Professional UML with Visual Studio® .NET
Unmasking Visio® for Enterprise Architects

Andrew Filev
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Kevin McNeish
Ben Schoellmann
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Chaur G. Wu

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Programmer to Programmer™

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Andrew has implemented numerous solutions in various high-tech fields – Web Services, ERP applications, medical systems, development frameworks, among others. He can be reached at andrew@dotsitesoftware.com or www.dotsitesoftware.com.

Special thanks for my friend Igor for his help with the book, also for Doug, Charlotte, and Gerard for their great editorial work. Thanks for dotSITE team without whom I would never take a part in working on the architecture of such interesting projects.

Tony Loton

Tony Loton works through his company LOTONtech Limited (http://www.lotontech.com) as an independent consultant, course instructor, and technical writer. The current area of interest at LOTONtech is the enhancement of UML visual modeling tools – specifically Rational Rose and Visio for Enterprise Architects – to facilitate .NET application design. Further details can be found at http://www.lotontech.com/visualmodeling.

Tony graduated in 1991 with a BSc. Hons. degree in Computer Science and Management and he currently holds an appointment as associate lecturer with the Open University in the UK.

My contribution is dedicated to my wife and children, for respecting my need to "get on with it".

Kevin McNeish

Kevin is President of Oak Leaf Enterprises, a company that specializes in object-oriented developer tools, training, and software. He started his programming career twenty years ago working with Assembly Language, then moved to C, Visual FoxPro, and currently uses C# as his primary .NET development tool. He authored the book *.NET for Visual FoxPro Developers* and teaches both .NET and UML training classes in North America and Europe.

He has also written UML articles for *CoDe*, *FoxPro Advisor,* and *FoxTalk* magazines. Kevin, a Microsoft MVP, is the creator of a .NET business application framework called "The Mere Mortals Framework for .NET". He also mentors software companies in a variety of vertical markets to design and build component-based applications that scale from the desktop to the Internet. He can be reached at oakleaf@oakleafsd.com or www.oakleafsd.com.

As always, thanks to my wife Nicole and my sons Jordan, Timothy, and Alexander for their love and support while writing this book!

Ben Schoellmann

Benjamin Schoellmann credits his move to sunny Houston, Texas, with providing the inspiration necessary to pursue a development and writing career. Currently he is involved with evangelizing .NET technologies among his coworkers at Synhrgy HR Technologies. Among his favored activities are golfing, tinkering with his network, talking incessantly, and integrating hardware and software solutions, primarily home automation, to enhance his leisurely pursuit of Slack. He maintains several content-free WEB domains, including Benjammin.com. He is obsessive about keeping pace with emerging technologies, and is very quick to credit his developer friends with all his success in the IT field.

And while he's quick to blame the dog for just about everything, his friends know better.

I'd like to thank all my friends and family for putting up with me during this process… and the rest of the time as well.

John Slater

John Slater is a project manager at Management Reports International in Cleveland, OH. At MRI he is currently developing applications for the property management industry. Right now, he is working on several projects using .NET development tools and .NET Enterprise servers.

In his free time John enjoys outdoor activities and playing with his children Rachel and Nathan. He can be reached at jr_slater@hotmail.com.

Chaur G. Wu

Chaur Wu currently works for Trend Micro Inc. as a senior software engineer. He started software programming before was old enough to qualify for a driving license. The first program he wrote was a bingo game – in assembly code on a 8051 single chip. To capitalize on the program, he ran a small casino in the lab – he developed primitive game boxes that connected his pals and allowed them to place bets.

He's also been involved in much larger projects. For example, he developed a program in C++ to simulate the movement and geographical coverage of GPS satellites. As a research assistant in his graduate study, he implemented a wavelet-based video compression algorithm for a traffic surveillance system sponsored by Boston City Department of Transportation. He also helped solve a blurred image problem using inverse filters and other image processing algorithms for a client who designs fiber optics components in San Jose, CA.

