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AUGUST 2016 VOLUME 31 NUMBER 8

ID STATEMENT MSDN Magazine (ISSN 1528-4859) is published monthly by 1105 Media, Inc., 9201 Oakdale Avenue, Ste. 101, Chatsworth, CA 91311. Periodicals postage paid at Chatsworth, CA 91311-9998, and at additional mailing offices. Annual subscription rates payable in US funds are: U.S. $35.00, International $60.00. Annual digital subscription rates payable in U.S. funds are: U.S. $25.00, International $25.00. Single copies/back issues: U.S. $10, all others $12. Send orders with payment to: MSDN Magazine, P.O. Box 3167, Carol Stream, IL 60132, email MSDNmag@1105service.com or call (847) 763-9560. POSTMASTER: Send address changes to MSDN Magazine, P.O. Box 2166, Skokie, IL 60076. Canada Publications Mail Agreement No: 40612608. Return Undeliverable Canadian Addresses to Circulation Dept. or XPO Returns: P.O. Box 201, Richmond Hill, ON L4B 4R5, Canada.

CORPORATE ADDRESS 1105 Media, 9201 Oakdale Ave. Ste 101, Chatsworth, CA 91311 www.1105media.com

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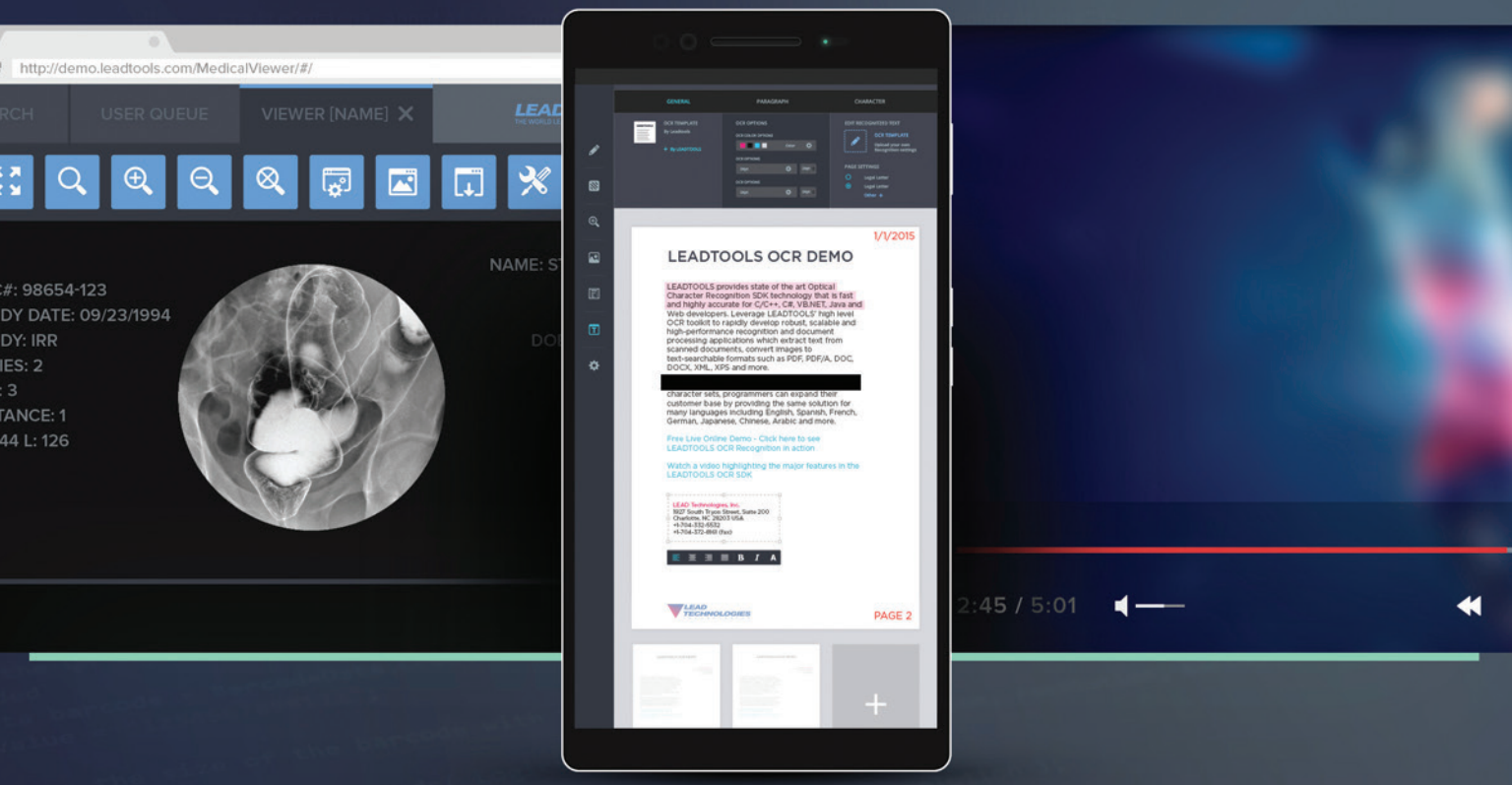

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Editor's Note

MICHAEL DESMOND

DevOps Directive

Writing good software is hard. Managing the process of writing, maintaining and delivering good software is even harder—particularly when you add cross-platform mobile app development to the mix. Which is why Microsoft has been so busy improving and extending its DevOps solutions, addressing the software development lifecycle from planning and development, to testing and build, to deployment and monitoring.

Donovan Brown is a senior DevOps program manager at Microsoft. He defines DevOps as "the union of people, process and products to enable continuous delivery of value to our end users." That focus on value is important, as it goes beyond simple code metrics to emphasize the tangible impact that delivered software has on the business, its workers and customers.

> Every code writing effort, from traditional client-server applications to Android- and iPhone-based mobile apps, stands to improve within a robust DevOps environment.

"To continuously deliver value implies that you are able to monitor and validate that value is actually delivered," he says. "Just copying files to a server and hoping that people use them—there is no way to quantify or even qualify if I delivered value."

How serious is Microsoft about DevOps? Based on the company's $400 million-plus purchase of Xamarin in March and the acquisition of tools-maker HockeyApp at the close of 2014—very. At the Build conference in March, Brown demoed the extended DevOps capabilities in the cloud-based Visual Studio Team Services tool. As he told the audience before showing how the DevOps tool chain can improve a mobile app development scenario: "I'm just going to rub a little DevOps on it and make it better."

Al Hilwa, program director for software development research at IDC, was impressed. "Microsoft wants its tools for developers to be what Office is for knowledge workers. That is, they want to be the No. 1 toolchain for cross-platform development, mobile, cloud, everything," he says. "This is a tall order, but they are in fact executing on it and building a multi-platform ecosystem. Given their history with developers, you have to give them good odds on this."

This is exciting stuff. Features like Xamarin Test Cloud let developers test app code against ranks of cloud-hosted smartphones and devices, while HockeyApp provides a way to distribute pre-release code to select groups of testers and receive both user feedback and app telemetry.

To help get ahead of it all, this month we're launching the first in a series of articles focused on mobile DevOps, starting with Kraig Brockschmidt's feature, "From Code to Customer: Exploring Mobile DevOps." Also this month, the ALM Rangers team at Microsoft shows how to leverage DevOps to build Visual Studio Team Services Extensions, while Jonathan Waldman explores the integration of Git source code management with Visual Studio 2015.

The Microsoft effort on DevOps is intriguing in that it promises to lift all boats. Every code writing effort, from traditional client-server applications to Android- and iPhone-based mobile apps, stands to improve within a robust DevOps environment.

What are your thoughts on Microsoft's DevOps push?

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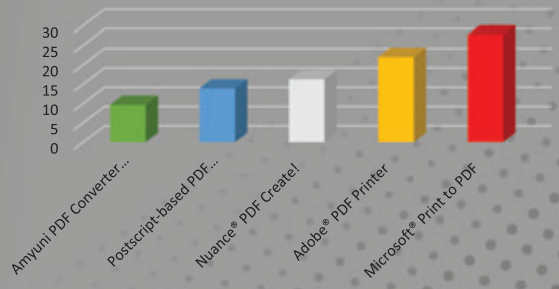

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DINO ESPOSITO

Beyond CRUD: Commands, Events and Bus

In recent installments of this column, I discussed what it takes to build a Historical create, read, update, delete (H-CRUD). An H-CRUD is a simple extension to classic CRUD where you use two conceptually distinct data stores to persist the current state of objects and all the events that happened during the lifetime of individual objects. If you simply limit your vision to the data store that contains the current state, then all is pretty much the same as with classic CRUD. You have your customer records, your invoices, orders and whatever else forms the data model for the business domain.

The key thing that's going on here is that this summary data store isn't the primary data store you create, but is derived as a projection from the data store of events. In other words, the essence of building a historical CRUD is to save events as they happen and then infer the current state of the system for whatever UI you need to create.

Designing your solution around business events is a relatively new approach that's gaining momentum, though there's a long way ahead for it to become the mainstream paradigm. Centering your design on events is beneficial because you never miss anything that happens in the system; you can reread and replay events at any time and build new projections on top of the same core data for, say, business intelligence purposes. Even more interesting, with events as an architect, you have the greatest chance to design the system around the business-specific ubiquitous language. Well beyond being a pillar of Domain-Driven Design (DDD), more pragmatically the ubiquitous language is a great help to understand the surrounding business domain and plan the most effective architectural diagram of cooperating parts and internal dynamics of tasks and workflows.

> Most of the time, acknowledging requirements means mapping understood requirements to some relational data model.

The implementation of events you might have seen in my May (msdn.com/magazine/mt703431) and June 2016 (msdn.com/magazine/mt707524) columns was very simple and to some extent even simplistic. The main purpose, though, was showing that any CRUD could be turned into an H-CRUD with minimal effort and still gain some benefits from the introduction of business events. The H-CRUD approach has some obvious overlapping with popular acronyms and keywords of today such as CQRS and Event Sourcing. In this column, I'll take the idea of H-CRUD much further to make it merge with the core idea of Event Sourcing. You'll see how H-CRUD can turn into an implementation made of commands, buses and events that at first might look like an overly complex way to do basic reads and writes to a database.

> The real cardinality of the event/aggregate association is written in the ubiquitous language of the business domain.

