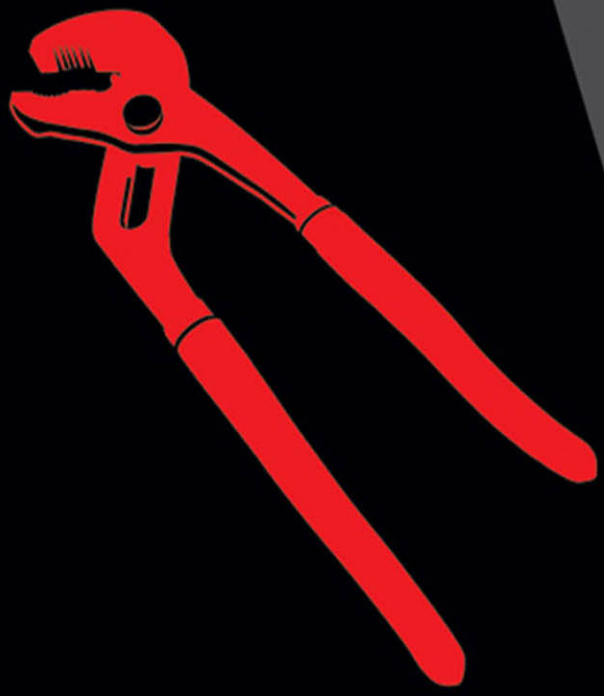
Microsoft

Inside Microsoft Dynamics AX 2012 R3



Professional

The Microsoft Dynamics AX Team

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PUBLISHED BY
Microsoft Press
A Division of Microsoft Corporation
One Microsoft Way
Redmond, Washington 98052-6399

Library of Congress Control Number: 2014940599
ISBN: 978-0-7356-8510-9

Printed and bound in the United States of America.

First Printing

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Contents

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Foreword

The release of Microsoft Dynamics AX 2012 R3 and this book coincide with the tenth anniversary of my involvement with the development of this product. I've had the pleasure to work with a great team of people throughout that period. When I reflect on the modest ambition we set out with a decade ago, I'm excited to see all that we have achieved and am grateful for all the support we received along the way from our customers, partners, and the community around this product.

We set out to build a next-generation line-of-business system that empowered people. We wanted to go beyond traditional ERP in multiple ways:

- First and foremost was to create a system of empowerment, not a system of records. Microsoft Dynamics AX is designed to help people do their jobs, not to record what they did after they did it.
- Second, we wanted to maintain an agile system that allowed businesses to change at their own pace and not at the pace of previous generations of electronic concrete.
- Third, we wanted to provide functional depth and richness while maintaining simplicity of implementation, to allow both midsize and large organizations to use the same system.

The embodiment of our first goal is role-tailored computing and pervasive BI. Those new to the Microsoft Dynamics AX community after AX 2009 can't imagine a day when that wasn't a standard part of the product. AX 2012 takes that richness to a whole new level with more than 80 predefined security roles, and Role Centers for more than 40 distinct functions in an organization.

The implementation of our second goal is in the richness of the AX 2012 metadata system and tools, combined with the fact that all of our solutions and localizations are designed to work together. AX 2012 enhances those capabilities even further while adding the organizational model, self-balancing dimensions, date effectivity, and other powerful application foundation elements.

The realization of the third goal came in the form of deep industry solutions for manufacturing, distribution, retail, service industries, and the public sector, along with a comprehensive set of life cycle services for design, development, deployment, and operations.

This book focuses on the enhancements to the Microsoft Dynamics AX developer toolset and is written by the team that brought you those tools. It's truly an insider's view of the entire AX 2012 development and runtime environment (now updated for the AX 2012 R3 release). I hope you enjoy it as much as we enjoyed writing the book and creating the product.

Here's to the next ten years of our journey together.

Thanks,

Hal Howard

Head of Product Development, Microsoft Dynamics AX
Corporate Vice President, Microsoft Dynamics Research and Development

Introduction

Microsoft Dynamics AX 2012 represents a new generation of enterprise resource planning (ERP) software. With more than 1,000 new features and prebuilt industry capabilities for manufacturing, distribution, services, retail, and the public sector, AX 2012 provides a robust platform for developers to deliver specialized functionality more efficiently to the industries that they support. AX 2012 is a truly global solution, able to scale with any business as it grows. It is simple enough to deploy for a single business unit in a single country, yet robust enough to support the unique requirements for business systems in 36 countries/regions—all from a single-instance deployment of the software. With AX 2012 R3, Microsoft Dynamics AX delivers new levels of capability in warehouse and transportation management, demand planning, and retail.

AX 2012 R3 also represents an important step forward in the evolution of Microsoft Dynamics AX for the cloud. As Microsoft Technical Fellow Mike Ehrenberg explains:

> *Microsoft is transforming for a cloud-first, mobile-first world. As part of that transformation, with the AX 2012 R3 release, we are certifying the deployment of Microsoft Dynamics AX on the Microsoft Azure cloud platform, which uses the Azure Infrastructure as a Service (IaaS) technology. This opens up the option for customers ready to move to the cloud to deploy the power of Microsoft Dynamics AX to run their business; for customers that favor on-premises deployment, it complements the option to harness the Microsoft Azure cloud platform for training, development, testing, and disaster recovery—all workloads with the uneven demand that the cloud serves so well. One of the most exciting new capabilities introduced with AX 2012 R3 is Lifecycle Services, our new Azure cloud-based service that streamlines every aspect of the ERP deployment, management, servicing, and upgrade lifecycle—regardless of whether AX 2012 itself is deployed on-premises or in the cloud. We are leveraging the cloud to deliver rapidly evolving services to help all of our customers ensure that they are following best practices across their AX 2012 projects. We are already seeing great results in rapid deployments, streamlined support interactions, and performance tuning—and this is only the beginning of our very exciting journey.*

Customers have also weighed in on the benefits of Microsoft Dynamics AX 2012:

> *Microsoft Dynamics AX 2012 allows us to collaborate within our organization and with our constituents … using built-in controls and fund/encumbrance accounting capabilities to ensure compliance with Public Sector requirements … and using out-of the-box Business Analytics and Intelligence … so executives can make effective decisions in real time.*
>
> *Mike Bailey*
> *Director of Finance and Information Services*
> *City of Redmond (Washington)*

> *With AX 2012, developing for and customizing Microsoft Dynamics AX will be easier than ever. Developers will be able to work with X++ directly from within Microsoft Visual Studio and enjoy more sophisticated features in the X++ editor, for example. Also, the release includes more prebuilt interoperability with Microsoft SharePoint Server and SQL Server Reporting Services, so that developers spend less time on mundane work when setting up customer systems.*
>
> *Guido Van de Velde*
> *Director of MECOMS™*
> *Ferranti Computer Systems*

AX 2012 is substantially different from its predecessor, which can mean a steep learning curve for developers and system implementers who have worked with previous versions. However, by providing a broad overview of the architectural changes, new technologies, and tools for this release, the authors of *Inside Microsoft Dynamics AX 2012 R3* have created a resource that will help reduce the time that it takes for developers to become productive.

The history of Microsoft Dynamics AX

Historically, Microsoft Dynamics AX encompasses more than 25 years of experience in business application innovation and developer productivity. Microsoft acquired the predecessor of Microsoft Dynamics AX, called Axapta, in 2002, with its purchase of the Danish company Navision A/S. The success of the product has spurred an increasing commitment of research and development resources, which allows Microsoft Dynamics AX to grow and strengthen its offering continuously.

The development team that created AX 2012 consists of three large teams, two that are based in the United States (Fargo, North Dakota, and Redmond, Washington) and one that is based in Denmark (Copenhagen). The Fargo team focuses on finance and human resources (HR), the Redmond team concentrates on project management and accounting and customer relationship management (CRM), and the Copenhagen team delivers supply chain management (SCM). In addition, a framework team develops infrastructure components, and a worldwide distributed team localizes the Microsoft Dynamics AX features to meet national regulations or local differences in business practices in numerous languages and markets around the world.

To clarify a few aspects of the origins of Microsoft Dynamics AX, the authors contacted people who participated in the early stages of the Microsoft Dynamics AX development cycle. The first question we asked was, "How was the idea of using X++ as the programming language for Microsoft Dynamics AX conceived?"

> *We had been working with an upgraded version of XAL for a while called OO XAL back in 1996/1997. At some point in time, we stopped and reviewed our approach and looked at other new languages like Java. After working one long night, I decided that our approach had to change to align with the latest trends in programming languages, and we started with X++.*
>
> *Erik Damgaard*
> *Cofounder of Damgaard Data*

Of course, the developers had several perspectives on this breakthrough event.

> *One morning when we came to work, nothing was working. Later in the morning, we realized that we had changed programming languages! But we did not have any tools, so for months we were programming in Notepad without compiler or editor support.*
>
> *Anonymous developer*

Many hypotheses exist regarding the origin of the original product name, Axapta. Axapta was a constructed name, and the only requirement was that the letter X be included, to mark the association with its predecessor, XAL. The X association carries over in the name Microsoft Dynamics AX.

Who should read this book

This book explores the technology and development tools in AX 2012 through the AX 2012 R3 release. It is designed to help new and existing Microsoft Dynamics AX developers by providing holistic and in-depth information about developing for AX 2012—information that may not be available from other resources, such as SDK documentation, blogs, or forums. It aids developers who are either customizing AX 2012 for a specific implementation or building modules or applications that blend seamlessly with AX 2012. System implementers and consultants will also find much of the information useful.

Assumptions

To get full value from this book, you should have knowledge of common object-oriented concepts from languages such as C++, C#, and Java. You should also have knowledge of relational database concepts. Knowledge of Structured Query Language (SQL) and Microsoft .NET technology is also advantageous. Transact-SQL statements are used to perform relational database tasks, such as data updates and data retrieval.

Who should not read this book

This book is not aimed at those who install, upgrade, or deploy AX 2012. It is also beyond the scope of this book to include details about the sizing of production environments. For more information about these topics, refer to the extensive installation and implementation documentation that is supplied with the product or that is available on Microsoft TechNet, Microsoft Developer Network (MSDN), and other websites.

The book also does not provide instructions for those who configure parameter options within AX 2012 or the business users who use the application in their day-to-day work. For assistance with these activities, refer to the help that is included with the product and available on TechNet at *http://technet.microsoft.com/en-us/library/gg852966.aspx*.

Organization of this book

Although *Inside Microsoft Dynamics AX 2012 R3* does not provide exhaustive coverage of every feature in the product, it does offer a broad view that will benefit developers as they develop for AX 2012.

This book is divided into four sections, each of which focuses on AX 2012 from a different angle. Part I, "A tour of the development environment," provides an overview of the AX 2012 architecture that has been written with developers in mind. The chapters in Part I also provide a tour of the internal AX 2012 development environment to help new developers familiarize themselves with the designers and tools that they will use to implement their customizations, extensions, and integrations.

Part II, "Developing for AX 2012," provides the information that developers need to customize and extend AX 2012. In addition to explanations of the features, many chapters include examples, some of which are available as downloadable files that can help you learn how to code for AX 2012. For information about how to access these files, see the "Code samples" section, later in this introduction.

Part III, "Under the hood," is largely devoted to illustrating how developers can use the underlying foundation of the AX 2012 application frameworks to develop their solutions, with a focus on the database layer, system and application frameworks, reflection, and models.

Part IV, "Beyond AX 2012," focuses on developing companion apps for mobile devices that allow AX 2012 users to participate in critical business processes even when they are away from their computers. It also describes exciting new techniques and tools, such as Lifecycle Services, that help partners and customers manage every aspect of the application life cycle.

Conventions and features in this book

This book presents information by using the following conventions, which are designed to make the information readable and easy to follow.

- Application Object Tree (AOT) paths use backslashes to separate nodes, such as *Forms\AccountingDistribution\Methods*.
- The names of methods, functions, properties and property values, fields, and nodes appear in italics.
- Registry keys and T-SQL commands appear in capital letters.
- User interface (UI) paths use angle brackets to indicate actions—for example, "On the File menu, point to Tools > Options."
- Boxed elements with labels such as "Note" provide additional information or alternative methods for completing a step successfully.
- Text that you type (apart from code blocks) appears in bold.
- A plus sign (+) between two key names means that you must press those keys at the same time. For example, "Press Alt+Tab" means that you hold down the Alt key while you press the Tab key.

System requirements

To work with most of the sample code, you must have the RTM version of AX 2012 installed. For the Language-Integrated Query (LINQ) samples, you must be using AX 2012 R3. For information about the system requirements for installing Microsoft Dynamics AX 2012, see the Microsoft Dynamics AX 2012 Installation Guide at

http://www.microsoft.com/en-us/download/details.aspx?id=12687

You must also have an Internet connection to download the sample files that are provided as supplements to many of the chapters.

Note Some of the features described in this book, such as data partitioning and the EP Chart Control, apply only to AX 2012 R2 and AX 2012 R3. That is noted where those features are discussed.

Code samples

Most of the chapters in this book include code examples that let you interactively try out the new material presented in the main text. You can download the example code from the following page:

http://aka.ms/InsideDynaAXR3

Follow the instructions to download the *9780735685109_files.zip* file.

Installing the code samples

Follow these steps to install the code samples on your computer:

1. Unzip the file that you downloaded from the book's website.
2. If prompted, review the displayed end user license agreement. If you accept the terms, select the accept option, and then click Next.

Note If the license agreement doesn't appear, you can access it from the same webpage from which you downloaded the file.

Using the code samples

The code examples referenced in each chapter are provided as both .xpo files that you can import into Microsoft Dynamics AX and Visual Studio projects that you can open through the corresponding .csproj files. Many of these examples are incomplete, and you cannot import and run them successfully without following the steps indicated in the associated chapter.

Acknowledgments

We want to thank all the people who assisted us in bringing this book to press. We apologize for anyone whose name we missed.

Microsoft Dynamics product team

Special thanks go to the following colleagues, whom we're fortunate to work with.

Margaret Sherman, whose Managing Editor duties included wrangling authors, chasing down stray chapters, translating techno-speak into clear English, keeping numerous balls in the air, and herding a few cats. Margaret kept the project moving forward, on schedule, on budget, and with a real commitment to quality content. Thank you, Margaret! This project wouldn't have happened without your leadership!

Mark Baker and Steve Kubis, who contributed ace project management and editing work.

Margo Crandall, who provided a quick and accurate technical review at the last minute for Chapter 23.

Hal Howard, Richard Barnwell, and Ann Beebe, who sponsored the project and provided resources for it.

We're also grateful to the following members of the product team, who provided us with the reviews and research that helped us refine this book:

Ned Baker
Ian Beck
Andy Blehm
Jim Brotherton
Ed Budrys
Gregory Christiaens
Ahmad El Husseini
Josh Honeyman
Hitesh Jawa
Vijeta Johri
Bo Kampmann
Vinod Kumar
Arif Kureshy
Josh Lange
Mey Meenakshisundaram
Igor Menshutkin
Jatan Modi
Sasha Nazarov
Adrian Orth
Christopher Read (Entirenet)
Bruce Rivard
Gana Sadasivam
Alex Samoylenko
Ramesh Shankar
Tao Wang
Lance Wheelwright
Chunke Yang

In addition, we want to thank Joris de Gruyter of Streamline Systems LLC. His SysTestListenerTRX code samples on CodePlex (*http://dynamicsaxbuild.codeplex.com /releases*), with supporting documentation on his blog (*http://daxmusings.blogspot.com/*), and his collaboration as we investigated this approach for executing SysTests from Microsoft Dynamics AX were valuable resources as we prepared the chapter on testing.

Microsoft Press

Another big thank you goes to the great people at Microsoft Press for their support and expertise throughout the writing and publishing process.

Carol Dillingham, the Content Project Manager for the book, who provided ongoing support and guidance throughout the life of the project.

Rosemary Caperton—Acquisitions Editor

Allan Iversen—Technical Reviewer

Kathy Krause—Project Editor and Copyeditor with Online Training Solutions, Inc. (OTSI)

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This edition of the book is dedicated to Hal Howard, with many thanks for your leadership.

—The Microsoft Dynamics AX Team

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CHAPTER 2

The MorphX development environment and tools

In this chapter

Introduction

AX 2012 includes a set of tools, the MorphX development tools, that you can use to build and modify AX 2012 business applications. Each feature of a business application uses the application model elements described in Chapter 1, "Architectural overview." With the MorphX tools, you can create, view, modify, and delete the application model elements, which contain metadata, structure (ordering and hierarchies of elements), properties (key and value pairs), and X++ code. For example, a table element includes the name of the table, the properties set for the table, the fields, the indexes, the relations, and the methods, among other things.

This chapter describes the most commonly used tools and offers some tips and tricks for working with them. You can find additional information and an overview of other MorphX tools in the MorphX Development Tools section of the AX 2012 software development kit (SDK) on the Microsoft Developer Network (MSDN).

Tip To enable development mode in AX 2012, press Ctrl+Shift+W to launch the Development Workspace, which holds all of the development tools.

Table 2-1 lists the MorphX tools and components.

TABLE 2-1 MorphX tools and other components used for development.

Tool	Purpose
Application Object Tree (AOT)	Start development activities. The AOT is the main entry point for most development activities. It allows the developer to browse the repository of all elements that together make up the business application. You can use the AOT to invoke the other tools and to inspect and create elements.
Projects	Group related elements into projects.
Property sheet	Inspect and modify properties of elements. The property sheet shows key and value pairs.
X++ code editor	Inspect and write X++ source code.
Label editor	Create and inspect localizable strings.
Compiler	Compile X++ code into an executable format.
Best Practices tool	Automatically detect defects in both your code and your elements.
Debugger	Find bugs in your X++ code.
Reverse Engineering tool	Generate Microsoft Visio Unified Modeling Language (UML) and entity relationship diagrams (ERDs) from elements.
Table Browser tool	View the contents of a table directly from a table element.
Type Hierarchy Browser and Type Hierarchy Context	Navigate and understand the type hierarchy of the currently active element.
Find tool	Search for code or metadata patterns in the AOT.
Compare tool	See a line-by-line comparison of two versions of the same element.
Cross-Reference tool	Determine where an element is used.
Version control	Track all changes to elements and see a full revision log.

You can access these development tools from the following places:

- In the Development Workspace, on the Tools menu
- On the context menus of elements in the AOT

You can personalize the behavior of many MorphX tools by clicking Options on the Tools menu. Figure 2-1 shows the Options form.

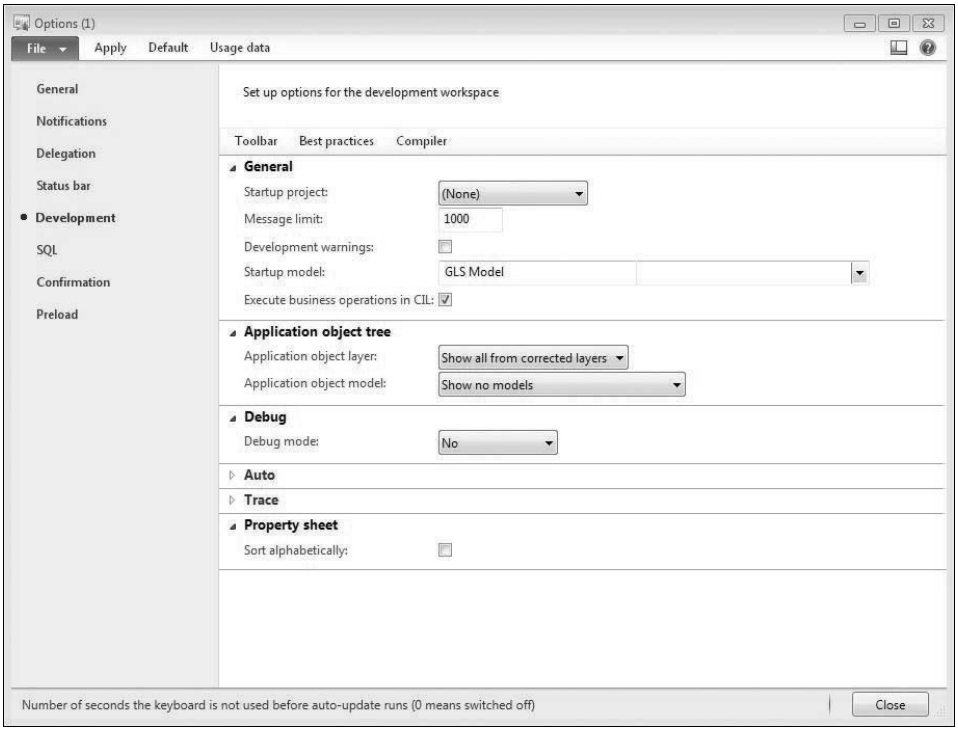

FIGURE 2-1 The Options form, in which development options are specified.