His technical interests include distributed software systems in Java, COM, and .NET, generative programming, software design, and neural networks. Outside of work, his favorite vacation combines a one-night gambling trip to Reno followed by a day of skiing at some resort near Lake Tahoe.

You can e-mail Chaur at cha_urwu@hotmail.com.

I would like to dedicate my efforts in this book to my two-year-old daughter, Sarah.– CGW

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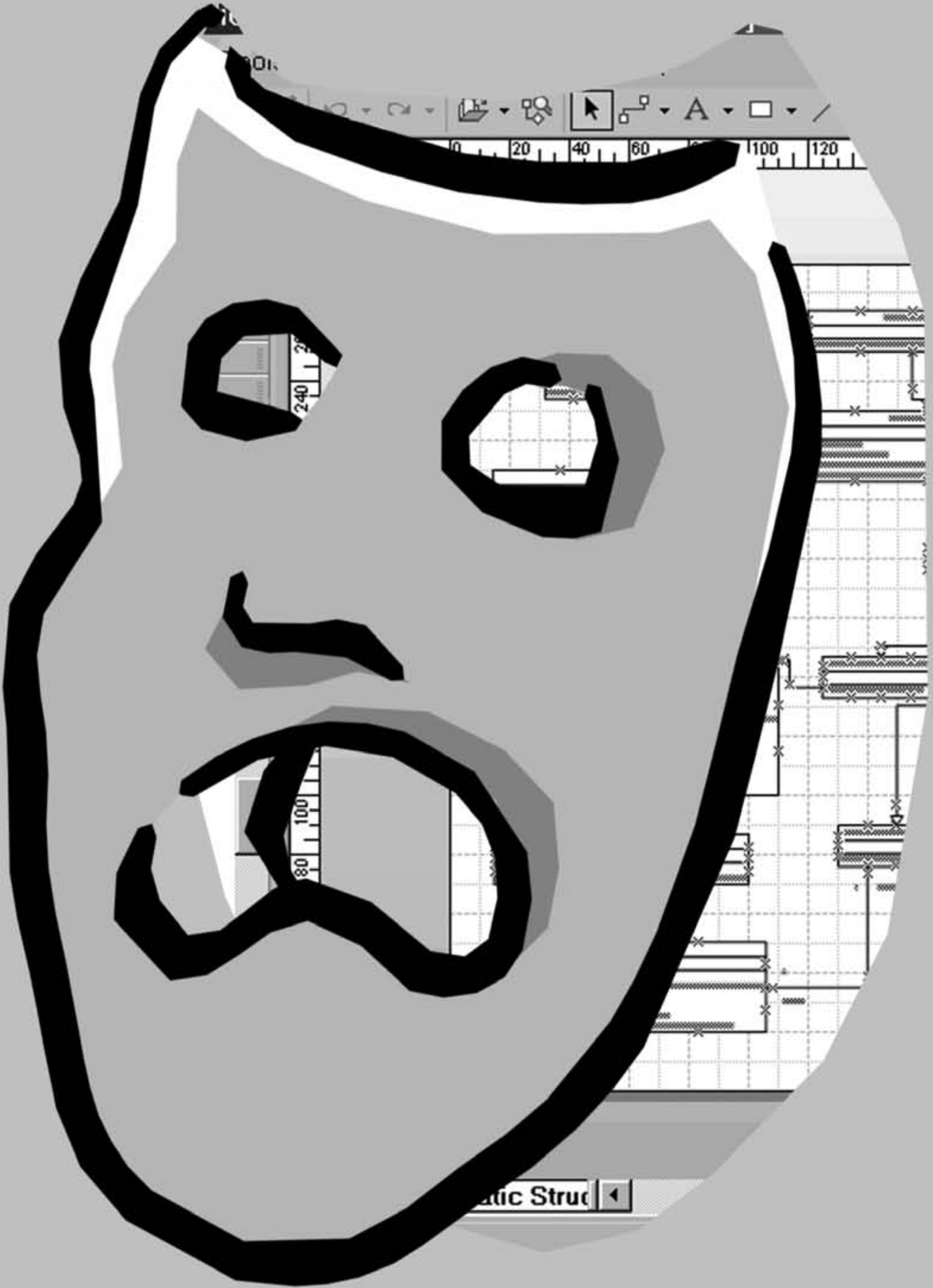
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Introduction

