THE SOFTWARE DEVELOPERS MAGAZINE

EXE

JULY 1998

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Apps as fast as games

Testing in black & white

Cleaning up Java garbage

Mentoring keeps bugs at bay

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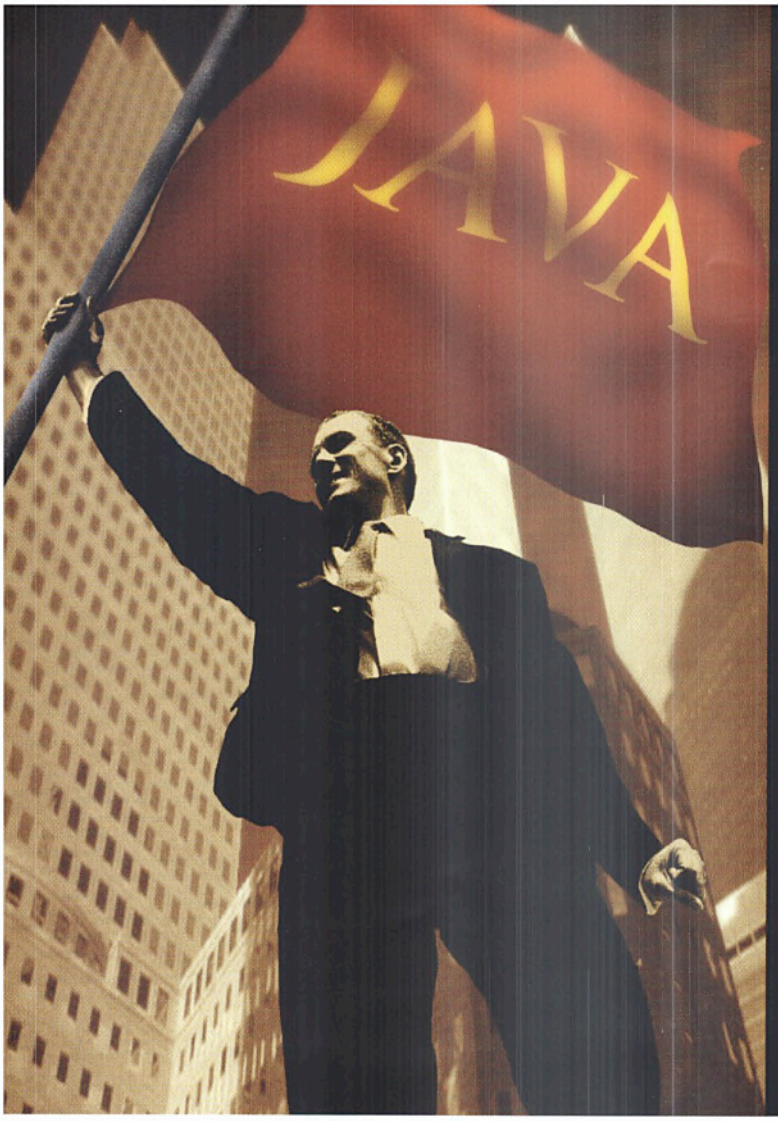

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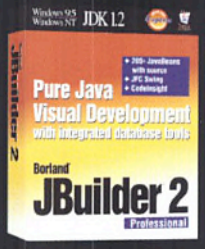

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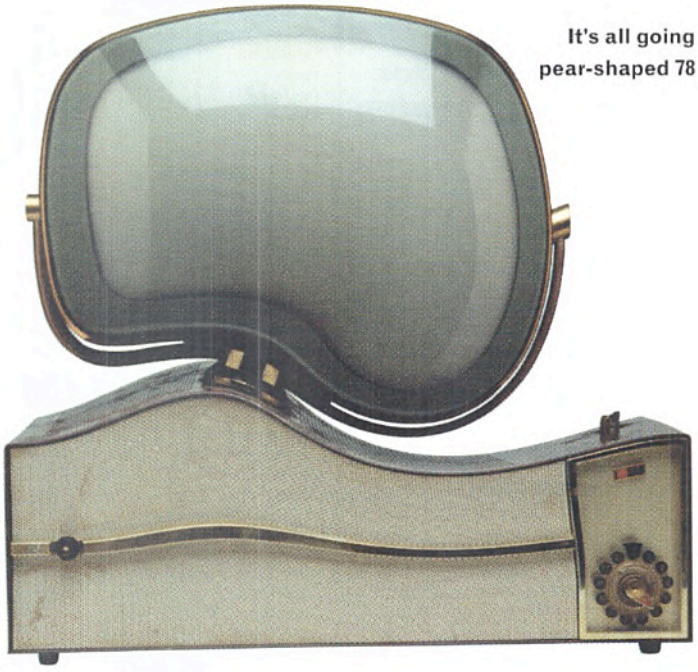

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News & Views

JBuilder 2.0

The Best Java Development Tool on the Market?

If you're thinking of developing Java code then JBuilder 2.0 should be a serious contender. With Standard, Professional & Client/Server variants it is ready for all types of developers. The new version 2.0 contains the latest developments in Java supporting the JDK 1.1.6 and JFC/Swing.

UCalc Fast Math Processor

Evaluate algebraic expressions within your application

If you've ever wanted or needed to evaluate algebraic expressions that are defined during runtime then UCalc Fast Math Processor is for you. Shipped as an ActiveX Component it is ideal for either heavy duty number crunching or solving simple mathematical problems.

CodeBase for Windows CE

Port Your CodeBase Applications to Windows CE

CodeBase for Windows CE is a low-memory version of CodeBase, designed specifically for programmers targeting Windows CE. In order to keep the size of the database library to a minimum, any unusable code (such as locking) has been removed, and only core database features have been implemented. The result is that it now adds only 150K to your executable.

TeeChart Pro ActiveX

Now Everyone Can Use TeeChart Pro!

Award-winning TeeChart Pro is now available as an ActiveX control with direct access to ODBC data sources and sample projects for Visual Basic, FoxPro, Access 97, Word 97, Excel 97 & Internet Explorer.

ActiveX Voice Tools

Drag and Drop Speech Recognition into Your Windows Applications

ActiveX Voice Tools are the only ActiveX controls for free-dictation, command and control that work with the proven accuracy of the IBM ViaVoice Dictation System for Windows. They are the easiest way to add voice recognition to your Windows 95 or NT applications, without the need for the programmer to directly interface with the speech engine at the API level.

Genitor

Think C++ Objects, Not Files

Genitor is a development tool for C/C++ programmers that automates the construction and maintenance of code and documentation. An object editing environment lets you rapidly construct any kind of class, struct, union, function, or template. Genitor helps programmers focus more on concepts and less on syntax. The Corporate let you import your existing code into the Genitor repository.

Greenleaf CommX

Greenleaf's ActiveX Control for Serial Communications on Special Offer

Greenleaf's new CommX is a set of three ActiveX controls providing functions for serial communications, file transfer and terminal emulation. Now everyone can take advantage of Greenleaf's experience in communications - and it is on special offer at the moment.

Year 2000 Detective

Isn't It About Time You Checked Your Programs?

Year 2000 Detective will analyse every line of source code in Visual Basic, Access and Delphi projects and report any code that needs checking. It also analyses text-based source code for languages such as C/C++, Clipper, FoxPro and Java.

DEBUGGING TOOLS

BoundsChecker Standard 5.0	£276
DevPartner Studio	£760
GreatCircle Professional	£507
MemCheck	£243
SoftICE/Win95 3.2	£396
SoftICE Suite	£553

Bedside manners for developers

From the start, the introduction of object technology was going to be different from any previous advance in programming technology.

Whereas in the past it had been largely a matter of learning a new syntax while the underlying programming process remained the same, object technology demands a completely new way of thinking. Syntax is just the beginning.

However, objects are here to stay. Most mainstream software claims to be at least object-based. So, like it or lump it, thousands of developers have had to make the change – or if they have not done so yet, had better start thinking about an alternative career.

Hand in hand with objects comes the visual programming paradigm. This represents another qualitative change, both in the way applications are produced and in the way they do their job. The best applications today are those which fully exploit the potential user-friendliness of object-oriented visual programming.

The big difference is that the process of learning to use the new generation of programming tools does not stop in the training room. The full capabilities of the technology can only be exploited once the application development is under way, by which time the instructor is no longer around.

The main pitfall here is that, with a technology so new and unfamiliar, leaving people to struggle on their own is inviting them to fall back on familiar procedural techniques, losing the benefits of the new technology altogether.

Those benefits are not trivial. Two recent and irreversible developments put that beyond doubt. The first is the proliferation of platforms on which applications can be delivered, from the green screen dumb terminal to the Web. It is simply not feasible to write – or rewrite – specifically for each. The other is the proliferation of products coming out of an increasingly competitive financial services industry. The need to be first to market with yet another type of mortgage, for example, is putting enormous pressure on development teams. Other industries are following the same path.

Object-oriented, component-based technology offers the only solution. But speed of development is only half the story: users demand applications that are not just easy but enjoyable to use. In other words, beyond the science of producing functionality, there is an art.

This is how the concept of mentoring first arose. The spectacular failure of a number of high-profile OO projects in the early 90s led to demands on suppliers of Analysis & Design software that they remain involved with projects over a longer period, in order to pass on their expertise in handling these new and unfamiliar concepts.

Initially, this was seen as a straightforward consultancy arrangement, providing a fix for a specific problem. But over the past five years or so, the role of the mentor has emerged as a crucial one in bringing large-scale object oriented applications to market: both in terms of the best use of technology and ensuring that the finished application is as user-friendly as it can be.

Over the past five years or so, the role of the mentor has emerged as a crucial one in bringing large-scale object oriented applications to market.

The first true OO technology was Smalltalk. Because Smalltalk was always more than just a language, and concerned itself with the aesthetics of the finished application as much as with its functional guts, its originators had to take detailed account of the real world of users.

Thus began the process, which has become established, of allocating resources specifically for getting the development team up to speed in the early stages of a project.

The need is made more acute now that more applications are being delivered to users across the Net. Developers are having to learn to deliver applications that don't confront users with problems. Just think of the incomprehensible error messages that even the latest desktop applications can still confront the user with!

This is like calling on doctors to be sensitive to the emotional as well as the physical needs of their patients: in many cases it goes against the grain. But it must be done in order to avoid confronting, say, the user of a home shopping service with a set of technical hardware and software requirements.

Because users have nobody to turn to once the application is delivered, their interests have to be represented during the development process. This is where the mentor – someone with an inside-out knowledge of the AD software and real world experience of building applications with it – comes in.

To begin with, this is likely to be a body supplied by the vendor under a formal mentoring arrangement. However, the goal is always to develop key members of the development team to take on the mentoring role, so that the needs and interests of the end-user remain paramount.

It is now recognised within the industry that organisations new to object technology that miss out on the benefits of mentoring are likely to find their projects failing. Mentoring should be budgeted for in every object pilot project. ■

Peter Day, Managing Director Bloomsbury Software Company

Two Weeks that changed the World

From telecommunications networks to supermarket locations, Smallworld's software shows companies where customers and assets are located and how they are connected.

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As Jill Ming, Technology Transfer Manager at Smallworld, observed, "It's vital to our business that our products are produced to a very high quality and delivered on time. That's why we trust LSL to handle all our manufacturing and distribution."

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Mind the software testing gaps

Visual PureCoverage provides code coverage analysis for Windows NT applications written in Visual Basic, Visual C++, or Java. The customisable tool, from Rational Software, automatically identifies tested and untested areas of code and displays application analysis data.

It is aimed at developers or QA engineers to help identify gaps in testing and make the testing efforts more efficient.

Features of the tool include PowerCov, Coverage Browser and Function List windows, and Object Code Insertion.

PowerCov allows users to specify the amount of coverage data collected, providing control over the testing. This is intended to make testing efforts more efficient.

The Coverage Browser and Function List are two customisable data presentation windows that allow users to configure the display of analysis data and sort data functions. The idea is to allow the creation of specific test cases based on analysis results.

Finally, Object Code Insertion (OCI) enables the tool to analyse an entire application, including components for which there is no source code.

Visual PureCoverage can be used with Purify for NT for a combination that will display untested parts of an application while simultaneously identifying the runtime and memory access errors. It is distributed in the UK by PtS.

Visual PureCoverage is available for Windows NT and performs code coverage analysis for applications built with VB 5.0 and above, VC++ 2.2 and above, and Java from any SDK using the Microsoft JVM. An evaluation copy can be downloaded from the PtS website.

w www.pts.com

Cyberprise for databases

There are two additions to the Wall Data Cyberprise line of products: the web development tools Cyberprise DBApp Developer and Cyberprise DBApp Publisher. These are for developers to create intranet-ready database applications, with a minimum of programming and making use of existing data sources if needs be (migrating ODBC-compliant databases to Microsoft SQL Server/Access or Oracle).

Cyberprise DBApp Developer is a set of development tools for the creation of database applications for an intranet (based on Wall Data's Semantic Object Modelling). It has three components: Semantic Object Modeller for developers to model, create, and change database-powered programs; Semantic Templates providing a choice of pre-defined page layout templates used by DBApp Publisher to generate HTML code; and Page Generator, which uses the Semantic Templates and a Semantic View of the database model to generate Active Server Pages.

Cyberprise DBAppPublisher is a set of ActiveX/COM components that are installed on Microsoft IIS, running on NT. It enables users to interact with applications, and allows create, read, update and delete capabilities against a database, using their Web browser. It sits on the Cyberprise Server platform.

All the business rules created by DBApp Developer are enforced by DBApp Publisher, and any required SQL queries are generated dynamically as users run an application.

Cyberprise DBAppDeveloper costs $2500 and DBApp Publisher $200 per concurrent user licence.

w www.cyberprise.com

Building C++ enterprises

C++Builder Enterprise, based upon Inprise's C++Builder RAD system, integrates Windows development with Corba, COM, and Inprise Entera. The C++ and middleware development system is designed to support enterprise-class applications, with large volumes of users and data, and the inclusion of legacy systems.

Among other enterprise features, object-oriented client and server applications can be created visually using C++. Scalable, distributed applications can be deployed and managed with VisiBroker (this includes the use of the VisiBroker Event and Naming Services for object access and management). A MIDAS development kit is included for the development of multi-tier database applications.

C++Builder Enterprise is available directly from Inprise, with pricing being based around product maintenance releases, major upgrades, and developer support.

w www.inprise.com

New **ActiveX** controls within OLETools 6.0, **BeCubed**'s toolset for developing interfaces, include an International control, a Floating Text Extender, a Bi-Directional Slider, and a Flowcharting control. Enhancements have been made to the WAV Player, Date and Time, and ListBox controls. Price £165.

www.contemporary.co.uk

The loading, saving, displaying, printing, and converting of images in **raster** and vector formats is provided by **ImageMan** DLL Suite V6.0. It supports hosting **Adobe** plug-ins, interpolated scaling for preserving an image's quality when scaling, and some new filters.

www.componentsource.com

Sax Basic Engine 5.0 is a VBA-compatible **macro language**. Its editor and debugger have been enhanced to look more like **VB**. An unlimited macro size, improved Windows integration, and improved performance are the other main developments. Professional editions costs £325.

www.contemporary.co.uk

Lynx 97 is Viking Technology's file transfer and **backup** software. Files, directories, or the whole contents of a hard disk can be transferred through serial, parallel, or network connections. The Lynx 97 Backup Module software creates **ZIP** compatible FileStores. For Windows 3.1 and 95.

www.guildsoft.co.uk

CA-TV is a free Internet-based service to deliver news about **CA**, technical updates, software maintenance releases and sales promotions, directly to subscribers. Security features encrypt and digitally sign each message to ensure content is not tampered with.

www.cai.com

What's the score? Delphi 4 the Internet too

Compuware's DevPartner for **Visual C++** includes NuMega TrueTime Visual C++. The automatic performance analysis tool locates **performance** bottlenecks and reports application and component performance data. The **TrueTime** Edition is available at £309.
www.numega.com

QNX/Neutrino, the real-time OS for the x86 platform, will support the **PowerPC** and MIPS processor architectures. Selected beta sites will receive the new versions from **QSSL** in the 3rd quarter of this year.
www.qnx.com

QSSL has announced that **CodeWarrior** for QNX will be the primary software development environment for the QNX/Neutrino real-time OS. Metrowerks has committed to providing tools for future processors supported by **QNX/Neutrino**, in addition to the new PowerPC, and MIPS targets
www.metrowerks.com

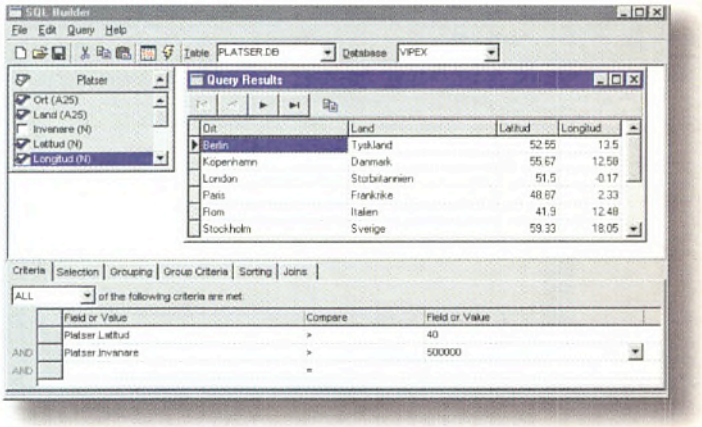
PowerSQRIBE 2.0, from SQRIBE Technologies, is a release of the Java-based tool for interactive query and **analysis** that is available in three versions: Workgroup, Enterprise, and Unplugged. It has a **browser**-based interface and pricing begins at £73 per user.
www.sqribe.com

IONA Technologies has announced plans to integrate its **OrbixOTM** with Microsoft's **Transaction Server** (MTS). This will enable transactions started by components in either MTS or OrbixOTM to involve components in the other environment: **Corba** and COM+ based transaction communication.
www.iona.com

Delphi 4, the latest version, is expected to ship in the last week of June. There is increased support for project management, improved debugging, and new language extensions. Windows 98 controls have been added to the VCL and Internet functionality is provided via a Native Internet VCL and WebBroker. Visually constructing reusable Corba objects is possible with the One-Step Corba tool.

Support for project management has been seen as overdue: the Project Manager tool helps the organising, coding, and debugging of multiple-project applications. The integrated debugger includes remote and multi-process debugging. There are inspectors, breakpoint enhancements, debugger specific sub-menus, and now, officially, a CPU view.

The primary language extensions for Object Pascal include method overloading, default parameters for procedures or functions, and dynamic arrays. With method overloading objects can have more than one method with the same name. The versions must be distinguishable by different type signatures in their arguments. Default parameters also follow the path of C++, with assignment allowable only at the end of the parameter list. For dynamic arrays memory is reallocated with assignment or with calling the `SetLength` procedure. Dynamic array variables are implicitly pointers and are managed by the same reference-counting technique used for long strings.



Delphi 4 attempts to simplify the development of web-enabled applications, and getting data and applications to the Web with a One-Step ActiveForm wizard. Native Internet VCL includes 25 Internet components to build dedicated applications like mail servers, event dispatchers, and newsgroup readers.

For databases, Delphi's data access components have been enhanced to allow adjustments to a data model while building a form or data module. Changes to the data access components and the Borland Database Engine (BDE) let you access the data in new types of database servers, including Access '97 and Oracle extensions to SQL, including ADTs (Abstract Data Types), arrays, references, and nested tables. The visual Query builder has been replaced by SQL Builder (pictured), an 'intelligent' query builder.

Some of the features described are available only in the client/-server version.

System requirements for all versions (Standard, Professional, and Client/Server) are Windows 95 or NT 4.0 (SP 3), 16 MB RAM (32 or higher recommended), and 60 MB of spare disk space.
w www.inprise.com

A management diamond

Diamond CM 5.0 is a software configuration management toolset for multiple platforms. The system from Diamond Optimum Systems provides the following services: process flow control, impact analysis, version control, release/build management, audit trails and historical reporting, problem tracking, and software distribution.

Release 5.0 enhances team development support, including branching, merging, a graphical file revision tree, and integration with PowerBuilder, MS Visual Studio, and Oracle.
w www.DiamondOS.com

DynaWeb cleans up XML

Inso's DynaWeb and DynaText Professional Publishing have both reached version 4.0. DynaText Professional Publishing (which includes the DynaWeb Server) enables the efficient publishing of documents via the Web, LAN, and CD-ROM. The Windows and Unix versions now have additional support for XML and enhanced search capabilities.

The DynaText XML-related enhancements include an 'export XML' option, support for XML links, and the action associated with the activation of an XML link can be defined by the publisher. Existing XML support includes the ability to parse, index, store, publish and search XML content. DynaWeb converts XML content into HTML 'on the fly' for publishing to browsers.

For Version 4.0, Inso's own 'query expansion search technology' has been integrated with the DynaText search engine. The new searching capabilities expand a user's query to achieve more precise results.

w www.inso.com

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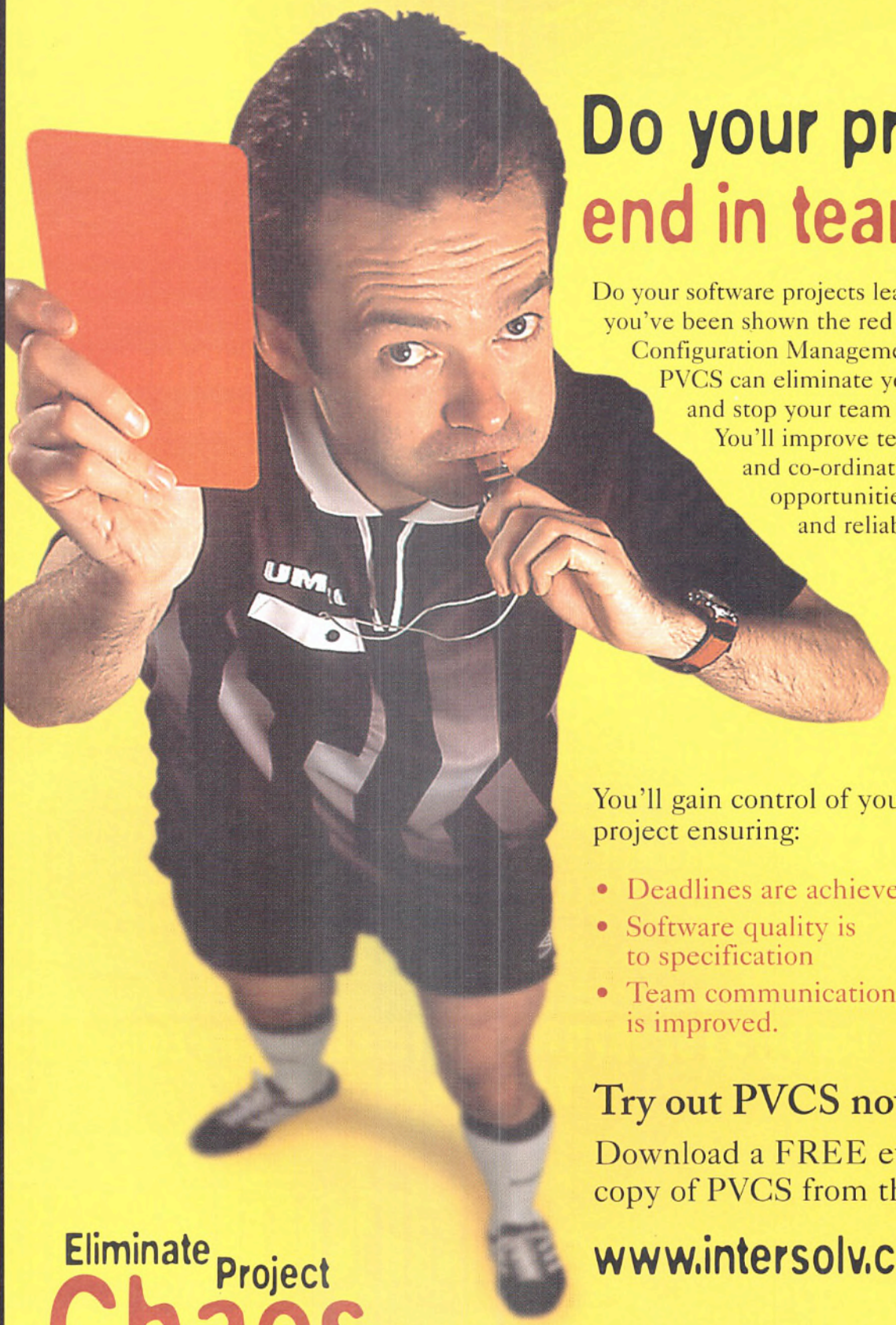

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Write once Help any format

RoboHELP Office 6.0, the Help authoring suite from Blue Sky Software, addresses the new Windows 98 Help format, Microsoft HTML Help (this format will also apply to NT 5.0). There is a WYSIWYG environment for creating the new Help files as well as continued support for the WinHelp format for Windows 95, 3.1, and NT 3.51 and 4.0. For migration, it allows the conversion of existing WinHelp (RTF) projects into HTML Help projects.