One Event, Many Aggregates

In my opinion, one of the reasons software is sometimes hard to write on time and on budget is the lack of attention to the business language spoken by the domain expert. Most of the time, acknowledging requirements means mapping understood requirements to some sort of relational data model. The business logic is then architected to tunnel data between persistence and presentation, making any necessary adjustments along the way. While imperfect, this pattern worked for a long time and the number of cases where monumental levels of complexity made it impractical were numerically irrelevant and, anyway, brought to the formulation of DDD, is still the most effective way to tackle any software projects today.

Events are beneficial here because they force a different form of analysis of the domain, much more task-oriented and without the urgency of working out the perfect relational model in which to save data. When you look at events, though, cardinality is key. In H-CRUD examples I discussed in past columns, I made an assumption that could be quite dangerous if let go without further considerations and explanation. In my examples, I used a one-to-one event-to-aggregate association. In fact, I used the unique identifier of the aggregate being persisted as the foreign key to link events. To go with the example of the article, whenever a room was booked, the system logs a booking-created event that refers to a given booking ID. To retrieve all events for an aggregate (that is, the booking) a query on the events data store for the specified booking ID is sufficient to get all information. It definitely works, but it's a rather simple scenario. The danger is that when aspects of a simple scenario become a common practice, you typically move from a simple solution to a simplistic solution. And this isn't exactly a good thing.

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Aggregates and Objects

The real cardinality of the event/aggregate association is written in the ubiquitous language of the business domain. At any rate, a one-to-many association is much more likely to happen than a simpler one-to-one association. Concretely, a one-to-many association between events and aggregates means that an event may sometimes be pertinent to multiple aggregates and that more than one aggregate may be interested in processing that event and may have its state altered because of that event.

As an example, imagine a scenario in which an invoice is registered in the system as a cost of an ongoing job order. This means that in your domain model, you probably have two aggregates—invoice and job order. The event invoice registered captures the interest of the invoice aggregate because a new invoice is entered into the system, but it might also capture the attention of the JobOrder aggregate if the invoice refers to some activity pertinent to the order. Clearly, whether the invoice relates to a job order or not can be determined only after a full understanding of the business domain. There might be domain models (and applications) in which an invoice may stand on its own and domain models (and applications) in which an invoice might be registered in the accounting of a job order and subsequently alter the current balance.

However, getting the point that events may relate to many aggregates completely changes the architecture of the solution and even the landscape of viable technologies.

Dispatching Events Breaks Up Complexity

At the foundation of CRUD and H-CRUD lies the substantial constraint that events are bound to a single aggregate. When multiple aggregates are touched by a business event, you write business logic code to ensure that the state is altered and tracked as appropriate. When the number of aggregates and events exceeds a critical threshold, the complexity of the business logic code might become hard and impractical to handle and evolve.

At the foundation of CRUD and H-CRUD lies the substantial constraint that events are bound to a single aggregate.

In this context, the CQRS pattern represents a first step in the right direction as it basically suggests you reason separately on actions that "just read" or "just alter" the current state of the system. Event Sourcing is another popular pattern that suggests you log whatever happens in the system as an event. The entire state of the system is tracked and the actual state of aggregates in the system is built as a projection of the events. Put another way, you map the content of events to other properties that altogether form the state of objects usable in the software. Event Sourcing is built around a framework that knows how to save and retrieve events. An Event Sourcing mechanism is append-only, supports replay of streams of events and knows how to save related data that might have radically different layouts.

Event store frameworks such as EventStore (bit.ly/1UPxEUP) and NEventStore (bit.ly/1UdHcfz) abstract away the real persistence framework and offer a super-API to deal in code directly with events. In essence, you see streams of events that are somewhat related and the point of attraction for those events is an aggregate. This works just fine. However, when an event has impact on multiple aggregates, you should find a way to give each aggregate the ability to track down all of its events of interest. In addition, you should manage to build a software infrastructure that, beyond the mere point of events persistence, allows all standing aggregates to be informed of events of interest.

The concept of an aggregate comes from DDD; in brief it refers to a cluster of domain objects grouped together to match transactional consistency.

To achieve the goals of proper dispatching of events to aggregates and proper event persistence, H-CRUD is not enough. Both the pattern behind the business logic and the technology used for persisting event-related data must be revisited.

Defining the Aggregate

The concept of an aggregate comes from DDD and in brief it refers to a cluster of domain objects grouped together to match transactional consistency. Transactional consistency simply means that whatever is comprised within an aggregate is guaranteed to be consistent and up-to-date at the end of a business action. The following code snippet presents an interface that summarizes the main aspects of just any aggregate class. There might be more, but I dare say this is the absolute minimum:

```
public interface IAggregate
{
  Guid ID { get; }
  bool HasPendingChanges { get; }
  IList<DomainEvent> OccurredEvents { get; set; }
  IEnumerable<DomainEvent> GetUncommittedEvents();
}
```

At any time, the aggregate contains the list of occurred events and can distinguish between those committed and those uncommitted that result in pending changes. A base class to implement the IAggregate interface will have a non-public member to set the ID and implement the list of committed and uncommitted events. Furthermore, a base Aggregate class will also have some RaiseEvent method used to add an event to the internal list of uncommitted events. The interesting thing is how events are internally used to alter the state of an aggregate. Suppose you have a Customer aggregate and want to update the public name of the customer. In a CRUD scenario, it will simply be an assignment like this:

```
customer.DisplayName = "new value";
```

With events, it will be a more sophisticated route:

```
public void Handle(ChangeCustomerNameCommand command)
{
 var customer = _customerRepository.GetById(command.CompanyId);
 customer.ChangeName(command.DisplayName);
 customerRepository.Save(customer);
}
```

Let's skip for a moment the Handle method and who runs it and focus on the implementation. At first, it might seem that ChangeName is a mere wrapper for the CRUD-style code examined earlier. Well, not exactly:

```
public void ChangeName(string newDisplayName)
{
  var evt = new CustomerNameChangedEvent(this.Id, newDisplayName);
  RaiseEvent(e);
}
```

The RaiseEvent method defined on the Aggregate base class will just append the event in the internal list of uncommitted events. Uncommitted events are finally processed when the aggregate is persisted.

Persisting the State via Events

With events deeply involved, the structure of repository classes can be made generic. The Save method of a repository designed to operate with aggregate classes described so far will simply loop through the list of the aggregate's uncommitted events and call a new method the aggregate must offer—the ApplyEvent method:

```
public void ApplyEvent(CustomerNameChangedEvent evt)
{
  this.DisplayName = evt.DisplayName;
}
```

The aggregate class will have one overload of the ApplyEvent method for each event of interest. The CRUD-style code you considered way back will just find its place here.

> When aggregates and business rules are too numerous, a bus greatly simplifies the overall design.

There's still one missing link: How do you orchestrate front-end use cases, end-user actions with multiple aggregates, business workflows and persistence? You need a bus component.

Introducing a Bus Component

A bus component can be defined as a shared pathway between running instances of known business processes. End users act through the presentation layer and set instructions for the system to deal with. The application layer receives those inputs and turns them into concrete business actions. In a CRUD scenario, the application layer will call directly the business process (that is, workflow) responsible for the requested action.

When aggregates and business rules are too numerous, a bus greatly simplifies the overall design. The application layer pushes a command or an event to the bus for listeners to react appropriately. Listeners are components commonly called "sagas" that are ultimately instances of known business processes. A saga knows how to react to a bunch of commands and events. A saga has access to the persistence layer and can push commands and events back to the bus. The saga is the class where the aforementioned Handle method belongs. You typically have a saga class per workflow or use case and a saga is fully identified by the events and commands it can handle. The overall resulting architecture is depicted in **Figure 1**.

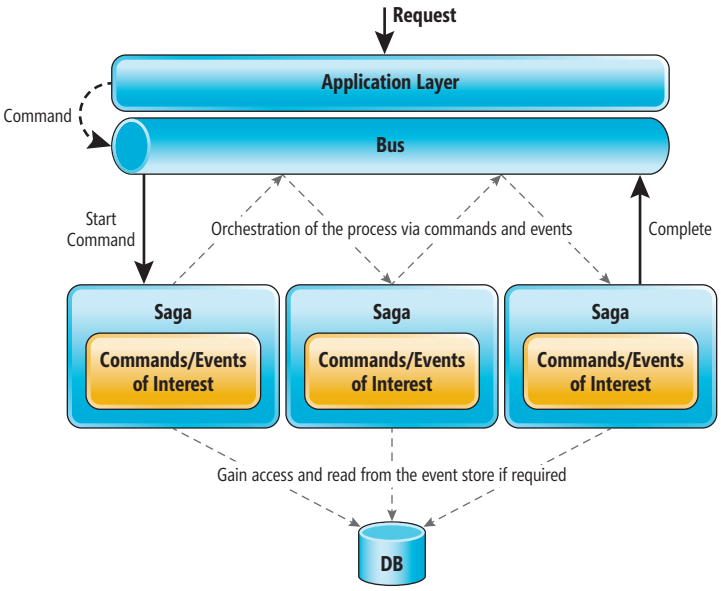

Figure 1 **Using a Bus to Dispatch Events and Commands**

Finally, note that events must also be persisted and queried back from their source. This raises another nontrivial point: Is a classic relational database ideal to store events? Different events can be added at any time in the development and even post production. Each event, in addition, has its own schema. In this context, a non-relational data store fits in even though using a relational database still remains an option—at least an option to consider and rule out with strong evidence.

Wrapping Up

I dare say that most of the perceived complexity of software is due to the fact that we keep on thinking the CRUD way for systems that although based on the fundamental four operations in the acronym (create, read, update, delete) are no longer as simple as reading and writing to a single table or aggregate. This article was meant to be the teaser for more in-depth analysis of patterns and tools, which will continue next month when I present a framework that attempts to make this sort of development faster and sustainable. ■

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Thanks to the following Microsoft technical expert for reviewing this article: *Jon Arne Saeteras*

JULIE LERMAN

EF Core Change-Tracking Behavior: Unchanged, Modified and Added

Did you see what I did there, in this column's title? You may have recognized Unchanged, Modified and Added as enums for EntityState in Entity Framework (EF). They also help me describe the behaviors of change tracking in EF Core compared to earlier versions of Entity Framework. Change tracking has become more consistent in EF Core so you can be more confident in knowing what to expect when you're working with disconnected data.