To many, Visio for Enterprise Architects appears to be a mysterious diagramming tool. In conjunction with Visual Studio .NET Enterprise Architect it potential seems clear – going from design to code, and back from code to design offers the developer tremendous benefits for rapidly developing applications. Why do we say 'mysterious'? This is because Visio's range of features can daunt the user, but most importantly, many aspects of its use directly relevant to software developers are frustratingly lacking in explanation.

This book aims to address this problem – here we focus exclusively on Visio's features for developing .NET applications, encompassing:

- UML diagrams
- Generating code from UML diagrams
- Reverse engineering source code into UML diagrams
- Database modeling

Along the way, we'll see some more general applications of Visio to the software development lifecycle, and also learn about Visio's idiosyncrasies, which almost every user of Visio will have encountered, and wondered "Is it just me?"

In other words, this book will allow you to finally unmask Visio for Enterprise Architects.

What Does This Book Cover?

Chapter 1 starts us off by reviewing the key UML concepts, the main diagram types, and the role of those diagrams within the software development process. If you're quite new to UML this will serve as a practical introduction that will help you make sense of the rest of the book.

In Chapter 2 we have our first dip into Visio, and have a look around the general Visio environment. Before we hit the main feature of the book, the UML diagrams, we look at other aspects of Visio that aid software development, and make an attempt to familiarize ourselves with Visio, its pages, shapes, and connectors.

In Chapter 3 we cover using Visio for object modeling – defining data access base classes for your .NET applications, defining a business object base class, deriving business classes from use cases, working with abstract and concrete classes, and using sequence diagrams to model the flow of messages between objects. Along the way we'll meet many of Visio's UML diagramming features, setting us up for the next chapter.

Visio for Enterprise Architects can generate skeleton source code from an existing UML diagram in C#, Visual Basic .NET, or C++. Moreover, Visio provides further options that give the developer greater control over the implementation of this source code. In Chapter 4 we look at how to generate code from a UML model in Visio, the various options available for generating code, including the use of code templates to specify the structure of the source code generated by Visio. We look at a variety of UML to code mappings, typical of the situations you will encounter in more complex models.

The Visual Studio .NET Enterprise Architect and Visio for Enterprise Architects combination provides a facility for reverse engineering existing C#, VB.NET, or C++.NET source code into a Visio UML static structure model. In Chapter 5 we'll look at this reverse engineering feature and cover why reverse engineering is useful how to reverse engineer .NET source code from within the Visual Studio .NET IDE, explore the structure of a typical reverse-engineered Visio UML model, and look at the code to UML mappings for important constructs such as generalization (inheritance) and association. We finish the chapter by using reflection to reverse engineer .NET assemblies to provide .NET Framework base class models for our UML diagrams.

In Chapter 6, we take a step back from the world of diagramming, generating code, and generating more diagrams from code, and look at the role of Visio and UML in the entire software development lifecycle. In effect, we'll be discussing how we document our work at different stages of a typical development project using Visio and UML – at the end of this chapter you'll take away some deeper insight into using Visio and UML in the course of working on your own projects.

Chapter 7 sees us move on to another area of using Visio to assist with general design issues. Designing a distributed system is an iterative process from **requirements analysis** to **modular breakdown** and to **packaging** and **deployment strategies**. However, designing a distributed system is different from designing a non-distributed one. In this chapter we look at a .NET Remoting example, a Bank application. We begin with an overview of .NET Remoting, and we see how to decide which classes in our application should be .NET Remoting types, how to decide the activation mode of each .NET remoting type, and how this can be diagrammed in Visio, what code elements should be grouped in a component, how to prepare a component diagram, and how to prepare a deployment diagram.

