Effective GUI Test Automation: Developing an Automated GUI Testing Tool

Kanglin Li
Mengqi Wu

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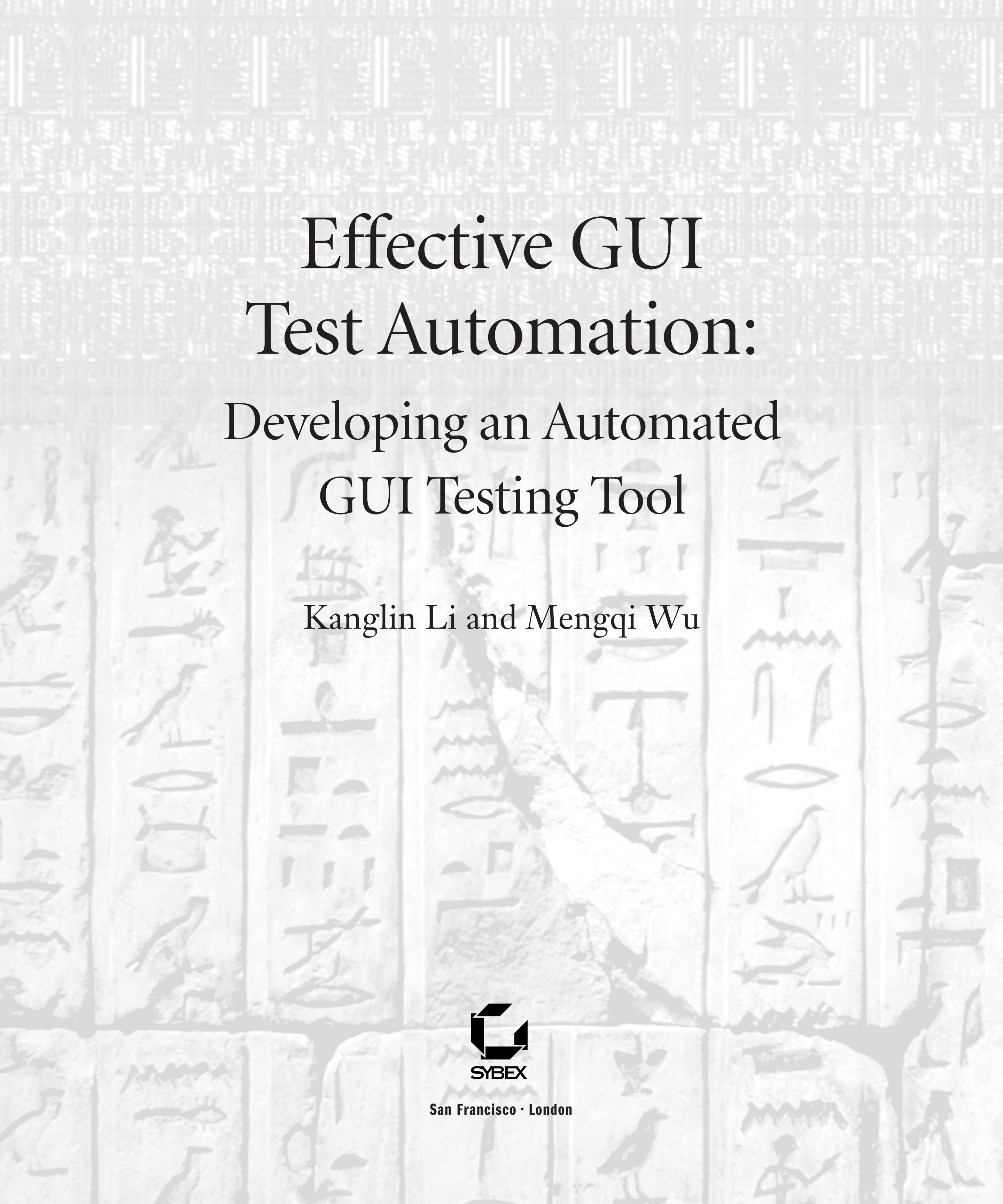

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To Li Xuanhua and Tang Xunwei

And

In memory of Luo Youai, Luo Xulin,
and Li Congyang

Acknowledgments

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I still need to thank other people, especially the readers who have provided me with their comments and suggestions about my previous works. During the process of writing this book, the test monkey in Chapter 3 frequently reminded me of my early days as a schoolboy. My friends and I spent most of my childhood summer nights listening to the stories of the monkey king told by the old folks in our village. What I learned from both the old folks and my friends makes it possible for me to write this book today.

When I was a small boy, my uncle OuYang Minghong carried me in a bamboo basket to visit my grandma. My uncles Zuomei and Zuodian carried me on their backs or in a wheelbarrow to watch movies and catch fish. Since I was five, my aunt Youai led me to the school and taught me to count with my fingers.

I didn't learn how to swim and fell into a pool when I was eight or nine. Meiqing risked his life and saved me from the water with the help of my uncle Zuohuang, Guicheng, and another whose name I don't know. Meiqing has always been my big brother. Then I learned how to swim at 20 and swam across the Xiangjiang River on a summer day and the Leishui River on a cold fall afternoon. Thank you all for teaching me about water, including Zeng Xilong, Li Wenbing, Kuang Chuanglun, Bai Maoye, Chen Xiaohu, Zeng Yigui, He Hechu, Wen Xiaoping, Long Yongcheng, and Xie Hengbing.