Application Object Tree

The AOT is the main entry point to MorphX and the repository explorer for all metadata. You can open the AOT by clicking the AOT icon on the toolbar or by pressing Ctrl+D. The AOT icon looks like this:

Navigating through the AOT

As the name implies, the AOT is a tree view. The root of the AOT contains the element categories, such as Classes, Tables, and Forms. Some elements are grouped into subcategories to provide a better structure. For example, Tables, Maps, Views, and Extended Data Types are located under Data Dictionary, and all web-related elements are located under Web. Figure 2-2 shows the AOT.

FIGURE 2-2 The AOT.

You can navigate through the AOT by using the arrow keys on the keyboard. Pressing the Right Arrow key expands a node if it has any children.

Elements are arranged alphabetically. Because there are thousands of elements, it's important to understand the naming conventions and adhere to them to use the AOT effectively.

All element names in the AOT use the following structure:

<Business area name> + <Functional area> + <Functionality, action performed, or type of content>

With this naming convention, similar elements are placed next to each other. The business area name is also often referred to as the *prefix*. Prefixes are commonly used to indicate the team responsible for an element. For example, in the name *VendPaymReconciliationImport*, the prefix *Vend* is an abbreviation of the business area name (Vendor), *PaymReconciliation* describes the functional area (payment reconciliation), and *Import* lists the action performed (import). The name *CustPaymReconciliationImport* describes a similar functional area and action for the Customer business area.

Tip When building add-on functionality, in addition to following this naming convention, you should add another prefix that uniquely identifies the solution. This additional prefix will help prevent name conflicts if your solution is combined with work from other sources. Consider using a prefix that identifies the company and the solution. For example, if a company called MyCorp is building a payroll system, it could use the prefix *McPR* on all elements added.

Table 2-2 contains a list of the most common prefixes and their descriptions.

TABLE 2-2 Common prefixes.

Prefix	Description
Ax	Microsoft Dynamics AX typed data source
Axd	Microsoft Dynamics AX business document
Asset	Asset management
BOM	Bill of material
COS	Cost accounting
Cust	Customer
Dir	Directory, global address book
EcoRes	Economic resources
HRM/HCM	Human resources
Invent	Inventory management
JMG	Shop floor control
KM	Knowledge management
Ledger	General ledger
PBA	Product builder
Prod	Production
Proj	Project
Purch	Purchase
Req	Requirements
Sales	Sales
SMA	Service management
SMM	Sales and marketing management, also called customer relationship management (CRM)
Sys	Application frameworks and development tools
Tax	Tax engine
Vend	Vendor
Web	Web framework
WMS	Warehouse management

Tip When creating new elements, ensure that you follow the recommended naming conventions. Any future development and maintenance will be much easier.

Projects, described in detail later in this chapter, provide an alternative view of the information in the AOT.

Creating elements in the AOT

You can create new elements in the AOT by right-clicking the element category node and selecting New <*Element Type*>, as shown in Figure 2-3.

FIGURE 2-3 Creating a new element in the AOT.

Elements are given automatically generated names when they are created. However, you should replace the default names with new names that conform to the naming convention.

Modifying elements in the AOT

Each node in the AOT has a set of properties and either subnodes or X++ code. You can use the property sheet (shown in Figure 2-9, later in this chapter) to inspect or modify properties, and you can use the X++ code editor (shown in Figure 2-11, later in this chapter) to inspect or modify X++ code.

The order of the subnodes can play a role in the semantics of the element. For example, the tabs on a form appear in the order in which they are listed in the AOT. You can change the order of nodes by selecting a node and pressing the Alt key while pressing the Up Arrow or Down Arrow key.

A red vertical line next to a root element name marks it as modified and unsaved, or *dirty*, as shown in Figure 2-4.

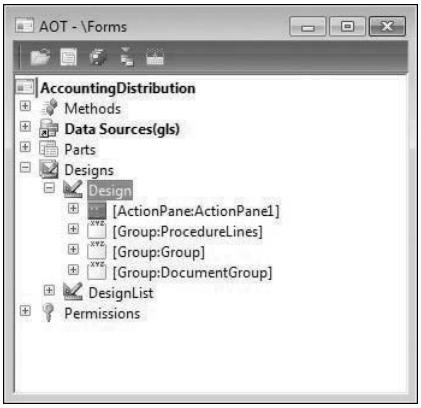

FIGURE 2-4 A dirty element in the AOT, indicated by a vertical line next to the top-level node, *AccountingDistribution*.

A dirty element is saved in the following situations:

- When the element is executed.
- When the developer explicitly invokes the Save or Save All action.
- When autosave takes place. You specify the frequency of autosave in the Options form, which is accessible from the Tools menu.

Refreshing elements in the AOT

If several developers modify elements simultaneously in the same installation of AX 2012, each developer's local elements might not be synchronized with the latest version. To ensure that the local versions of remotely changed elements are updated, an autorefresh thread runs in the background. This autorefresh functionality eventually updates all changes, but you might want to force the refresh of an element explicitly. You do this by right-clicking the element, and then clicking Restore. This action refreshes both the on-disk and the in-memory versions of the element.

Typically, the general integrity of what's shown in the AOT is managed automatically, but some operations, such as restoring the application database or reinstalling the application, can lead to inconsistencies that require manual resolution to ensure that the latest elements are used. To perform manual resolution, follow these steps:

1. Close the AX 2012 client to clear any in-memory elements.
2. Stop the Microsoft Dynamics Server service on the Application Object Server (AOS) to clear any in-memory elements.
3. Delete the application element cache files (*.auc) from the Local Application Data folder (located in %LocalAppData%) to remove the on-disk elements.

Element actions in the AOT

Each node in the AOT contains a set of available actions. You can access these actions from the context menu, which you can open by right-clicking any node.

Here are two facts to remember about actions:

- The actions that are available depend on the type of node you select.
- You can select multiple nodes and perform actions simultaneously on all the nodes selected.

A frequently used action is Open New Window, which is available for all nodes. It opens a new AOT window with the current node as the root. This action was used to create the screen capture of the *AccountingDistribution* element shown earlier in Figure 2-4. After you open a new AOT window, you can drag elements into the nodes, saving time and effort when you're developing an application.

You can extend the list of available actions on the context menu. You can create custom actions for any element in the AOT by using the features provided by MorphX. In fact, all actions listed on the Add-Ins submenu are implemented in MorphX by using X++ and the MorphX tools.

You can enlist a class as a new add-in by following this procedure:

1. Create a new menu item and give it a meaningful name, a label, and Help text.
2. Set the menu item's *Object Type* property to **Class**.
3. Set the menu item's *Object* property to the name of the class to be invoked by the add-in.
4. Drag the menu item to the *SysContextMenu* menu.
5. If you want the action to be available only for certain nodes, modify the *verifyItem* method on the *SysContextMenu* class.

Element layers and models in the AOT

When you modify an element from a lower layer, a copy of the element is placed in the current layer and the current model. All elements in the current layer appear in bold type (as shown in Figure 2-5), which makes it easy to recognize changes. For a description of the layer technology, see the "Layers" section in Chapter 21, "Application models."

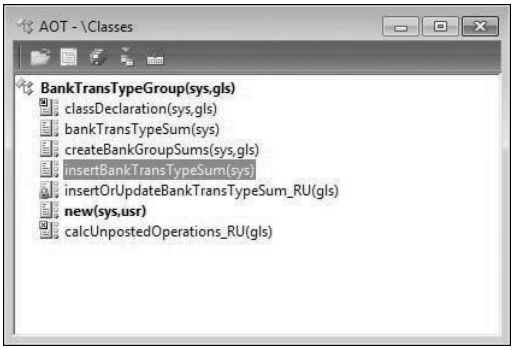

FIGURE 2-5 An element in the AOT that exists in several layers.

You can use the Application object layer and Application object model settings in the Options form to personalize the information shown after the element name in the AOT (see Figure 2-1, shown earlier). Figure 2-5 shows a class with the Show All Layers option set. As you can see, each method is suffixed with information about the layers in which it is defined, such as *SYS*, *VAR*, and *USR*. If an element exists in several layers, you can right-click it and then click Layers to access its versions from lower layers. It is highly recommended that you use the Show All Layers setting during code upgrade because it provides a visual representation of the layer dimension directly in the AOT.

Projects

For a fully customizable overview of the elements, you can use *projects*. In a project, you can group and structure elements according to your preference. A project is a powerful alternative to the AOT because you can collect all the elements needed for a feature in one project.

Creating a project

You open projects from the AOT by clicking the Project icon on the toolbar. Figure 2-6 shows the Projects window and its *Private* and *Shared* projects nodes.

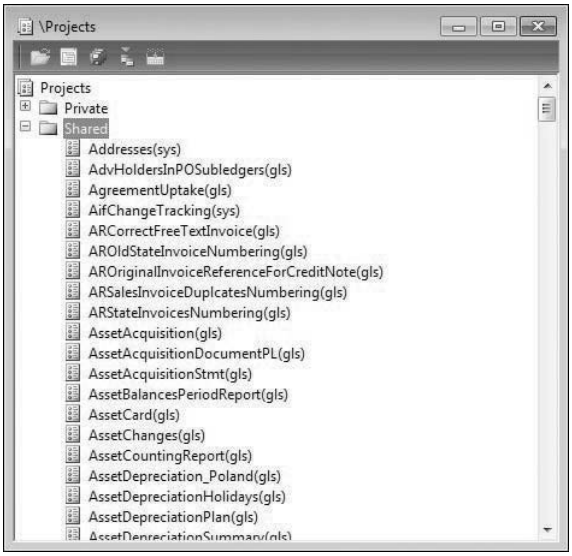

FIGURE 2-6 The Projects window, showing the list of shared projects.

Except for its structure, a project generally behaves like the AOT. Every element in a project is also present in the AOT.

When you create a new project, you must decide whether it should be private or shared among all developers. You can't set access requirements on shared projects. You can make a shared project private (and a private project shared) by dragging it from the shared category into the private category.

Note Central features of AX 2012 are captured in shared projects to provide an overview of all the elements in a feature. No private projects are included with the application.

You can specify a startup project in the Options form. If specified, the chosen project automatically opens when AX 2012 is started.

Automatically generating a project

Projects can be automatically generated in several ways—from using group masks to customizing project types—to make working with them easier. The following sections outline the various ways to generate projects automatically.

Group masks

Groups are folders in a project. When you create a group, you can have its contents be automatically generated by setting the *ProjectGroupType* property (All is an option) and providing a regular expression as the value of the *GroupMask* property. The contents of the group are created automatically and

are kept up to date as elements are created, deleted, and renamed. Using group masks ensures that your project is always current, even when elements are created directly in the AOT.

Figure 2-7 shows the *ProjectGroupType* property set to *Classes* and the *GroupMask* property set to *ReleaseUpdate* on a project group. All classes with names containing *ReleaseUpdate* (the prefix for data upgrade scripts) will be included in the project group.

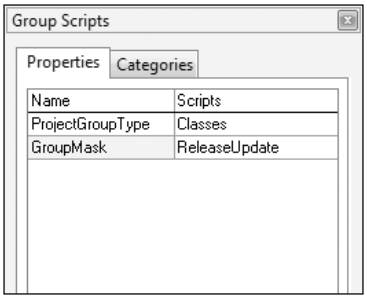

FIGURE 2-7 Property sheet specifying settings for *ProjectGroupType* and *GroupMask*.

Figure 2-8 shows the resulting project when the settings from Figure 2-7 are used.

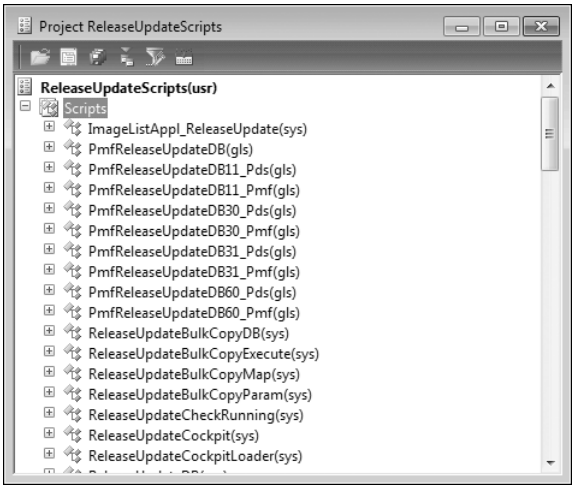

FIGURE 2-8 Project created by using a group mask.

Filters

You can also generate a project based on a filter. Because all elements in the AOT persist in a database format, you can use a query to filter elements and have the results presented in a project. You create a project filter by clicking Filter on the project's toolbar. Depending on the complexity of the query, a project can be generated instantly or it might take several minutes.

With filters, you can create projects containing elements that meet the following criteria:

- Elements created or modified within the last month
- Elements created or modified by a named user
- Elements from a particular layer

Development tools

Several development tools, such as the Wizard Wizard, produce projects containing elements that the wizard creates. The result of running the Wizard Wizard is a new project that includes a form, a class, and a menu item—all the elements that make up the newly created wizard.

You can also use several other wizards, such as the AIF Document Service Wizard and the Class Wizard, to create projects. To access these wizards, on the Tools menu, click Wizards.

Layer comparison You can compare the elements in one layer with the elements in another layer, which is called the *reference layer*. If an element exists in both layers and the definitions of the element are different, or if the element doesn't exist in the reference layer, the element is added to the resulting project. To compare layers, click Tools > Code Upgrade > Compare Layers.

Upgrade projects When you upgrade from one version of Microsoft Dynamics AX to another or install a new service pack, you need to deal with any new elements that have been introduced and existing elements that have been modified. These changes might conflict with customizations you've implemented in a higher layer.

The Create Upgrade Project feature makes a three-way comparison to establish whether an element has any upgrade conflicts. It compares the original version with both the customized version and the updated version. If a conflict is detected, the element is added to the project.

The resulting project provides a list of elements to update based on upgrade conflicts between versions. You can use the Compare tool, described later in this chapter, to see the conflicts in each element. Together, these features provide a cost-effective toolbox to use when upgrading. For more information about code upgrade, see "Microsoft Dynamics AX 2012 White Papers: Code Upgrade" at *http://www.microsoft.com/download/en/details.aspx?id=20864*.

To create an upgrade project, click Tools > Code Upgrade > Detect Code Upgrade Conflicts.

Project types

When you create a new project, you can specify a project type. So far, this chapter has discussed standard projects. The Test project, used to group a set of classes for unit testing, is another specialized project type provided in AX 2012.

You can create a custom specialized project by creating a new class that extends the *ProjectNode* class. With a specialized project, you can control the structure, icons, and actions available to the project.

The property sheet

Properties are an important part of the metadata system. Each property is a key and value pair. You can use the property sheet to inspect and modify properties of elements.

When the Development Workspace opens, the property sheet is visible by default. If you close it, you can open it again anytime by pressing Alt+Enter or by clicking the Properties button on the toolbar of the Development Workspace. The property sheet automatically updates itself to show properties for any element selected in the AOT. You don't have to open the property sheet manually for each element; you can leave it open and browse the elements. Figure 2-9 shows the property sheet for the *TaxSpec* class. The two columns are the key and value pairs for each property.

Tip Pressing Esc in the property sheet sets the focus back to your origin.

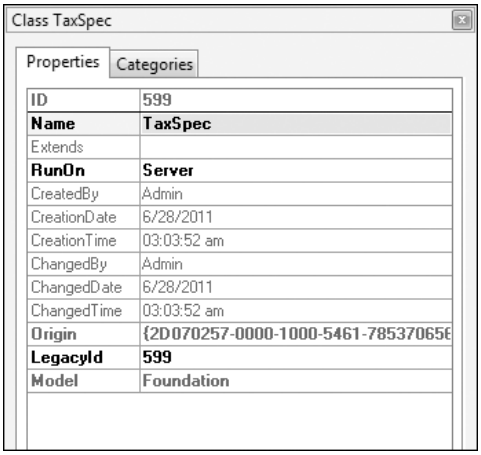

FIGURE 2-9 Property sheet for an element in the AOT.

Figure 2-10 shows the Categories tab for the class shown in Figure 2-9. On this tab, related properties are categorized. For elements with many properties, this view can make it easier to find the right property.

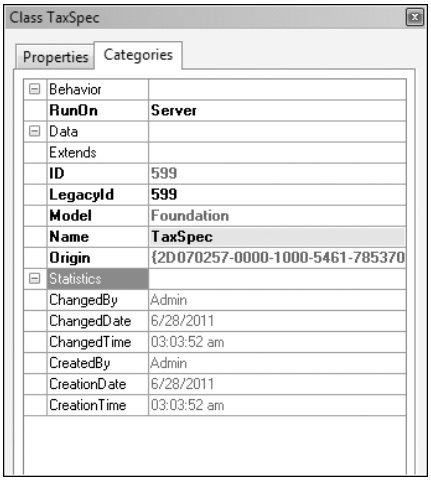

FIGURE 2-10 The Categories tab on the property sheet for an element in the AOT.

Read-only properties appear in gray. Just like files in the file system, elements contain information about who created them and when they were modified. Elements that come from Microsoft all have the same time and user stamps.

The default sort order places related properties near each other. Categories were introduced in an earlier version of Microsoft Dynamics AX to make finding properties easier, but you can also sort properties alphabetically by setting a parameter in the Options form.

You can dock the property sheet on either side of the screen by right-clicking the title bar. Docking ensures that the property sheet is never hidden behind another tool.

X++ code editor

All X++ code is written with the X++ code editor. You open the editor by selecting a node in the AOT and pressing Enter. The editor contains two panes. The left pane shows the methods available, and the right pane shows the X++ code for the selected method, as shown in Figure 2-11.

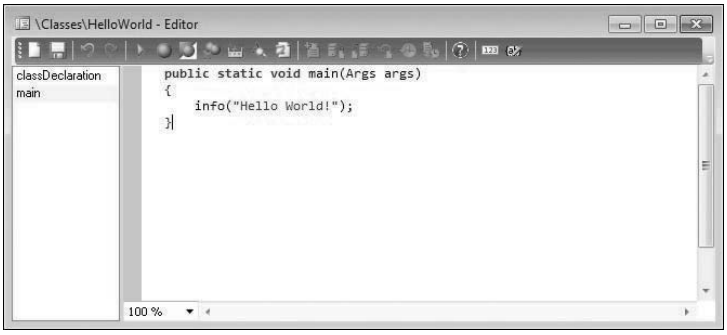

FIGURE 2-11 The X++ code editor.

The X++ code editor is a basic text editor that supports color coding and IntelliSense.

Shortcut keys

Navigation and editing in the X++ code editor use standard shortcuts, as described in Table 2-3. For AX 2012, some shortcuts differ from those in earlier versions to align with commonly used integrated development environments (IDEs) such as Microsoft Visual Studio.

TABLE 2-3 X++ code editor shortcut keys.

Action	Shortcut	Description
Show the Help window	F1	Opens context-sensitive Help for the type or method currently selected in the editor.
Go to the next error message	F4	Opens the editor and positions the cursor at the next compilation error, based on the contents of the Compiler Output window.
Execute the current element	F5	Starts the current form, job, or class.
Compile	F7	Compiles the current method.
Toggle a breakpoint	F9	Sets or removes a breakpoint.
Run an editor script	Alt+R	Lists all available editor scripts and lets you select one to execute (such as Send To Mail Recipient).
Open the Label editor	Ctrl+Alt+Spacebar	Opens the Label editor and searches for the selected text.
Go to the implementation (drill down in code)	F12	Goes to the implementation of the selected method. This shortcut is highly useful for fast navigation.
Go to the next method	Ctrl+Tab	Sets the focus on the next method in the editor.
Go to the previous method	Ctrl+Shift+Tab	Sets the focus on the previous method in the editor.
Enable block selection	Alt+<mouse select> or Alt+Shift+arrow keys	Selects a block of code. Select the code you want by pressing the Alt key while selecting text with the mouse. Alternatively, hold down Alt and Shift while moving the cursor with the arrow keys.
Cancel the selection	Esc	Cancels the current selection.
Delete the current selection or line	Ctrl+X	Deletes the current selection or, if nothing is selected, the current line.
Start an incremental search	Ctrl+I	Starts an incremental search, which marks the first occurrence of the search text as you type it. Pressing Ctrl+I again moves to the next occurrence, and Ctrl+Shift+I moves to the previous occurrence.
Insert an XML document header	///	Inserts an XML comment header when you type ///. When typed in front of a class or method header, this shortcut prepopulates the XML document with template information relevant to the class or method.
Comment the selection	Ctrl+E, C	Inserts comment marking for the current selection.
Uncomment the selection	Ctrl+E, U	Removes comment marking for the current selection.