Keep in mind that while EF Core attempts to keep the paradigms and much of the syntax of earlier versions of Entity Framework, EF Core is a new set of APIs—a completely new code base written from scratch. Therefore, it's important not to presume that everything will behave exactly as it did in the past. The change tracker is a critical case in point.

Because the first iteration of EF Core is targeted to align with ASP.NET Core, a lot of the work focused on disconnected state, that is, making sure Entity Framework can handle the state of objects coming out of band, so to speak, where EF hasn't been keeping track of those objects. A typical scenario is a Web API that's accepting objects from a client application to be persisted to the database.

In my March 2016 Data Points column, I wrote about "Handling the State of Disconnected Entities in EF" (msdn.com/magazine/mt694083). That article focused on assigning state information to the disconnected entities and sharing that information with EF when passing those objects back into EF's change tracker. Though I used EF6 to lay out the example, that pattern is still relevant for EF Core, so after discussing the EF Core behaviors, I'll show an example of how I'd implement that pattern in EF Core.

Tracking with DbSet: Modified

DbSet always included the Add, Attach and Remove methods. The result of these methods on a single object are simple enough, they set the state of the object to the relevant EntityState. Add results in Added, Attach in Unchanged and Remove changes the state to Deleted. There's one exception, which is that if you remove an entity that's already known as Added, it will be detached from the DbContext because there's no longer a need to track the new entity. In EF6, when you use these methods with graphs, the effects on the related objects were not quite as consistent. A formerly untracked object couldn't be removed and would throw an error. Already tracked objects may or may not have their state altered, depending on what those states are. I created a set of tests in EF6 in order to comprehend the various behaviors, which you can find on GitHub at bit.ly/28YwwYd.

Code download available at msdn.com/magazine/0816magcode.

While creating EF Core, the EF team experimented with the behavior of these methods throughout the betas. In EF Core RTM, the methods no longer behave as they did in EF6 and earlier. For the most part, the changes to these methods result in more consistent behavior on which you can rely. But it's important to understand how they've changed.

When you use Add, Attach and Remove with an object that has a graph attached, the state of every object in the graph that's unknown to the change tracker will be set to the state identified by the method. Let me clarify this using my favorite EF Core model from the "Seven Samurai" film—samurais with movie quotes attached, and other related information.

If a samurai is new and not being tracked, Samurais.Add will set that samurai's state to Added. If the samurai has a quote attached to it when Add is called, its state will also be set to Added. This is desired behavior and, in fact, is the same as it was in EF6.

Keep in mind that while EF Core attempts to keep the paradigms and much of the syntax of earlier versions of Entity Framework, EF Core is a new API.

What if you're adding a new quote to an existing samurai and, rather than following my recommendation to set newQuote.SamuraiId to the value of Samurai.Id, you instead set the navigation property, newQuote.Samurai=oldSamurai. In a disconnected scenario, where neither the quote nor the oldSamurai is being tracked by EF, Quotes.Add(newQuote) will do the same as the preceding. It will mark the newQuote as Added and the oldSamurai as Added. SaveChanges will insert both objects into the database and you'll have a duplicate oldSamurai in the database.

If you're in a client application, for example, Windows Presentation Foundation (WPF), and you use your context to query for the samurais and then use that same context instance to call context.Quotes.Add(newQuote), the context already knows about the

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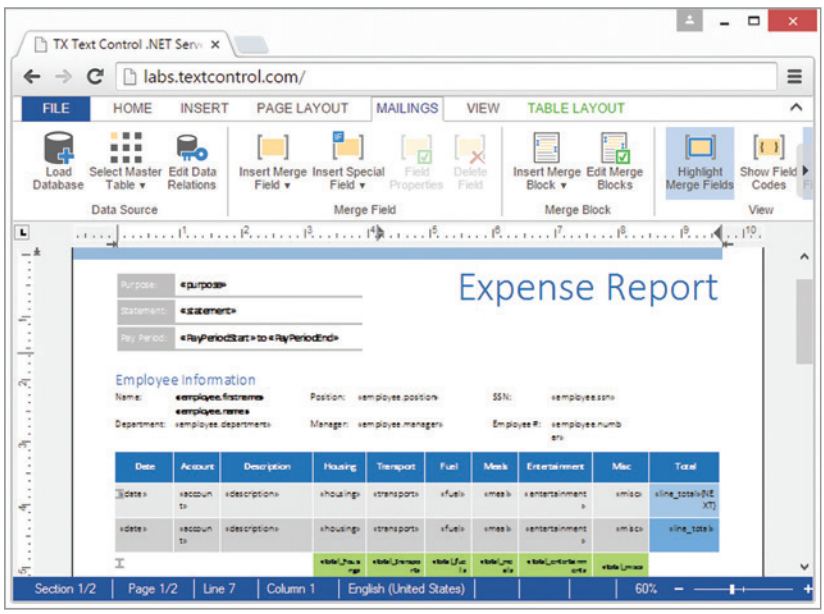

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A The Text Control Reporting Framework combines powerful reporting features with an easy-to-use, MS Word compatible word processor. Users can create documents and templates using ordinary Microsoft Word skills. It is completely independent from MS Word or any other third-party application and can be completely integrated into business applications. The Text Control Reporting Framework is included in all .NET based TX Text Control products including ASP.NET, Windows Forms and WPF.

Q What sets Text Control Reporting apart from other reporting vendors?
A Text Control Reporting is based on the powerful word processing component TX Text Control. The MS Word compatible template can be merged with a data object (business object) or database content with one line of code. At the same time, Text Control provides a powerful API to customize this merge process completely. The report generation can be fully integrated into .NET applications.

Q Tell us more about the cross-browser, cross-platform WYSIWYG HTML5-based template editor.
A TX Text Control allows the creation of MS Word compatible documents and templates using any operating system with an HTML5 capable browser including Chrome, Firefox, Safari, Internet Explorer and Edge. Because the product is being built with pure HTML5 and JavaScript, it will have a zero footprint with no client-side browser plugins required. It includes all sophisticated word processing features such as headers and footers, sections, text frames, tab positions, charts, barcodes and spell checking.

Q How do developers typically use Text Control components?
A Our products help thousands of developers add mail merge, reporting and word processing functionality to their Windows Forms, WPF and ASP.NET applications. They create elegant and powerful business reports with an easy-to-use, MS Word compatible template editing interface. Using TX Barcode .NET, developers add fast and accurate 1D and 2D barcodes to.NET based applications. Barcodes are integrated into reports, invoices and mail merge templates. TX Spell .NET enables extremely fast, highly reliable and very accurate spell checking in TX Text Control based applications.

For more detailed information and a 30-day trial version, visit www.textcontrol.com/reporting.

oldSamurai and won't change its Unchanged state to Added. That's what I mean by not changing the state of already tracked objects.

The way the change tracker affects related objects in a disconnected graph is notably different and you should keep these differences in mind when using these methods in EF Core.

Rowan Miller summarized the new behavior in a GitHub issue (bit.ly/295goxw):

Add: Adds every reachable entity that isn't already tracked.

Attach: Attaches every reachable entity, except where a reachable entity has a store-generated key and no key value is assigned; these will be marked as added.

Update: Same as Attach, but entities are marked as modified.

Remove: Same as Attach, and then mark the root as deleted. Because cascade delete now happens on SaveChanges, this allows cascade rules to flow to entities later on.

In EF Core, DbContext.Entry now affects only the object being passed in. If that object has other related objects connected to it, DbContext.Entry will ignore them.

There's one more change to the DbSet methods that you might notice in this list: DbSet finally has an Update method, which will set the state of untracked objects to Modified. Hooray! What a nice alternative to always having to add or attach and then explicitly set the state to Modified.

DbSet Range Methods: Also Modified

Two range methods on DbSet (AddRange and RemoveRange) were introduced in EF6 and allow you to pass in an array of like types. This provided a big performance boost because the change tracker engages only once, rather than on each element of the array. The methods do call Add and Remove as detailed earlier and, therefore, you need to consider how related graph objects are affected.

In EF6, the range methods existed only for Add and Remove, but EF Core now brings UpdateRange and AttachRange. The Update and Attach methods that are called individually for each object or graph passed into the Range methods will behave as described earlier.

DbContext Change Tracking Methods: Added

If you worked with EF ObjectContext prior to the introduction of the DbContext, you might recall that ObjectContext had Add, Attach and Delete methods. Because the context had no way of knowing to which ObjectSet the target entity belonged, you had to add a string representation of the ObjectSet name as a parameter. This was so messy and most of us found it easier just to use the ObjectSet Add, Attach and Delete methods. When DbContext came along, those messy methods went away and you could only Add, Attach and Remove via the DbSet.

In EF Core, the Add, Attach and Remove methods are back as methods on the DbContext, along with Update and the four related Range methods (AddRange, and so forth). But these methods are much smarter now. They're now able to determine the type and automatically relate the entity to the correct DbSet. This is really convenient because it allows you to write generic code without having to instantiate a DbSet. The code is simpler and, more important, more discoverable. Here's a comparison of EF6 and EF Core:

```
private void AddToSetEF6<T>(T entity) where T : class {Pull
  using (var context = new SamuraiContext()) {
    context.Set<T>().Add(entity);
  }
}

private void AddToSetEFCore(object entity) {
  using (var context = new SamuraiContext()) {
    context.Add(entity);
   }
}
```

The range methods are even more helpful because you can pass in a variety of types and EF can work them out:

```
private void AddViaContextEFCore(object[] entitiesOfVaryingTypes) {
  using (var context = new SamuraiContext()) {
     context.AddRange(entitiesOfVaryingTypes);
  }
}
```

DbContext.Entry: Modified—Beware This Change in Behavior

Even though we've been warned that EF Core is not EF6 and that we should not expect familiar code to behave as it did in EF6, it's still difficult not to have such an expectation when so many behaviors have carried forward. DbContext.Entry is a case in point, though, and it's important you understand how it has changed.

The change is a welcome one to me because it brings consistency to change tracking. In EF6, the DbSet Add (and so forth) methods and the DbContext.Entry method combined with the State property had the same impact on entities and on graphs. So using DbContext.Entry(object).State=EntityState.Added would make all of the objects in a graph (that were not already being tracked) Added.

Moreover, there was never an intuitive way to disconnect graph objects before passing them to the change tracker.

