 generates test scripts on a per file (.c or.cpp) basis only. For C++ Cantata++ automatically allows access to the private implementation details of the class under test (through an automated Friends mechanism) White Box tests access private elements directly Call private methods Set and check private data More efficient testing, better enables discovery of bugs Unit Tester automated Friends mechanism Copy of the original class source code instrumented Copy declares test script as Friend of class under test Grants access to private implementation details of class Retains encapsulation integrity of source code Source code does not have to be changed just for testing18 "" %:1" Base Class Base Class Test Derived Class A Derived Class A Test Derived Class B Derived Class B Test 18 Cantata++ enables Re-use of Test Scripts in a parallel inheritance hierarchy Each class has an associated test class Each test class defines one or more test cases (coded as methods) Inheritance is used to derive tests from base class tests Templates are used to instantiate from template test class The process is aided by the Factory Method approach #19 4" Stubs Simulate interface to external objects Replace real object with a dummy Inputs Checks Checks Checks Checks Wrappers Control real interface to external objects Valuable when simulation is not possible or wanted Solves C++ Stubbing problem 19 Contrast the two techniques of stubbing and wrapping. NB Occasionally IPL will build and validate on a simulator and then get the customer to validate on their actual target processor if that cannot be supplied to IPL. Feel more comfortable re-using code Monitor quality of outsourced development To Quality Managers Consistent, objective project-wide reporting Verify that code meets maintainability standards Implement coverage rules to meet compliance requirements To Engineers Powerful, flexible easy to use tool suite plug-in in Eclipse Makes writing and running test-cases fast, easy, and thorough.37 , 8 Built on Eclipse TM Fully integrated with Eclipse 3.2 and CDT Automated wrapping All the control of stubs plus more Uses the real interface to external object Integrated code coverage Integrated with the test harness no external tool required Advanced syntax code coverage highlighting, not just by line Simple scripting Developers can use the language they know (C, C++) instead of learning a new testing language (TCL, TTCN-3, etc) 37 This slide is technical summary highlighting the unique advantages of Cantata++. The build and run either uses Eclipse CDT Managed Make, or the external compiler IDE standard Build and Run functionality. User defined types can also be checked as long as an equality operator has been defined. Automated negative testing for global data i.e. initialising all global data and expected global data to Hex 55 and checking that it has not been inadvertently changed. Analyse the thoroughness with Cantata++ coverage instrumentation of these tests. Some of the bugs in this class are obscure and difficult to find unless white box methods are employed. More efficient testing Training staff in making designs more testable in the first place, improves the efficiency curve. The test script generator provides intelligent suggestions on stubbing or wrapping for all calls made by the software under test, and when the stub/wrap/do nothing action is selected by the user the Stub and Wrapper code are written to the end of the test script with full prototypes. #59 4,4B8+ CHECK(actual, expected) CHECK_RANGE(actual, lower, upper) CHECK_MEMORY(description, &act, &exp, length) CHECK_OBSERVATION(question, Y/N) 59 The CHECK_RANGE directive is particularly useful for floating point checks. #86 $ %$ 8 Generated Cantata++ Results in XML & HTML file formats showing the tests passed to 100% decision coverage, and the list class correctly meets its specification Wrapped the call to operator new to test the out of memory functionality White box tested this class 86 #87 09:15 Introduction to IPL and Emenda 09:20 Introduction to Unit & Integration Testing 09:30 Cantata++ v5.0 Overview 10:15 Demonstration of Cantata++ v5 10:30 break 10:45 Installation of Cantata++ v5 11:00 Example 1 Reverse String (Dynamic Testing) 12:15 Lunch 13:15 Example 2a Blood Pressure (Integration Testing) 14:00 Example 2b Blood Pressure with Advanced Coverage 14:45 break 15:00 Example 3 List (White Box Testing C++) 15:30 Design for Testability 16:00 Testing on Target 87 Questions Don t worry if you think of a question after the training. Double-clicking links directly to the appropriate point in the test script. Clear and Flexible Reporting Unambiguous pass/fail results Standards compliant reports Drill-down test and code coverage results Integrated Eclipse views, summary results, full text results and XML project-wide report 14 Flexible Test Build / Run Builds done inside Eclipse use CDT (with the GCC compiler toolchain) Builds done with a users compiler IDE have a mirrored project inside Cantata++ Eclipse project view. Test cases can be generated in a generic or test case per function/method format. There is a non-linear trade-off between achievement of code coverage levels and the test effort to required. EXPECT_EXCEPTION(MyException x) CHECK(x.except_errno, EINVAL); END_EXCEPTION57 9,8+ OPEN_LOG(results file name, false) START_SCRIPT(title, true) END_SCRIPT(true) START_TEST(test case name) END_TEST() 57 The results will be appended to an existing output file if the second argument to OPEN_LOG() is true. Cantata++ V5 is shipped with Eclipse 3.2, but if customers already have an Eclipse environment, then the