Tang Duzhang, Li Zuojin, Li Zuojun, Luo Xixing, Chen Xinhua, and Kuang Chuangren and I spent our best years in the middle school. At that time we learned food was valuable. Together, we discovered that boys were shy and girls were caring. Thanks to all of the former classmates who form the memory of my childhood.

—Kanglin Li
Leiyang, China
2004

Contents at a Glance

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Introduction

There are many books about software testing management. When they discuss software test automation, they introduce third-party testing tools. I have used many of the commercial software testing tools. Their developers declare that they have the capability to conduct various types of software tests and meet the requirements of an organization. But they have limitations. For example, many of GUI testing tools require users to record a series of mouse clicks and keystrokes. Others require users to write test scripts in a specified script language. Furthermore, the test scripts produced by these tools and methods need to be edited and debugged before they can be executed to perform the desired tests.

This book presents ideas for automating graphical user interface (GUI) testing. The sample code in this book forms a foundation for a fully automated GUI testing tool. Using this tool, users don't need to record, edit, and debug test scripts. Testers can spend their time creating testing cases and executing the testing.

Who This Book Is For

Software engineers have long relied on the tools and infrastructures supplied by the current software testing tool vendors. Some engineers tell successful stories. But more engineers experience frustration. The tools are not automated enough, the tests are not efficient, the tests are not driven by data, and the test script generation and data composition methods need to be improved. One solution to software test automation is to develop testing tools instead of purchasing commercial tools based on the current inadequate infrastructure

This book is written for people who are involved in software engineering and want to automate the software testing process for their organizations. With the methods introduced in this book, software engineers should gain a good understanding of the limited automation provided by the available testing tools and how to improve the current test infrastructure and conduct a fully automated software test.

This book is for software engineers who want more effective ways to perform software tests. The automated testing tool introduced in this book can serve as an independent software test tool as well as an adjunct to the commercial tools.

To get the most out of this book, you should be a moderately experienced software developer and a test engineer in the process of conducting software tests for your organization. The explanations and examples in this book can be easily understood and followed by any intermediate- to advanced-level programmer interested in expanding their knowledge in both software development and software testing.

This book's content includes programming techniques with examples in C#. Then it gradually progresses to the development of a fully automated GUI testing tool. Although the sample code is in C# using the Microsoft Windows platform, the tool has been evolved from a Visual Basic 6 project. I have also used these methods and developed a Java testing tool for a test project.

This book is also for the managers of organizations where software is developed and used. As economists have reported, software failures result in substantial economic loss to the United States each year. Approximately half of the losses occur within the software manufacturing industry. If you are a senior managerial administrator of a software organization, you are most likely interested in an improved software testing method. The other half of the losses is out of the pockets of the software end users. If your business or institution consists of software end users, you probably maintain teams to support the software purchased from the contract vendors. Being aware of testing methods will assist you with efficient software application in your organization.

How This Book Is Organized

To present ideas well, the first two chapters in this book are an introduction to software testing, the available testing tools, and the expectations of software testers. Chapters 3 through 6 focus on Win32 API programming and .NET fundamentals needed for the development of the GUI test library. Chapters 7 through 14 are devoted to designing and implementing the Automated-GUITest tool until full automation is achieved. The following list includes a short description of each chapter.

Chapter 1, "GUI Testing: An Overview," describes the management of software GUI testing and the techniques built into .NET that can make it possible to test software dynamically.

Chapter 2, "Available GUI Testing Tools vs. the Proposed Tool," presents a brief review of some of the automated GUI testing tools on the market and the main points of the testing methods proposed in this book. The available tools have been proved by studies to be inadequate. The purpose of this chapter is to demonstrate the necessity of an new and improved test method, of adding more testing capabilities to a testing tool, and of creating a fully automated test for new and complex software projects.

Chapter 3, "C# Win32 API Programming and Test Monkeys," deals with how to marshal the Win32 API functions to be used as C# code for developing the tool. It also includes the code for you to develop a C# API Text Viewer to take the place of the old API Text Viewer for Visual Basic 6 programmers. The newly developed C# API Text Viewer will be used in three ways. First, it will generate C# code to marshal the Win32 functions needed for developing a fully automated GUI testing tool. Second, it will serve as an application under test for the GUI testing tool as the testing tool is developed throughout the book. Third, the C# API Text Viewer will test the tool with different degrees of automation as the book progresses. In the end of this chapter, the C# API Text Viewer is used to present you with a test monkey.

Chapter 4, “Developing a GUI Test Library,” guides you through the development of a GUI test library with functions for finding GUI objects from an interface and manipulating the mouse actions.

Chapter 5, “.NET Programming and GUI Testing,” introduces.NET technologies—including reflection, late binding, serialization, and XML programming—with regard to data store, data presentation, and GUI testing.