In EF Core, DbContext.Entry now affects only the object being passed in. If that object has other related objects connected to it, DbContext.Entry will ignore them.

If you're used to using the Entry method to connect graphs to a DbContext instance, you can see why this change is drastic. It means you can target an individual object even if it's part of a graph.

More important, you can now explicitly use the DbSet and DbContext tracking methods (Add, and the like) to work explicitly with graphs, and you can use the DbContext.Entry method to work specifically with individual objects. This, combined with the next change I explain, means you now have clear options to select from when passing object graphs into the EF Core change tracker.

DbContext.ChangeTracker.TrackGraph: Added

TrackGraph is a completely new concept in EF Core. It provides ultimate control for each object in an object graph that you want your DbContext to begin tracking.

TrackGraph walks the graph (that is, it iterates through each object in the graph) and applies a designated function to each of those objects. The function is the second parameter of the TrackGraph method.

The most common example is one that sets the state of each object to a common state. In the following code, TrackGraph will iterate through all of the objects in the newSword graph and set their state to Added:

```
context.ChangeTracker.TrackGraph(newSword, e => e.Entry.State = EntityState.Added);
```

The same caveat as the DbSet and DbContext methods applies to TrackGraph—if the entity is already being tracked, TrackGraph will ignore it. While this particular use of TrackGraph behaves the same as the DbSet and DbContext tracking methods, it does provide more opportunity for writing reusable code:

The lambda ("e" in this code) represents an EntityEntryGraphNode type. The EntityEntryGraphNode type also exposes a property called NodeType and you might encounter it via IntelliSense as you type the lambda. This seems to be for internal use and won't have the effect e.Entry.State provides, so be careful not to use it unwittingly.

In a disconnected scenario, the caveat about already tracked objects being ignored may not be relevant. That's because the DbContext instance will be new and empty, so all of the graph objects should be new to the DbContext. However, consider the possibility of passing a collection of graphs into a Web API. Now there's a chance of multiple references to a common object and EF's change tracker will check identity to determine if an entity is already being tracked. That's a good case for it not to add the object to the change tracker a second time.

This default behavior is designed to cover the most common scenarios. But I can imagine that, like me, you may already be thinking of edge cases where this pattern might fail.

This is where I'll hearken back to my March 2016 article and the pattern I shared for setting the object state on your classes and then reading that state to tell the change tracker what the object's EntityState should be. Now I can combine that pattern and the TrackGraph method by having the function TrackGraph calls perform the task of setting the EntityState based on the object's State method.

Figure 1 **The ChangeTrackerHelpers Class**

```
public static class ChangeTrackerHelpers
    {
    public static void ConvertStateOfNode(EntityEntryGraphNode node) {
      IObjectWithState entity = (IObjectWithState)node.Entry.Entity;
      node.Entry.State = ConvertToEFState(entity.State);
    }

    private static EntityState ConvertToEFState(ObjectState objectState)
{
      EntityState efState = EntityState.Unchanged;
      switch (objectState) {
        case ObjectState.Added:
          efState = EntityState.Added;
          break;
        case ObjectState.Modified:
          efState = EntityState.Modified;
          break;
        case ObjectState.Deleted:
          efState = EntityState.Deleted;
          break;
        case ObjectState.Unchanged:
          efState = EntityState.Unchanged;
          break;
      }
      return efState;
    }
  }
```

The work on the domain classes doesn't change from what I did in the March article. I start by defining an enum for the locally tracked ObjectState:

```
public enum ObjectState {
    Unchanged,
    Added,
    Modified,
    Deleted
  }
```

Then I build an IEntityObjectWithState interface that exposes a State property based on the enum:

```
public interface IObjectWithState
{
  ObjectState State { get; set; }
}
```

Now, I fix up my classes to implement the interface. As an example, here's a small class from Location, with the interface in place:

```
using SamuraiTracker.Domain.Enums;
using SamuraiTracker.Domain.Interfaces;

namespace SamuraiTracker.Domain
{
  public class Location : IObjectWithState
  {
    public int Id { get; set; }
    public string Name { get; set; }
    public ObjectState State { get; set; }
  }
}
```

In the March article, I showed how to build intelligent classes that are able to manage their local state. I haven't repeated that in this example, which means that in my sample I've left the setter public and will have to manually set that state. In a fleshed out solution, I'd tighten up these classes to be more like those in the earlier article.

For the DbContext, I have some static methods in a helper class called ChangeTrackerHelpers, shown in **Figure 1**.

ConvertStateOfNode is the method TrackGraph will call. It will set the EntityState of the object to a value determined by the ConvertToEFState method, which transforms the IObjectWithState.State value into an EntityState value.

With this in place, I can now use TrackGraph to begin tracking my objects along with their correctly assigned EntityStates. Here's an example where I pass in an object graph called samurai, which consists of a Samurai with a related Quote and Sword:

```
context.ChangeTracker.TrackGraph(samurai, ChangeTrackerHelpers.ConvertStateOfNode);
```

In the EF6 solution, I had to add the items to the change tracker and then explicitly call a method that would iterate through all of the entries in the change tracker to set the relevant state of each object. The EF Core solution is much more efficient. Note that I haven't yet explored possible performance impact when dealing with large amounts of data in a single transaction.

If you download the sample code for this column, you'll see me using this new pattern within an integration test named CanApplyStateViaChangeTracker in which I create this graph, assign various states to the different objects and then verify that the resulting EntityState values are correct.

IsKeySet: Added

The EntityEntry object, which holds the tracking information for each entity, has a new property called IsKeySet. IsKeySet is a

great addition to the API. It checks to see if the key property in the entity has a value. This eliminates the guessing game (and related code) to see if an object already has a value in its key property (or properties if you have a composed key). IsKeySet checks to see if the value is the default value of the particular type you specified for the key property. So if it's an int, is it 0? If it's a Guid, is it equal to Guid.Empty (00000000-0000-0000-0000-000000000000)? If the value is not the default for the type, IsKeySet returns true.

But even as you embark on new projects with confidence that the feature set in EF Core has what you need, don't presume things will work the same.

If you know that in your system you can unequivocally differentiate a new object from a pre-existing object by the value of its key property, then IsKeySet is a really handy property for determining the state of entities.

EF Core with Eyes Wide Open

While the EF team has certainly done what they can to ease the pain of transitioning your brain from earlier versions of Entity Framework to EF Core, replicating plenty of the syntax and behavior, it's so important to keep in mind that these are different APIs. Porting code will be tricky and isn't recommended—especially in these early days when the RTM has only a subset of familiar features. But even as you embark on new projects with confidence that the feature set in EF Core has what you need, don't presume things will work the same. I still have to remind myself about this. Nevertheless, I'm pleased with the changes to the ChangeTracker. They bring more clarity, more consistency and more control for dealing with disconnected data.

The EF team has a roadmap on the GitHub page for which I created a convenient shortcut: bit.ly/efcoreroadmap. This lets you keep track of the features, though it won't list the minutia of things like behavior changes. For that I recommend tests, lots of tests, to ensure things are working the way you expect. And if you're planning to port code from earlier versions of EF, you may want to look into Llewellyn Falco's Approval Tests (approvaltests.com), which let you compare output from tests to ensure that the outputs continue to match. ■

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Thanks to the following Microsoft technical expert for reviewing this article: *Erik Ejlskov Jensen*

From Code to Customer: Exploring Mobile DevOps

Kraig Brockschmidt

By historical standards, writing code is easy. Today we enjoy enormously powerful tools like IntelliSense, auto-complete, syntax coloring, error highlighting and support through communities like Stack Overflow. We also enjoy an ever-growing repository of exceptionally useful libraries and tools, many of them free. But there's a big gap—a veritable chasm, you might say—between the mere act of writing code and the development of mobile apps that deliver the highest value to customers, and do so at the lowest cost to your business.

The various practices that have come to be known collectively as *DevOps* are essentially what help you bridge that chasm. I say "various practices" because there are many ways to build that bridge. There are different ways to define the processes themselves, and there are many different tools to help you communicate and manage those processes with all the people involved—including ways to learn directly from your customers. As such, the whole DevOps space oftentimes seems quite chaotic, with too many choices and too little clarity.

This article discusses:

- The primary components of Microsoft's DevOps stack for mobile apps and back-end services
- The release pipeline and the DevOps activities involved at each stage
- The need to start with a clear release process, then applying tooling and automation
- The MyDriving project as an example of DevOps in action
- The role of Visual Studio Team Services/Team Foundation Server

Technologies discussed:

Visual Studio, Visual Studio Team Services, Team Foundation Server, Microsoft Azure, Xamarin Test Cloud, HockeyApp, Application Insights

> DevOps is not an all-or-nothing commitment. Rather, it involves a system of loosely coupled activities and practices that you can build up incrementally.

Fortunately, as I'll explore in this series of articles, Microsoft now provides an answer: a full end-to-end stack that enables DevOps for mobile apps and their associated back ends. This stack, shown in **Figure 1**, consists of Visual Studio, Visual Studio Team Services, and Team Foundation Server, along with Xamarin Test Cloud, HockeyApp, Application Insights, and CodePush.

This stack is applicable to all types of mobile apps: native apps written for a single mobile platform, hybrid apps written with Apache Cordova, and cross-platform apps written with React

Native or Xamarin. Better still, DevOps is not an all-or-nothing commitment. Rather, it involves a system of loosely coupled activities and practices you can build up incrementally, to add real value to your business of producing mobile apps. It's also possible with new projects to build the entire DevOps pipeline before a single line of code is written.

The approach I'll take in this series is to focus on different stages of the "release pipeline" and look at what parts of the DevOps stack come into play. In this inaugural article, however, I'll first need to establish some necessary background. I'll begin by describing what a release pipeline is and identifying the activities involved, then discuss the overall need for DevOps and the role of tooling and automation. Next, I'll look at the MyDriving project as an example of DevOps in action (and you can find another example in this issue, in the article "Embracing DevOps When Building a Visual Studio Team Services Extension"). Finally, I'll review the central role that Visual Studio Team Services (and Team Foundation Server) play in the overall DevOps story, setting the stage for the follow-on articles.