Chapter 8 moves us on to yet another aspect of Visio directly relevant to the enterprise developer – data modeling. We take a detailed walk through database modeling and Object Role Modeling (ORM), looking at Visio's ORM Source Diagrams and Entity Relationship Source Diagrams. We then see how to generate a database schema from these models, and further tweak the design with reverse engineering of the database into ORM and ER models, and updating the database with our modifications to yield round-trip database engineering.

Who Is This Book For?

This book is for the .NET developer who:

- ❑ Is comfortable with the basic concepts of UML
- ❑ Wants to learn how to use Visio for Enterprise Architects effectively
- ❑ Wants to see how UML and Visio can benefit their projects in general

What You Need to Use This Book

This book is based around the following combination:

- ❑ Visual Studio .NET Enterprise Architect Edition
- ❑ Visio for Enterprise Architects

Thus, having access to each is a prerequisite for using this book.

Conventions

We've used a number of different styles of text and layout in this book to help differentiate between different kinds of information. Here are examples of the styles we used and an explanation of what they mean.

Code has several fonts. If it's a word that we're talking about in the text – for example, when discussing a `for (...)` loop, it's in this font. If it's a block of code that can be typed as a program and run, then it's also in a gray box:

```
public Employee this[int index]
```

Sometimes we'll see code in a mixture of styles, like this:

```
public Employee this[int index]
{
   get
   {
      foreach (Employee em in employees)
      {
         if (em.ID == index)
```

```
                    return em;
                }
            return null;
            }
        }
```

In cases like this, the code with a white background is code we are already familiar with; the line highlighted in gray is a new addition to the code since we last looked at it.

Advice, hints, and background information come in this type of font.

Important pieces of information come in boxes like this.

Bullets appear indented, with each new bullet marked as follows:

❑ **Important Words** are in a bold type font.

❑ Words that appear on the screen, or in menus like the Open or Close, are in a similar font to the one you would see on a Windows desktop.

