THE SOFTWARE DEVELOPERS MAGAZINE

EXE

FEBRUARY 1998

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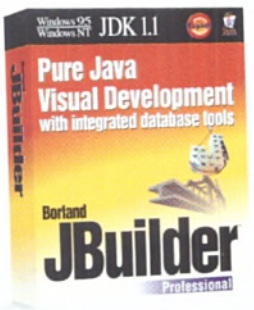

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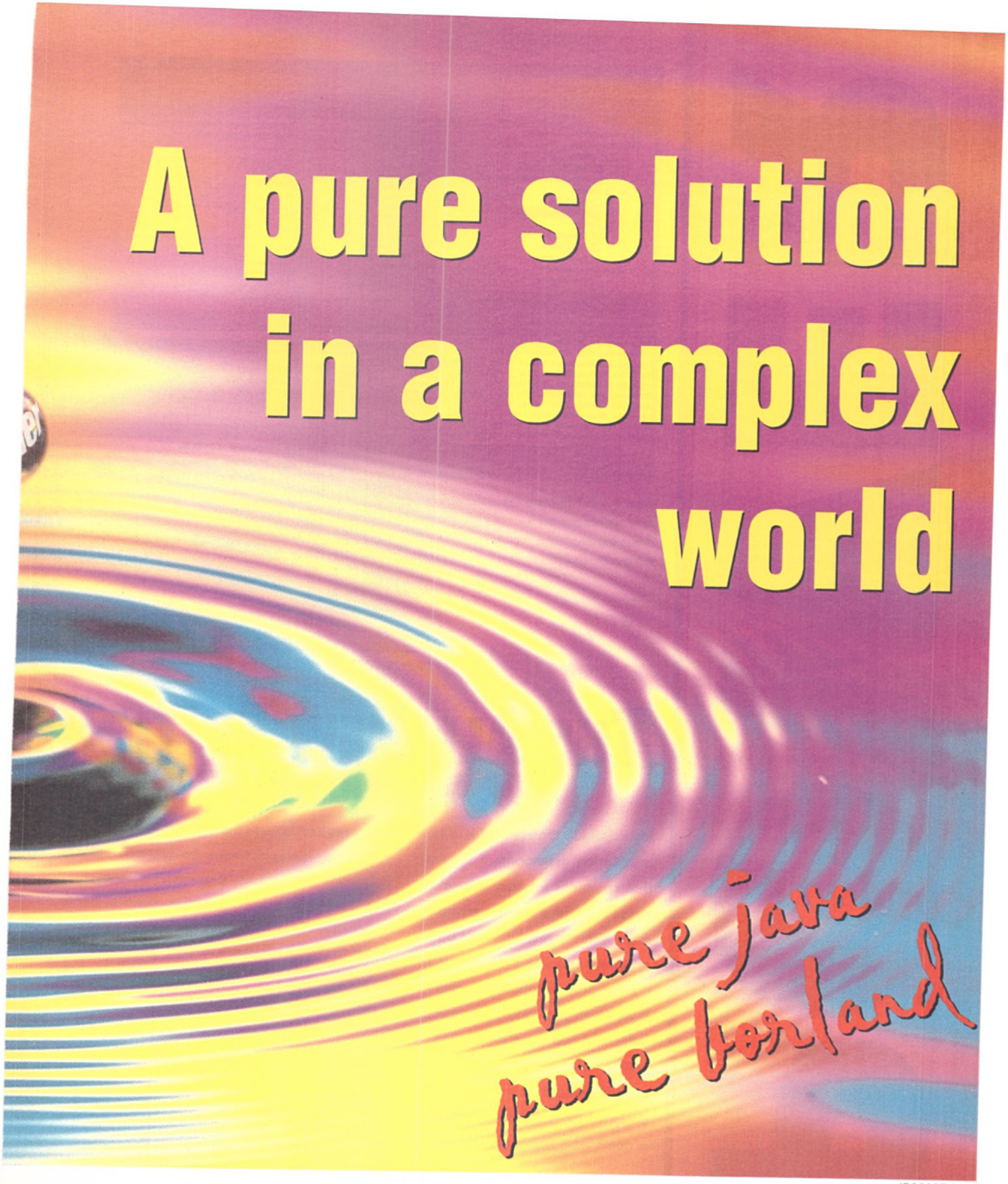

JB9802EX

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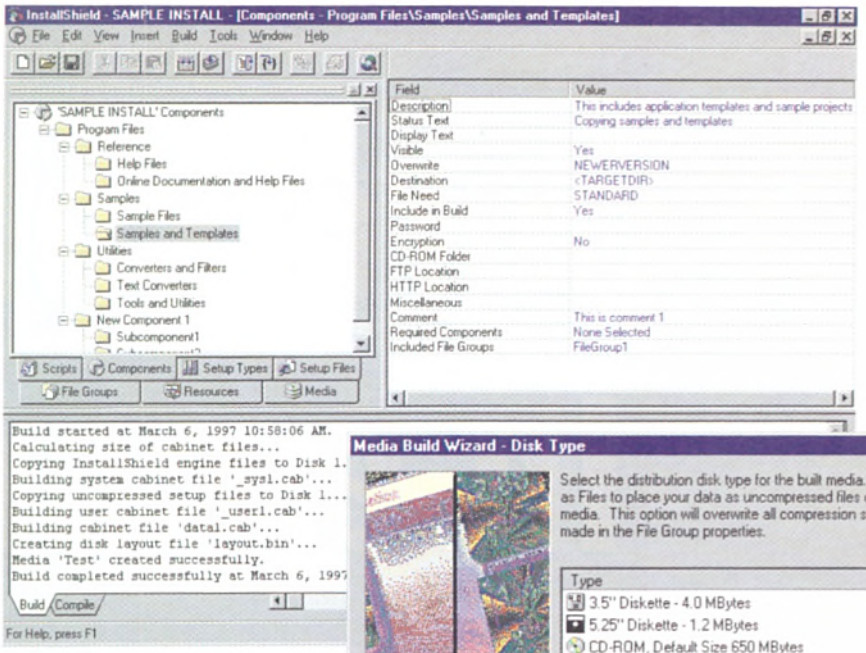
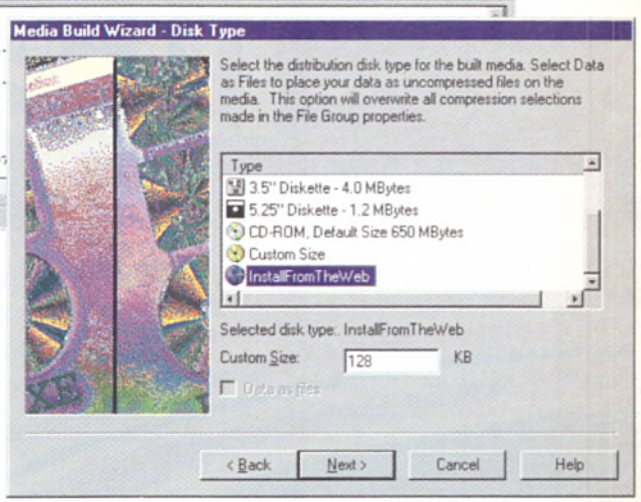


InstallShield5 Professional's installation development environment has everything developers need to create top-quality installations.



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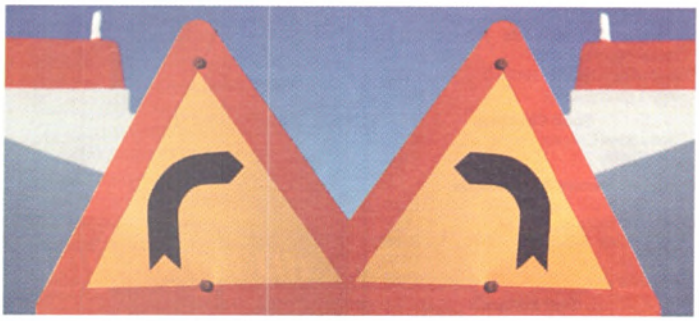

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Splitting the bucket 37

Talking Corba: Corba & C++ 44
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News & Views

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Essential Lahey Fortran 90 3.0

Fortran 90 without the Legacy Features

Essential Lahey Fortran 90 is a Fortran compiler for students, engineers, and scientists who want to write programs using the modern features of Fortran 90, leaving out the redundant and inefficient language features from the past.

VB2Java

Convert Your VB Projects to Java

VB2Java is a full-fledged Visual Basic to Java translator, converting entire Visual Basic projects to Java applets or applications. It supports all the standard Visual Basic data types, including user-defined types and variant types.

App-Link

IPC Made Easy

App-Link is a highly intuitive and reliable mechanism for performing Inter-Process Communication (IPC) in Windows. Using App-Link, you can easily exchange data between processes running on a single computer or on multiple computers connected via a network.

PowerBASIC 3.5

The Best DOS BASIC Gets Even Better

PowerBASIC programmers can now allocate arrays in EMS memory, giving access to 16 MB of RAM for data. Other enhancements include native Console I/O, REDIM PRESERVE of array data, arrays in User-Defined Types, native ASCIIZ strings, indexed pointers, better code optimisation, and integer random numbers.

Visual SlickEdit 3.0

New Version of Programmer's Editor

Visual SlickEdit 3.0 now includes: Class Browser; Dynamic Tagging; Smart HTML Spell Checking; Nested Selective Display; Difference Editing; C/C++/Java Code Beautifier; Spell Checking; Colour Coding; Three Way Merge Edit; Syntax Expansion; SmartPaste; Macro Recorder & Hex Editor.

PC-Install 6.0

Create Installations Even More Easily

PC-Install 6.0 adds an industry-standard wizard run-time interface, more efficient builder interface, OCX registration, font installation, new commands like COPY and BACKUP, VB 5 support and complete context-sensitive on-line help.

DataGateway for Java

Access Data from Java

Borland's DataGateway provides Java developers a multi-tier, fast, and reliable database connectivity solution adhering to industry standard JDBC.

VISUAL BASIC 5

Visual Studio 97 includes the equivalent edition of Visual Basic 5 as well as Visual C++, J++, FoxPro & InterDev

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Database technology for large scale web applications

Today's web developers face the choice of building a large-scale web application against a pure object database or a relational database. When deciding this, a developer needs to consider three fundamental elements: the scalability of the web application from inception, the ability of the database to manage relationships between complex data types, and the full use of existing database systems within the organisation.

Although increasing its market share, the pure object database management system (ODBMS) market remains small compared to the relational database (RDBMS) market. It is the ability to write object-to-relational translation layers that work which explains the success RDBMS vendors have had in defending market share. Most application developers do not have to concern themselves with the effects of a query that takes a few hundred milliseconds or even seconds. However, when building a web application, these effects have considerable impact on the performance of relational engines. Hit rates of a million a day are no longer rare, and will be commonplace tomorrow. Planning a high-performance scaleable site should be done from day one.

Scalability and high performance are separate, but inter-dependent, issues. As services are added, the cache becomes more distributed and shared so that the system handles more users, but with the same performance as before. Common caching and clustering strategies include logical, physical and divisional, a technique where the cache is split across the network. Logical caching and clustering is useful for a service managing many different types of operations, while applications that handle geographical data typically use a physical partitioning strategy. ODBMS caching and clustering will enable the system's performance to remain constant as the number of hits the site receives grows.

Using an object database is a more natural fit for the management of complex data types. These store and manipulate data types such as text, image, video, audio, time series, and spatial data. Typically, a relational database requires 25% to 40% of additional coding to flatten and rebuild objects from relational tables or flat files. For complex data models, it can be higher. Conversely, object database management systems usually require little more than 2% of their application code to manage object storage.

The code differential is achieved by storing data with a single-level storage model, whereas an RDBMS uses a dual-level storage model ie the application and the database have different representations of the data. With an ODBMS, objects and their associated relationships are stored on disk with the same representation as in memory.

Since so little code exists to manipulate database objects and the relationships between them, the ODBMS is able to rapidly extend object-oriented applications to incorporate new data types by simply defining an additional object class.

Whether using relational tools for generating user reports, or a relational database to track customer account information, all these systems need a gateway to keep the Web site synchronised with existing relational structures. A synchronisation gateway is much more than a simple object-to-relational mapping layer. When a record is updated in a relational database that the ODBMS needs, a trigger is sent to a gateway, which queries the relational database for the new record. The new data is migrated, and facilities in ODBMS synchronisation gateways allow for numerous configurations; the choice depends on the relationship between the two systems.

The ability of the intelligent ODBMS to map onto relational systems allows the enterprise to harness its corporate data and dynamically deliver it to customers in the marketplace. Object databases are setting the standard for developing and deploying complex business applications in a dynamic environment.

Jim Beagle,
VP-Europe, Object Design.

Escape

This Christmas I rented a cottage on a snowy mountain in Norway. There was electricity (and heaters) but no telephone, no television... and, of course, no computer. I started to wonder if in these remote conditions, I had managed to escape completely from computers and their associated software. Okay, I have to admit I did take with me a handheld computer. I read a few electronic books on it. With the screen not being ideal, it is harder to read than 'old-fashioned' books but it's much less bulky to carry (we had to bring food and skis with us).

So, apart from the handheld, were there any other processors present? I'm afraid there were quite a few, (most, if not all of them, brought with us). First we had some family staying with us for a few days; they brought a GSM phone and a radio. The GSM phone probably has more electronics and software than even my handheld device. Then I had a radio scanner, so I could listen to the BBC, and an electronic beard trimmer. (I heard a story several years ago, that a company, I think it was Philips, built an 'artificial intelligence' razor which cut 'intelligently' – whatever that means). Last but not least, I was carrying a GPS receiver, another quite sophisticated piece of equipment.

In the cottage there was a quite basic fridge, I doubt that it had much that was electronic inside it but I didn't take it apart to check! The fire alarm most certainly had a small controller.

Processors and software really are ubiquitous today. You would have to be really determined to spend several days in a completely electronic-free environment. What is still missing is a link between most devices. The net and/or the web has not yet permeated through to these small appliances.

David Mery

Visual dBase 7 ships – at last

Cosmic Software has upgraded its **C** cross-compilers for **Motorola's** 68HC05, HC08, HC11, HC12, and HC16 microcontroller families. Source-code compatible with previous versions, version 4.1 introduces an extended debug format and further processor-specific optimisations for each **microcontroller**
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NAG has announced Release 3 of the **Fortran 90** Library, NAG *fl90*, of numerical and statistical routines. New areas covered in Release 3 include: Kelvin functions, norms of a matrix, 2D quadrature, and multivariate analysis. Unix and Windows compatible.
www.nag.co.uk

Open Market has introduced **siteDirector 4.1**, for the delivery and maintenance of large volumes of data on the Web. It features new **searching capabilities**, such as relevancy ranking and phrase proximity. It runs on Windows NT 4.0.
sitedirector.folio.com

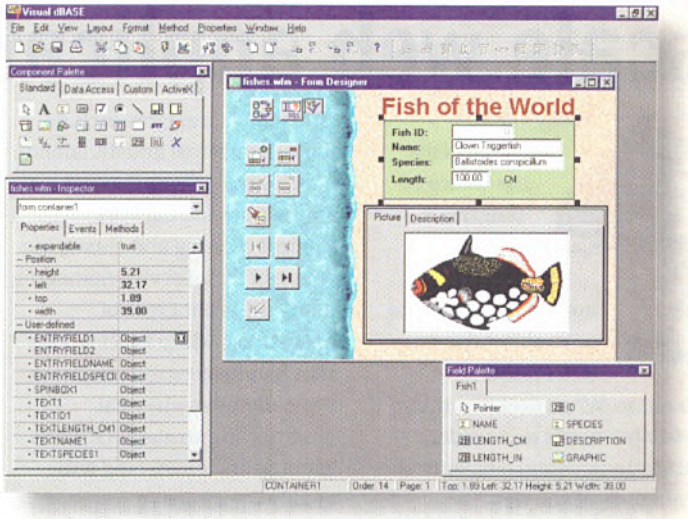
Business Objects is shipping its enterprise query, reporting, and analysis system for the Web, **WebIntelligence**. It is a thin client decision support system (**DSS**) that uses a Java query applet to extend DSS capabilities to suppliers or customers.
www.businessobjects.com

Telemedia Systems (TSL) has released **ProBuilder**, a tool for customising interactive network multimedia applications. A suite of **ActiveX** controls allow the control, display, and recording of both live streams and video on demand.
www.telemedia.co.uk

The new 32-bit version of the database development tool includes ActiveX support for reuse of components, a new integrated report writer, a visual SQL query builder, a Project Explorer for visually managing application files with hierarchical and custom views, and an enhanced 32-bit integrated compiler for royalty-free application distribution. There is data connectivity for Microsoft FoxPro, Access, and corporate database servers including Oracle, Sybase, Informix, and DB2. xBase developers will use the same RAD Workbench IDE found in Delphi and JBuilder.

Other features include Web wizards for the publishing of dynamic data over the Internet and a programmatic grid control for the user interface to data.

InstallShield Express is bundled for the creation of installation programs. New Data Modules and Object Containers manage and maintain the relationship between visual components and database components.



Borland ships two editions of Visual dBase 7: Professional and Client/Server. The latter includes everything in the Professional edition plus Interbase 95 Server for building and testing client/server applications, Borland SQL Links for database server connectivity, a data migration wizard, and support for Borland's MIDAS application server. For a more detailed description of these features and a matrix comparing the two editions see the Visual dBase 7 web site.

Visual dBase 7 Professional is expected to retail at £249.00. Current dBase and Visual dBase owners can upgrade to the Professional edition for £149.00. Equivalent prices for the Client/Server edition and upgrades from the current Visual dBase Client/Server are £995.00 and £795 respectively.
w www.borland.com/VdBase

Seeding the object-oriented database garden

Computer Associates (CA) and Fujitsu have released Jasmine, an object-oriented development platform to provide support for dynamic multimedia applications together with the practical data management required by mainstream businesses. Fujitsu has provided the object database technology.

It is intended to support a wide-range of business applications including electronic commerce and customer support. Applications can be deployed across the Internet or corporate intranets and can be run in Microsoft and Netscape web browsers.

JADE, the Jasmine Application Development Environment, provides a code-free multimedia authoring and application development environment with tools for rapid design and debugging. Its open architecture allows a variety of development tools, including (100% pure) Java, C++, Visual Basic, and ActiveX components. Jasmine comes with class libraries for creating and managing multimedia data, including bitmaps, animation, audio, and full-motion video.

Jasmine's object architecture is designed to eliminate the overhead associated with mapping objects to underlying relational structures (in combination with SQL class libraries to access existing data stores). Native access to relational and other data sources is provided, including OpenIngres, Oracle, Informix, SQL Server, CA-IDMS, CA-Datacom, and DB2. Support for OLE DB and ODBC standards enable compatibility with report writers and decision support tools (integration is provided with ISG Navigator to provide Microsoft ADO/OLE DB connectivity).

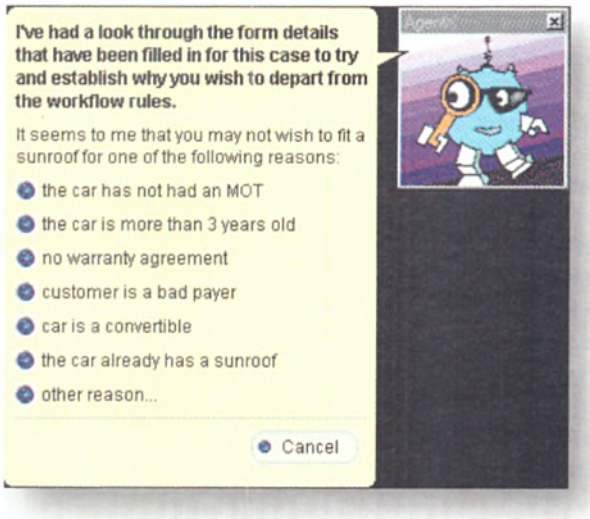
CA has also announced a development partnership with Excalibur Technologies to provide Jasmine users with knowledge retrieval capabilities. Excalibur's natural language retrieval and native image retrieval will be integrated with Jasmine's object-oriented database. This will enable developers to access multimedia content such as image, text, picture archives, or complex HTML-based Web applications.

Pricing for Jasmine starts at £550.00 with discounts for volume purchases. A Developer Edition is currently available at no charge. This initial release of Jasmine supports Unix and Windows NT servers and Windows 95 and NT clients.
w www.cai.com

ActiveX in search of an assistant

IntelliFlo's ActiveAssistant provides developers with the means of producing an assistant – in the manner of the Microsoft Office Assistant – for their own applications. This ActiveX control provides context-sensitive help and tips. It can show specific animations based on options users have chosen or steps they have taken. Generally, it will act as a guide to users of a system.

You can add seven types of information to the assistant's speech bubble, all via methods: `AddButton`, `AddLabel`, `AddLine`, `AddOption`, `AddText`, `AddCheckBox`, and `AddTriangular` option. An animation builder is provided to put together the images to show. These animations can be loaded at both design and runtime. Positioning, sizing, and colouring are all under the developer's control.



A free trial download is available from the IntelliFlo web site. The control is priced at £99 and is compatible with any fully compliant ActiveX host environment.

w www.intelliflo.com

BLOB support for database server

Velocis Database Server 2.0 has been released by Raima. New features concern binary large objects (BLOB), very large database (VLDB) support, and hot on-line back ups. It includes programming interfaces for Visual Basic, Delphi, and Perl 5.0.

Version 2.0 enables standard ODBC inserting, deleting, and updating of untyped data including graphics, text, sound, and video. This includes support via SQL for the `long varbinary` type, which handles binary data, and for the `long varchar` type, which handles variable length text.

VLDB support received two new enhancements. Database files in previous versions were limited to approximately 2 gigabytes, and a database could only consist of 256 files. The new version allows additional files to be logically added to existing files: a new file in any location is treated as an extension of one of the existing 256 database files. A change in database addressing allows a database to contain 65000 files and over 2 billion records.

In addition to access through ODBC, developers have an interface for Visual Basic. VB Global Definition files define low-level function prototypes and the input to be passed to each function. A Delphi interface allows developers to embed API functions in the Delphi code.

There is multiple protocol server support (the same server can communicate simultaneously with clients using different network transport protocols), an enhanced SQL optimiser, an NML Client for NetWare, and improved TCP/IP features for Unix.

A hot on-line backup facility increases database availability. For consistency checking, tools to check for key and data file corruption are built into the database (available through both an API and a utility). Version 2.0 of the Velocis Database Server extends encryption capabilities by allowing data to be encrypted prior to the transfer between client and server. International character sets are catered for with Unicode.

w www.raima.com

Integrating requirements

Rational Software has released RequisitePro 3.0, the latest version of its Windows-based requirements management tool. Cross-project traceability, hierarchical requirements, and enhanced integration (with Rational's ClearCase on Windows NT, Rational Rose, and SQA Suite) have been added to the product.

Hierarchical requirements allow development teams, whatever their programming style or methodology, to group related requirements and automatically establish traceability between them.

Cross-project traceability enables users to break large projects into smaller, more manageable units, or to group common requirements into separate projects, and still trace related requirements. For example, changes to a business rule will visibly flag related requirements in other projects.

Integration with ClearCase is to enable development teams to manage requirements in association with the code being developed.