Figure 1 **Primary Components of the Microsoft DevOps Stack for Mobile Apps and Back-End Services**

Tool or Service	Purpose with DevOps
Visual Studio (bit.ly/25EVbAw)	Central development tool for app, services and test code, along with diagnostics and integration with source control.
Visual Studio Team Services (bit.ly/1srWnp9)	Cloud-hosted Agile planning tools, source control, build services, test services and release management. (Note that planning tools will not be covered in this series.)
Team Foundation Server (bit.ly/1TZZo9o)	On-premises capabilities equivalent to Visual Studio Team Services, allowing full customizations of servers and complete control over those physical machines.
Xamarin Test Cloud (xamarin.com/test-cloud)	Automated and manual testing of all mobile apps (including those not written with Xamarin) on thousands of real, physical devices accessible through a Web portal.
HockeyApp (hockeyapp.net)	Pre-launch app distribution directly to devices of test customers (not involving platform app stores). Also pre-launch and production monitoring with custom telemetry, crash analytics and user-feedback reporting.
Application Insights (bit.ly/1Zk9Qd3)	Telemetry, diagnostics and monitoring of back-end services.
CodePush (bit.ly/28X07Eb)	Deployment of app updates for Cordova and React Native apps directly to user devices without going through app stores.

> As a form of testing, every activity that falls under the DevOps umbrella exists to validate the quality, reliability, and value of the app being delivered.

The Release Pipeline

The idea of a pipeline is that for any particular release of an app or its back-end services, its code and other artifacts must somehow flow from the project's source code repository to customer devices and customer-accessible servers. Once on those devices and servers, runtime issues (crashes), insights from telemetry and direct customer feedback must all flow back as learnings that drive subsequent releases.

Of course, none of this happens by magic. It happens through a sequence of distinct stages after code is committed to the repository, as shown in **Figure 2**. The stages include:

- **Build/CI:** Build the app and run unit tests; continuous integration (CI) means that a commit to the repository triggers a build and test run if those processes are automated.
- **Internal QA:** Perform any number of additional tests and acquire approver sign-offs.
- **External or pre-launch QA:** Put the app in the hands of real customers prior to public release, testing the app and services under real-world conditions and collecting feedback. This stage may also involve additional approver sign-offs.
- **Production monitoring and learning:** Regardless of how much testing you do, customers will almost certainly encounter problems once the app is made public (that is, "released to production"). Customers will provide feedback on what works and what doesn't, and their usage patterns are revealed by telemetry.

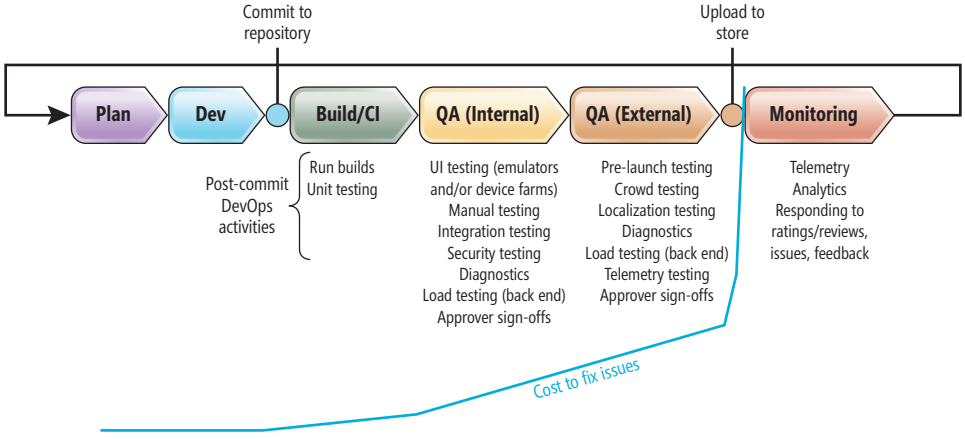

Figure 2 **The Stages of a Typical Release Pipeline with Associated DevOps Activities**

You'll notice in **Figure 2** that I've labeled most DevOps activities as some form of testing. In fact, it's not much of a stretch to think of *every* activity as a kind of testing. Running a build, for example, tests the structure of the repository and whether all other artifacts are where they need to be. Running diagnostics tools is a form of exploratory testing. Gathering and analyzing telemetry is a way to test your assumptions about how customers actually use the app. And what are approver sign-offs, if not a direct check by a human being that everything is as it should be?

Continuous Validation of Performance

As different forms of testing, all activities that fall under the DevOps umbrella exist to validate the quality, reliability and value of the app being delivered. Put another way, the activities are designed to catch or identify defects, which means anything that will cause the app to deviate from fulfilling customer expectations. It almost goes without saying, then, that the more often you engage in DevOps activities—continuously, if possible—the better chance you have of finding problems prior to release.

DevOps activities are also designed to catch defects as early as possible in the pipeline when the cost of fixing them is lowest (illustrated by the blue line in **Figure 2**). Clearly, costs go much higher once the app is released and defects are out in the open, at which point the cost might include lost customers, damage to your reputation and even legal liabilities!

> The foundation of DevOps is being clear about the processes and policies that define how your apps and services move from the hands of your developers into the hands of your customers.

Putting all this together, apps that deliver the highest value to customers, and do so at the lowest cost, are your best "performers" because of what they ultimately bring to your business. Great apps, simply said, are great performers. For this reason, I like to think of DevOps as the *continuous validation of performance* in the broadest sense of the term. DevOps is to software development what training, practice, rehearsals, and post-performance reviews are to professional musicians, athletes, and other performers in their respective fields. It's how you know and trust and monitor the complete value of what you're delivering, both for customers and for your business.

Process First, Then Tooling and Automation

In a series about the Microsoft tooling stack for mobile DevOps, you might think the next step is to jump right into those tools and start "doing" DevOps. But DevOps doesn't start with tooling, or even with automating anything. The foundation of DevOps is being clear about the processes and policies that define how your apps and services move from the hands of your developers into the hands of your customers. It's really that simple; so simple, in fact, that you can certainly define an entire release pipeline by writing down the necessary steps on paper and performing each one manually.

> Great apps, simply said, are great performers.

This is sometimes the hardest part of starting a journey to effective DevOps. Within a team environment, especially a young team that's trying to move rapidly, a release pipeline might consist of a bunch of steps that have evolved ad hoc, that individual team members "just remember" to do. Here are some examples:

- Run a build
- Run some tests
- Check that the right non-code artifacts are in place
- Collect feedback from test users
- Post the app package to the appropriate store
- Deploy service code to the appropriate server (dev, staging, production and so on)
- Change an API key from dev to production
- Tweet availability
- Update the product page on your Web site

With short development iterations, all of these activities can easily become so enmeshed in the team's day-to-day routine that nobody realizes that none of it is actually written down anywhere—until, of course, someone goes on vacation, gets sick or leaves the company! What's more, if all your release processes and policies exist only in people's minds, it's difficult to apply them consistently. They invariably get intertwined with hundreds of other unrelated yet important tasks. This is clearly fraught with peril, especially in environments in which a single oversight can be disastrous.

By taking the time to clearly identify all the steps involved, you define a process that's predictable, repeatable and auditable. Having it all spelled out in a place that's accessible to everyone also makes the process easy to review and modify because all the interdependencies are visible. This, in turn, is the basis for applying tooling and automation. Otherwise it'd be like setting up a bunch of industrial machinery to build widgets without knowing what it is you're actually trying to build in the first place.

Let's be very clear about this. Automation is not actually essential in any release pipeline—every step can be done manually if needed. This includes even trivial but time-consuming matters like sending notification e-mails. But manual processes are expensive to scale, prone to human error, often tedious (and therefore somewhat boring to humans), and put every step at risk of competing for the attention of your human employees with all their other work. Computers, on the other hand, are very adept at endlessly repetitive and mindlessly trivial tasks without getting bored or negligent. It's also much simpler to add a few more machines if demands increase and to decommission them when demands go down, than it is to hire (and fire) qualified people.

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The purpose of automation, then, is to simultaneously lower the cost and increase the frequency and quality of your processes as they're defined, separate from the tooling. That is, when your processes and policies are in place, you can then incrementally automate different parts, use tools to enforce policies, and get everything into a form that's transparent and auditable. As you do so, you free human employees to concentrate on those areas that aren't readily handled by a computer, such as reviewing and interpreting user feedback, designing telemetry layers, determining the most effective forms of testing, and continuously improving the quality of DevOps activities that are in place.

An Example: the MyDriving Project

Let's now see how all this comes together with the Microsoft mobile DevOps stack by looking at the already-working project called MyDriving (aka.ms/iotsampleapp), introduced by Scott Guthrie at Microsoft Build 2016. MyDriving is a comprehensive system that gathers and processes Internet of Things (IoT) data through a sophisticated Azure back end and provides visualization of the results through both Microsoft Power BI and a mobile app written with Xamarin. It was created as a starting point for similar IoT projects and includes full source code, Azure Resource Manager deployment scripts and a complete reference guide ebook.

For my purposes, the MyDriving release pipelines are of particular interest. I use the plural here because there are four of them: one for the back-end code that's deployed to Azure App Service, and one each for the Xamarin app on iOS, Android and Windows.

Here's an overview of the pipeline flow, including some activities that aren't presently implemented:

- Manage source code in a GitHub repository (bit.ly/28YFFWg).
- Run builds using the code in the repository, including the following sub-steps:
  - Replace tokens with necessary keys depending on target environment (dev, test, production).
  - Restore necessary NuGet packages and Xamarin components.
  - Update version names and numbers.
  - Run the build (using the MacinCloud service for iOS).
  - (App only) Create and sign the app package as required by the mobile platform.
  - (Not implemented) Build any available unit test project.
  - (Not implemented) Run tests in the test project, failing the build if any tests fail.
- For the service code:
  - Copy the output of the successfully tested build to a staging server.
  - Deploy from the staging server to a test server, and run tests.
  - If that succeeds, deploy to the production server and repeat the test run.
  - Monitor the service and obtain diagnostic reports using Application Insights.

> By taking the time to clearly identify all the steps involved, you define a process that's predictable, repeatable and auditable.

- For the mobile app on all platforms:
  - Deploy the app to Xamarin Test Cloud and run UI tests, failing the build if any UI tests fail.
  - If the build and UI tests are successful, copy the app package to a staging server.
  - Deploy the app from the staging server to alpha testers via HockeyApp.
  - (Not implemented) Upon approver sign-off, deploy the app to beta testers via HockeyApp.
  - (Not implemented) Upon additional approver sign-off, push the app to the appropriate app store.
  - Monitor the app with telemetry and crash reporting via HockeyApp.