Editor scripts

The X++ code editor contains a set of editor scripts that you can invoke by clicking the Script icon on the X++ code editor toolbar or by right-clicking an empty line in the code editor, pointing to Scripts, and then clicking the script you want. Built-in editor scripts provide functionality such as the following:

- Send to mail recipient.
- Send to file.
- Generate code for standard code patterns such as *main*, *construct*, and *parm* methods.
- Open the AOT for the element that owns the method.

Note By generating code, in a matter of minutes you can create a new class with the right constructor method and the right encapsulation of member variables by using *parm* methods. *Parm* methods (*parm* is short for "parameter") are used as simple property getters and setters on classes. Code is generated in accordance with X++ best practices.

Tip To add a main method to a class, add a new method, press Ctrl+A to select all code in the editor tab for the new method, type **main**, and then press the Tab key. This will replace the text in the editor with the standard template for a static main method.

The list of editor scripts is extendable. You can create your own scripts by adding new methods to the *EditorScripts* class.

Label editor

The term *label* in AX 2012 refers to a localizable text resource. Text resources are used throughout the product as messages to the user, form control labels, column headers, Help text in the status bar, captions on forms, and text on web forms, to name just a few uses. Labels are localizable, meaning that they can be translated into most languages. Because the space requirement for displaying text resources typically depends on the language, you might fear that the actual user interface must be manually localized as well. However, with IntelliMorph technology, the user interface is dynamically rendered and honors any space requirements imposed by localization.

The technology behind the label system is simple. All text resources are kept in a Unicode-based label files that are named with three-letter identifiers. In AX 2012, the label files are managed in the AOT and distributed by using model files. Figure 2-12 shows how the *Label Files* node in the AOT looks with multiple label files and the en-us language identifier.

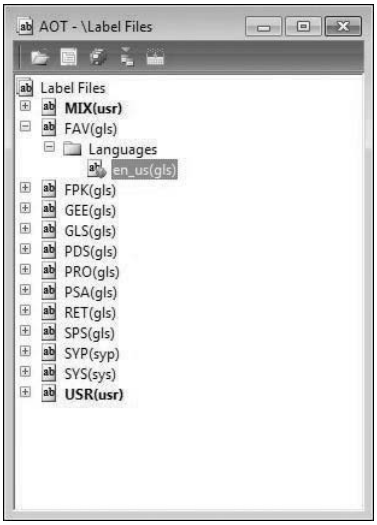

FIGURE 2-12 The *Label Files* node in the AOT.

The underlying source representation is a simple text file that follows this naming convention:

Ax<Label file identifier><Locale>.ALD

The following are two examples, the first showing a U.S. English label file and the second a Danish label file:

Axsysen-us.ALD

Axtstda.ALD

Each text resource in the label file has a 32-bit integer label ID, label text, and an optional label description. The structure of the label file is simple:

@<Label ID><Label text>

[Label description]

Figure 2-13 shows an example of a label file.

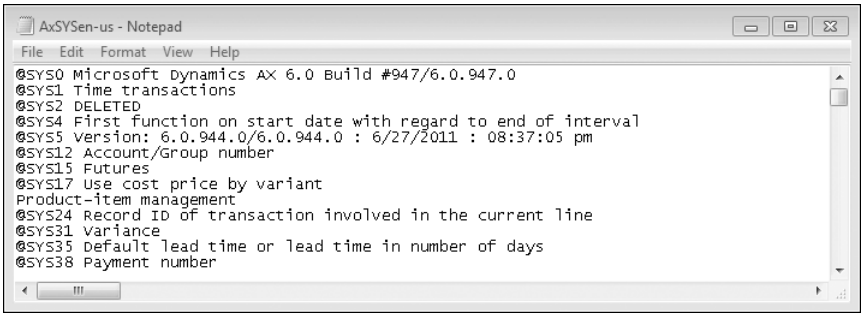

FIGURE 2-13 Label file opened in Notepad showing a few labels from the en-us label file.

This simple structure allows for localization outside of AX 2012 with third-party tools. The AOT provides a set of operations for the label files, including an Export To Label file that can be used to extract a file for external translation.

You can create new label files by using the Label File Wizard, which you access directly from the *Label Files* node in the AOT, or from the Tools menu by pointing to Wizards > Label File Wizard. The wizard guides you through the steps of adding a new label file or a new language to an existing label file. After you run the wizard, the label file is ready to use. If you have an existing .ald file, you can also create the appropriate entry in the AOT by using Create From File on the context menu of the *Label Files* node in the AOT.

Note You can use any combination of three letters when naming a label file, and you can use any label file from any layer. A common misunderstanding is that the label file identifier must match the layer in which it is used. AX 2012 includes a *SYS* layer and a label file named *SYS*; service packs contain a *SYP* layer and a label file named *SYP*. This naming standard was chosen because it is simple, easy to remember, and easy to understand. However, AX 2012 doesn't impose any limitations on the label file name.

Consider the following tips for working with label files:

- When naming a label file, choose a three-letter ID that has a high chance of being unique, such as your company's initials. Don't choose the name of the layer, such as *VAR* or *USR*. Eventually, you'll probably merge two separately developed features into the same installation, a task that will be more difficult if the label file names collide.
- When referencing existing labels, feel free to reference labels in the label files provided by Microsoft, but avoid making changes to labels in these label files because they are updated with each new version of Microsoft Dynamics AX.

Creating a label

You use the Label editor to create new labels. You can start the Label editor by using any of the following procedures:

- On the Tools menu, point to Label > Label Editor.
- On the X++ code editor toolbar, click the Lookup Label > Text button.
- On text properties in the property sheet, click the Lookup button.

You can use the Label editor (shown in Figure 2-14) to find existing labels. Reusing a label is sometimes preferable to creating a new one. You can create a new label by pressing Ctrl+N or by clicking New.

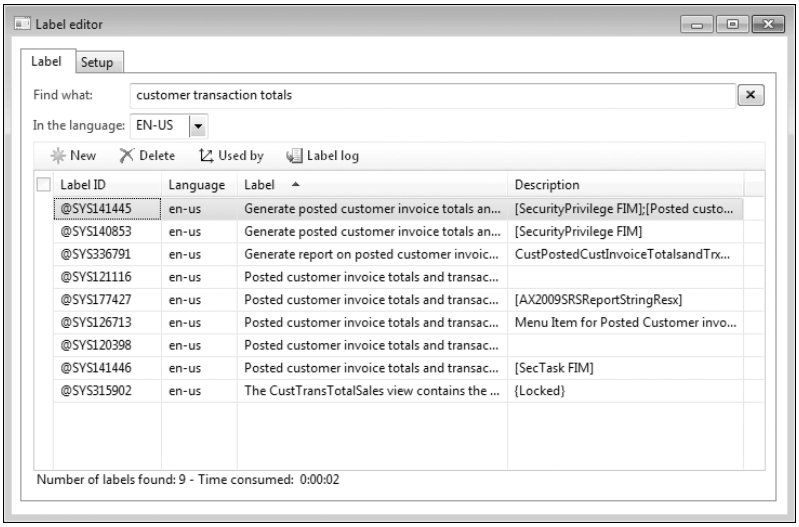

FIGURE 2-14 The Label editor.

In addition to finding and creating new labels, you can use the Label editor to find out where a label is used. The Label editor also logs any changes to each label.

Consider the following tips when creating and reusing labels:

- When reusing a label, make sure that the label means what you intend it to in all languages. Some words are homonyms (words that have many meanings), and they naturally translate into many different words in other languages. For example, the English word *can* is both a verb and a noun. Use the description column to note the intended meaning of the label.
- When creating a new label, ensure that you use complete sentences or other stand-alone words or phrases. Don't construct complete sentences by concatenating labels with one or two words because the order of words in a sentence differs from one language to another.

Referencing labels from X++

In the MorphX design environment, labels are referenced in the format @<*LabelFileIdentifier*><*LabelID*>. If you don't want a label reference to be converted automatically to the label text, you can use the *literalStr* function. When a placeholder is needed to display the value of a variable, you can use the *strFmt* function and a string containing %*n*, where *n* is greater than or equal to 1. Placeholders can also be used within labels. The following code shows a few examples:

```
// prints: Time transactions
print "@SYS1";

// prints: @SYS1
print literalStr("@SYS1");

// prints: Microsoft Dynamics is a Microsoft brand
print strFmt("%1 is a %2 brand", "Microsoft Dynamics", "Microsoft");
pause;
```

The following are some best practices to consider when referencing labels from X++:

- Always create user interface text by using a label. When referencing labels from X++ code, use double quotation marks.
- Never create system text such as file names by using a label. When referencing system text from X++ code, use single quotation marks. You can place system text in macros to make it reusable.

Using single and double quotation marks to differentiate between system text and user interface text allows the Best Practices tool to find and report any hard-coded user interface text. The Best Practices tool is described in depth later in this chapter.

Compiler

Whenever you make a change to X++ code, you must recompile, just as you would in any other programming language. You start the recompile by pressing F7 in the X++ code editor. Your code also recompiles whenever you close the editor or save changes to an element.

The compiler also produces a list of the following information:

- **Compiler errors** These prevent code from compiling and should be fixed as soon as possible.
- **Compiler warnings** These typically indicate that something is wrong in the implementation. See Table 2-4, later in this section, for a list of example compiler warnings. Compiler warnings can and should be addressed. Check-in attempts with compiler warnings are rejected unless specifically allowed in the version control system settings.
- **Tasks (also known as *to-dos*)** The compiler picks up single-line comments that start with *TODO*. These comments can be useful during development for adding reminders, but you should use them only in cases in which implementation can't be completed. For example, you might use a to-do comment when you're waiting for a check-in from another developer. Be careful when using to-do comments to postpone work, and never release code unless all to-dos are addressed. For a developer, there is nothing worse than debugging an issue and finding a to-do comment indicating that the issue was already known but overlooked.
- **Best practice deviations** The Best Practices tool carries out more complex validations. For more information, see the "Best Practices tool" section later in this chapter.

Note Unlike other languages, X++ requires that you compile only code you've modified, because the intermediate language the compiler produces is persisted along with the X++ code and metadata. Of course, your changes can require other methods that consume your code to be changed and recompiled if, for example, you rename a method or modify its parameters. If the consumers are not recompiled, a run-time error is thrown when they are invoked. This means that you can execute your business application even when compile errors exist, as long as you don't use the code that can't compile. Always ensure that you compile the entire AOT when you consider your changes complete, and fix any compilation errors found. If you're changing the class declaration somewhere in a class hierarchy, all classes deriving from the changed class should be recompiled, too. This can be achieved by using the Compile Forward option under Add-Ins in the context menu for the changed class node.

The Compiler Output window provides access to every issue found during compilation, as shown in Figure 2-15. The window presents one list of all relevant errors, warnings, best practice deviations, and tasks. Each type of message can be disabled or enabled by using the respective buttons. Each line in the list contains information about each issue that the compiler detects, a description of the issue, and its location.

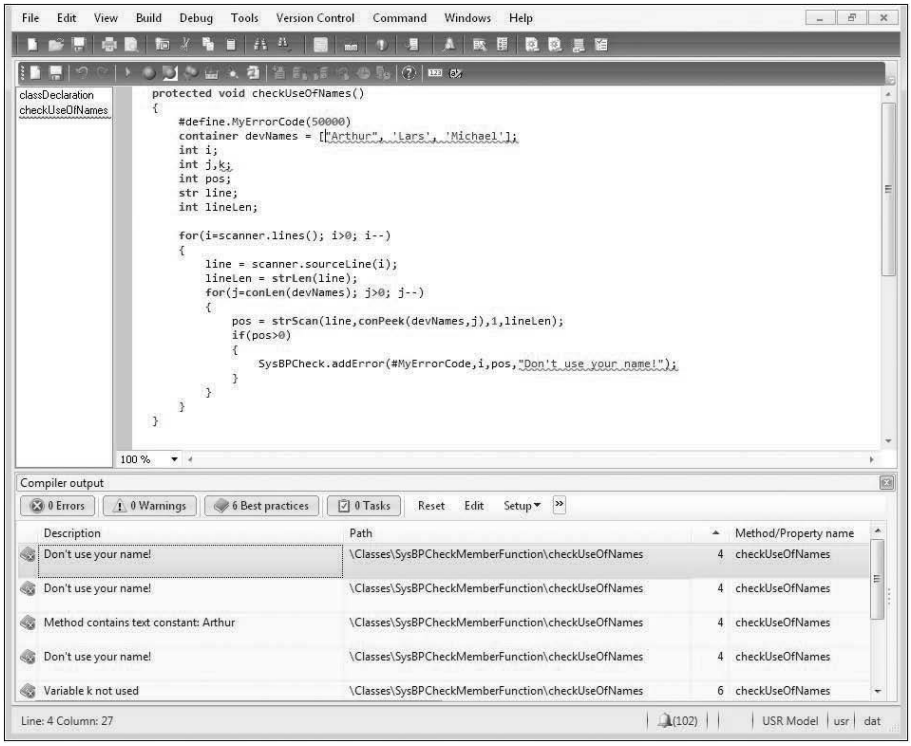

FIGURE 2-15 The powerful combination of the X++ code editor and the Compiler Output window.

You can export the contents of the Compiler Output window. This capability is useful if you want to share the list of issues with team members. The exported file is an HTML file that can be viewed in Internet Explorer or reimported into the Compiler Output window in another AX 2012 session.

In the Compiler Output window, click Setup > Compiler to define the types of issues that the compiler should report. Compiler warnings are grouped into four levels, as shown by the examples in Table 2-4. Each level represents a certain level of severity, with 1 being the most critical and 4 being recommended to comply with best practices.

TABLE 2-4 Example compiler warnings.

Warning message	Level
Break statement found outside legal context	1
The new method of a derived class does not call super()	1
The new method of a derived class may not call super()	1
Function never returns a value	1
Not all paths return a value	1
Assignment/comparison loses precision	1
Unreachable code	2
Empty compound statement	3
Class names should start with an upper case letter	4
Member names should start with a lower case letter	4

Best Practices tool

Following Microsoft Dynamics AX best practices when you develop applications has several important benefits:

- You avoid less-than-obvious pitfalls. Following best practices helps you avoid many obstacles, even those that appear only in borderline scenarios that would otherwise be difficult and time consuming to detect and test. Using best practices allows you to take advantage of the combined experience of Microsoft Dynamics AX expert developers.
- Your learning curve is flattened. When you perform similar tasks in a standard way, you are more likely to be comfortable in an unknown area of the application. Consequently, adding new resources to a project is more cost effective, and downstream consumers of the code can make changes more readily.
- You are making a long-term investment. Code that conforms to standards is less likely to require rework during an upgrade process, whether you're upgrading to AX 2012, installing service packs, or upgrading to future releases.

- You are more likely to ship on time. Most of the problems developers face when implementing a solution in Microsoft Dynamics AX have been solved at least once before. Choosing a proven solution results in faster implementation and less regression. You can find solutions to known problems in both the Developer Help section of the SDK and in the code base.

The AX 2012 SDK contains an important discussion about conforming to best practices in AX 2012. Constructing code that follows proven standards and patterns can't guarantee a project's success, but it minimizes the risk of failure because of late, expensive discovery, and it decreases the long-term maintenance cost. The AX 2012 SDK is available at *http://msdn.microsoft.com/en-us/library/aa496079.aspx*.

The Best Practices tool is a powerful supplement to the best practices discussion in the SDK. This tool is the MorphX version of a static code analysis tool, similar to FxCop for the Microsoft .NET Framework. The Best Practices tool is embedded in the compiler, and the results are reported in the Compiler Output window the same way as other messages from the compilation process.

The purpose of static code analysis is to detect defects and risky coding patterns in the code automatically. The longer a defect exists, the more costly it becomes to fix—a bug found in the design phase is much cheaper to correct than a bug in shipped code running at several customer sites. The Best Practices tool allows any developer to run an analysis of his or her code and application model to ensure that it conforms to a set of predefined rules. Developers can run analysis during development, and they should always do so before implementations are tested. Because an application in AX 2012 is much more than just code, the Best Practices tool also performs static analysis on the metadata—the properties, structures, and relationships that are maintained in the AOT.

The Best Practices tool displays deviations from the best practice rules, as shown earlier in Figure 2-15. Double-clicking a line on the Best Practices tab opens the X++ code editor on the violating line of code or, if the Best Practices violation is related to metadata, it will open the element in an AOT window.

Rules

The Best Practices tool includes about 400 rules, a small subset of the best practices mentioned in the SDK. You can define the best practice rules that you want to run in the Best Practice Parameters dialog box: on the Tools menu, click Options > Development, and then click Best Practices.

Note You must set the compiler error level to 4 if you want best practice rule violations to be reported. To turn off best practice violation reporting, in the Compiler Output window, click Setup > Compiler, and then set the compiler error level to less than 4.

The best practice rules are divided into categories. By default, all categories are turned on, as shown in Figure 2-16.

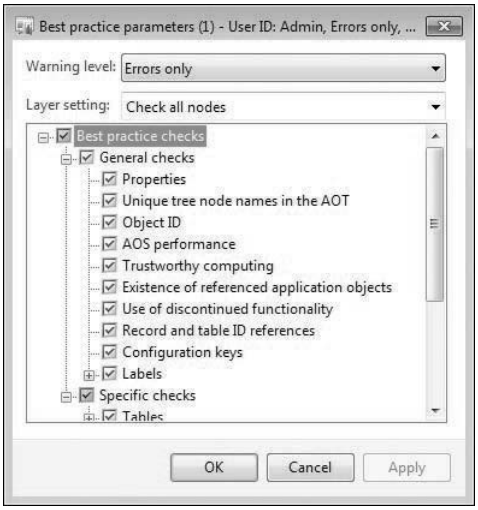

FIGURE 2-16 The Best Practice Parameters dialog box.

The best practice rules are divided into three levels of severity:

- **Errors** The majority of the rules focus on errors. Any check-in attempt with a best practice error is rejected. You must take all errors seriously and fix them as soon as possible.
- **Warnings** Following a 95/5 rule for warnings is recommended. This means that you should treat 95 percent of all warnings as errors; the remaining 5 percent constitute exceptions to the rule. You should provide valid explanations in the design document for all warnings you choose to ignore.
- **Information** In some situations, your implementation might have a side effect that isn't obvious to you or the user (for example, if you assign a value to a variable but you never use the variable again). These are typically reported as information messages.

Suppressing errors and warnings

The Best Practices tool allows you to suppress errors and warnings. A suppressed best practice deviation is reported as information. This gives you a way to identify the deviation as reviewed and accepted. To stop a piece of code from generating a best practice error or warning, place a line containing the following text just before the deviation:

```
//BP Deviation Documented
```

Only a small subset of the best practice rules can be suppressed. Use the following guidelines for selecting which rules to suppress:

- **Dangerous API exceptions** When exceptions exist that are impossible to detect automatically, examine each error to ensure the correct implementation. Dangerous application programming interfaces (APIs) are often responsible for such exceptions. A dangerous API is an API that can compromise a system's security when used incorrectly. If a dangerous API is used, a suppressible error is reported. You can use some so-called dangerous APIs when you take certain precautions, such as using code access security (CAS). You can suppress the error after you apply the appropriate mitigations.
- **False positives** About 5 percent of all warnings are false positives and can be suppressed. Note that only warnings caused by actual code can be suppressed this way, not warnings caused by metadata.

After you set up the best practices, the compiler automatically runs the best practices check whenever an element is compiled. The results are displayed in the Best Practices list in the Compiler Output dialog box.

Some of the metadata best practice violations can also be suppressed, but the process of suppressing them is different. Instead of adding a comment to the source code, you add the violation to a global list of ignored violations. This list is maintained in the macro named *SysBPCheckIgnore*. This allows for central review of the number of suppressions, which should be kept to a minimum. For more information, see "Best Practice Checks" at *http://msdn.microsoft.com/en-us/library/aa874347.aspx*.

Adding custom rules

You can use the Best Practices tool to create your own set of rules. The classes used to check for rules are named *SysBPCheck<Element type>*. You call the *init*, *check*, and *dispose* methods once for each node in the AOT for the element being compiled.