RequisitePro 3.0 supports Windows 95 and NT 4.0. UK pricing is £1050 and support.

w www.rational.com

MKS has released version 6.1 of its **Toolkit**. Over 20 new entries include **NT** security utilities, Web development utilities, Windows specific graphical applications, and Visual KornShell scripting.
www.mks.com

Visual Intercept, a project-oriented bug tracking tool, has been released by **Elsinore Technologies**. It automates the tracking of bugs, feature requests, and support calls. It is integrated with Microsoft's **Visual Studio** and runs on Windows 3.x, 95 and NT.
www.elsitech.com/vintercept

Borland UK has announced the availability of **Interbase 5.0**. It has new SQL and server features to provide improved scaleability and concurrency. The SuperServer multi-client, multi-threaded architecture aims to eliminate bottlenecks and reduce the overhead of multiple-process tasks.
www.interbase.com

JChart 2.1, from **Rogue Wave**, is a charting tool for Java, offering a palette of **overlay charts** built from **JavaBeans** components, with the ability to mix and match the components to create custom overlay charts. It enables multi-dimension versions of bar, area, line, pie, and scatter-plot charts.
www.roguewave.com

Information Builders, the middleware vendor, has announced **Enterprise Component Broker** to provide enterprise-wide **Java** based data access. Developers can visually develop and deploy Internet applications that interact with an organisation's existing applications or data.
www.ibi.com

Sniffing out a development environment

An **NT** version of the OO case tool Engineer has been released by **Lincoln Software**. Engineer is used for the development of information systems using **object-oriented** techniques. Engineer provides 100% code generation to deliver two, three, or n-tier Intranet, Internet, client/server solutions.
www.lincolnsoftware.com

Web access to **IBM mainframes** and AS/400 systems is available with WRQ's **Reflection for IBM** v6.2. It combines **ActiveX Document** support with the functionality of existing WRQ IBM connectivity for Windows 95/NT desktops.
www.wickhill.com

Object Team 7, from **Cayenne Software**, is a component-based systems modelling tool. It includes improved reverse engineering and code generation, and OMG UML 1.0 compliance for notation and diagram editors.
www.cayennesoft.com

REAL/32 Legacy Server, from **Intelligent Micro Software** (IMS), enables access to **legacy applications** from any Java enabled device. The server can enable the design of Java or Web-based 'front-ends' to any existing **DOS** application, providing a link into NT or NC environments.
www.imsltd.com

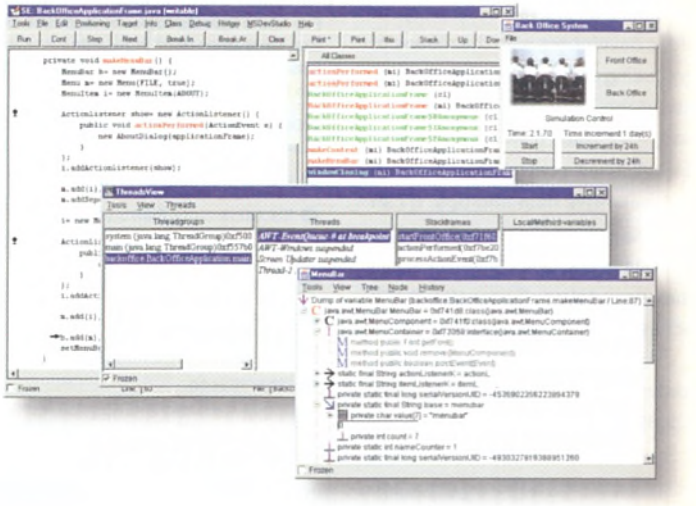
Embedded systems programmers will be able to use Microsoft **Visual C++ 5.0** in conjunction with **Phar Lap**'s Realtime ETS Kernel. It is the core component of Version 9.0 of the company's **TNT Embedded ToolSuite**, and provides a Windows compatible realtime operating system for embedded applications.
www.pharlap.com

TakeFive Software has released SNiFF+ version 2.4. New wizards, an improved GUI, third party tool support, and expanded Java support are included in the project development environment.

There is a 'get to know SNiFF+' helper for new users. This wizard automatically checks the installation and important SNiFF+ properties, to shorten installation time and administrative tasks.

In addition to support for Emacs, and TakeFive's own Source Editor, version 2.4 is integrated with the vi and Premia CodeWright editors. Functions such as symbol and object highlighting are available with these editors, in conjunction with the browsing and navigation features of SNiFF+.

Enhancements to the browsing and navigation tools give the user more information about source code objects and symbols without the necessity to launch a source



editor. Information about the structure of the source code, and the relationship of the objects within the program structure, is presented to the user.

Expanded Java support can be found in SNiFF+*J*. It works with Sun's JDK 1.1 and offers support for language elements like anonymous and inner classes, and threads. A graphical Java debugger provides thread and data browsing facilities.

SNiFF+ 2.4 will be available, from the Web and on CD, by February. It supports Windows 95 and NT, and most Unix derivatives.
w www.takefive.co.at

The Tao of embedding

Tao Systems has released the Elate runtime environment. The object based system has been designed to achieve optimum performance levels in conjunction with full portability. It is targeted at the whole embedded market place, up to and including NCs. With its 'virtual processor' (VP) it incorporates a unique translation technology enabling a range of dynamic or static binding. It has a real-time kernel within which elements, such as a particular type of scheduler, are user selectable. Portability is a central feature; Elate can not only run natively, but as a runtime on top of other platforms, such as Windows.

It may offer support to the future of widespread, commercial Java development by achieving an optimised C level of performance out of Java, running on an embedded platform, with a small footprint. Only the application specific 'tools' are loaded in memory.
w www.tao.co.uk

HTML 4.0 a W3C Recommendation

The World Wide Web Consortium (W3C) has announced the release of the HTML 4.0 specification as a W3C Recommendation. This indicates that a specification is stable, contributes to Web interoperability, and has been reviewed by all W3C Members, who are in favour of supporting its adoption by the industry.

HTML 4.0 improves the look and functionality of Web pages. Features include advanced forms, in-line frames, enhanced tables, and support for objects and scripts.

Advanced forms enable content providers to display rich HTML in any button, create read-only controls, group form controls together, add labels to controls, and provide keyboard shortcuts on controls. Advanced frame features, including in-line frames, allow authors to create compound documents by placing frames in HTML documents. Table enhancements involve row and column groupings, and improved border control. Object support provides a standard way for authors to embed objects and scripts, and support style sheets in their documents.

HTML 4.0 provides the markup needed for any language, including multilingual documents, allowing authors to manage differences in language, text direction, and character encoding schemes. HTML 4.0 is more accessible to users with disabilities, allowing table and form text to be rendered into braille or speech.

W3C has introduced a W3C HTML Validation service at *http://validator.w3.org*. Content providers can use this to validate their Web pages against the HTML 4.0 Recommendation. (It can also be used to check conformance against previous versions of HTML, including the HTML 3.2 Recommendation and the IETF HTML 2.0 standard.)
w www.w3c.org

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Fighting Tamagotchi

After getting bored with multimedia high-speed CD ROM games consoles, Jules has been playing with the smallest game of all.

Last August I lamented that, in order to play modern games you need as much processing power on one desk as existed in the world ten years ago. It has been pointed out to me, in the most direct manner possible, that I was wrong, and that it's possible to play the most fashionable game of all on the simplest of machines. I have even been given one of these machines. It's called a Tamagotchi.

Probably you have heard of Tamagotchi (or in very loose translation, Cyberpets), but since you're likely to be a sane, intelligent adult, you're unlikely to have played with one. My benefactor, however, must have thought that I had the intellectual prowess and attention span of a ten-year old, because after giving me the toy, he suggested I use it.

Here's a mini-review. The machine integrates motherboard, processor, display, and keyboard into one case, which is about an inch square by an inch deep, and is pleasantly curved to fit the hand. There are several colour options; mine was a brilliant orange with acid yellow details – a colour scheme which was rather less soothing than the physical shape of the case. After pulling out the paper tab and setting the time, an egg appears on the display, which, after a few minutes, wriggles and then hatches into a thing which looks like a Pac-man, but eats more.

The point of the game is that this creature lives in the device, and requires constant care. When it wants something it lets you know, by bleeping. If it's hungry, you feed it. If it's bored, you either feed it snacks or play a stupid and pointless (and very noisy) game with it. Sometimes it's neither bored nor hungry, it just wants attention, so it needs discipline (a very non-PC smack). If it gets ill, you take it to the vet for an injection, and if it craps on the screen (which it does from time to time), there's a duck which comes and clears it up. (Why a duck? Dunno. I guess it is probably some hysterically funny pun in Japanese.) When it goes to sleep, you can't do anything with it, so you turn out the lights. The device is controlled using three buttons to navigate around and make selections from a hierarchical menu (which is surprisingly effective – this three-button interface could control absolutely anything!).

Assuming you look after it, and don't either starve it, overfeed it, condemn it to lonely misery, a lingering illness, a screenful of excrement or – heaven forfend – a lack of discipline, it mutates into something a bit bigger. Then it mutates again, and again, and again, until eventually it packs its bags and leaves, leaving nothing but an empty screen (sniff!) and a few statistics. My first one lasted eight days – not a patch on the record (held, no doubt, by some obsessive ten-year old) of 58 days. Eight days is still my personal best.

In order to look after the stupid thing, you have to take it everywhere. It would bleep at me in the pub, when I was watching telly, even in meetings. ('Aren't you going to answer your phone?' Not on your life!) It has been designed to have the same body clock as a Japanese schoolchild, so it got me out of bed at six am every day, crying for a feed.

Schoolchildren the world over have discovered to their cost that the appeal of these things is precisely their nuisance value. But it says a lot about the resilience of children that they still persist.

At one level, I can see the advantages. Today, American couples treat bags of flour as babies to see how they cope with the responsibility of real parenthood, and these Tamagotchi do something similar for children. Also, I'm sure that many parents would be delighted with a gadget which would get their children up in time for school.

But there are two things which concern me about them. Firstly, the fact that the creatures make demands which have to be fulfilled right away – when they're hungry, for example, feeding them is all you can do. The game you play to entertain them is not cooperative at all. There's no scope for shaping them; making them fit your routine rather than vice-versa. At the end of the day, you're left with a creature which is, in any real sense, wild, and no more rewarding as a pet than a spider or stick insect. Secondly (and even more worrying), there is the next generation of Tamagotchi; after you've raised them, you can get them to fight each other by plugging the cases together. While a fight is the inevitable consequence of anything Japanese and cutesy (as any fan of Japanese comics will testify), I don't think even Japanese children would consider raising a puppy just so it could tear another kid's pet limb from limb – until the Tamagotchi taught them to do so, of course. I have no doubt that the world's children are better at separating real life and games than adults give them credit for, but if so, what value is left of the original design?

If you ask me, an educational toy which children enjoy so much that they collect them is too valuable an idea to waste on a virtual fight. I think that the gadgets should be trainable, that they should be able to learn tricks, and that the game should be a cooperative pattern-recognition game, something like a Simon. Not only that, when a creature dies, it should require the input of two other machines to create a new one (and those two machines should genuinely contribute to the kind of creature which will emerge). Teach children to make something persistent, teach them about genetics and pedigree and mutation (and the dangers of inbreeding, too), and allow them to create a bloodline with real, cash value to their friends. Finally, create a game which gets more sophisticated with time, requiring larger, more expensive receptacles – something which continues to be rewarding to children (and the manufacturers) as they turn into adults.

I quite fancy writing that program. Net pets, anyone? ■

Tamagotchi is made by Bandai, and is available in toy stores, chemists, market stalls, and schools worldwide. Jules is still torturing his Tamagotchi, and lives in hope of extending the poor creature's life to two weeks.

Area 51

Dear reader,
As you probably noticed, page 51 of the January issue was somehow mysteriously scrambled. You can view an HTML version on EXE OnLine or download a PDF version of the page as it should have appeared. Go to the Codebin section. If you do not have Web access and would like to receive the correct page by email, fax, or snail-mail, do not hesitate to contact me (contact details are at the bottom of the contents page). I promise that we'll do our utmost to ensure that this never happens again. Please accept my apologies.

What happened to cause this problem? Well, this layout is possibly the result of a software bug! Pages are created at EXE in Quark XPress, then uploaded to our typesetter where they are output to films. The films are then sent to our printer for the magazines to be printed, bound, and sent. At the typesetter, Quark XPress obviously didn't correctly interpret the code for this page. It somehow misinterpreted the 'leading' (the space between two lines) for most of the lines containing the Courier font (used for the code).

Why did this happen? We have not yet found out why. It has never happened in EXE before, not even when test printing in the office and never before at our typesetter. We compared the content of the problematic file with files of other articles and couldn't find any particular formatting difference apart from Quark suddenly choosing relative values instead of absolute ones for the leading, but even that didn't corrupt our test printing.

Once again, apologies. I hope that this will not stop any volunteer giving a hand to Will Watts (willw@cix.co.uk) to create an English help file for RxLib.
David Mery, Editor

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

More on sequence points

Dear Sir,
First, Mr Howells (Letters, January 1998) is wrong in stating that the expression is undefined behaviour as `&&` is a sequence point, otherwise how else would common expressions such as:

```
if (p != NULL && *p != x)
    ...;
```

work if the right-hand side could be executed before the left-hand side test was performed?

Second, the statement from Mr Harman:

'Most compiler implementations do not observe the ISO standard.'

Agreed, there are probably no compilers that obey the ISO standard 100%, and many implementations have their own extensions, but the common ones such as GNU, Microsoft and Borland only fall down in extreme examples.

Third, and what really made me want to write to you, was later in the reply he states:

'It is important to define transformations which work on the source as accepted by the local development environment, rather than that expected by the standard.'

If code violates the standard, just because it happens to work today with the current compiler, any change to the compiler version, compiler options, machine spec, or just the day of the week could render the program invalid. Take these two examples which really do produce undefined behaviour:

```
a[x] = x++;
```

and:

```
x = 3; foo( x = 4, x );
```

I have seen real production code that invokes these types of undefined behaviour. Possible interpretations are:

```
a[x] = x; x++;
```

or

```
a[x+1] = x;
```

and:

```
foo( 4, 4 );
```

or

```
foo( 4, 3 );
```

or the compiler could crash, reformat your hard drive or fire up Quake. Either of the pairs of interpretations could be produced by a compiler, depending on how it felt, and, as Mr Howells rightly pointed out, we need to return to the original programmer to find out what he or she really meant.

On another point in the original article, I've just noticed that given:

```
for (e1, e2, e3) s;
```

and `s` is `continue`, it is not equivalent to:

```
e1; while (e2) {s; e3;}
```

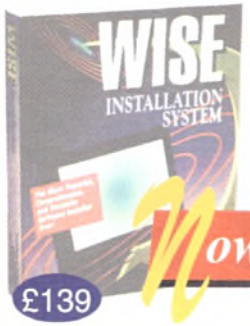
Ken Nicolson
kenn@owl.co.uk

Well, of course you're completely right about the example. Thank you for pointing that out. It's quite amazing that none of us did spot it.

What might have confused us in the standard is that 'between the previous and next sequence point an object shall have its stored value modified at most once by the evaluation of an expression. Furthermore, the prior value shall be accessed only to determine the value to be stored.' But it is further stated 'except as indicated by the syntax or otherwise specified later (for the function call operator (), &&, ||, ?: and comma operators), the order of evaluation of subexpressions and the order in which side effects take place are both unspecified.'

So effectively, the short-circuit evaluation of && means that there's an unambiguous order of evaluation. ('If the first operand compares equal to zero, the second operand is not evaluated.')

As for your last point, there isn't really such a strong conflict between your remark and Mark Harman's article. The article was focusing on the problem of program comprehension which is equally valid whether the code is conformant or not. The issue was trying to understand what programs do independently of whether what they're doing, or how they're doing it, is good or bad. – Ed.



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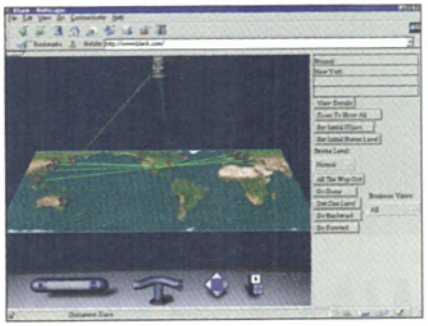

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Michael Bramman

SOFTWARE TO GO
Developing applications for handheld computers

Iain Barclay reviews the development languages and tools used for creating applications for Windows CE, PalmPilot, Psion Series 5, and the Nokia 9000 Communicator, the most popular handheld platforms.

Handheld computing has finally come of age! Long saddled with over-hyped claims and disappointing realities the smallest class of computing platforms has finally shed its much derided PDA (Personal Digital Assistant) label and is at last beginning to deliver solutions that are both useful and usable.

Microsoft's entry into the handheld computing world with its Windows CE operating system has given this sector of the industry much needed credibility. This has been complimented by the novel and useful functionality of devices like 3Com's PalmPilot, Nokia's 9000 Communicator (a combined GSM telephone and computer), and Psion's new Series 5 machine.

Platform descriptions

Windows CE

Windows CE is the handheld operating system of choice for the major PC hardware manufacturers, including Compaq, Toshiba, Casio, Philips and Hewlett-Packard. Windows CE is like a mini-Windows 95 and presents a familiar user interface to its users. Windows CE comes complete with 'pocket' versions of popular Microsoft applications, including Word, Excel, and PowerPoint. Windows CE devices are targeted at users who are already familiar with the Windows interface and who are looking for something more portable than a laptop to take on their travels. Windows CE comes complete with connectivity to the desktop PC, so that files and data can be easily shared and exchanged between the two devices.

Psion Series 5

Psion's latest handheld computer is the Series 5. This model draws upon the strengths of the incredibly popular Series 3 machines. The Series 5 has a much updated operating system and a novel – and highly usable – keyboard which offers far more than the traditional tiny-buttoned keyboards usually associated with handheld computers. Psion Series 5's come with a set of built-in applications which share data formats with the popular Microsoft desktop applications – including a Word compatible wordprocessor. Psion provides excellent desktop connectivity with Windows through its PsiWin product.

Palm Pilot

3Com's PalmPilot is a shirt pocket sized organiser which has pen-only input. PalmPilot users enter information using a pen and a novel character recognition system called Graffiti. Graffiti represents each character with a unique key stroke, and is surprisingly quick to learn and use. The PalmPilot offers foolproof connectivity to either a PC or a Mac which enables the handheld's diary, address book, and memo pad to synchronise with their desktop companions. The great strength of the PalmPilot is its small size and the elegant simplicity of the applications it comes with.

Nokia 9000 Communicator

Nokia's 9000 Communicator is one of the grooviest gadgets around, and is certain to bring out the James Bond in every one who uses it! At first glance the Communicator looks like an old fashioned mobile phone, but stand by for gasps as you open it to reveal a screen and keyboard hidden inside! This is the 'computer' part of the Communicator which provides simple diary and memo taking capabilities along with a rich set of communication-capable applications. These include programs to send and receive faxes and email, and an address book which dials the numbers for you!

Windows CE is the operating system of choice for the major computer hardware manufacturers, and has been adopted by Hewlett-Packard, Compaq, Hitachi, and others for their handheld computing devices. That's not to say that it is the only option available when starting a development project. The PalmPilot is currently the best selling handheld device and has an almost evangellistic following. Psion's devices are still very popular and well regarded, especially in Europe, where they have achieved great success. And if your application needs to communicate information back to base, then Nokia's 9000 Communicator with its built-in GSM phone is well worth investigating! More details on each of todays most popular handheld platforms is given in the box *Platform descriptions*.

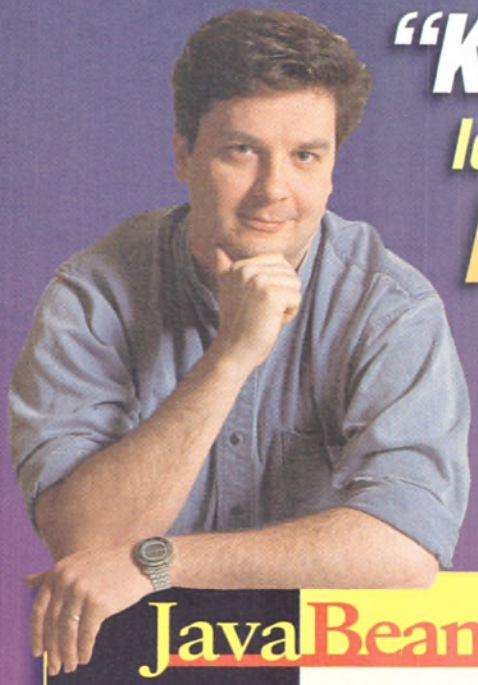
Unfortunately each of these popular handheld computers runs its own operating system – so applications developed for machines running Microsoft's Windows CE won't run on PalmPilots or Psions, for example. You should carefully consider which platform to target your development to before beginning work, as they are all quite different. If you want an application to run on multiple handheld platforms then you will need to develop a new version of the application for each.

The same, only different

Developing applications for handheld computers has much in common with the development of applications for the desktop. Indeed, development of applications for handhelds is usually carried out on a desktop PC, with the resultant application only sent to the target device for the later stages of testing and debugging. Similarities exist in the languages used for development, as well as in the development tools. We'll look shortly at the development languages and tools used for creating applications for the most popular handheld platforms.

To develop applications which work well on handheld computers it is important to remember that handheld applications are used in a different way to those in the desktop world. By their very nature, handheld computers are held in the hand, and carried from place to place. Software designed and developed for these platforms will be used in all kinds of places and under many varied circumstances. Keener users will take their handhelds everywhere with them, so your software could really make an impact on the way they do things in their lives – not just when they're in the office, but in the supermarket, at the beach, or on the golf course! Developers need to make sure that their software supports this type of casual, often hurried, use. Handhelds only have tiny keyboards (if they have keyboards at all) so users can't be expected to enter a lot of text. The most common mode of interaction with an application should be tapping points on the screen – it's quick, easy, and can be done standing up!

The small size of handheld devices places many constraints on developers. Memory and system resources are at a premium. It's like going back in time to the days when applications consumed kilobytes



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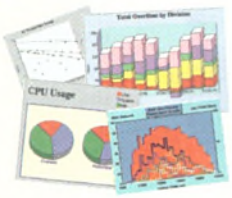

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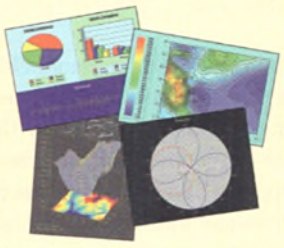

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Psion Series 5
General: *http://www.psion.com/*
Developers: *http://www.software.psion.com/*

Nokia 9000
General: *http://www.nokia.com/*
Developers: *http://www.geoworks.com/*

All platforms
For many more links to handheld software development resources, visit RoadCoders at *http://www.roadcoders.com*.

of space rather than megabytes. Efficiency and optimisation rule and every feature and function added needs to be justified. My experience in the PalmPilot world is that users will carefully assess the utility that an application provides compared to the amount of space that it will occupy in their machines. It is far better to create several smaller applications which all do something specific, rather than one big application which attempts to do everything. That way, each user can just choose the functionality they need.

Lets turn our attention to the details of building applications. Each platform has its own operating system and set of development environments and languages. (See the box *Internet resources for handheld computers* for a summary of useful Web links.)

Windows CE application development

Microsoft calls devices which run its Windows CE operating system Handheld PCs, or HPCs. This makes a lot of sense, as Windows CE is effectively Windows 95 for smaller devices! Not only is the user interface instantly familiar to users, but the development environment is well known to millions of developers. Windows CE uses a slightly reduced version of the Win 32 API, and Microsoft claims that if you know Win 32 then you already are a Handheld PC programmer!

While this might make application development simpler, it doesn't mean that a Windows 95 application can run directly on a Windows CE machine. For a start, HPCs don't use the x86 series of microprocessors. Although the actual processor choice is left up to the hardware manufacturers, most are based on Hitachi's SH-3 32-bit RISC processor.

Microsoft released the second version of Windows CE – version 2.0 – in December 1997. As well as numerous improvements to the functionality, performance, and user interface of Windows CE, version 2.0 came with a new set of development tools. At the time of writing beta versions of these are available from Microsoft's Windows CE web site – *http://www.microsoft.com/windowsce*. Like the operating system, Microsoft's Windows CE development tools should be instantly recognisable to developers with experience of its desktop development tools.

The first of Microsoft's HPC development options is Windows CE Toolkit for Visual C++. This is purchased as an additional component to Visual C++ 5.0 and adds new versions of MFC, AppWizard, and ClassWizard. The toolkit gives developers the ability to cross-compile projects developed in Visual C++ to the processors used in Handheld PCs. The Windows CE component adds a Windows CE emulator to Visual C++ so that compiled applications can be tested on the desktop. Source-level debugging is provided to enable you to step through the application while it runs in the emulator. A set of tools will give support for remote debugging, once the application is actually running on the Handheld PC.

For developers not familiar with C++ or Win32, Microsoft offers Windows CE Toolkit for Visual Basic and Windows CE Toolkit for Visual J++. Be warned that the applications produced by these toolkits will not be as efficient in terms of application size or performance as those coded in C++, but if you are looking to develop an application quickly then they could be perfect for you.

The Windows CE Toolkit for Visual Basic provides a high-level path into Windows CE development. The Toolkit hides parts of the Visual Basic functionality which are not available on the Windows CE machine and adds new components to support handheld-specific capabilities. Developers taking this route will need to ensure that the Visual Basic runtime component is installed on the target HPC. Microsoft has left it up to the manufacturers of devices running Windows CE to decide whether to put this component in ROM. It is available for downloading from the web for those users who need to install it themselves – though this will occupy RAM in their machines.

It's like going back in time to the days when applications consumed kilobytes of space rather than megabytes.

The Windows CE Toolkit for Visual J++ enables Java developers to build applications for Handheld PCs. The toolkit comes with a set of Java classes which give access to Windows CE functionality, as well as an emulator and support for debugging applications once they are on the target device. Again, developers need to ensure that the Java virtual machine is installed on the machine which the HPC application is to run on – with Microsoft leaving the decision to put it into ROM up to the manufacturers.