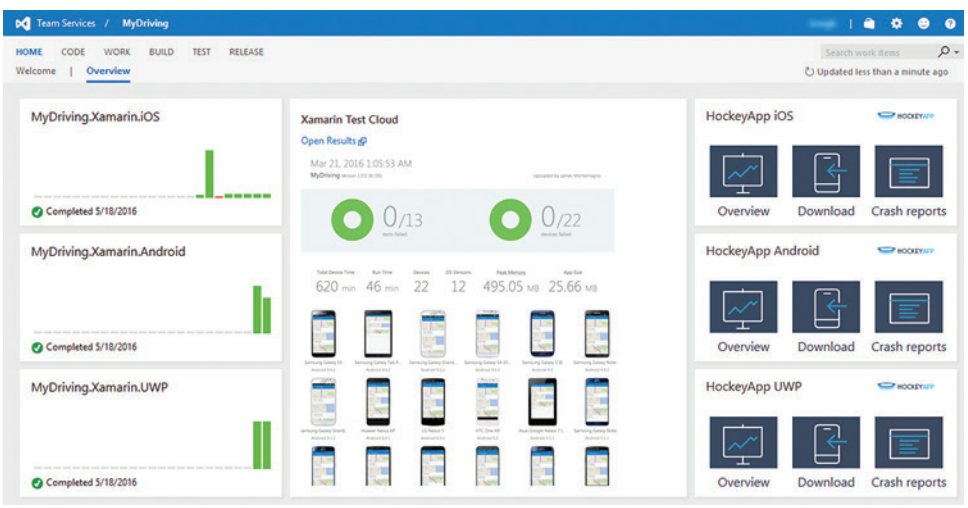

Figure 3 **The Visual Studio Team Services Dashboard for MyDriving**

As you can see, this is a straightforward list of what needs to happen for each release. But notice especially that it describes *what* needs to happen and identifies some of the services involved, but doesn't specify *who* actually performs the steps. This is very important, because a human being can always sit down with the list and perform each step manually. In fact, that's exactly what happened in the early days of MyDriving—we did manual builds and so forth so we could get test apps into people's hands right away. But, simultaneously with the dev team's coding efforts, others focused on

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incrementally automating different steps until the whole automated release pipeline was established.

A similar story is told in another article in this issue, "Applying DevOps to a Software Development Project." Notice in particular how the section "Building and Publishing an Extension" does exactly what I've talked about here: It writes out a list of the exact steps in the release process. The rest of the article then explains, in the author's words, "Our journey toward an automated build and release pipeline."

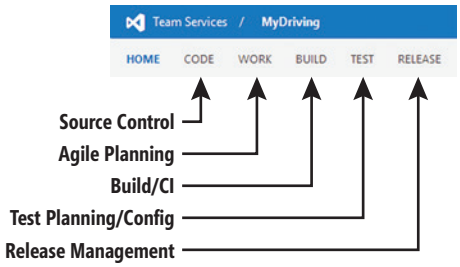

Figure 4 **Location of Features in Visual Studio Team Services**

> The end of a pipeline where Team Services is concerned is the point at which an app is sent out to its final assigned environment.

The Central Role of Visual Studio Team Services/Team Foundation Server

In the MyDriving project, Visual Studio Team Services (Team Services for short) is the hub for managing and automating the release pipelines and the interactions with various services (see **Figure 3**). Because MyDriving was created as an open source project from the start, using a cloud-hosted service like Team Services isn't an issue. For other scenarios, organizations may not be comfortable or permitted to use the cloud, in which case Team Foundation Server (TFS) provides the same capabilities with your own on-premises servers. In my series, I'll work primarily within the context of Team Services, but understand that everything applies also to TFS.

Those core capabilities are listed here (refer to **Figure 4** for placement in the Team Services UI):

- **Source control:** Host unlimited private and public source repositories using Git or Team Foundation Version Control (TFVC), or work easily with repositories on GitHub.
- **Agile planning:** Track work items, user stories and so on with collaboration on Kanban boards, reporting and so forth. (Note again that planning aspects aren't covered in this series.)
- **Build:** Create build definitions for service code and mobile apps (iOS, Android and Windows), using a wide variety of available tasks, including building and running test projects (for continuous integration) and deploying to Xamarin Test Cloud (XTC).
- **Release management:** Define arbitrary sequences with optional manual approvals for any tasks that happen between build and release to an "environment," such as deploying to HockeyApp, Azure or an app store. Release management is centered on whatever environments you want to define, such as staging, alpha, beta and production.

The end of a pipeline where Team Services is concerned is the point at which an app is sent out to its final assigned environment (see **Figure 5**). After that, DevOps is primarily concerned with actively monitoring the app in those environments. This is where HockeyApp and Application Insights come into play, along with any other mechanism you establish for getting additional user feedback (also shown in **Figure 5**).

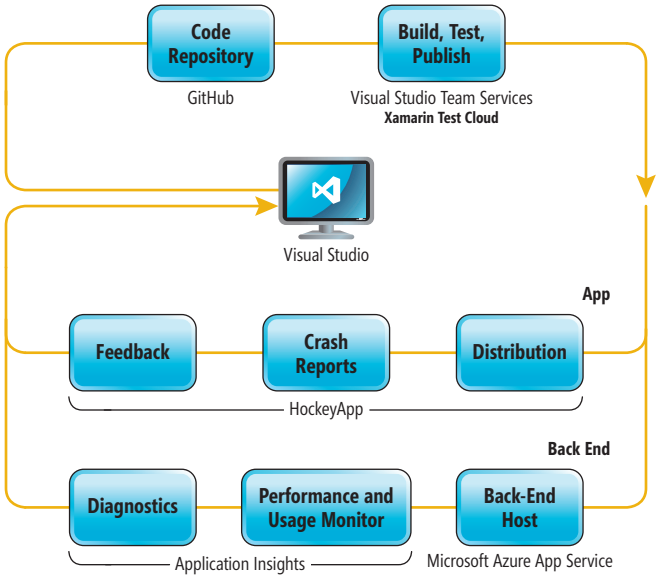

Figure 5 **Complete DevOps Flow for the MyDriving Project, Where the Code Repository Is on GitHub**

Looking Ahead

At the beginning of this article I said that the various activities and practices known as DevOps are what bridge the gap between writing code and delivering value to customers at the lowest cost to your business. You can now see that the Microsoft stack for mobile DevOps provides everything you need to manage quality, lower costs through automation, get the app and services into the hands of customers, monitor ongoing health and operations, and gather user feedback, all of which feeds back into the backlog for subsequent releases. That's the DevOps cycle—from code commit to backlog—that I'll be exploring in more detail in the coming months. ■

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Thanks to the following technical experts for reviewing this article: *Donovan Brown, Jonathan Carter, Glenn Gailey and Karl Krukow*

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Applying DevOps to a Software Development Project

Wouter de Kort, Willy Schaub and Mattias Sköld

"DevOps is the union of people, process, and products to enable continuous delivery of value to our end users."—Donovan Brown in the book, "DevOps on the Microsoft Stack" (Wouter de Kort, 2016).

Every DevOps journey begins with an idea that you want to turn into a solution based on a culture of learning and continuous delivery of value. The goal of this article is to share the learnings we gathered during the exploration of implementing an automated release pipeline for our development, user acceptance testing and production environments. We'll walk you through an automated release pipeline, which you can adopt "as is," or evolve to meet your requirements.

This article discusses:

- How to implement a release pipeline using Visual Studio Team Services out-of-the-box for extension projects
- Reduce cycle times and lead times from days to minutes using automation and embracing DevOps
- Introduce the Build Task Extension for packaging and publishing Team Services extensions to the Visual Studio Marketplace

Technologies discussed:

DevOps, Visual Studio Team Services

So why did we decide to embrace DevOps? As we became intimately familiar with the "why" (goal), the "what" (features), and the "how" (technology, code) of building extensions, we needed a culture and an environment that lets us build, test, release, and monitor the rapidly evolving and growing family of extensions. The promise of DevOps encouraged us to explore and embrace the processes and tools offered by Visual Studio Team Services (Team Services for short). Our self-organized and autonomous teams were empowered to evolve a culture and a pipeline that reduced release cycle times from chaotic, error-prone and manually intensive days to minutes. A similar story and explanation of the pipeline is told in another article in this issue ("From Code to Customer: Exploring Mobile DevOps").

If you're unfamiliar with the Rangers, we're a community of internal and external engineers who work with the product group to provide professional guidance, practical experience and gap-filling solutions to the developer community. It's the latter—gaps—that got us excited about and committed to extensions.

Extensions provide you with an integration and extensibility experience for Team Services and Team Foundation Server (TFS). Extension points include the work item form, build and release tasks, dashboard widgets, menu actions, Agile and other hubs. These let you provide gap-filling solutions, blending into and enhancing the product, UX and productivity.

Figure 1 **Windows PowerShell Build Task (Top) and Command Build Task (Bottom)**

Tool	Windows PowerShell
Arguments	cha -command "(Get-Content vss-extension.json).replace('0.0.1', ('%BUILD_BUILDNUMBER%').replace('SampleData ','')) | Set-Content vss-extension.json" rt

Tool	tfx
Arguments	extension publish –token $(PublishExtToken) –overrides-file $(ManifestOverrideFile) –share-with $(SharedAccounts)

A typical extension consists of a set of JavaScript, HTML and CSS files, as shown in the 2015 blog by Willy P. Schaub, "Extensions 101—Attempting to Visualize the Main Processing Flow" (bit.ly/28Yfj7A). One or more JSON manifest files describe basic information, files included with and contributions provided by the extension. Refer to the open source Folder Management extension sample, which lets you quickly create a folder in your Team Services source repositories from the Web without cloning the repository locally or installing extra tools.

As the family of extensions and revisions grows, these seemingly simple manual steps will quickly become laborious and error-prone.

Each extension is described in a JSON-based manifest, called vss-extension.json, by default. For consistency, we have made a choice to base all future extensions on the Team Services Project Template, and TypeScript for all our JavaScript code. Node Package Manager (NPM) is used for downloading external dependencies, such as the Typings library, required for TypeScript IntelliSense. We leverage the ability of NPM to define a basic set of scripts for initializing the development environment. A dose of consistency ensures that team members can easily move between teams and that issues can be investigated and resolved much easier. It enables shorter cycle times!