One of the most interesting classes is *SysBPCheckMemberFunction*, which is called for each piece of X++ code whether it is a class method, form method, macro, or other method. For example, if

developers don't want to include their names in the source code, you can implement a best practice check by creating the following method on the *SysBPCheckMemberFunction* class:

```
protected void checkUseOfNames()
{
    #Define.MyErrorCode(50000)
    container devNames = ['Arthur', 'Lars', 'Michael'];
    int i;
    int j,k;
    int pos;
    str line;
    int lineLen;

    for (i=scanner.lines(); i>0; i--)
    {
        line = scanner.sourceLine(i);
        lineLen = strLen(line);
        for (j=conLen(devNames); j>0; j--)
        {
            pos = strScan(line, conPeek(devNames, j), 1, lineLen);
            if (pos)
            {
                sysBPCheck.addError(#MyErrorCode, i, pos,
                    "Don't use your name!");
            }
        }
    }
}
```

To enlist the rule, make sure to call the preceding method from the *check* method. Compiling this sample code results in the best practice errors shown in Table 2-5.

TABLE 2-5 Best practice errors in *checkUseOfNames*.

Message	Line	Column
Don't use your name!	4	28
Don't use your name!	4	38
Don't use your name!	4	46
Variable *k* not used	6	11
Method contains text constant: 'Don't use your name!'	20	59

In an actual implementation, names of developers would probably be read from a file. Ensure that you cache the names to prevent the compiler from going to the disk to read the names for each method being compiled.

Note The best practice check just shown also identified that the code contained a variable named *k* that was declared, but never referenced. This is one of the valuable checks that ensures that the code can easily be kept up to date, which helps avoid mistakes. In this case, *k* was not intended for a specific purpose and can be removed.

Debugger

Like most development environments, MorphX features a debugger. The debugger is a stand-alone application, not part of the AX 2012 shell like the rest of the tools mentioned in this chapter. As a stand-alone application, the debugger allows you to debug X++ in any of the following AX 2012 components:

- AX 2012 client
- AOS
- Business Connector (BC.NET)

For other debugging scenarios, such as web services, Microsoft SQL Server Reporting Services (SSRS) reports, and Enterprise Portal web client, see Chapter 3, "AX 2012 and .NET."

Enabling debugging

For the debugger to start, a breakpoint must be hit when X++ code is executed. You set breakpoints by using the X++ code editor in the Development Workspace. The debugger starts automatically when any component hits a breakpoint.

You must enable debugging for each component as follows:

- In the Development Workspace, on the Tools menu, click Options > Development > Debug, and then select When Breakpoint in the Debug Mode list.
- From the AOS, open the Microsoft Dynamics AX Server Configuration Utility under Start > Administrative Tools > Microsoft Dynamics AX 2012 Server Configuration. Create a new configuration, if necessary, and then select the check box Enable Breakpoints to debug X++ code running on this server.
- For Enterprise Portal code that uses the BCPROXY context to run interpreted X++ code, in the Microsoft Dynamics AX Server Configuration Utility, create a new configuration, if necessary, and select the check box Enable Global Breakpoints.

Ensure that you are a member of the local Windows security group named Microsoft Dynamics AX Debugging Users. This is normally ensured by using setup, but if you did not set up AX 2012 by using your current account, you need to do this manually through Edit Local Users And Groups in Windows Control Panel. This is necessary to prohibit unauthorized debugging, which could expose sensitive data, provide a security risk, or impose unplanned service disruptions.

Caution It is recommended that you do not enable any of the debugging capabilities in a live environment. If you do, execution will stop when it hits a breakpoint, and the client will stop responding to users. Running the application with debug support enabled also noticeably affects performance.

To set or remove breakpoints, press F9. You can set a breakpoint on any line you want. If you set a breakpoint on a line without an X++ statement, however, the breakpoint will be triggered on the next X++ statement in the method. A breakpoint on the last brace will never be hit.

To enable or disable a breakpoint, press Ctrl+F9. For a list of all breakpoints, press Shift+F9.

Breakpoints are persisted in the SysBreakpoints and SysBreakpointLists database tables. Each developer has his or her own set of breakpoints. This means that your breakpoints are not cleared when you close AX 2012 and that other AX 2012 components can access them and break where you want them to.

Debugger user interface

The main window in the debugger initially shows the point in the code where a breakpoint was hit. You can control execution one step at a time while inspecting variables and other aspects of the code. Figure 2-17 shows the debugger opened to a breakpoint with all the windows enabled.

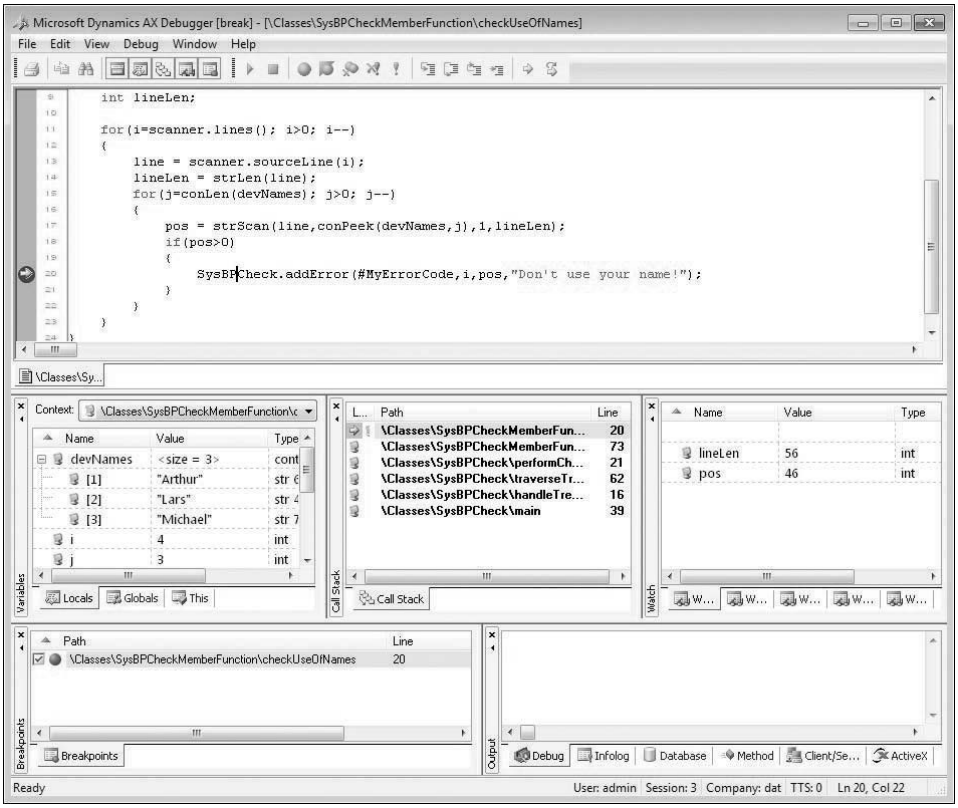

FIGURE 2-17 Debugger with all windows enabled.

Table 2-6 describes the debugger's various windows and some of its other features.

TABLE 2-6 Debugger user interface elements.

Debugger element	Description
Code window	Shows the current X++ code. Each variable has a ScreenTip that reveals its value. You can drag the next-statement pointer in the left margin. This pointer is particularly useful if the execution path isn't what you expected or if you want to repeat a step.
Variables window	Shows local, global, and member variables, along with their names, values, and types. Local variables are variables in scope at the current execution point. Global variables are variables on global classes that are always instantiated: *Appl*, *Infolog*, *ClassFactory*, and *VersionControl*. Member variables are shown on classes. If a variable is changed as you step through execution, it is marked in red. Each variable is associated with a client or server icon. You can modify the value of a variable by double-clicking the value.
Call Stack window	Shows the code path followed to arrive at a particular execution point. Clicking a line in the Call Stack window opens the code in the Code window and updates the local Variables window. A client or server icon indicates the tier on which the code is executed.
Watch window	Shows the name, value, and type of the variables. Five different Watch windows are available. You can use these to group the variables you're watching in the way that you prefer. You can use this window to inspect variables without the scope limitations of the Variables window. You can drag a variable here from the Code window or the Variables window.
Breakpoints window	Lists all your breakpoints. You can delete, enable, and disable the breakpoints through this window.
Output window	Shows the traces that are enabled and the output that is sent to the Infolog application framework, which is introduced in Chapter 5, "Designing the user experience." The Output window has the following views: ■ **Debug** You can instrument your X++ code to trace to this page by using the *printDebug* static method on the *Debug* class. ■ **Infolog** This page contains messages in the queue for the Infolog. ■ **Database, Client/Server, and ActiveX Trace** Any traces enabled on the Development tab in the Options form appear on these pages.
Status bar window	Provides the following important context information: ■ **Current user** The ID of the user who is logged on to the system. This information is especially useful when you are debugging incoming web requests. ■ **Current session** The ID of the session on the AOS. ■ **Current company accounts** The ID of the current company accounts. ■ **Transaction level** The current transaction level. When this level reaches zero, the transaction is committed.

Tip As a developer, you can provide more information in the value field for your classes than what is provided by default. The defaults for classes are *New* and *Null*. You can change the defaults by overriding the *toString* method. If your class doesn't explicitly extend the *object* (the base class of all classes), you must add a new method named *toString*, returning and taking no parameters, to implement this functionality.

Debugger shortcut keys

Table 2-7 lists the most important shortcut keys available in the debugger.

TABLE 2-7 Debugger shortcut keys.

Action	Shortcut	Description
Run	F5	Continue execution.
Stop debugging	Shift+F5	Break execution.
Step over	F10	Step over the next statement.
Run to cursor	Ctrl+F10	Continue execution but break at the cursor's position.
Step into	F11	Step into the next statement.
Step out	Shift+F11	Step out of the method.
Toggle breakpoint	Shift+F9	Insert or remove a breakpoint.
Variables window	Ctrl+Alt+V	Open or close the Variables window.
Call Stack window	Ctrl+Alt+C	Open or close the Call Stack window.
Watch window	Ctrl+Alt+W	Open or close the Watch window.
Breakpoints window	Ctrl+Alt+B	Open or close the Breakpoints window.
Output window	Ctrl+Alt+O	Open or close the Output window.

Reverse Engineering tool

You can generate Visio models from existing metadata. Considering the amount of metadata available in AX 2012 (more than 50,000 elements and more than 18 million lines of text when exported), it's practically impossible to get a clear view of how the elements relate to each other just by using the AOT. The Reverse Engineering tool is a great aid when you need to visualize metadata.

Note You must have Visio 2007 or later installed to use the Reverse Engineering tool.

The Reverse Engineering tool can generate a Unified Modeling Language (UML) data model, a UML object model, or an entity relationship data model, including all elements from a private or shared project. To open the tool, in the Projects window, right-click a project or a perspective, and point to Add-Ins > Reverse Engineer. You can also open the tool by selecting Reverse Engineer from the Tools menu. In the dialog box shown in Figure 2-18, you must specify a file name and model type.

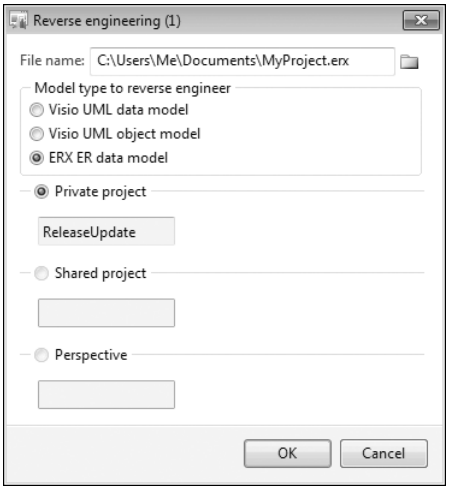

FIGURE 2-18 The Reverse Engineering dialog box.

When you click OK, the tool uses the metadata for all elements in the project to generate a Visio document that opens automatically. You can drag elements from the Visio Model Explorer onto the drawing surface, which is initially blank. Any relationship between two elements is automatically shown.

UML data model

When generating a UML data model, the Reverse Engineering tool looks for tables in the project. The UML data model contains a class for each table and view in the project and the class's attributes and associations.

The UML data model also contains referenced tables and all extended data types, base enumerations, and X++ data types. You can include these items in your diagrams without having to run the Reverse Engineering tool again.

Fields in AX 2012 are generated as UML attributes. All attributes are marked as public to reflect the nature of fields in AX 2012. Each attribute also shows the type. The primary key field is underlined. If a field is a part of one or more indexes, the field name is prefixed with the names of the indexes; if the index is unique, the index name is noted in braces.

Relationships in AX 2012 are generated as UML associations. The *Aggregation* property of the association is set based on two conditions in metadata:

- If the relationship is validating (the *Validate* property is set to *Yes*), the *Aggregation* property is set to *Shared*. This is also known as a UML aggregation, represented by a white diamond.
- If a cascading delete action exists between the two tables, a composite association is added to the model. A cascading delete action ties the lifespan of two or more tables and is represented by a black diamond.

Figure 2-19 shows a class diagram with the CustTable (customers), InventTable (inventory items), SalesTable (sales order header), and SalesLine (sales order line) tables. To simplify the diagram, some attributes have been removed.

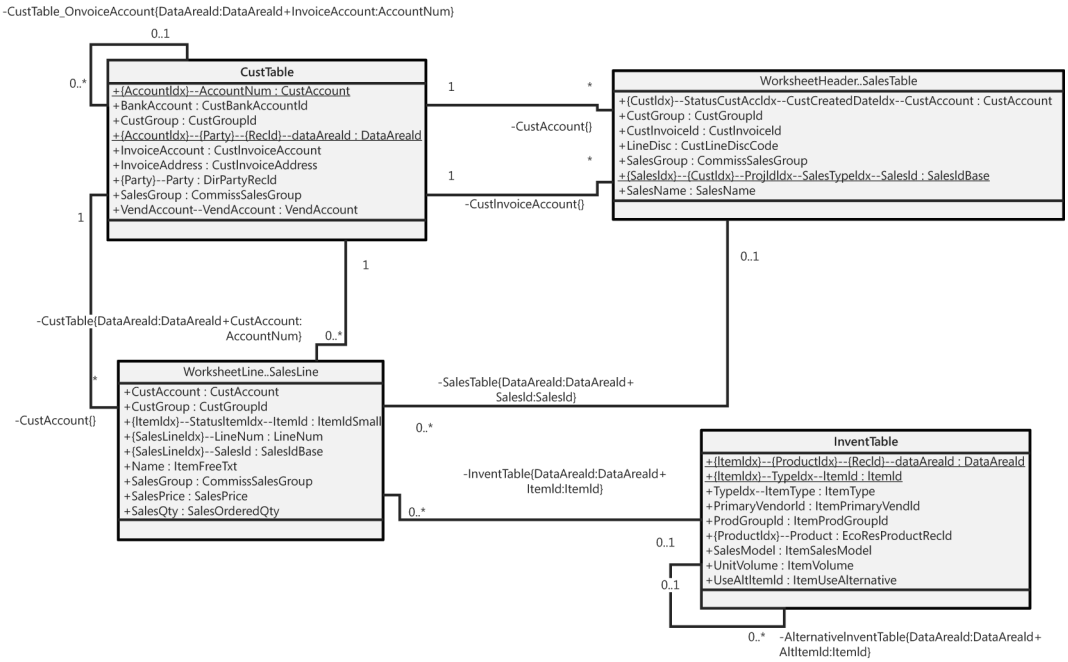

FIGURE 2-19 UML data model diagram.

The name of an association endpoint is the name of the relationship. The names and types of all fields in the relationship appear in braces.

UML object model

When generating an object model, the Reverse Engineering tool looks for Microsoft Dynamics AX classes, tables, and interfaces in the project. The UML model contains a class for each Microsoft Dynamics AX table and class in the project and an interface for each Microsoft Dynamics AX interface in the project. The UML model also contains attributes and operations, including return types, parameters, and the types of the parameters. Figure 2-20 shows an object model of the most important *RunBase* and *Batch* classes and interfaces in Microsoft Dynamics AX. To simplify the view, some attributes and operations have been removed and operation parameters are suppressed.

The UML object model also contains referenced classes, tables, and all extended data types, base enumerations, and X++ data types. You can include these elements in your diagrams without having to run the Reverse Engineering tool again.

Fields and member variables in AX 2012 are generated as UML attributes. All fields are generated as public attributes, whereas member variables are generated as protected attributes. Each attribute

also shows the type. Methods are generated as UML operations, including return type, parameters, and the types of the parameters.

The Reverse Engineering tool also picks up any generalizations (classes extending other classes), realizations (classes implementing interfaces), and associations (classes using each other). The associations are limited to references in member variables.

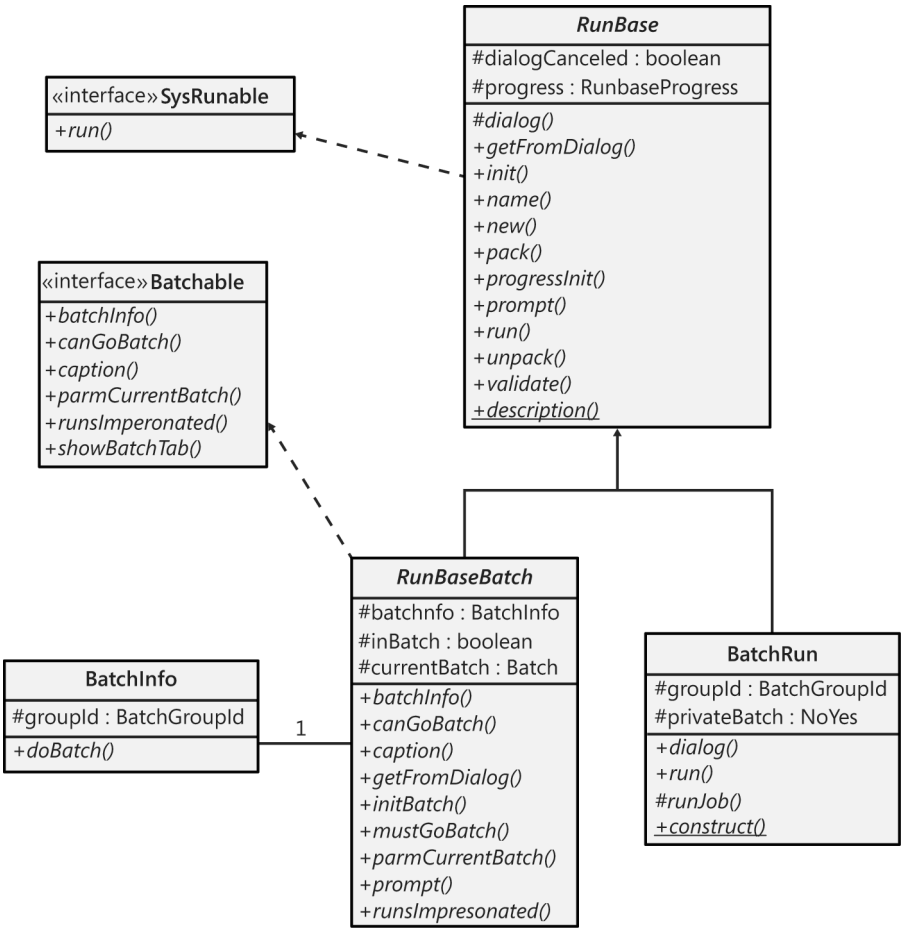

FIGURE 2-20 UML object model diagram.

Note To get the names of operation parameters, you must reverse engineer in debug mode. The names are read from metadata only and are placed into the stack when in debug mode. To enable debug mode, on the Development tab of the Options form, select When Breakpoint in the Debug Mode list.

For more information about the elements in a UML diagram, see "UML Class Diagrams: Reference" at *http://msdn.microsoft.com/en-us/library/dd409437.aspx*.

Entity relationship data model

When generating an entity relationship data model, the Reverse Engineering tool looks for tables and views in the project. The entity relationship model contains an entity type for each AOT table in the project and attributes for the fields in each table. Figure 2-21 shows an entity relationship diagram (ERD) for the tables HcmBenefit (Benefit), HcmBenefitOption (Benefit option), HcmBenefitType (Benefit type), and HcmBenefitPlan *(*Benefit plan*)*.

Note For AX 2012 R2, Microsoft has introduced a website that hosts ERDs for the core tables in AX 2012 R2 application modules. You can use the site to quickly get detailed information about a large number of tables. To access the site, go to *http://www.microsoft.com/dynamics/ax/erd/ax2012r2/Default.htm*.