HTML Help features an Explorer pane to improve navigation within HTML Help files, and supports Dynamic HTML, ActiveX controls, and other Help extensions. Authors can establish links to an URL from the table of contents, the index, or within a topic in their HTML file, expanding the range of information that can be included and updated automatically. Using a standard HTML editor, Help authors would have to hand-code the new features; RoboHelp Office automates the creation of features such as a dynamic table of contents, multi-level indexes, and related topics buttons.

Functionality of version 6.0 includes the capture of on-screen actions to create 'live' video product demonstrations and tutorials in a Help system. The suite contains a library of graphics and images that can be incorporated royalty-free into any Help file (the WinHelp Graphics Locator is pictured). Completed Help files can be inspected and debugged, and lost source code can be recreated from existing Help files.

The complete range of Help formats supported by Office 6.0 is: WebHelp, Windows CE Help and Netscape NetHelp 1.0 and 2.0, WinHelp 3 and 4, and HTML Help. The idea of the first of these, WebHelp, is to allow authors to create full-featured Help systems that are universal. It is an HTML and Java-based solution that should be both cross-platform and browser independent, allowing Help authors to write one Help system that can be deployed anywhere.

RoboHELP Office 6.0 will run on Windows 98, 95, and NT 4. A 16-bit version of the product is also available.

w *www.blue-sky.com*

The Unix 98 brand

The Open Group has announced the availability of a family of product standards for Unix 98 (Unix 98 Base, Unix 98 Workstation, and Unix 98 Server). IBM, Sun Microsystems, and NCR have already registered the availability of products that carry the Unix 98 'brand'.

Following on from Unix 95, Unix 98 is a result of collaboration between vendors and users to increase the compatibility of Unix operating systems, and to incorporate state-of-the-art Internet capabilities.

The new set of product standards, which are designed to complement the recent network computing program (http://www.opengroup.org/nc/), provides the server functionality for an open platform and Internet server.

Unix 98 Workstation adds CDE, a standard GUI which is shipped by major Unix system vendors.

Unix 98 Server adds the following web services to Unix 98: JVM support, TCP/IP, SNMP, Hypertext Transfer Protocol, Domain Name Service, Terminal and File services, Mail Services, Client Booting Services, Time Services, and Directory Services.

Unix 98 mandates requirements to support standardised threads, real-time control, large file system APIs, and to be 'Y2k and 64-bit clean and architecture neutral'. A register of Unix 98 products is available on the Web at http://www.opengroup.org/regproducts/.

w *www.opengroup.org*

Model your components

SELECT Enterprise v6 is a model-driven toolset for component management, from SELECT Software. Part of the SELECT Component Factory, it supports UML and the adoption of component-based development (CBD) with such features as an enterprise-scale repository and code 'synchronisation' (for C++, Java, Visual Basic, or Forte).

Version 6 provides modelling support for all stages of a development lifecycle – business process modelling, UML-based object and component modelling, and data modelling. The repository enables elements of software (components, code, models) from a variety of sources to be centrally stored and reused in a consistent manner.

w *www.selectst.com*

Report Designer Component for **Visual Basic** is an ActiveX control, from **Seagate**, that converts the report design functionality of **Crystal Reports 6** into an add-in for VB 5.0. The tool is available free of charge for a limited time from the Web.
www.seagatesoftware.com

The Phar Lap **Embedded WebFarm** allows embedded systems engineers to try out Phar Lap's realtime operating system, the Realtime ETS Kernel, on different x86 hardware platforms. Comparative **benchmarks** can be run and **Phar Lap**'s Embedded Web technology investigated in action.
webfarm.pharlap.com

NetDynamics 4.1, the **application server**, includes enhanced support for team development, remote debugging, and IDE improvements. There is expanded support for applets and for external **JavaBeans** running in applets. Available for NT, HP-UX and AIX versions will follow.
www.netdynamics.com

The Advantage Consultancy's **Mail Manager** is a package to automatically detect and delete **spam** email at the Mail Server before the mail is downloaded to your client. The criteria for **detection** include keywords and unreachable originating addresses.
www.demon.co.uk/advantage

There are new versions of **Compuware**'s Dile-AID/CS and **QARun** products. They can automate the time-dimensional testing process for client/server environments. Developers can age or set up test data more quickly. **FILE-AID/CS** works with Oracle, Sybase, Microsoft SQL Server, and Informix.
www.compuware.com

Java post-it

CodeWarrior for **NetWare** is a package of development tools for Novell's network server platform. Its features include: Novell source-level debugger for NetWare, for debugging NLM applications; **CodeWarrior** plug-in tools for NetWare using **C/C++**; NetWare DDK and SDK and GroupWise SDK; a Java toolset supporting JDK 1.1.5.
www.metrowerks.com

Requisite Pro 3.1, the Windows-based **requirements** management tool, is bi-directionally integrated with Microsoft **Project**. This allows users to capture project requirements and customise the interaction between requirements and tasks in a schedule. It is integrated with Microsoft Word 95/97 and Project 95/98. It supports Windows 95 and NT 4.0.
www.rational.com

The RasterNote/Java Annotation Toolkit enables developers to enhance their programs with annotation and redlining capabilities. The Java class library, from Snowbound Software, provides the ability for an end user to communicate comments on a document or engineering drawing by using a mouse to draw circles, lines, or freehand shapes, and then to add 'post-it' notes as an overlay to the document.

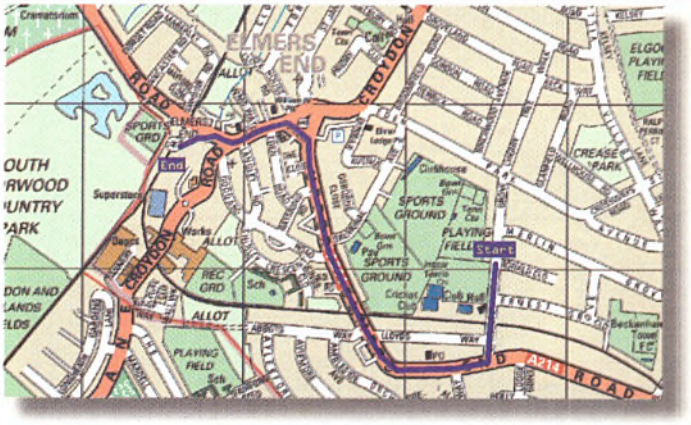
Features include the ability to add, resize, or delete objects, add lines of various widths and styles, select different text fonts, and to edit text within objects.

The annotation objects that are available include rectangles, highlighted rectangles, filled rectangles, lines, ellipses, freehand drawings, bitmaps (logos or symbols) post-its, and text.

The toolkit costs $995.

w www.snowbnd.com

Finding the fastest route



RouteFinda, from Graticule, is software to find the shortest or fastest route between any two or more points selected on a map and displaying the resulting route as a list and on a map (with Graticule's MapServer 4) using Windows 95 or NT.

RouteFinda works with vector map data that has been topologically checked to form an integrated network of nodes and links. Such data may include railway or aircraft routes provided that the data has nodes at appropriate intersection points.

When combined with satellite global positioning systems and traffic reports, RouteFinder can provide dynamic shortest route tracking and navigation.

MapServer 4 is available as a DLL for use with C/C++, as an OCX for VB, and a VCL for Delphi. It lets developers import and export map data in various formats, and pan, zoom, print, and query map objects.

w www.graticule.com

Books received

Publisher	Title	Author	ISBN	RRP	Date Rec'd
John Wiley & Sons	Requirements Engineering: Processes & Techniques	Gerald Kotonya & Ian Sommerville	471972088	£27.50	13/05/98
John Wiley & Sons	Computer Graphics for Java Programmers	Leen Ammeraal	471981427	£24.95	15/05/98
AP Prof/Harcourt Brace	Interactive Web Applications with Tcl/Tk	Hattie Schroeder & Mike Doyle	122215419	£29.95	20/05/98
Cambridge University Press	Advanced Object-Oriented Analysis & Design Using UML	James J. Odell	052164819X	£19.95	22/05/98
O'Reilly & Associates	Virtual Private Networks	Scott, Wolfe & Erwin	1565923197	£21.95	27/05/98
O'Reilly & Associates	Frontier: The Definitive Guide	Matt Neuburg	1565923839	£25.95	27/05/98
O'Reilly & Associates	Managing the Windows NT Registry	Paul Robichaux	1565923782	£29.50	27/05/98
O'Reilly & Associates	Developing Windows Error Messages	Ben Ezzell	1565923561	£29.50	27/05/98
O'Reilly & Associates	Windows NT Desktop Reference	Aeleen Frisch	1595924371	£5.50	27/05/98
O'Reilly & Associates	Managing Mailing Lists	Alan Schwartz	156592259X	£21.95	27/05/98
John Wiley & Sons	Building Business Objects	Peter Eeles & Oliver Sims	471191760	£34.95	27/05/98
John Wiley & Sons	Ready to Run Visual Basic Algorithms - 2nd Ed	Rod Stephens	471242683	£39.95	27/05/98
John Wiley & Sons	Official Guide to Programming with CGI.pm	Lincoln Stein	471247448	£24.95	27/05/98
SIGS Reference Library	Object Modeling and Design Strategies	Sanjiv Gossain	052164822X	£24.95	27/05/98
SIGS Reference Library	The Netscape Programmer's Guide	Richard B. Lam	521648203	£29.95	27/05/98
SIGS Reference Library	Java Gems	Dwight Deugo	521648246	£19.95	27/05/98
SIGS/Cambridge	Building Object Applications That Work	Scott W. Ambler	521648262	£24.95	29/05/98
O'Reilly & Associates	Frontier: The Definitive Guide	Matt Neuburg	1565923839	£25.95	01/06/98
AP Prof/Harcourt Brace	Personal Encryption: Clearly Explained	Pete Loshin	124558372	£29.95	01/06/98
Sybex Network Press/ Pitman Publsihing	MCSD: Visual Basic 5 Study Guide	Michael McKelvy	782122280	£40.99	03/06/98
Cambridge University Press	Developing Business Objects	Andy Carmichael	521648254	£24.95	10/06/98
Cambridge University Press	Upgrading Relational Databases with Objects	Robert Vermeulen	135706076	£24.95	10/06/98
John Wiley & Sons	Developing JavaBeans Using VisualAge + CD	Nilsson & Jakab	471297887	£32.50	12/06/98
John Wiley & Sons	Programming with JFC +CD	Weiner	471247316	£32.50	12/06/98

Friends in need

There seems to be a widening circle around Microsoft – everybody is sidling away. Is there a particular reason why?

Microsoft in general, and His Billness in particular, have been so concerned with where you and I want to go today, fixing bugs, and even (whisper it quietly) making lots of money that they didn't stop to enjoy the finer things in life, such as smelling flowers, saving whales, and bathing in the warm glow of friendship. That's a shame, because it looks like they could do with some friends, or even (if things go really pear-shaped) a bunch of flowers or two.

Microsoft has never cared much about friendship. Why should it, when it can buy all the friends it needs from among the ranks of the starving little people? But, life doesn't seem to be working out that way. The poor dears seem to be embroiled in one lawsuit after another, and (over there being over there) lawyers and writs are attracted to existing suits like sharks to half a swimmer. Take this as an example: the US Department of Justice and twenty US states plus the District of Columbia have filed suits against Microsoft. They are asking for a preliminary injunction to stop Microsoft forcing computer makers to install IE, and to remove IE from Windows 98 (or include Netscape as well) until the anti-trust cases are sorted. The anti-trust cases are not going to get sorted, of course, and most people now know that they can download Internet Explorer 4, install it into Windows 95, and get an instant Windows 98 for free. That's not the point; the twenty states dearly want to annoy Microsoft for a couple of years, and these twenty states are not starving little people.

Hewlett Packard, Corel, and Sun are also not starving little people. Annoyed by Microsoft's development strategy of watching what other people do, then doing the same thing in an incompatible manner and pressuring all developers to do it its way (thus vaping all the kudos-laden invention and expensive development), the aforementioned (along with a few friends) have formed ProComm – the Project for the Promotion of Competition in Computing (I guess the name sounds best when processed through an echo machine). It's difficult to know what this is apart from an anti-Microsoft pressure group, although it seems an odd kind of group; most of HP's output runs Microsoft products, all Corel's output runs on top of it, and both belong to the committees which design the bulk of Microsoft's bloated technical standards. Microsoft, no doubt, would regard this as biting the hand that feeds them.

It's not just software companies who are upset with Microsoft. You wouldn't think that Intel would have much difficulty making a crust, what with its fortunes so intimately tied up with Microsoft's, but look what's happening to them. Loads of money developing and advertising MMX, but because Microsoft didn't ask for it, and nobody else knew what it was, nobody was impressed. Now MMX has been dumped, and the investment (and kudos) has all been dumped with it. Loads of money down the toilet; three thousand jobs lost – oh heck! Now they are pinning their hopes for the future on Celeron, which is a Pentium without an instruction cache. Can you imagine how they're going to advertise that? 'Those clever boffins at Intel have discovered that all you ever needed was a 486 in treacle'. AMD and Cyrix should be rubbing their hands with glee; while people are not buying Celeron in droves, Intel has created a huge hole in the market, and has manifestly failed to kill off Socket 7. Intel may be starving (for the moment), but little people they definitely are not.

I'll tell you another group which isn't starving little people: it's the starving little people themselves. You may already have seen that the *LA Times* uncovered a plot by Microsoft and its PR agency to get ordinary people (and ordinary journalists) to write spontaneous letters and articles expressing the general niceness, quality-consciousness, and cuddliness of the company – the spontaneity being supplied, of course, by the PR agency (or even better, a Word 6 compatible OCX, but they couldn't get that to work properly). Personally, I'm amazed that Microsoft thought anyone, anywhere, would fall for it, but because the American press (and the great *LA Times* in particular) is still largely free (which, of course, would be rapidly corrected by anyone who managed to attain overall control of the Internet – sound familiar?) Microsoft has actually shot itself in the foot big-time. By leaving a purely technical or commercial sphere, and starting a propaganda war, it is taking on a sophisticated public and an even more sophisticated (and cynical) political machine. As one grinning attorney general put it, 'Welcome to *my* world, Mr Gates!'.

Taken separately, these stories are funny, sad, exciting, and (on occasion) inspiring (I bet you never thought the business was so cinematic!), but taken together, a picture is emerging. Microsoft has been beating off legal threats and problems for years, but nobody really thought that those threats were serious challenges, and everyone, even the legislators, thought Microsoft was untouchable (and that Stacker was just bad luck). I guess it never really had any friends, but now it seems that the world is divided into those who sulk about Microsoft and those who are big enough to take them down a peg. While its public image suffers one trouncing after another, Microsoft can see the US Government repeatedly aiming at it, and is increasingly worried, so it is manoeuvering to play a different game. ProComm is actually no more than an attempt by the members (who were happy to share the ride to the top) to distance themselves from Microsoft so they have a better chance of ducking when the poo really starts flying, and I suspect that Intel, who got a bloody nose for stepping out of line (and who, by some strange coincidence, is now designing a chip specially for Linux), will be flinging a fair proportion of its own.

It doesn't matter how much money you've got if your money is no good, and you can only buy friends on subscription. ■

Jules is a journalist who has a deep respect for Mr Gates, his famed generosity, and all his achievements. He can't understand why they haven't made a movie about his life. That will be five grand, please. If you want to know where to send the money, call 01707 662698, or email jules@cix.co.uk.

We welcome short letters on any subject relevant to software development. Please write to: The Editor, *EXE Magazine*, St. Giles House, 50 Poland Street, London W1V 4AX, or email editorial@dotexe.demon.co.uk

Agnostic Corba

Dear Sir,
I read the *Inheritance considered harmful* piece in your May 1998 issue. I found it very interesting.

There have been academic papers along these lines in the past, but not many. The best is by Alan Snyder, published long ago in *Research Directions in Object Systems*, edited by Peter Wegner.

I certainly agree that implementation inheritance is a violation of encapsulation and therefore prejudicial to building well-modularised programs. On the other hand, it's the principal mechanism for reuse in OO languages such as Smalltalk. You pays your money and you takes your choice.

The author of the EXE feature is (quite correctly I think) careful to distinguish implementation inheritance (which *does* have this problem) from interface inheritance (which does not). Corba's inheritance is interface inheritance, which provides a form of subtyping, and is emphatically not 'harmful', despite what he says in his conclusion ('Inheritance, both of implementation and interface, has many problems'). Corba is agnostic on implementation inheritance – you can use languages with implementation inheritance (Java, C++, Smalltalk) or ones without (Eiffel, C, Cobol).

The ironic thing about this piece is that the author draws his examples from COM/DCOM, which used to tout their use of aggregation as an alternative to implementation inheritance (for the reasons stated above), but are now moving very much towards it, and away from aggregation, principally because no one uses the latter. Have a look at COM+ previews to see how Microsoft is firmly embedding COM in C++, and therefore implicitly embracing its implementation inheritance model. Aggregation is now rarely referred to in the Microsoft documents.

The bottom line – Corba takes no position on implementation inheritance. It does use interface inheritance, which is quite different, and the assertions in this paper that interface inheritance is problematic are, to be polite, unproven. The bottom, bottom line is that users like inheritance.

Andrew Watson
Director, Architecture
Object Management Group

I realise that I am going to have a hard time trying to convince the OMG that inheritance of interface is a bad idea!

While interface inheritance does not have the problem of breaking modularity (as implementation inheritance does), it *does* have the problem of restricting polymorphism. Both forms of inheritance are bad, but for very different reasons.

Inheritance of interface *is* harmful if it encourages people to force certain methods to be implemented together. Forcing methods to be implemented together restricts polymorphism by preventing one having objects that require or implement only a subset of those methods. It is very hard to know in advance what subsets will be needed. See for example the abundance of 'not implemented' return codes in COM.

In my opinion, the only reasons for using the concept of interfaces as opposed to freely implemented methods are the following:

- **It is easier to implement efficiently (though free methods can be implemented just as efficiently if one puts a little thought into one's implementation)**
- **Current type systems are bad at specifying multiple constraints for an object (Java doesn't even allow it – arguments can only have one interface specified).**

Finally, although users like inheritance, I would argue that this is not because inheritance is good, but because the available alternatives are usually worse or non existent. We need to look at ways of doing things better.

Robert Ennals

So-called dongles

Dear Sir,
Following the *Mayhem* article in the April issue I would like to point out that, as a dongle manufacturer, we found the article covered exactly what we have been trying to introduce to software developers over the past five years.

It goes without saying that this article highlights that dongles have other uses besides protection of software; these can range from data protection to user defined computer settings or even virus protection – all by the use of the so called dongle.

Dongles as we know them today are a way of controlling software piracy and casual copies. But this is not the only form of protection. We are certain that software developers are aware of other methods: software-based solutions, large volumes of manuals, or to release software with bugs, etc. However, the dongle in its current form, or even in a smartcard format, is in many cases user-friendly and it offers additional features that will make it a necessity for the application to be protected by dongles.

We have had a number of instances where end-users have contacted us to protect their unprotected software. This is primarily due to the fact that when a computer is stolen the software or data is of no use if the dongle is placed in a safe securely over night. Not to mention that in many cases the company's management does not feel confident that they could prevent their employees from making illegal copies of their legitimate software.

The majority of our customers use our Anchor key as a form of control for their application, and not purely as software protection. The security of software is also dependent on how the codes are implemented – this is where BLCS is different; we give free advice, and when it comes to supply we do not break the bank.

In your May issue there was a letter from Aladdin UK criticising the April *Mayhem*. A question, which comes to mind is, why were they shaken up by the reality of dongles (in the majority of instances)?

However, we do agree with them that the security sector is on the increase. The simplest question is: 'Do you lock your house when you go to work?' If so, why not protect the source of your income? Or the information which you depend on?

El-Azar Levy, M.D.
B.L. Computer Security Ltd

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Testing in black & white

Software testing is still regarded by many as an art. Mark Harman explains coverage analysis, which allows us to put the whole process onto a more sound engineering footing.

Testing need not simply be a process of inserting output statements into our code to see if the values we expect appear. We can put the whole process onto a more sound engineering-lead footing.

Many software developers would admit that when they test their own software they tend to choose test cases that do not really *push* the software particularly hard. For example, last time you tested a piece of software, how many statements of the code do you think went unexecuted by any of the test cases you tried? If your answer is greater than zero then you have, I'm afraid, failed what is regarded by software testing specialists to be the *weakest* testing adequacy criterion.

This article introduces coverage techniques for finding and assessing software test cases. I will start by briefly explaining why software testing is so much harder for software engineers than the testing of products for engineers in other disciplines. Then I'll go on to explain how coverage analysis allows us to assess just how stringent our testing is and how software tools can and cannot help with the testing process.

Software testing can never establish the correctness of software - only its incorrectness.

What is software testing?

Edsger Dijkstra noted that 'software testing can never establish the correctness of software – only its incorrectness'. He was observing that test cases can reveal faults in software, but that we cannot infer from the absence of errors for all test cases tried that the software itself is fault free. We could *attempt* to test every possible input to the program, to see that the output (and/or its behavioural properties) conform to the specification. This is called 'exhaustive testing'. Sadly, in most real systems exhaustive testing would require an unacceptably large set of test cases.

Dijkstra's aphorism was used to argue for an alternative approach in which software is constructed directly from its specification using a sequence of formal refinement steps. He wanted this construction process to be accompanied by mathematical proofs to establish the software's correctness with respect to its specification. Nowadays this highly rigorous form of verification is reserved for the most safety critical aspects of software development, as it is typically time-consuming and expensive. This leaves us with software testing as our main tool of verification for the less safety critical systems. (Of course, testing is also used as a backup technology for safety-critical systems.)

```
if(p)
   S1
   else if (q)
      S2
      else S3
S4
```

Listing 1 – White box testing: a simple example.

Testing seeks to answer, among other things, the following questions: What is a good test case? When have we tested a system enough? How many bugs have we failed to find with our test set?

Why is testing software so hard?

Testing software is not like testing components in other engineering applications. For example, consider the problem of testing a software component when compared with the problem of testing a structural component in a civil engineering application. The civil engineering product will undergo certain stresses and strains and may be subjected to a variety of weather conditions and temperatures. An important aspect of all these loads is their *continuous* nature, which requires testing to take place only at the *extremes*.

If we know that a component behaves well at temperatures T1 and T2 (where T1 < T2), then we can reasonably conclude that the component will behave well at all temperatures *between* temperatures T1 and T2. With software, we do not have this considerable luxury. If we know that a loop statement with one determining integer variable, `v`, terminates when `v=T1` and also when `v=T2` (where T1 < T2) we cannot reasonably conclude that the loop terminates for all inputs between T1 and T2. Software systems are essentially *discrete* systems.

This discreteness makes testing a more demanding task than one might think. Ideally, we have to test a software product at all points, not just at the extremes. Unfortunately, this is usually impossible, due to the number of points we would have to consider. Therefore, we have to satisfy ourselves with some measure of 'just how much' of the system we have managed to test.

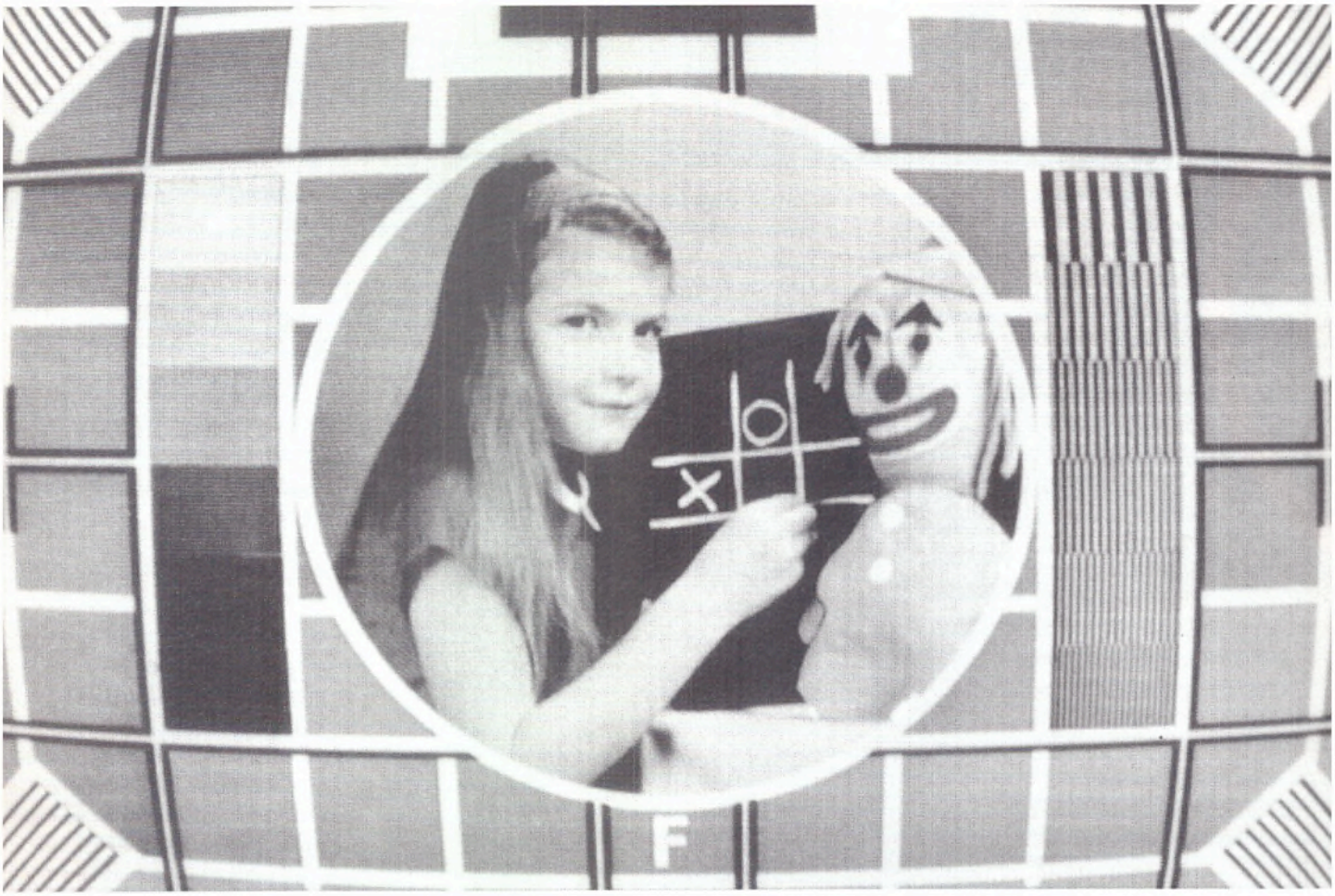
Surprisingly, for most systems only about 60% of the program's statements are *ever* executed. Therefore, if we could manage to ensure that every statement was executed by at least one test case, then we would probably be testing more thoroughly than average. This is the sort of statement of test thoroughness that coverage analysis makes precise. To decide whether we have tested a system enough, we must decide what level of coverage we think is suitable. Usually, coverage is expressed as a percentage; the percentage of some syntactic structure that has been executed by the test set in hand.