PalmPilot application development

Developers looking to develop applications for the PalmPilot have a number of programming options open to them.

The 'official' route is to use the C development environment CodeWarrior from Metroworks. CodeWarrior for PalmPilot is a Windows or Macintosh based product which provides a full visual development tool, all the libraries for the PalmPilot, a cross-compiler to the PalmPilot's 68xxx series processor (MC68328 DragonBall), and tools for debugging either in a desktop emulator or on the PalmPilot itself.

There are also many third party solutions for PalmPilot developers to choose from: commercial products, shareware, and even some which are free.

The commercial products include two form-based development tools, Satellite Forms and Pendragon Forms. These tools provide a very high-level visual way of designing and developing data capture applications. They enable desktop integration, so that applications can be deployed on the PalmPilot and be used remotely. When users return to base they can dock the PalmPilot and transfer the data back to a PC, for integration into a database or whatever.

The Nokia 9000 provides a glimpse of the future of computing and communications.

The free solutions for PalmPilot development include implementations of Basic, Lisp, and Forth, and a port of the GNU C libraries and tools. cBasPad is one of the few development solutions for handheld computers where development is actually carried out on the device itself – and given the PalmPilot's small screen and pen-only input this is no mean feat! The ports of the GNU C libraries and development tools to the PalmPilot provide a more practical approach to developing real and usable applications – for a long time this was the only way to develop PalmPilot applications from a PC. This Internet-based project has provided a full development solution for Windows and many Unix platforms. Many of the applications available for the PalmPilot have been developed with these tools.

Psion Series 5 application development

Psion's recent release of the Series 5 model builds on the strength and success of its popular Series 3 range. The Series 5 is the first Psion machine to use the new 32-bit operating system, EPOC32.

There are two Psion-supported choices for developers planning to program the Series 5. The first of these is the language OPL32, an update of the OPL which has been built-in to Psions since the early days. The second official option, and the one most likely to be made by professional developers, is the EPOC32 C++ SDK.

OPL32 is a simple language, akin to Basic, which is both written and run on the Psion. Its strength is its simplicity. Programs are developed on the Series 5 itself. OPL32 is easy to learn and use, and is ideal for prototyping ideas and applications.

The EPOC32 C++ SDK runs on Windows NT and makes use of Microsoft's Visual C++ development environment. The SDK provides a PC-based EPOC32 emulator which can be used for development and initial testing. When the time comes to compile the application for the Series 5 computer itself the SDK uses a GNU GCC compiler to generate the appropriate ARM code for the Series 5's processor. Psion provides extensive support to developers using the C++ SDK through its subscription-based EPOC World service.

A nice twist to the C++ SDK is that it can be used to build components known as OCX modules. These OCX modules can be called from within OPL applications in the same way as any other OPL function. This combination of the flexibility of C++ components and the simplicity of the OPL environment for application development could be the perfect answer in many situations.

Developing applications for Nokia 9000 Communicator

The Nokia 9000 provides a glimpse of the future of computing and communications. This device is just a little larger than a standard cell phone, but incorporates both a phone and a fully fledged computer. Developing applications for the Nokia 9000 is far from futuristic.

The device runs on an operating system called GEOS, which was developed by a small US-based company called Geoworks. GEOS was originally developed as an alternative operating system for the Commodore 64 home computer and has morphed its way into becoming a handheld computer operating system! This does mean that the operating system is mature and stable, although the development environment lacks the gloss of the Microsoft, PalmPilot, and Psion products.

Nokia 9000 development is carried out using Geowork's own object-oriented variant of C. The language is complex, and does take a while to get to grips with, but is rich in functionality and was designed specifically to support devices with minimal memory resources.

The Nokia 9000 Development environment comes with a set of libraries for the Nokia 9000 as well as utilities to send applications to the device itself. These libraries cover all of the novel functionality of the Communicator, including the ability to send SMS messages and faxes via the GSM network and to initiate phone calls (for both voice and data transmission) from inside applications.

The SDK includes debugging tools which allow applications to be stepped through line-by-line when they are running on a Nokia 9000 connected to the development machine by serial cable.

Get to it!

Just as handheld computing technology has come of age, so has handheld software development. Software development tools for the popular platforms are plentiful and varied, and there is a development solution to meet every developer's background and ambition. Whether you are looking to redesign or port an existing application into a new market or looking to develop new applications, you'll find the world of handheld computers ready and waiting – and able to meet your needs. ■

Iain Barclay is the founder and web master of the RoadCoders web site – www.roadcoders.com – which offers links to hundreds of handheld programming resources. Iain is a PalmPilot developer and can be contacted by email at iain@hausofmaus.com.

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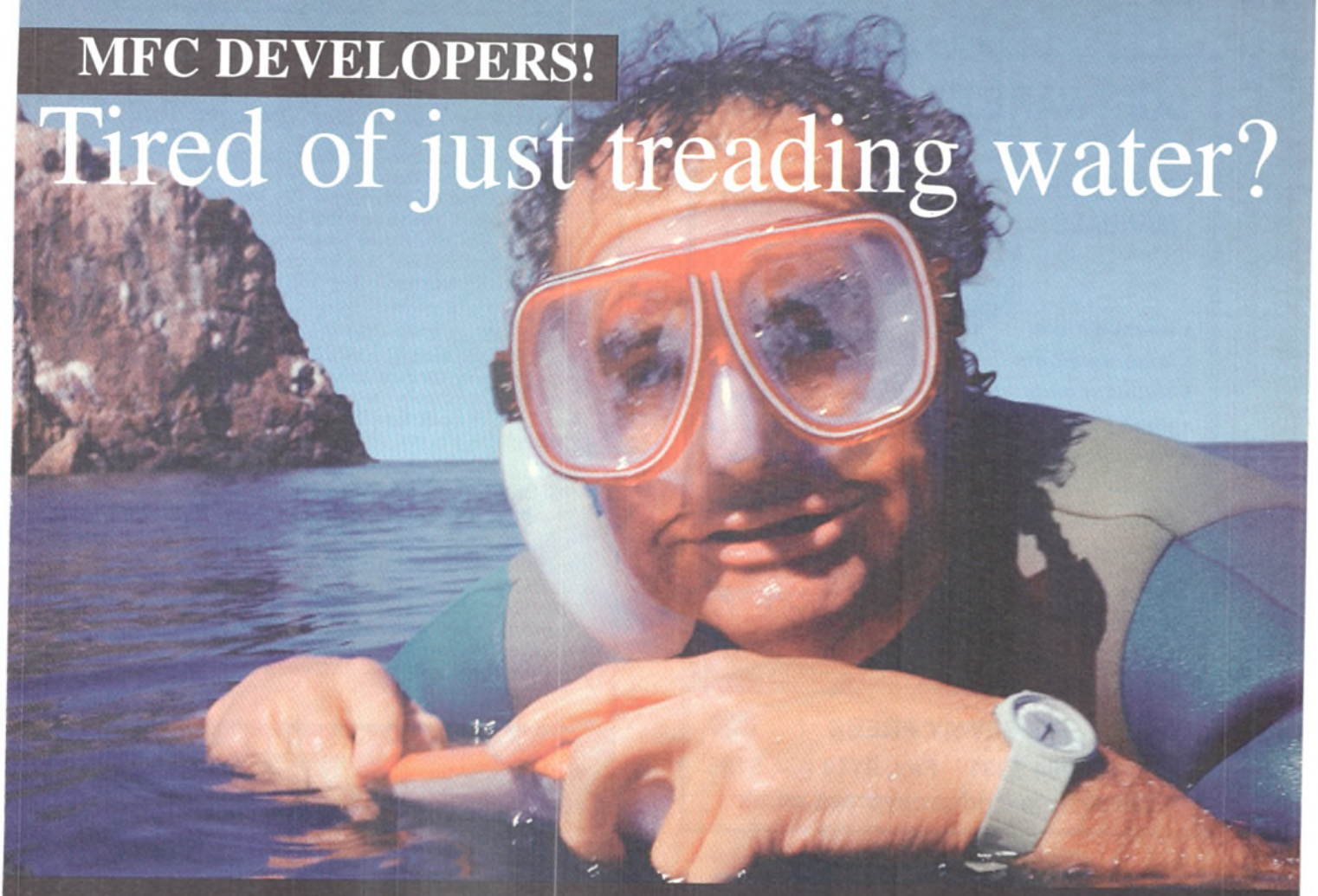

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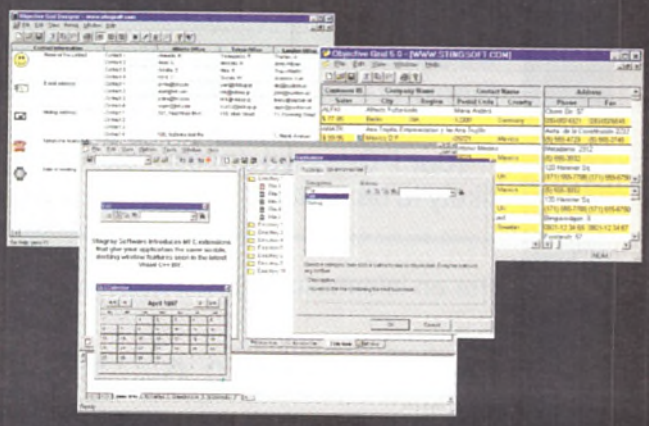

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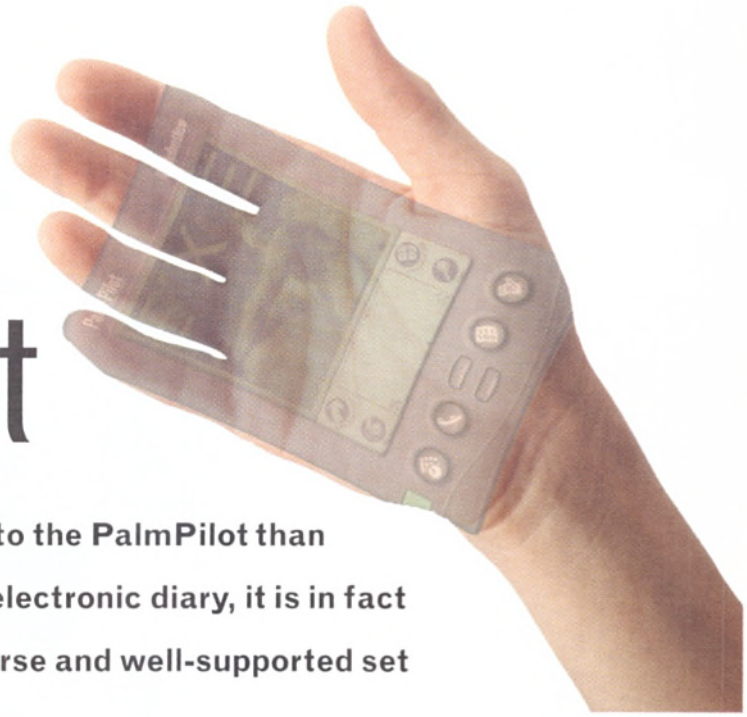
PalmPilot software development



Iain Barclay shows that there is a lot more to the PalmPilot than first meets the eye. Far from being just an electronic diary, it is in fact a fully programmable computer with a diverse and well-supported set of development options.

Since making its debut in the middle of 1996, the PalmPilot Organiser has taken the world of handheld computing by storm. The pocket-sized device is marketed heavily as a PC companion and its seamless integration with desktop applications has made it a big hit around the world.

Development for the PalmPilot, in common with most handheld computing platforms, usually takes place on a desktop computer, with the resulting source code being compiled for the device's processor. The application is loaded onto the device only when it's time for testing and executing. This model of development has advantages in that one gets to use 'proper' development environments and can take full advantage of the resources of a desktop computer – not to mention the large screen and proper keyboard! The downside to this is that the development cycle becomes that much longer, introducing an extra download-to-device step to every iteration. The situation is aided somewhat by PalmPilot emulators which run on the desktop platform, but for serious testing you really do need to run the application on the device itself.

The PalmPilot uses a Motorola processor (MC68328 DragonBall). Motorola chips have long been associated with the Apple Macintosh series and it was no surprise that early PalmPilot development tools only ran on Apple Macs – sadly limiting development opportunities for the masses.

Fortunately, things have moved on and the latest release of the 'official' development environment – Metroworks CodeWarrior for PalmPilot – includes a version that runs on PCs with Windows 95 or NT. There is also a very lively Internet-based developer scene for the PalmPilot, with a variety of development environments and tools to choose from. The tools range from the 'official' Windows and Macintosh-based Metroworks CodeWarrior through free implementations of the C libraries on Windows and Unix to interpreters, which actually run on the device itself. A description of each of these development tools and some Internet development resources are listed on pages 27 and 29.

Found me?

In this article I'll discuss the development of a simple PalmPilot application. The application was originally developed using CodeWarrior, though most of this article is applicable to development using any of the C-based development tools – and in particular the free tools based on the GNU GCC project.

The application I'm going to dissect is called *Found Me?*. It is fairly simple – but it's a real application (downloadable from all good PalmPilot software archives) and it illustrates many of the key techniques of PalmPilot programming.

Found Me? sits in the application launcher screen of the PalmPilot, displaying a cheery icon with the message 'Found Me?' underneath (Figure 2). The hope (and I'll admit that it is an ambitious hope) is that someone finding the PalmPilot will pick it up, switch it on, see the Found Me? Icon, and tap it! If they do then they'll be greeted with

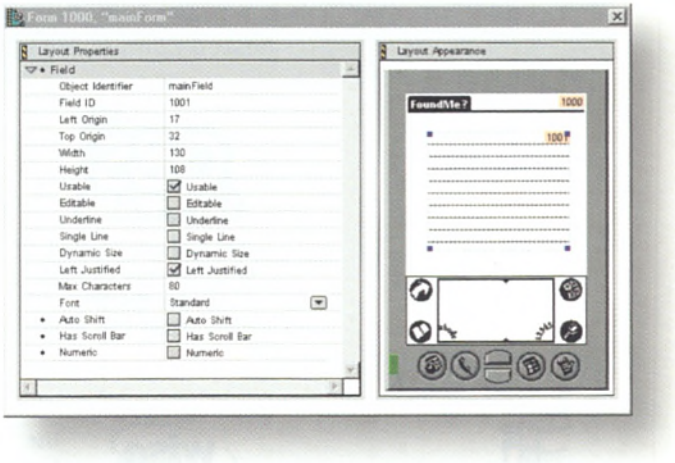
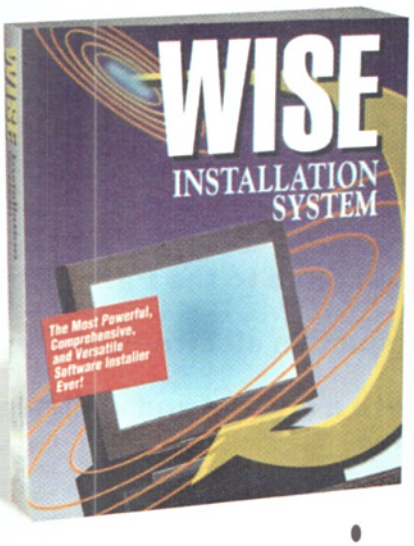


Figure 1 – Code Warrior Constructor, the tool used for building user interfaces.

They say wisdom comes with age.



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PalmPilot development tools & environments

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http://www.metrowerks.com

GCC – A free port of the GNU C compiler for targeting PalmPilots.
http://www.shoppersmart.com/jlehett/gccwin32.html

CASL – A full featured and high-level Basic-like language.
http://www.caslsoft.com

cBasPad – A Basic interpreter for programs actually written on the PalmPilot itself!
http://www.nicholson.com/rhn/pilot.html

ASDK – A collection of tools for 68xxx assembly language development.
http://www.massena.com/darrin/pilot/index.html

Figure 2 – The PalmPilot applications screen with the cheery FoundMe? icon.

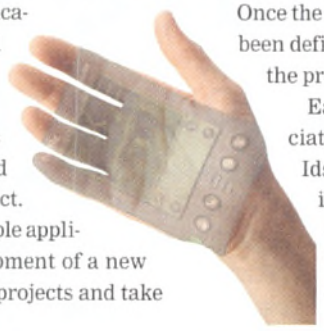
Figure 3 – The FoundMe? screen, showing the owner's information.

a message set by the PalmPilot's owner, typically showing some contact information and the promise of a reward if the device is found (Figure 3). Believe it or not, I've actually had email messages from two people saying that their lost PalmPilots had been returned to them thanks to Found Me?

Anatomy of a PalmPilot application

Before we dive into the details of Found Me? we need to look at the way PalmPilot applications are put together.

CodeWarrior is a project-based development environment. Whenever you want to begin development of a new application you need to create a new project, containing all the components necessary to build the application for the PalmPilot. These components include the source code and a description of the application's user interface, as well as some essential bits and pieces which CodeWarrior places in every new project. CodeWarrior for PalmPilot comes with a set of example applications and often the best way to start the development of a new application is to make a copy of one of the example projects and take it from there.



The source code of a CodeWarrior PalmPilot project is written in C and it makes use of extensive libraries to support the PalmPilot's functionality. These libraries provide hundreds of functions which make calls to the PalmPilot operating system's API. Fortunately, CodeWarrior comes with extensive API documentation, which is freely available for downloading from 3Com's developer web site, *http://www.palmpilot.com*. The header files for all the libraries can also be downloaded from this site. We'll look in more detail at some of these function calls when we step through how Found Me? works.

The user interface components of a PalmPilot project are a bit of a hangover from the days when PalmPilot development was a Macintosh-based task. Early versions of CodeWarrior for PalmPilot used the old Mac favourite ResEdit to create the user interfaces for PalmPilot applications. Thankfully, the Windows development environment comes with a visual user interface building tool, called the Constructor (see Figure 1). It allows you to pick the user interface components from a palette – called the Catalog – and drag them onto the application's main form. You can then easily change the properties of the components through a form in the Constructor. The PalmPilot does support all the user interface components that you'd expect, including buttons, lists, text fields, and many more. The user interface description produced by the Constructor is called a resource. It contains a 'recipe' for building the user interface for the application. We'll see shortly how the screen is actually built when the application is running on the PalmPilot itself.

Once the source code and the user interface of an application have been defined there are just a couple more tasks to perform before the project can be compiled and the application tested.

Each application needs to have a unique identifier associated with it. These are four character tags, called Creator Ids, which the PalmPilot's operating system uses to send instructions to the application once it is installed on the device. It uses the Creator ID to identify each application and to send it messages. For example, if your application needs to set an alarm, then the operating system will use the Creator ID to find your application when the alarm needs to be raised. You can choose any four character combination for the Creator ID, but if you want to release your application to a wider audience then you need to make sure that you have chosen something unique, and register it so that no-one else uses it. 3Com's Developer Web Site is the place to do this.

The application's project is compiled and linked from inside the CodeWarrior environment. Successful compilation results in an application file which can be loaded onto the PalmPilot device. The quickest way to install the application onto the PalmPilot is to use the HotSync application which comes with the device. HotSync is usually used to synchronise the applications which run on the PalmPilot with their desktop equivalents, moving meetings from one diary to another and copying phone numbers between PalmPilot and PC.

We'll now turn our attention back to Found Me? and follow the sequence of events which takes place on the PalmPilot when the application is installed and run.

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Ray's PalmPilot Software Archive – A collection of hundreds of shareware, freeware, and demo programs.
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```
typedef struct
   {
      Char message[300];
   } FoundPreferenceType;

FoundPreferenceType prefs;

DWord PilotMain(Word cmd, Ptr cmdPBP, Word launchFlags)
{
   Err error;
   if (cmd == sysAppLaunchCmdNormalLaunch)
   {
      // Set up initial form.
      FormPtr frm;
      FieldPtr  opPtr;

      // Check that the preferences have been set
      if (PrefGetAppPreferences('Foun', 1, &prefs,
            sizeof(FoundPreferenceType)) == NULL)
      SetPrefs("\r\r This device belongs to\r
            (Your name)rIf you've found it please call\r
            (your number)\r\rA reward will be paid!");

      // Initialize and draw the main form.
      frm = FrmInitForm(mainForm);
      FrmDrawForm(frm);

      // Display the message on the screen
      opPtr = (FieldPtr)(FrmGetObjectPtr(frm,
            (FrmGetObjectIndex(frm, mainOPField))));
      FldSetTextPtr(opPtr,prefs.message);
      FldRecalculateField(opPtr, true);

      // Start up the event loop.
      EventLoop();