Chapter 6, “Testing a Windows Form in General,” describes how a GUI test script is created manually. This handcrafted test script forms the base on which a fully automated GUI test will be built.

Chapter 7, “Architecture and Implementation of the Automatic GUI Test Tool,” lays out the architecture for a automated GUI testing tool and helps you build the first evolution of the proposed AutomatedGUITest tool.

Chapter 8, “Methods of GUI Test Verification,” explains how to effectively verify the test results and add code to the AutomatedGUITest project for automatic verification.

Chapter 9, “Testing Label and Cosmetic GUI Controls,” describes the processes of testing Label and other cosmetic GUI controls.

Chapter 10, “Testing a TextBox Control with Input from a Keyboard,” discusses the `SendKeys` class of .NET Framework and updates the AutomatedGUITest for testing TextBox controls.

Chapter 11, “Testing RadioButton and CheckBox Controls,” shows you how the RadioButton and CheckBox controls are used in software applications and discusses ways to test them.

Chapter 12, “Menu Clicking for GUI Test Automation,” introduces more Win32 API functions for discovering menu items and testing them.

Chapter 13, “User-Defined and COM-Based Controls,” introduces methods for developing custom GUI controls in the Microsoft Visual Studio .NET IDE and Microsoft Visual Studio 6 IDE and updates the AutomatedGUITest tool for testing such controls.

Chapter 14, “Testing Issues for Non .NET Applications,” presents the methods for testing an unmanaged application. This chapter tests `Notepad.exe` as an example after new code is added to the tool project.

About the Examples

The examples start with the programming precepts of C# and Win32 API functions. The goal is to use the predefined methods of a programming language to complete an AutomatedGUI-Test tool project and avoid reinventing the wheel. There are four kinds of sample code in the chapters:

- Sample code for developing a C# API Text Viewer
- Simple examples to demonstrate using C# and Win32 API functions
- Example projects to be tested by the AutomatedGUITest tool
- Sample code of the AutomatedGUITest tool project

The code examples in the first category most often appear in Chapters 3 through Chapter 6. Thereafter, Chapters 7 through 14 are totally dedicated to automating the test project. The sample code in these chapters is in the third category. There are only three examples of the second category, simulating real assemblies under test. They are implemented in Chapters 3 and 12 and submitted to testing throughout the book.

Besides the C# API Text Viewer, the code in Chapter 3 also develops a test monkey. Chapter 5 develops an XML document viewer that will be used to present the test results for the Automated-GUITest tool.

In Chapter 4 and thereafter, some code is added to the GUI test library and AutomatedGUI-Test project in each chapter. At the end of each chapter, the sample code can be compiled to produce an executable assembly. The testing tool achieves different degrees of automation until a fully automated test tool is developed by the end of the book.

Where to Find the Source Code

The sample and project code for each chapter can be downloaded from `www.sybex.com` by performing a search using this book's title, the author's name, or the ISBN (4351). This saves you from having to type in the code. It also includes a complete compiled version of the project, which allows you to put the AutomatedGUITest into immediate practice for your software project.

To execute the `AutomatedGUITest.exe` file, you can copy the files from the `Chapter14\AutomatedGUITest\bin\Debug` folder of the downloaded sample code to a computer system. The minimum requirements for a computer system are as follows:

- Windows 95/98/2000/NT/XP
- Preinstalled .NET Framework
- 20MB of free hard disk space

If you are still using earlier versions of the Microsoft Visual Studio .NET integrated development environment (IDE) at this point (older than Microsoft Visual Studio .NET 2003 IDE), you will not able to open the sample projects directly. The problem is that the C# project files with the extension `.csproj` are incompatible with earlier versions of the Microsoft Visual Studio .NET IDE. To use the code, you can follow the procedures in each chapter to create new projects and include the code files with extensions of `.cs` downloaded into your projects.

Although the sample code in this book is developed under the Microsoft Visual Studio .NET 2003 IDE, there are other open-source .NET IDEs available through free download:

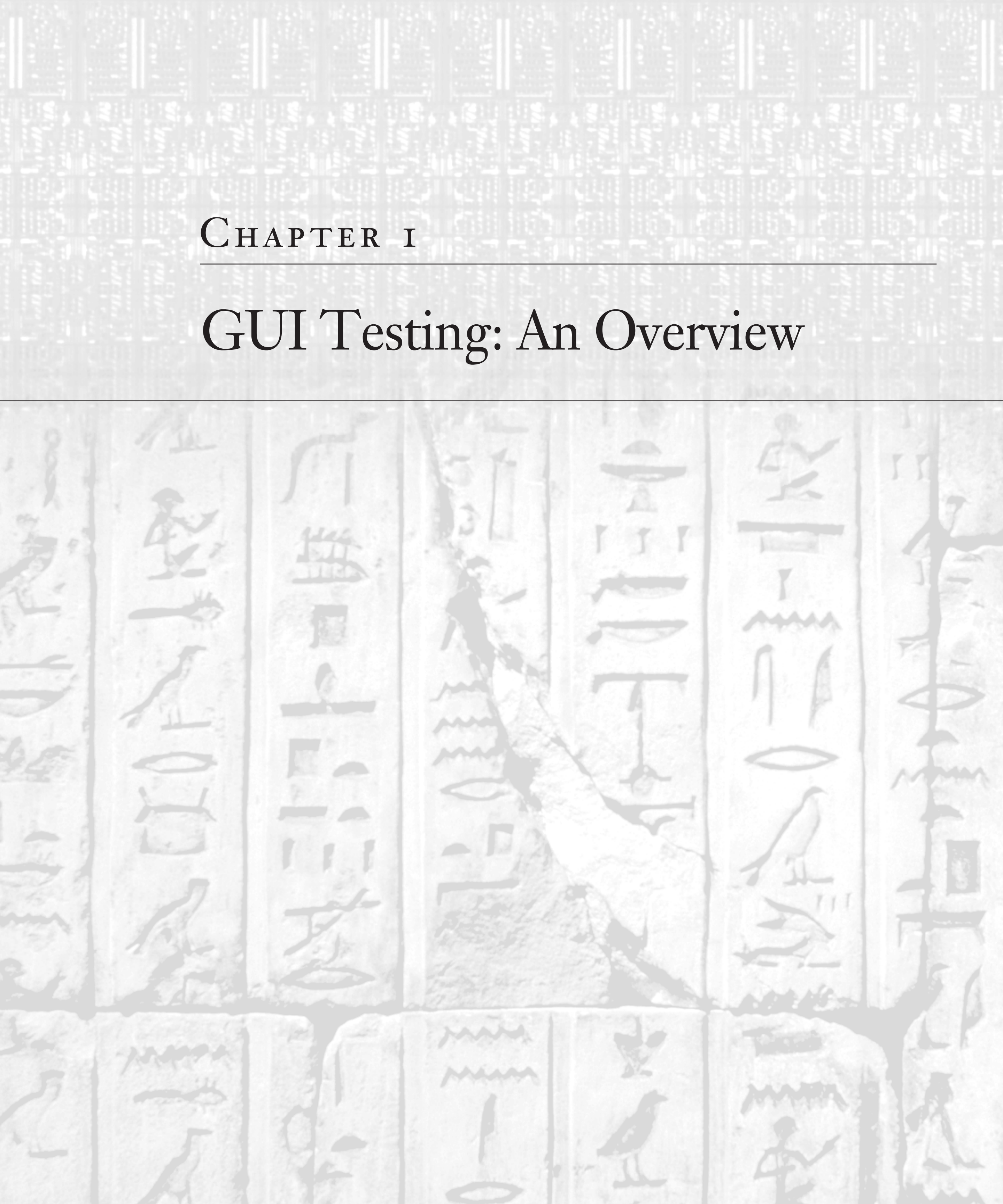
Eclipsing .NET IBM released the Eclipse .NET to the open-source community. This product works on Windows 95/98/NT/2000/XP. You can download the components for the Eclipse .NET from `www.eclipse.org`. After downloading the `eclipse-SDK-2.1.1-win32.zip` file, install it with the combination of the Microsoft .NET SDK, which is also a free download from `msdn.microsoft.com/netframework/technologyinfo/howtoget/default.aspx`. Then get the open-source C# plug-in through the Eclipse .NET IDE. An article at `www.sys-con.com/webservices/articleprint.cfm?id=360` introduces the downloading and installation in detail.

#develop Short for SharpDevelop, this is another open-source IDE for C# and VB.NET on Microsoft's .NET platform. You can download #develop from `www.icsharpcode.net/OpenSource/SD/Default.aspx`.

DotGNU Portable .NET This open-source tool includes a C# compiler, an assembler, and a runtime engineer. The initial platform was GNU/Linux. It also works on Windows, Solaris, NetBSD, FreeBSD, and MacOS X. You can download this product from `www.southern-storm.com.au/portable_net.html`.

CHAPTER 1

GUI Testing: An Overview



The saturation of software in industry, educational institutions, and other enterprises and organizations is a fact of modern life almost too obvious to mention. Nearly all of the businesses in the United States and in most parts of the world depend upon the software industry for product development, production, marketing, support, and services. Reducing the cost of software development and improving software quality are important for the software industry. Organizations are looking for better ways to conduct software testing before they release their products.

Innovations in the field of software testing have improved the techniques of writing test scripts, generating test cases, and introducing test automation for unit testing, white box testing, black box testing, and other types of testing. Software testing has evolved over the years to incorporate tools for test automation. Mercury Interactive, Rational Software of IBM, and Segue are a few of the main tool vendors. The purpose of these tools is to speed up the software development life cycle, to find as many bugs as possible before releasing the products, to reduce the cost of software development by automating effective regression testing, and to increase application reliability. The apparent goal of the software testing tools is to generate test scripts that simulate users operating the application under development. Usually test engineers are trained by the tool manufacturers to write test scripts by hand or to use a capture/playback procedure to record test scripts. Both writing and recording test scripts is labor intensive and error prone. The potential of the available tools to reduce the manual, repetitive, labor-intensive effort required to test software is severely limited.