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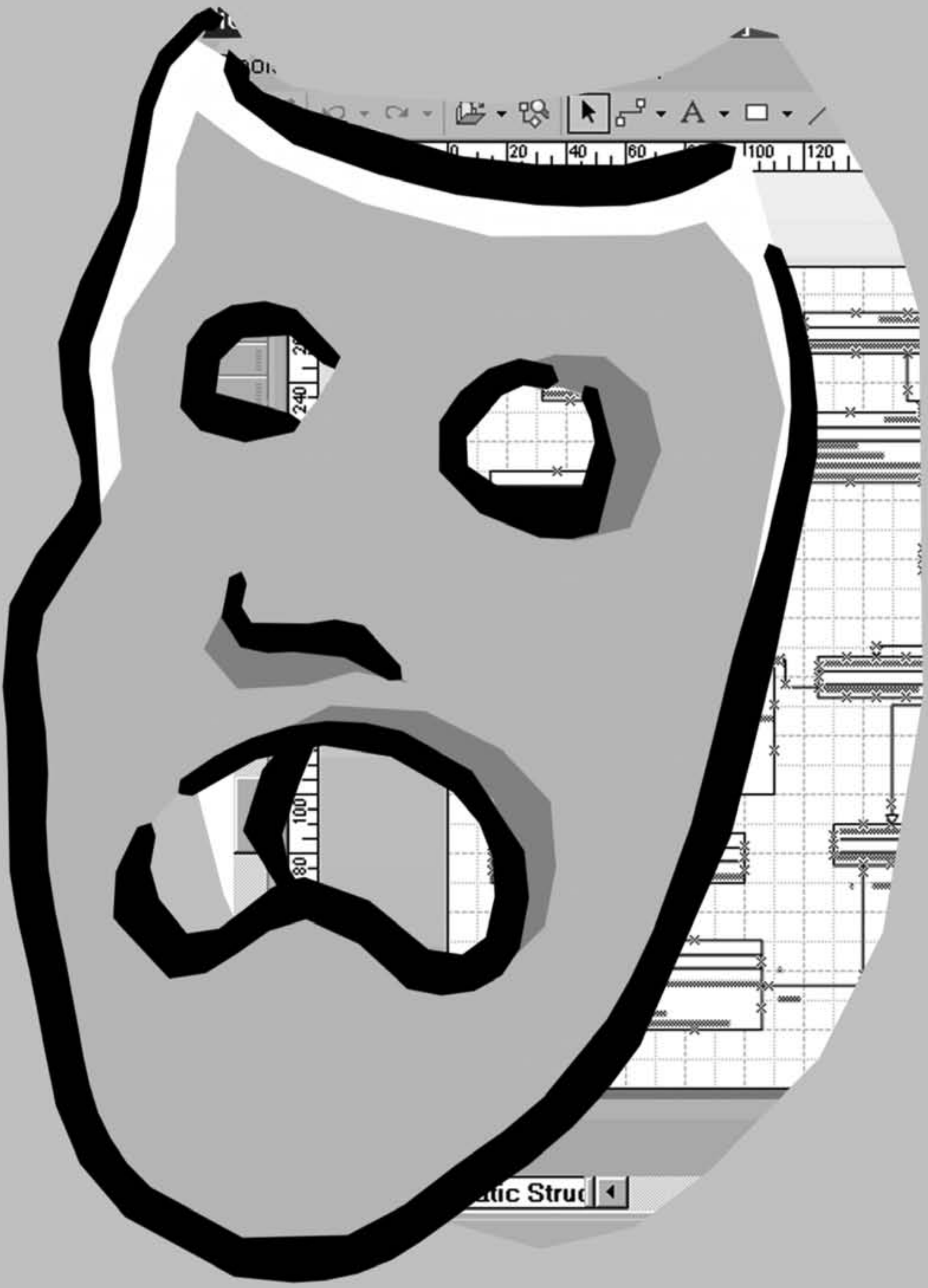

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Review of UML

The purpose of this chapter is to set the scene by reviewing the key UML concepts, the main diagram types, and the role of those diagrams within the software development process. If you're quite new to UML this will serve as a practical introduction that will help you make sense of the rest of the book, before you move on to further reading. If you're experienced with UML the chapter will serve as handy revision and you might just find some nuggets of information that have so far eluded you.

Either way we'll all be moving on from roughly the same starting point: with the same appreciation of UML notation, with an understanding of relevant software development processes, and with a common bias towards .NET and the Visio for Enterprise Architects tool.

The final point is quite important, and the raison d'être for this book. In recent years the body of UML literature has focused mainly on Java development and the use of modeling tools such as Rational Rose. In this book we're applying a .NET development perspective at the same time as demonstrating the so far under-documented Visio modeling tool that comes bundled with the Visual Studio .NET Enterprise Architect.

With all this in mind we can now press on with the introduction to – or revision of, depending on your background – the Unified Modeling Language.

What is the Unified Modeling Language?

When discussing UML, we need to establish one important point right up front.

*The **Unified Modeling Language** is a **notation**; that is a set of diagrams and diagram elements that may be arranged to describe the design of a software system. UML is not a **process**, nor is it a **method** comprising a notation and a process.*

In theory you can apply aspects of the notation according to the steps prescribed by any process that you care to choose – traditional **waterfall**, **extreme programming**, **RAD** – but there are processes that have been developed specifically to complement the UML notation. You'll read more about the complementary process(es) later in this chapter.

Why use UML?

Hidden inside that specific question there's a more generic question, which is **"Why use a formal analysis and design notation, UML or otherwise?"** Let's start to answer that question by drawing an analogy.