      // An appStopEvent must have arrived!
      // Our application is about to exit, so tidy up
      FrmCloseAllForms();
   }
   return(0);
}
```

Listing 1 - PilotMain

Starting up

After a successful HotSync the new application's icon will appear on the PalmPilot's application launcher screen. Applications are usually started up by the user of the device tapping the icon. This icon tap is conveyed by the launcher to the application with a call to its `PilotMain` function. This is analogous to the `main` function in any C program; every application must have one, and it is the known starting point. `PilotMain` is passed a number of parameters, one of which – `cmd` – tells the application why it has been woken up. An application started by an icon tap will receive a `sysAppLaunchCmdNormalLaunch` parameter in the `PilotMain` call. Applications will actually receive calls to `PilotMain` for a number of reasons – but the reason will always be stated in the `cmd` parameter. Applications can use the value of `cmd` to decide what to do and can quite happily ignore many of the requests which they receive.

When acting on a call with a `sysAppLaunchCmdNormalLaunch` value `PilotMain` has to get the application into its initial state and then pass control back to the event loop, so that the PalmPilot can continue with normal operations.

The `PilotMain` function in Found Me? (see Listing 1) is simple, but typical. When it is called it first checks to see why. Found Me? is only interested if it has been called by the user from an icon tap, so it checks the `cmd` parameter for a `sysAppLaunchCmdNormalLaunch` value. If it doesn't receive that then it returns immediately, giving control back to whatever part of the system made the call. If the value matched then Found Me? is happy to start up.

Its next job is to find the preferences set by the user the last time that it was run. Each PalmPilot application is able to store a set of preferences for its own use and these make it possible to maintain continuity between the sessions which the user has with the application. The application developer is able to choose which pieces of the session state that he would like to preserve for the next session. In Found Me? we want to keep the text of the message which the user entered, so that it can be displayed each time the application is run.

An application's preferences are marked with the application's unique Creator ID and its version number. These are used in the call to the system's `PrefGetAppPreferences` function. Also passed to the function is a pointer (to the place where we want to store a copy of the preferences for use in the application) and the size of the preferences. If the system can't find any preferences for our application – which would be the case if the application is running for the first time – then the search for preferences returns `NULL`. This allows the application to use default hard coded values instead. Applications typically store these default values as preferences straight away. A common trick, in more sophisticated PalmPilot applications, is to use the absence of preferences at startup as a sign that the application is running for the first time and to welcome the new user with a message in a dialog box.

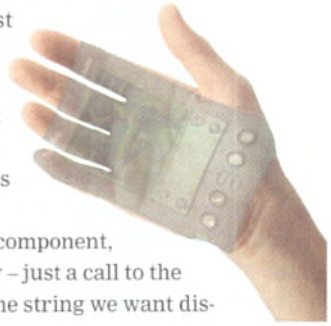
Most PalmPilot applications have a user interface. The next job of `PilotMain` is to initialise that interface and display it on the screen. As we have already discussed, user interface elements in our application sit beside the code in a separate resource. Our programming interface to the UI components is through a set of UI functions and there are separate UI functions for each class of user interface component.

PalmPilot application windows are called forms, and there is a whole bunch of system functions which deal with forms. The first one which we use in Found Me? is `FrmInitForm`. This takes the name of the form

(ie the name we defined for the form in the UI resource) as a parameter and returns a pointer to an instantiation of that form. In other words, we tell it that we want a form of the type which we called `mainForm` and it makes one for us, returning a handle to the one it made. To get the form actually displayed on the screen we call `FrmDrawForm`, passing the handle as a parameter. `FrmDrawForm` will draw the form window and all the components of the form onto the PalmPilot's screen.

One of the components on Found Me?'s main form is a text area – or Field, in PalmPilot terminology – which displays the user's message. The `PilotMain` function needs to put that message into the field.

It first needs to find a pointer to the text field component which exists on the PalmPilot's screen. This involves a few function calls, as we have to do a mapping between the name which we gave the text field in the UI resource when we designed the application and the actual text field which has been created by the form when it was built by the call to `FrmInitForm`. The first thing we do is to get the index number of the text field in the form, ie where it is in the list of components that the form has created. We then ask the form to give us the memory pointer to the component at that position in the list. Finally, we cast that to the type of component we are looking for – in this case a text field. This is a bit complicated but it's a standard piece of PalmPilot programming, and soon becomes second nature.



Having got a pointer to the field component, placing the text message in it is easy – just a call to the `FldSetTextPtr` function, passing the string we want displayed as a parameter.

`PilotMain`'s work is almost done. It has created a screen for the application and filled in the blanks with the data which the current user has specified. Its final task is to call the event loop, so that its own user interface can receive interaction from the user and – more importantly – the PalmPilot system can continue to receive and process events.

The main event

The function `EventLoop` (see Listing 2) is an infinite loop which collects events from the system event queue and passes them down to handling functions. The loop is broken only by a system event indicating that the user has chosen to launch another Pilot application, this is the `appStopEvent`.

At the top of the loop a call is made to the system function `EvtGetEvent` in order to retrieve an event from the system event queue. The function then goes through a list giving different parts of both the operating system and the application itself chances to handle the event. When an event is handled, a `true` is returned and the loop begins again, fetching the next event from the operating system. Events are caused by all sorts of things. They can be caused by the user tapping on the screen, the time changing, an alarm going off, or just about anything else you can think of. Most events will be handled by the operating system, but some will trickle through to the application's own functions – these are the events which the application needs to be able to handle itself.

Found Me? has been programmed to handle several user interface events. Part of its functionality is to let the user change the message which is displayed on its main screen. It does this by popping up a dialog box with an editable text field when a 'Set Menu' item is chosen. The action of popping up the dialog box comes in response to an event which is detected in the main form's event handler (see List-

About the PalmPilot

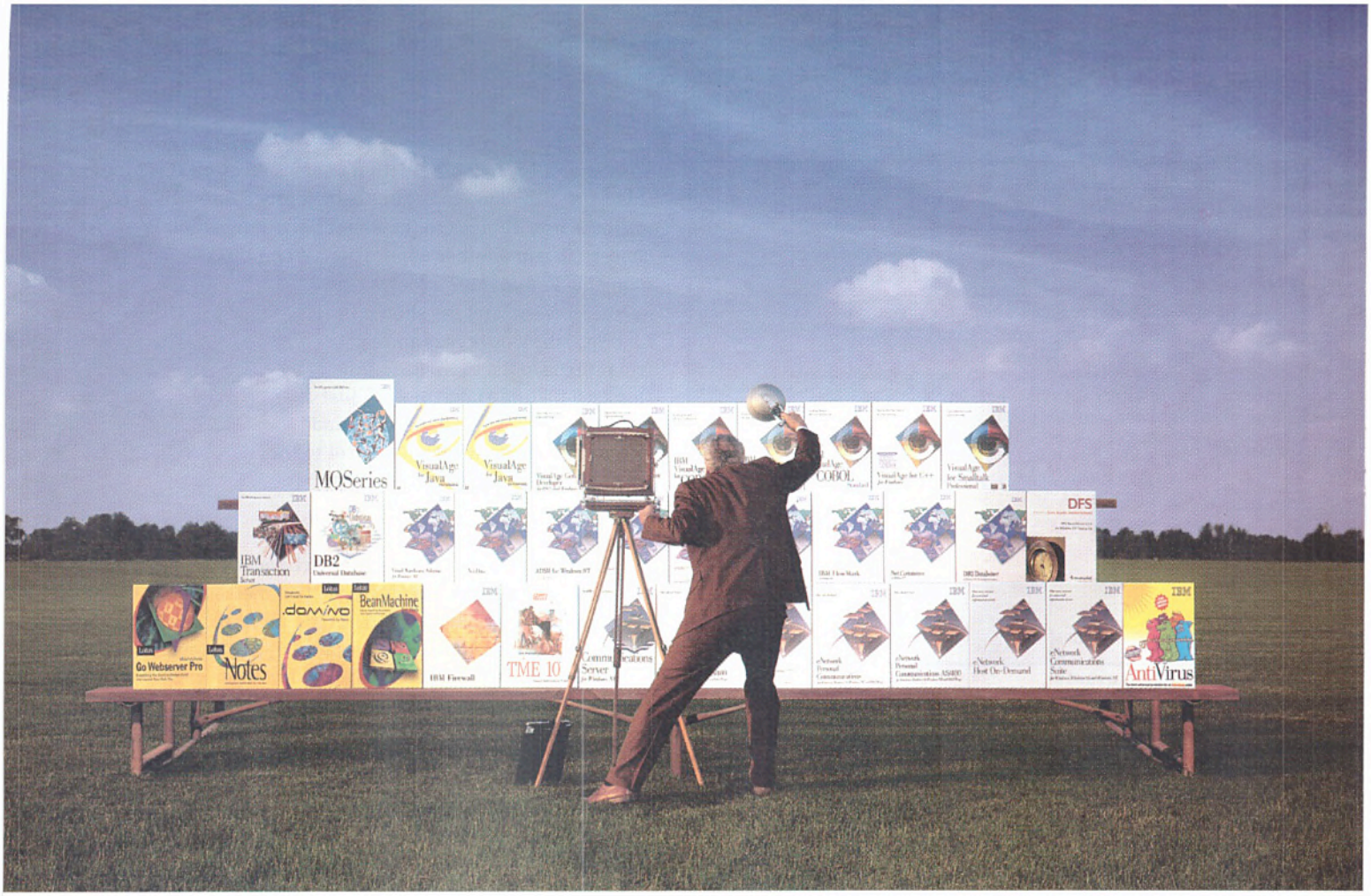
The PalmPilot is produced by 3Com, who inherited it from US Robotics during its recent takeover. The PalmPilot was first released in 1996, and updated in 1997. There are two models of PalmPilot – the Personal and the Professional. Both models are pocket-sized and come complete with a set of built-in organiser-type applications – including a diary, address book, and a memo pad. The Professional model has the added functionality of a TCP/IP stack and email application, as well as more memory (1 MB versus 512 KB).

The PalmPilot achieves its small size by not having a keyboard. All input from the user is made via a stylus. Characters are entered on a touch-sensitive screen using the handwriting recognition software called Graffiti. This assigns a unique keystroke to every character. It is surprisingly quick to learn as the keystrokes closely resemble the characters they represent, and is a nice way around the traditional problems of true character recognition which blighted early handheld computers – Apple's Newton in particular.

The PalmPilot comes with a cradle that can be connected to a desktop PC. This offers the ability to synchronise data between the built-in applications on the PalmPilot and their desktop equivalents – either those bundled with the device or third party solutions. The cradle and synchronisation functionality is also the way that additional applications are added to the PalmPilot. There is a very productive third-party software scene, encompassing free, shareware and commercial applications of all types.

```
static void EventLoop(void)
{
   EventType event;
   Word      error;

   //This is where the application spends most of its
   //time just getting and dispatching events...

   do
      {
      // Get the next available event.
      EvtGetEvent(&event, evtWaitForever);

      // Give the system a chance to handle the event.
      if (! SysHandleEvent (&event))

         // Give the menu bar a chance to update and
         // handle the event.
         if (! MenuHandleEvent(NULL, &event, &error))

            // Give the main form a chance to handle
            // the event.
            if (! MainFormHandleEvent(&event))

               // Give the Settings Dialog a chance
               // to handle the event.
               if (! SetFormHandleEvent(&event))

                  // Let the form object provide default
                  // handling of the event.
                  FrmHandleEvent(FrmGetActiveForm(),
                                 &event);
      }
   while (event.eType != appStopEvent);

   //The user has chosen another application
   //Return to PilotMain for tidyup and exit…
}
```

Listing 2 – The event loop.



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```
static Boolean MainFormHandleEvent(EventPtr event)
{
   Boolean handlded = false;
   if (event->eType == menuEvent)
   {
      // A menu item was selected.
      if (event->data.menu.itemID == settingsCmd)
      {

         // Load the settings form, then display it.
         frm = FrmInitForm(setForm);
         FrmSetActiveForm(frm);
         FrmDrawForm(frm);

         // Tell the system that we've handled this
         // event so it can loop
         handled = true;
      }
   }

   return handled;
}
```

Listing 3 - Handling events

ing 3). The event handler first looks at the type of the event which has been received. If it is a type which the application wants to process then it looks a little further, identifying the name of the event. Found Me? first identifies a menu event and as it is interested in some menu events it looks further to see which menu item has caused the event. Depending on the menu item which has been chosen by the user, different events can take place. If Found Me? detects that the user has chosen the Settings menu then it will pop up the settings dialog.

Whenever a Found Me? function handles an event it returns `true`, this causes the loop to begin again, a procedure which continues until the user returns to the PalmPilot's application launcher and chooses to run another application. When this happens Found Me? receives an `appStopEvent` and (as shown in Listing 2) the loop breaks and control returns to the `PilotMain` function (see Listing 1). `PilotMain` just does a little bit of tidying up and Found Me? closes, passing control to the new application.

Take it away

Of course, there is much more that can be added to a PalmPilot application than just displaying a simple text message. The PalmPilot's operating system includes support for a virtually unlimited range of applications and even a quick perusal of the Internet's PalmPilot resources will show what a PalmPilot developer and some imagination can deliver.

I hope that this has whetted your appetite for PalmPilot development and has shown that there is far more to this little organiser than first meets the eye. ■

Iain Barclay develops PalmPilot software under the name Haus Of Maus. FoundMe? and other fine programs can be downloaded from his Web site http://www.hausofmaus.com. You can reach Iain by email at iain@hausofmaus.com

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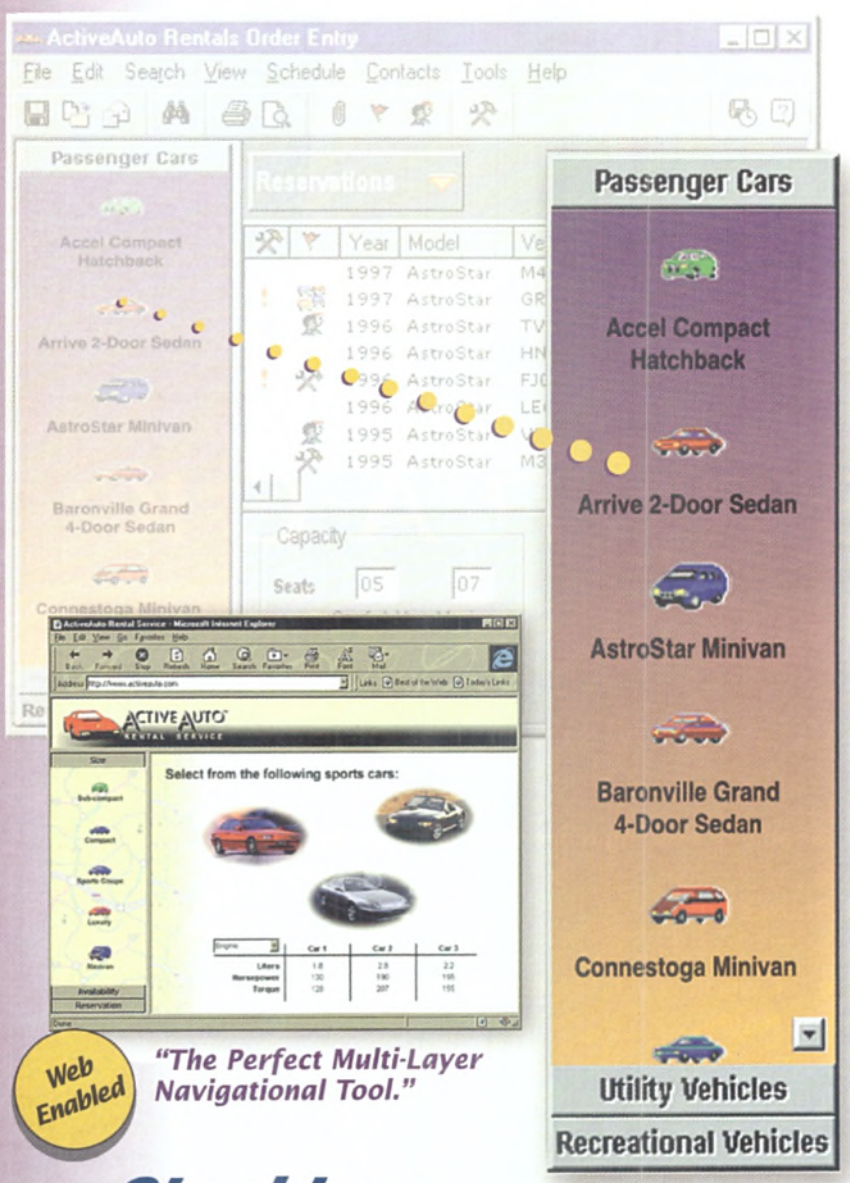

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Bucket overflow

Peter Collinson takes a look at the Unix programming interface for using hash tables, DBM and its clones (DB and the NDBM suite).

I think most of the programs which I have ever written manipulate text in some form, rather than dealing with numbers. I'm sure I've made this observation before in these pages. At some point, when you are dealing with text – from the user, the data, or the program itself – you want to use it as an index or a key into a data array, translating from the text into some other set of information.

Of course, the way that the translation is effected depends on the application. If I am taking commands as tokens from a user and want to convert them into some constant form for syntactic analysis, then I often use a simple linear table embedded in the program. A command set is small, doesn't alter over time, and is essentially a set of constants. As the program designer, I can pick the strings which are used so that they are easily differentiated. Also, I can make decisions on possible frequency of occurrence of each keyword so that the most used words appear near the top of the table, speeding recognition by reducing comparison time. I commonly use the trick of comparing the first character of each token and only entering the string comparison routine if a match is found.

Processing text strings derived from user data is more complicated because there is likely to be greater variation in the keys which are used and we can rarely make assumptions about the keys. Traditionally, we'll use a hash table to speed up processing. We apply a function to the text key we are looking up, and use the result of the function to access a data structure containing the value which matches the key. The name of the game is the reduction of multiple character comparisons to identify the key and thereby to obtain the correct value quickly.

When the key and its value vary slowly over time, we want to store the hash table on disk, so that we don't have to rebuild the hash table every time we call the program. Perhaps we want to build up the hash table slowly over time. For lookup, we'd like to open the file, and then say 'get me the data that matches *so-and-so* key'. We want our hashing access routines to efficiently handle a disk file. Ideally, we want there to be a minimum amount of disk access before we find the data which we need. We'd also like the number of disk accesses to remain relatively constant as the data set we are inspecting grows from tiny, to medium, to large and huge.

DBM access routines

Unix has long had a programming interface which is aimed at this last application. The DBM access routines were created by Ken Thompson and made their appearance with the Version 7 release of Unix. The API is easy, there is a pair of routines which open and close a database:

```
int dbminit(char *file);
int dbmclose(void);
```

The return values are used solely for success or failure conditions. Then there are three routines which read, write, and delete data records:

```
datum fetch(datum key);
datum store(datum key, datum val)
int delete(datum key);
```

Illustration: Patricia Deardorff

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A datum structure is a pointer and a length:

```
typedef struct {
  char *dptr;
  int size;
} datum;
```

Note that `datum` structures are passed by value, not by using a pointer. It was rare to define interfaces which passed structures by value at the time DBM was created. However, Thompson knew his system and had deep knowledge of how the C compiler worked on the PDP-11. It was possible to pass two 16-bit values back from routines in registers, so returning the `datum` in this way was efficient.

When reading data, failure to find a matching key was signalled by the NULL `dptr` value in the returned `datum` structure. A couple of routines permit the enumeration of all the items in the file:

```
datum firstkey(void);
datum nextkey(datum key);
```

To use the database, it's necessary to call the `dbminit` routine supplying a filename. The database is actually stored in two files: if you gave the name `database` to `dbminit` then it would use `database.dir` and `database.pag`. These files need to exist when `dbminit` is called. To create a new database, two zero length files with appropriate names have to exist.

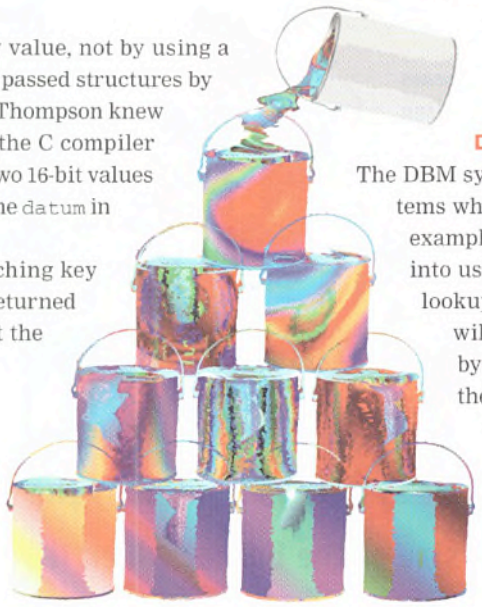
The `.pag` file stores the data which comprises the database. Each key and value pair is stored in a fixed sized 'bucket' which maps onto a disk area. The original system used a 1024-byte bucket, mapping onto two disk blocks. The `.dir` file stores a bitmap which is used by the hashing algorithm, and this bitmap is read into memory by the DBM routines. When looking up a key, its 32-bit hash value is computed and then that value is used to determine which bucket needs to be read to find the key and its associated data.

In fact, not all of the hash is used, the `.pag` file is kept small by masking the key and only using a portion of it to determine where to find the bucket. The size of the mask is controlled by the bitmap in the `.dir` file. As the database expands, buckets get full and are split, some (key, value) pairs will be copied to a new bucket depending on an extra bit of their hash value.

The bitmap in the `.dir` file is used to indicate which buckets are full and have been split, and which have remained unsplit. So, the bitmap in the `.dir` file controls the masking applied to the hash, and this variable masking allows the file to grow while retaining the single disk access lookup. Actually, the algorithm is best described by looking at the code used to go from a key to a bucket:

```
hash = calchash(key);
mask = 0;
while(isbitset((hash & mask) + mask))
  mask = (mask<<1) + 1;
bucket = hash & mask;
```

Each bucket holds variable length sets of data, with a 16-bit byte count being used between each key and value to provide space management and the ability to find each (key,value) pair. Once the bucket is located, byte by byte data comparison is used to find the appropriate key.



As the database expands, buckets get full and are split.

The `.pag` file can have 'holes', places where there is no data. Unix supports files with holes, only allocating disk resources to blocks in a file which have been written; the `.pag` file can appear to be very large, but will only occupy enough blocks on the disk to contain the data. Well, this is true until you copy the file, general purpose copy programs cannot see the holes and the new copy will be filled with real disk blocks containing nothing but zeros.

DBM in action

The DBM system worked well, and was used by many systems which needed to look up values by keywords. For example, mail systems have used DBM to map aliases into user names, allowing fast translation. Most alias lookups will fail, so you need to use a system which will fail quickly, hopefully without performing any byte-by-byte key comparison. When I was running the UK's UUCP gateway, I needed to translate from a domain name on the network to a path, and DBM was used to contain the huge table of machine names, and the path through the network to those machines.

I've used the DBM system for years to generate an index to my text based personal address book. Each person in my address book is represented by a variable length record, with several variable length fields containing their work and home addresses, phone numbers, and the like. For speed of access, I build a DBM index which points at this file. The keywords I might want to use are: first and last names, the email address split into name and host fields, values from a space separated key field in the record, etc. The value attached to each key is a comma separated list of byte offsets for the start of the record which contains the key. To find a relevant record, I can use `seek` to get to the right point in the file, and then just pull the text lines which comprise the record. So, I can do very fast lookups into my database. For instance, finding all the people who are called 'David' or whose email address host is `dotexe.demon.co.uk`.

Incidentally, the trick with this type of system is to make access work even when the DBM index is out of date. Access is slower without the index, but still generates a result. I choose not to rebuild the index whenever I update the address book because I often want to make several changes and having to wait for an index rebuild every time would be a pain. So the programs complain that the index needs rebuilding, but they still generate the information which I need at that moment.

Berkeley addressed a problem with the original DBM routines in one of its early system releases. The routines had no provision for dealing with more than one database at a time, and there were occasions where the ability to deal with multiple databases was needed. Berkeley created the NDBM, the new DBM suite, which retained the algorithms but added an external data structure to the interface. The data structure is used to contain the state of the database including the file handles into its open pair of `.dir` and `.pag` files.

Other problems remained, and are somewhat insidious. The system is limited by the size of the bucket which it was compiled to use. A key and a value must occupy less than 1024 bytes. Also, the system didn't cope well with hash collisions. You were stuffed if the

hashing algorithm placed a great many keys into one bucket and the total data size which was needed summed to greater than 1024 bytes. These failures could be catastrophic, because there was no provision to check for them and the database access could continue but give misleading results.

In-memory hash tables

While the DBM system is great at dealing with databases which are fairly permanent, it's not so hot at dealing with programs, like compilers and interpreters, which require a hash table for short-term intensive use. There's no good reason why such a hash table should be placed on disk, the application generally wants to have the object in memory. The folks who created Unix System V realised this and produced a small suite of routines which were derived from various Knuth algorithms. Perhaps the most useful of these was `hsearch`, allowing you to create and maintain an in-memory hash table.

The API is simple too:

```
int hcreate(size_t elems);
```

creates the hash table and initialises it. You can trash it by:

```
int hdestroy(void);
```

Then a single routine is used to add or lookup elements:

```
ENTRY *hsearch(ENTRY item, ACTION action)
```

Actions are an enumeration with two values (`FIND` and `ENTER`) and an `ENTRY` is similar to the data structure used by DBM:

```
typedef struct {
  char *key;
  char *data;
} ENTRY;
```

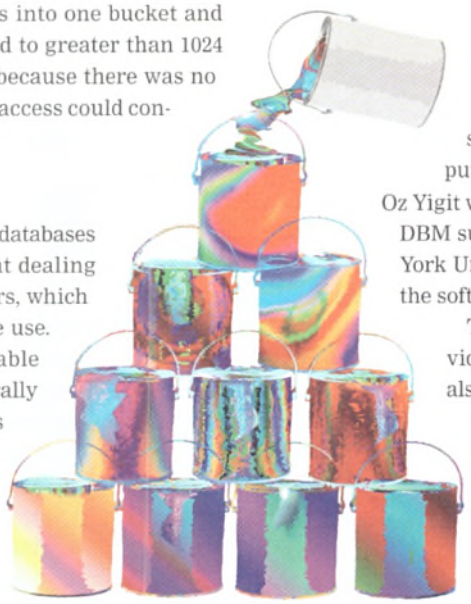
The `key` is constrained to be a null terminated string, the `data` can be anything. Since the data only resides in memory, there's no need to worry about its length.

I've used these routines on a couple of occasions to take the strain out of generating a hash table. Its biggest problem is the guesswork needed to supply a sensible value to the `hcreate` routine. The value is used to condition the hash algorithm and if it's too small then the algorithm can degrade. When hash buckets get full, the algorithm generates a secondary hash value used to probe for an overflow bucket, and additional computation is needed. If the value is too large, then you can end up with a sparsely populated table which may not make best use of resources. You have the Goldilocks problem: picking a value that's just right.

The DB library

DBM, NDBM, and `hsearch` pose deployment problems. They are part of official Unix system releases created at some point by AT&T and are not freely available. Various people have created clones of the code over time, notably the Free Software Foundation's `gdbm` for the DBM suite. Cloners have also tried to tackle the fundamental problems with the systems: the bucket size problems with `dbm` and the initial value problem with `hsearch`.

In the early 1990's, Margo Seltzer teamed up with Ozan Yigit to take a fresh look at the algorithms. Seltzer was a graduate student working in Prof. Stonebreaker's department at the University of California, Berkeley. Stonebreaker had been responsible for a great many database systems, notably Ingres, so the department was clued up about files, access times, and performance. Seltzer is still an academic, an Assistant Professor in Computer Science (a lecturer in UK terms) at Harvard. Oz Yigit was responsible for one of the early clones of the DBM suite, calling his version `sdbm`. Yigit was then at York University (in the USA) working as a member of the software staff. I don't know where he is now.



The system is limited by the size of the bucket which it was compiled to use.

The result was the Berkeley DB library. DB provides an interface which clones the NDBM one, and also one which replicates `hsearch`. These two interfaces meant that existing code which used these two differing systems could simply be recompiled to take advantage of the new library.

The DB library uses a modified version of Larson's linear hashing algorithm published in *Communications of the ACM* (CACM) in 1988. The idea is that the hash table starts as a single bucket and grows in generations, where a generation is defined as a doubling in size of the hash table. It starts at 1 bucket, and goes to 2, 4, 8, etc. At the start of each generation there is a range of buckets which starts at zero and extends to the maximum split point (the bucket at the current size of the file) defining the current active size. All numbering starts at zero, and this allows easy conversion between masks and values. As the data expands, buckets are split into the space above the maximum split point.