Recently, organizations have purchased the commercial testing tools but the test engineers can't use them because of their inadequate test infrastructure. Often these tools don't have the capabilities to handle the complexity of advanced software projects, aren't capable of keeping up with technology advancements, and aren't diverse enough to recognize the varieties of third-party components in today's software development business. Needless to say, profitable organizations have trade secrets the commercial testing tools are not aware of. Because of these inadequacies, the United States loses $59.5 billion each year due to the bugs in the software not detected by the current testing means (Tassey 2003). Test engineers and experts are working to develop more effective testing tools for their organizations. Thus, they can improve the current test infrastructure with regard to the following:

- Enhanced integration and interoperability testing
- Increased efficiency of testing case generation
- Improved test code generation with full automation
- A rigorous method for determining when a product is good enough to release
- Available performance metrics and testing measuring procedures

It is estimated that an improved testing infrastructure should try to reduce the current software bugs by one-third, which can save the United States $22.2 billion. Each year, in order to achieve such a software testing infrastructure, researchers have published their findings. For example, in my previous book, *Effective Software Test Automation: Developing an Automated Software Testing Tool* (Sybex 2004), I discussed the methods to develop a testing tool that can be adapted to various software programming languages and platforms. The outcome of the book was a fully automated testing tool. It automated the entire process of software testing—from data generation and test script generation to bug presentation—and broke a number of bottlenecks of the current testing tools in the following ways:

- *By actively looking for components to test instead of recording test scenarios by capture/playback.* This approach can enable the test script to conduct a thorough testing of an application. It is reported that testing cases are more effective in finding bugs after the test script is developed. Thus, testers don't spend time writing test scripts; instead, they spend their time studying and creating multiple testing cases.
- *By effectively generating one script to test all the members (constructors, properties, and methods) of a DLL or an EXE, including members inherited from base classes.* This test script prepares a real and complete object that can be reused for integration testing and regression testing. Therefore, the number of test scripts for one software project can be reduced, making the management of test scripts easy.
- *By effectively reusing the previously built test scripts of lower-level modules for testing higher-level modules with a bottom-up approach.* This helps you avoid stubbing and using mock objects to conduct integration testing.
- *By automatically writing test scripts in a language used by the developers.* The testers don't have to learn a new script language. The developers can understand the test scripts. This enhances the collaboration between testers and developers.
- *By innovatively integrating automated script generation with a Unified Modeling Language (UML).* The project can generate test scripts early when a detailed design is available. The test script can be executed for regression testing and reused for integration testing throughout the development life cycle. Because the test can be conducted nightly in an unattended mode, it guarantees that all the newly developed code will be tested at least once at any stage.
- *By automatically compiling and executing the generated test scripts without editing or debugging.* If the design of the software architecture is modified in middle of the development process, a new test script can be automatically generated immediately with accuracy.

However, due to the uniqueness of the graphical user interface (GUI) components in software products, techniques and programming methods for developing an effective automated GUI testing tool required a separate book. We will use the same philosophy used for automating the non-GUI testing in the preceding book and develop a fully automated GUI testing tool; that is, the users feed the GUI testing tool with an application and get the defect (bug) reports.

Unique Features of GUI Testing

Early software applications were command-line driven. Users remembered and typed in a command and the system performed some actions. A more effective application could display possible commands on the screen and then prompt the user for the next command. Nowadays, the software industry is in the windowing system era. Virtually all applications are operated through graphical user interfaces (GUIs). GUI components are often referred to as windows, icons, menus, and pointers. Users drag a mouse, click buttons, and apply various combinations of keystrokes. The applications are triggered to perform desired actions by the mouse events and keystroke events. Thus, GUIs have made the software friendlier to users.

Software verification and validation through testing is a major building block of the quality assurance process. GUI tests are vital because they are performed from the view of the end users of the application. Because the functionality of the application is invoked through the graphical user interface, GUI tests can cover the entire application,

To automatically test software before the GUI era, testers relied on test scripts with a collection of line commands. The executions of the programs were independent from the screen status. Testing GUI components is different and more difficult because it requires a script to reassign the input stream, to click buttons, to move the pointer, and to press keys. Then the scripts need to have mechanisms to record the responses and changes of the dynamic states of the software. Comparing the responses and changes with the expected baselines, the scripts are able to reports bugs.

There are some specialist tools available to test GUI-based applications. They often come with a variety of features. Testers expect that these features will enable them to conduct GUI testing with regard to platform differentiation, recognition of GUI components, test script automation, synchronization, result verification, and easy management. The currently available tools are very much influenced by platforms. For example, the 32-bit Microsoft Windows operating system (Win32) is currently the dominant platform for development. Testing tools developed for Win32 can not be used with other platforms, such as the Unix, Linux, and Macintosh operating systems.

The broadly accepted method today of generating GUI test scripts relies on the capture/playback technique. With this technique, testers are required to perform labor-intensive interaction with the GUI via mouse events and keystrokes. The script records these events and later plays them back in the form of an automated test. Test scripts produced by this method are often hard-coded. When different inputs are needed to conduct the test, the test script needs to be re-created. Regression testing using these test scripts is also impractical when the GUI components are under development. It is often hard to generate all the possible test cases for all of the GUI components and conduct a thorough test. Human interaction with the GUI often results in mistakes. Thus, the capture/playback procedure records the redundant and wrong clicks and keystrokes.