Figure 2 **Manifest File Extract**

```
{  "manifestVersion": 1,
  "id": "FolderManagement",
  "version": "0.0.0",
  "publisher": "",
  "name": "Folder Management",
  "description": "Quickly create a folder in your Visual Studio Team
    Services source repositories from the web. No need to clone the
    repository locally or install extra tools.",
  "public": false,
  "icons": {
    "default": "images/VSO-Folder-196x.png"
  },
  "categories": [
    "Code"
  ],
  snipped rest of manifest file ...
}
```

Publishing an Extension Manually

If you clone the Folder Management repository to your local development machine, you can quickly package and publish the extension to your marketplace account manually. Here's how:

- Use the NPM Scripts Task Runner (bit.ly/28Qmktu) or run the commands from the command line.
- Open the solution and run the setup task: npm run setup. This will download the NPM packages, initialize the Typings required for TypeScript and put your external dependencies in the correct location.
- Use Visual Studio to compile the TypeScript files and generate the output JavaScript.
- Run the package NPM task to create an output VSIX file based on the manifest in the project.
- Upload the generated VSIX to the Marketplace or run npm run publish to automatically package and publish your extension.

But first, some background. Team Services is made up of isolated accounts. The Marketplace is global and made up of publishers, and created and managed by the gallery publisher (you). An extension is published as private and explicitly shared with Team Services accounts. Alternatively, an extension can be published as public once it has been validated, making it visible to everyone. We strongly recommend that you never publish this or other sample extensions as public in order to avoid a confusing and potentially bad UX.

To publish your extension, ensure that the publisher field in the manifest matches the name of your Marketplace publisher. If your publisher isn't verified by Microsoft, you can only publish an extension as private. To publish your extension from the command line or the NPM Task Runner, you also need a personal access token that grants permission to manage your Marketplace publisher. See the article, "Publish an Extension to the Marketplace" (bit.ly/28SDs0M), for more details.

An Automated Build and Release Pipeline

As the family of extensions and revisions grows, these seemingly simple manual steps will quickly become laborious and error-prone. Therefore, we started working on the automated pipeline, using scripts and build tasks to automate the manual steps.

You can use Windows PowerShell and the Command Line build tasks to package the extension manifest and revise the version number, as shown in **Figure 1**. This is described more fully in the article, "Our First Steps of Embracing DevOps When Building Visual Studio Team Services Extensions" (aka.ms/tOwfh6)—simple and effective!

Alternatively, you can use the Build and Release Tasks for Extensions to fine-tune your build-and-release process. The rest of this article is based on this extension.

Let's explore how we used the Build and Release Tasks for Extensions and implemented a blueprint for all other extension projects. Each extension starts its journey in an isolated Team Services account, which is the first stage of the deployment of an extension. Release Management refers to these stages as environments; therefore, we're calling it the development (DEV) environment. It then goes through a series of design, coding, feature, UX and performance validations in a separate user and product owner acceptance (BETA) environment. Similar to the development environment,

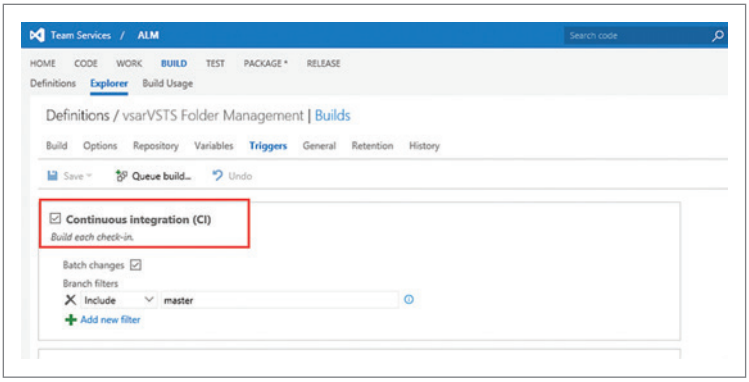

Figure 3 **Build Trigger**

this is an isolated Team Services account, and the second stage of the extension deployment. Once an extension meets our definition of done (bit.ly/28PLYyi), it's deployed to the Marketplace and visible to everyone. You may recognize the DEV → BETA → PROD stages of the release pipeline taking shape.

To prepare the extension project for the automated pipeline, we recommend the following changes to the extension manifest, as shown in **Figure 2**:

- Set your version to 0.0.0 and your publisher to an empty string ("")
- Mark the extension as private (public: false)
- Remove the galleryFlags attribute

These values will be updated during the release deployment and the defaults will ensure that the extension is not deployed or made public by accident.

Adopting a consistent naming convention will simplify traceability through your various environments. If, for example, you suffix the ID with your environment during the release, FolderManagementBeta would be the Folder Management extension running in the BETA environment.

Continuous Integration (CI) is a practice that enables you to have a production-ready build of the latest code in a source control repository (bit.ly/280tZ8K). This is done by automated build and tests are run on every commit.

Our extension projects are typically stored in a Team Services hosted Git repository, or on GitHub for open source projects, such as the Folder Management extension. The pipeline starts with a build definition triggered with every commit made to the repo, then it builds the VSIX extension package and triggers the release definition to deploy it to the DEV, BETA and PROD environments.

As shown in **Figure 3**, ensure you enable continuous integration and optionally batch changes to reduce the number of running builds.

The astute reader might have noticed that our CI Build outputs only a VSIX package and does not copy the extension source files. The reason we do this is one of the foundational principals of a delivery pipeline: build once and only once. Instead of compiling and packaging the extension files at each deployment step, we package only once at the beginning of the pipeline with different configurations per environment. We do this to be absolutely certain that we deploy exactly the same extension to each different environment.

Versioning your extension and build tasks is important. In Team Services, the latest version wins. If you install a public and a beta version of the same extension to a Team Services account, it must be clear which version will activate.

The astute reader might have noticed that our CI Build outputs only a VSIX package and does not copy the extension source files.

What options are there for versioning? The Team Services developer tools let you use any three-part version number as your extension. Foremost, for the simplicity and clear traceability, we've decided to use the Build.BuildNumber as our version number, as shown in **Figure 4**.

Alternatively, you can use the Query Extension Version task, which gives greater control over the version numbers you publish by taking the current version from the marketplace and incrementing a specific part each time the extension is published. While reducing the traceability between the marketplace version and artifacts in Team Services, it provides a nicer sequential numbering toward your customers in the Marketplace.

What about self-testing? The CI Build is also a good place to run things like unit tests. The Folder Management extension doesn't use any unit tests because all logic places calls to the Team Services REST APIs. Other extensions, such as the Countdown Widget (bit.ly/28PTCag), include unit tests that validate the logic for calculating the time difference. These unit tests are run as part of the build. Other automated tests that we want to add in the future are Selenium Web Tests. This lets us not only run unit tests, but also automate UI testing.

Figure 5 shows the build steps. The NPM dependencies are installed with the npm install (**1**) and the setup script processed with the npm exec tasks. As an alternative, you

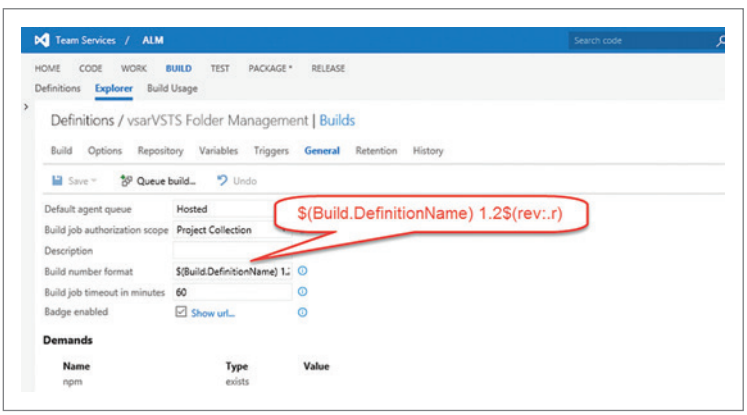

Figure 4 **Build Number Format**

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PNG, PDF...

Aspose.BarCode
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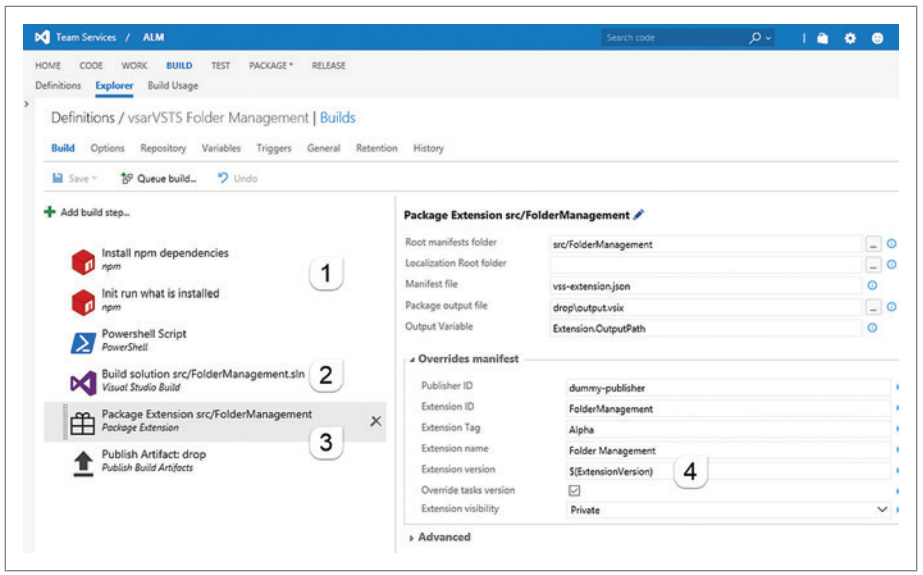

Figure 5 **Build Definition**

could use NuGet and the NuGet restore activity. The Visual Studio Build task (**2**) then builds the solution, followed by the Package Extension task (**3**) which produces the VSIX extension package.

Optionally, you can configure the publisher and extension IDs, tag, and name to override the manifest values. The pipeline only configures the version number (**4**) as part of the build, setting it to the build number to ensure that every instance of the pipeline can be uniquely identified and tracked.