Coverage

To get a feeling for how coverage analysis works, consider the C program fragment in Listing 1.

In looking at the structure of this fragment we can see that there are four basic statements: `S1`, `S2`, `S3`, and `S4`. We might try to construct a set of test cases that ensures that each of these statements is executed at least once (this is statement coverage).

Alternatively (or in addition), we might decide that we should test both the predicates (`p` and `q`) with two cases each. One of which tests their behaviour when they evaluate to `true` and the other of which tests their behaviour when they evaluate to `false` (this is branch coverage).



Of course, we might not have time to perform *all* these tests so we might want to decide to cover a certain percentage of statements. Clearly this is a very weak testing requirement; if we settle for less than 100% coverage then we are guaranteeing *not* to have tested some statements.

The control flow graph

The three most common forms of coverage are based on the *control flow graph* (or CFG). Sometimes this is simply referred to as a 'flow graph'. A CFG is a graphical representation of the way in which the sequence of control flows from one part of the program to the next. The nodes of the CFG represent simple primitive statements (such as input, output, and assignment) and its edges represent the flow of control. A CFG is simply a formalisation of the very old and familiar flow chart.

To understand what a CFG is, we need to know a little bit about graphs.

A *graph* is simply a collection of nodes (you can think of these as points which can be 'visited') and arrows between these nodes (called edges), which link nodes together, indicating which nodes can be reached from which other nodes. The map of a one-way traffic system is a graph. Strictly speaking, we call graphs that contain arrows, 'directed graphs', because there is a direction indicated by the arrowhead. A one-way system is a directed graph. The London Underground tube map is a graph. The stations are the nodes and the lines between stations are the edges. However, the underground map is not directed because we can travel in either direction.

A *path* in a graph is a list containing two or more nodes. In a path, each node in the list can be reached in one step down an edge from the node that precedes it. We need at least two nodes in the path as these form the start and the end of the path. We say that a path is 'a path from A to B' if the first node in the list is A and the last node in the list is B. In the graph of the London Underground, a path is just a way of getting from station A to station B.

A control flow graph is simply a graph that has a few constraints placed on it to ensure that it corresponds to a sensible model of a program. These constraints ensure that it is possible to get from any node in the graph to the exit node of the graph and that every node can be reached from the entry node. Listing 2 contains a simple program, for which the corresponding complete CFG is depicted in Figure 1. The exit node is labelled 'STOP' and the entry node is labelled 'START'.

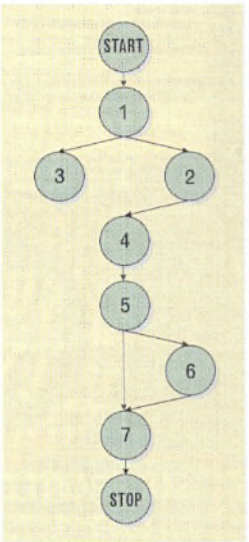


Figure 1 – Control Flow Graph for the program in Listing 1.

Statement coverage

In statement coverage, we seek to design test cases that cause statements to be executed. The *level* of coverage achieved by a set of test cases is simply the fraction of statements that get executed by one or more of the test cases. This fraction is typically expressed as a percentage: 50% statement coverage means that half the statements get executed by one or more test cases (and half do not get executed by any test case).

Throughout this article, I shall use the simple example program in Listing 2. You will need to refer to the control flow graph of this program fragment, depicted in Figure 1.

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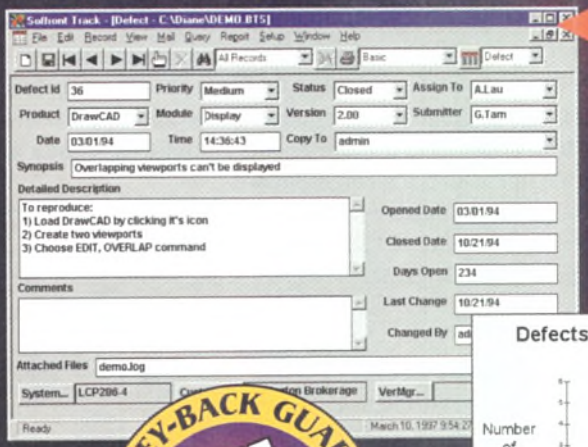

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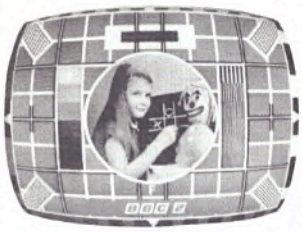

In Listing 2, I have labelled each primitive statement and predicate with a number to allow you to correlate them to the nodes of the control flow graph.

In this context 'statement' means 'node in the control flow graph'. In a (rather pathological) program that contained only nested body-less `if` statements we would be required to cover all the predicates with at least one of our test cases. In 100% statement coverage, we are certain that every node of the CFG has been executed at least once. Of course, this does not mean that we are guaranteed to uncover any faults in the statements, but if we hadn't covered 100% we could be certain that sometimes we would fail to uncover faults. It does not matter whether a statement is executed once or a thousand times – all that matters is whether the statement gets executed or not. This means that, in trying to achieve coverage, we suppose that all statements are equally likely to contain bugs. Therefore, the more statements we manage to 'hit' with our set of test cases, the better.

To achieve 100% statement coverage of the program in Listing 2, we would have to define a set of test cases that covered lines 1, 2, 3, 4, 5, 6, and 7. The tests can be defined in terms of initial values for the 'unbound variables' (in this case `p`, `q` and sometimes, `x`). Although `z` and `y` are mentioned in the code, their initial values are never required in the definition of a test case, because their initial value does not affect the course the execution takes. (The course that execution takes is simply the path it follows in the CFG of the program.)

In order to execute statements 2 and 3, two test cases are required as the statements are alternatives. However, a careful choice of test cases ensures that at least one of these covers statement 6, and so an additional test case for statement 6 is *not* required. Obviously, since it does not matter how many times we execute a statement, we shall want to cover all the statements with as few test cases as possible, thereby reducing the effort required to reach 100% coverage. A suitable (and minimal) test set for the program in Listing 2 need only contain two tests, for example:

Test One: **p has the value 4 and**
q has the value 3
Test Two: **p has the value 2,**
q has the value 6 and
x has the value -1

Notice that, in order to achieve 100% statement coverage of the program, it was necessary to cover both the case where the first predicate evaluated to `true` and the case where it evaluated to `false`. However, it was *not* necessary to cover the case where the second predicate was `false`. We have covered every possible statement, but not every possible branch. In terms of the CFG, we have hit every node at least once, but there remain edges down which execution has not passed. This is what branch coverage is all about.

Branch coverage

A branching node is one that has more than one outgoing edge in a graph. In a CFG as defined earlier, this means a predicate node.

In order to achieve 100% branch coverage it is necessary to execute each predicate at least twice. In one instance the predicate must evaluate to `false` and in another it must evaluate to `true`. If we have achieved 100% branch coverage, we know that every edge of the CFG has been covered. Notice that we can manage to cover every node of the graph and yet fail to cover every edge, because there may be several possible ways of getting to a node and we may only cover one of the possibilities. For example, the test set defined in the previous section does not achieve 100% branch coverage for the program in Listing 2, although it did achieve 100% statement coverage. We shall have to re-think our test set. However, this does not necessarily entail an increase in the *number* of test cases. It simply means (in this case) that more care is required in selecting test cases. A test set that achieves 100% branch (and statement) coverage is:

Test One: **p has the value 4 and**
q has the value 3
Test Two: **p has the value 2,**
q has the value 6 and
x has the value 17

Path coverage

Remember that a path (from node A to node B) through a graph is a list of nodes: the list of nodes that gets executed when execution starts with A and ends up at B. Of course, there may be many ways to start at a node A and end up at a node B, each of these will be a different path from A to B. To achieve 100% path coverage, every path from the entry node to the exit node of the CFG of the program must be traversed during at least one execution of the program.

In general, the presence of loops means that there are infinitely many paths; we can keep on creating ever-longer paths by simply going round a loop one extra time. Obviously, we cannot cover infinitely many paths with our test set. To overcome this a limit may be placed upon the number of executions of the loop, or only loop-free paths may be tested. Really, path testing is only defined to give us an idea of the limit of coverage-based testing.

The program in Listing 2 contains only four paths, so it is possible to achieve 100% path coverage. The four paths are <1,2,4,5,7>, <1,2,4,5,6,7>, <1,3,4,5,7> and <1,3,4,5,6,7>. In order to cover them all, four test cases will be required. For example, the following four test cases will do the trick.

Test One: **p has the value 4 and**
q has the value 3
Test Two: **p has the value 2,**
q has the value 6 and
x has the value -1
Test Three: **p has the value 5,**
q has the value 3 and
x has the value 20
Test Four: **p has the value 2,**
q has the value 6 and
x has the value 19

Notice that the values for `p` and `q` are reused in the test cases. This is clearly bad from a practical point of view, as less of the program's input domain is exercised (even though all paths through the program are). There is nothing in the definition of path coverage (or in the other two forms of coverage) that *requires* different

```
1 if (p>q)
2    x=1;
3    else y=2;
4 z=x+3;
5 if (z==p)
6    z=z+1;
7 y=x+1;
```

Listing 2 – A simple program.

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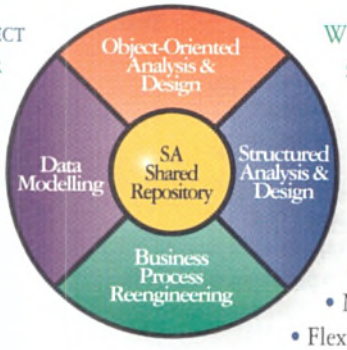

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Software testing basics

Levels of testing

Testing is carried out at several levels of granularity. Usually three are considered worthy of special note: *unit* testing, *module* testing, and *system* (or *integration*) testing.

Unit testing is at the lowest level of granularity. Individual functions and procedures are tested (usually by the programmer who wrote them, though this is not necessarily the best practice). Often this testing is carried out manually and is ad-hoc and effectively amounts to random testing conducted by a highly biased random number generator.

This is a shame; it is for unit testing that automation has perhaps been most successfully applied in commercially available testing tools. It is in individual units that some of the most disastrous bugs lurk (for example, Year 2000 bugs, the bug which caused the second crash of the London Ambulance Service system, and the Pentium FDIV bug). It is also in unit testing that *coverage analysis* has a role to play.

Module testing consists of testing collections of functions and procedures that belong to a single module. At this level of granularity, coverage analysis provides a way of describing the relative amount of testing effort each module should receive (or has received). That is, we shall not always want to spend the same amount of time testing each module. Some modules matter more than others and should accordingly receive more thorough testing. If we can achieve 100% coverage for all our modules then obviously this would be nice, but often we cannot. In such situations, we can use coverage to say things like, 'Module A has been tested to 80%, but module B has only been tested to 55%'.

It is possible to test units and modules as they are developed and the costs of fixing a fault found at these levels are comparatively low. *Integration* testing, by definition, has to wait until there is something to integrate, and so the faults tend to be uncovered only after more time and effort have been invested in the system. Unfortunately, coverage analysis cannot help us much with integration testing.

Acceptance testing

We often find that some bugs are only found by the user. In recognition of this observation, we often allow the user to form part of the testing process, in an 'acceptance testing' phase of the development life cycle.

Typically, acceptance testing is regarded as the familiar two-stage process, consisting of:

Alpha testing: In which the user tests the system in a controlled environment under the supervision of the developers.

Beta testing: In which the user tests the software on their own site.

The concept of beta testing has sadly become synonymous with the practices of unscrupulous software developers who perform no testing whatsoever – leaving it all to the customer, in what is inappropriately termed the 'beta testing phase'.

Coverage analysis can be useful during acceptance testing because we can use it to measure how much of the system the user is actually exercising when the system is in operation.

Black box versus white box

Testing techniques fall into two categories: white box and black box. In white box testing, we can 'look into the box' and use the *structure* of the software under test to guide the choice of test cases. White box testing is considered good at finding errant behaviour and additional unwanted behaviour, but not so good at finding missing (or unimplemented) behaviour. By contrast, in black box testing, we cannot 'see' into the box and so our test cases must be of a purely *behavioural* nature. In black-box testing we ask the question, 'If I supply this input, what output do I observe?' Coverage analysis is the most widely used white box testing technique.

values to be selected on each test case. All that is required is the achievement of coverage.

Some paths are impossible

Some paths are impossible; no execution will ever cause them to be traversed. This can happen because, for example, we might write an `if` statement that always executes its `else` branch. In the CFG of this program, any path that goes through the `then` part of such an `if` statement will be infeasible. These paths (that exist in the CFG, but which no execution can go down) are called 'infeasible paths'.

In the presence of infeasible paths, it may be impossible to achieve 100% statement or branch coverage and it will obviously be impossible to achieve 100% path coverage. For example, consider the program in Listing 3. If you try to generate a test case which guarantees that both the predicates in this program will evaluate to `true` you will find that you cannot.

```
1 if (p==q)
2 { x=x+1;
3   y=x+1; }
4 else y=2;
5 z=x*x;
6 if (y==x)
7   z=z+4;
```

Listing 3 – An example program fragment which contains infeasible paths.

That is, should the initial value of `p` be equal to the initial value of `q` then the assignments `x=x+1; y=x+1;` will be executed, guaranteeing that `y` and `x` have different values, and therefore guaranteeing that the predicate `y==x` will evaluate to `false`. For this program, we can define test sets that achieve 100% statement and branch coverage. However, even though there are no loops, we cannot achieve 100% path coverage, as the path <1,2,3,5,6,7> is infeasible.

Which is the best technique?

How can we decide whether coverage criterion *A* is better than coverage criterion *B*? We would ideally like to know whether *A* finds faults that *B* does not, but this is a hard concept to define and use in practice. We can provide some theoretical analysis however, and this is achieved using the *subsumes* relationship. *A* subsumes *B* if all test sets that satisfy *A* also satisfy *B*.

For example, 100% path coverage subsumes 100% branch coverage, because if all paths are covered by a test set *t* then *t* must cover all branches. Similarly, if all branches are covered then all statements must be covered, so 100% branch coverage subsumes 100% statement coverage. The subsumes relationship is transitive, so we also know

that 100% path coverage subsumes 100% statement coverage. We can therefore say with theoretical certainty that, of the three techniques we've looked at, 100% path coverage is best (though usually unachievable), 100% branch coverage is next best, and 100% statement coverage is worst. Because 100% path coverage is usually impossible, branch coverage is considered by most testers to be a good criterion to aim for. Notice that, in comparing coverage criteria, it is only possible to compare 100% coverage in each category. If we cover all but one path using path coverage, we cannot be sure that we have covered every statement of the program.

The *level* of coverage achieved by a set of test cases is simply the fraction of statements that get executed by one or more of the test cases.

Tool support

Tool support is an essential ingredient in a successful software testing strategy. Because of the number of test cases that have to be considered, an un-automated testing strategy is doomed to failure.

Most testing tools provide facilities for capturing test cases as they are executed, so that these test cases may be subsequently 'replayed'. This capture/replay mechanism provides a log of testing effort and helps an organisation to improve its testing process. The implementation of capture/replay is technically un-demanding, but it has proved remarkably effective and productivity enhancing.

Tools also exist which can generate test cases, based upon a desired level of coverage. Most existing tools use a rather simplistic and expensive approach – they generate test cases at random and measure the level of coverage achieved (by inserting probe code into the software under test). The creation of further random test cases ceases when either a sufficient level of coverage is attained or when the level of coverage appears not to be increasing (indicating, perhaps, the presence of infeasible paths, or paths down which the system is forced by relatively few test cases).

Unfortunately, completely automated test data generation is *impossible*. That is to say, the automated generation of a set of test data that is *guaranteed* to achieve 100% statement coverage is impossible. This is because the question as to whether a test set achieves 100% statement coverage is *undecidable*; it is theoretically impossible to write a program that can decide whether 100% statement coverage has been achieved.

It is easy to show that this question is undecidable. We can do this by showing that a solution to the problem would allow us to solve a different undecidable problem – that of whether or not two functions are equivalent.

Consider the simple program fragment:

```
scanf('%d',&x);
if (f(x) != g(x)) z=1;
```

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In this program fragment, `f` and `g` are arbitrary side-effect free functions on integers. If it were to turn out that `f` and `g` were equivalent functions, then the assignment statement would not be executed and so 100% statement coverage could be achieved by a set of test cases that did not execute the assignment. However, if the two functions are not equivalent, then there will be some input value for `x` which will drive the program through the assignment statement and 100% coverage cannot be achieved without the inclusion of a test case which mentions just such an input value for `x`.

Suppose that there exists an automated system for answering whether or not 100% statement coverage has been achieved by some set of test cases. It would be possible to use this system to decide whether the two functions `f` and `g` were equivalent. All that would be required would be to generate a singe test case (any one will do – some input value for `x`). Next, execute the program on this input. If the assignment statement is executed, then conclude that the two functions are not equivalent. If the assignment is not executed, then ask the automated system whether the test set consisting of this single test case achieves 100% statement coverage. If the system answers 'no' then the functions are not equivalent, if the system answers 'yes' then the two functions are equivalent.

If we had a tool for deciding whether a test set achieves 100% statement coverage, we could use it to answer the question as to whether or not two functions were equivalent. However, the question as to whether two arbitrary functions on the integers are equivalent is known to be undecidable, and therefore we have to conclude that the problem of deciding whether 100% statement coverage is achieved by a test set is also undecidable.

Tools can help us with software testing by measuring coverage and by recording and replaying our test cases. They can also be used to generate test cases in an attempt to reach a good (ie high) level of coverage, but they can never do the whole job for us.

The final criteria

Software testing is much harder than testing in other engineering domains because of the discrete nature of the product (software) to be tested. It is possible to make some sensible choices as to what tests to subject a system to, based upon the structure of the software. What we do is to attempt to *cover* the software, ensuring that all aspects of its structure are exercised by the test set. This does not guarantee that we will trap all faults – nothing can do this for us. It does however, give us a measure of how much testing we have performed and provides us with a way of comparing one testing criterion with another. ■

Mark Harman is a lecturer in computer science at Goldsmiths' College. He can be contacted by email at m.harman@gold.ac.uk, or by post to Mark Harman, Department of Mathematical and Computing Sciences, Goldsmiths' College, University of London, New Cross, London SE14 6NW.

Thanks are due to Robert Hierons, who checked earlier versions of this article and provided valuable insights into the nature of the software testing process.

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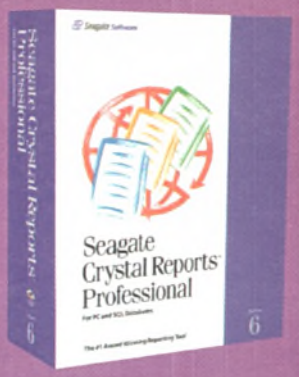

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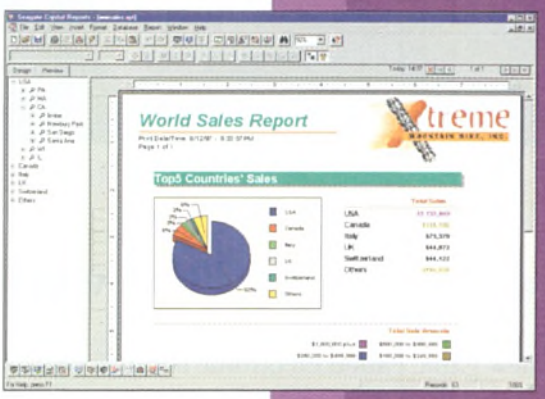

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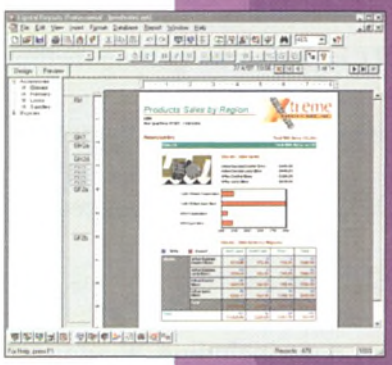

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Writing to the screen

Do you need to use a direct screen access API to bypass the graphics libraries straight to the video card memory? Duncan Wilcox compares the relative performance of BeOS, Windows 95, and OS/2 Warp 4.

As operating systems become more complex and implement more abstraction, they also significantly slow down some classes of applications. For instance, some would benefit from a more straightforward, low overhead access to the screen. While not every application will benefit – and the added complexities aren't always justifiable – applications that perform continuous output to screen should show significant performance improvements, either in the form of faster rendering or lower CPU utilisation.

Libraries that let applications bypass the user interface and graphics libraries, directly accessing the screen (the so called frame buffer memory, which resides on the video card and is directly displayed on screen), were developed to ease the transition of games from the raw DOS environment to graphical user interface operating systems. Currently, 3D accelerated video cards are cheap enough to make it reasonable for games under development to require one, making the 2D APIs that I'm exploring here less interesting for resource intensive games. My intention for this article is to focus on how applications, as opposed to games, can benefit from a direct screen access API. This is certainly true on any platform, and I'll give specific examples in BeOS, OS/2, and Windows 95.

Benefits?

How much an application will benefit from directly accessing the screen is very dependent on how well its features match the specific API. For example, some functionality, like the font renderer, is more easily accessed through the standard graphics API.

A couple of screen shots show that an application that accesses the screen in a discrete way can significantly gain from the BeOS BDirectWindow interface. The Charts demo is available with full sources from Be's ftp site at *ftp://ftp.be.com/pub/samples/r3/game_kit/BDirectWindow.zip*.

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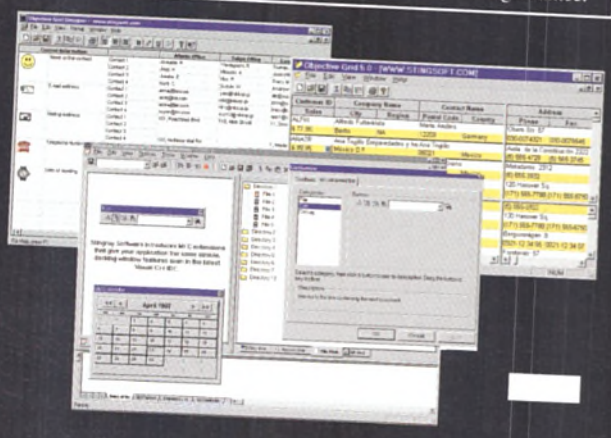

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Figure 1 shows the demo rendering the stars by first drawing them in an offscreen buffer, then copying that on screen using the normal graphics APIs. For Figure 2, I switched to using BDirectWindow, and while maintaining the same frame rate, the application uses significantly less CPU.

This technique has its drawbacks. You lose the comfortable hardware independence and you have to deal with bits per pixel, colour encoding and row size, and you have to cooperate with the user interface by restricting drawing at your window boundaries (clipping) if you run in a window. The architecture of the direct screen access APIs on different platforms in some way reflects the original target application (usually games), and often becomes the limiting factor, making development of different kinds of applications difficult or unnatural.

Obviously the performance gains are directly related to the number of layers of software the application manages to skip, and as operating systems become more complex and implement more abstraction, the direct screen access performance gains start to offset the added coding complexity and become inviting for a broad range of highly interactive or graphically intensive applications.