Based on the current testing technologies, GUI test automation invariably requires manual script writing, editing, and debugging. On one hand, tool vendors keep on informing testers of the powerful functions their tools are capable of. On the other hand, testers must face a great number of technical challenges getting a tool to work with the application under test (AUT). It is well known that GUI components are modified and redefined throughout the development process. The generated test scripts are unable to keep up with design changes.

Compared with non-GUI software testing, a GUI test infrastructure based on the current testing tools is also expensive with regard to purchasing the tools and the efforts that must be made to maintain the tests. Very often, only a part of the GUI components are tested automatically. The other part still requires manual tests. In the following sections, I'll address the inadequacy of GUI testing by discussing an approach for improving the current test infrastructure.

Developing an Automated GUI Testing Tool

The raw GUI test scripts recorded by the capture/playback technique perform the apparent mouse and key actions if they don't fail to execute. But even when the execution succeeds, the captured results don't verify whether the invocation of the business functions (often, non-GUI modules) caused by the GUI events is correct. Complicated graphic output must be tested. The GUI test scripts don't test the input variation to the GUI components. Without manual editing and debugging, these test scripts are not able to test whether the GUI components are created and drawn as desired.

The purpose of this book is to show how to use more effective programming methods to develop a GUI testing tool. This tool will help you avoid the drawbacks and pitfalls of the current testing methods. The generated test script should be able to capture the event actions and changes performed on the GUI component being tested and the invocation of the related non-GUI components caused by the GUI events. It will also verify the position and the appearance of the GUI components and test the input to the GUI components. The result of the event actions and invocations will be converted from GUI to readable text formats. Then the test result reports will be used by the developers to fix the detected bugs.

To achieve an improved test infrastructure, this book will discuss ways to develop GUI testing tools that can generate flawless test scripts. These scripts will have functions to test various aspects of the GUI components. They will not become obsolete due to changes of the GUI components. If more GUI controls are added or reduced, a new test can be regenerated by feeding the modified application to the tool.

In this book, I'll also discuss methods for developing testing tools that require minimum training. The current testing tools have complicated user interfaces and users must be trained to use them. Almost every GUI testing tool has a script language for writing test scripts. Developers are often isolated from software testing automation by the language differences. In this book you'll learn how to develop a tool to write test scripts in the same language that is used by the developers in an organization. Thus, the testing tool, the application under test, and the automatically generated test scripts are all developed in one language. The test projects become more readable and maintainable and bring testers and developers together.

I'll also discuss methods for generating testing cases so the combination of the testing cases and scripts will be more effective in finding bugs. None of the tools on the market that rely on the capture/playback or reverse-engineering technique is able to locate a GUI component and write a relevant test script for it automatically. Thus, we need a method to conduct an automatic and exhaustive survey of the GUI components and write test scripts and test data with respect to different testing issues of the components.

Finally, using these methods to develop a testing tool will save time and money, deliver accurate products, and make the job interesting for the organization.

Expectation of Automated Testing

Automated tests help to greatly reduce the time and the cost spent on software testing throughout the entire development life cycle. Furthermore, automation ensures that tests are performed regularly and consistently, resulting in early error detection that leads to enhanced quality and shorter time to market.

Current testing techniques are not able to automate the GUI testing process before an executable test script is created. The tester is often required to use a capture/playback method to record scripts. The recording process is in fact a labor-intensive interaction between the tester and the GUI. If there is a bug the process fails to record and one bug is detected during testing, the tester must repeat and continue the script recording process until the bug is fixed. Thus, bugs are detected one by one throughout manual script recording. When the recorded script is ready to be executed, the possibility of finding bugs by replaying it is limited.

Testers expect the testing tools to actively find GUI components, generate the respective testing data, and use the generated data to drive the test script generation and execution. There is not a tool that is capable of conducting an active survey for the existing GUI components of an application. Although vendors often claim their tool is capable of data-driven script generation, testers often need to start a wizard and enter testing data. This wizard-driven data generation is also labor intensive and error prone. The first execution of this data is not effective in detecting bugs. To find bugs, one test script should be able to test against many test data sheets. Testers expect a fully automated method to generate multiple copies of testing data.

Commercially available testing tools are very much platform dependent. They often have their own testing environment. A recorded test script usually runs in the environment in which it has been recorded. Tools also are accompanied by tool-dependent script languages. Thus, software testing is often limited by the tester's system. If developers and other personnel need to be involved in testing, more tool licenses need to be purchased from the tool vendors. This limits the test script portability.