Cantata++ plug-ins can just be copied straight into the customers set up. It is a quasi code generator. It s often a good idea if one test function tests one part of the specification, and there should be independence of tests too so that one test failure doesn t cause all other tests to fail.46 &11/8 Uses normal C++ coding practice global_int_variable = 42; int* pointer = &global_int_variable; List a_list; a_list.append(42); Need to set any value needed for by the software under test (parameters and global data) The input data should be set in each test case to ensure that dependencies between tests do not arise 46 Many of these initialisations are provided automatically by Cantata++ 5.0, commented out in the generated test script.47 0/% The software under test should be invoked as normal Class* ptestobject = new Class(param); Class testobject(param); ret_val1 = testobject.method(param1, param2); ret_val2 = ptestobject->method(param1, param2); A variable should be declared to receive the return value from the software in order to allow it to be checked (if applicable) 4748 4%-8 Return values, output parameters and global data CHECK(variable, 42); CHECK(a_stack.size(), 1); CHECK_NAMED(description, a_list.length, 9); CHECK_RANGE(square_root, 1.414, 1.415); CHECK(a_string, String(expected)); Execution Time CHECK_RANGE(GET_TIMER(cppth_tt_elapsed), 0.0, 0.5); 48 CHECK is a C++ template, able to check all compiler types (float, int, etc). Supports all styles of OO testing assisted by the Factory method approach. Normally, it is only in error handling cases, or fault injection/ robustness testing where we would expect exceptions to be propogated from the software under test (eg. Engineers can start being productive within a day.)51 A+ After the software has been executed, the data can be checked CHECK(glb_1, 10); CHECK(glb_2, 20); CHECK(glb_3, 0x55); These checks will ensure that the software has not altered the values of glb_1 and glb_3 but has set the value of glb_2 correctly 51 Checked automatically in Cantata via the helper functions for global data in the generated test script. This is assessed by IPL prior to accepting an order for a Non-Standard licence, and helps identify feasibility of the port and required timescales. Follow the instructions after running cantpp.exe on Windows, or cantpp.bin on Unix and always have your license.dat file available at install time, as this determines which compilers you can install Cantata++ for. Each call will have different parameters May need to change return value from some calls Need to distinguish different call instances through the use of the expected call sequence (as seen in stubbing) EXPECTED_CALLS(wrapper#instance); // call software under test END_CALLS(); 7172 9"/ All examples described in exercise handouts Create a test project, as before Compiler configuration for MS2005 or GCC This is an integration test.)31 Reverse String is a simple first example to demonstrate Cantata32 Reverse String Specification reverse_string is a function taking a single char* as input. When generating a Test Script a coverage Rule Set is selected. 89 Only thinking about testing once code has been written is not advisable. And this is where the clever bit comes in Cantata++ takes a copy of the source code is instrumented to call the wrapper before the external object, so your original source is not modified in any way and the copy is destroyed after the test build.24 /6+$ 11 Action Call original function Call original with modified params Original function linked with test Use with system calls Use selectively Check parameters Check call order Set return value Change output parameters Stubbing (optional) Must Must Must Wrapping (optional) (optional) Must (optional) (optional) (optional) (optional) (optional) (optional) 24 Contrast the flexibility of Stubs and Wrappers. The call sequence can validate the precise call order by removing the {}, and each call can have an unlimited number of instances for controlling stub or wrapper actions on any specific cal. The friend then has permission to access the private data and functions of the class The access granted via the friend mechanism is tightly controlled Friendship is not necessarily mutual (commutative in mathematical terms) - it must be explicitly granted in each direction. Note that Cantata++ also supports MC/DC coverage in both relaxed and masking modes. The test case per function style test case includes a call sequence entry (with a default instance) for each stub if the object stubbed is called by that function. Note that this deferred approach requires an additional stage of capturing the data stream from the target to a file to be de-multiplexed. For any given input string, the reverse of that string should be returned.)104 %-C/ Any more questions? What happens if memory allocation fails (malloc, operator new)? 