To split a bucket, its contents are divided between the current split bucket and a new empty bucket which is computed by (1 + current bucket + the maximum split point). Pairs of keys and values are moved into the new bucket depending on the *n*th bit of their hash value, where *n* is the generation number.

When the last bucket in a particular generation has been split, then the generation number is incremented; and the process starts again, recomputing the maximum split point by doubling the old point and adding one. To locate a key, we use two masks: the low mask is equal to the current maximum split point and the high mask is equal to the next maximum split point. The bucket can then be computed:

```
h = calchash(key);
bucket = h & high_mask;
if (bucket > max_bucket) bucket = h & low_mask;
```

The DBM library only split a bucket when it was full. DB will do this too, but also splits buckets when a defined fill factor is exceeded (the fill factor is computed as the average of the number of keys per bucket).

The DB library paid considerable attention to the major deficiency of DBM: what happens when data which we want to legitimately store in the bucket is too large to fit. Extra overflow buckets are allocated between each generation, and bitmaps are used to indicate which buckets have overflowed. The bitmaps are themselves stored in overflow pages.

The library uses paging techniques to map pages on the disk file into memory. In fact, the `mpool` system it employs is usable as a standard method of managing pages from files in your program's memory space. Where supported by the underlying implementation, `mpool` routines will use memory-mapped files to further improve file-handling speed.

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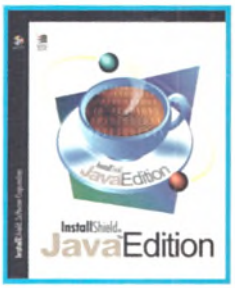

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While the DB library was designed to use extant APIs, it does have its own `dbopen` routine which allows you to set up things specially for your application: you can choose your own hash function, set fill factors, and the like.

All of this might not have been much to write home about, but Seltzer did go on to measure the performance of her system and compare it with the extant mechanisms. On all her tests, the DB library performed faster than the libraries which were available at the time, in some cases there was a 75% to 80% speed increase, which can't be bad. Incidentally, she found that `gdbm` was desperately slow, although I'll guess that something has been done about improving it in the interim.

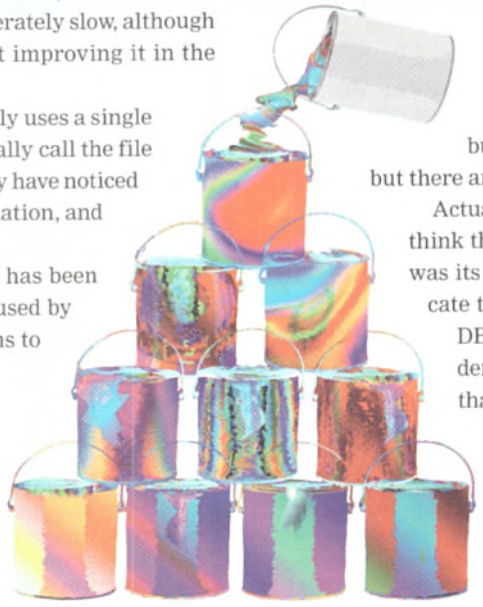
You may have noticed that the DB system only uses a single file to store its information, the routines generally call the file `database.db`. If you use Netscape, then you may have noticed that it uses `.db` files to store its internal information, and yes these are DB files.

The widespread version 1.85 of the library has been stable for some time, and is the version being used by Linux and most (free and non-free) BSD systems to provide DBM interfaces.

DB 1997

Margo Seltzer and her spouse, Keith Bostic, have put considerable effort into expanding the DB library in the last year, creating Version 2. The underlying database format has altered, and a complete set of native access routines has been implemented. The major changes supply transactional functionality for database management, with database logging, data security, and file locking all being bundled into the main package. The API is in C, but there are 'thin' C++ and Java interfaces.

Actually, I do wonder about Version 2 of the library. I think that one of the appealing things about Version 1 was its simplicity and this library appears to complicate things greatly. You are still able to use the old DBM, NDBM and `hsearch` interfaces, and I wonder whether people will continue to do this rather than take a new API on board. ■



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.

Where to get things

The DB library, in various versions, is available from *http://www.sleepycat.com*.

If you pull the distribution, you'll find PostScript versions of the original Usenix papers from which this article is largely derived. Incidentally, both versions of the DB library will compile and run on Wintel machines.

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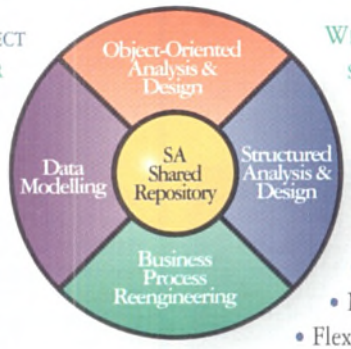

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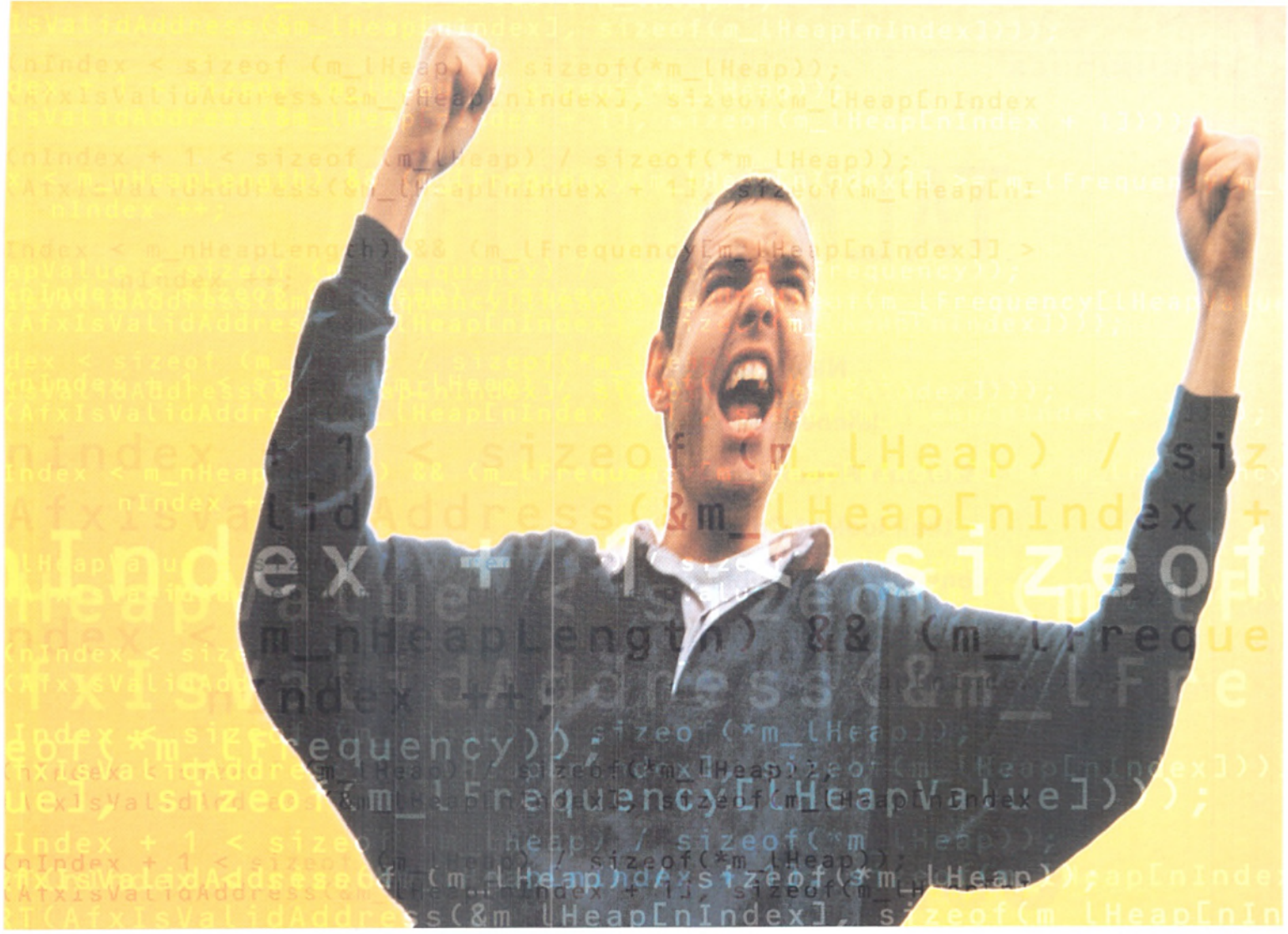

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TALKING CORBA

Nicola Baldini, Michele Bini, and Duncan Wilcox continue their look at Corba and consider the possible role of C++ in the distributed object space.

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Corba & C++

In the previous issue we outlined Corba (Common Object Request Broker Architecture) and some of its complexities. It was a relatively easy start since the Java language bindings, which we used, are nice, clean, and standardised. However, a more probable scenario of a Corba based system will see the use of Java to implement a multi-platform client with the use of C++ either to implement a high-performance server or as glue that integrates a legacy system in the distributed object space.

We will show what a remote object – produced by the same IDL (Interface Definition Language) we used for Java – looks like in C++. (The scenario was of a superpower 'World Crisis Manager', a facility to circulate the rumours that agents and analysts, scattered over the world, have collected and analysed! These distributed 'rumour mills' were implemented as Corba objects.) We have no need to show a C++ client as the Java client we presented in our previous article works correctly with the C++ server.

We should try not to repeat this too often: C++ distributed objects are less natural and harder to implement than their Java equivalent. In part, this comes from the well-known language differences: the principles of coding ease versus efficiency. On the other hand, some problems arise simply because the Corba C++ mapping predates ANSI/ISO C++ standardisation and, in particular, makes no use of the standard C++ library. To make matters worse, some of its conventions blend badly with those of the standard library.

A free C++ ORB

An ORB (Object Request Broker) can take many forms. It can be a library that is linked to your code, for example, or it can be a daemon that talks with your code through shared memory... Whatever shape the ORB has, it should provide the implementation repository and the interface repository.

The implementation repository is a collection of ORB-dependant information, such as how to start a given server, whether it can serve multiple objects, etc. The interface repository is a machine-readable collection of IDL-equivalent object descriptions of interfaces, actions, and data types implemented by an ORB. The interface repository is a key component of the Corba Dynamic Invocation Interface (DII) and Dynamic Skeleton Interface (DSI). Both of these interfaces deal with the problem of using objects without using the stubs generated by the language binding process. (DII is something for the client, which deal with object interfaces. DSI is for servers, which deal with object implementation code skeletons).

Although DII and DSI are of little interest to most programmers, they enable automated and interactive development tools and some special applications such as bridges and proxies – servers acting as a relay for a group of Corba objects.

Finally, a desirable feature for an ORB is concurrent execution of method invocations. While an ORB can use the multitasking features of the host OS to some extent, concurrent requests from different clients, to different instances, or to different actions of the same instance, or all of these at the same time are possible. It is clear that multithreaded design is a winner.

Among the candidate (free) ORBs we found the Olivetti/Oracle omniORB2 and Frankfurt University's MICO to be the most interesting. The omniORB's strength is its performance; its authors claim it to be the fastest Corba ORB, and we certainly found it to be quite fast.

```
module Crisis1 {
        typedef long cid;
        struct crisis {
                cid id;
                string description;
        };
        exception outOfResources { };
        interface iterator {
                crisis curr() raises (outOfResources);
                void next();
                // After last() returns TRUE the
                // iterator isn't valid.
                boolean last();
        };
        typedef sequence<crisis> cseq;
        interface Repository {
                exception notPresent {};
                void ping();
                void add(in string d)
                        raises (outOfResources);
                void remove(in cid id)
                        raises (outOfResources,
                                notPresent);
                long len();
                void retrieve(out cseq s)
                        raises (outOfResources);
                iterator iterator()
                        raises(outOfResources);
        };
};
```

Listing 1 – IDL for the base server.

MICO's greatest shortcoming in this regard is its single threaded nature – and multithreading doesn't seem to be a priority for the authors. On the other hand, MICO offers both an implementation repository and an interface repository, while omniORB doesn't include either, making it, strictly speaking, a non-compliant implementation.

We decided that performance and ease of use (due to threads) offset the potential compatibility problems with advanced tools: for this article, we chose omniORB. In the spirit of a free development environment, we used it under Linux. The omniORB platform compatibility is defined mostly in term of threads and sockets implementations; in addition to Linux, it currently runs in pthreads, Solaris, AIX, and Win32 compatible environments.

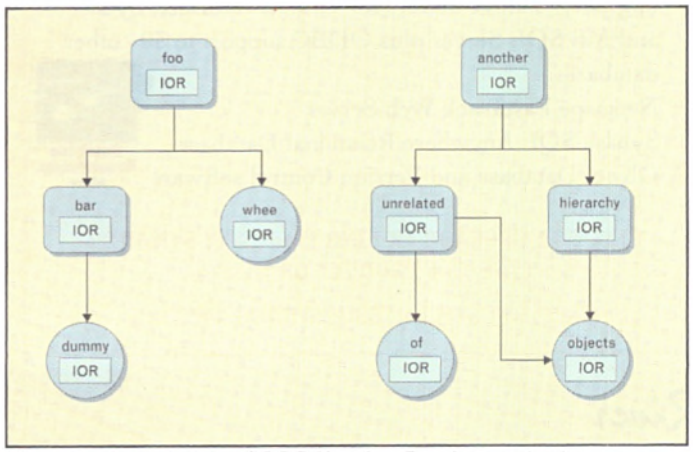

Figure 1 – An example of COS Naming Service contents.

Porting the server to C++

Listing 1 presents the IDL description. The basic structure of the C++ server is the same as the Java one: we declare a class, deriving it from a skeleton stub class generated by the omniORB IDL-to-C++ translator (`Repository_i` stands for 'Repository implementation'):

```
class Repository_i : public virtual
Crisis1::_sk_Repository {
public:
  Repository_i();
  virtual ~Repository_i();
  ...
protected:
  omni_mutex mutex;
  map_t data;
  Crisis1::cid unique_id;
}
```

To implement our high-performance server we need an efficient data structure to store our crises. An associative array (`map<key, value>` in STL) mapping the unique crisis id to its description comes to mind. The type `map_t` is declared for brevity as:

```
typedef map<Crisis1::cid, Corba::String_var> map_t;
```

The omniORB servers are inherently multithreaded, so we must provide for synchronised access to shared data. While in Java we can rely on language constructs to handle mutual exclusion and synchronisation, in C++ we must handle it explicitly, resorting to OS-level thread facilities. Luckily omniORB provides its own thread library which hides the differences between thread implementations on omniORB supported platforms. The `omni_mutex` class is defined by the omnithread library to handle a mutual exclusion device (a simple kind of semaphore). We will use it via a `mutex_owner` class, implementing the 'object acquisition is initialisation' policy often used in C++ to handle `mutex` locking and unlocking. In other words, the `mutex` will lock when an instance of the `mutex_owner` class is constructed and unlock when it is destructed, for example when an automatic variable goes out of scope.

Since the hard work of decoding incoming IIOP (Internet Inter ORB Protocol) requests and assembling IIOP replies is handled by the stubs, simple methods don't look more complex than their Java counterpart:

```
Corba::Long Repository_i::len() throw()
{
  Corba::Long r;
  {
    mutex_owner m(mutex);
    r = data.size();
  }
  return r;
}
```

As soon as a method needs to handle variable length arguments (or return values) however, we hit hard into the C++ explicit allocation policy and Corba C++ mapping rules:

```
void Repository_i::add(const char *d)
  throw (Crisis1::outOfResources)
{
  const char *s = Corba::string_dup(d);
  if (s == NULL)
    throw Crisis1::outOfResources();
  {
    mutex_owner m(mutex);
    data[unique_id++] = s;
  }
}
```

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C++ mapping specifies that any string received from or passed to the Corba ORB must be duplicated before the server can store it. Any allocation and deallocation must be accomplished by dedicated functions in the Corba class (such as `Corba::string_dup()` above), not by the C++ string class and not even by C string handling functions. Since `data` is an array of `Corba::String_var` elements, we are using `Corba::String_var::operator=()` when assigning to it. This is why we assign the newly created string to a variable of `const char *` instead of `char *`. The function `Corba::String_var::operator=()` calls `Corba::string_dup()` if we are assigning to a `const char *` (or another `Corba::String_var`), but it does a simple copy-assignment if we assign it to a `char *`.

In fact, for simplicity we could have written:

```
data[unique_id++] = d;
```

without messing with explicit duplication of `d` at all. However we must check if `string_dup()` returns a `NULL` value to signal an out-of-memory condition.

Writing a Corba server in C++, while not very difficult, is trickier than writing it in Java, and certainly takes more time

Along with `Corba::String_var`, the Corba C++ mapping defines a `_var` type for all `struct` types you declare in the IDL file. Just like `String_var`, even these 'user defined' `_var` types take care of memory allocation and deallocation. Moreover, their copy constructor and assignment functions do deep copies of all the data they contain (ie if the structure contains a string it is correctly `string_dup()`'d, etc.). As we'll see later, managing Corba object references instead (ie implementation instances of some IDL interface) is not so easy.

The constructor for `Repository_i` reveals another tricky point. The type `Corba::Long` (as well as other type names in the Corba namespace) is defined with a `typedef` as an alias for a suitable 32-bit integer (usually C++ `long`). However, since the semantics for the construction of native C++ types are to leave them uninitialised, we must explicitly handle its initialisation:

```
Repository_i::Repository_i() : unique_id(0) { }
```

Just like with the Java server, the `retrieve()` method is the most complex. First, we need to lock the repository:

```
void Repository_i::retrieve(Crisis1::cseq *&s)
   throw (Crisis1::outOfResources)
{
   {
      mutex_owner m(mutex);
```

Corba conventions are that, when a parameter requires dynamic allocation, the caller passes a reference to a pointer (in this case `s`) and the callee allocates the pointed object and sets the pointer:

```
      Corba::Long l = data.size();
      try {
         s = new Crisis1::cseq(l);
      }
      catch (const std::bad_alloc &ex) {
         throw Crisis1::outOfResources();
      }
```

N. of ops	C(local)	C(net)	Java(local)	Java(net)
5000	1278.6	434.6	169.4	138.0
10000	1271.7	426.3	81.2	93.5

Table 1 – C++ and Java server performance comparison (in operations/second).

The size `l` we are asking for `s` is only a hint to optimise memory allocation, `s` may grow larger if required and its real length will be zero until we explicitly set it:

```
      try {
         s->length(l);
```

Now we have fixed the length of `s` and we are required fill all and only the first `l` items:

```
         map_t::iterator j = data.begin();
         for (Corba::Long i = 0; i < l; i++, j++) {
            Crisis1::crisis &c = (*s)[i];
            c.id = (*j).first;
            c.description =
                  Corba::string_dup((*j).second);
         }
      }
      catch (const std::bad_alloc &ex) {
         delete s;
         throw Crisis1::outOfResources();
      }
   }
}
```

Note that not filling some items of `s` (as well as accessing an item past its end) is an error and will lead to runtime memory corruption.

Finally, the `getIterator()` method must return a Corba reference to an iterator object. Corba references come in two flavours: a `_var` reference, handling automatic deallocation as described earlier and a 'plain' `_ptr` reference. It is usually easier to use `_var` references, as they free us from the burden of explicit deallocation, but `getIterator()` must return the reference and Corba calling conventions state that the caller is responsible for return value deallocation. We must resort to an `iterator_ptr` (`iterator_i` is our implementation class we'll describe in a moment):

```
Crisis1::iterator_ptr Repository_i::getIterator()
   throw (Crisis1::outOfResources)
{
   iterator_i *i;
   {
```

References

OMG home page *http://www.omg.org/*

OOCs Corba page *http://www.ooc.com/corba.html*

The free Corba page *http://adams.patriot.net/~tvalesky/freecorba.html*

Corbanet – the ORB interoperability showcase *http://corbanet.dstc.edu.au/*

OMG technical library *http://www.omg.org/library/library.htm*

Corba news *http://www.omg.org/news/news.htm*

omniORB2 C++ ORB *http://www.orl.co.uk/omniORB/omniORB.html*

MICO C++ ORB *http://www.vsb.cs.uni-frankfurt.de/~mico/*

```
    mutex_owner m(mutex);
    try {
      i = new iterator_i(data);
    }
    catch (const std::bad_alloc &ex) {
      throw Crisis1::outOfResources();
    }
  }
```

Note that the call to the `iterator_i` constructor is protected by a semaphore. This eases the implementation of `iterator_i`.

We must now inform the ORB that our object is ready to handle requests. This is accomplished through the Basic Object Adaptor (BOA) that behaves as an interface between the object implementation and the ORB. It provides, among other things, object reference generation, client authentication, and activation and deactivation of implementations and objects. We need a Corba reference for the BOA, which is handled just as a regular Corba object. Corba C++ mapping specifies we can use the `_boa()` member function:

Maybe the real question is 'can you afford a longer development time?'...

```
  Corba::BOA_var boa = _boa();
  boa->obj_is_ready(i, NULL);
```

Since `boa` is declared as a reference of the `_var` variety, we won't have to explicitly call `Corba::release()`.

Finally we need to turn our `iterator_i *` into a Corba object reference. While the C++ object pointer, or `this`, is only a pointer to the implementation object, the `_this()` function returns an IOR reference to the object in Corba terms, and that's what we use:

```
  return i->_this();
}
```

An iterator class

Implementing the `iterator_i` class shows us a couple of tricks:

```
class iterator_i : public virtual
Crisis1::_sk_iterator {
  map_t data;
  map_t::iterator i;
public:
  iterator_i(map_t &d);
  virtual ~iterator_i();
  virtual Crisis1::crisis *curr()
  throw (Crisis1::outOfResources);
  virtual void next() throw();
  virtual Corba::Boolean last() throw();
};
```

First, the constructor copies the repository data it is passed (this is not efficient but, as we discussed in our previous article, is the only easy solution). It accomplishes this simply by invoking the STL map copy constructor:

```
iterator_i::iterator_i(map_t &d) : data(d),
                        i(data.begin())
{}
```

Correction

After the first article had been published, we were alerted to a bug that affects the behaviour of the Java server. Specifically, the iterator isn't copying the array of crisis report strings as we intended, but only copying the reference. The following code should be used instead of the original constructor:

```
public iteratorServant(ORB oorb, Vector d) {
  orb = oorb;
  data = (Vector) d.clone();
  data.trimToSize();
  i = 0;
}
```

Note that `Vector.clone` only performs a shallow copy of the `d` (that is, the new `Vector` will point to the original strings). That's okay, since the strings aren't modified, and Java garbage collection will make sure that if they're removed from the Repository the iterator will still have valid ones.

We wish to apologise for any inconvenience caused to spies world wide already using this service.

Then the `curr` method must fiddle with explicit allocation and out-of-memory checks. It's in these easy housekeeping tasks that Java shines over the C++ shown here:

```
Crisis1::crisis *iterator_i::curr()
  throw (Crisis1::outOfResources)
{
  Crisis1::crisis *r = NULL;
  try {
    r = new Crisis1::crisis;
    r->id = (*i).first;
    r->description = Corba::string_dup((*i).second);
    if (((char *) r->description) == NULL)
      throw std::bad_alloc();
  }
  catch (const std::bad_alloc &ex) {
    if (r != NULL) delete r;
    throw Crisis1::outOfResources();
  }
  return r;
}
```

Finally, there is the `last()` method. We must destroy our object in order to avoid resource leaks, and we must release references to it, too.

```
Corba::Boolean iterator_i::last() throw()
{
  if (i == data.end()) {
    Corba::BOA_var boa = _boa();
    Corba::Object_var thisob = _this();
    boa->dispose(thisob);
    return 1;
  }
  return 0;
}
```

Note that we call `dispose()` first, to tell the BOA that the object no longer accepts incoming requests and that it asks to be destroyed. The BOA defers object deactivation until the last request the object is serving completes (this enables us to commit suicide in a clean way: the object will exist until `last()` returns).