I have developed a few code snippets that let me compare BDirectWindow (running under BeOS R3 for Pentium processors) with

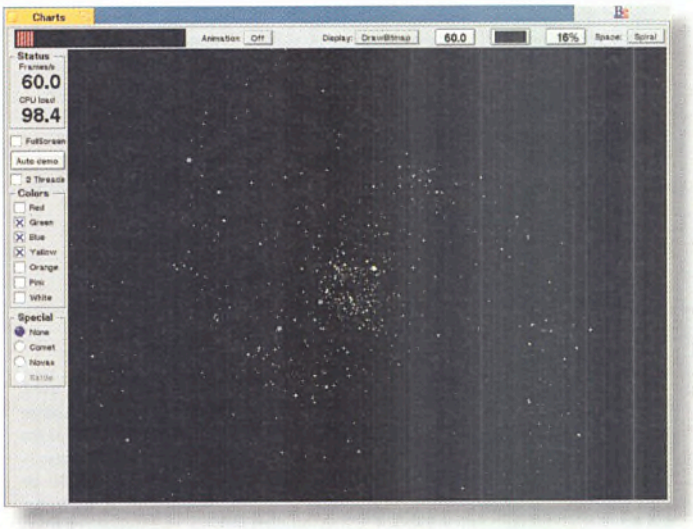

Figure 1 – The BeOS Charts demo, rendering through the standard graphics libraries.

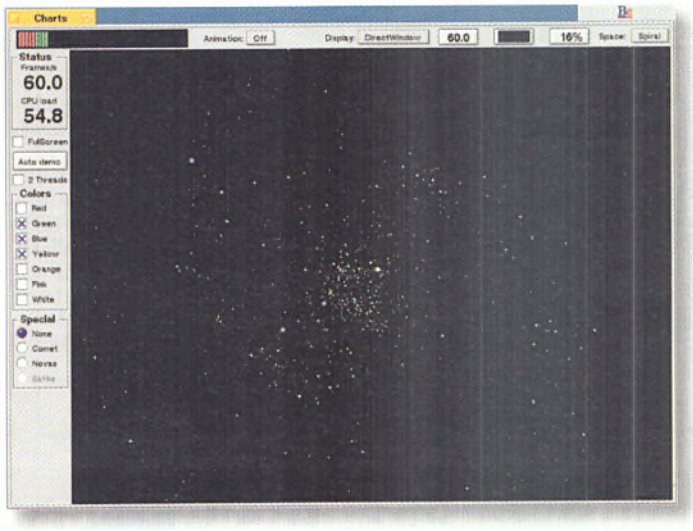

Figure 2 – The BeOS Charts demo, directly accessing the screen.

The architecture of the direct screen access APIs on different platforms in some way reflects the original target application, usually games.

the DirectX DirectDraw component (running under Windows 95) and DIVE (running under OS/2 Warp 4).

Windows 95

Windows 95's gaming and media API, DirectX, was born with the intent of attracting DOS game programmers to the Windows platform. DirectX has grown into a large, multi-faceted API, with interfaces ranging from joystick control to full hardware accelerated 3D support.

The API that is of interest for this article, DirectDraw, provides direct access to the video memory through an entity called 'surface'. Surfaces can also be used for non-visible bitmaps in a way that lets DirectDraw take advantage of hardware supported features. These include blitting (screen to screen or memory to screen bitmap copying), stretching, colour keying, and alpha blending (selectively blitting with relation to source or target pixel colour or transparency).

Hardware acceleration is very convenient if it's possible to store bitmaps inside the video card memory, since screen to screen blitting is usually much faster than memory to screen throughput. In the former case the limit is the video memory bandwidth, in the latter it's the PCI or AGP bus bandwidth.

DirectX will emulate the features that aren't implemented in hardware. Unfortunately, certain combinations of hardware supported features and emulation can actually result in slower performance than emulation alone.

For example, on hardware that doesn't support alpha blending (certainly less common than blitting), performing an alpha blend between invisible bitmaps and blitting the result to screen will be slower if bitmaps are stored in video memory than if they are stored in main memory. This happens because the software-based alpha blending will have to access the bitmaps from the other side of the PCI or AGP bus. The effect is that apps typically end up being coded with a lot of flag checking and special case code.

Regarding access to video memory, while DirectDraw allows an application to modify the frame buffer contents directly, use of this feature is discouraged because locking the surface associated with the display (the 'primary' surface) causes DirectDraw to lock Windows 95's infamous `Win16Lock`. The `Win16Lock` serialises access to GDI and USER, typically blocking Windows and any application that uses the user interface, for the duration of the access.

Blitting of surfaces can be clipped by DirectX, but when running in windowed mode and directly accessing the frame buffer, clipping must be manually (and slowly) checked through the standard GDI functionality, or the `IDirectDrawClipper` interface, which are equally slow for this use.

Initialising DirectDraw is a matter of calling the `DirectDrawCreate` function to build an instance of the DirectDraw interface object, and the `SetCooperativeLevel` method to configure Windows

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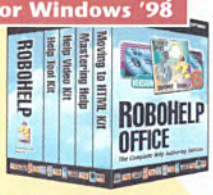

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Figure 3 – Windows 95 DirectDraw test application.

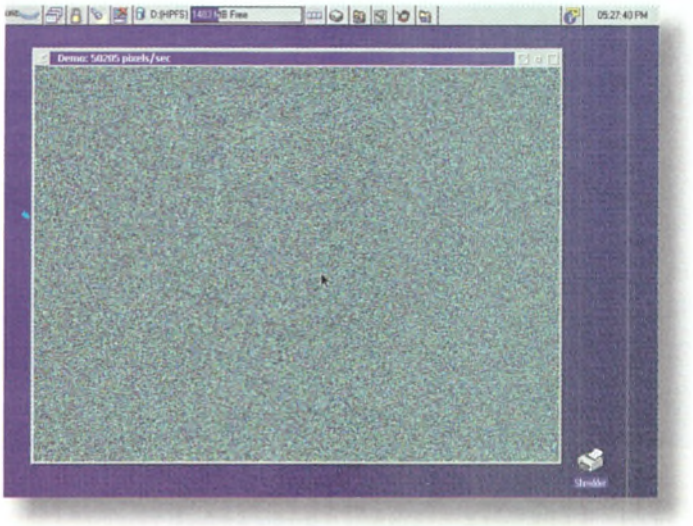

Figure 4 – OS/2 DIVE test application.

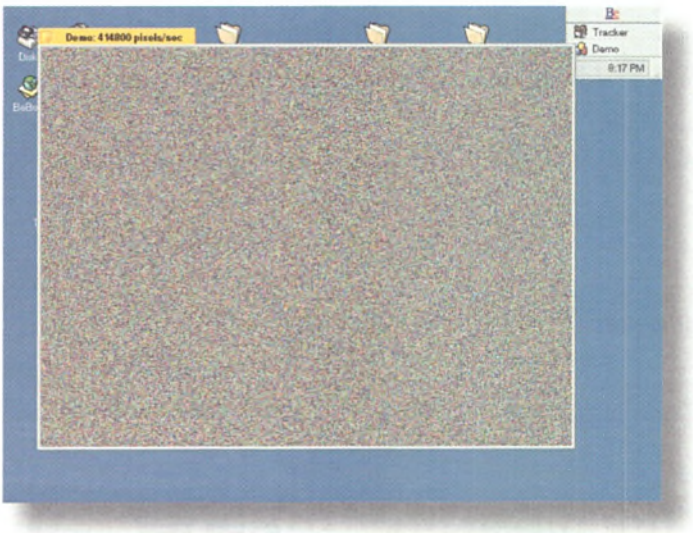

Figure 5 – BeOS BDirectWindow test application.

Unfortunately, certain combinations of hardware supported features and emulation can actually result in slower performance than emulation alone.

integration, followed by surface creation and initialisation, through the `CreateSurface` method.

While running in windowed mode, care must be taken to track `WM_MOVE` messages to draw (or blit) in the right place. Clipping is automatically tracked by an `IDirectDrawClipper` instance, if you choose to use it and associate it with the window. In the sample code, I have used the regular `PtVisible` GDI function.

A pointer to the frame buffer is returned by the surface `Lock` method, and it must be returned as soon as possible through the `Unlock` method.

OS/2

OS/2's DIVE (Direct Interface Video Extension) lets applications request access to the frame buffer or perform blitting, possibly hardware accelerated. Accessing the frame buffer, like with DirectDraw, is subject to a lock.

At the cost of a little more complexity, DIVE speeds up clipping through asynchronous notification of the exposed regions (through messages sent to a window). The application can then cache the visible region rectangles and quickly scan them when clipping, instead of taking a costly roundtrip through the system API.

Basic use of the DIVE API is as simple as calling `DiveOpen`, which returns a pointer to the frame buffer. `DiveAcquireFrameBuffer` requests exclusive access to it, and `DiveDeacquireFrameBuffer` releases it. `WinSetVisibleRegionNotify` can be used to enable asynchronous clipping notifications, through `WM_VRNDISABLED` and `WM_VRNENABLED` messages sent to the controlling window; `WinQueryVisibleRegion` and `GpiQueryRegionRects` enumerate the visible rectangles that should be cached for later use in clipping, at drawing time.

Unfortunately, all the coordinates are referred to in the OS/2 GPI coordinate system with (0, 0) in the bottom left corner. A few coordinate system conversions have to be sprinkled across the source to be able to directly address the correct point on the screen. This is quite clumsy, and makes it feel like the DIVE API is an afterthought, badly integrated with the main OS/2 graphics API.

BeOS

Moving to BeOS, the `BDirectWindow` class is slightly more complex to use than DirectDraw or DIVE because of the higher degree of interaction between the user interface manager (the Application Server or app_server) and the application itself.

BeOS applications using the `BDirectWindow` class have unrestricted continuous access to the video frame buffer, without any form of global screen lock request. Instead, in addition to clipping information like in DIVE, `BDirectWindow`-derived objects are asynchronously notified of system imposed screen locks.

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Linux

For comparison purposes, I had picked the operating systems that I could run on the same hardware, and I initially included Linux.

Unfortunately, the only API that improves performance is the MIT shared memory extension for X, which doesn't give applications direct access to the video frame buffer.

MIT-SHM is used by Xanim, Xdoom, and other X apps, since it lets them shortcut the Xlib inter-process communication channel by instantiating bitmaps in a shared memory segment.

It is in fact much faster than the canonical interface used to render bitmaps, but the shared bitmap will still have to be rendered into the frame buffer by the X server – an additional step that makes this technique slower than the ones I have been testing.

While it was in fact hard to build a test that would compare Linux with the other operating systems, the MIT-SHM should be of interest to Linux developers who need fast graphics performance.

In other words, instead of requesting exclusive access to the screen every time they want to access it, applications will be told when they can't access it, and will be otherwise free to do so. This is an obvious improvement over continuous lock requests, because locks will succeed most of the time anyway, wasting CPU time and context switches.

Unlike the more game oriented, fullscreen BWindowScreen interface, BDirectWindow doesn't support any form of hardware acceleration – though the word is that it will be introduced in an upcoming BeOS release.

Since it builds an additional communication channel between a window and the app_server, BDirectWindow code that mixes both direct screen access and regular GUI functionality can be tricky to structure in a way that is deadlock safe. However, as an aid to developers, or against errant applications, the app_server will automatically kill the app if it detects a deadlock.

Accessing the frame buffer under BeOS is a matter of subclassing the `BDirectWindow` class, implementing a separate drawing thread, and handling the `DirectConnected` callback method. As mentioned, the drawing only has to synchronise itself with the `DirectConnected` events.

As a specific example, the asynchronous protocol used by BDirectWindow and the provided pointer to the frame buffer in the PCI address space lets applications initiate direct, DMA-based PCI to PCI or PCI to AGP transfers from video input cards directly to the video display card. When the target window is moved, resized, obscured, or

Unlike the more game oriented, fullscreen BWindowScreen interface, BDirectWindow doesn't support any form of hardware acceleration.

exposed, the acquisition card is reprogrammed on the fly, to adjust DMA transfer size and clipping.

This feature is commonly demonstrated by Be using two regular video acquisition/TV tuner cards flowing video to the screen at the same time. However, it can reasonably be extended to any DMA capable video input or video synthesis card (like a dedicated DVD decoder or a separate 3D engine).

DirectX has an interface, `IDirectDrawVideoPort`, which apparently serves the same function. Unfortunately `IDirectDrawVideoPort` uses 'overlay' surfaces, which need specific hardware acceleration that common video cards don't currently provide. The DirectDraw and DIVE requirement to wrap frame buffer access with locking and unlocking makes it virtually impossible to synchronise DMA-based transfers with screen access.

Testing

First, for the sake of simplicity, I have taken a few shortcuts in the accompanying sample code by only supporting 15/16 bits per pixel modes. Second, the code won't run on bank switched displays under OS/2. This is a mode, supported by older cards or older drivers, that doesn't map the entire video card memory in main memory but forces the application to explicitly select the desired segment of video memory.

I decided to build the test applications in a way that exposes the API overhead. The test apps on the three platforms all have a separate thread that will access the frame buffer, write a random pixel performing the necessary clipping, and release the frame buffer.

Since BDirectWindow doesn't currently let applications access hardware supported blitting (which is indeed a drawback for many kinds of applications), that feature isn't tested in the sample code. However, testing features that are supported by hardware acceleration would tend to flatten the difference in performance and hide relative inefficiencies.

The test apps are actually working frameworks for direct frame buffer access applications, though use of specific features (like hardware acceleration) that might be useful in some cases aren't exploited by the sample code.

The results, shown in pixels per second in the test application title bars, aren't a measure of screen bandwidth but rather a measure of overhead – higher numbers mean less overhead.

The overhead is naturally related to the amount of system code that is called, which is expensive (probably because it requires a context switch, or perhaps a CPU privilege switch).

The DirectDraw code performs both locking and clipping at every cycle through a system call, turning out to be the highest overhead API at around 20,000 pixels per second. In my tests, removing the clipping check from the DirectDraw code resulted in a 2.5x performance improvement (or, more correctly, overhead reduction).

The DIVE code only performs a system call for screen locking, at every cycle, since clipping information is gathered asynchronously. It reaches around 50,000 pixels per second.

The BDirectWindow code is, as expected, the one with least overhead, reaching well over 400,000 pixels per second. Before reaching that result I had been using the system semaphore functionality for synchronisation, and got around 80,000 pixels per second. This shows how expensive a round trip inside the system can be.

The synchronisation in the final sample code, needed to block the drawing thread when the app_server requests a screen lock, uses a user-level, lightweight semaphore construct that won't call the system semaphore as long as only one thread holds the lock – all the drawing code is normally executed without context switches.

When gaming was the main focus, contention (caused by locking) wasn't a big concern. But as soon as direct screen access becomes commonly used by more applications, or multiple windows within one application, contention becomes an issue.

I tested this by running five copies of the test application, at the same time. Windows 95 exposes some quirks in its scheduler by giving different results depending on whether a test application window has focus or not. The bottom line is a 50% slowdown.

OS/2's scheduler is very fair in giving each DIVE window the same time, but the contention brings the overall rate to around 15,000 pixels per second total, a slowdown of over 60%.

BDirectWindow doesn't lock the screen at all, so the BeOS applications don't step into each other, there's no contention, and the overall pixel rate is about 10% higher than with a single application (each application running at around 90,000 pixels per second).

It seems clear that running the multiple test applications on a multiprocessor system isn't going change the overall pixel rate at all under Windows 95, or very little under some SMP version of Warp, but will scale just fine with BeOS, with an increase in performance proportional to the number of processors (up to the PCI or AGP bus bandwidth limit).

Real world

What about real world applications? A photo retouching application that stores large images in an internal non-contiguous format (as is common for applications manipulating very large images) might benefit from being able to render directly into the frame buffer instead of first going through system bitmap structures.

An application updating a view with high frequency, but sparsely, might benefit from the immediate updates limited to the affected areas.

An application working with different image layers in motion (like a multimedia authoring package) will benefit from hardware accelerated blitting with colour keying or alpha blending support.

This article mostly compares the APIs one against the other and, hopefully, suggests how future applications might take advantage of raw graphics interfaces.

DirectDraw and DIVE are already fairly good for general use in applications, though the contention problem might get serious if multiple direct-access windows are used at the same time. BDirectWindow is much more scaleable and more suited for general use in applications, even though it's still a bit lacking in acceleration support.

Developers working on graphically intensive applications should definitely take a hard look at direct screen access. ■

Duncan Wilcox is a freelance consultant and programmer. You can contact him at duncan@mclink.it.

EXE ONLINE *The code for this article is available on EXE OnLine and directly via ftp at ftp://ftp.exe.co.uk/pub/exestuff/9807_screen.*

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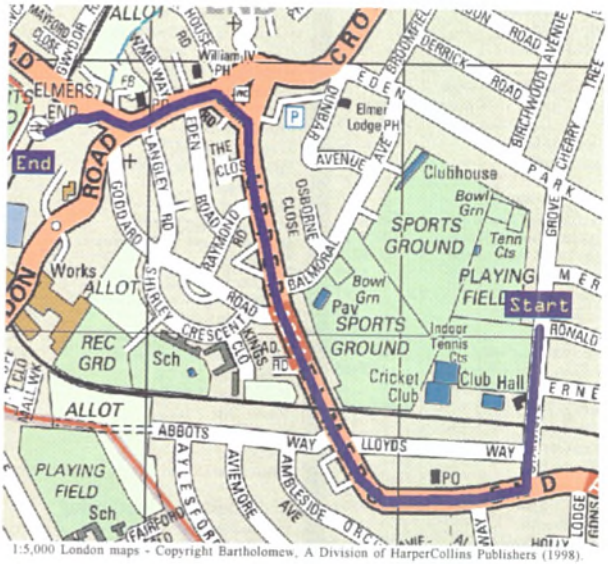

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Getting on with your garbage collector

Patricia Deardorff

While garbage collection certainly makes it easier to manage object lifetimes, an understanding of what is going on will still often be needed to avoid leaking memory. Robert Ennals explains, with reference to some new Java classes.

In C++ one always has to think about when objects are deallocated. It is very easy for a programmer to make mistakes, either failing to deallocate memory and causing memory leaks, or deallocating it when it is still in use and causing program errors.

Java, like many other languages, tries to reduce this problem by using a technique known as garbage collection (GC). The garbage collector works out when objects are no longer needed and automatically deallocates them, saving the programmer from having to do the work. Unfortunately, garbage collection is not perfect. Unless one is careful, the garbage collector may think that objects that are not needed *are* needed and one's programs will still leak memory. While garbage collection does make managing memory much easier, one still has to think a little about what is going on.

Push and pull

Relationships between objects generally follow either the pull model or the push model.

In the pull model an object asks another object for information and uses that information. If object A is the information provider and object B is the information user, then object B will call object A asking for information when it wants to update its state. Here the action is performed by the user of the information and the user must hold a reference to the provider of the information.

In the push model an object tells another object when information is available. If object A is the information provider and object B is the information user, then when object A has new information it will call object B, giving it this information, and object B will then use it. Here, the action is performed by the provider of the information and it must hold a reference to the user.

If data flow always followed a pull model, then Java-style garbage collection would always work without the programmer having to pay any attention to it. Problems can arise when one tries to use a push model.

The logic behind garbage collection

The purpose of a garbage collector is to find those objects that are no longer needed and to delete them. It is very important that the garbage collector should not affect the behaviour of the program that it is garbage collecting. A garbage collected program should behave just as it would if unneeded objects were never deleted and were simply allowed to pile up. In order to avoid affecting the behaviour of the program, the garbage collector should only delete objects if it can prove that they have no effect on the outputs of the machine. If the outputs of the machine do not depend on an object then it is unneeded and can be disposed of.

An object is needed if either an output depends on it directly, or another object that is known to be needed depends on it. Thus, if an output depends on object A, then A is needed, and if object A depends on object B, then B is needed as well.

Likewise, we can define an object A as being no longer needed if no object that we need depends on A and A is not an output. If no object that we are interested in depends on object A, then one can delete A without affecting the objects we are interested in.

In a pull model it is easy to work out what objects depend on other objects: an object depends on those objects that it has a reference to.

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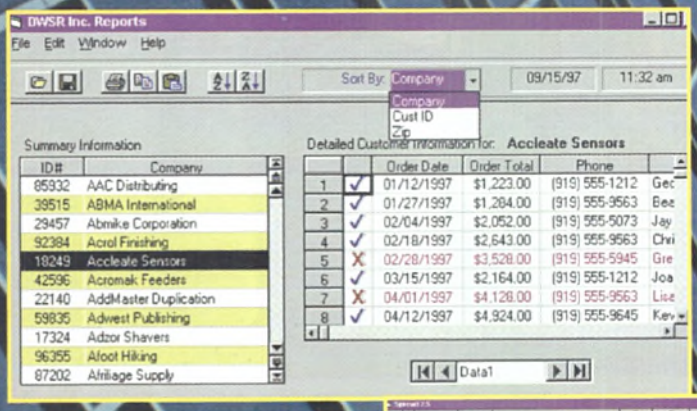

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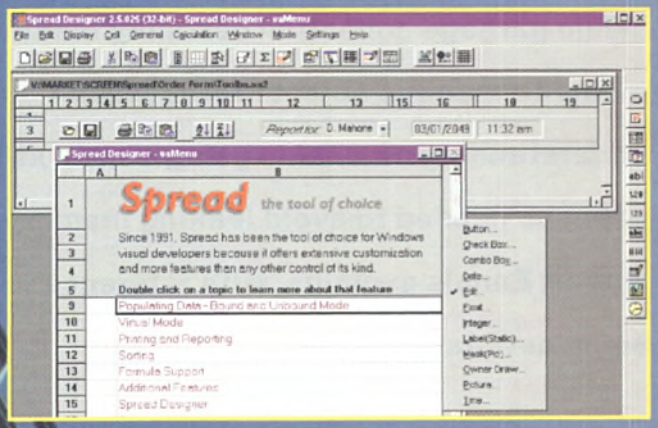

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Concurrent garbage collection

The simplest garbage collector will collect all garbage in one go and all other threads will stop until the garbage collector has finished. However, this is often unsatisfactory. If one has an interactive GUI, often Java GC pauses can be very irritating. For example, if one runs a Swing program and slides a scrollbar around a lot, every now and then it will pause while the GC pass takes place. There are other reasons why garbage collection pauses might be a problem. If one has threads that have real-time demands, garbage collection pauses are unacceptable. If one has multiple processors, then it is highly undesirable to have to stop everything while the garbage collector does its work. It is thus useful to be able to collect garbage in a thread that runs concurrently with the other threads.

In order to do concurrent GC safely one needs a more refined algorithm to the one presented earlier. If one simply traverses through the tree of referenced objects, marking things as needed when they are found, then one is in danger of missing an object. Let us suppose our garbage collector has finished looking at object `A` and is about to look at object `B`. Just before the garbage collector has looked at object `B`, a thread running concurrently with the garbage collector might add a reference (to some object `C`) to object `A` and remove such a reference from object `B`. As a result, the garbage collector will miss the reference to object `C` and will incorrectly believe it to be garbage.

One way to get round this problem is to add the concept of a write barrier. With a write barrier, a thread must notify the garbage collector if it is writing a reference to an object. One way to do this is to write a tag to the object being referenced. This is likely to be a relatively cheap operation as the object is likely to be in the CPU cache. When the garbage collector has finished its garbage collection pass, it looks at the objects that it believes to be unneeded. If any of these objects have been tagged, it knows that it must have missed them in its mark pass and it treats them as needed objects.

A garbage collector can thus work out which objects are needed by tracing through references that are held.

A conventional garbage collection algorithm works as follows. It starts with the outputs to the outside world, which clearly cannot be thrown away. If these objects reference any other objects, then these objects are determined to be needed and are marked as such. The same process is then repeated for the objects referenced by these objects. By the time the process has finished, any objects that can be reached by tracing through references from the root objects will be marked as needing to be preserved. Any objects that have not been marked as needing to be preserved can now be safely thrown away without affecting the behaviour of the program.

This is an over-simplified algorithm. Real garbage collectors can be much more complex, especially if they need to be able to garbage collect objects while the programs that use them continue to run, or if they need to collect objects distributed over several machines.

See the box out *Concurrent garbage collection* for information on more elaborate flavours of garbage collection.

If the pull model is being used then this method will indeed find all the objects that need to be preserved and throw away all unneeded objects, however this is not the case in the push model. In the push model an object may depend on another object without having a reference to it and it may have references to objects that it doesn't depend on. This causes problems for the garbage collector. Although it does not cause objects that are needed to be thrown away, it may not find all the objects that are unneeded and so unneeded objects may accumulate in memory. If the push model is being used, then one may need to use special types of reference in order for objects to be correctly garbage collected.

Notifications

Notifications can introduce complications for garbage collection. If one is using notifications, then objects will have references to objects that wish to receive notifications from them. If these are standard references then the existence of these references prevents the referenced objects from being deleted while the broadcaster of the notifications continues to exist. Thus even though the broadcaster does not depend on the objects that it is notifying, the garbage collector thinks that it does and thinks that they are needed.

As a result, if standard references are used, one cannot rely on garbage collection to dispose of notified objects. The notified objects cannot be garbage collected until they have disconnected themselves from all notification broadcasters, and they don't know when they have to do this. They can't disconnect themselves from within a finalisation method as this won't be called while they are still connected to notification broadcasters. The objects need to know when they are no longer needed so that they can disconnect themselves, however if one needs to know when an object is no longer needed, one is losing the advantages of garbage collection.

Java 1.2 provides a solution to this problem in its new reference classes. These can be found in the package `java.lang.ref`. Java provides several new special types of reference that allow one to hold a reference to something while still allowing it to be destroyed. One of these classes is `java.lang.ref.WeakReference`.