Suppose you wanted to make a bridge across a small stream. You could just place a plank of wood across from one side to the other, and you could do so on your own. Even if it failed to hold your weight, the only downside would be wet feet.

Now suppose you wanted to make a bridge across a narrow river. You'd need to do some forward planning to estimate what materials you'd need – wood, brick, or metal – and how much of each. You'd need some help, and your helpers would want to know what kind of bridge you're building.

Finally, suppose you wanted to build a bridge across a very wide river. You'd need to do the same kind of forward planning as well a communicating your ideas to a much bigger team. This would be a commercial proposition with payback from fare-paying passengers, so you'd need to liaise with the relevant authorities and comply with health-and-safety requirements. You'd also be required to leave behind sufficient documentation to allow future generations to maintain the structure long into the future.

In a software context, this means that formal design becomes increasingly important as a function of the size and complexity of the project; in particular, as a function of the number of people involved. Based on that analogy, and wider project experience, we could conclude that a formal design notation is important in:

- Establishing a blueprint from the application
- Estimating and planning the time and materials
- Communicating between teams, and within a team
- Documenting the project

Of course, we've probably all encountered projects in which little or no formal design has been done up-front (corresponding with the first three bullet points in that list); in fact more projects than we care to mention! Even in those situations, UML notation has been found to be invaluable in documenting the end result (the last bullet point in that list). Though not recommended, if that's the extent of your commitment to UML you'll be most interested in the Reverse Engineering discussion in Chapter 5.

Now that we've answered the generic question, let's return to the specific question of **why use UML**?

Well it's become something of an **industry standard**, which means that there's a good chance of finding other people who understand it. That's very important in terms of the **communication** and **documentation** bullet points in our list. Also if you or anyone else in the team does not understand it, there's a good chance of finding relevant training courses, or books like this one.

That's very pragmatic reasoning and perhaps more convincing than a more academic (or even commercial) argument such as:

"The application of UML has a proven track record in improving the quality of software systems."

A Brief History of UML

Taking the phrase **Unified Modeling Language** as our starting point, we've discussed in the previous section the "language" (namely, notation) aspect. In the next section, we'll investigate the "modeling" aspect, which leaves us here with the word "unified". What, or who, preceded the UML and how did it all become **unified**? This will become clear as we step through a brief history of UML.

In the beginning although there was a plethora of object-oriented "methods", there were three principal methods:

- The **Booch** method devised by Grady Booch
- **Object Modeling Technique** (OMT) devised by Jim Rumbaugh
- **Object Oriented Software Engineering** (also known as Objectory) devised by Ivar Jacobson

These three methods have many ideas in common, yet different notation for expressing those ideas. Some of you may remember that in an OMT class diagram the classes were represented as rectangular boxes whereas in the Booch method they were represented as stylized cloud shapes. Also, each method placed emphasis on different aspects of object-oriented software development. For example Jacobson introduced the idea of use cases, not addressed by the other methods.

In simple terms, a use case is a unit of functionality provided by the system to an actor (such as a user). For example, in a word-processing application one of the use cases might be "Run spell checker".

The unification of these three methods combined the best bits of each method with a common notation (UML) for the common concepts – the end result being an industry-standard notation for analysis and design. If you speak with anyone who claims to be doing **object modeling**, chances are they'll be using UML.

So how did this unification play out in time? The key dates are:

- OOPSLA '94 – Jim Rumbaugh leaves General Electric to join Grady Booch at Rational Software, so as to merge their methods and achieve standardization across the industry.
- OOPSLA '95 – Booch and Rumbaugh publish version 0.8 of the **Unified Method**. Rational Software buys Objectory and Ivar Jacobson joins the company.
- January 1997 – Booch, Rumbaugh, and Jacobson (**the three amigos**) release – through Rational – a proposal for the UML version 1.0.
- September 1997 – UML version 1.1 is adopted by the Object Management Group (OMG).