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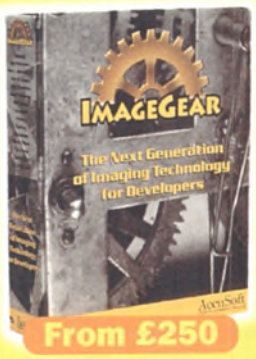

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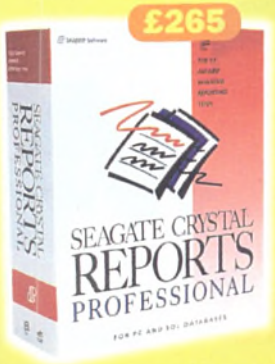

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The main function

We are only missing a `main()` function to have a working server. First, we need to set up the ORB and the BOA:

```
int main(int argc, char **argv)
{
  Corba::ORB_ptr orb =
    Corba::ORB_init(argc,
                    argv,
                    "omniORB2");
  Corba::BOA_ptr boa =
    orb->BOA_init(argc,
                  argv,
                  "omniORB2_BOA");
```

Then we create a `Repository_i` object and we tell the BOA that it's ready to accept requests:

```
  Repository_i *myobj =
            new Repository_i;
  boa->obj_is_ready(myobj, NULL);
```

Then comes a long part dealing with object registration into the COS (Common Object Services) naming service. The important point is a call to a utility function we have written (we'll describe the COS naming service in more detail later):

```
  COSSupport::bindObjectToName(
                  orb,
                  myobjRef,
                  name);
```

Finally, we tell the ORB that the whole server is ready. The `impl_is_ready()` function will never return except in consequence of a fatal error or explicit implementation deactivation:

```
  try {
    boa->impl_is_ready(NULL);
  }
  catch (const
          Corba::Exception &ex) {
    boa->dispose(myobj);
    throw;
  }
}
```

And that's all.

Performance comparison

Writing a Corba server in C++, while not very difficult, is trickier than writing it in Java, and it certainly takes more time. The question is: is it worth the effort?

We wrote a simple benchmark that repeatedly adds strings to the server. You can see the results in Table 1. While benchmarks of this kind are often meaningless, there are some facts that we can extrapolate from the numbers.

First, given the similar results obtained from local and networked use, the Java server is probably CPU bound, and this will probably get worse as the Java remote method gets more complex. On the other hand, the C++ server throughput seems to be limited by the network speed for this simple test case.

... or 'can you afford a much slower performance, by a factor of four?'

Second, while C++ server timings are roughly constant for different number of requests, Java ones are not, probably due to the Java memory allocation policy and garbage collection: it makes Java easier to use but hits performance. If we looked at single-method invocation timing, the scenario would be even worse: methods whose invocation triggers the garbage collector would be far slower than average.

So, is it worth developing a C++ server? Maybe the real question for you is 'can you afford a slower performance, by a factor of four?', or 'can you afford a longer development time?'.

Common Object Services

Beyond the basic connectivity functionality provided by the ORB, the OMG defines the Common Object Services (COS). Most services that are part of COS are layered above the ORB (ie they are implemented as Corba objects), and some partially extend ORB functionality (for example, the security services). Others provide additional functions such as full object persistence, true asynchronous communication, and 'data push', or transaction control. Other services, however, are only guidelines for object implementors. For example, the lifecycle service is a set of recommendations on how to handle objects created on the fly (like the iterator objects in our example server). As always, the OMG doesn't provide an implementation, but only guidelines and specifications for the service implementor.

Two of these services are very important because they accomplish the basic task of finding other services. One is the naming service,

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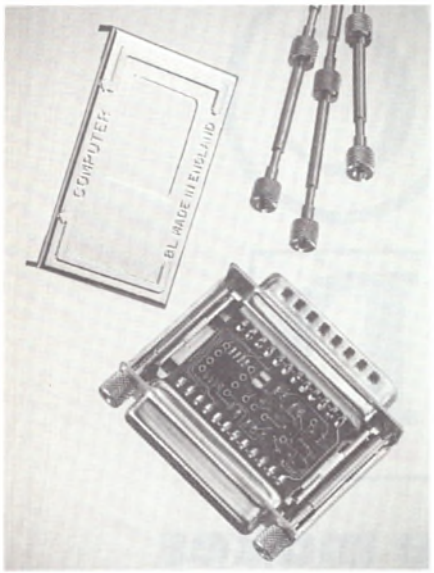

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which enables object retrieval 'by name'. The second is the trader service, which is capable of retrieving objects 'by function'. Alas, while the naming service is widely available in free implementations, the trader service is not.

The naming service

The naming service is modelled after the familiar hierarchical disk filing systems. It associates IORs to arbitrary strings called name components. These name components are, in fact, pairs of strings: an 'id' (a mnemonic name) and a 'kind', which can be used to describe the type of the object. Name components, in turn, are collected in a naming context (a fancy name for a directory). A naming context is naturally implemented as a Corba object, so naming contexts can be nested. You can use a Corba sequence of name components (called, unsurprisingly, `name`) to retrieve the IOR for an object.

But, unlike your PC filing system, the naming service has no 'root' context. This is important, so that different applications can handle separated name spaces thus avoiding name clashes. Let's explain this with an example. Figure 1 is a snapshot of some hypothetical naming service content. Let's pretend we already have the IOR for `foo` (you may suppose it's stored on disk somewhere for the moment). To retrieve `dummy`, a Java client will do the following:

```
import org.omg.CosNaming.
            NamingContextPackage.*;
// ...
NameComponent[] nc = {
  new NameComponent("bar", ""),
  new NameComponent("dummy", "")
};
dummy = foo.resolve(nc);
```

If `bar`'s IOR is known the client can also do:

```
NameComponent[] nc = {
  new NameComponent("dummy", "")
};
dummy = bar.resolve(nc);
```

As you can see, the client asks a naming context to resolve names on its behalf. The naming context then looks for a child of its own, with name `nc[0]`, and so on. Another unrelated client can start all its name lookups from `another`, so it will never know that the name hierarchy rooted in `foo` exists. However, there is still a problem. How can the client find the first IOR pointing to `foo` or `another`? Well, IORs are just strings, so it could be retrieved from disk or read from a socket, or anything else. But these are not standard, interoperable solutions. To solve this problem Corba specifies that the ORB must provide the action:

`resolve_initial_references(string)`

This action accepts a string and returns an IOR associated (supposedly by the ORB administrator) with that string. To retrieve the `root` assigned to us, our client does something like:

```
COSNamingRoot =
  orb.resolve_initial_references(
            "NameService");
```

Currently, OMG doesn't specify how the ORB retrieves these 'initial IORs'. An omniORB reads them from a configuration file, while JavaIDL retrieves them via an extension to the naming service daemon. This causes some interoperability problems and, in real world applications, it's currently best to resort to some other method. For our example server we wrote a short perl script that reads omniORB configuration files and writes the IORs on a socket to anybody requiring them. Instead of using `resolve_initial_references()` our clients open a socket connection to the server and read the IOR they require. Obviously this is not an optimal solution and OMG is working toward a standard way for the clients to retrieve the initial references, probably modelled after the JavaIDL extension to the naming service. By the way, the added complexity of retrieving the initial reference is the main reason we chose to hide the naming service calls in some utility functions.

Scratched the surface

Corba has some tricky aspects, but we find that it's a perfect technology to complement Java with C++ or to integrate legacy systems in open client/server environments. Moreover, it's reaching maturity with its second major release being consolidated by a number of very complete commercial implementations.

We hope the two articles have tickled your interest, and the free tools and sample code will get you started without too much effort. ■

Nicola Baldini, Michele Bini, and Duncan Wilcox work on databases and data mining applied to decision support system applications in client/server environments. You can reach them at www.psitrust.com.

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Virtual machine functionality

The most basic functionality provided by a Java VM is the ability to load and link Java classes. Tom Guinther covers the basics of processing and manipulating the Java class file format.

Does the Java virtual machine implement the semantics required by the Java language, or does the language incorporate and reflect the design semantics of the virtual machine? At times, it can be difficult to separate the Java language and its APIs from the Java runtime environment, but don't spend too much time thinking about the answer because the point is probably moot.

The Java virtual machine is a runtime execution environment, which is to say that it is very similar to, but completely unlike, an interpreter. Part of the purpose of the JVM is to model, in software, the operation of a computer processor which, among other things, defines and executes an instruction set. But the Java VM transcends basic instruction execution. It dives head first into the realm of the traditional operating system, providing a secure environment in which Java applications and applets can execute. The virtual machine also provides system services such as multi-threading, garbage collection, just-in-time compilation, and other dynamic optimisations, as well as a host of specialised features such as debugging APIs and hooks.

Virtual machine specification

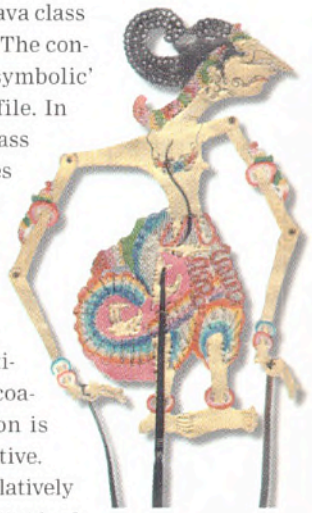
Java's creators have documented the theoretical workings of the Java virtual machine in the book *The Java Virtual Machine Specification* published as part of the Java Series by Addison-Wesley. It contains most of the basic information about the JVM, including a description of the Java class file format and the JVM instruction set.

The most basic functionality provided by a JVM is the ability to load and link Java classes. Loading is the act of finding a specific Java class file, and translating from the Java class file binary format into a more manageable class data structure defined by the JVM. During the loading process the virtual machine will, at a minimum, make a superficial check that the class file is well formed. This might include version and revision checks, and that all sub-components of the class file appear to be properly constructed. Once the loading phase is complete the JVM will perform the link step.

Linking a class file is much more complicated than loading the class file. One major reason is that, according to the specification, during the link phase the Java virtual machine should perform extensive verification of the class. One part of this is an exhaustive bytecode verification of all methods within the class.

The Java class file format

If you need to write a Java VM or develop tools which work directly with the JVM or Java classes there are two things that are difficult to avoid; the Java class file format, and the JVM instruction set. This month I will cover the basics of processing and manipulating the Java class file format and provide a C++ implementation of a class file dump utility, ClassDump. This utility displays the contents of a binary class file, which to all intents and purposes is the definition of the original Java class. Next month, during the discussion of the Java instruction set, I will present an extended version of the ClassDump utility which includes a Java bytecode instruction decoder and disassembler.



Central to any discussion of the Java class file format is the Java constant pool. The constant pool acts as a repository for 'symbolic' information used within the class file. In lieu of having each item within the class file make explicit reference to pieces of data such as constants, strings, or method and field type descriptions, the components of the class file use indices into the constant pool. By centralising access to class file data, the class file format is dramatically simplified; redundant data is coalesced (saving space) and validation is both simplified and made more effective.

The constant pool item types are relatively simple. The types `Class`, `Field`, `Method`, `InterfaceMethod`, and `NameAndType` each contain indices to other constant pool items which describe the class name or the name and type of a field or method. The type `String` contains an index to a constant item which represents the actual string value. Finally, the integral types `Integer`, `Float`, `Long`, `Double`, and `Utf8` contain the actual values referred to by other constant pool types.

Overall structure

The overall layout of the class file is similar to the following C pseudo structure. It's a pseudo structure because most of the sub-components are of variable length and thus are difficult to describe using static description methods.

```
struct ClassFile {
  struct ClassFileHeader {
    u4 magic;
    u2 minor_version;
    u2 major_version; };
  struct ClassFileConstantPool {
    u2 constant_pool_count
    cp_info constant_pool[constant_pool_count-1]; };
  struct ClassFileInfo {
    u2 access_flags;
    u2 this_class;
    u2 super_class; };
  struct ClassFileInterfaces {
    u2 interfaces_count;
    u2 interfaces[interfaces_count]; };
  struct ClassFileFields {
    u2 fields_count;
    field_info fields[fields_count]; };
  struct ClassFileMethods {
    u2 methods_count;
    method_info methods[methods_count]; };
```

```
struct ClassFileAttributes {
  u2 attributes_count;
  attribute_info attributes[attributes_count]; }; };
```

Like most file formats the Java class file starts with a header which contains an identifiable signature and version information. The Java class file signature is the hex constant 0xCAFEBABE, and the current version number is 45.3. Following this simple header is the variable length `constant_pool`, which is made up of `constant_pool_count-1` variable length entries. Constant pool indices are zero-based, where index #0 is always a 'null' index. Because the first physical entry in the class file is index #1 the constant pool has one less entry than might be expected. This subtlety is a common source of bugs so beware! Beyond the constant pool is a small information section which contains the access flags for the class (`public`, `private`, `abstract`, etc.) and constant pool indices for the name of the class (or interface), and its super class.

After the class file information are the three 'member' sections, `interfaces`, `fields`, and `methods`. The `interfaces` section is simply an array of constant pool indices that detail the name of each interface directly extended by the class. The `fields` and `methods` sections are variable length arrays, with one entry for each field or member. These contain a description of the item, including its name, access flags, a type description, and a variable length number of attributes that provide special information related to the field or method. For example, a constant field will have an attribute which specifies the constant value. Every method within the class has, at a minimum, one attribute which contains its bytecode.

The final section of the class file is a variable length array of attributes for the class, which provide information exactly like the attributes for `fields` and `methods`. Attributes are a very important part of the class file format because they provide a simple mechanism for extending the class file format without breaking current virtual machines. This is possible because attributes are identified by name, some of which are well known. Current virtual machine implementations look for attributes by these well known names. If necessary, you can add extra information to a class or any of its fields or members by adding new, uniquely named, attributes. This new attribute would be ignored by current virtual machines but still be available for your use. Microsoft and other vendors make extensive use of attributes to describe special features such as COM (Component Object Model) or J/Direct. Sun has also added new attributes to extend features of the Java language, specifically an attribute, `InnerClasses`, to describe classes contained within other classes.

ClassDump – the implementation details

The ClassDump utility is written in C++ (Visual C++ 5.0) and was designed and tested under Windows NT 4.0. The code is relatively portable to other platforms and should generally work for Windows 95 although I did not test it explicitly. If you plan to port the code watch out for explicit uses of Unicode functions and types. Windows 95 may not implement some or all of the required functionality.

Because the Java class file format uses the big-endian (high byte first) format for multi-byte values and the Intel x86 series of CPUs and all versions of Windows NT use little-endian (low byte first) any values read from the class file have to be byte-swapped.

To solve this problem you could use macros or inline functions whenever you reference an item which needs to be byte-swapped. Unfortunately (speaking from years of experience porting between Windows and Macintosh systems) this method is extremely error-prone. With C++ there is a better approach which solves the problem in a manner that is very transparent. You guessed it, inline-operators. All the Java programmers out there have been told that use of inline operators is a bad thing, but when they are used appropriately they are extremely powerful.

Here's how it works. Rather than describing the Java class file data structures using primitive types such as `unsigned short` or `unsigned long`, create special data types such as `class JavaU2` (for `unsigned short`) and `class JavaU4` (for `unsigned int`). These act as wrappers around the primitive type. For each type/class define one inline operator that acts as its conversion routine. In this conversion function perform the byte-swap inline or call a helper function.

Here is a slightly abbreviated version of the class used for translating `unsigned int` values. The helper function `LittleEndian` is overloaded to perform the appropriate byte-swap, in this case `sizeof(unsigned int)` or four bytes.

```
class JavaU4 {
public:
  operator unsigned int (void) const
            { return LittleEndian(m_javaType); }
protected:
  unsigned int m_javaType;
};
```

If you need multi-platform code, for big-endian systems just add a type definition, such as:

```
typedef unsigned int JavaU4;
```

and you're all set. For more information, see the ClassDump files, ClassFileTypes.h and ClassFileTypes.cpp (available on EXE Online).

The second technique I use is a C++ template class which acts as a base class for each class file component type. This is useful because most of the items in the Java class file are of variable length and a method for easily accessing them is needed. ClassDump uses the template class `CJavaAccessor` to store pointers to each item in an array.

```
template <class T> class CJavaAccessor {
protected:
  ULONG  m_itemCount;
  T *  m_Items;
  ...
public:
  CJavaAccessor(ULONG numItems)
            { m_Items=new T[m_itemCount=numItems]; }
};
class ConstantPoolAccessor : public
            CJavaAccessor<PCONSTPOOLENTRY> {...};
```

For example, when we walk the constant pool for the class file we use the `CJavaAccessor` base class functionality to allocate an array of the appropriate number of items. Then as we parse each constant pool item we save a pointer to it under the appropriate index in the array. Later when we need to look up the index value it becomes a simple matter to correlate that to the array.

There is a lot of code for the ClassDump utility but if you trace through it a few times you should get a good idea of how the class file format fits together. It will keep you busy until next month when we add the bytecode dissassembly. ■

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

The code for this article is available on EXE Online and directly via ftp at ftp://ftp.exe.co.uk/pub/exestuff/9802_Java.

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Clues for quality training

Francis Glassborow considers how you can assess, in advance, the quality of a C++ training course.

In a couple of previous columns I wrote about the criteria for choosing books on programming. That is only one aspect of developing professional skills. It is a relatively cheap one. Buying the wrong book can waste upwards of £50, hours of time, and considerably raise your blood pressure. However, you can throw it in the bin (if it is really bad, return it and demand your money back). Training is another matter altogether. It will cost a four-figure sum of money and take up a week or more of your time. Neither you nor your employer can easily write off a bad deal.

How can you choose a good trainer? Before I try to answer that I need to declare a direct interest as I present C and C++ training courses both individually and for a couple of training companies. As do several other senior members of the Association of C & C++ Users.

It has been our collective experience that almost invariably the first thing we have to require of a company which contracts us to present its course is that the course be rewritten. The overwhelming majority of courses are like most of the books, of very little use. To make matters worse, many training companies require their presenters to present the material as provided. Good, well-informed presenters will not do this. Many courses are slickly presented rubbish. 'Slickly' because the presenter needs to get a good rating from the delegates, 'rubbish' because most often the presenter does not know enough to insist that the many gross errors in the course material be corrected.

Let me focus on C++ training, though much of what I write can be applied to other courses. Now that we effectively have a C++ standard, courses should converge on an accurate presentation of C++ at an appropriate level of use for the delegates. In general, programmers need to learn how to use C++ at a high level of abstraction and to reap maximum benefit from components (a combination of those provided by the standard C++ Library and third party designers).

Unfortunately, like many other things, programming courses are too often judged by their packaging. Of course, well-presented notes are an advantage, but not at the cost of keeping them up to date. A copy of a good text such as *The C++ Programming Language, 3rd Edition* will be of much more use to you when you have finished your course. In my opinion, course notes are better treated as a checklist of areas which are covered.

Before you are committed

There are a number of clues which you can use before committing yourself to a course. Find out who is going to present it. If the company cannot tell you, start getting suspicious. If they do not know who will present the course then the quality of the presenter will be pure luck. For example, I recently presented a course for a company whose standard contract specified that I would only receive half payment if the delegates' assessment of the course dropped below a certain level. I would receive nothing if it dropped below a further level. I declined: I would consider it unethical for a company to employ a presenter which they were not convinced would do a quality job. For training, one of the things you pay for is the certainty that your time will not be wasted.

The next clue is to discover the level of commitment of the company to keeping its courses up to date. Forget the Microsoft Certified Trainer, IBM whatever, etc. That just means a specific company approves use of its products (actually it means a little more, such as that the trainer uses a particular company approved – usually US – style). Much more important is to enquire about which compiler will be used. Give top marks to a company which passes the buck back to you. If you want C++ training you want to use the latest compiler from a quality implementor. The best C++ courses will be language, not compiler, dependent. The only advantage to the presenter of using a specific compiler is familiarity with quirky error messages, etc. If the course uses anything but the latest compilers then forget it, they are not keeping their courses current.

If the company actively participates in the standardisation process you can expect accurate material, but still be a little wary because some of its presenters may not be so well informed. I know of one UK training company which takes the standards process seriously enough to be voting members of X3J16 – they not only pay for membership they are also regularly represented at meetings (Microsoft lost its voting rights some time ago through lack of attendance). I know of another whose key presenters are active members of BSI's C++ panel.

Another clue is to discover the level of abstraction they use in presenting C++. A course which still starts by introducing non-C programmers to the complications of raw C-style arrays, near the start of the course, is unlikely to be well-suited to application-level programmers.

The number of people on a typical course is helpful information. However experienced the presenter, once you go much above a dozen delegates the course will be constrained by the projected needs of the typical delegate. Such courses will not address the special needs of individuals.

Finally, try to get the company to name a couple of referees who have attended the course you are interested in. Follow these up and listen to what they say. If they focus on such matters as the environment, the food, etc, ask yourself why they want to talk about the packaging. You can always ask me if I would present for a company you are considering. You could also ask the training company to send me the material for the first day of the course, on which I could base an opinion. Any such opinion would be based on technical content.

(Note to trainers: ACCU will provide one or more people to do a critical technical review of your C and C++ courses if you are interested in improving their accuracy.)

Last month's problem

What was the connection between the different parts of that column? Can you think of any way to resolve the problem of providing non-const copy semantics for return values?

The problem with the Committee Draft 1 (CD1) version of auto_ptr was exactly the problem of using non-const copy semantics. As auto_ptr needs to pass ownership of the raw pointer it encapsulates, to the copy (or to the left-hand operand of an assignment), it needs non-const copy semantics. Providing it with const-copy semantics is a horrific breach of coding standards.

What the C++ standards committees were left with was a choice between the devil and the deep blue sea. Those of us who understood the problem knew that ideally we needed to revisit the core of the language to fix the problem with non-const copying. There were two simple changes we could have suggested and either would fix the problem. However, there was no way that we were going to get a majority, let alone a consensus, for either change. Each had too much potential for far reaching side effects. It was for this reason that we found ourselves with the CD2 version of auto_ptr. The experts believed they could get users to avoid its damaging uses.

The UK WG21 delegation, dominated by users rather than implementors, was appalled. We considered the proposal to be such a terrible example of programming, and so fraught with danger to users, that we required it to be fixed before we would support the Draft International Standard. Others could not understand why we wanted to make such a big issue about what was one of the smallest template classes in the whole standard Library.

How to fix it

The first thought which crosses the mind of most people is to tweak the rules about binding references to values. But language designers have a natural repugnance for special cases. Though C++ has a number of instances of special cases (such as the automatic return of 0 from main()) few of us would wish to draft words which allowed non-const references to bind to return values but nowhere else. Allowing non-const references to bind to general values (rvalues) would certainly open up a nasty can of worms. It was hard enough to achieve a consensus on the rules allowing member functions to chain together so that the following code would work:

```
class Turtle {
  // data
public:
  // ctors etc.
  Turtle & left (Degrees );
  Turtle & forward (Distance);
};

int main(){
  Turtle t;
  t.left(90).forward(20);
};
```

Some still do not like the rules which support this programming idiom.

If we cannot find an acceptable way for an rvalue to bind to a non-const parameter perhaps the answer is that we can provide a mechanism to convert an rvalue into an lvalue. We can certainly write code to do this:

```
class X {
  // data
public:
  // various
  X (X); // create an X from an X value
};
```

Unfortunately, the C++ FDIS (Final Draft International Standard) allows you to write such a constructor but states that it will never be called. In other words, you can write it but not use it. Most of us are certain that this is an over constraint but no one was willing to relax the relevant rule at this late stage. Experience has taught us to be wary of making such apparently simple changes.

So how to fix it? I am not going to go into the gruesome details of the complete solution for template classes with member templates (auto_ptr is such a class). However, here are the bare bones of an answer (thanks to Bill Gibbons) which the class designers among you can add to your toolkits (if you need more than this then probably you should not be using this idiom yet).

```
class Plain {
  int i; // just some data
  struct Plainref {
    Plain const & pref;
    // constructors etc.
  };
public:
  // normal baggage
  Plain (Plainref);
  Plain & operator=(Plainref);
};
```

The idea is that you provide a private nested helper class which allows you to create a special reference object from an rvalue of the class. We then provide copy semantics using such an object. This mechanism allows the programmer to do such silly things as binding a non-const reference parameter to a value. However, code constructed according to good practice will be free of hidden surprises.