Unlike a conventional strong reference, a weak reference does not prevent the referenced object from being disposed of by the garbage collector. A weakly referenced object will be destroyed by the garbage collector if there are no strong references to it from needed objects, regardless of whether there are any weak references to it. If an object that is referenced by a weak reference is garbage collected, any weak references to it will be set to null.

One will generally hold a weak reference to something if one does not depend on that object and instead that object depends on us. They can be thought of as being the opposite of `const` references in C++. If one holds a `const` reference to something in C++, then one is telling the system that we depend on that object, but it does not depend on us. One will generally use a weak reference when we don't depend on the object that we are referencing, but it does depend on us.

Weak references introduce a degree of non-determinism into a program. If an object really doesn't depend on the object that it holds a weak reference to, then the behaviour of the program is unaffected by the behaviour of the garbage collector, but unlike C++ `const` references, the system makes no attempt to prove that this is the case. If an object reads from an object that it has a weak reference to, or changes its behaviour when a weak reference becomes null (eg by failing to check for null and so breaking), then the behaviour of the object will

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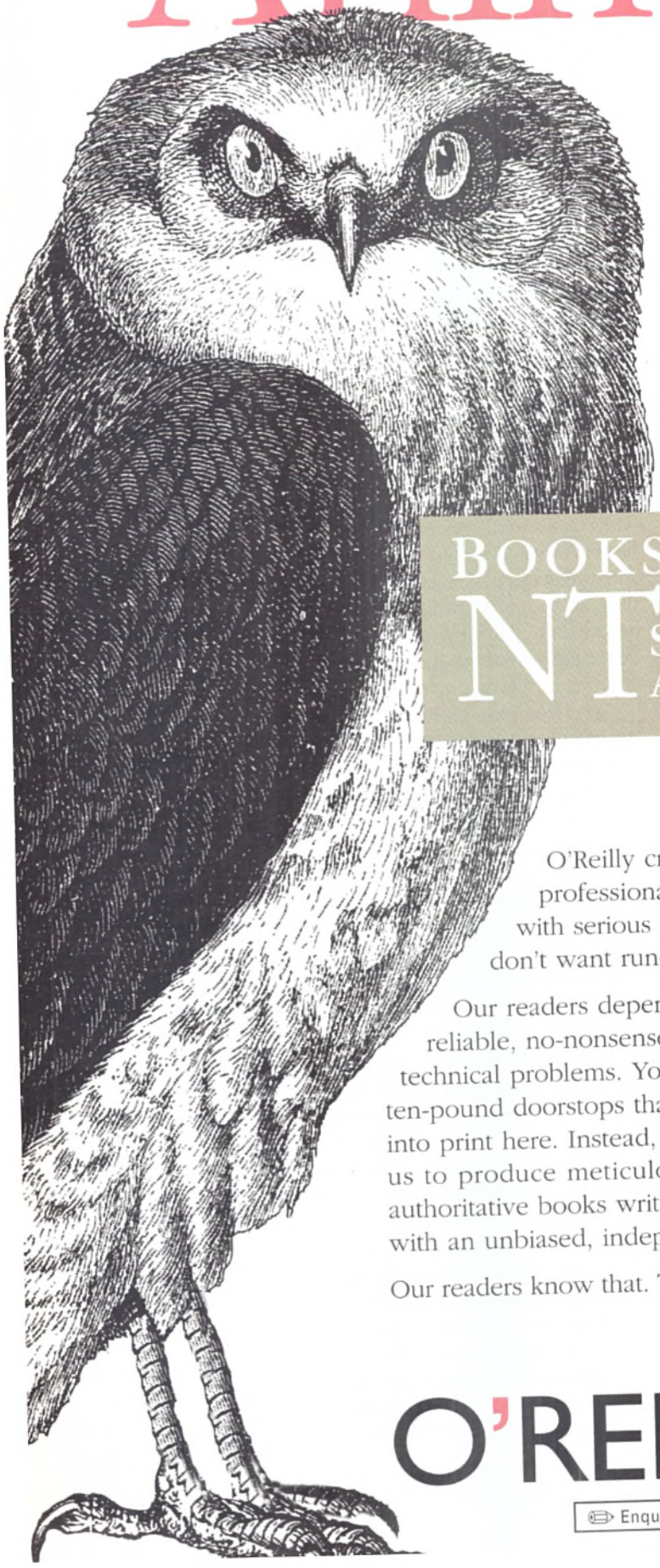

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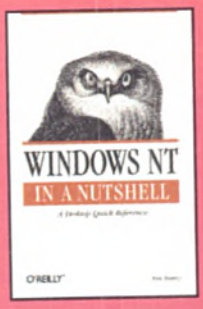

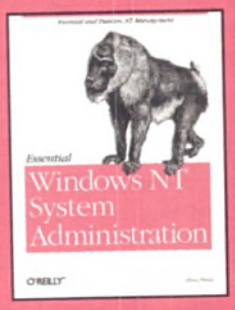

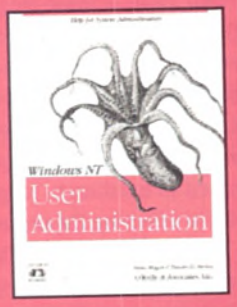

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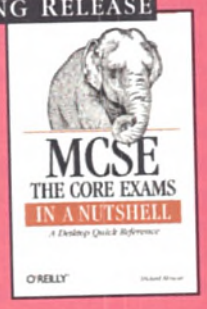

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Enquiry No. Jy31

Pre Java 1.2

Previous to Java 1.2 things were much more difficult. Without weak references, one had to manage object lifetimes manually. The only weak reference that one could use was a class in the `sun.*` package that implemented cached reference, but that was unsupported, undocumented, and largely unused except for by Sun. Many people complained about this. They thought that it was unfair that Sun thought that weak references were important enough to provide them for themselves, but not important enough to provide weak references that other people could use.

Luckily, special references are now part of the standard, supported Java API and so everyone is much happier.

depend on the garbage collector and be unpredictable.

Sometimes one might use a weak reference in cases where one does depend on the object that is referenced, but where one isn't interested in it when it ceases to exist. For example, one might want a list of active programs, but not want this list to keep these programs alive. In such cases one will have to bear in mind that the time at which a weak reference becomes null is not predictable.

If one is not careful with weak references, then one can end up losing objects that one wants. Take for example the case of several objects that notify each other: object A notifies object B, which in turn notifies object C. In order to avoid memory leaks, all these objects only hold weak references to the objects that they notify. Let us consider the case in which there are strong references to A and C, but not to B. Here C depends on B even though it does not hold a reference to it. The garbage collector will notice that there are no strong references to B, and will destroy it, even though C depends on it. One solution to this problem is to make sure that notified objects always hold a strong reference to any objects that notify them, even though they may never actually do anything with this reference.

When using weak references it is not necessary to unregister event registrations as the weak reference mechanism will automatically inform the notifier when notified objects cease to exist. As a result, it is very easy to find oneself depending on an object that one does not have a strong reference to.

Threads

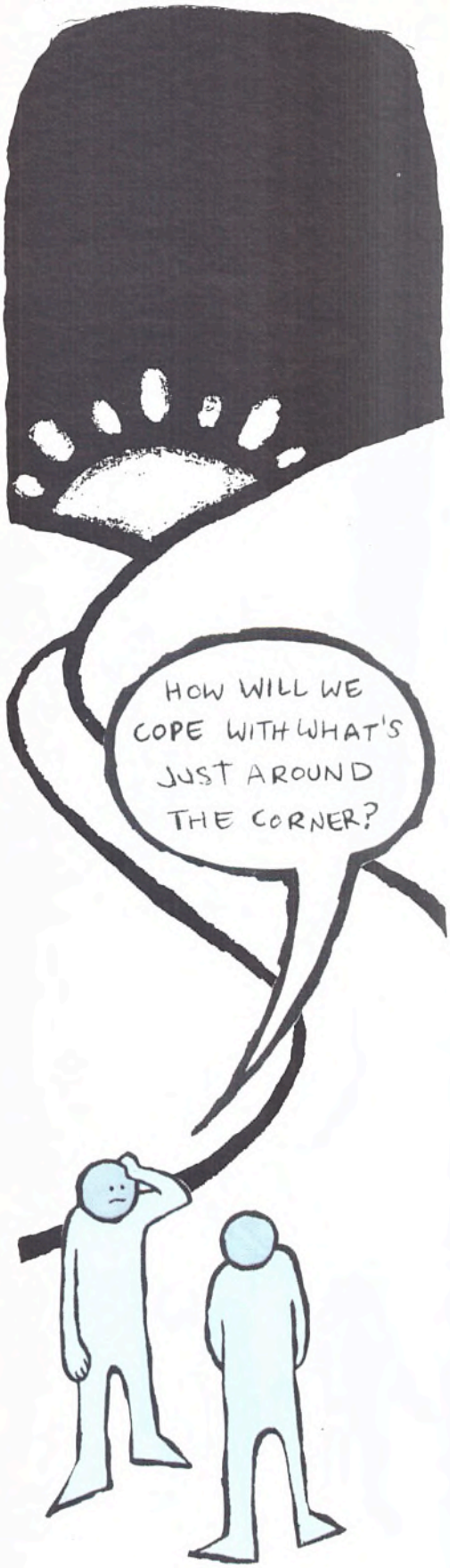
As was stated earlier, in the push model it is possible for an object to depend on another object, but not have a reference to it. Instead of the information user having a reference to the information provider, the information provider has a reference to the information user and calls it to give it information. Thus, it is possible for us to depend on an object without having a reference to it.

If one is using a single-threaded system without weak references, then this is not a problem for the garbage collector. There must be a reference to the information provider at some point. If there is no reference to the provider then its code can never be called and so it can never update other objects and thus nothing depends on it. Thus in a single threaded system, it is safe to throw away objects that are not referenced from the root.

The same is not the case with a multi-threaded system. If the information provider has its own thread then code in that object will be executed even if it is not referenced from a root object. The objects it references thus still depend on it – any object that is referenced from any thread cannot be deleted by the garbage collector.

In Java, threads are not garbage collected. If an object creates a thread and that thread contains a strong reference to the creator object then that creator object will never be able to be destroyed. One can't destroy the thread in a finalise method as the finalise method would not be called unless the object was garbage collected and the object would not be garbage collected as the thread had a strong reference to it.

One way round this, and similar problems, is to use weak or guarded references. Instead of holding a strong reference to the things it writes to, the thread holds weak or guarded references to them. The thread



then keeps running until the objects that it writes to are disposed of, at which point it terminates itself.

The thread should keep running as long as some of the objects that depend on it still exist. If it stops running before all the objects that it depends on have ceased to exist, then the behaviour of the program is non deterministic as the act of the thread stopping will have an effect on the program and the time at which the thread stops is non-deterministic.

Caches

Often one will need the same object more than once. If the object takes a significant amount of effort to generate, then it can be useful to implement a cache. Unfortunately, it is often difficult to know what to cache. If one caches too little, then one will be regenerating objects that one could have cached, and so run slower. If one caches too much, then one wastes memory and if the cache is paged out to disk, then the act of paging it back into memory may be slower than the act of generating the items in the cache, thus causing the cache to actually slow down the machine.

Fortunately, Java 1.2 provides a special reference type called a `CachedReference`. Cached references are like weak references in that they do not prevent the garbage collector from disposing of the referenced object. However, the garbage collector will try to keep cached objects alive for as long as possible before deleting them, while it deletes weakly referenced objects as soon as possible. A cached reference is essentially a way of saying to the garbage collector that one does depend on the referenced object but one can regenerate it later.

One will generally use cached references by creating a subclass from `java.lang.ref.CachedReference` that implements the method `reconstitute()`. The system will call `reconstitute()` if one attempts to get the contents of `CachedReference` for which the referenced object has been deleted. The implementation of `reconstitute()` should attempt to recreate the referenced object so that it can be used. Ideally, the implementation of reconstitute should create the same object every time and have no other side effects, thus causing the system's decisions as to when to delete cached objects to have no effect on the behaviour of the program.

Theoretically, a garbage collector could prioritise different cached objects according to how likely they were to be needed and how long the `reconstitute` method took to execute. If the system noticed that cached references of a certain class were often used again, or that they took a long time to be reconstituted, then it could decide to give these objects priority over objects that could be reconstituted more quickly or reconstituted less often. As a result, it is a good idea to actually put your reconstitution code into the `reconstitute` method rather than outside of it, so as to let an intelligent garbage collection system know what work is being done to regenerate an object. Theoretically, one could not bother to implement `reconstitute` and instead simply test references for null and regenerate them outside of the reference class. However, if this were done, then the system would not have a way of knowing which objects took a long time to `reconstitute`. Proper use of the reconstitute method probably won't make your code run faster on current implementations, but probably will make it run faster on future implementations.

Giving a little help

Garbage collection is a good idea. If the system can work out when objects are no longer needed and save the programmer the bother of managing object lifetimes, then that is good. However, if one is to get the most out of a garbage collector, one needs to understand how it works and give it a little help sometimes. Although garbage collection makes managing object lifetimes a lot easier, one cannot forget about it completely. One needs to know which objects depend on other objects and use different reference types to let the garbage collector know this information. In an imperative language such as Java, it is often difficult to know which objects depend on other objects and so the garbage collector needs a little help in order to decide which objects should be thrown away. ■

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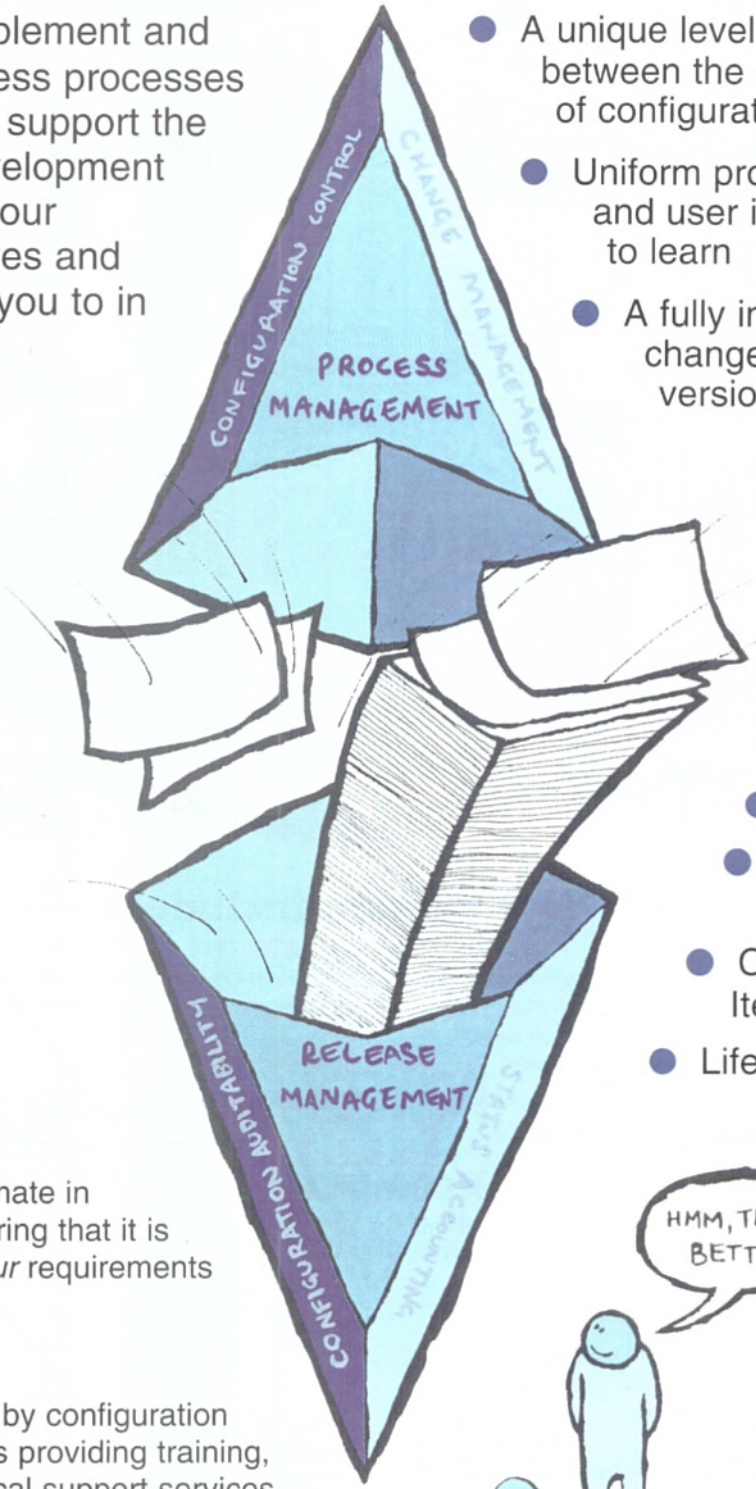

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Network Flight Recorder

How can you tell what is travelling over your network? Network Flight Recorder stores information from the last set of packets that have crossed its path, for examination in cases of disaster, evil intent, or just curiosity. Peter Collinson takes the controls.

I've always been curious about what is happening on my network since it was first connected to the Internet. Initially I used ISDN, with both ends dialling when there was a packet to send, so my servers could be 'fully connected' to the net. There's no reverse charging on ISDN, and both ends have to pay for their call. I put a lot of work into minimising costs, trying to drop the connection sensibly using some Tcl/Tk code in the Netblazer that drove the connection. It niggled me that BT charges in 5-minute units, and the default setup for automatic connection on the Netblazer could result in me buying some part of the same 5 minute unit several times.

Anyway, the little red light on the modem clicked on, the other end had dialled, and someone had decided to visit me. Curiosity set in. As a result, I created my web Visitors Book, which I continue to claim was the first on the Web, but I expect that the claim is open to dispute. Of course, I was only told what people wanted me to know.

I'm now connected to the Internet via a leased line, and have been wondering idly about how much of the 64 K bandwidth is consumed by people wandering into the various websites that are springing up on my server. Also, I'd like to know quite how my network is being used, and by what. Network security drives this particular thirst for knowledge. My router, which is my gateway to the world, has some packet filtering to prevent external sites from poking at my printer, or any X Window session, among other things. The filtering is also designed to inhibit IP-spoofing, sending a packet into my network from the outside that actually contains an internal source address. When this is done, the local software thinks that it's a packet from a local machine and can be fooled into misbehaving. IP spoofing is a basic hacker's tool, and is actually easy to defend yourself against. However,

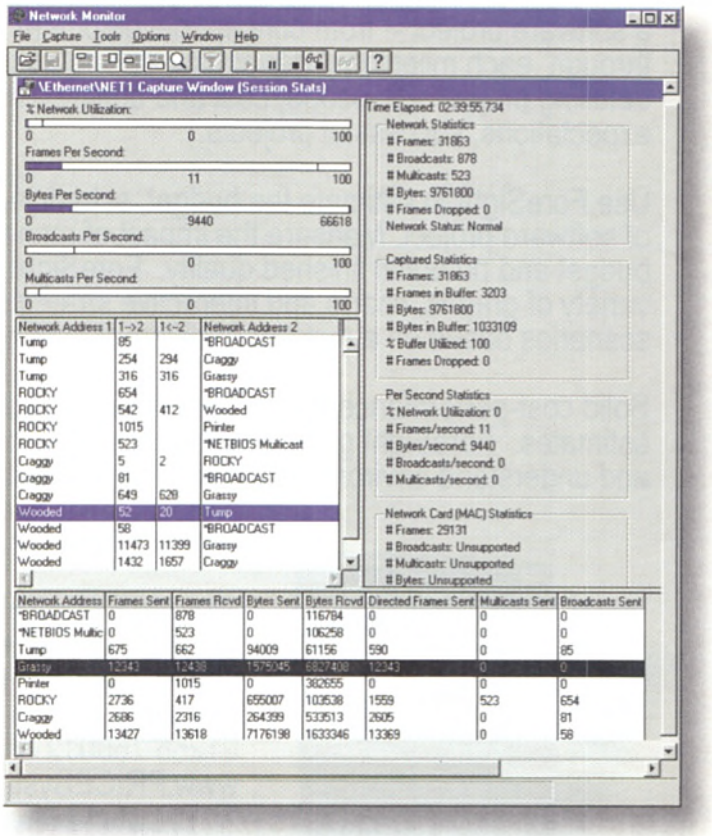

Figure 1 – NetMon: Windows NT GUI for network monitoring.

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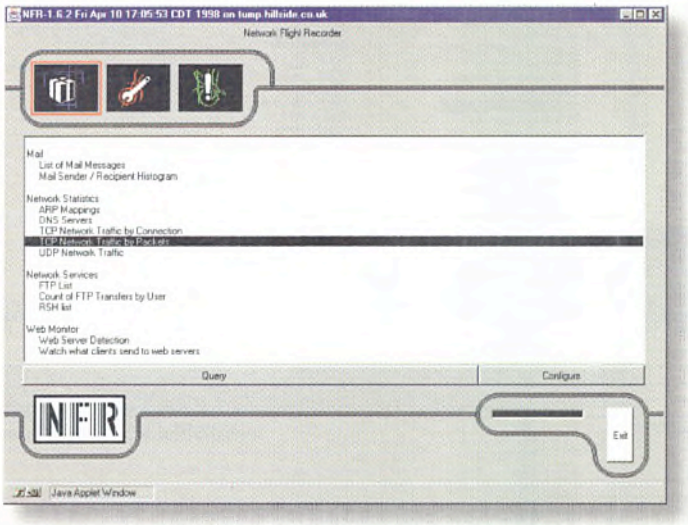

Figure 2 – Network Flight Recorder GUI.

there are still endless questions. What is happening? Who is talking to whom? What are they sending?

On my Unix machines, I have access to several tools that are designed to aid network monitoring. Most of the standard tools monitor the interface that's connected to the machine, which is not the same as looking at the network, unless you only have one machine. There are some tools that capture packets that go past the network interface and print out interesting contents. These programs are often called *packet sniffers*. I've got access to two: `snoop` under Solaris and `tcpdump` on my BSD/OS machines. Of course, there is a vast amount of information flying by on the wire, and the programs have arguments that permit you to select some portion that seems sensible to you at the time. The programs are really designed to allow you to track a specific conversation between two processes on the network rather than inspecting the general chatter.

Unix has never been good at real-time processing, and selective packet sniffing demands fast response and decoding of information. Most packet sniffers will drop network packets when things get hectic. In an attempt to drop less packets, BSD/OS (and other systems derived from the BSD releases) uses the Berkeley Packet Filter interface to the network, originally written by Van Jacobsen. The interface allows a programmer to push down a small byte-coded filter sequence into the kernel so that filtering can be done at interrupt time, only pushing the interesting packets up into the user process for printing by the packet sniffer. A small proportion of packets is still dropped.

Packet sniffers give you a tiny snapshot of what is happening on your network. You need to be careful interpreting the results. If you display names instead of IP numbers then the sniffer can be responsible for generating lots of DNS lookups. Sniffers are not really designed for global data gathering. Many system administrators and people worrying about network security have wrapped sniffers with scripts and programs designed to abstract global usage and security information.

Netmon

I had not found anything that was closer to looking at global network performance until I stumbled on the Windows NT 4.0 network monitor program (`NETMON.EXE`). I found a copy of NetMon on my Microsoft Developer Network (MSDN) CDs. I suppose that this proves that MSDN CDs do occasionally contain something more useful to me than the zillion versions of Windows 95 tuned for far off places. Please don't mail to ask me which CD contains NetMon, I have forgotten. Do what I did and use the find command. Actually, this is also a standard part of the NT Server release. *[It's on the SMS CD. The MSDN version is more feature-complete than the NT Server one – Ed.]*

NetMon looks at the Ethernet traffic and tracks packets between interfaces on the local network. The screenshot in Figure 1 shows the program being used in its most basic mode, simply listening to the network and telling you what it finds. Actually, the default display shows the Ethernet hardware address (the MAC address) of each interface that is working on the network, and I've edited those values into machine names to make them more readable by me (and also to hide the actual addresses from you).

The top left hand corner of the display shows some moving bar charts that tell you what is happening now, showing network utilisation, bytes per second, and frames per second (a frame is Microsoft-speak for an Ethernet packet). The long column on the right gives you cumulative statistics showing the number of different events that have occurred. The narrow central white box shows which machine has transmitted to which other machine. If you can read the text in Figure 1, it should be possible to see that most traffic is between my web server (`Wooded`) and the Cisco Router (`Grassy`). No surprises here. You can also see that my NT machine (`ROCKY`) attempts to chat to the printer from time to time. The printer is off, so its overtures are ignored. NT machines are noisy on the network. The bottom bar on the GUI shows the per-interface statistics in more detail.

The screen is shown in capture mode, and the data can be saved to a file and processed further. You can set logical filters to examine parts of the data and it's possible to replay stored data back to the network, after editing parts of it. Ostensibly, this is for network debugging, although I guess that it makes the program into an interesting tool for hackers. They probably know that already. You may not (there are several other aspects to NetMon that I do not have space to cover).

NetMon is actually quite a good tool and does its job fairly well. It's easy to use and set up. However, as I said, the tool is designed to look at Ethernet packets and is not optimised to pull out the IP information that they contain. An understanding of what you are looking at is needed to make great sense of its output. I suppose it does reassure me that in general the bandwidth that I need on my network is available.