The Object Management Group, previously best known for the CORBA standard, is a non-profit organization – comprising many member companies – that encourages, standardizes, and supports the adoption of object technologies across the industry. You can find out more about the OMG at http://www.omg.org.

If we've given the impression that the Unified Modeling Language is the exclusive work of only three contributors, the three amigos, then let's set the record straight. Some of the concepts are based in the early work of other individuals – for example, David Harel's work on Statechart diagrams – and some further enhancements have come from other member organizations of the OMG; for example, the Object Constraint Language (OCL) devised by IBM.

OCL was devised so that additional rules could be added to a UML model in a language that less ambiguous than English. For example, the statement "Person.Employer=Person.Manager.Employer" may be less ambiguous than "a person and their manager must both work for the same company."

More information on OCL can be found at
http://www-3.ibm.com/software/ad/library/standards/ocl.html.

At the time of writing, the UML specification is at version 1.4 and in mid-2001 the OMG members started work on a major upgrade to UML 2.0. Modeling tools – including Visio for Enterprise Architects – will always be one or two steps behind in their support for the specification, but that's not usually a big problem because the core concepts discussed in the next section are now quite mature and stable.

At the time of writing, the version of Visio for Enterprise Architects used in the construction of this chapter provides support for UML at least up to version 1.2 – this can be determined from the *About error checking in the UML model* section of the Microsoft Visio Help:

"Semantic error checking occurs automatically, noting errors in the design of UML model elements, based on the well-formedness rules in the UML 1.2 specification."

End-to-End UML Modeling

Having looked at why UML is useful, and where it came from, we'll now look at the notation itself. To cover the complete notation in a single chapter would be impossible, so for a deeper coverage I'll refer you to some other works.

- **Instant UML** by Pierre-Alain Muller (Wrox Press, ISBN 1-86100-087-1).
- **The Unified Modeling Language User Guide** by Grady Booch, James Rumbaugh, and Ivar Jacobson (Addison Wesley, ISBN 0-201-57168-4).
- **UML Distilled** by Martin Fowler with Kendall Scott (Addison Wesley, ISBN 0-201-65783-X).

What we'll do here is cover the essential notation and core concepts that will allow us to progress through the rest of the book with a common understanding.

We'll also aim to address one of the problems of many UML courses and books. The problem being, that all too often the various diagrams are presented in isolation without a clear indication of how they relate to one another. To make matters worse, different examples are often used to demonstrate the different diagrams, not one of those examples being for a system that you might actually want to build. Think here of a **statechart diagram** that describes a motor car gearbox, or a **sequence diagram** that describes the operation of a hotel elevator.

So in the following section we'll have a single example, an Order Processing system, which you should be able to relate to even if you don't intend to build such a thing, and at the end, we'll pull it all together.

UML Essential Notation and Core Concepts

Now we'll step through the UML diagrams in turn, all the way from an **activity diagram** through to a **deployment diagram** in this order:

- Activity Diagram
- Use Case Diagram
- Sequence and Collaboration Diagram
- Statechart Diagram
- Static Structure Diagram
- Component Diagram
- Deployment Diagram

Each diagram is labeled in light gray with some of the names given to the UML elements that are shown, which – for the record – reflects the **UML metamodel**.