This month's problem

Integer division tends to be an expensive operation for most hardware. This means that the numerical-methods specialists frequently look for ways of avoiding its use. When dealing with integers, the problem of finding the highest common factor (HCF) frequently occurs. There is an ancient algorithm for this which is attributed to Euclid. What is wrong with the following implementation (you do not need to know Euclid's algorithm to locate the problem)?

```
int findHCF(int first, int second) {
  int temp;
  while(first != second) {
    if(first<second) temp = first, first = second,
      second = temp;
    first -= second;
  }
  return first;
}
```

■

Association of C/C++ Users subscriptions: individual £15, student £7.50, corporate £80, Overload & C++ SIG £30 (including ACCU membership). For further information and application forms write to Francis Glassborow, 64 Southfield Road, Oxford, OX4 1PA, call 01865 246490 or email francis@robinton.demon.co.uk

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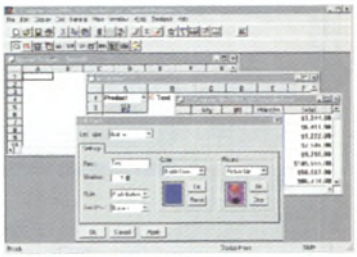

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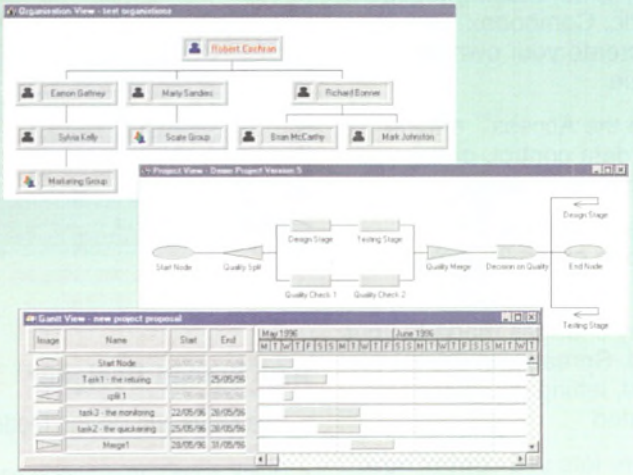

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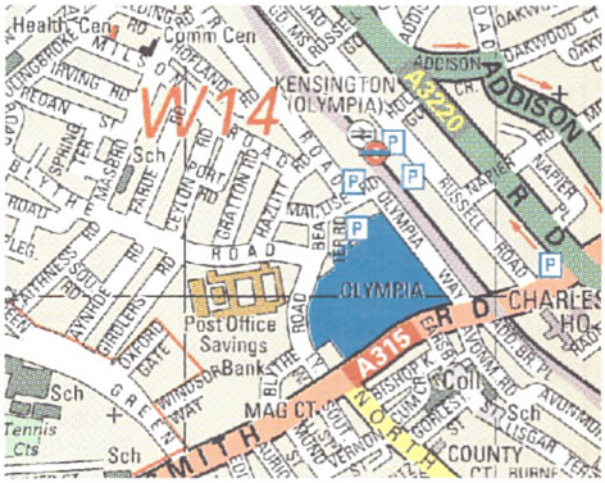

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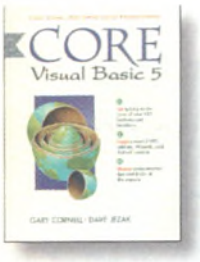
A trio of Visual Basic programming books reviewed by Gavin Smyth

I feel Visual Basic has grown up with the release of version 5.0, for two reasons. Firstly, a lot has been added to the language, such as the ability to produce ActiveX controls. Secondly, Microsoft has made the Control Creation Edition (VBCCE) freely available. Here I take a look at a few books which claim to make you competent in VB programming. All three books cover most of the language and environment, including the creation of ActiveX controls and servers, Add-Ins, and Wizards.

The front cover of ***Core Visual Basic 5*** proclaims that Core books are 'for experienced programmers' but what is meant by 'experienced'? Not VB experts, since the book includes a significant amount on the development environment (stating the obvious in many cases) and a detailed description of the language (with just a few errors to keep us on our toes). Not programming experts, since the authors include yet another introduction to object-oriented programming and feel the need to describe how linked lists work. Nevertheless, the basics (sorry) are covered quite rapidly and the book reads well.



There is a fair amount of overlap between parts of this book and the Microsoft supplied documentation, such as the language and IDE reference sections. I always feel slightly cheated when presented with this sort of material but, in this particular case, the rest of the book makes up for it. There is no coverage of data access controls and very limited mention of the security issues involved in ActiveX control distribution. However, virtually all the rest of VB is adequately addressed. I found the sections on drag and drop, debugging, and ActiveX servers to be particularly good.

As with most recent Windows programming books, the authors attempt to place COM in context but the description is really too brief to be useful. Many of the VB wizards are described, and Messrs Cornell and Jezak take pains to show what the wizards are doing instead of just using them, which leads to a better understanding of when and how to tweak the resultant code. The associated CD includes extended example code and a few potentially useful templates and Add-Ins.

Title:	*Core Visual Basic 5*
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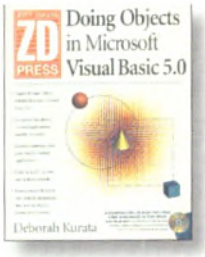
ISBN:	*0-13-748328-7*
Price:	*£26.95*
Pages:	*880 pages*

Doing Objects in Microsoft Visual Basic 5.0, is not just a Visual Basic text. Ms Kurata spends very little space covering the language itself. She assumes that you are familiar with an earlier version of VB (or maybe that you have read the Microsoft manuals). Almost half of the book is about object-oriented software engineering, including yet another OO design method, called GUIDS (Goal-centred design, User-interface design, Implementation-centred design, Data design, and Strategies for construction – the steps covered by the method). The sections on object-oriented techniques are clear and the GUIDS method is quite pragmatic and useable, if vague in places. There is a good discussion of data storage mechanisms, from simple files to more complex databases, but the high point of the book is the clear discussion of polymorphism and interfaces versus inheritance. My main criticism is the amount of repetition with many topics being introduced, then described in depth, and then summarised, as well as being mentioned in other chapters. Nevertheless, if you want to learn both object-oriented design and Visual Basic, this book would be ideal if it wasn't almost as expensive as a pair of books on each topic individually! The obligatory CD contains sample code from the book, a few sample chapters from other Ziff-Davis Press titles, and a couple of third party demonstration programs (which are not discussed in the book).



Title:	*Doing Objects in Microsoft Visual Basic 5.0*
Author:	*Deborah Kurata*
Publisher:	*Ziff-Davis Press, 1997*
ISBN:	*1-56276-444-6*
Price:	*£46.95*
Pages:	*560*

Visual Basic 5 Fundamentals Unleashed, is the final book, and it has an unusual approach. It dives into use of the App-Wizard (after one of those irritating chapters which explain how to click buttons in the IDE), before explaining what makes a Visual Basic application at all. In fact, it is not until about halfway through the book that things like `for...next` loops are explained, and this language description could, I think, have been omitted anyway as it repeats the Microsoft documentation. The large number of authors shows occasionally, with jarring style changes between some of the chapters. Having said that, the book is very clearly written, with plenty of diagrams and code snippets to show what is going on. This book is clearly aimed at a less knowledgeable audience than the other two and it does not cover the more advanced topics in much detail. In addition to the sample code, the accompanying CD contains VBCCE, demonstration copies of Numega tools, and Adobe Acrobat format texts for two other SAMS Visual Basic books. (Note that the VBCCE and Numega tools can already be freely downloaded from the Microsoft and Numega web sites, and have even appeared on computer magazine cover disks.)

In conclusion, all three books are well written and more than adequate for their different target audiences. If you are a VB beginner, choose the SAMS book. If you want to delve into advanced VB, pick Cornell & Jezak. If you want to find out about object orientation with VB, Kurata's book is for you, though it really is too expensive. Don't be swayed by the supplementary CDs; despite the prominence awarded them on the covers of the books, they actually add very little.

✓**Verdict:** all recommended, but make sure you know how you fit the book.

Title:	*Visual Basic 5 Fundamentals Unleashed*
Author:	*M.Amundsen, R.Bernavich, J.Charlesworth, J.Conley, P.Kimmel, R.Layymon, L.Mauer, M.McMillan, G.Perry, A.Reich*
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Leading Management Consultancy is currently seeking Visual Basic developers to join their internal corporate structure within their headquarters in Cambridge. Working with the latest technology you will be involved in a number of exciting projects that will fully utilise your technical abilities and offer you a challenging and rewarding career path. Central to their IT strategy is a global information system which collects and provides information on all the companies activities. Seeking all levels of experience from junior (6 months) to team leader (2 yrs+) with good Visual Basic 4.0-5.0 and MS SQL Server 6.5 experience. Additional knowledge of MS Exchange, Lotus Notes or Intranet development would be advantageous. *Ref: CL08/98*

C++/VISUAL BASIC SUPPORT ANALYST

£30,000 + Banking Benefits City

Major Investment Bank is currently recruiting for a Support Analyst to play a key role in supporting all Front Office Traders. A demanding role that will secure a firm position within the Financial Industry, you will initially be required to deliver enhancements and develop interfaces to one of the most advanced trading systems on the market. To be considered you will need strong 'C' programming experience with knowledge of Visual Basic and SQL Server. Ideally you will have at least 2 years commercial experience and be a capable team player with excellent communication skills. *Ref: CL09/98*

SENIOR ANALYST/PROGRAMMER

£25-28,000 + Benefits City

Looking for a challenging programming role with possible progression to team leader? This AAA rated investment house seeks a focused graduate to provide applications support and development for their credit risk systems. You will possess a minimum of 3 yearsapplications development or database design experience using a RDBMS preferably Ingres or Oracle, plus 2 years of C programming. If you work conducively in a team and have aspirations to progress to a management position then this is the opportunity that you have been looking for! *Ref: JG04/98*

JUNIOR - SENIOR C/C++/VISUAL C++ DEVELOPER

£18-35,000 + Benefits London

Do you have an exemplary academic background, with a computer science bias and wish to pursue development in a financial environment but shy away from the banking arena? Here is the answer! My client is part of a progressive group producing leading edge Financial Data Warehouse products with powerful client/server functionality for financial institutions with high volume processing requirements. Possessing at least one of the following: C/C++, Visual Basic or Visual C++ plus either SQL or Oracle/Sybase/SQL server you will be involved in all stages of the development process from specification to final testing and delivery. *Ref: JG05/98*

UNIX

SENIOR UNIX SYSTEMS ADMINISTRATOR

£28,000 + Benefits Warrington

This state of the art communications organisation with a blue chip client base, the envy of the industry, seeks an experienced administrator with a minimum of 4 years UNIX admin including the use of LVM tools. Joining the systems management team your responsibilities will include installation and maintenance of computer systems, management of network connectivity and evaluation of new products and systems features. Preferably coming from a degree background you will be a self starter able to work in a close knit team. *Ref: JG01/98*

UNIX CAPACITY PLANNER

£32,000 + Benefits London

With a minimum of 3 years UNIX admin including shell scripting, performance tuning and hardware configuration planning experience you will have a keen interest in capacity planning and expert knowledge to a senior level. Responsibilities will include the forecasting and monitoring of capacity requirements for designated systems, hence a pre-requisite is a solid understanding of UNIX operating system concepts including memory management, interprocess communication, devices and file systems architecture. Excellent progression opportunities. *Ref: JG02/98*

CONSULTANTS

SQL CONSULTANT

£50,000 + Benefits City

To join one of the foremost Microsoft Windows NT and BackOffice Consultancies in the UK, this elite team of consultants have been building complete Microsoft BackOffice based solutions for many of the UK's leading corporations. Focusing on providing consultancy to corporate level companies they are currently seeking SQL Server specialists. As a Microsoft Solution Provider Partner you will have access to the latest Microsoft information and activities enabling you to deliver the best in client-server technology through Windows NT within SQL Database Development, SQL Server Systems Management and Internet/Intranet technology. *Ref: CL06/98*

SYSTEMS CONSULTANT

£25-30,000 + Bonus London

Do you have 2-3 years experience of implementing accounting systems or are a Trainer looking for your next career move then this is an opportunity not to miss! A leader in the industry, this financial systems house is seeking high calibre consultants to develop and support client applications and build client relationships to new levels. Working in this high pressure but conducive environment you will possess excellent technical and communications skills and be comfortable with client negotiations. Superb prospects for an ambitious and focused individual with opportunities to cross-train. *Ref: JG12/98*

INTERNET / INTRANET CONSULTANTS

£40,000 + Benefits City/Central London

We currently have several clients in the London area seeking Internet/Intranet consultants. To join either some of the leading management consultancies offering your specialist knowledge and expertise to some of the most demanding customers today or working internally within corporate divisions responsible for the construction of internet/ intranet sites, development and design of all Web sites. Key skills required are an in depth knowledge of Internet/Intranet, MS FrontPage, Domino, HTML, Java, Windows NT and SQL Server. *Ref: CL10/98*

SQL SERVER DBA

£30,000 + Benefits Cambridge/Hertfordshire Border

If you are seeking a solid career in a leading International management consultancy then look no further. Operating worldwide from around 50 offices in over 20 countries our client is distinguished as a consultancy that focuses on creating rather than just proposing change. With over 2,000 employees it is essential not only to service their clients but the consultancy as a whole. Working internally for the company within the corporate division, you will be involved in the implementation of a mission critical system. With a minimum of 1 years DBA experience you will have a thorough understanding of SQL databases, preferably MS SQL Server 6.5 running under Windows NT server. *Ref: CL07/98*

GRADUATES

GRADUATE ANALYST PROGRAMMER

£20,000 + O/T + Benefits City

Are you a high flyer with ambition and the drive to succeed, recently graduated and nowhere to turn? My client, one of the 'Big 6' is currently seeking top level graduates with an upper class honours degree ideally in Computer Science or another Information Technology subject. They require the highest in academic qualifications and in return will offer you a structured and solid career path, with ongoing training and challenging projects that will keep you abreast of the latest in technology. Working internally, you will initially be joining as an Analyst Programmer providing support to in-house applications and developing for the oil industry and then moving onto larger projects. *Ref: CL11/98*

GRADUATE ANALYST/PROGRAMMER

£20-25,000 + Benefits London

Looking for your first job move? Then look no further! This multi-national communications organisation is seeking ideally a technically orientated graduate, with a good all round familiarity with the IT environment, to provide analysis of business reporting requirement for key functional areas. It is essential that you have 4GL programming experience, ideally Oracle v7 and are keen to progress in a high pressure environment. *Ref: JG03/98*

CAREERS & CONTRACTS

EXE brings you the cream of vacancies in the development and programming business.
For more information contact Ben Boswell 0171 970 4838 Fax: 0171 970 4895 Email: benb@dotexe.demon.co.uk

Ninety four per cent of candidates using Connections, in response to a recent survey, have successfully been found a position which promised greater career prospects and, furthermore, higher salaries.

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Fax: 01189 893322
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VISUAL C++

VISUAL C++/FINANCE
Cambs – To £30k

Our client designs and develops financial software for the offshore markets. A vacancy currently exists within their team for a Visual C++ developer. All work is under NT and/or 95. Candidates must be from a strong academic background, preferably with a good University degree. Excellent opportunities to work for a dynamic and successful organisation. *Ref:CP/1*

VISUAL C++/MFC
Wales – £20k-£30k + Car

Leading developer of integrated telephone products requires software engineers with at least 1-2 years Visual C++ and 32bit development experience. This is a customer facing development role and you must enjoy working with people as well as being prepared to travel. You will be responsible for the full project life cycle of bespoke software solutions. An exciting opportunity to develop your skills. *Ref: KB/2*

VISUAL C++/BANKING
California – To £45k

Get away from the drab UK and work in the sun in California. You will be working on software for the financial markets, using Visual C++. There will be a heavy emphasis on OLE work and any experience of ODBC and/or relational databases with SQL would be advantageous. Successful candidates' responsibilities will also include product management and liaising with clients. Initial interviews will be held in the UK. *Ref: DE/3*

WINDOWS DEVELOPMENT

OLE/ACTIVE X/NT
West London – £25k-£40k

Exciting new product for the travel industry. We require programmers through to senior programmers with Visual C++/MFC experience. The successful candidates will be working on Windows NT and 95 platforms using OLE and Active X technologies. There will also be the opportunity to work with JAVA. *Ref: LC/5*

C/C++ DEVELOPERS
Berks – £20k-£30k

This rapidly expanding company manufacture anti fraud check systems. They are currently looking for a developer with at least one years experience of C and C++ under Windows 3.1. Excellent technical and career prospects are available, with this successful and friendly company. *Ref: KB/6*

VISUAL C++/VISUAL BASIC
Herts – To £27k

Our client is the leading independent provider of distributed IT systems and services. They are currently searching for a highly motivated developer with good skills in Visual C++ and/or Visual Basic and excellent client/server or relational database skills. Excellent remuneration packages available and you will have the opportunity to learn other technologies. *Ref: CP/7*

NETWORK MANAGEMENT
Herts – To £35k

Two vacancies with rapidly expanding company to work on the development of new products for global markets. Candidates should have strong Object Oriented Design experience including Visual C++ or Java. Experience of developing network management products and a team spirit are essential for these positions. *Ref: LC/8*

VISUAL BASIC/SYBASE/SQL
Berks – To £30k

This leading insurance company has a vacancy for an Application Developer. Candidates must have at least two years Visual Basic programming, preferably under NT. Sybase or SQL Server experience is also required. Good communication skills are essential as is the ability to learn. *Ref: CP/9*

C++/NT/SYBASE - FINANCE
City/Amsterdam – To £30k

Eight vacancies exist with this major City based European investment bank. Opportunities are at all levels from programmers to project managers. Development is carried out using Visual C++/MFC under Windows NT running with a Sybase back-end. No previous financial knowledge is necessary for candidates with the above technical skills. Excellent benefits package and opportunities to work in Holland. *Ref: FS/10*

VISUAL BASIC

VISUAL BASIC - FINANCE
CITY – To £35k

This Broking company requires two Visual Basic v4 developers to produce GUI's for financial products. Working in a client/server environment, you will require Windows NT and SQL Server experience, as well as a maths or banking background. Bonus skills would be any knowledge of VBA and Excel. Excellent benefits package and career progression. *Ref: RC/17*

VISUAL BASIC DEVELOPERS
City – £22k-£30k

Leading consultancy developing solutions for the asset management community require strong Visual Basic developers. Any SQL or financial markets knowledge an advantage, but not essential. Excellent opportunities to work for a dynamic and successful organisation. *Ref: PP/18*

VISUAL BASIC/ACCESS
City – £24k

This city bank is keen to employ an additional Visual Basic developer who has also used Clipper. New development will all be done using Visual Basic v4. There are a number of existing banking systems, written in Clipper, which will need to be supported. They are soon to implement Windows NT so these skills would be of particular interest. *Ref: RC/19*

Logistix Recruitment Limited, Lamb House, Church Street, Chiswick Mall, London W4 2PD

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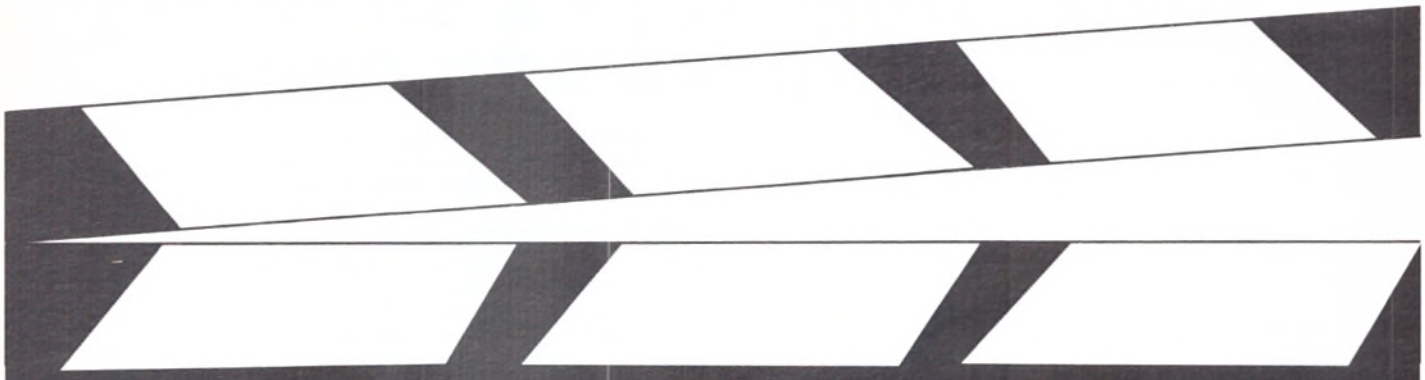

NT 4,5, Object Databases, C++, Client Server, HTML, UML etc.

C. London

Software Engineers
Senior Software Engineers
Principal Analysts
Software Managers

to £50K

Advanced projects utilising C/C++, NT4/5, object databases, high bandwidth servers, RAID techniques, video and audio processing, performance critical systems and quality software delivery techniques. Positions exist at all levels from Developer to Engineering Manager. Specialists in the industry or associated technologies welcome.

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email **mike_jenkins@ers.co.uk** web **http://www.ers.co.uk/ers**

In and Around West Yorkshire

We have clients currently seeking the following:

Developers required for consultancy roles working on client sites in UK & Europe. Experience needed in either Visual BASIC with SQL or in 'C' under UNIX. .....£20,000+

PC Developer for financial systems, experienced in 'C' and Visual BASIC. £18,000

Visual Developer with Visual 'C++' or Visual BASIC or DELPHI or Visual FOXPRO experience to re-develop an existing DOS-based package into an NT environment £16,000 to £20,000

Visual FOXPRO or FOXPRO for DOS Developer.....£17,000

UNIFACE Developers for financial/leasing systems .....£very wide range

Web Page Developers with JAVA, JAVA Script, Internet Server SQL/database or similar experience.....£20,000+

Visual 'C++' Developer to work with MFC5 writing comms software for PCs running NT.....+ excellent benefits to £33,000

For your next career move around West Yorkshire telephone Vincent Atherton on Leeds (0113) 250 4560 or write to:

Airedale Recruitment

Realtex House, Micklefield Lane,
Rawdon, Leeds, LS19 6 AX

THE DEVELOPERS REGISTER

Readers of this magazine will remember our adverts run in early 1995 for the Developers Register. This was for dedicated Software Developers seeking a career path driven by technology rather than management.
This has proved to be very successful with many excellent registered engineers having started with new employers, advancing both their skills and careers. They successfully moved into New Technology gaining and enhancing skills to enable them to move into more technically challenging roles and applications or go into contracting. Importantly, more than a few of those early members have come back ready to move to even greater possibilites. This is a great time to be a Software Engineer.

The Opportunities Are Out There. Call James or Ron for details.

High Quality Jobs for High Quality Software Engineers

SURREY to £28,000 DEFENCE SYSTEM C++ ADA EMBEDDED

This designer of Software for both the Defence and Commercial Environments is expanding it's Software Team. They seek two Qualified Software Engineers to work on a variety of New Embedded Control System Projects. One to specialise exclusively in C++ the other to work on both C++ and ADA development. Good opportunity to enhance your career and C++ skills in a Formal Methods environment. Keywords: C/C++, OOA/OOD, (Booch) ADA, Windows 95, Sun Solaris, UNIX, VxWorks, Rational Rose, MIL STD 2167A etc.

Call James Hunt or Email: james@ash-associates.com

LONDON to £30,000 INTERNATIONAL SECURITIES C++ WINDOWS WIN 32 SDK

This City based International Securities company is expanding it's team working on the development of cutting edge information and analysis software for the Securities Markets. They need bright young qualified Software Engineers with a real interest in the Financial Markets and at least 1 years experience developing Windows applications using C++. The company offers rapid career progression, regular salary reviews and excellent benefits. Keywords:- C++, Windows 95, Win 32, SDK, MFC, Visual C++, OOA/OOD.

Call Kaye Chambers or Michelle Maxwell or Email: kaye@ash-associates.com

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A SUCCESSFUL PAST - A SPARKLING FUTURE...YOURS AND OURS

Our client, Contemporary Software, has some of the most exciting and up to date posts available today. Working in the Windows, Crystal Reporting, JAVA, Internet and Client Server environments they have an enviable client list, lots of work, a successful past and a sparkling future. Headquartered in Berkshire with branch offices in Exeter they are seeking flexible, positive, skilled and dynamic people.

TRAINERS TO £21,000 + BENEFITS INCLUDING CAR

Based at our training centre in Berkshire and providing training to Corporates throughout the UK, you should have training certification for a Windows database, language or reporting application. You will be a highly important member of our team of trainers and consultants, and should have a confident and flexible approach. You will have opportunities to develop your skills in a professional training environment and to help promote and expand a successful business.

CONSULTANTS TO £25,000 + BENEFITS INCLUDING CAR

Based at our Head Office, providing consulting to Corporates throughout the UK, this is a challenging role for confident, dynamic individuals who want to expand their technical skills. Skills in Databases, SQL or Crystal Reports are very highly regarded and any knowledge of Windows, NT, VB, VC++, Delphi or JAVA would be highly beneficial.