Network Flight Recorder

I first came across Network Flight Recorder (NFR) when it was described at the Eleventh LISA Conference (San Diego, October 1997). The paper won the Best Paper of the Conference award. I had filed it

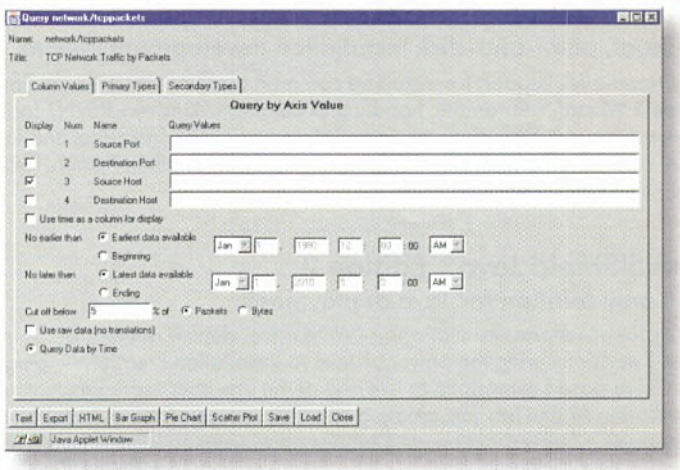

Figure 3 – Histogram processing for TCP packet statistics.

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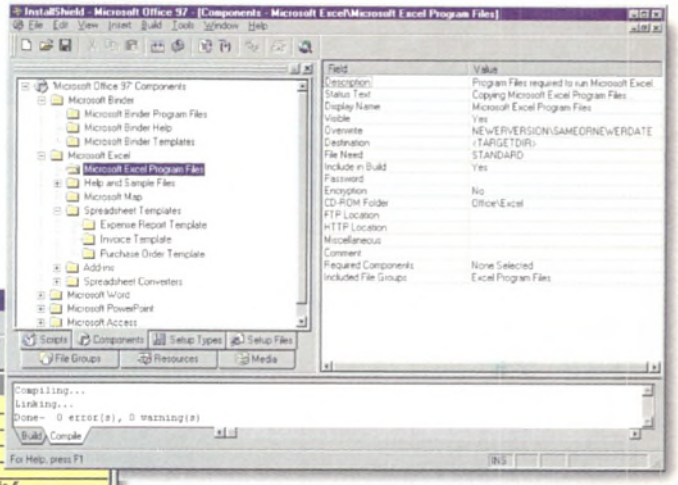

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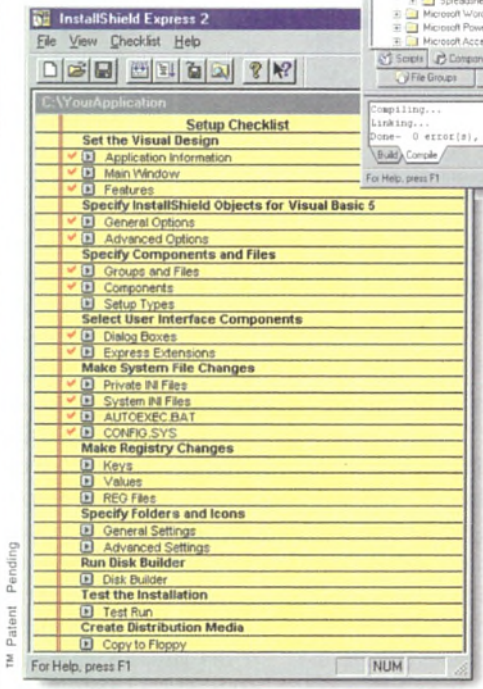

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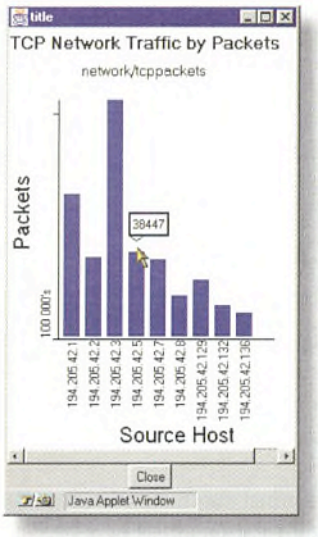


Figure 4 – Barchart output showing packet counts and source hosts.

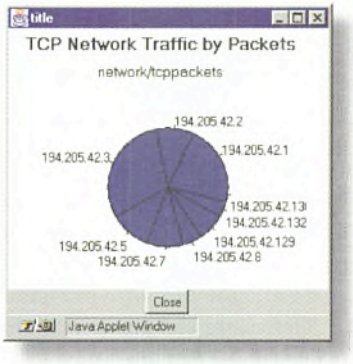


Figure 5 – Pie chart output showing packet counts and source hosts.

as 'something interesting that needs looking at'. My interest was reawakened when I received the May edition of *;login:*, the magazine for members of Usenix. It was a special security edition and contained a short paper by Chris Lalonde talking about his experiences with NFR. He's a security consultant and is primarily concerned about trapping attacks from the bad guys. He's also interested in finding out more about what is happening on his network.

A flight recorder on a commercial aircraft is designed to store some amount of recent information. If disaster strikes, whoever is investigating the event will, hopefully, have sufficient evidence of activity to reconstruct the events that lead up to the failure. Network Flight Recorder operates on the same principle, storing information from the last set of packets that have travelled over the network so that they can be examined to discover what has happened.

In very simple terms, NFR is a packet sniffer process that passes data to a programmable filter and storage daemon (`nfrd`). The output of the data is then viewed using a Java GUI, meaning that you can run the GUI anywhere on your network on any platform that supports a Java 1 enabled browser. Splitting the query interface from the data collection is done to minimise the impact of the user's query on the collection process. NFR also comes with an alerting program `alertd`, which can be started by a user-defined event. This is designed to shout loudly by email, fax, pager, or whatever when a specific event occurs, like someone trying to hack into the web server with a `phf` script or an IP spoofed packet actually getting into the network.

Packets from the packet sniffer are passed initially to `nfrd` using an API that's intended to allow the sniffers to be separate processes on the collection machine. The first section of `nfrd` is a decision engine that looks at the packets coming in and applies filters to the data. Filters are written in a language called *n-code* that is, linguistically, a hybrid between C and Perl. It's derived from a language used to program a MUD, UberMud. Filters are read into the daemon, compiled, and stored as bytecode instructions for fast execution. Filters output data to *backends* that are responsible for storing values. A packet is discarded when it has been passed through all the filters.

Backends are similarly written in n-code. Originally, it was anticipated that a large number of backends would be needed, but the system has ended up with two. The *list* backend stores values sequentially with timestamps like a regular log file. The *histogram* backend stores a dynamically allocated multi-dimensional spreadsheet where cumulative instance counts can be recorded. (The word 'histogram' is used somewhat misleadingly.) Every so often the system 'closes' the current spreadsheet and starts a new one, so over some period of time you can get cumulative statistics for the last fixed period. It's possible to write your own backends should this be needed, and the one suggestion is that you might wish to drive a relational database from the output.

The final part of the system is the GUI written in Java that presents queries in a somewhat generalised form to 'query backends'. Configuration of the GUI is done from an n-code program that defines the values that are stored, their types, and a text tag to make them comprehensible to mortals.

Installation

NFR is commercially available for Windows NT. It's available for free download in source form for several Unix platforms with the proviso that the system is not to be used commercially. The Intel based Unix platforms that are supported are: BSD/OS 3.x, FreeBSD 2.2, Redhat Linux 4.x and 5.x, and Slackware Linux 3.x. HP-UX 10.20 is supported on PA RISC, and Solaris 2.5 and 2.5.1 on Sparcs. The code is known to work on NetBSD 1.2 on Intel and Solaris 2.6 on Sparcs.

You need a version of the Apache web server (1.2 at least). NFR creates its own web tree and offers HTTP on port 2001 so it will not interfere with any extant web offerings from your machine. You'll need a C compiler to make programs from the C source, but the Java is distributed in source and in precompiled form so you don't need a Java compiler.

To look at the information using the GUI, you'll need a web browser that supports Java 1, any version higher than these should work: IE 3.02, Netscape Navigator 3.01, or Netscape Communicator 4.0. These days, this is not a difficult requirement.

The documentation recommends that you have at least 64 MB of memory on your machine. Of course, you'll need a network card of some form. You are advised that you need loadsa disk space.

I decided to test the system on my laptop. I've prudently got two disks for the machine so I can swap in BSD/OS 3.1 and Windows 95 with no great grief. The machine acts as a hot standby for my web server and has been used with great effect on several occasions when I've had hardware problems or wanted to upgrade the operating system. The laptop only has 40 MB of memory and the system seems okay, but then my network isn't busy when compared with many sites.

For security reasons, a special unprivileged user should be installed on the machine to run NFR. I used the recommended user name of `nfr` and created a group called `nfr` too. The idea here is to prevent odd people on the system from seeing what can be sensitive data.

The source is placed in `nfr`'s home directory, is compiled, and the running version is installed there too. The programs compiled okay, following the instructions on the NFR website and later locally, when I discovered a copy of the documentation in the distribution. As the system uses the Berkeley Packet Filter, you do need to install a patched version that permits larger internal buffer sizes and records packet times. There is thus another requirement for BSD/OS users: you need the source version of the system.

You then need to edit several constants into several files, telling the system the IP addresses of your network, the Ethernet MAC address of your gateway router, and where to find the binary of Apache. I wondered why this tailoring was not put into one central file and distributed as part of the build process. Anyway, once you've done the editing, you can start the recording system.

Interpreting the output

Shortly after that, when the system has some data, you can start the GUI. It's prudent to change the default password for the `nfr` web user so that it's not generally known. When you access the correct machine and port number, you are asked to log in as the `nfr` user and are presented with a web page. This web page gives you access to all the documentation for the system and contains a 'Start' button. Pressing this, starts the GUI (see Figure 2). The three large buttons across the top give you access to the 'Packages', configuration for the alert and disk space management systems (the spanner), and the log file for alerts. Packages is the generic name for a collection of query backends for the various filters that are being run. The GUI shows these by default. Clicking on one of the lines in the window lights the 'Query' button and pressing that takes you into the query GUI for the relevant filter.

Getting used to the query system takes a little time. You are presented with two styles of query processing window. Figure 3 is used when histogram data is processed. The list style is a somewhat abbreviated form of the histogram window. Like anyone, when the box first opened, I stabbed at the button row along the bottom to see what could be seen. I was presented with an error message unless I hit the 'Text' and 'HTML' buttons that gave me tabular output in a browser page. This is because the other buttons show a graphical display of only one variable, or two variables in the case of the 'Scatter Plot' that plots one against the other. The variables that you wish to examine are selected in the small column of tick boxes on the left of the window. When the window opens these are all ticked, which works well for the text and HTML output. To make the other buttons work you need to unselect all but one tickbox (or two for scatter plots).

In the example, I've unselected all but the Source Host and put a 5 into the 'Cut off' box, suppressing a great deal of output. If you run the collection system for some period, you obtain a lot of data from sites that have not contributed greatly to the overall traffic, and suppressing them can give more meaningful results. Figure 4 shows what happens if you select 'Source Host' and ask to see a bar chart. The figure also shows how the Java GUI gives you numeric values when you wave the mouse over the image. You'll see that IP addresses are shown as numbers and not names; this helps to make the display of data non-intrusive on your network.

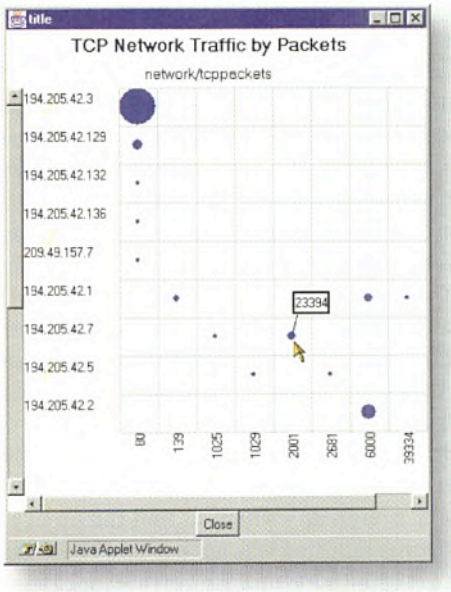


Figure 6 – Scatter plot of source hosts against source TCP ports.

Where to get things

The NFR website is *http://www.nfr.com*. You need to fill in some personal details before you can pull the data.
All the documentation for NFR is available on this site too.
You can find details of Usenix conferences on *http://www.usenix.org/events*.

The bar chart in Figure 4 confirms that my web server is responsible for emitting most of the data on my network, but there have been a significant number of packets sent in from the outside from a couple of sites. You can elect to see this information presented as a pie chart, and this is shown in Figure 5.

The scatter plot pits one variable against another, and contrasting two variables can give you a lot of information about how your network is behaving. The scatter plot can also be used to show the performance of the network over time. In Figure 6, I'm plotting source host against source port, so we are continuing to look at the data coming out from machines. We can confirm that most of the data from my web server is on port 80, which would make sense. The web machine has some virtual servers that use their own IP addresses and you can see the traffic from these in column 1 too. There's some traffic from an X Window system coming from the bottom-most machine (port 6000). Actually, this is a Windows 3.1 machine running an X server that's talking to my Sun.

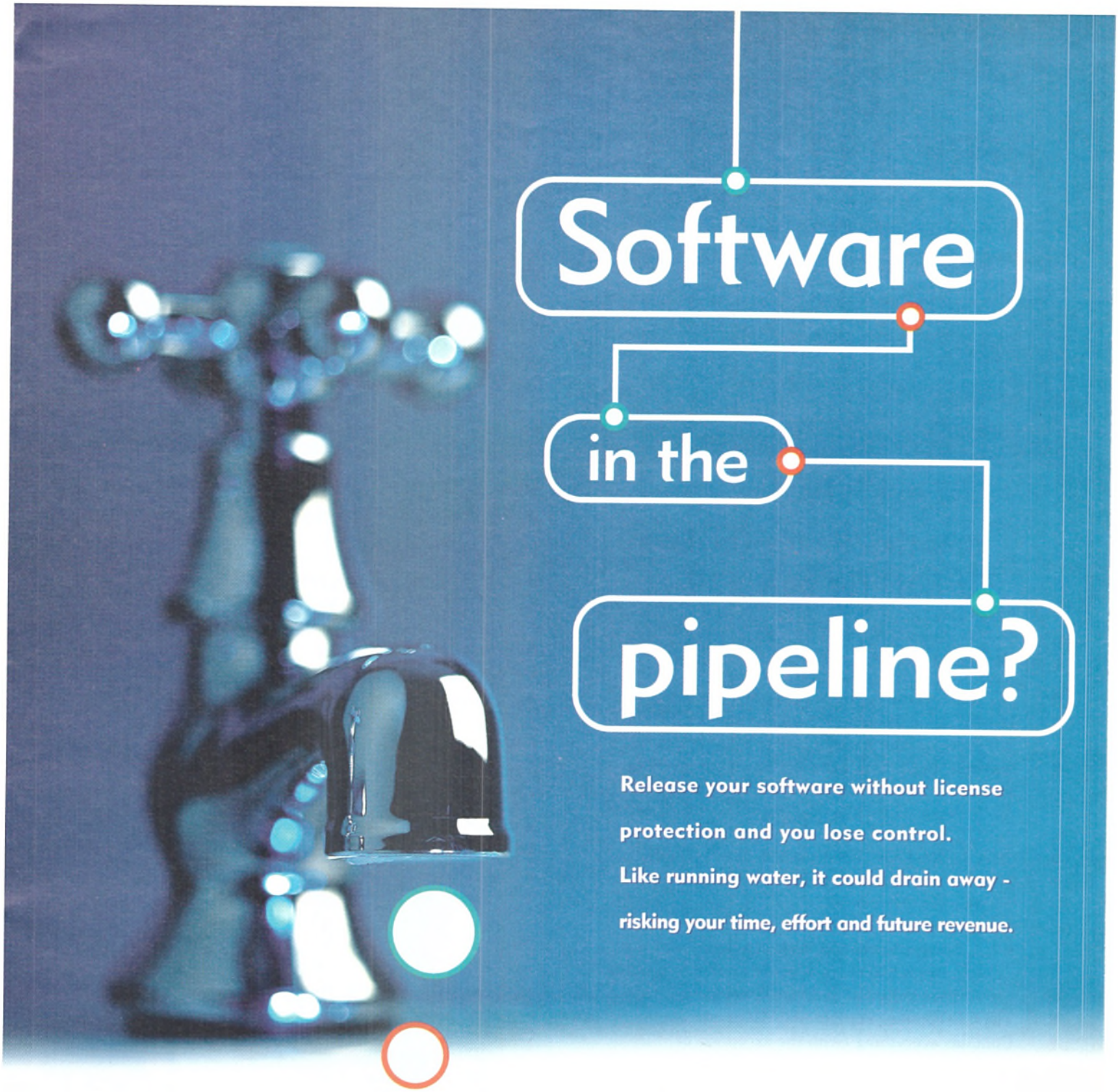
Once you have looked at the raw data, you can return to the histogram query window and make more specific queries by entering values in the dialogue boxes. It's quite easy to isolate specific parts of the data, identifying traffic in and out of a particular machine, or looking at overall network use of one port number. The system can also show you how your network software creates and presents reply ports for processes that call in. As you can see, you do need a certain amount of knowledge about how TCP/IP works to make sense of the numeric data that the system provides.

The system comes with several sets of filters that are available from the initial GUI. You can list the mail messages that have passed down the wire using SMTP, with their time, sender, and recipient. You can look at various aspects of IP networking, tracking the two basic protocols TCP and UDP, as well as ARP and DNS performance. You can check on FTP access obtaining a list of who has pulled or pushed what file and from where. Finally, you can look in detail at your web server, seeing who has connected to port 80 and examining details of the data that's been sent over the wire. The results from these are all displayed into the same GUI, so it's easy to understand how to extract information once you are familiar with it.

A final recording

I've only really managed to scratch the surface of Network Flight Recorder. I've not talked about the alert system or how to write programs. There is copious documentation available from your local web server that supports the GUI and the examples are well commented. However, the sets of default filters are fine for my personal use, so I've not felt the need to get into hacking new code. It's an excellent system with lots of promise. ■

Peter Collinson is a freelance consultant specialising in Unix. He can be reached electronically as pc@hillside.co.uk, by phone on 01227 761824, or on the Web at http://www.hillside.co.uk.



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Attributes and objects

Francis Glassborow gives a few pointers for books on C/C++ programming and looks at the distinction between attributes and objects in the light of Java's approach to ints and strings.

During the course of an average year several hundred books on C, C++, Java, and related issues cross my desk. Many of these are poor and some are positively dangerous. Sadly, some authors have acquired reputations that are not in any way merited by their work. There is far more to writing a book on programming than simply explaining the syntax of a language in readable English. Most programmers need good examples of how to use that syntax to write good code. Even such people as Bjarne Stroustrup and Andrew Koenig, to name but two of the most knowledgeable C++ experts in the world, rely on examples when studying points raised by other experts.

Herbert Schildt is one of the most successful authors (in terms of copies sold) of books on programming. However, his knowledge of the syntax of the languages he writes about is rarely matched by an understanding of how that syntax should be used to write good quality code. Much of the difficulty that many experience with using C++ can be attributed to such poor quality books. Schildt is by no means the only guilty person but the very success of his books means that he has misled more than most other authors.

Books can be readable, technically accurate, *and* provide good examples of the application of the language rules. Two recent books deserve a great deal of success because they address the needs of experienced newcomers to C++ and C respectively. The latest edition of Stan Lippman's *C++ Primer* (ISBN 0 201 82470 1, £28.99) should be on the reading list of every programmer moving to C++. The addition of Josée Lajoie as co-author has resulted in a good book becoming outstanding.

Pointers on C by Kenneth Reek (ISBN 0 673 99986 6, £23-95) is an excellent introduction to C for those that already know something about programming in some other language. Unlike many other authors, Reek understands that a study of C includes both its correct use and a firm grounding in the Standard C Library. An understanding of pointers acts as the backbone for this text on C programming. The result of this approach is that the reader will obtain a sound grounding in this powerful aspect of C.

If you are already an experienced C or C++ programmer it is still worth noting these titles so that you can direct colleagues to sound study texts and away from the dubious, even if popular, alternatives.

A cluster of other books arrived on my desk at the same time and, while I do not have space to even mention the rest, one stood out as deserving to be widely read. *AntiPatterns* by William Brown et al. (ISBN 0 471 19713 0, £32.50) documents a number of typical 'patterns' (repeated solutions) that fail. It is easy to list failures, but what sets *AntiPatterns* apart is that it provides guidance on how to avoid the problems in the first instance and what to do about them when your software is already suffering.

Still wrong

In an earlier column I claimed that there were no problems with the following statement.

```
i ^= (4 ? (i &= 7) : (i |= 4));
```

Oh dear! First it does not do what I claimed and second it contains a very nasty, if subtle, instance of undefined behaviour. Let me pretend that the compiler avoids the undefined behaviour (I will get to that in a moment). It will first mask out all but the three low bits of `i` because it will execute `(i &= 7)`. When that statement has been completed `i` will have been changed and in C++ (remember that the statement is not valid C) we will next XOR `i` with itself (assignment operators return references to the left-hand operand in C++ – I think this means that there is further potential for undefined behaviour). The result of that must be zero. Regardless of the intent the result will be zero. This was spotted by the reader who started this thread by sending in a question to Pete Becker's column in *The C/C++ Users Journal*. He must be a member of a very elite group who read both *CUJ* and EXE Magazine.

The undefined behaviour comes about because the sequence point in the conditional operator has been nested in a larger statement. The left-hand operand of the '`?`' must be fully evaluated (including side effects) before the relevant other operand is evaluated. However, that does not mean everything to the left of '`?`' is somehow protected. The full statement requires that `i` be written to twice without an intervening sequence point. That results in undefined behaviour.

Thanks also to Edward Collier for his comments on the same column, the non-appearance of which was due to lack of space in last month's letters page – Ed.

Attributes v objects

It took me many years to get a clear grasp of the difference between these two things. Interestingly, it was studying the problems with Java that finally consolidated my understanding. Let us look at the built-in types that are shared by C, C++, and Java. All three provide a type `int`. All three allow you to 'derive' a type array of `int`. That is about as far as the common ground goes. C and C++ support a derived type `int *` and C++ supports another type `int &`.

Conceptually an `int` is an attribute type. We are fundamentally interested in the value and not in where it is stored. Java takes this to the logical conclusion; it does not allow you to treat an `int` as anything but a value. When you compare two `int`s for equality it is the values that are compared. There is no way of comparing anything but the values.

In C we have the added option of using the address where an `int` is stored. This opens up a problem because it is possible for more than one pointer variable to contain the address of the same storage. This is a far more serious problem than some realise because it opens up a classic computer science problem called 'aliasing'. The classic case is when you are copying a block of memory to another block of memory. If the two blocks are distinct, everything works as expected but if the two blocks overlap you may get surprising results.

The use of a pointer allows the programmer to view an `int` as an object. One symptom of an object view of the world is that it becomes possible to ask if two things are actually the same thing rather than just have the same value. If they are the same thing, changing one will result in the other being changed, if they just have the same value then changing one will not change the other. Think of identical twins, changing one does not change the other. Compare that with an individual working under an alias; putting the alias in prison results in the original being there as well – the two are fundamentally inseparable. They are the same object even if their outward appearances are different.

C++ goes one step further and allows us to treat an `int` as an object in its own right. The reference-based view of the world is an object-based one. In C++ we can deal with an `int` as a value, as an implicit object (by using a pointer), or as an explicit object (by using a reference). Whenever we have such a choice we have to learn to use our power sensibly.

Java protects us from that type of problem by removing the potential for choice. If you need an `int` object in Java, you must create an array. However, you should note that making the choice to use an array commits you to an object view. You can use the values of individual elements of an array, but these will be values and not sub-objects. Java forces you to decide.

Actually, it not only forces you to decide but also proceeds to prevent you from creating new attribute types for yourself. For example, complex numbers are attributes. We are rarely concerned with whether two complex number identifiers refer to the same storage (the same object); though we frequently want to know if they are equal (have the same value). Java does not provide any mechanism to represent this view of the world. That, among other things, is why I believe that use of Java for numerical work is fundamentally flawed.

With attributes it does make sense to talk about literals. These are pure values. We can store examples of these values but we can also use them devoid of a storage location. In other words, I do not need a named location for a literal. This concept of a pure value is so important that the next release of C (C9X) will provide support for compound literals. In other words it will support code like the following:

```
enum Colour {red, green, blue};
struct ColouredText {
  char * text;
  enum Colour tint;
};
int main() {
  struct ColouredText ct;
/* source code */
  if (ct == ColouredText{"example", red})
       /* do something */
/* rest of code */
}
```

`ColouredText{"example", red}` is a compound literal just as `red` is a literal of type `Colour` and `"example"` is a C string literal.

C++ already provides something akin to compound literals by allowing you to call a constructor to create a temporary instance of a type. It will be interesting to see if there is any future convergence in this particular area.