Researchers and tool developers are making an effort to achieve a fully automated testing tool that will recognize the GUI components and generate testing data and test scripts in sequence. It should also be capable of being executed for regression testing unattended. Based on the facts reported in *The Economic Impacts of Inadequate Infrastructure for Software Testing* (Tassey 2003), the current approaches to testing need to be revised or improved, and some even need to be discarded. We will therefore heed the experts' advice to develop a testing tool. A new tool capable of locating bugs more effectively will have the following features:

- *The test script language will be the same one used to develop the application under test.* Users won't be required to manually click mouse buttons, press keys, and record test scripts. Thus, testing can be run on the tester's systems as well as on the developer's systems. The capability of executing the test on user's systems will be helpful for the alpha and beta version release of the application.
- *Management of software testing will become easy.* Because the tool will actively search for GUI components and write test scripts, a maximized test will be achieved and the redundancy of test script generation will be reduced. One test script will be capable of testing against an optimal number of testing cases.
- *The developed tool will have an open architecture that makes it flexible and easily modified for extended testing functionality.* Upgrading of the tool can be accomplished within the resource limits of an organization. Thus the tool will always be compatible with the advancement of technologies and the complexity of the software projects. It will also be able to recognize third-party GUI components, custom controls, and generic objects for test data and script generation.
- *Regression testing will be fully automated.* Test execution has always been a boring, mechanical, repetitive, dreary aspect of testing. With this tool, the regression testing process can be conducted nightly and daily without human attention.
- *Test results will be reported and stored in a widely accepted format (e.g., a popular spreadsheet program, an XML document, or an HTML format).* When a bug is found, the report will pinpoint the problem in the source code. Users don't need to be trained in order to understand and use the report to fix defects. In addition, an Internet bug tracing system can be enabled.

Automated Test Teams

We all agree that with a properly automated testing process, more testing cases can be conducted and more bugs can be found within a short period of time. Charles Schwab & Co., a major U.S. stockbroker, reported that, based on the current testing means, a typical system test required 52 hours of effort manually but only 3 hours after automation. Automated Data Processing (ADP) reports that its elapsed time for testing has been reduced 60% through automation. Studies indicate that the number of defects discovered by tool users increase by 10% to 50%. Many organizations today rely on automated testing tools for the high quality of their products.

On the other hand, a survey in 250 organizations found that only 35% of testers were still using automated tools one year after the tool installation due to the reported testing inadequacy. To avoid turning back to the tedious and time-consuming manual testing method, many organizations train their staff to develop more effective automated tests. Figure 1.1 shows an organizational chart for a test team. An effective test team must involve senior administrators interested in quality products and a high degree of test automation. Developers should be willing to share and convey knowledge with regard to testing issues. Tool developers develop more effective testing tools based on the experience of manual testers and tool users. Alpha testers work independently but share test scripts (automated or manual) with other testers.

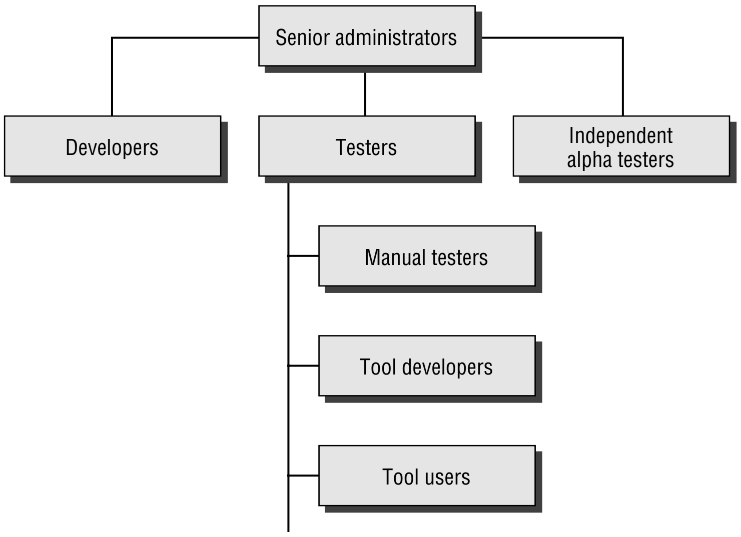


FIGURE 1.1 The organizational chart of a test team with the components of senior administrators, supportive developers, testers, and alpha testers

An automated testing process is the result of the evolution and maturity of manual testing efforts. During the tool development life cycle, manual testers continuously make contributions of automation strategies and testing techniques. Thus, before the test of a new component can be automated, manual testing should be conducted and verified. Then the optimal testing method can be implemented and integrated into the automated tool. As the testing methods are accumulated, the tool will become useful for future projects instead of just the current project.

Members of a conventional automated test team are tool users. A new automated test team would ideally include tool developers, tool users, and manual testers. Manual testers analyze project risks, identify project requirements, develop the documentation to design the overall testing scenarios, and specify the test data requirements to achieve the needed test coverage. The manual test engineers also prioritize testing jobs to be integrated into the automated testing tool.

The management strategy for developing a testing tool should resemble the management strategy used in the development of other applications. First, the team will select a development model and environment. The project described in this book will be implemented in the same language as the application under test. This will enhance the collaboration between the testers and the developers. Thus, testers will have the knowledge they need to test the application and make effective testing cases, and developers will make suggestions for improving the tool development and test script generation. The developers can use the tool to complete the unit and integration testing at code time.