DEVELOPER TO £18,000 + BENEFITS

Based at our technology centre in Exeter, heading up client based development projects which may be office or site based, we are looking for a keen individual who wants to work on the latest techniques to gain experience alongside expert colleagues. Skills including Internet Application Development or Crystal Reports along with programming in one of the following: VB, VC++, Delphi, SQL or HTML would be ideal. Training is readily available to bring your skill set right up to date.

TELESALES OTE £25,000 + BENEFITS

Based at our Head Office this post needs Telesales experience, preferably in the Internet field. You will be a clear communicator and Windows proficient looking to develop new sales opportunities for exciting Internet development software. We are sole distributors for this advanced, innovative software. The role involves dealing with Corporate clients and could evolve into an external sales role. Full product and sales training will be given.

We believe that these are amongst the best posts available in this field and will carry negotiable salaries, excellent benefits, full training and a real career path to senior positions, so why not give us a call - ring Mike Hessian or Lindy Smith on 01527 585855 (24 Hours), Skillquest, Bordesley Hall, Alvechurch, Birmingham, B48 7QB. Fax: 01527 60140. E-mail skillquest@btinternet.com

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CONTEMPORARY software

VISUAL BASIC SENIOR ANALYST PROGRAMMER

Peterborough **Salary to £25,000 + excellent bens**

Are benefits and career progression top of your list ? What about interesting project work, at the fore front of the financial sector. With 2 yr. experience of Visual Basic 4/5 and thorough knowledge of Internet technologies this Senior Analyst Programmer position will prove to be an excellent career move. So don't hesitate to make the most of your potential, call to find out more !!!

Ref: MC-1173/EX

VISUAL C++, MFC DEVELOPMENT WITHIN MOTOR RACING

Woking, **Salary £21,000 to £33,000**

We have a very prestigious client involved in the development of **real time Windows systems** for use within precision timing and racing car management environments. They are now seeking **Windows engineers** with skills in **VISUAL C++** and the **MFC** to work on their latest range of award winning software. You will have the opportunity to work within a very fast-moving dynamic team, within an environment that everyone will envy. Ref: JJ - 1160/EX

OO, C++, JAVA, WINDOWS, UNIX A PARTNERSHIP FOR SUCCESS

Coventry **Salary depending on experience**

Software developers!!!! Here's your chance to join one of Europe's leaders in JAVA and C++ development. Do you have a good understanding of Object Orientated Methods as well as a knowledge of JAVA? Excellent opportunities await prestigious company based on the outskirts of Coventry if your a team player and enjoy a varied and challenging role, apply now and be one of the best!

Ref: MC - 1174/EX

VISUAL BASIC DEVELOPERS

Stevenage, **£18,000 - £30,000**

One of our top clients now have a number of great opportunities for motivated and ambitious Visual Basic Developers. To be considered you must have at least 6 months Visual Basic experience with a solid knowledge of SQL coupled with a genuine desire to succeed. This company offers superb remuneration package, travel opportunities and a fantastic working environment. Get in touch today for more info.! Ref: KC - 1172/EX

VISUAL BASIC AND THE INTERNET

North London **From £20,000**

A top name in the ISP Industry is currently looking for solid Visual Basic developers to join their team working on new development projects. **2 years VB experience** is essential as well as experience in at least 1 of the following: **CGI, Perl, Java or HTML.**
Knowledge of database implementation/design techniques and a formal IT qualification are highly advantageous. Varied career options and interesting work will be just part and parcel of your career here.

Ref: KO-1173/EX

VISUAL C++ & JAVA for WEB DEVELOPMENT

London (City) **£30,000 to £70,000 + Benefits**

As one of (if not **THE**) major investor in IT technology this financial information service provider has a number of vacancies from Software Engineer to Technical Architect. Projects are based around Microsoft's Internet Information Server (IIS), Active Server Pages (**ASP**) and Windows NT. You will need between 1-5 years Visual C++/MFC experience along with any experience of JAVA, PLUS any additional knowledge of **ActiveX, COM, DCOM** or **OLE** would be very beneficial. *(Experience in these technologies will be gained).* Ref: DL-1177/EX

VIDEO IMAGING - VISUAL C++

Dartford, **Kent to £30,000**

Our client is currently looking for talented individuals to develop leading edge video imaging products. A Team player is required with at least 18 months Visual C ++ MFC development skills. In return our client will offer you an excellent salary along with good benefits. This is your chance to develop your career in a "state of the art organisation" Ref: TS - 1175/EX

VISUAL C++ AND MULTIMEDIA

South East London **From £25,000**

My client is currently involved in developing European versions of CD ROM and Multimedia software for one of the biggest names in IT. Working with a sister team in Ireland, your expertise will form an essential part of the latest project in this highly successful joint venture.
A minimum of 2 years **Visual C++ MFC** experience is required under Windows NT. Previous experience in the multimedia industry and technologies is highly advantageous, although not essential.

Ref: KO-1174/EX

C++ SOFTWARE ENGINEER

Henley-on-Thames **To £30,000 p.a.**

The Company: Has a leading position in the field of computer telephony integration within the global marketplace.
The Job: Using your C++ and Windows NT/95 skills you will implement code changes, write accurate design specifications and also analyse requirements and problems.
The Person: Motivated professional with at least one year of experience with C++. Also, good communication skills are desirable as there will be some customer contact.
Ref: NB-1178/EX

VISION COMPUTER RECRUITMENT

These are a small selection of our current vacancies. Please call for more information or send/fax/email a CV and we will contact you as soon as possible.
Bessemer House, 3 Canon Harnett Court, Wolverton Mill, Milton Keynes, MK12 5NF.
Telephone: 01908 319600 Fax: 01908 319638 Email: mail@visioncr.co.uk

A whole new way of doing time

Radio 4's *Today* programme recently reported that a more interesting occupation than sewing mailbags is being sought for British prisoners. Fair enough, you say. And the suggestion? That available prison manpower should be devoted to solving the Y2K problem. Under the firm guiding hand of ICL, apparently.

Yes, you read it right the first time. Bored prisoners with time on their hands, and the most serious software problem of the century. Obviously a perfect match. We're surprised no-one thought of it before.

Those convicted of fraud (erm, doesn't that mean all convicted computer experts?) will, we hear, not be considered.

We look forward to receiving email from men with names like 'Knuckles' and 'Razor' on that perennial question of whether to declare a parameter to a class method as a reference or a pointer. In the meantime, for all you novice lags out there, Ctrl-Break heartily recommends *Visual Cobol in 4 years (two and a half with time off for good behaviour)*, HMP Dartmoor Press, price £49.95 from all good bookshops or half a bar of chocolate and a packet of snout in the exercise yard.

Her Majesty's alternatives

But why stop there: what other possible penal schemes could the great and the good invent in their dreams, memo to their secretaries, and present at the next board meeting? Here's some more suggestions from Ctrl-Break...

Software contracting

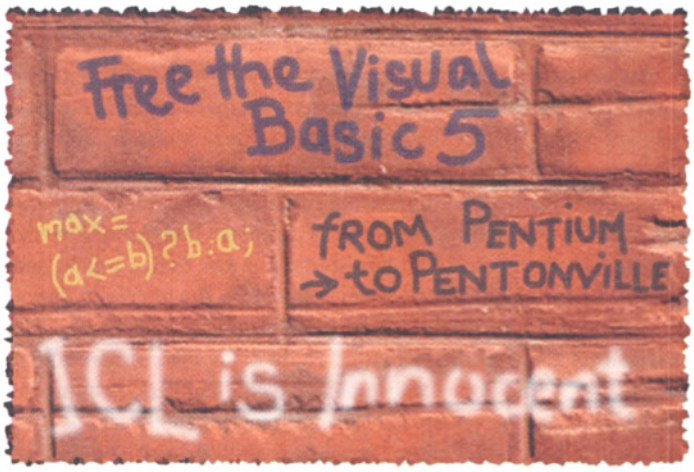
Whatever the length of the contract – one year to twenty years – you can find the personnel to match. Availability for the duration is not in question (prison walls permitting). Of course, your average prison sentence is probably shorter than the realistic completion date of the software project in question, but that's another matter...

Quality assurance

Give old 'Fingers' five minutes and he'll suss-out your software. No locks can contain him and there's no code he can't break. Black box testing, white box testing: breaking out, breaking in, destructive testing...

Project management

'Unit-testing will be finished by Friday or <menace laden pause> *Saturday night you will sleep with the fishes*'. Perhaps with someone



to put the threat back into *dead*lines, a few more of them might be met. A frightening thought: has this policy *already* been implemented. Think of your last project manager. Rational? Understanding? Well balanced? Prone to aggression? Now you know...

Park Gates

Apparently the rumours that Bill Gates is looking for a pied à terre in Holland Park are not true. Verity Stob can't contain her disappointment.

To: marcie.de.raspberry@microsoft.com
Hi Marcie,

Well we did make it to England – or rather me and Jennifer Katharine did – Bill had to stay over to speak to the lawyers; apparently Borland is kicking up a row saying Bill is stealing all their programmers. I don't know why they make all the fuss – it's easy to see why anybody would rather work for Bill than that Mr Potato Head Borland guy – is it Philip something? I'm sure Bill agrees with me on this.

Anyway, England is a real *awful* place, Marcie honey; there are gales and rainstorms and typhoons in trailer parks – it's just like that week we spent in Birmingham Alabama launching Windows for Rednecks. All English cows are poisonous (even the Brits admit this – can you believe it? A whole island, and all they can do is grow poisonous cows!) so I have had the local ethnic grocer, Al Fayed, air-freight over best Florida milk for JK every morning. As I said to Al, where kids are concerned you can't be too careful.

We are renting a condo in this little backwater called Holland Park, which is quite near London, although not on the main island. You can get CNN on cable, so I guess it's not too bad. Yesterday three guys turned up on our doorstep – a fat guy, a little smiley guy, and a guy who looks like that guy who played the Devil in, I forget, was it Exorcist III? Anyway, the little smiley guy asked 'Was Bill in?' and I said 'Maybe' although of course he wasn't and moved my finger to the alarm button, because you cannot be too careful in a place like Holland Park. Then the little smiley guy said his name was Blare and he'd come about the Y2K software problem and the dome. I said I was real sorry about the software problem, but Bill didn't do personal stuff any more and they would have to call the tech support line just like everybody else, and be sure to have their license number, their zip code, and a brief description of their problem ready when the Microsoft operative answered. Then I shut the door in their faces.

Thinking about it later, I figured Blare & Co were probably real estate agents – 'The Dome' is the name of a chain of little restaurants they have around here instead of proper MacDonalds. Perhaps they have a condo near one of these Domes or something. Still, I'm so glad they've gone – Marcie I can't tell you how **creepy** they were!

There's JK wanting new diapers – must go!
Love you,
Mel

To: marcie.de.raspberry@microsoft.com
Marcie,

I apologise, honey! I was wrong and you were right! Nobody here speaks like that woman in Frasier – so I guess she must be Scotch, just like you said. I can't think why she doesn't wear more tartan though – if I were Scotch I'd absolutely, definitely flaunt it!

Talking of Scotland, we went to that training college that Bill bought at Cambridge. It's quite an impressive place, Marse; we must go there together when you come over to visit – it's got its own gym and everything. No room for a proper campus like we have at Redmond though – the Brits went and built it in the middle of this old town, well duh!, so I guess they'll never get a proper 'studenty' atmosphere going.

Still no sign of Bill – he got tied up with Sun over how he was making their Java stuff better by putting Windows code into it, and the lousy ingrates are suing! Can you believe that? I said to Bill, if they don't want their product to work with the World's Number One Operating System, he should have nothing to do with their lousy stinking Java trash, and I think he is coming around to my way of thinking.

Oops, there's the doorbell – got to dash.
Love
Lindy

To: marcie.de.raspberry@microsoft.com
Marcie Darling,

That's it. I'm coming home. Bill's never going to be able to make it over here. Have you heard? Some two-bit outfit called Netcheapskate or something want Bill to stop putting Explorer into Windows, and some stinking bunch of superannuated (big word huh? I'm like that when I'm mad) lawyers, the so-called Supreme Court, are backing them up. I say: what if Netscape was allowed to go on selling its nasty little browser – just how would that make money for Microsoft? If these lawyers are as smart as they say they are, let's hear 'em answer that one. I said this to Bill and he agreed with me absolutely.

Oh, and do you remember the doorbell in my last email? You'll never guess Marse – it was those real estate agents again – Mr Blare and the two others. Luckily I had opened the door on the chain.

Blare – he was the extra-creepy, smiley little one – said: 'Hello again Mrs Gates! I was hoping to have a word with Bill about the Millennium Dome.'

I said: 'I'm sorry about the misunderstanding we had last time Mr Blare, but we are really looking for property in Holland Park, not in Millennium.'

The fat one sniggered and said to the real ornery-looking guy, the Devil, 'Hey Mandy, hadn't you better tell her it's in Grennitch?' (He had an accent a bit like that woman in Frasier, so perhaps he is Scotch too. Although he wasn't wearing a kilt.)

Mr Blare began to say: 'Mrs Gates, I think you have misunderstood. I wanted to ask Bill if he'd be prepared to contribute...', but I popped out the can of mace that I keep by the door (you can't be too careful) and pointed it at him, and said: 'Ok guys – the party is over. Scram.' And to my relief they did – with the Devil running the fastest.

Marse, I guess that it won't come as a surprise that after this we have decided not to buy a place in England – it's not the sort of atmosphere I want for JK. If they want people to live here, the English should stop growing those poison cows, for starters.
Lots of love
Melinda ■

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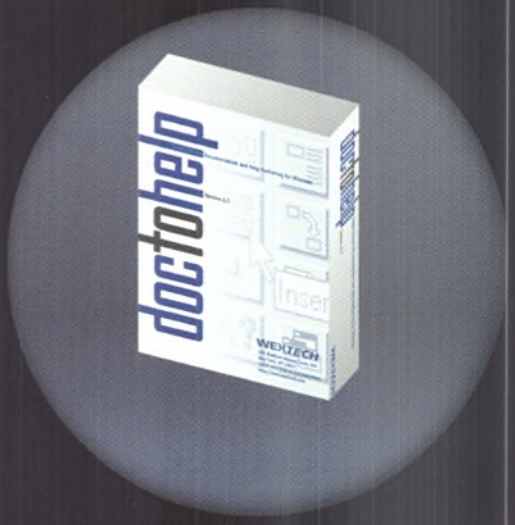

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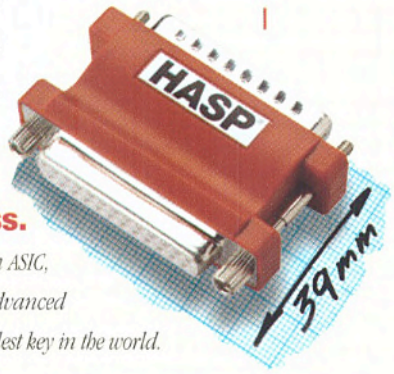

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Enquiry No. Fb33

THE SOFTWARE DEVELOPERS' MAGAZINE

EXE

What are you really worth?

Is your salary right for the job you do? Software development is thought by some to be a goldmine where you can dictate whatever salary you want and come to work in scruffy jeans and a T-shirt. We want to know if this is really so. We're sure many of you think that you should be paid more. Here's your chance to find out how your salary compares with colleagues in similar jobs. For the first time, EXE Magazine will publish a comprehensive survey of the salaries in the software development industry. Help us to understand the current situation by telling us about your job, and we'll give you the real story.

The questionnaire is anonymous and all details will remain confidential. Just tick which job you do, fill in your rate of pay and tell us a bit about your track record, then send this form to us (postage paid). And please pass it on – photocopy this and get your colleagues to complete it, too. The more of you who respond, the more accurately we can tell you what the going rates for your skills and experience are.

Fold, secure and send completed questionnaires back to us or simply fax it to 0171 437 1350.

Your job

1. **Are you in full-time employment?** ☐ a Yes ☐ b No

   1.a. If yes, how many years have you been in full-time employment?
   ☐ a less than 1 ☐ c 2-4 ☐ e 6-10
   ☐ b 1-2 years ☐ d 4-6 ☐ f 10+

   1.b. If no, are you in part-time employment
   ☐ a Yes ☐ b No

   1.b.1 If yes, how many years have you been in part-time employment?
   ☐ a less than 1 ☐ c 2-4 ☐ e 6-10
   ☐ b 1-2 years ☐ d 4-6 ☐ f 10+

   1.c. If no, are you self-employed? ☐ a Yes ☐ b No

   1.c.1 If yes, how many years have you been self-employed?
   ☐ a less than 1 ☐ c 2-4 ☐ e 6-10
   ☐ b 1-2 ☐ d 4-6 ☐ f 10+

2. **Which of the following best describes your company's main activity?**
   ☐ a IT ☐ d Telecoms ☐ h Government
   ☐ b Finance ☐ e Services ☐ i Other
   ☐ c Industry ☐ f Education _____

3. **Which of the following best describes your current job title?**
   ☐ a Software developer ☐ k Database manager
   ☐ b Software engineer ☐ l Design engineer
   ☐ c Software architect ☐ m Information manager
   ☐ d Project engineer ☐ n Web developer
   ☐ e PC programmer ☐ o Multimedia developer
   ☐ f System analyst ☐ p Researcher
   ☐ g System designer ☐ q Contract programmer
   ☐ h Analyst/Programmer ☐ r Technical director
   ☐ i Consultant ☐ s Technical support
   ☐ j Database developer ☐ t Other _____

4. **Which department are you in?**
   _____

5. **Do you currently have a formal flexi-time arrangement?**
   ☐ a Yes ☐ b No

6. **Are you expected to dress formally (suit and tie), smartly (shirt and trousers), or casually (jeans and T-shirt)?**
   ☐ a Formal ☐ c Casual ☐ b Smart

7. **Which programming languages do you use in your job?**
   ☐ a Visual Basic ☐ g Cobol ☐ m JavaScript
   ☐ b Delphi ☐ h 4GL ☐ n VBScript
   ☐ c C ☐ i Lisp ☐ o Assembler
   ☐ d C++ ☐ j Smalltalk ☐ p HTML
   ☐ e Java ☐ k Perl ☐ q Others
   ☐ f Fortran ☐ l TCL _____

8. **What platforms do you develop for?**
   ☐ a Windows ☐ c Unix
   ☐ b MacOS ☐ d Others_____

9. **What platforms do you do development work on?**
   ☐ a Windows ☐ c Unix
   ☐ b MacOS ☐ d Others_____

10. **What type of development are you primarily involved with?**
    ☐ a System software ☐ c Embedded apps
    ☐ b Off-the-shelf apps ☐ d Other
    ☐ c Bespoke apps _____

11. **Are the users of your software primarily in-house?**
    ☐ a Yes ☐ b No

Money matters

12. **Which range does your current salary fall into?**
    ☐ a £10k ☐ f £23k-£26k ☐ k £38k-£41k
    ☐ b £10k-£15k ☐ g £26k-£29k ☐ l £41k-£50k
    ☐ c £15k-£17k ☐ h £29k-£32k ☐ m £50k+
    ☐ d £17k-£20k ☐ i £32k-£35k
    ☐ e £20k-£23k ☐ j £35k-£38k

13. **Do you feel your current salary is:**
    ☐ a Too high ☐ c About right ☐ e Very Low
    ☐ b Quite high ☐ d Slightly Low

14. **Do you feel your current salary accurately reflects your skills and abilities?** ☐ a Yes ☐ b No

15. **Do you receive an annual bonus?** ☐ a Yes ☐ b No

    15.a. If yes, what % of your salary does this bonus represent? _____

16. **What was your salary range 12 months ago?**
    ☐ a <£10k ☐ f £23k-£26k ☐ k £38k-£41k
    ☐ b £10k-£15k ☐ g £26k-£29k ☐ l £41k-£50k
    ☐ c £15k-£17k ☐ h £29k-£32k ☐ m £50k+
    ☐ d £17k-£20k ☐ i £32k-£35k
    ☐ e £20k-£23k ☐ j £35k-£38k

17. **Roughly what amount of salary increase do you expect to receive within the next 12 months?**
    ☐ a No increase ☐ d £2k-£3k ☐ g £5k+
    ☐ b £500-£1k ☐ e £3k-£4k
    ☐ c £1k-£2k ☐ f £4k-£5k

18. **If you changed job what increase in salary would you expect?**
    ☐ a No increase ☐ d £2k-£3k ☐ g £5k+
    ☐ b £500-£1k ☐ e £3k-£4k
    ☐ c £1k-£2k ☐ f £4k-£5k

19. **What range do you expect your salary to fall into in three years time?**
    ☐ a <£10k ☐ f £23k-£26k ☐ k £38k-£41k
    ☐ b £10k-£15k ☐ g £26k-£29k ☐ l £41k-£50k
    ☐ c £15k-£17k ☐ h £29k-£32k ☐ m £50k+
    ☐ d 17k-£20k ☐ i £32k-£35k
    ☐ e £20k-£23k ☐ j £35k-£38k

20. **Is earnings potential the main reason you work within the IT industry?** ☐ a Yes ☐ b No

Your track record

21. **How many employees are there in your company?**
    ☐ a <5 ☐ d 50-99 ☐ g Don't know
    ☐ b 5-9 ☐ e 100-499
    ☐ c 10-49 ☐ f 500+

22. **Where are you based?**
    ☐ a London ☐ f Midlands ☐ k Scotland
    ☐ b M4 corridor ☐ g Wales ☐ l Northern Ireland
    ☐ c South East ☐ h East Anglia ☐ m Other
    ☐ d Southern England ☐ i North West _____
    ☐ e South West ☐ j North East

23. **Which if any of the following qualifications do you possess?**
    ☐ a GCSE ☐ d Degree ☐ g MCP
    ☐ b A-Level ☐ e Masters ☐ h MCSE
    ☐ c HND ☐ f Doctorate ☐ j CNE
    ☐ k Other _____

24. **Are you a member of any professional body or association?**
    ☐ a BCS ☐ d ACCU ☐ g UK Unix UG
    ☐ b ACM ☐ e BUG ☐ h Institute of Analysts & Programmers
    ☐ c IEEE ☐ f VBUG
    ☐ i Others _____

25. **How many years have you been involved in software development?**
    ☐ a 0-1 ☐ c 2-4 ☐ e 6-10
    ☐ b 1-2 ☐ d 4-6 ☐ f 10+

26. **Were you in full-time employment 12 months ago?**
    ☐ a Yes ☐ b No

27. **How long ago did you last change job?**
    ☐ a Have not changed job ☐ e Between 2-3 years
    ☐ b Less than six months ☐ f Between 3-5 years
    ☐ c 6 months to a year ☐ g More than 5 years
    ☐ d Between 1-2 years

28. **Was salary the primary reason for changing?**
    ☐ a Yes ☐ b No

    28.a. If yes, how much did your salary increase?
    ☐ a No increase ☐ d £2k-£3k ☐ g £5k+
    ☐ b £500-£1k ☐ e £3k-£4k
    ☐ c £1k-£2k ☐ f £4k-£5k

    28.b. If no, what was the primary reason for changing?
    _____

29. **How many years have you worked for your current employer?**
    ☐ a less than 1 ☐ c 2-4 ☐ e 6-10
    ☐ b 1-2 years ☐ d 4-6 ☐ f 10+

30. **How many years have you held your current job title?**
    ☐ a less than 1 ☐ c 2-4 ☐ e 6-10
    ☐ b 1-2 ☐ d 4-6 ☐ f 10+

31. **Do you foresee a long-term career with your current employer?** ☐ a Yes ☐ b No

32. **How would you go about finding a new job?**
    ☐ a Recruitment consultant
    ☐ b Word of mouth
    ☐ c Newspaper or magazine advertisement
    ☐ d Direct application to a company

33. **Does your company provide any job-related training?**
    ☐ a Yes ☐ b No

    33.a. If yes, do you feel this training is worthwhile?
    ☐ a Yes ☐ b No

    33.b. How many days of training courses has your company provided within the year?
    ☐ a <3 ☐ c 5-10
    ☐ b 3-5 ☐ d 10+

    33.c. Is this training externally supplied? ☐ a Yes ☐ b No

34. **Have you paid privately for any IT-related training?**
    ☐ a Yes ☐ b No

    34.a If yes, how much did you pay for this training?
    _____

About you

35. **Which of the following age ranges do you currently fall into?**
    ☐ a <20 ☐ e 30-32 ☐ i 42-45
    ☐ b 21-23 ☐ f 33-35 ☐ j 46-50
    ☐ c 24-26 ☐ g 37-39 ☐ k 51+
    ☐ d 27-29 ☐ h 40-42

36. **Are you:** ☐ a Male ☐ b Female

37. **If you have any further comments which you would like us to include in our survey, please enter them below.**
    _____
    _____
    _____
    _____