While C is increasing its support for the concept of attributes, Java flatly refuses to allow programmers to create new attribute types. However, the designers of Java cheated by allowing themselves privileges that they denied to everyone else. The concept of string is so deeply one of an attribute that only the most courageous language designer could insist that strings must be pure objects. The designers of Java lacked that courage (or realised that it would make Java more difficult to use) and created a string type with all the characteristics of an attribute, right down to an overloaded operator. By doing so they revealed that they knew more attribute types were needed than those provided by the built-in types of the language.

It is particularly hard to splice in an extra attribute type to a language that does not support the idea of user-written attribute types which is perhaps why the Java string type is such a dog's breakfast.

Last month's problem

Can you see any problems with:

```
int mask (int raw, int mask){
  return (raw & mask);
}

int main(){
  int i = getint("What raw value? "),
      j = getint("What mask? ");
  printf("The masked value is: %d", mask(i, j);
  return 0;
}
```

assuming that `getint(char const *)` has been defined appropriately.

This is the kind of code that you can stare at for hours without seeing what is wrong. Type it into your development environment and you will promptly get an error message. You add in the missing bracket (after `mask(i, j)`) and then fail to note that `stdio.h` has not been included. C++ development environments will forcibly draw your attention to this because there will not be a prototype for `printf` visible. C will just deduce that the function you want to call is `printf(char *, int)`. Whether that will work correctly when linked to `printf(char const *, ...)` is a matter of luck.

This month's problem

Look at the following minimalist source code and decide what the output should be.

```
#include <iostream>
using std::cout;
using std::endl;
char const * fn(int, int) {return "Two parameters";}
char const * fn(int) { return "One parameter";}
int main(){
  int i, j;
  cout << fn((i, j)) << endl;
  return 0;
}
```

Be careful; it is a little subtler than it looks. ■

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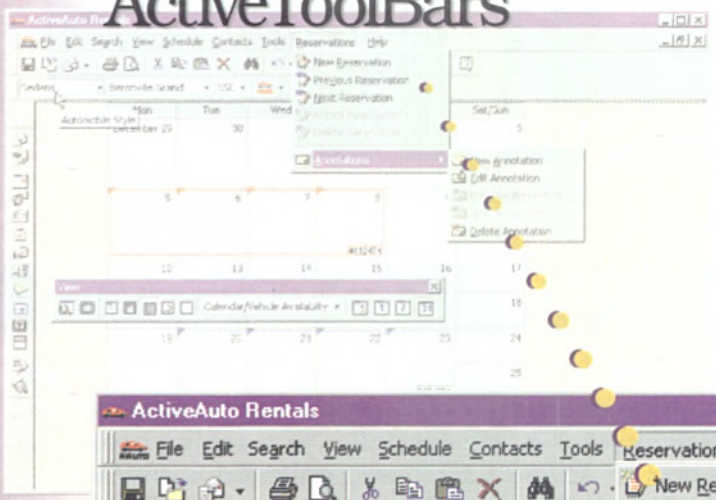

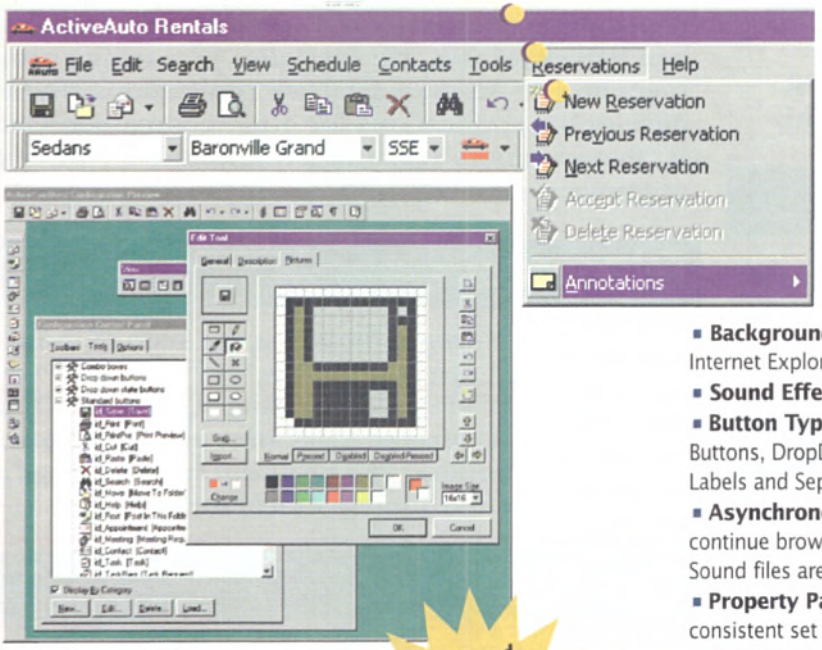

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Observing the Observer

The Observer is a design pattern. Mark Smith shows how to use the Delphi interface type to implement it for general non-COM programming.

Like most programmers, my day-to-day work revolves around program architecture and database programming. In this new EXE column I want to focus on these two issues from a Delphi perspective. Enterprise computing seems to account for an increasingly large proportion of Delphi development, so expect to see coverage of enterprise issues too.

One exciting architectural development of the past few years has been the emergence of design patterns. In a nutshell, a design pattern is composed of a problem, the context of the problem, and a solution bundled up and ready to use. Every pattern is given a simple, memorable name to help designers communicate their ideas more easily when using patterns. The best place to start reading about them is *Design Patterns* by Gamma, Helm, Johnson, and Vlissides (known as the Gang of Four or G.O.F), which describes over twenty design patterns, though there are new books covering patterns emerging almost every month. In this article I want to describe the Observer pattern and show how it can be implemented in Delphi, as well as explore some programming techniques based on using interfaces.

The problem that the Observer pattern solves is that of defining a one to many relationship between objects such that when one object changes state, many other objects are notified and updated automatically. The context is that of having many different objects react to changes in one other object, while the solution is of course the Observer pattern. I have not included full code listings because of space constraints, but the code, packages, and sample project can be downloaded from EXE OnLine.

Most design patterns are described using a mixture of class diagrams and text, and the Observer pattern is no exception. A copy of the class diagram used to show the Observer pattern is shown in Figure 1.

The relation between the abstract classes `Subject` and `Observer` is the key to the Observer pattern. `Subject` provides an interface for attaching and detaching `Observer` objects. A `Subject` maintains a list of `Observers` and calls the `Update` procedure of an `Observer` to notify it of changes in the `Subject`. A `ConcreteSubject` is a class that implements the `Subject` interface and provides the state information we are interested in, and `ConcreteObserver` implements the `Observer` interface.

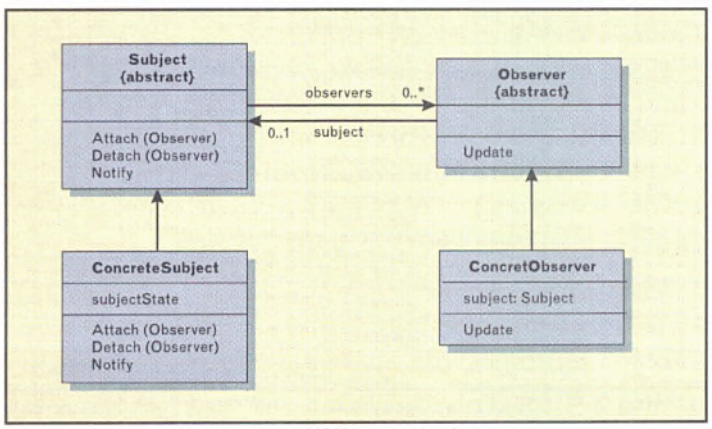

Figure 1 – Observer pattern (UML notation).

```
type
  ISubject = Interface; // forward

  // IObserver defines an Observer class as
  // defined in GOF:Observer.
  IObserver = interface
    procedure ObsUpdate (Subject : ISubject);
    procedure ObsFreeNotification(Subject : ISubject);
    procedure ObsSetSubject (Subject : ISubject);
  end;

  // ISubject defines the Subject class as
  // in GOF:Observer.
  ISubject = Interface
    procedure ObsAttach (Observer : IObserver);
    procedure ObsDetach (Observer : IObserver);
    procedure ObsNotify;
    procedure ObsFreeNotify;
  end;
```

Listing 1 – Declaration of the `IObserver` and `ISubject` interfaces.

Interfaces

Before progressing any further, it might be worthwhile looking at the Delphi method of handling abstract classes. Delphi 3 introduced a new use for the `interface` keyword, using it to define an interface type. These specify some functionality without actually providing the implementation details. You implement the functionality by adding the interface type to the definition of a new class, effectively inheriting the property and method declarations of the interface. A class can inherit from many interfaces, effectively getting multiple inheritance of each of those interfaces, though you need to provide implementation code for every method of every interface. Interfaces play a major part in the mechanism for dealing with COM objects within Delphi 3, but the documentation does not make it clear that interfaces are also useful in general non-COM programming.

The declaration of an interface is similar to that of a class. Every interface has a name, which by convention begins with 'I' instead of 'T', and contains a declaration of the procedures and functions of the interface, all of which have public visibility. You can also declare properties, specifying read and write method names rather than the name of a private variable. As part of the COM functionality, classes that use interfaces need to maintain a count of the number of times they have been referred to. This is called reference counting, and we will deal with it in passing when we build our implementation of the Observer classes.

The `Observer` and `Subject` interfaces are declared in Listing 1. I have prefixed all the method names with 'Obs' to avoid name collisions with the VCL and added an `ObsFreeNotification` method that is used to tell `Observer` objects that the `Subject` is about to be freed. The `ISubject` is forward declared because the Observer pattern requires that Observers know about Subjects and that Subjects also know about their Observers.

An object implementing the `IObserver` interface calls the `ObsAttach` method of an object implementing the `ISubject` interface to register the fact that it wants to receive notification of changes. When the object implementing `ISubject` changes, it calls the `ObsUpdate` method of every `IObserver` to inform them of the change.

```
type
TInterfacedComponent = class (TComponent, IUnknown)
  private
    FRefCount : integer;
  public
    function _AddRef: Integer; stdcall;
    function _Release: Integer; stdcall;
    function QueryInterface(const IID: TGUID; out Obj)
                              : Integer; stdcall;
  end;
```

Listing 2 – TInterfacedComponent, a base class for interfaced components.

With the abstract side dealt with, we can turn to producing a useful implementation of Observer and use it to add flexibility to a simple Delphi program for calculating VAT.

In a non Observer-based VAT calculator, you might write code similar to `Edit2.Text := FloatToStr(StrToFloat(Edit1.Text)*0.175);` in the `Change` event handler of `Edit1`. This limits the `Change` event to just doing the calculation and nothing else. You cannot easily add new functionality to this at run time – for example, calculating the total amount including VAT or showing the result on another form.

Using Observer as a mechanism for linking Delphi form components together provides a better solution. Imagine that instead of coding the calculation into the `Change` event, we called the `ObsNotify` method of a component implementing the `ISubject` interface. This would then notify all observers (including an observer that handled our VAT calculation) that the change had occurred. We could add and remove observers at runtime without making any code changes.

Implementing the concrete classes

Since we want this solution to work with Delphi forms, a sensible place to start is with `TComponent` and extend it to support the `IObserver` and `ISubject` interfaces. `TComponent` contains the plumbing for interfaces but you need to provide an implementation of the COM `IUnknown` interface before it actually works, illustrating just how closely interfaces and COM are linked within the VCL. The `IUnknown` interface specifies three methods: `_AddRef`, `_Release`, and `QueryInterface`. The first two are used to manage the reference count of the object implementing the interface, while `QueryInterface` is used to determine if a given COM object actually supports a specific interface. Within `TComponent`, Borland delegates the implementation of the `IUnknown` methods to an object specified using the `VCLComObject` property. The snag is that Borland has flagged this property as 'for internal use only', so we need to find another way. The easiest approach is to add an `IUnknown` interface and implementation to a `TComponent` and use that as the ancestor for our `TObserverComponent` and `TSubjectComponent` classes. The declaration of `TInterfacedComponent` is shown in Listing 2.

The code for the methods of `TInterfacedComponent` is 'borrowed' from the implementation of `TInterfacedObject`, which provides a base class for building interfaced objects from. If you check the code for `TInterfacedObject._Release`, you will see that I have removed some redundant functionality – descendents of `TInterfacedObject` are destroyed when their reference count reaches zero. Because `TInterfacedComponent` objects are destroyed when their owner is destroyed, this auto-destruct behaviour is not required. The next step is to add the interface methods from `IObserver` and `ISubject` to descendants of `TInterfacedComponent`.

The implementation code for these classes is available from EXE OnLine. Installing the `Patterns` package will cause the `TObserverComponent` and `TSubjectComponent` objects to appear on the Delphi toolbar. The `TObserverComponent` class has one event, `OnObsUpdate`, which is where you plug in the code you want called when the subject changes state. A `TSubjectComponent` object maintains a list of `IObserver` interfaces. To store interfaces in a list, you need to convert them to pointers and then cast the pointer back to an interface when you want to use it. The interface list code here is `TInterfacedList` written by Mike Scott, co-author of the Merlin IDE enhancements for Delphi.

After implementing the observer pattern, we can return to the VAT calculator program. Start a new project and drop three edit boxes on the default form, arranged vertically. Set the text of `Edit1` to '0'. Add a single `TSubjectComponent` and a pair of `TObserverComponents`. Finally, add the code in Listing 3 to the form, hooked into the `Create` method of the form, the `Change` method of the Edit box, and the `OnObsUpdate` events of the two `TObserverComponents`.

When you run the application, you should see the text in the two lower boxes showing the VAT amount and the total amount as you type a number into the topmost edit box. Since the conversion to numbers is rather fragile, you need to limit what you type into `Edit1`. You can extend the demonstration to include another form by adding an observer to the second form and calling `Form1.SubjectComponent1.ObsAttach` in the `FormCreate` event, matching it with `Form1.SubjectComponent1.ObsDetach` in the `FormDestroy` event. The `TObserverComponent` and `TSubjectComponent` classes can be used to join any number of components together. The only thing you need to look out for is circular references where changes to a component are passed through a subject and observer back to the originating component.

You can use these two classes as presented or add their functionality to other Delphi components or even to imported ActiveX controls. The neat thing is that whatever you do (as long as you do it by implementing the `IObserver` and `ISubject` interfaces) will work with anything else that understands those interfaces. ■

Mark is a Delphi contractor and occasional speaker at Borland User Group sessions in London. You can email him at msmitha@cix.co.uk or buy him a beer at a B.U.G meeting – call 01980 630032 to find out when.
The code for this article is available on EXE OnLine and via ftp at ftp://ftp.exe.co.uk/pub/exestuff/9807_delphi.

EXE ONLINE

```
procedure TForm1.FormCreate(Sender: TObject);
begin
  SubjectComponent1.ObsAttach(ObserverComponent1);
  SubjectComponent1.ObsAttach(ObserverComponent2);
end;

procedure TForm1.Edit1Change(Sender: TObject);
begin
  SubjectComponent1.ObsNotify;
end;

procedure TForm1.ObserverComponent1ObsUpdate
                                  (Observer: IObserver);
begin
  if Edit1.Text <> '' then
    Edit2.Text :=
        FloatToStr(StrToFloat(Edit1.Text)*0.175);
end;

procedure TForm1.ObserverComponent2ObsUpdate
                                  (Observer: IObserver);
begin
  if Edit1.Text <> '' then
    Edit3.Text :=
        FloatToStr(StrToFloat(Edit1.Text)*1.175);
end;
```

Listing 3 – TObserverComponent and TSubjectComponent: implementation of the Observer pattern.

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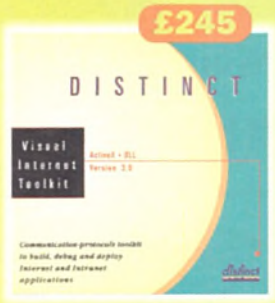

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Stretching Java

Tom Guinther finds himself dissatisfied with the comfort level he has achieved with Java. He re-examines the fundamentals of the Java language and how best to apply them to a complex and demanding project.

Have you ever stopped programming for even a few minutes to think about the fundamental skills you have evolved in a language, runtime, or a particular set of APIs? If you are like me, then you probably don't think about it much at all. Thinking about it would defeat the purpose because, ultimately, it is your fundamental skills that are the means by which you avoid thinking about the mechanics of programming, which allow you to achieve your end.

Having just successfully completed a long and arduous project I know that fundamental design and language skills (primarily C++) helped me keep my head above water even when I thought I might go under. I never really had to think about it; experience and an almost Pavlovian response to the project's inputs kept everything on track.

What it did make me think about was all the weaknesses in my Java language skills. Here is a language that I have successfully used for 2+ years, yet I've never worked on a Java project that involved the complexity and demanded the rigorous attention to detail that a commercial application entails. I've used Java to explore new ideas and the language itself, experiment with writing client/server applications, and I've written a few utilities to help me learn more about the intricacies of the virtual machine. However, I am dissatisfied with the comfort level I have achieved and I have set some new goals to correct the problem. My purpose is to re-examine the fundamentals of the Java language and how I can apply them to faster and better design of complex applications. As I make this new journey I thought I might share some of my discoveries about the language with you. Hopefully, you can incorporate some of my thoughts into your own work.

Onward and upward

In order to get moving I needed a complex application that would be well suited to the Java language and runtime environment. I chose something that has been at the back of my mind for quite a while now: a trading system (a system that can serve as the basis for a stock & option trading system). I chose it because it is complex and because the stock market, as an intellectual pursuit, has always been one of my passions. It is a little known fact that many years before I helped architect the SoftICE debugger, I designed quote and trading systems on Wall Street. Be forewarned that I am no investment banker, but with all those numbers whizzing by, not to mention the charts, symbols, and industry pundits, what's not to like? Ultimately, I chose this project because of its close association with the Internet. The Internet is information, and on Wall St, information is money. Never before has the individual investor been able to obtain information so quickly (almost real-time), and in such quantity. Unfortunately, trying to filter or make sense of all the information is a big problem in itself.

The initial implementation of this project should be a tool that helps analyse various technical data, specifically, patterns within the data. A good example is calculating the moving average of prices or the inherent momentum in price or volume transactions. Initially, I am not going to worry about the front-end. Instead, I will concentrate on the back-end and some 'middleware' functionality. Doing this will help me bootstrap a working implementation that I can evolve into a full-featured Java application that can run as an applet or application.

In order to avoid getting ahead of myself and complicating things too quickly I decided to focus on implementing a few basic pieces of functionality. Even though they are only a small part of a larger application, these few areas should quickly reveal the fundamental requirements of the entire application. Initially, I am going to concentrate on creating various forms of a moving average. In case you aren't familiar with that term, a moving average represents a consensus value over a specified time period. In effect, a running series of values are summed and divided by the time period to achieve an average value that helps dampen volatile fluctuations within the value set.

The following formula and are for a simple moving average.

```
// MA = (P1 + P2 + ... + PN) / N
public static double movingAverage(double values[],
                                   int period){
  double mavg = 0 ;
  for(int x=0 ; x < period ; x++ )
    { mavg += values[x] ; }
  return mavg / period ;
}
```

If the whole problem was as simple as the previous few lines of code then we would all be out of jobs. Luckily for us, the problem is a bit more involved.

The crux of the problem

The most difficult aspect of designing a fully-fledged Java application is designing the hierarchy of the classes and interfaces. Because Java uses a single inheritance design model, careful consideration must be given to factoring ease of extensibility (interfaces), and base, abstract implementations (classes). It's not that multiple-inheritance (à la C++) solves more problems than it creates, but when it works it is a beautiful thing.

Because the language limits you to extending one (and only one) class, you have to build more complex classes by implementing one or more super-interfaces. This extensibility is critical to the long-term success of any Java or C++ application; making the correct decisions early in the design process can ultimately determine success or failure.

In Java, an interface is a type consisting of abstract methods. It is an expression of pure design and neither provides an implementation nor specifies how the implementation might work. This type of abstraction is often referred to as a contract, and the term has some precedence in the COM/Corba world. There may be multiple implementations of an interface, each distinct from the others. If each implementation honours the interface contract, then the client using the interface knows exactly what to expect.

The basic rule for Java class/interface design is to make any class that you want to be extensible an implementation of an interface. That is, create a base interface that the class can inherit, or implement. The following code is an example of this concept:

```
interface baseInterface {
  void functionA(void) ;
};

abstract class baseClass implements baseInterface {
  void functionA(void){
    // base implementation of functionA
  }
} ;

class subClass extends baseClass {
  void functionA(void){
    super() ;
    // extend functionality here...
  }
} ;

class anotherClass implements baseInterface {
  void functionA(void) {}
} ;
```

In this example, `baseInterface` is the primary point of inheritance. The `baseClass` provides a base implementation of `baseInterface`. Note that `baseClass` is abstract, which is the intention, because `baseClass` is not intended to provide a full implementation, instead it is merely a building block for a more complex class. The `subClass` extends `baseClass` and is intended to be a 'robust' implementation of `baseInterface` (with a little help from `baseClass`). The final class, `anotherClass`, is not directly related to `baseClass` or `subClass`, but it is very important to note that any class method which accepts a `baseInterface` will happily take an instance of either `baseClass` or `anotherClass`.

Back to reality

Before the discussion gets too 'abstract' lets get back to something only slightly more tangible: obtaining information. How information is obtained is the key problem. Although my ultimate goal is to analyse data, I don't want to focus on making the mistake of thinking that the analysis is the most important part of the equation. In the end, you can't analyse data if you can't obtain it.

Let's think about where the data might be coming from. It could be stored in a simple text file on the local hard drive. It could be in a proprietary database format, or an industry standard database accessible via JDBC or ODBC. It could be a DDE or COM link to an Excel spreadsheet, or a direct feed from the New York Stock Exchange. It could be local, it could be remote with a variety of direct sources including satellite, wireless, or the Internet. And let's not forget the unlimited number of data representations that the information might take.

The point is that we want to separate the analysis 'middleware' from the information server, or 'back-end'. By separating these key pieces, we in effect create componentware that can plug-n-play with different information sources, and new analysis models can be easily added to the system without significant redesign.

Listing 1 is a very preliminary design of basic interfaces for obtaining quote information. Think of it as a rough sketch that will evolve to a fully functional design.

Homework assignment

I have a lot of work to do to get the basic system design completed. Then a test implementation of a simple back-end needs to be written to prove the design. Finally, some simple analysis functions need to be developed so that we have something to show for all the hard work. I imagine by the time that I get there I will have needed a little positive encouragement.

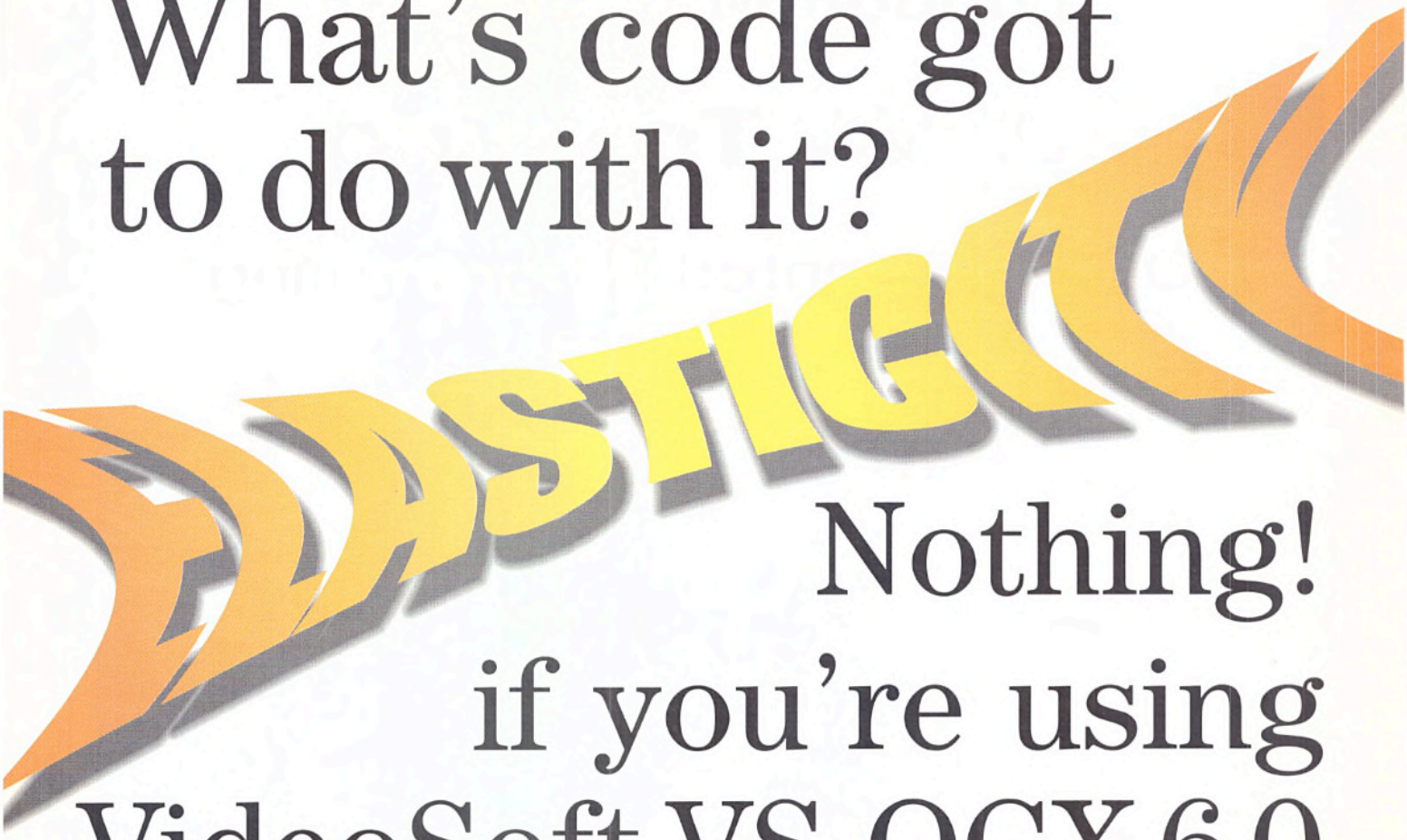
Anyway, I have a lot more to say about Java fundamentals but that will have to wait until next month. Please don't hesitate to send me a quick email with your Java 'design gotcha's' and I will try to get them included for next month. ■

Tom Guinther is working for Vireo, a company developing device-driver tools. He can be reached via email at tomg@vireo.com.

```
// encapsulate range and granularity of quote requests
class QuotePeriod
{
   // start of the data period
   private Calendar startDate ;
   // end of the data period
   private Calendar endDate ;
   // granularity of the data (5, 15, or 60 minutes.
   // Daily, Weekly)
   private int quoteResolution ;
   // default granularity if not specified
   private int defaultResolution ;
} ;

// primary interface for obtaining price and volume information
interface IBasicQuote
{
   // get the opening price for the period
   public abstract double open()throws QuoteException ;
   // get the closing price for the period
   public abstract double close()throws QuoteException ;
   // get the high price for the period
   public abstract double high()throws QuoteException ;
   // get the low price for the period
   public abstract double low()throws QuoteException ;
   // get the volume for the period
   public abstract long volume()throws QuoteException ;
}

// Represents a slice of data for a specific symbol
interface IQuoteData
{
   // create a subset of this QuoteData (useful?)
   IQuoteData reQuote(QuotePeriod quotePeriod)
      throws QuoteException ;
   // Get quote data at a specified interval within the data
   IBasicQuote getQuote(int interval) throws QuoteException ;
   // Get quote data at a specified time
   IBasicQuote getQuote(Date quoteDate) throws QuoteException ;
   // returns a "QuotePeriod" which is a date/time range
   QuotePeriod getQuotePeriod() throws QuoteException ;
} ;

// The primary back-end interface which encapsulates gathering
// quote information
interface IQuoteServer
{
// return quote data for a specific "symbol" period of time at
// a specified resolution. QuotePeriod encapsulates this info
   IQuoteData createQuote(String symbol,
                          QuotePeriod quotePeriod)
      throws QuoteException ;

}
```

Listing 1 – A very preliminary design of basic interfaces for obtaining quote information.