91 It would make sense to put this #ifdef code in a header file. Forgetting to add in one of these directives is the main cause of a Script Error in the Cantata++ results file. The XML Test Report is presented in a Cantata++ view, but also written out to the project directory in a Cantata++ Output sub-directory, by default in HTML format, or RTF if selected. The level is best set by management, and can be project / company wide standard or vary according to the requirements of a particular object. They contain the correct function prototype will in the default instance simply pass through to the original call. It is fully thread-aware and thread-safe Multiple Environments Cantata++ supports host and target platforms (non-standard licences provide both). Ask whether the customer has seen these dangers in their own work.)102 %"! Build HOST Test Exe Download to target Test Exe TARGET Run Stdout Results Summary Compiler IDE De-Multiplex Upload from Target Multiplex Pass/Fail Return.CTR ASCII Text.CTG results stdout stream via USB, LAN or Serial Memory Buffer.COV coverage 102 This slide animates, show the flow of files from host to target and the process of multiplexing / de-multiplexing the data to get them back on the host. We will use wrapping where necessary to complete code coverage and execute difficult to test conditions If your test fails, check your source code for obvious mistakes/ bugs (note: this is debugging, different to testing) Build, Run, Extend the test suite until full coverage has been achieved Generate Cantata++ Results in XML & HTML file formats 7273 $ %$ 8 Created our first test project for Cantata++ Configured the build with our chosen compiler Implemented the tests as according to the specification Discovered 2 bugs! The not condition was not implemented correctly, and the < and > inequality operators were the wrong way around Fixed the bug, re-ran all the tests Generate Cantata++ Results in XML & HTML file formats showing the tests passed, and coverage had been achieved 73 Is there more we can test here? If you re concerned about different functions of the same name being present in different files, then consider using namespace qualification, and placing each function inside its own namespace. Static analysis of source code can be an effective aid to this process, and Cantata++ Static Analysis provides over 300 metrics on code complexity, maintainability and reliability. - First points relate to what code coverage gives you. Eliminate the high costs of having to field fix bugs in shipped products Code base maintainability. Example of when to stop testing There are two test phase exit criteria which can be measured: 1 - Functional Requirements (measured by requirements coverage & that the code correctly performs to specified requirements. #29 0> Existing Code Base Design risk assessment Static Analysis or other static analysis tools Existing tests Code Coverage and plugging gaps Incremental Testing of new functionality Isolation / Bottom-up / Top-Down / Bolt-on Controlling interfaces to existing system Existing non-eclipse CDT projects Enable Cantata++ Options file: #tool.use=true or #tool.use=false One time makefile addition to compile / link commands ipg_comp --optfile [path to ipg.cop] comp/link 29 Existing Code Base Testing is expensive, and few start from blank sheet of paper so where and how to focus: Design risk assessment Assess risk of failure + where verification effort needs to be focussed. (70 $ $ 115/ Wrapper functions are just normal C++ functions Written by the tester or auto generated in Cantata Template wrapper functions are created by These functions can be used unchanged, only need to modify them if checking parameters or setting return value The wrapper functions are part of the test script Configuration controlled along with the test script/options 70)71 4 "$ 119%+/ What if the same function is called more than once? Just as for wrapping, a copy of the source code is instrumented for coverage according to the metrics defined in the RuleSet, so your original source is not modified in any way and the copy is destroyed after the test build. Procedural / Object Oriented / Multi-threaded Supports testing of procedural code with both black and white box techniques. This is helpful when addressing the question of automatic test case generation. The Cantata++ target Validation suite is available to any customer purchasing a Cantata++ Non-Standard licence. 2 Test thoroughness (measured by code coverage) More functional tests may just end up exercising the same code over and over again. Firstly Cantata++ parses the project, then automated test script generation for the selected source code file is just a right-click away. Building for a specific target requires access to the required development environment in full. The second half of the animation relates to the ROI (Return on Investment) for Cantata++. If the second parameter to START_SCRIPT() is true, the banner is also written to stdout. Cantata++ generates stubs for calls as selected by the user on test script generation. No other commercial C/C++ unit testing tool is built on Eclipse. NB the precise instance used is specified in call sequence using the EXPECTED_CALLS directive for each test case. A number are provided with Cantata++ and it is incredibly simple edit the text files to create your own bespoke one. (98 E $ %' Development stages Software unit / integration tests Hardware / software integration tests System acceptance tests Application layer code Automatically re-run host-based tests unchanged Remove host Stubs for target, interact with the real target Target Dependent Code Interacts heavily with the firmware or hardware target environment. A Test Script Warning directive prompts users to check that the data values used in the tests are acceptable. Code Verification Cantata++ uses CHECK directives for data and exceptions (for C++ data CHECKs use an overloaded function so the user does not need to specify the data type). Impossible. Hardware failure, out of memory, etc).55 4%-5A01 The normal (and simplest) case START_EXCEPTION call_software_under_test(); NO_EXCEPTIONS END_EXCEPTION If any exceptions are thrown then a check failure is recorded (control jumps to END_EXCEPTION) If no exception is thrown then a check pass is recorded 55 Note that these macros roughly translate to START_EXCEPTION: try { NO_EXCEPTION: CHECK_PASS(); END_EXCEPTION: } catch( ) { CHECK_FAIL(); }56 4%-501 Typically verifying correct error behaviour START_EXCEPTION call_software_under_test(); EXPECT_EXCEPTION(MyException) END_EXCEPTION If an exception of type MyException is thrown then a check pass is recorded 56 If no exception is thrown, or any other type of exception is thrown, then a check failure is recorded Note that this macro roughly translates to EXPECT_EXCEPTION: CHECK_FAIL(); } catch (MyException) { CHECK_PASS(); We could expect a particular value for an exception and check it. Its tight integration with Eclipse and simple scripting allows developers to code tests in a powerful IDE and with the programming language they are testing.38 09:15 Introduction to IPL and Emenda 09:20 Introduction to Unit & Integration Testing 09:30 Cantata++ v5.0 Overview 10:15 Demonstration of Cantata++ v5 10:30 break 10:45 Installation of Cantata++ v5 11:00 Example 1 Reverse String (Isolation Testing) 12:15 Lunch 13:15 Example 2a Blood Pressure (Integration Testing) 14:00 Example 2b Blood Pressure with Advanced Coverage 14:45 break 15:00 Example 3 Stock List 15:30 Design for Testability 16:00 Testing on Target 38 We all need a break from time to time! #39 09:15 Introduction to IPL and Emenda 09:20 Introduction to Unit & Integration Testing 09:30 Cantata++ v5.0 Overview 10:15 Demonstration of Cantata++ v5 10:30 break 10:45 Installation of Cantata++ v5 11:00 Example 1 Reverse String (Dynamic Testing) 12:15 Lunch 13:15 Example 2a Blood Pressure (Integration Testing) 14:00 Example 2b Blood Pressure with Advanced Coverage 14:45 break 15:00 Example 3 List Class (White Box Testing) 15:30 Design for Testability 16:00 Testing on Target 39 Cantata++ Installation Automated installers are provided as part of the training, either via DVD, CD or USB Stick. Target Dependent Code Wrapping is more useful for hardware interactions than stubbing, and does not have to be removed to re-run the tests using the real hardware (like stubs). If you are not testing the software object against its designed requirements, then you will end up testing against the code implementation (i.e. only testing that the code does is what the code does) which can give you a false confidence. The XML project wide report is available in summary or detailed variants, supporting HTML and RFT formats, and comes with XSLT transformations so users can configure the style of the reports for their own needs.15 ,$ -./" /! Other Libraries Source Code Test project created in Cantata++ for software under test and C/C++ Test Script dependencies. Cantata++ generates wrappers for calls as selected by the user on test script generation. #)81 /$ %90 Depends on the class implementation For example, of sort(). #49 A+ It is easy to test that the return value is set as expected However, if the software altered the value of some global data it should not be accessing, the test would still pass We may wish to ensure that certain data areas remain unchanged by the software 49 Does our software not do what it should not do?)103 64?? In these cases, more advanced metrics are needed. (93 *6>* Testing & Polymorphism C Code (functional) C++ Code (object oriented) 93 Switch(ShapeType) Shape->getSides(); /* virtual function */ { }; case SQUARE: Sides = 4; case TRIANGLE: Sides = 3; case PENT: Sides=5; The decision has moved from code, to run time! New metrics are needed to measure the execution of the abstract base class (94 86"!;1"< All examples described in exercise handouts Learn to test static and const functionality Test template code Try to achieve full decision coverage 94 Exercise 4 tests code written with static functions, using const data, and template code. (4) For boolean coverage? What does coverage of a template mean? This allows for the following #ifdef CANTPP #define STATIC /* only for Cantata++ testing */ #else #define STATIC static /* for normal release build */ #endif Then declare data with the keyword STATIC If you re concerned about different functions of the same name being present in different files, then consider using namespace qualification, and placing each function inside its own namespace. For this reason, it is a little more realistic in comparison to the reverse_string example we looked at earlier.64 Integration Testing 64 Cantata++ is both a unit and integration level testing tool, as this example demonstrates.65 Sometimes it is not desirable to perform true isolation testing We may require the real functionality of the external routine, e.g. operator new() We may wish to ensure that a number of functions/classes interact correctly as a unit In these cases, we will still want to control the software s behaviour when testing (e.g. checking call order, manipulating parameters/returns, etc.) Can help us in these situations? Cantata++ automatically sets up white-box access for C++. A test harness allows the unit to be run as an executable on the desired environment. Existing non-eclipse projects An options file in the test project ipg.cop, stores whether Cantata++ is enabled/disabled. Minimize chance that untested code branches exist in shipping products. It can however also support testing at System and Acceptance testing stages with: Code Coverage on non-cantata++ system level tests Static Analysis of source code Wrappers used in system tests outside tests scripts Phase Exit Criteria What determines how we move from one testing stage to the next Phase exit critera: Does the implementation match the design / does it do what it should do (and nothing else)?

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