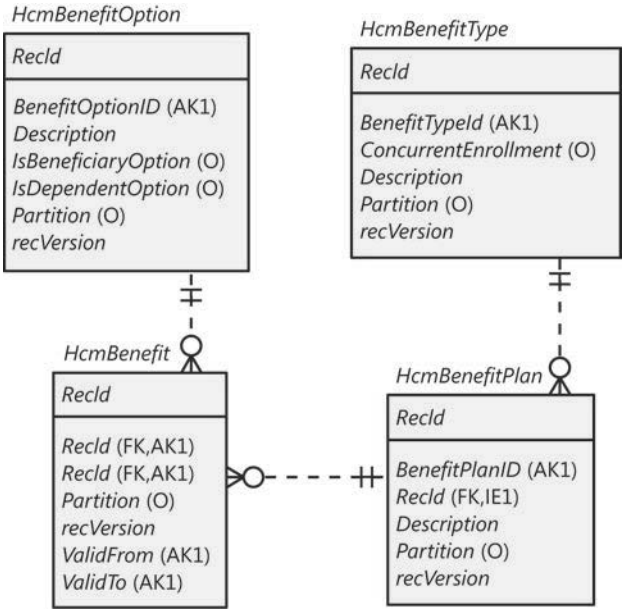

FIGURE 2-21 ERD using Crow's Foot notation.

Fields in AX 2012 are generated as entity relationship columns. Columns can be foreign key (FK), alternate key (AK), inversion entry (IE), and optional (O). A foreign key column is used to identify a record in another table, an alternate key uniquely identifies a record in the current table, an inversion entry identifies zero or more records in the current table (these are typical of the fields in nonunique indexes), and optional columns don't require a value.

Relationships in AX 2012 are generated as entity relationships. The *EntityRelationshipRole* property of the relationship is used as the foreign key role name of the relation in the entity relationship data model.

Note The Reverse Engineering tool produces an ERX file. To work with the generated file in Visio, do the following: In Visio, create a new database model diagram, and then on the \Database tab, point to Import > Import ERwin ERX File. Afterward, you can drag relevant tables from the Tables And Views pane (available from the Database tab) to the diagram canvas.

Table Browser tool

The Table Browser tool is a small, helpful tool that can be used in numerous scenarios. You can browse and maintain the records in a table without having to build a user interface. This tool is useful when you're debugging, validating data models, and modifying or cleaning up data, to name just a few uses.

To access the Table Browser tool, right-click any of the following types of items in the AOT, and then point to Add-Ins > Table Browser:

- Tables
- Tables listed as data sources in forms, queries, and data sets
- System tables listed in the AOT under System Documentation\Tables

Note The Table Browser tool is implemented in X++. You can find it in the AOT under the name *SysTableBrowser*. It is a good example of how to bind the data source to a table at run time.

Figure 2-22 shows the Table Browser tool when it is started from the *CustTrans* table. In addition to the querying, sorting, and filtering capabilities provided by the grid control, you can type an SQ *SELECT* statement directly into the form by using X++ *SELECT* statement syntax and see a visual display of the result set. This tool is a great way to test complex *SELECT* statements. It fully supports grouping, sorting, aggregation, and field lists.

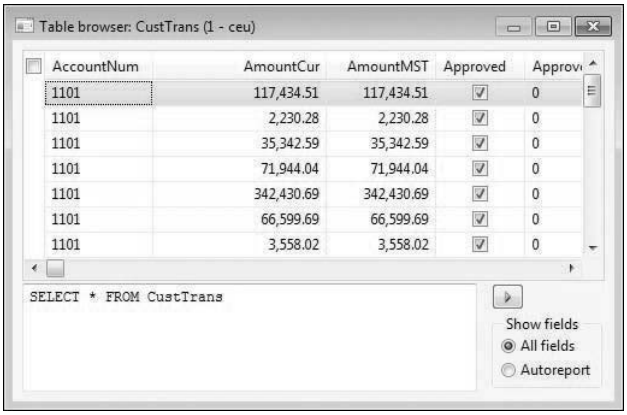

FIGURE 2-22 The Table Browser tool showing the contents of the *CustTrans* table demo data.

You can also choose to see only the fields from the auto-report field group. These fields are printed in a report when the user clicks Print in a form with this table as a data source. Typically, these fields hold the most interesting information. This option can make it easier to find the values you're looking for in tables with many fields.

Note The Table Browser tool is just a standard form that uses IntelliMorph. It can't display fields for which the *visible* property is set to *No* or fields that the current user doesn't have access to.

Find tool

Search is everything, and the size of AX 2012 applications calls for a powerful and effective search tool.

Tip You can use the Find tool to search for an example of how to use an API. Real examples can complement the examples found in the documentation.

You can start the Find tool, shown in Figure 2-23, from any node in the AOT by pressing Ctrl+F or by clicking Find on the context menu. The Find tool supports multiple selections in the AOT.

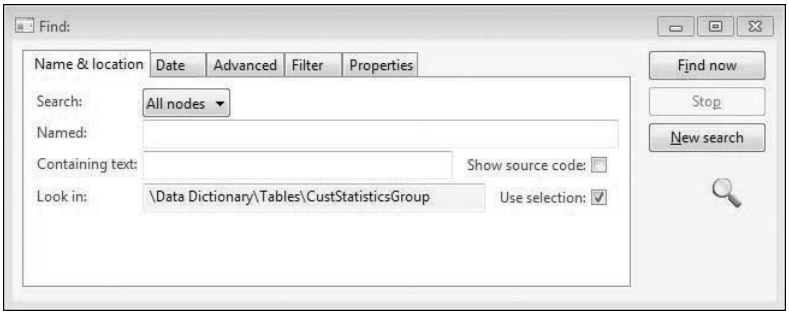

FIGURE 2-23 The Find tool.

On the Name & Location tab, you define what you're searching for and where to look:

- In the Search list, the options are Methods and All Nodes. If you choose All Nodes, the Properties tab appears.
- The Named box limits the search to nodes with the name you specify.
- The Containing Text box specifies the text to look for in the method, expressed as a regular expression.
- If you select the Show Source Code check box, results include a snippet of source code containing the match, making it easier to browse the results.

By default, the Find tool searches the node (and its subnodes) selected in the AOT. If you change focus in the AOT while the Find tool is open, the Look In value is updated. This is quite useful if you want to search several nodes by using the same criterion. You can disable this behavior by clearing the Use Selection check box.

On the Date tab, you specify additional ranges for your search, such as Modified Date and Modified By.

On the Advanced tab, you can specify more advanced settings for your search, such as the layer to search, the size range of elements, the type of element, and the tier on which the element is set to run.

On the Filter tab, shown in Figure 2-24, you can write a more complex query by using X++ and type libraries. The code in the Source text box is the body of a method with the following profile:

```
boolean FilterMethod(str _treeNodeName,
                     str _treeNodeSource,
                     XRefPath _path,
                     ClassRunMode _runMode)
```

The example in Figure 2-24 uses the class *SysScannerClass* to find any occurrence of the *ttsAbort* X++ keyword. The scanner is primarily used to pass tokens into the parser during compilation. Here, however, it detects the use of a particular keyword. This tool is more accurate (though slower) than using a regular expression because X++ comments don't produce tokens.

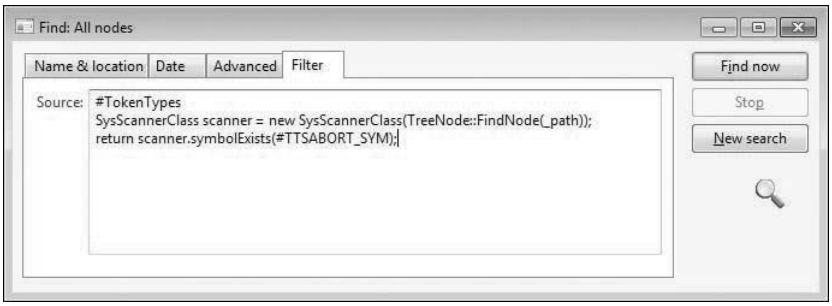

FIGURE 2-24 Filtering in the Find tool.

The Properties tab appears when All Nodes is selected in the Search list. You can specify a search range for any property. Leaving the range blank for a property is a powerful setting when you want to inspect properties: it matches all nodes, and the property value is added as a column in the results, as shown in Figure 2-25. The search begins when you click Find Now. The results appear at the bottom of the dialog box as they are found.

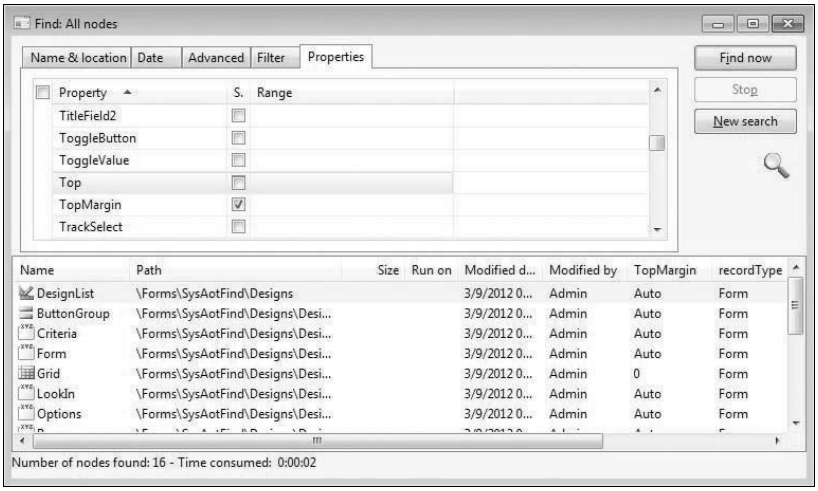

FIGURE 2-25 Search results in the Find tool.

Double-clicking any line in the result set opens the X++ code editor and sets the focus on the code example that matches. When you right-click the lines in the result set, a context menu containing the Add-Ins menu opens.

Compare tool

Several versions of the same element typically exist. These versions might emanate from various layers or revisions in version control, or they could be modified versions that exist in memory. AX 2012 has a built-in Compare tool that highlights any differences between two versions of an element.

The comparison shows changes to elements, which can be modified in three ways:

- A metadata property can be changed.
- X++ code can be changed.
- The order of subnodes can be changed, such as the order of tabs on a form.

Starting the Compare tool

To open the Compare tool, right-click an element, and then click Compare. A dialog box opens where you can select the versions of the element you want to compare, as shown in Figure 2-26.

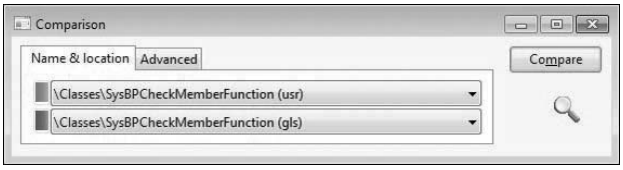

FIGURE 2-26 The Comparison dialog box.

The versions to choose from come from many sources. The following is a list of all possible types of versions:

- **Standard layered version types** These include *SYS*, *SYP*, *GLS*, *GLP*, *FPK*, *FPP*, *SLN*, *SLP*, *ISV*, *ISP*, *VAR*, *VAP*, *CUS*, *CUP*, *USR*, and *USP*.
- **Old layered version types (old *SYS*, old *SYP*, and so on)** If a baseline model store is present, elements from the files are available here. This allows you to compare an older version of an element with its latest version. For more information about layers and the baseline model store, see Chapter 21, "Application models."
- **Version control revisions (Version 1, Version 2, and so on)** You can retrieve any revision of an element from the version control system individually and use it for comparison. The version control system is explained later in this chapter.
- **Best practice washed version (Washed)** A few simple best practice issues can be resolved automatically by a best practice "wash." Selecting the washed version shows you how your implementation differs from best practices. To get the full benefit of this, select the Case Sensitive check box on the Advanced tab.

- **Export/import file (XPO)** Before you import elements, you can compare them with existing elements (which will be overwritten during import). You can use the Compare tool during the import process (Command > Import) by selecting the Show Details check box in the Import dialog box and right-clicking any elements that appear in bold. Objects in bold already exist in the application.
- **Upgraded version (Upgraded)** MorphX can automatically create a proposal for how a class should be upgraded. The requirement for upgrading a class arises during a version upgrade. The Create Upgrade Project step in the Upgrade Checklist automatically detects customized classes that conflict with new versions of the classes. A class is conflicting if you've changed the original version of the class, and the publisher of the class has also changed the original version. MorphX constructs the proposal by merging your changes with the publisher's changes to the class. MorphX requires access to all three versions of the class—the original version in the baseline model store, a version with your changes in the current layer in the baseline model store, and a version with the publisher's changes in the same layer as the original. The installation program ensures that the right versions are available in the right places during an upgrade. Conflict resolution is shown in Figure 2-27.

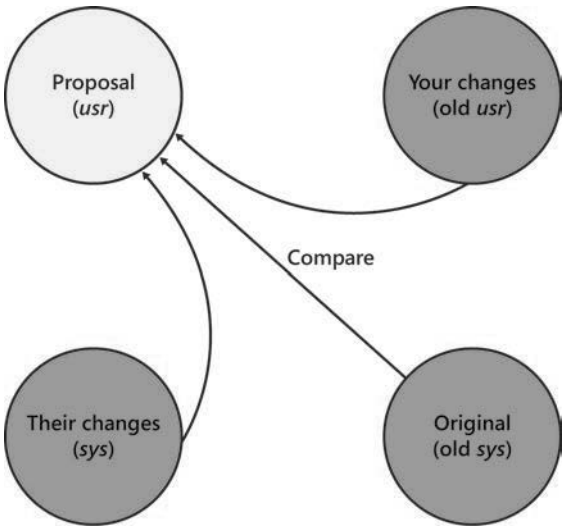

FIGURE 2-27 How the upgraded version proposal is created.

Note You can also compare two different elements. To do this, select two elements in the AOT, right-click, point to Add-Ins, and then click Compare.

Figure 2-28 shows the Advanced tab, on which you can specify comparison options.

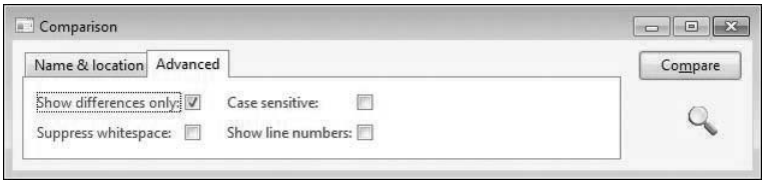

FIGURE 2-28 Comparison options on the Advanced tab.

The following list describes the comparison options shown in Figure 2-28:

- **Show Differences Only** All equal nodes are suppressed from the view, making it easier to find the changed nodes. This option is selected by default.
- **Suppress Whitespace** White space, such as spaces and tabs, is suppressed into a single space during the comparison. The Compare tool can ignore the amount of white space, just as the compiler does. This option is selected by default.
- **Case Sensitive** Because X++ is not case sensitive, the Compare tool is also not case sensitive by default. In certain scenarios, case sensitivity is required and must be enabled, such as when you're using the best practice wash feature mentioned earlier in this section. This option is cleared by default.
- **Show Line Numbers** The Compare tool can add line numbers to all X++ code that is displayed. This option is cleared by default but can be useful during an upgrade of large chunks of code.

Using the Compare tool

After you choose elements and set parameters, start the comparison by clicking Compare. Results are displayed in a three-pane dialog box, as shown in Figure 2-29. The top pane contains the elements and options that you selected, the left pane displays a tree structure resembling the AOT, and the right pane shows details that correspond to the item selected in the tree.

Color-coded icons in the tree structure indicate how each node has changed. A red or blue check mark indicates that the node exists only in a particular version. Red corresponds to the *SYS* layer, and blue corresponds to the old *SYS* layer. A gray check mark indicates that the nodes are identical but one or more subnodes are different. A not-equal-to sign (≠) on a red and blue background indicates that the nodes are different in the two versions.

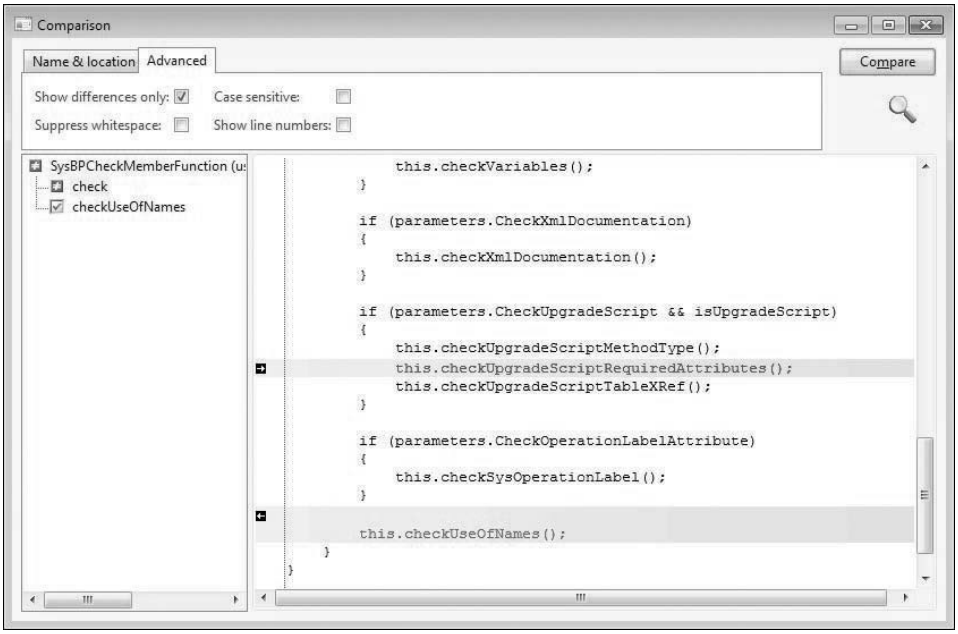

FIGURE 2-29 Comparison results.

Note Each node in the tree view has a context menu that provides access to the Add-Ins submenu and the Open New Window option. The Open New Window option provides an AOT view of any element, including elements in old layers.

Details about the differences are shown in the right pane. Color coding is also used in this pane to highlight differences the same way that it is in the tree structure. If an element is editable, small action icons appear. These icons allow you to make changes to code, metadata, and nodes, which can save you time when performing an upgrade. A right or left arrow removes or adds the difference, and a bent arrow moves the difference to another position. These arrows always come in pairs, so you can see where the difference is moved to and from. If a version control system is in use, an element is editable if it is from the current layer and is checked out.

Compare APIs

Although AX 2012 provides comparison functionality for development purposes only, you can reuse the comparison functionality for other tasks. You can use the available APIs to compare and present differences in the tree structure or text representation of any type of entity.

The *Tutorial_CompareContextProvider* class shows how simple it is to compare business data by using these APIs and present it by using the Compare tool. The tutorial consists of two parts:

- ***Tutorial_Comparable*** This class implements the *SysComparable* interface. Basically, it creates a text representation of a customer.
- ***Tutorial_CompareContextProvider*** This class implements the *SysCompareContextProvider* interface. It provides the context for comparison. For example, it creates a *Tutorial_Comparable* object for each customer, sets the default comparison options, and handles context menus.

Figure 2-30 shows a comparison of two customers, the result of running the tutorial.

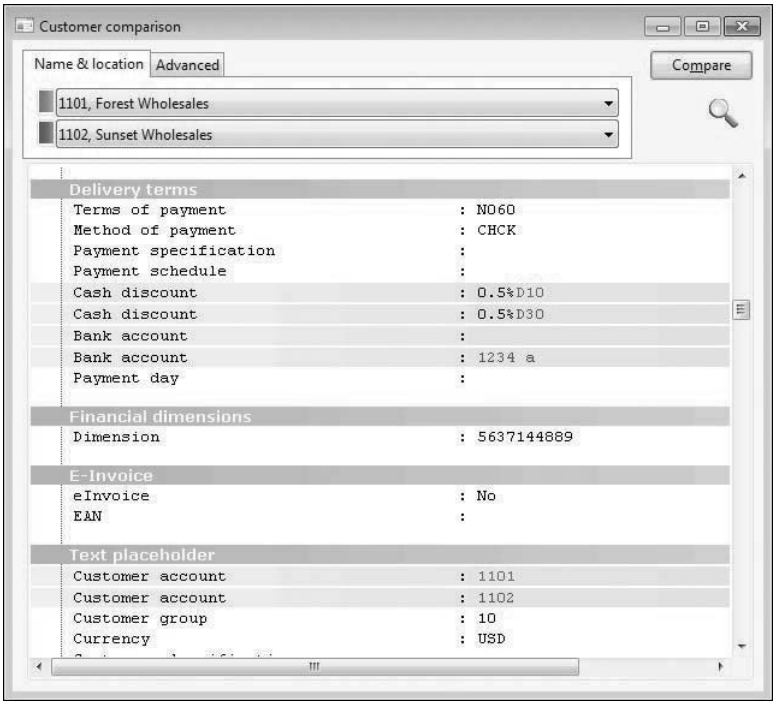

FIGURE 2-30 The result of comparing two customers by using the *Compare* API.