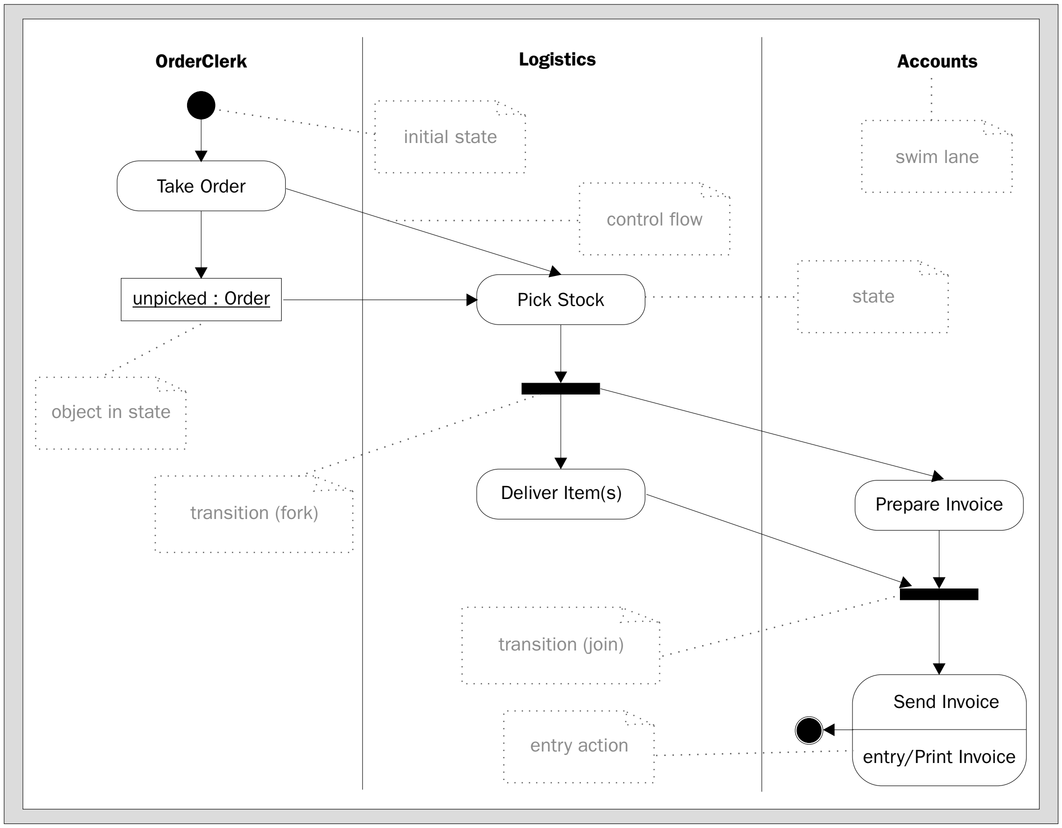
The UML Metamodel is itself a UML model, which defines the rules for constructing other UML models. Whereas in one of your own models you might state "Bank is associated with one or more Accounts", the metamodel would state a more generic relationship of "a Class may be associated with any Other Class".

On the whole, the model elements have been labeled using Visio EA terminology so as to reduce the potential for confusion when you come to use the tool. Historically – and in other modeling tools – you may have encountered alternative UML terminology. The alternative terms have been tabulated towards the end of this chapter.

As you'll see later in this chapter, the software development process that you follow might well be described as **use-case driven**, which implies the **use case diagram** as an obvious starting point. But those use cases will doubtless fit into some kind of overall **business process**, perhaps modeled up-front by a business analyst. So we'll take a business process as our starting point and use this as a vehicle for demonstrating the most suitable diagram for that purpose; the **activity diagram**.

Activity Diagram

The activity diagram is the closest you'll get in UML to a **flow chart**, and the closest you'll get to a **business process diagram**. Here is a sample activity diagram with the important UML elements labeled, followed by a description of those elements.



- **Initial state** is where the diagram begins.
- **Control flow** shows a transfer of control from one activity to another.
- **State** represents a period of time during which a piece of work is carried out by person or team.
- **Transition (fork)** shows the point as which two or more parallel activities will commence.
- **Transition (join)** shows the point as which two or more parallel activities must synchronize and converge.
- **Swim lane** allows all of the activities carried out by a particular person or team arranged into a column.
- **Entry action** shows what must happen when the activity begins.
- **Object in state** shows an object that is produced or consumed in the course of an activity, with the production or consumption (object flow) being represented by the dashed line.