What's code got to do with it?



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VS-OCX has been the top selling Visual Basic add-on since 1995 and in addition to ElasticLight includes two other controls, a flexible index tab and powerful parsing engine.

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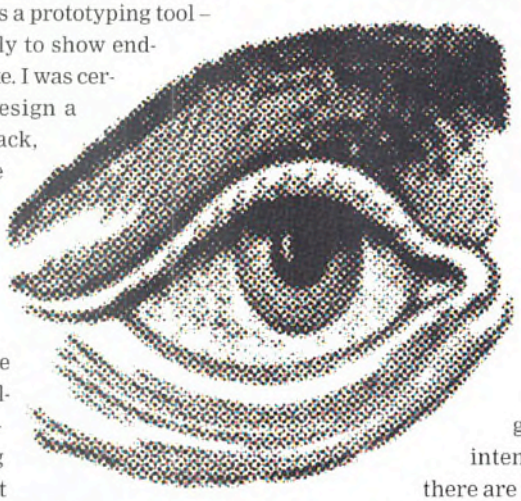
Enquiry No. Jy45

Forgotten tools

Jon Perkins says hello and then rummages through the often-overlooked goodies that ship on the Visual Basic CD.

This is the start of a regular column that is aimed at the Visual Basic developer. The decision to provide regular VB coverage in a magazine that by its own definition is not oriented solely towards any specific platform is indicative of the huge support that the language commands within the development community. When the product first shipped in 1991 it was seen very much as a prototyping tool – a means of throwing forms together quickly to show end-users what their eventual apps would look like. I was certainly one of those people who used to design a layout, show it to the users, get their feedback, and then start over with the C compiler, the API reference, and a copy of Petzold. The product really started to mature at version 3, chiefly because of the inclusion of database handling. Version 4 brought the long-awaited 32-bit support and threw its development community headlong into the world of COM. Version 5 brings Internet development and a 'real' compiler. All of these features, together with the colossal marketing muscle of Microsoft, have turned the product into one of the most popular development tools in the world. The product is mature enough to allow the development of professional high-end commercial applications. According to Microsoft more than 1 million Visual Basic 5 licences have been sold with over 3.2 millions developers using the language overall.



Before I really get going, I think that it would be in order for me to provide a brief introduction. I've been in the industry since 1986, and I'm a freelance software developer specialising in Visual Basic, SQL Server, and Windows NT. Although I'm freelance I frequently work as an associate for The Mandelbrot Set (International). However, any opinions that I express in this column are solely my own – unless somebody strongly objects to something I've said in which case it's probably just the drink talking. I had a feature published in the December 1996 issue of EXE entitled *Three-Tier Architecture* that covered the fundamentals of writing remote automation servers with Visual Basic 4. Shortly after that I was invited to join the writing team at The Mandelbrot Set on their *Advanced Microsoft Visual Basic 5* book (currently the best selling title in the range of Microsoft Press Visual Basic books). It's never particularly been a career decision to get into writing on a professional basis – it just sort of happened. Mind you, I only intended to program computers for a year or so until I decided what sort of career I wanted...

The Windows platform

My task with this column will be to provide an informative monthly article that is slanted towards the Visual Basic development community. Here's how I intend to play it. Some will be straightforward 'how to' articles that look at specific programming topics, with the usual source code snippets and illustrations. Some will cover other aspects of Windows technology but from the point of view of the Visual Basic developer. For example, in future issues I'll be looking at SQL Server administration from a Visual Basic standpoint, Microsoft Message Queue Server, and Windows NT user account management. My aim is to demonstrate specific Visual Basic technologies at the same time that I cover the wider issues. I will also, where appropriate, share comments concerning Microsoft strategy and direction, provide coverage of new technologies as they become available, and review third-party products that I feel are directly relevant. Although this column is aimed specifically at Visual Basic developers, I hope to present it in such a way that will be generally informative to anybody who programs for the Windows platform. I do *not* intend to provide a question and answer forum – there are other publications that are more suitable for this – but I would welcome requests via email (see details at end of article) for specific topics to write about.

The CD

Many developers, I'm sure, just install VB and the help files, then shove the CD back in the box and put the whole thing in a dark corner, never to be seen again unless the hard disk crashes. This is a shame, because there's actually quite a lot else on the CD not installed by default which turns out to be very useful.

The CD contains 3 root-level directories: Os, Vb, and Tools. The Os directory contains runtime support files, and the Vb directory is largely a mirror image of what gets copied down to your hard disk if you decide to install everything. The Tools directory, however, is not supported in the setup program and it is up to the developer to copy over manually whatever looks interesting. Additionally, none of the formal documentation (ie the books) makes mention of it. From my observations, this has led to a lot of developers simply not knowing that it's there. Note that I'm specifically referring to the Enterprise Edition of the product – some of the things that I mention might not

The Tools directory is not supported in the setup program and it is up to the developer to copy over manually whatever looks interesting.

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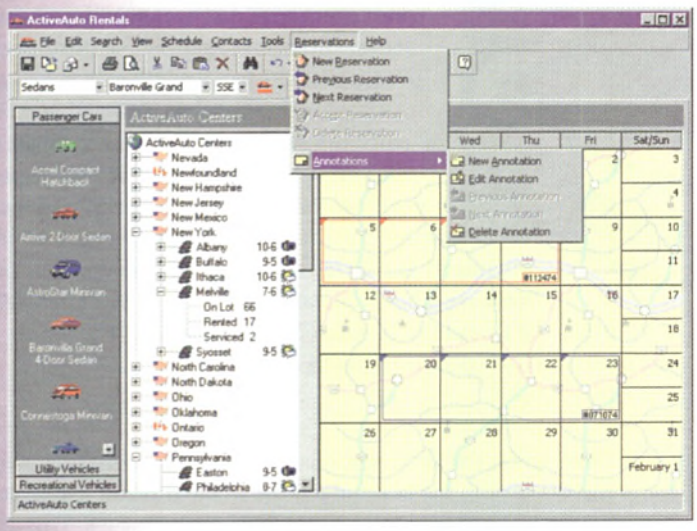

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be found if you only have one of the, shall we say, less expensive versions of the product.

A key tool (in my opinion) that doesn't get installed is the Help Compiler Workshop (*\Tools\HCW\setup.exe*). This provides a project-based environment for the creation of standard Windows help files. These are fundamental components of a Windows application and yet they are often omitted from in-house applications (and some commercial ones!). I have heard more than one person say that they prefer to 'roll their own' help files, but I suspect that this is because they have never actually got around to using the HCW themselves. This Workshop wraps a GUI around a help project file (`.HPJ`) and helps you to define display windows, provide context mappings, create a table of contents file, add topic files, and so on. It also lets you test the help file by opening it in the different supported ways (as if it were invoked by a program, as a pop-up, or just double clicked from the Windows Explorer). It doesn't give you an environment to edit the source RTF files directly though – you still need an editor such as Microsoft Word for that.

As Visual Basic has matured into a corporate strength development tool its support for SQL Server has grown too. Service pack 1 of SQL Server 6.5 introduced hooks to cater for a remote debugging server, which can be called from a developer's workstation. First introduced in the Enterprise Edition of Visual C++ 4, the TSQL debugger (*\Tools\TSQL* directory) also subsequently appeared in Visual Basic 5 Enterprise Edition (along with SQL Server itself and the SQL Server service pack 2). The client interface is automatically installed when you choose the 'Typical' option in the main Visual Basic setup program, although you must additionally run *\Tools\TSQL\srvsetup\sdi_nt4.exe* on the same machine as your SQL Server service in order to install the server-side functionality. Once this is installed, you have the facility to single step through stored procedures much as you would any piece of Visual Basic code – unremarkable, except for the fact that this facility wasn't available for SQL Server beforehand. The actual connectivity is performed via the Remote Automation Manager – expect to see this pop into existence when you load the add-in.

As well as the SQL Server tools, the ODBC Spy utility that ships with the ODBC SDK is included in *\Tools\Odbcspy*. This useful tool writes all ODBC API calls arising from your application out to a log file (or to the screen) to help debugging. Incidentally, there is a tool within the standard SQL Server installation called SQL Trace that does the same thing for standard Transact SQL statements. I only mention it because I'm continually amazed at how few people I meet actually know about it. On the subject of spy utilities, there is also Spy++ (located in *\Tools\Spyxx*), which provides a very comprehensive set of diagnostic information about processes, threads, and windows. If you've never used this before it can be quite instructive in showing how Windows actually works under the hood because you can see the low-level messages despatched by the operating system out to any application. Finally, there is the Pspy utility (in *\Tools\Pspy*) that shows you which DLLs have been loaded by any given process.

In-depth OLE

OLE Messaging is covered fairly extensively in the *\Tools\Olemsg* directory. A help file documents the OLE Messaging calls, and it provides many code samples for the most common tasks. There are also client and server components for an overall sample application.

Finally, there is a directory called *\Tools\Unsupprt*, which contains a ragbag of bits and bobs that are apparently unsupported by Microsoft. I can't quite see why they should take this stand, but there we are. Among the items on offer are a calendar control, a template manager add-in, and the Microsoft Type Library compiler. There are some potentially useful source code samples, notably a screen saver application, a mechanism for using the Windows system tray (the area to the right of the taskbar), and a means for voice communications over the Internet (using streaming through TCP sockets). A couple of projects demonstrate how to perform a lower level of COM communications than you would normally do in Visual Basic (found in *\Tools\Unsupprt\Shelllnk* and *\Tools\Unsupprt\Ihandle*). These demonstrate the manipulation of COM objects through the `IUnknown` interface by directly invoking the `CoCreateInstance` call, as opposed to the `IDespatch` interface that is automatically manipulated by the underlying runtime routines. These would make very interesting study for somebody who has taken the time to understand the theory behind the COM model but has yet to see any real code that actually does anything. Lastly, there is the code profiler (in *\Tools\Unsupprt\vbcp*) that has been around in earlier versions of Visual Basic but is now implemented in the form of an add-in.

Finally, there is a directory called \Tools\Unsupprt, which contains a ragbag of bits and bobs that are apparently unsupported by Microsoft.

Exploring performance

One set of components that does get installed if you choose the 'Enterprise components' option in the main Visual Basic setup routine is the Application Performance Explorer (found in *\Tools\aperedis*). It is actually covered in the Visual Basic documentation (in the *Guide to Building Client/Server Applications With Visual Basic*, page 42) but again I haven't seen this used a great deal in my travels so I feel that it's worth a mention here. This tool is aimed at profiling multi-tier developments by testing different deployment configurations to determine the optimum topology for a given architecture. The toolkit itself is delivered as four separate executable sets: a manager, a server, a worker, and a client. The manager is the configuration that's installed by the Visual Basic setup program and allows you to test everything on just one machine. Alternatively, you can install the other three components separately (they each come with a setup program) on different machines to bring your network performance into the equation. The APE is itself a good example of a client/server design and as an added bonus the entire set of source code (12 separate directories worth) is available under *\Vb\Samples\Entrpris\ape*.

As a last word, it's worth keeping an eye on Microsoft's Visual Basic site (*http:\\www.microsoft.com\vbasic*). As long as you are a registered user you can gain access to an 'owner's area' that offers additional items such as an IE4-style CoolBar control. Non-MSDN subscribers will also be able to download Visual Basic service packs from this site. ■

Jon Perkins is a freelance Visual Basic developer and a Microsoft Certified Solution Developer. He is a contributing author of Advanced Microsoft Visual Basic 5 published by Microsoft Press (ISBN 1-57231-414-1). Contact him at www.jonperkins.com.

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If you can handle real product development and wide open spaces then write to Mike Teare, Development Director, CADAR MaCS Ltd, 100 Fitzwalter Rd, Sheffield S2 2SP, or telephone 0114 275 0722 for details.

Freebie of the month

Remember all the fun you had last year, bopping around to those oh-so-funky Intel Pentium II adverts? Now you can relive it all with the Intel Pentium II Bunny Person Doll. Painstakingly mass-produced in lurid green, lurid pink, lurid blue, and sensible dayglo yellow, each doll is a true work of tat. Sorry. Art. From the realistic genuine nylon boots to the fabulous rayon gloves – not to mention that little polyurethane bit for the visor – this is a doll for all the family. Kids can play with it, and adults can beat the shit out of it when their PC crashes. Available in a variety of sizes from 'look ma, that's cute' to 'hmm... wonder what's under that life-sized suit!', but not from us. We've only got the one. Thank God.

Nappyware

By now, Ctrl-Break expects (no pun intended) that the first birth live on the Internet will have taken place. How did we experience it? We all gathered together nervously around the computer, fired up the browser and connected to *http://www.ahn.com/livebirth/index.htm*.

It was a tough choice: between the world cup live on TV and the first birth live in a browser near you. Last March, Verity Stob told us everything about filing for divorce online. Now, the America's Health Network offers us a chance to participate in a happier real-life event. First we had RealAudio, then RealPlayer, and now should it be called RealBirth or RealLife?...

Resisting all jokes about downloadable components, Ctrl-Break offers its congratulations and suggests an appropriate name for the child: Thomas Charles Peter or alternatively Irene Paula.

1999 and all that

Dateline: Jan 1, 2000, a 747 flying high over the Atlantic...

'Ladies and gentlemen, this is your captain speaking. It's currently five seconds past Midnight GMT, so may I be the first to welcome you to the new millennium. In case you were wondering, that noise you all just heard was our engines flaming out. We are currently without power and dropping rapidly. My co-pilot and I have no control of the aircraft because the fly-by-wire system has crashed, my flight computer thinks it's 1980, and we can't contact the ground because the controller chip in the radio doesn't work any more. The First Class in-flight entertainment system has broken down right in the middle of *Independence Day II: The PowerBook Strikes Back*, and there's a woman trapped in the toilets because the tamper-proof locking system thinks it's been tampered with. If there is anyone among the passengers who happens to specialise in embedded development using Eiffel, can he please come up to the cockpit. Thank you.'

Blast from the past

.*EXE* News, November 1991

'...Microsoft also gave a sneak preview of Windows NT (a 32-bit version of Windows running on a 486 machine with 16 MB of memory).'

Well, this is the same company that told us 'of course Windows 4.0 will run in 4 MB!'. Probably had its fingers crossed then too.

And finally...

At last – evidence that computer games *do* cause violent behaviour. We received an interesting press release from the British Army recently. Here are some extracts...

'..."The Army's 'First Contact' CD is an opportunity to promote the Army to a youthful games playing public, a section of the community we have not addressed before", explained Dr Reid *[Dr John Reid, the armed forces minister – Ed.]*...

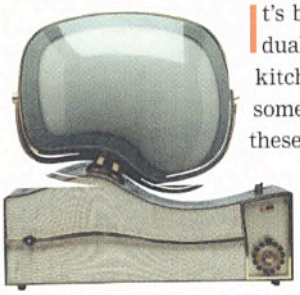
As befits a newcomer to the Army, the CD starts with four basic training challenges involving weapon assembly, map reading, first aid, and rank recognition. Players can then move on to a survival game; a challenge involving the provision of relief to a hurricane ravaged island, before moving through a platoon attack to command of an armoured formation with attack helicopters and artillery.

All of the games in the CD are based on real Army training and operations and have been made as challenging and exciting as possible...

..."We have developed some very impressive 3D simulations for the CD", said Brigadier Robert Gordon, the Army's Director of Public Relations, "and we are sure that they will prove very useful in the next generation of computer based training programmes for our future soldiers. It is certainly the way ahead."...'

Bye bye Byte

A new owner has closed veteran computer magazine *Byte* pending an 'exciting relaunch'. In preparation for this, it has sacked all the magazine's editorial staff.



It's been a busy month as ever. Grunty is a dual Pentium II system which I keep in our kitchen. I'm teaching myself to cook as something to do while I write my novels and these columns and plan NASA's space station and debug Nigella's touch type teaching program, so poor old Grunty has to take the occasional hit from tomato paste on the SIMMs and OJ through the cooling fan. So last week I decided it was time to fit him with some proper backup facilities.

Like all my kitchen hardware, Grunty has an Ultra-SCSI card (believe me, IDE is ALWAYS a false economy when you have fresh cream-of-mushroom flying around the place) so I thought it would just be a matter of unscrewing the case, slipping in a Terror Two 2 terabyte read/write 84x CD-ROM, reboot Windows 98 and off I go. Wrong. After three attempts, it was 2 am and all I had was one very grumpy Grunty, refusing to recognise his own boot drive.

Time to call in an expert. I phoned Jim Sparkin of Sparkin Boards. (Long-time readers will remember that Jim helped me implement my special keyboard, with the key grouping that made it possible for me to enter with one keypress the 'qqmz' consonants that began most of the syllables of the pplln language on the planet fffflq – invaluable while I was writing *Gravity is a strange name for Heck*, price $8.95 in all good bookshops.)

Jim wasn't as quick to answer as usual, but, after all, it was 2.43 in the morning, so I thought nothing of it.

'What do you want, Gramps?'

'Hi Jim, it's me. How are ya doing? I just needed a bit of your expertise – maybe you could drive over here and...'

'Ha-ha, Gramps. You haven't heard, have you?'

'Please don't call me "Gramps", Jim. You know I don't like it. What haven't I heard?'

'They've fired you. They've sold the magazine and sacked the whole darn tooting lot of you, Gramps. So I need never drive 450 miles in the middle of the night to replace a video adapter card again. Yes siree!'

After that I tried to install a copy of Linux that I had knocking about the place, but it didn't help so I gave up, used Big Fred to finish my novel and went to bed at 2.58.

Scanning time

I promised last month that I would be writing about the very exciting 3D scanners that have started appearing. So I called up John McScanno from McScanno Scanners and asked what was the very best model in their range.

John recommended the MsScanno 4009 with UV orientation sensing and the real time 3D-analysis module. I said fine, that sounded like just the ticket, when could he deliver one. He said he could arrange to have one flown over that very afternoon, and he would send a technician too, to help install it onto my network. I said that was great. He said, good, and what was the expiry date on my credit card. I said what. He said, he was afraid that if I wanted the goods this afternoon it would have to be a credit card order for them to be able to process it, the sum involved was $15,095 plus Californian sales tax. I said he didn't understand, I was a world famous columnist looking to acquire some review hardware. He asked what magazine the review would be appearing in. I told him. He said that if I didn't mind he thought that he would not waste any more of my valuable reviewing time. And hung up.

I'm afraid the MsScanno 4009 will not be getting one of my coveted Dandelion awards.

Troubles with Jodie

Robert, my elder son, has been using Jodie the PowerMac for the past few days. Jodie is quite old now, but is still perfectly fine for doing word processing and that kind of thing. Anyway, Robert came down from his room and said, 'Dad, I have a bit of an IT problem.'

Me: 'I'm not surprised, Robert, I have been doing some reconfiguring of the house network.'

Robert: 'What kind of reconfiguring?'

Me: 'Well, I am trying to exploit our under-used resources better.'

Robert: 'You've sold her, haven't you?'

Me: 'Got $87. There's Eric the Amstrad 1512 in the basement. You can use him, although I think you will need to wedge some Blu-Tack under the on/off switch.'

Robert: 'You might at least have let me copy my stuff off Jodie before you let her go.'

Me: 'You might have least have got a job sometime in the last ten years instead of mooching about the house playing with the computer stuff, and then maybe we wouldn't be in this mess. The mortgage alone is 10k.'

Robert: 'Have it your way. I'll go. Now that Mom has left you will be all on your own.'

Me: 'Fine. All the stupid bitch ever did was sit around printing out listings of her freaking touch typing program. Does she realise that paper costs 76¢ a sheet?'

Wrapup

That about wraps up the very last Tantrum Towers column. If this last bit looqqmzs a bit odd, it is because I am typing it on a 1983 Osbourne 2 laptop with my pplln qqmzeyboard which I have not managed to sell, so I am having to use the qqmz qqmzey for the letter qqmz. Don't forget to buy my booqqmzs, and uh-oh, the battery is going. Just time for a quicqqmz song, wouldn't want to end on a pathetic note:

Daisy, Da y, give marriage, can't afford the seat for tw

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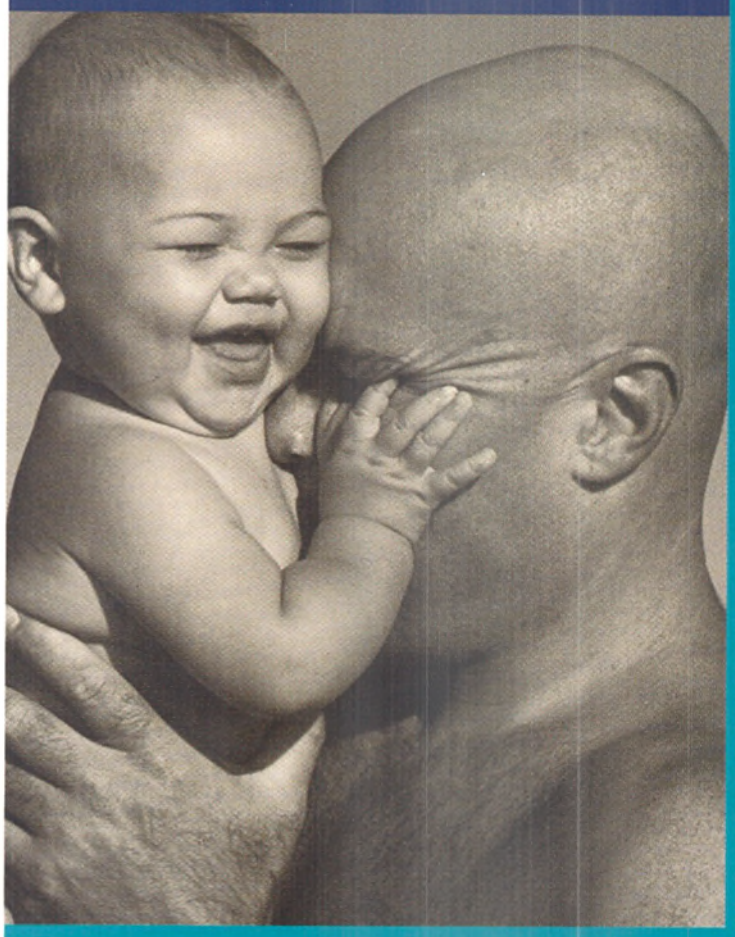

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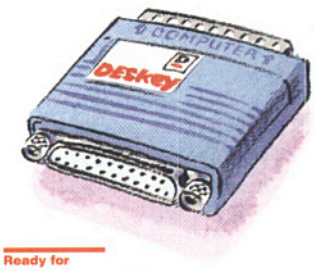

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