You can also use the line-by-line comparison functionality directly in X++. The static *run* method on the *SysCompareText* class, shown in the following code, takes two strings as parameters and returns a container that highlights differences in the two strings. You can also use a set of optional parameters to control the comparison.

```
public static container run(str _t1,
      str _t2,
      boolean _caseSensitive = false,
      boolean _suppressWhiteSpace = true,
      boolean _lineNumbers  = false,
      boolean _singleLine  = false,
       boolean _alternateLines = false)
```

Cross-Reference tool

The concept of cross-references in AX 2012 is simple. If an element uses another element, the reference is recorded. With cross-references, you can determine which elements a particular element uses and which elements other elements are using. AX 2012 provides the Cross-Reference tool for accessing and managing cross-reference information.

Here are a couple of typical scenarios for using the Cross-Reference tool:

- You want to find usage examples. If the product documentation doesn't help, you can use the Cross-Reference tool to find real implementation examples.
- You need to perform an impact analysis. If you're changing an element, you need to know which other elements are affected by your change.

You must update the Cross-Reference tool regularly to ensure accuracy. The update typically takes several hours. The footprint in a database is about 1.5 gigabytes (GB) for a standard application.

To update the Cross-Reference tool, on the Tools menu, point to > Cross-Reference > Periodic > Update. Updating the Cross-Reference tool also compiles the entire AOT because the compiler emits cross-reference information.

Tip Keeping the Cross-Reference tool up to date is important if you want its information to be reliable. If you work in a shared development environment, you share cross-reference information with your team members. Updating the Cross-Reference tool nightly is a good approach for a shared environment. If you work in a local development environment, you can keep the Cross-Reference tool up to date by enabling cross-referencing when compiling. This option slows down compilation, however. Another option is to update cross-references manually for the elements in a project. To do so, right-click the project and point to Add-Ins > Cross-Reference > Update.

In addition to the main cross-reference information, two smaller cross-reference subsystems exist:

- **Data model** Stores information about relationships between tables. It is primarily used by the query form and the Reverse Engineering tool.
- **Type hierarchy** Stores information about class and data type inheritance.

For more information about these subsystems and the tools that rely on them, see the AX 2012 SDK (*http://msdn.microsoft.com/en-us/library/aa496079.aspx*).

The information that the Cross-Reference tool collects is quite comprehensive. You can find a complete list of cross-referenced elements by opening the AOT, expanding the S*ystem Documentation* node, and clicking Enums and then xRefKind. When the Cross-Reference tool is updating, it scans all metadata and X++ code for references to elements of the kinds listed in the xRefKind subnode.

Tip It's a good idea to use intrinsic functions when referring to elements in X++ code. An intrinsic function can evaluate to either an element name or an ID. The intrinsic functions are named *<Element type>Str* or *<Element type>Num,* respectively. Using intrinsic functions provides two benefits: you have compile-time verification that the element you reference actually exists, and the reference is picked up by the Cross-Reference tool. Also, there is no run-time overhead. Here is an example:

```
// Prints ID of MyClass, such as 50001
print classNum(myClass);

// Prints "MyClass"
print classStr(myClass);

// No compile check or cross-reference
print "MyClass";
```

For more information about intrinsic functions, see Chapter 20, "Reflection."

To access usage information, right-click any element in the AOT and point to Add-Ins > Cross-Reference > Used By. If the option isn't available, either the element isn't used or the cross-reference hasn't been updated.

Figure 2-31 shows where the *prompt* method is used on the *RunBaseBatch* class.

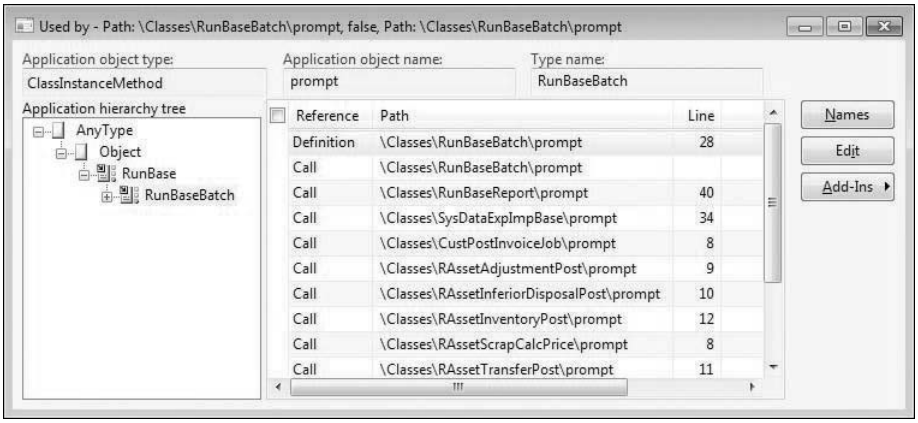

FIGURE 2-31 The Cross-Reference tool, showing where *RunBaseBatch.prompt* is used.

When you view cross-references for a class method, the Application hierarchy tree is visible, so that you can see whether the same method is used on a parent or subclass. For types that don't support inheritance, the Application hierarchy tree is hidden.

Version control

The Version Control tool in MorphX makes it possible to use a version control system, such as Microsoft Visual SourceSafe or Visual Studio Team Foundation Server (TFS), to keep track of changes to elements in the AOT. The tool is accessible from several places: from the Version Control menu in the Development Workspace, from toolbars in the AOT and the X++ code editor, and from the context menu on elements in the AOT.

Using a version control system offers several benefits:

- **Revision history of all elements** All changes are captured, along with a description of the change, making it possible to consult the change history and retrieve old versions of an element.
- **Code quality enforcement** The implementation of version control in AX 2012 enables a fully configurable quality standard for all check-ins. With the quality standard, all changes are verified according to coding practices. If a change doesn't meet the criteria, it is rejected.
- **Isolated development** Each developer can have a local installation and make all modifications locally. When modifications are ready, they can be checked in and made available to consumers of the build. A developer can rewrite fundamental areas of the system without causing instability issues for others. Developers are also unaffected by any downtime of a centralized development server.

Even though using a version control system is optional, it is strongly recommended that you consider one for any development project. AX 2012 supports three version control systems: Visual SourceSafe 6.0 and TFS, which are designed for large development projects, and MorphX VCS. MorphX Version Control System (VCS) is designed for smaller development projects that previously couldn't justify the additional overhead that using a version control system server adds to the process. Table 2-8 shows a side-by-side comparison of the version control system options.

TABLE 2-8 Overview of version control systems.

Requirements and features	No version control system	MorphX VCS	Visual SourceSafe	TFS
Application Object Servers required	1	1	1 for each developer	1 for each developer
Database servers required	1	1	1 for each developer	1 for each developer
Build process required	No	No	Yes	Yes
Master file	Model store	Model store	XPOs	XPOs
Isolated development	No	No	Yes	Yes
Multiple checkout	N/A	No	Configurable	Configurable
Change description	No	Yes	Yes	Yes
Change history	No	Yes	Yes	Yes
Change list support (atomic check-in of a set of files)	N/A	No	No	Yes
Code quality enforcement	No	Configurable	Configurable	Configurable

The elements persisted on the version control server are file representations of the elements in the AOT. The file format used is the standard Microsoft Dynamics AX export format (.xpo). Each .xpo file contains only one root element.

There are no additional infrastructure requirements when you use MorphX VCS, which makes it a perfect fit for partners running many parallel projects. In such setups, each developer often works simultaneously on several projects, toggling between projects and returning to past projects. In these situations, the benefits of having a change history are enormous. With just a few clicks, you can enable MorphX VCS to persist the changes in the business database. Although MorphX VCS provides many of the same capabilities as a version control server, it has some limitations. For example, MorphX VCS does not provide any tools for maintenance, such as making backups, archiving, or labeling.

In contrast, Visual SourceSafe and TFS are designed for large projects in which many developers work together on the same project for an extended period of time (for example, an independent software vendor building a vertical solution).

Figure 2-32 shows a typical deployment using Visual SourceSafe or TFS, in which each developer locally hosts the AOS and the database. Each developer also needs a copy of all .xpo files. When a developer communicates with the version control server, the .xpo files are transmitted.

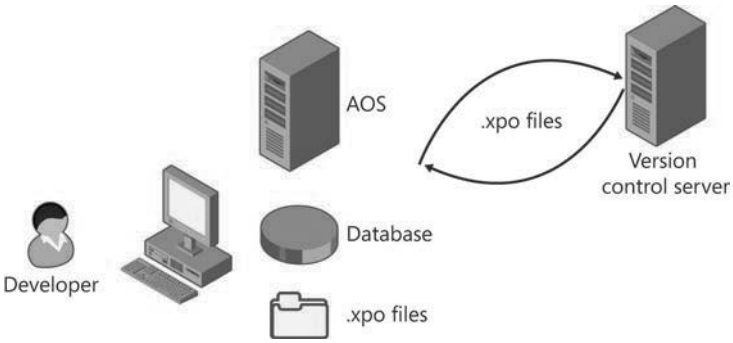

FIGURE 2-32 Typical deployment using version control.

Note In earlier versions of Microsoft Dynamics AX, a Team Server was required to assign unique IDs as elements were created. AX 2012 uses a new ID allocation scheme, which eliminates the need for the Team Server. For more information about element IDs, see Chapter 21.

Element life cycle

Figure 2-33 shows the element life cycle in a version control system. When an element is in a state marked with a lighter shade, it can be edited; otherwise, it is read-only.

You can create an element in two ways:

- Create a new element.
- Customize an existing element, resulting in an *overlayered* version of the element. Because elements are stored for each layer in the version control system, customizing an element effectively creates a new element.

After you create an element, you must add it to the version control system. First, give it a proper name in accordance with naming conventions, and then click Add To Version Control on the context menu. After you create the element, you must check it in.

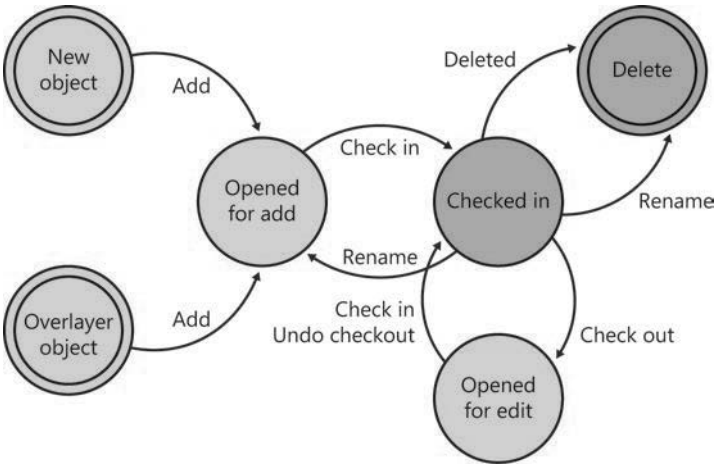

FIGURE 2-33 Element life cycle.

An element that is checked in can be renamed. Renaming an element deletes the element with the old name and adds an element with the new name.

Quality checks

Before the version control system accepts a check-in, it might subject the elements to quality checks. You define what is accepted in a check-in when you set up the version control system. The following checks are supported:

- Compiler errors
- Compiler warnings
- Compiler tasks
- Best practice errors

When a check is enabled, it is carried out when you do a check-in. If the check fails, the check-in stops. You must address the issue and restart the check-in.

Source code casing

You can set the Source Code Titlecase Update tool, available on the Add-Ins submenu, to execute automatically before elements are checked in to ensure uniform casing in variable and parameter declarations and references. You can specify this parameter when setting up the version control system by selecting the Run Title Case Update check box.

Common version control tasks

Table 2-9 describes some of the tasks that are typically performed with a version control system. Later sections describe additional tasks that you can perform when using version control with AX 2012.

TABLE 2-9 Version control tasks.

Action	Description
Check out an element	To modify an element, you must check it out. Checking out an element locks it so that others can't modify it while you're working. To see which elements you have currently checked out, on the Microsoft Dynamics AX menu, click Control > Pending Objects. The elements you've checked out (or that you've created and not yet checked in) appear in blue, rather than black, in the AOT.
Undo a checkout	If you decide that you don't want to modify an element that you checked out, you can undo the checkout. This releases your lock on the element and imports the most recent checked-in revision of the element to undo your changes.
Check in an element	When you have finalized your modifications, you must check in the elements for them to be part of the next build. When you click Check-In on the context menu, the dialog box shown later in Figure 2-34 appears, displaying all the elements that you currently have checked out. The Check In dialog box shows all open elements by default; you can remove any elements not required in the check-in from the list by pressing Alt+F9. The following procedure is recommended for checking in your work: ■ Perform synchronization to update all elements in your environment to the latest version. ■ Verify that everything is still working as intended. Compilation is not enough. ■ Check in the elements.
Create an element	When using version control, you create new elements just as you normally would in a MorphX environment without a version control system. These elements are not part of your check-in until you click Add To Version Control on the context menu. You can also create all element types except those listed in System Settings (on the Development Workspace Version Control menu, point to Control > Setup > System Settings). By default, jobs and private projects are not accepted. New elements should follow Microsoft Dynamics AX naming conventions. The best practice naming conventions are enforced by default, so you can't check in elements with names such as *aaaElement*, *DEL_Element*, *element1*, or *element2*. (The only *DEL_* elements allowed are those required for version upgrade purposes.) You can change naming requirements in System Settings.
Rename an element	An element must be checked in to be renamed. Because all references between .xpo files are strictly name-based, all references to renamed elements must be updated. For example, if you rename a table field, you must also update any form or report that uses that field. Most references in metadata in the AOT are ID-based, and thus they are not affected when an element is renamed; in most cases, it is enough to check out the form or report and include it in the check-in to update the .xpo file. You can use the Cross-Reference tool to identify references. References in X++ code are name-based. You can use the compiler to find affected references. An element's revision history is kept intact when elements are renamed. No tracking information in the version control system is lost because an element is renamed.
Delete an element	You delete an element as you normally would in Microsoft Dynamics AX. The delete operation must be checked in before the deletion is visible to other users of the version control system. You can see pending deletions in the Pending Objects dialog box.
Get the latest version of an element	If someone else has checked in a new version of an element, you can use the Get Latest option on the context menu to get the version of the element that was checked in most recently. This option isn't available if you have the element checked out yourself.

Working with labels

Working with labels is similar to working with elements. To change, delete, or add a label, you must check out the label file containing the label. You can check out the label file from the Label editor dialog box.

The main difference between checking out elements and checking out label files is that simultaneous checkouts are allowed for label files. This means that others can change labels while you have a label file checked out.

Figure 2-34 shows the Check In dialog box.

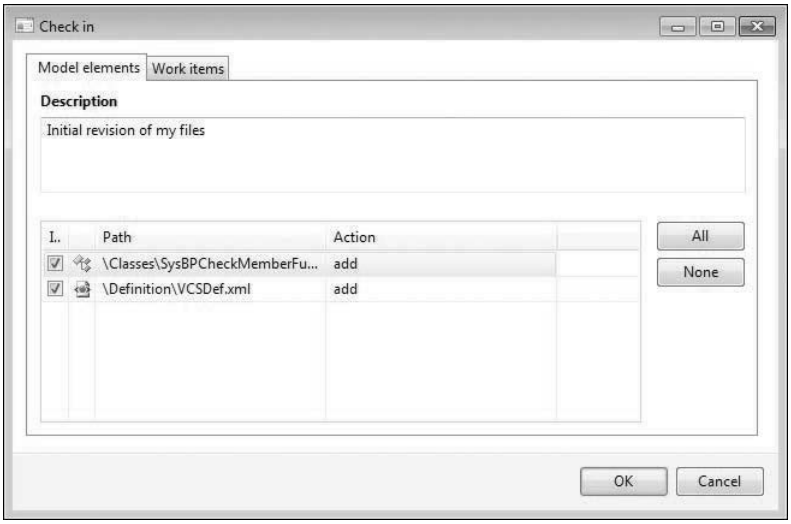

FIGURE 2-34 The Check In dialog box.

If you create a new label when using version control, a temporary label ID is assigned (for example, @$AA0007 as opposed to @USR1921). When you check in a label file, your changes are automatically merged into the latest version of the file and the temporary label IDs are updated. All references in the code are automatically updated to the newly assigned label IDs. Temporary IDs eliminate the need for a central Team Server, which was required for AX 2009, because IDs no longer have to be assigned when the labels are created. If you modify or delete a label that another person has also modified or deleted, your conflicting changes are abandoned. Such lost changes are shown in the Infolog after the check-in completes.

Synchronizing elements

Synchronization makes it possible for you to get the latest version of all elements. This step is required before you can check in any elements. You can initiate synchronization from the Development Workspace. On the Version Control menu, point to Periodic > Synchronize.

Synchronization is divided into three operations that happen automatically in the following sequence:

1. The latest files are copied from the version control server to the local disk.
2. The files are imported into the AOT.
3. The imported files are compiled.

Use synchronization to make sure your system is up to date. Synchronization won't affect any new elements that you have created or any elements that you have checked out.

Figure 2-35 shows the Synchronization dialog box.

FIGURE 2-35 The Synchronization dialog box.

Selecting the Force check box gets the latest version of all files, even if they haven't changed, and then imports every file.

When using Visual SourceSafe, you can also synchronize to a label defined in Visual SourceSafe. This way, you can easily synchronize to a specific build or version number.

Synchronization is not available with MorphX VCS.

Viewing the synchronization log

The way that you keep track of versions on the client depends on your version control system. Visual SourceSafe requires that AX 2012 keep track of itself. When you synchronize the latest version, it is copied to the local repository folder from the version control system. Each file must be imported into AX 2012 to be reflected in the AOT. To minimize the risk of partial synchronization, a log entry is created for each file. When all files are copied locally, the log is processed, and the files are automatically imported into AX 2012.

When synchronization fails, the import operation is usually the cause of the problem. Synchronization failure leaves your system in a partially synchronized state. To complete the synchronization, restart AX 2012 and restart the import. You use the synchronization log to restart the import, and you access it from the Development Workspace menu at Version Control > Inquiries > Synchronization log.

The Synchronization Log dialog box, shown in Figure 2-36, displays each batch of files, and you can restart the import operation by clicking Process. If the Completed check box is not selected, the import has failed and should be restarted.

The Synchronization log is not available with MorphX VCS.

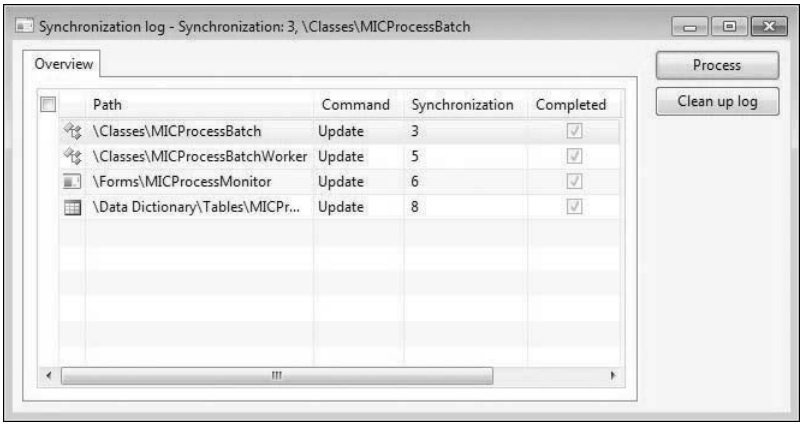

FIGURE 2-36 The Synchronization Log dialog box.

Showing the history of an element

One of the biggest advantages of version control is the ability to track changes to elements. Selecting History on an element's context menu displays a list of all changes to an element, as shown in Figure 2-37.