Next, requirements need to be collected based on experiences that other testers, developers, and all kinds of end users have had with manual testing. The tool project specification is a cooperative effort between managers of all levels, product learning personnel, testers, and developers. An object-oriented design document is also important for the success of the tool's reusable architecture. This document will not only be used to complete the current implementation, future upgrading will also be based on it. The tool developers should have broad knowledge of software engineering and software testing and automation and programming skills. When it is implemented, the code will need to be tested. Bugs should be found and fixed so that they will not be introduced into the applications under test. Finally, the automated testing team needs to create training materials for the end users. The team can recruit the developers, engineers, and other personnel to test the application. Within a short period of time, maximum testing will be conducted. As many bugs as possible will be detected and fixed, thus assuring high-quality code.

The automated test team benefits the current project as well as future projects because the tool will be maintained. Unlike commercial testing tools, this tool will always keep up with current technology advancements, adapt to project complexity, and be able to test the creative and innovative aspects of an application.

How to Automate GUI Testing

The degree of automation for the tool depends on the testing requirements collected for an organization. With the knowledge of what GUI components to search for, the automated test team can implement drivers to create test scripts in various situations that correspond to the testing scenarios of the manual testing. A team with skillful manual testers can develop a tool with a higher degree of automation. In that case, the tool development will require more investment, but because the technologies of the software industry change quickly, developing a highly automated tool quickly pays off by increasing productivity and quality.

The starting point of testing an application's GUI is to locate the GUI components. Currently available tools depend on mouse events and keyboard actions from users. A fully automated testing tool should recognize these GUIs programmatically. We need to enable the tool to move the pointer automatically to conduct a GUI component survey. If a GUI component is detected at the movement of the pointer, the tool will identify it by its unique properties, check its status, generate testing data, and write code to activate the GUI and catch the consequences. These consequences could be visible (external GUI level) or invisible (internal non-GUI modules) and are stored in the test results.

A GUI component can be recognized by its name, its position in hierarchy, its component class, the title of its parent window, and the programmer-assigned tag or ID. During each session of running an application, the GUI components are located with unique pairs of coordinates on the screen. However, GUI positions are often under modification by programmers, platforms, and screen resolution. A GUI test script should avoid hard-coding the position for tracking the GUI components. The component name is also not useful for writing test scripts. When we write a test script for testing a GUI component, we often find that programmers assign one name to several GUI components. In other cases, the component names are assigned automatically by the integrated development environment (IDE).

Usually, the programmer-assigned properties (label text, button captions, window titles, etc.) are unique and can be effectively used to identify a GUI component. We can develop our automated test tool to use the combination of the title of the parent window, the name of the component class, the caption, and other custom properties to locate the GUI components using test scripts.

After the survey and the identification of the GUI components, test scripts should be created. Current testing tools don't have the capability to generate test scripts automatically. When a tool has a capture/playback or a reverse-engineering processor to generate test scripts, the vendor claims it is a powerful testing tool. Testers in some teams don't trust the test scripts recorded by the capture/playback or reverse-engineering procedure, so they write test scripts from scratch. Because the test script can invoke the application, vendors claim this testing method is automatic. Thus, the testers are often found spending most of their time writing test scripts or playing with the capture/playback tool to edit and debug the generated test scripts. They don't have enough time to manually create testing data, which is time consuming and requires creativity.

However, more and more testers disagree that the capture/playback tools are automated testing tools. We need to develop our own testing tools with full automation. My book *Effective Software Test Automation: Developing an Automated Software Testing Tool* discussed technologies such as reflection, late binding, CodeDom and testing data generation. The result of the book was the creation of a fully automated testing tool for non-GUI components. This book will use an active GUI survey approach to collect GUI test data, and the collected data will drive the test. In order to conduct an automatic GUI survey, this book will also discuss some Win32 applications programming interface (API) techniques. During the GUI survey, some API-implemented functions will simulate a person manipulating the mouse and the keyboard. Reflection techniques can be used to dismantle the component under examination. Late binding can invoke related members of the GUI event. The generation of test data and scripts becomes fast. Furthermore, the survey and script generation will be done automatically without the human tester's attention. Testers will spend most of their time composing effective testing cases. The automatically generated test script will test the component against multiple copies of testing cases and thus maximize the bug finding process.

Based on the preceding discussion, current automated test teams have a lot of manual testing responsibilities because the commercially available automated testing tools are inadequate in data and script generation and the recorded raw scripts lack the capability to verify test results. In addition to a full test automation, the developed tool will have the following advantages:

Less intrusive An intrusive tool requires developers to implement testability hooks in the application. These hooks are not desired by end users. Using an intrusive tool and using extra coding in the application could cause problems in the future. GUI testing methods without capture/playback require less human interaction with the application, making the tool less intrusive.

Platform and language independent Although the sample code in this book will be written in one language within the Windows operating system, the method can be extended to any other environments and coded in different languages. There is also no need to purchase additional hardware to handle the testing overhead.

Flexibility for upgrading Software testing is influenced by continuous evolution and addition of new technology, including advances in computer science, new testing technologies, and new development methods from outside sources. In addition, organizations continuously strive to create profitable new techniques and products. When a technology is implemented in an organization, the testing tool will able to test the new features. If the tool lacks the capability to test new features, developers can upgrade the tool.