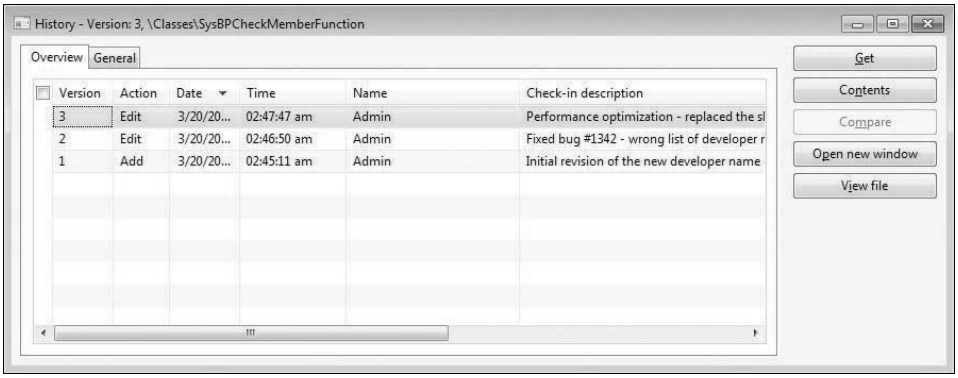

FIGURE 2-37 Revision history of an element.

For each revision, this dialog box shows the version number, the action performed, the time the action was performed, and who performed the action. You can also see the change number and the change description.

A set of buttons in the History dialog box allows further investigation of each version. Clicking Contents opens a form that shows other elements included in the same change. Clicking Compare opens the Compare dialog box, where you can do a line-by-line comparison of two versions of the element. The Open New Window button opens an AOT window that shows the selected version of the element, which is useful for investigating properties because you can use the standard MorphX toolbox. Clicking View File opens the .xpo file for the selected version in Notepad.

Comparing revisions

Comparison is the key to harvesting the benefits of a version control system. You can start a comparison from several places, including from the context menu of an element, by pointing to Compare. Figure 2-38 shows the Comparison dialog box, where two revisions of the form *CustTable* are selected.

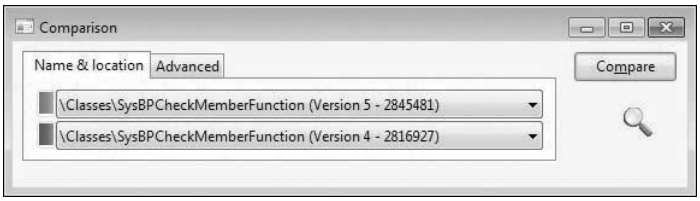

FIGURE 2-38 Comparing element revisions from version control.

The Compare dialog box contains a list of all checked-in versions, in addition to the element versions available in other layers that are installed.

Viewing pending elements

When you're working on a project, it's easy to lose track of which elements you've opened for editing. The Pending Objects dialog box, shown in Figure 2-39, lists the elements that are currently checked out in the version control system. Notice the column containing the action performed on the element. Deleted elements are available only in this dialog box; they are no longer shown in the AOT.

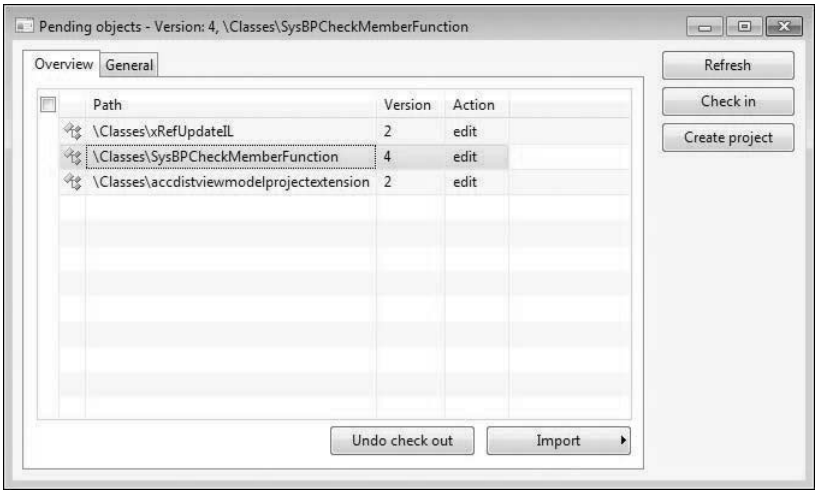

FIGURE 2-39 Pending elements.

You can access the Pending Objects dialog box from the Development Workspace menu: Version Control > Pending Objects.

Creating a build

Because the version control system contains .xpo files and not a model file, a build process is required to generate the model file from the .xpo files. The following procedure provides a high-level overview of the build process:

1. Use the CombineXPOs command-line utility to combine all .xpo files into one. This step makes the .xpo file consumable by AX 2012. AX 2012 requires all referenced elements to be present in the .xpo file or to already exist in the AOT to maintain the references during import.
2. Import the new .xpo file by using the command-line parameter *-AOTIMPORTFILE=*<FileName.xpo>*-MODEL=*<Model Name> to Ax32.exe. This step imports the .xpo file and compiles everything. After this step is complete, the new model is ready in the model store.
3. Export the model to a file by using the axutil command-line utility: *axutil export /model:*<model name> */file:*<model file name>.
4. Follow these steps for each layer and each model that you build.

The build process doesn't apply to MorphX VCS.

Integrating AX 2012 with other version control systems

The implementation of the version control system in AX 2012 is fully pluggable. This means that any version control system can be integrated with AX 2012.

Integrating with another version control system requires a new class implementing the *SysVersionControlFileBasedBackEnd* interface. It is the implementation's responsibility to provide the communication with the version control system server being used.

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CHAPTER 22

Developing mobile apps for AX 2012

In this chapter

Introduction

Device form factors and their associated interfaces are changing rapidly. At the same time, AX 2012 customers have an increasing need to interact with AX 2012 across a broad set of devices. In addition, new technologies are facilitating new scenarios, in which apps that provide personalized information in context are becoming more important for improving employees' productivity. Microsoft is investing in these new scenarios that let customers work with devices in new ways, and Microsoft Dynamics is taking full advantage of this work.

Microsoft Dynamics is creating new mobile device experiences for AX 2012 customers through apps. These apps are designed to help a broad range of employees improve their efficiency while on the go and stay connected to their business processes. Scenarios include native experiences for both smartphones and tablets. In addition to developing its own apps, Microsoft Dynamics is committed to helping developers build their own immersive device experiences for AX 2012.

These apps can interact directly with AX 2012 by using the existing AX 2012 services framework. This approach also uses existing AX 2012 user accounts so that no additional provisioning is required. For more information about AX 2012 services, see Chapter 12, "AX 2012 services and integration."

This chapter begins by providing an overview of the current mobile app landscape and how it relates to AX 2012. It then describes the AX 2012 mobile architecture and the technical and user interface considerations for developing mobile apps. For more detailed instructions about developing mobile apps for AX 2012, see the sources listed in the "Resources" section at the end of the chapter.

The mobile app landscape and AX 2012

With AX 2012 R3 and its associated investments in mobile solutions, the Microsoft Dynamics AX team expects that the Microsoft Dynamics AX ecosystem will see an increasing investment in mobile apps. There is an early-mover advantage for developers who identify and take advantage of these opportunities, and AX 2012 customers who equip their people with powerful mobile apps will have an advantage in their respective markets. The mobile architecture discussed throughout this chapter has been proven by mobile apps that are already available in the marketplace and by customers who are deploying those apps.

Creating mobile apps requires a different set of skills than developing for AX 2012, and customers and partners might find it advantageous to pair an AX 2012 developer with a mobile app developer. This way, necessary AX 2012 services can be created by experienced AX 2012 developers. Except for needing to understand the content of the services, typical mobile app developers can develop AX 2012 mobile apps without having to understand the intricate details of AX 2012. Thus, partners and customers can take advantage of the vast pool of mobile app developers.

Mobile architecture

The AX 2012 mobile architecture is designed to help developers overcome the following challenges that are inherent in developing mobile apps:

- How to facilitate communication between apps and on-premises installations
- How to authenticate users
- How to develop for multiple platforms

Because AX 2012 most often runs on-premises or is privately hosted, the average phone or tablet device does not have access to AX 2012 services, which are usually available only through a corporate network. To overcome this challenge, the mobile architecture uses the Microsoft Azure Service Bus Relay. The Service Bus Relay solves the challenges of communicating between on-premises applications and the outside world by allowing on-premises web services to project public endpoints. Systems can then access these web services, which continue to run on-premises, from anywhere.

The Service Bus Relay is based on a namespace that is set up for each company that deploys mobile apps for AX 2012. For example, an administrator from the Contoso company can create an Azure subscription and set up a unique namespace, such as *contosomobapps*. The namespace is a friendly identifier that end users enter into the mobile app to connect to their company's AX 2012 instance.

The second challenge is authenticating users. AX 2012 has existing user accounts that are based on Active Directory accounts. Ideally, device users simply use their corporate identities (user IDs and

passwords) to access AX 2012 from their devices. The mobile architecture accomplishes this by using Active Directory Federation Services (AD FS). AD FS is a Windows Server component that is used by users whose devices are not on the corporate network to authenticate themselves by using their existing corporate credentials.

Another challenge that mobile app developers face is providing apps for various device platforms, such as Windows 8.1, Windows Phone 8, iOS, and Android. By taking advantage of the mobile architecture, developers can create applications for the platform they choose, depending on customer requirements.

Note In some scenarios, you might want to use variations on the architecture described in this section. For more information, see the "Architectural variations" section later in this chapter.

Mobile architecture components

The AX 2012 mobile architecture includes the following key components:

- **AX 2012 services** Apps communicate with AX 2012 through the AX 2012 services framework.
- **Active Directory** Users who access AX 2012 through mobile apps are authenticated against their existing corporate identities.
- **AD FS** AD FS facilitates authentication of Active Directory–based users who are accessing AX 2012 through mobile apps.
- **Service Bus Relay** The Service Bus Relay ferries messages from the mobile app to an on-premises listener through which the app can reach an on-premises instance of AX 2012.
- **On-premises listener** The listener *listens* for messages from mobile apps that are relayed through the Service Bus Relay. The listener then makes calls to AX 2012 and responds to the mobile app through the Service Bus Relay.
- **Microsoft Azure Active Directory Access Control** Access Control verifies that the user has been authenticated through AD FS and then allows messages to be sent through the Service Bus Relay.
- **Mobile apps** These apps can be for a phone or tablet on any of the prevailing mobile platforms—Windows, iOS, or Android. The architecture provides the means for these apps to communicate with AX 2012. The apps can then interact with AX 2012 as appropriate, based on the business scenario. Apps can also be designed to communicate with other systems, depending on the needs of the business scenario.

Figure 22-1 shows the components of the mobile architecture.

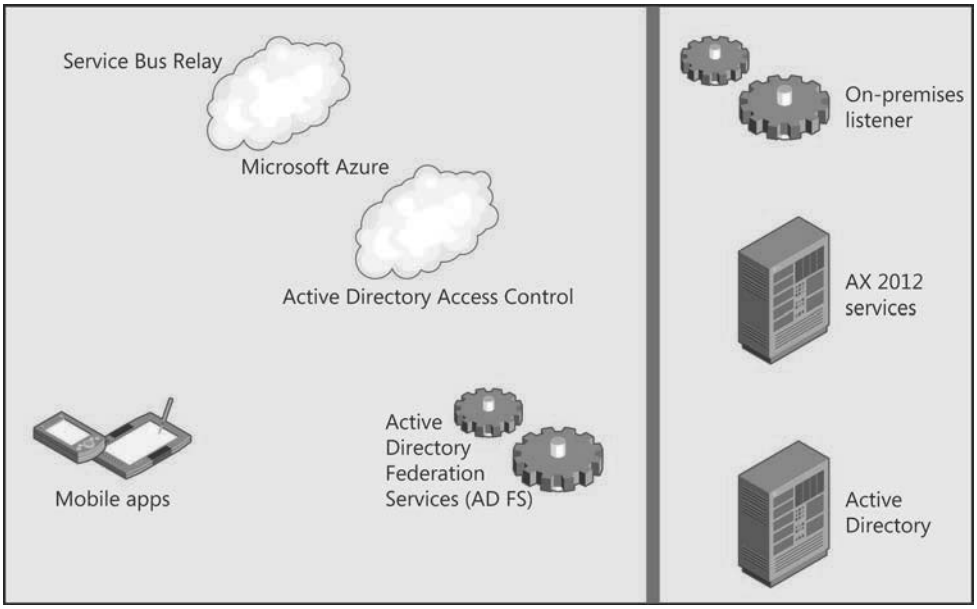

FIGURE 22-1 Mobile architecture components.

To become familiar with the mobile architecture, we recommend that you install and configure one or more of the AX 2012 mobile apps and the Microsoft Dynamics AX connector (on-premises listener) for mobile apps. Doing so will help you learn the configuration steps necessary for Azure, AD FS, AX 2012, and the listener. That familiarity will help you greatly in debugging and troubleshooting your apps. For more information about these components and their configuration, see the following white papers:

- Microsoft Dynamics AX 2012 White Paper: Developing Mobile Apps at *http://www.microsoft.com/en-us/download/details.aspx?id=38413*.
- Configure Microsoft Dynamics AX Connector for Mobile Applications at *https://mbs.microsoft.com/downloads/customer/AX/ConfigureAXConnectorforMobileApplications.pdf*. To access this paper, you must have CustomerSource or PartnerSource credentials.

You can download the AX 2012 expense app, which is used as an example throughout this chapter, at *http://apps.microsoft.com/windows/en-us/app/dynamics-ax-2012-expenses/07aab6f9-c6ce-4b81-b04c-4b43c3f6de67*.

Message flow and authentication

The following process outlines the flow of messages and describes how users are authenticated:

1. The user submits credentials to obtain a token from AD FS.
2. If the user's credentials are verified, a token is returned that is based on Security Assertion Markup Language (SAML). The token contains a claim that indicates the user name and company domain, such as *user@contoso.com*. The claim is used to verify the user's company affiliation and identity within the company.
3. The mobile app then presents the claim in the SAML token to Access Control. Access Control controls access to the Service Bus Relay; any app that calls the Service Bus Relay must have a token from Access Control.
4. Access Control validates the SAML token based on the previously established trust relationship between Access Control and AD FS for the Service Bus Relay namespace and company domain. Based on the claim in the SAML token, Access Control verifies that the user is from the company associated with the Service Bus Relay namespace. Access Control then provides a second token to the mobile app in Simple Web Token (SWT) format. The SWT token is then included in the request to the Service Bus Relay to send a message to AX 2012. The SAML token is also included and is used by the on-premises listener to authenticate the user.
5. The mobile app then sends the message (with associated tokens) through the Service Bus Relay to the on-premises listener. The Service Bus Relay ferries the message to the listener.

   The listener must also be authenticated to listen to the Service Bus Relay. This authentication is based on a Service Bus Relay namespace credential that is stored on the listener. The listener presents this credential as it starts to listen for messages coming from the namespace.
6. After a message is received from the Service Bus Relay, the listener validates the SAML token. The validation is based on a previously established trust relationship between the listener and AD FS. After verifying the token, the listener uses the claim to determine which AX 2012 user is using the mobile app making the call to AX 2012. The listener calls AX 2012 on behalf of the user identified in the claim.
7. The listener receives a response from AX 2012 and then returns the response message through the Service Bus Relay.
8. The Service Bus Relay sends the response message to the mobile app.

Figure 22-2 illustrates the message flow and authentication process. The numbering in the figure roughly corresponds to the numbers in the list.

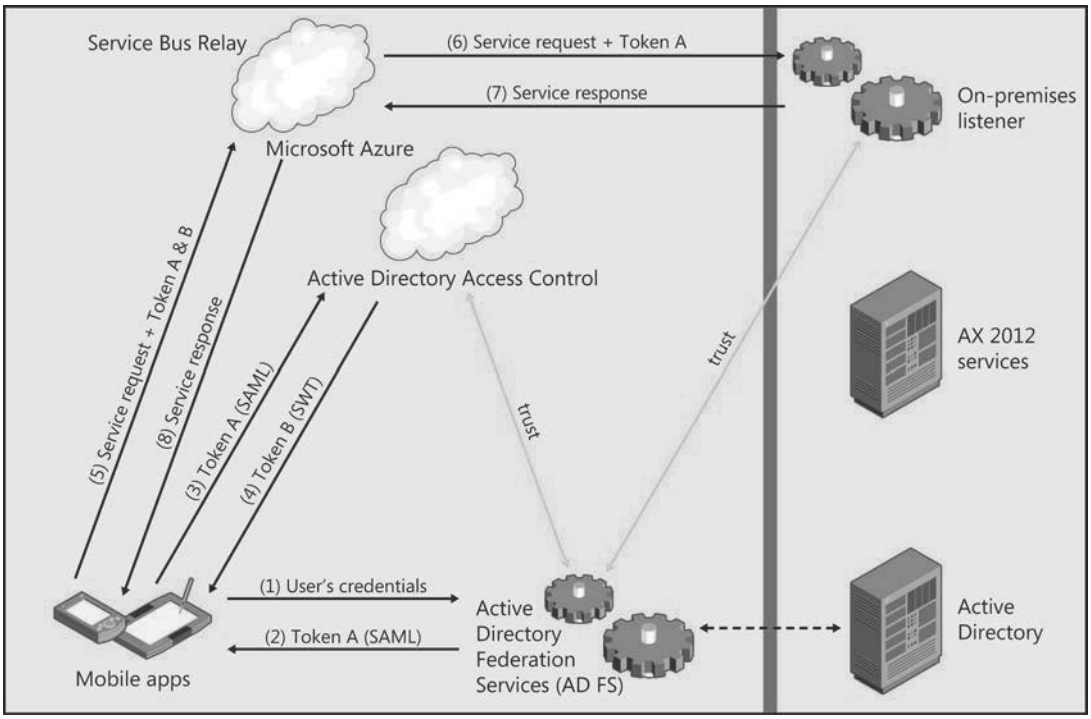

FIGURE 22-2 Message flow and authentication process.

Using AX 2012 services for mobile clients

To develop mobile apps, you must have an interface with AX 2012. The ideal approach is to use AX 2012 services for communication between mobile apps and AX 2012. For more information about AX 2012 services, see Chapter 12.

The AX 2012 services framework provides multiple types of services—system services, custom services, and document services—each with its own programming model. Custom services are the most likely to provide the exchange of messages that are appropriate for a mobile app.

To design an AX 2012 service that can be consumed by your mobile app, you will need to do the following:

1. Create AX 2012 services and data contracts, and deploy a basic inbound port to expose the service operations for consumption.
2. Implement the service methods in X++ classes to perform data operations in AX 2012.

The mobile client must communicate with the AX 2012 service, which is hosted on an Application Object Server (AOS) instance that is deployed behind a corporate firewall. Instead of configuring changes in the firewall, such as exposing an Internet Information Services (IIS) server externally to expose the on-premises service, the app makes use of a secured Service Bus Relay.

AX 2012 services are typically accessed by using Simple Object Access Protocol (SOAP). This approach might work well for some mobile applications. However, the trend in developing web and mobile applications is to interact by using *RESTful* services. (Representational state transfer [REST] is an architecture that allows developers to write asynchronous code that connects with cloud-based services more easily.) For information about RESTful services, see the article, "An Introduction To RESTful Services With WCF," at *http://msdn.microsoft.com/en-us/magazine/dd315413.aspx*.

Currently AX 2012 does not expose custom services by using a RESTful approach. One option is for the on-premises listener to translate RESTful calls from a mobile app to SOAP calls to AX 2012 (and vice versa). The Microsoft Dynamics AX product group used this approach to develop the Microsoft Dynamics AX Windows Store apps (expenses, timesheets, and approvals). For more information about the Microsoft Dynamics AX Windows Store apps, see "What's new: Companion apps for Microsoft Dynamics AX 2012 R2" at *http://technet.microsoft.com/en-us/library/dn527182.aspx*.

Developing an on-premises listener

As described earlier, you'll need an on-premises service that acts as an intermediary between the Service Bus Relay and AX 2012 services. One approach is to use Windows Communication Foundation (WCF) to build a simple listener.

Beyond the listener's primary purpose of passing messages between the Service Bus Relay and AX 2012, the listener can provide additional features that facilitate the development of mobile applications. For example, the listener can provide configuration information to the app, such as whether certain features of the app are enabled or disabled. The listener can expose RESTful calls to the client. The Microsoft Dynamics AX product group used WCF features to translate between the SOAP and JavaScript Object Notation (JSON) protocols for messaging to the Windows Store apps. This is a standard feature of WCF. The listener can also capture meaningful information in the event log and provide telemetry information.

Another approach is to use the Azure Service Bus adapter built into AX 2012 starting with AX 2012 R2 cumulative update 6. With this approach, you configure IIS as the listener. Depending on the requirements of your mobile app, you can choose the best approach. For a comparison of these approaches, see "Microsoft Dynamics AX White Paper: Developing Mobile Apps" at *http://www.microsoft.com/en-us/download/details.aspx?id=38413*.

Developing a mobile app

When you are developing a mobile app, it is helpful to start by prototyping and developing based on simple scenarios. For example, one initial prototype app that the Microsoft Dynamics AX team developed simply updated data to AX 2012; it didn't read data from AX 2012 or require authentication. Additional features were added as the app moved from prototype to production. Keeping apps as focused and as simple as possible is a good guideline for mobile apps in general.

Platform options and considerations

The mobile architecture described in this chapter is platform-independent and device-independent. You can use this architecture to develop applications across the spectrum of devices, including laptops, tablets, and phones. You can also use it across the landscape of development technologies, such as C# and Extensible Application Markup Language (XAML), HTML5 and JavaScript, Objective-C, and Java.

The underlying technologies used in the architecture, such as AD FS, the Service Bus Relay, and AX 2012 services, are commonly used in cross-platform development.

Developer documentation and tools

One of the goals of the mobile architecture is to solve the basic issues of interacting with AX 2012 so that mobile app developers can focus on their apps. With the problem of communicating with AX 2012 solved, developers can use the wealth of documentation and tools available to them. A large community of mobile app developers builds apps for AX 2012, without needing to understand the underlying AX 2012 framework. To the mobile app, calls to AX 2012 are simply web services calls, which is very common for mobile apps.

Microsoft offers an exhaustive set of samples, tutorials, and tools for developers who are creating apps for the Windows Store and for Windows Phone. As of this writing, the Windows 8.1 app sample pack includes more than 330 samples at *http://code.msdn.microsoft.com/windowsapps/Windows-8-Modern-Style-App-Samples/view/SamplePack#content*. The following are of particular of interest:

- "Windows Store app for banking: code walkthrough (Windows Store apps using JavaScript and HTML)" at *http://msdn.microsoft.com/library/windows/apps/hh464943*.
- A data binding overview (Windows Store apps using C#, Visual Basic, C++, and XAML) at *http://msdn.microsoft.com/en-us/library/windows/apps/hh758320.aspx*.

These types of samples can be relevant to developing mobile apps for AX 2012.

Third-party libraries

In addition to published samples, an extensive set of third-party libraries are available for developing mobile apps. Examples of functions provided by these libraries include data binding, storage, lookups, currency, controls (such as calendars), and date/time functions. If your organization allows the use of third-party libraries, using these libraries can help boost developer productivity.

Best practices

This section describes some valuable considerations to keep in mind when designing and developing mobile apps.

- **Take advantage of native device capabilities** Taking advantage of the capabilities of a device can greatly enhance mobile apps. For example the device's camera can be used to record documents or receipts. The camera can also be used to capture damage or repair situations (for construction, manufacturing, or field services) as part of an AX 2012 transaction. The geographic information from the device can be used to map a location or address known to AX 2012, such as a customer, vendor, or site.

- **Make use of data caching and local storage** Master and lookup data might need to be cached on the device as an alternative to requesting data from the service each time it is needed. For example, expense categories or currency types are relatively static and can be safely cached locally. The mobile app can refresh those on an infrequent basis. Some reference data can be cached but must be refreshed more frequently. For example, projects or customers can be stored locally but might need to be refreshed at app startup or on a regular basis.

  You can store data locally by using available technologies such as indexDB or SQLite. These technologies are supported across platforms and devices. You might need to use the *RecVersion* field to determine whether records are synchronized. For more information, see "Concurrency When Updating Data" at *http://technet.microsoft.com/en-us/library/cc639058.aspx*.

- **Consider bandwidth and connectivity in your design** Mobile devices typically have less bandwidth than desktop computers on corporate networks. You'll need to make appropriate tradeoffs to ensure that your apps work on lower bandwidths. For example, a phone app might impose a size limit on a picture that is sent with a transaction because of bandwidth limitations.

  You should also consider intermittent connectivity. Mobile apps should be designed to expect interruptions in connectivity. This might mean saving appropriate state information and data locally, and using that stored data when connectivity is restored.

- **Allow for offline use** In some scenarios, it is beneficial for users to have some app functionality when the app is offline (not connected). Consider whether you can enable some of the app's functionality offline. It is important to consider the level of business logic that should reside in the app for offline scenarios. It probably makes sense to enable offline features where extensive business logic (which is available in AX 2012) is not required. If you don't enable offline features in such cases, your app will need to apply the business logic and have the user react as appropriate when it reconnects.

Key aspects of authentication

Authentication was discussed earlier in this chapter as part of the overall message flow. However, because authentication is a key and potentially complicated part of the process, this section focuses on some of its more complicated aspects.

As mentioned earlier, because the mobile app will likely run on a device that is not on a corporate network, users must be authenticated. The first step in the process is to acquire the users' credentials (user names and passwords). We recommend that you store those credentials in the app by using a secure storage mechanism on the device. That way, the mobile app can silently authenticate users without prompting them for credentials each time the app runs.

Another complicated aspect of configuring authentication is setting up Secure Sockets Layer (SSL). AD FS uses SSL to ensure that the passing of credentials and tokens between the mobile app and AD FS is protected. The AD FS endpoint has a URL based on the company's domain. For example, the AD FS endpoint for the Contoso company might end in *contoso.com*. To enable SSL, you must install an appropriate SSL certificate in AD FS. More precisely, you must set up SSL in IIS, which is used as the front end for AD FS.

Setting up SSL in IIS is a common practice because many websites require the use of SSL for interactions that require authentication or share protected information. The SSL certificate must be issued by a recognized certificate authority (CA). In issuing an SSL certificate, the CA verifies that the entity requesting the certificate is associated with the domain for which the certificate is being issued. For example, the administrator for Contoso must prove to the CA that she is associated with the *contoso.com* domain. This is typically done by the CA making contact by using the contact information (phone number and email address) associated with the contoso.com domain in the Domain Name System (DNS) records. Whether you are setting up AD FS for demonstration, testing, or production purposes, it is necessary to have a CA-issued SSL certificate for the domain used by AD FS. For more information, see "Obtain an SSL Certificate" at *http://msdn.microsoft.com/en-us/library/gg981937.aspx*.

For more information about configuring authentication, see "Developing secure mobile apps for Microsoft Dynamics AX 2012" at *http://technet.microsoft.com/EN-US/library/dn155874.aspx* and "Microsoft Dynamics AX Connector for Mobile Applications" at *https://mbs.microsoft.com/downloads/customer/AX/ConfigureAXConnectorforMobileApplications.pdf* (CustomerSource or PartnerSource credentials are required).

User experience

Developing mobile apps for AX 2012 creates an opportunity for developers to reimagine user experiences. Across the landscape of devices, mobile apps are generating a wave of exciting new user experiences. We encourage you to be inspired by these immersive experiences when envisioning mobile apps for AX 2012. The expense app created by the Microsoft Dynamics AX product group provides some vivid examples.

The following illustrations show examples of the existing AX 2012 experience compared with the new mobile app experience in the expense app. The top half of Figure 22-3 shows the expense report experience in the AX 2012 Employee Services portal. The bottom half of Figure 23-3 shows the corresponding experience in the AX 2012 expense mobile app. Both user interfaces display views of a list of

expense reports. Note that the mobile app takes advantage of cards to represent expense reports and uses color to represent status. The app is designed to be touch-friendly and hides commands until needed. However, the mobile app also works well with a mouse and keyboard.

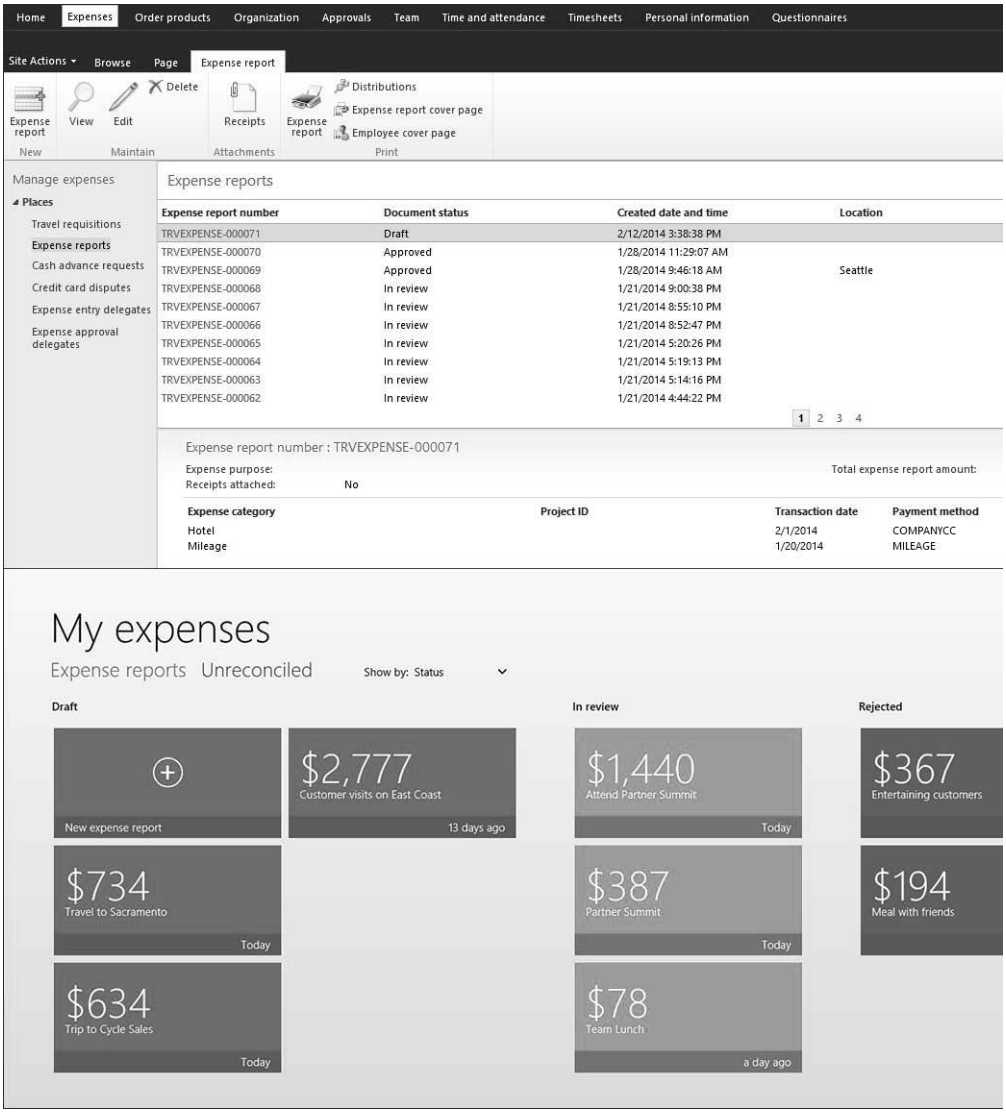

FIGURE 22-3 Screenshots of expense reports in the AX 2012 Employee Services portal and in the expense mobile app.

Figure 22-4 shows the edit experience within an expense report in the AX 2012 Employee Services portal and in the expense app. Again, the mobile app uses cards to represent expenses, and color and icons to show categories. The mobile app also uses a calendar to show the expenses during the week based on the transaction date.

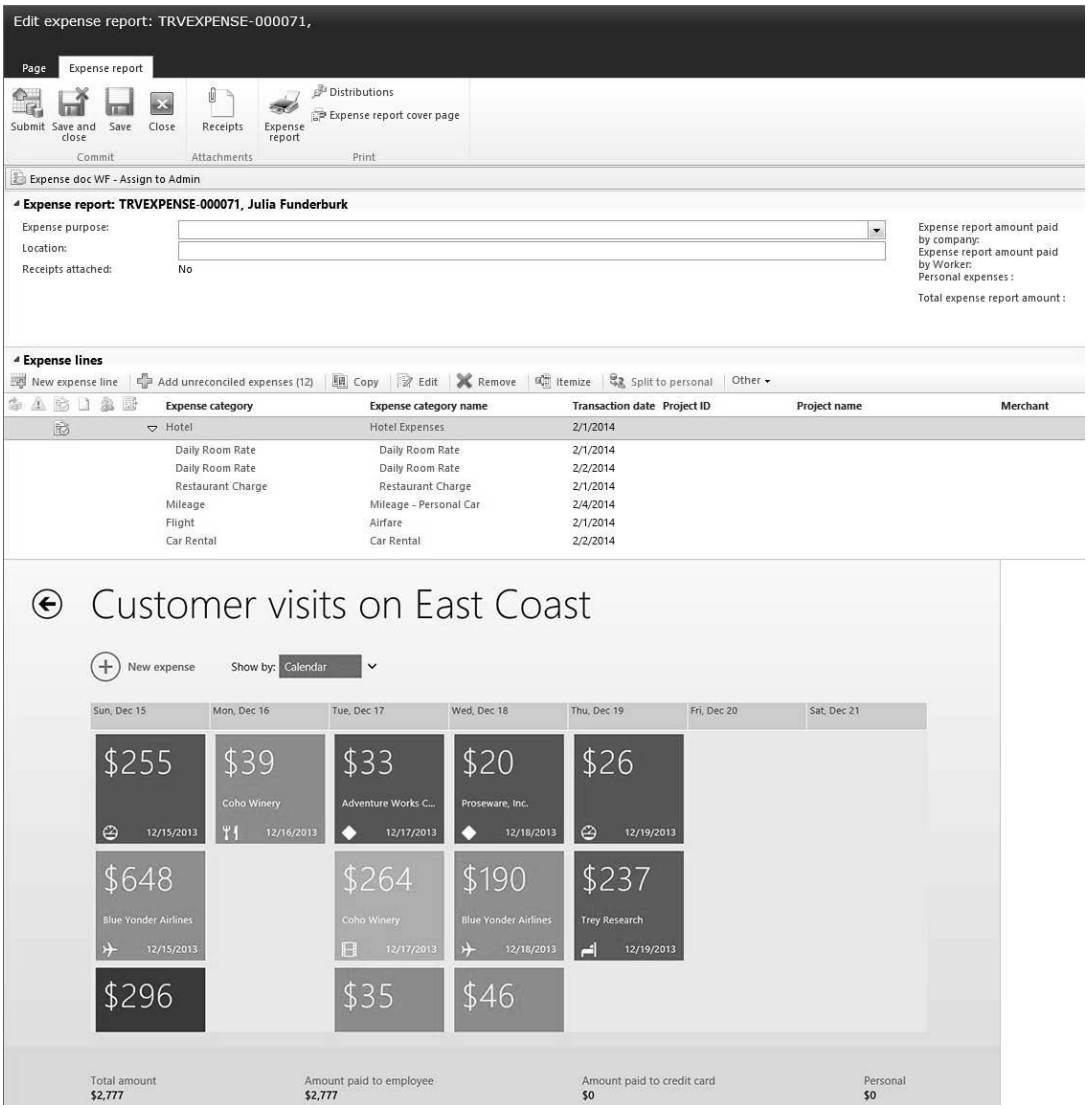

FIGURE 22-4 Screenshots of the edit expense reports experience in the AX 2012 Employee Services portal and in the expense mobile app.

User experience guidelines are quickly evolving as the role of devices expands. For detailed information and guidelines for developing mobile apps, see "Getting started with developing for Windows Phone 8" at *http://msdn.microsoft.com/en-us/library/windowsphone/develop/ff402529(v=vs.105).aspx*. This document is updated frequently, so check back often.

Globalization and localization

Mobile apps should support globalization and localization, as described here:

- Globalization entails using the correct formats for numbers, dates, times, addresses, and phone numbers for different locales. For the AX 2012 apps developed by Microsoft, globalization is based on the country or regional settings of the device.
- Localization entails displaying the user interface in the language of the user. For the AX 2012 apps developed by Microsoft, the app language is based on the user's language in AX 2012.

We recommend that you design apps so that resources, such strings and images, are separate from code. This enables them to be independently localized into different languages.

App monitoring

Having information about the usage of your mobile apps is generally valuable, so we suggest that you develop your apps to capture and save monitoring information. This approach is also referred to as telemetry or instrumentation. Windows Store apps and Windows Phone apps inherently capture some information, including downloads, basic usage, and errors. In addition, it is useful to capture more detailed information about how the apps are used. Application insights help you find out what users are doing with the app and help you diagnose performance or exceptions with the app. Application Insights for Microsoft Visual Studio Online is a cloud-based service designed for monitoring mobile or web apps. For more information, see *http://msdn.microsoft.com/en-us/vstudio/dn481095(v=vs.98).aspx*.

Web traffic debugging

The mobile app architecture relies heavily on calls to web services. These include calls to authenticate the user of the app and calls to AX 2012 (through the Service Bus Relay). It is very useful to capture and analyze the content of these calls. The Fiddler web debug proxy is an excellent tool for viewing and analyzing the web services calls. You can configure Fiddler to work with mobile devices.

The following blog posts describe how to use Fiddler to develop apps for Windows 8 phones:

- *http://www.geekchamp.com/news/windows-phone-8-and-fiddler*
- *http://www.spikie.be/blog/post/2013/01/04/Windows-Phone-8-and-Fiddler.aspx*
- *http://blogs.msdn.com/b/fiddler/archive/2011/09/14/fiddler-and-windows-8-metro-style-applications-https-and-private-network-capabilities.aspx*

And the following blog post describes how to use Fiddler with iPhone5:

- *http://blog.brianbeach.com/2013/01/using-fiddler-with-iphoneipad.html*

Architectural variations

So far, this chapter has focused primarily on a specific mobile architecture that solves the key challenges of allowing remote mobile apps to work with an on-premises deployment of AX 2012. This architecture is also optimized for apps that are distributed by app stores and installed on local devices. However, certain variations of this architecture might be appropriate in specific scenarios.

On-corpnet apps

In some scenarios, mobile apps are used exclusively within a corporate network environment. An example is a warehouse app that has corporate network connectivity throughout the facility. In such a case, the user is already authenticated when accessing the corporate network, so further authentication isn't necessary. Also, the app can access AX 2012 through the corporate network, so the Service Bus Relay might not be necessary.

Web apps

Another approach to mobile apps is the use of web apps targeted for mobile devices. In this case, the app is available through the web browser on the device. This approach has some tradeoffs. Some scenarios might be most appropriate for web apps, and other scenarios might be most appropriate for mobile apps that are installed on the device. Many popular websites today also deliver mobile apps that users install, even though the experience is also available through browsers.

Web apps have the following advantages:

- They work across devices, although they need to be tested and refined to handle device-specific nuances.
- They are more adaptable to AX 2012 customizations and extensions. Because they are rendered from the AX 2012 server, the apps can include the customizations and extensions that have been applied to the server.
- They do not require users to install or configure the apps.

Web apps have the following disadvantages:

- They don't provide the high-fidelity, immersive experiences available in modern mobile apps.
- They rely completely on the server to deliver the app and content. The server might not perform as well or might be less responsive than an app that is installed on the device.
- They typically don't have local caching or offline capabilities.
- They probably can't take advantage of device features such as a camera or GPS.

You can use these tradeoffs to decide which approach is most appropriate for your scenario.

Resources

This section contains a list of recommended sources of information to assist developers with troubleshooting and debugging.

- **CustomerSource and PartnerSource** The "Mobile Apps for Dynamics AX" page on CustomerSource and PartnerSource has a wealth of information for deploying the existing apps or developing mobile apps:
  - **CustomerSource** *https://mbs.microsoft.com/customersource/northamerica/AX/news-events/news/MSDYN_MobileAppsAX*
  - **PartnerSource** *https://mbs.microsoft.com/partnersource/northamerica/news-events/news/MSDYN_MobileAppsAX*

Note You must register to be able to access these sites.

- **Companion Apps blog** The Microsoft Dynamics AX Companion Apps blog is a source of regularly updated information. The blog includes an FAQ page for common questions and issues at *http://blogs.msdn.com/b/axcompapp/.*
- **Support** The normal Microsoft Dynamics AX support channels are available to support the mobile apps released by Microsoft for AX 2012. This includes support for the on-premises listener and its associated configuration.

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Index

A

B

C

D

E

F

G

H

I

J

K

L

M

N

O

P

Q

R

S

T

U

V

W

X