What's the PowerShell script task for? At the time of this writing, the following script was needed to extract the version information (future versions of the extension developer tools—build tasks [bit.ly/28ROoMh] will make the script obsolete):

```
$bldVerD =("$env:BUILD_BUILDNUMBER").replace("$env:BUILD_DEFINITIONNAME","").Trim();
Write-Verbose "Extracted buildVersion $bldVer";
Write-Host "##vso[task.setvariable variable=ExtensionVersion;]$bldVer"
```

Continuous Delivery is the ability to use the output from the CI to build and deploy the new known good build to one or more environments automatically (bit.ly/28PWsfk). There is a subtle difference between Continuous Delivery and Continuous Deployment. The latter is to a single environment. A small team might only implement Continuous Deployment because each change goes directly to production. Continuous Delivery is moving code through several environments, ultimately ending up in production, which may include automated UI, load and performance tests and approvals along the way.

The deployment to the DEV environment is fully automated and occurs frequently. This means that every successful CI build is deployed to DEV without manual steps. As shown in **Figure 6**, after DEV succeeds, a pre-approval is requested before deploying to the BETA environment. This stage is approved by the project lead or the program manager. Finally, there's a pre-approval step for the public release to production. This needs to be approved by both the project lead and the program manager. For simplicity, we chose to use only pre-approval steps and automate the post-approval step because there's no reason for us to approve a post-deployment step and then not deploy it to the next environment.

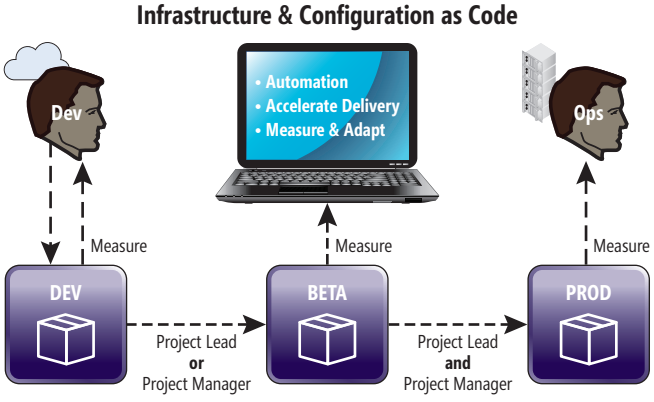

Figure 6 **Release Trigger**

> At this point, the pipeline consistently builds, packages, and updates the extension and, more important, protects environments from common failures.

Figure 7 shows the release definition, which deploys the VSIX extension package to three environments. The first environment, DEV (**1**), is owned and managed by the team that builds the extension. The extension is deployed as private and shared with a development sandbox account.

Once the release is tested and approved, the deployment continues to the second environment, BETA (**2**). The extension is still deployed as private and shared with a user acceptance sandbox account.

Once the user acceptance testing is complete and approved, the deployment continues by changing the publisher, setting the visibility to public and deploying the extension to the marketplace (**3**).

The Publish Extension task (**4**) is the heart of the deployment process and the secret sauce of the pipeline. This task updates the VSIX file by unzipping the content, updating the configuration values and zipping all the files. The task then deploys it to the configured Marketplace publisher account, such as the alm-rangers publisher configured for the Beta environment, as shown.

The extension ID Tag (**5**) and name are overridden to ensure that we have a unique instance of the extension running in each environment, that the Dev and Beta extensions are automatically

shared with development and user acceptance testing Team Services accounts, and that the DEV and BETA releases are private.

You need a Personal Access Token (**6**) to publish an extension using the Publish Extension task or the Command Line. To securely store the token, you can create a Team Services Service connection to the Marketplace. The connection defines a key/value pair where the key is the name of your connection and the value is the access token.

Some of the other tasks you should explore include:

- **Query Extension Version:** Checks the Marketplace for the version number of a published extension. The version can be stored in a variable and used by the pipeline to create a new version, such as incrementing the major, minor or patch version number.
- **Install Extension:** Deploys an extension to the Marketplace without installing it into an account.
- **Share Extensions:** Shares a private extension to the specified accounts.

At this point, the pipeline consistently builds, packages, and updates the extension and, more important, protects environments from common failures. Examples of build failures are when there are errors in the TypeScript code or if there are missing files. The deployment fails when the VSIX is invalid, if access to environments is restricted, or if one of the approvers rejects the release.

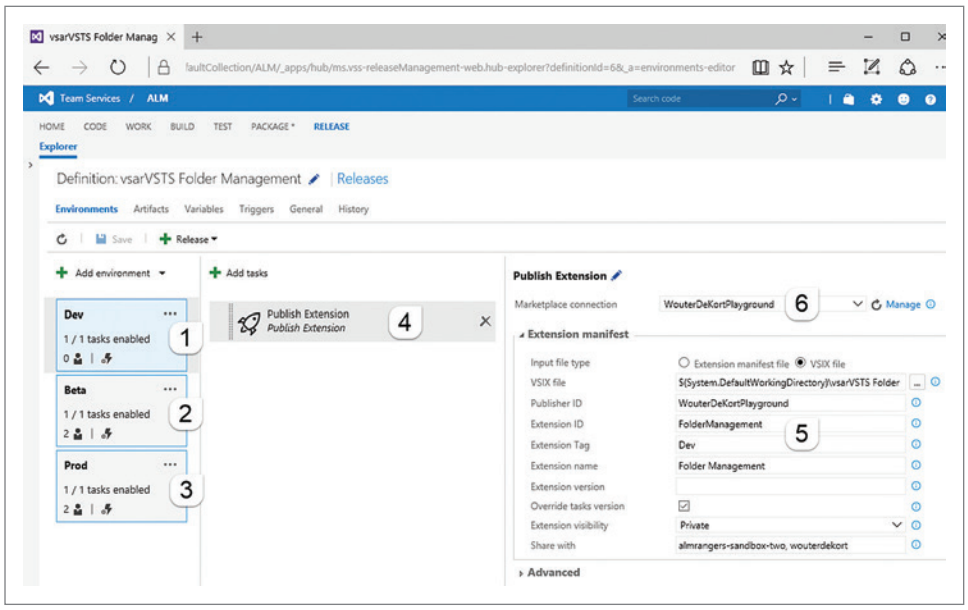

Figure 7 **Release Definition**

DevOps Resources

- Build and Release Tasks for Extensions
  aka.ms/tasksforext
- Folder Management extension also available as sample code on GitHub
  aka.ms/foldermanagement
- Library of tooling and guidance solutions
  aka.ms/vsarsolutions
- Overview of extensions for Visual Studio Team Services
  bit.ly/293YEOm
- Visual Studio Marketplace is a place to find extensions, tools, products and services for Visual Studio, Visual Studio Team Services, Visual Studio Code and Team Foundation Server
  marketplace.visualstudio.com
- Visual Studio Team Services Project Template contains everything you need to create a Visual Studio Team Services extension or a custom build/release task.
  aka.ms/extensiontemplate
- What is DevOps?
  aka.ms/whatisdevops

Wrapping Up

Now that you have an automated build-and-release pipeline, you can speed up your development process, reduce errors introduced by human intervention, and, more important, evolve your solutions, as well as continuously improve through continuous reflection, measuring and learning.

However, that's a topic for another day.

The automated CI and CD pipeline has reduced our manual and error-prone extensions build-and-release process from days to minutes. It's an invigorating experience and enables our development team to focus their time and effort on what is truly important.

The DevOps practices illustrated here can be applied to your own projects, as well. Team Services enables DevOps for any language targeting any platform, including on-premises, cloud, hybrid cloud and mobile. With features that allow you to plan, version, build, deploy and monitor your application, Team Services has everything you need to turn an idea into a working piece of software. Armed with this information, we're excited to see the extensions the community creates to enhance the capabilities of Team Services as you embark on your DevOps journey. ■

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Thanks to the following Microsoft technical experts for reviewing this article: *Donovan Brown, Jess Houwing and Will Smythe*

Commit to Git: Exploring Source Control in Visual Studio 2015

Jonathan Waldman

Since their 2013 releases, Visual Studio and Team Foundation Server have offered out-of-the-box support for Git, the enormously popular source code management system that has upended many traditional options. To complement this source control option, Microsoft has added feature-rich front-end tooling for Git to Visual Studio. But how do you access and leverage these tools?

In this article, I'll cover how Git differs from the source control technology that's associated with Team Foundation Server (TFS), formally called Team Foundation Version Control (TFVC). Then I'll delve into how to configure Git; how to create, connect to and work against a local repository (repo), including how to stage and commit changes; how to manage branches, including merging and viewing history; and how to connect to different types of remote repos, including how to sync changes.

I created the figures in this article from Visual Studio 2015 Update 2 Enterprise edition, but the items I discuss herein are available in all other Visual Studio 2015 versions, including the Community and Express editions. To preserve space, I've created figures that sometimes contain more than one screen image, and I make that clear in the text. Also, I use numbered markers to direct your attention to items within a figure. Once I refer to a figure, I generally mention just its markers. For instance, in the sentence, "See **Figure 1**, Marker 1 and then look at Marker 2," I'm implying that Marker 2 is in **Figure 1**.

This article discusses:

- Selecting Git vs. Team Foundation Version Control as your Visual Studio 2015 project's source control technology
- How to access and leverage specialized Git tooling
- How to place source code into a Git repository
- How to pull, commit and push code with a remote repository

Technologies discussed:

Visual Studio 2015, Git, Team Foundation Version Control

Overview

If you've been using Visual Studio for more than a few years, you might have the impression that TFVC is the right choice to make when developing solutions in a team environment. Often it is, especially if your projects are already using TFVC or if they need to store very large files, contain a great number of files (beyond what anyone would or could reasonably stream across a network) or must be able to lock files under source control. However, as developers more commonly work from disparate remote locations while contributing to a single collaborative software project, newer development teams have flocked to Git because it's a decentralized version control system with broad, cross-platform appeal that lets you work productively offline as you commit or undo changes, manage branches and access history. Best of all, when you're ready, you can go online and connect to the same remote repository that's being updated by the rest of the team and synchronize your offline changes using a variety of methods.

The Visual Studio 2015 IDE relies on the LibGit2 API and the LibGit2Sharp communication layer to implement all of the Git features it exposes in its front-end tooling. LibGit2 is a zero-dependency, cross-platform, open source Git core engine written entirely in C. LibGit2Sharp is a library written in C# that runs as a managed process under the Microsoft .NET Framework. It serves as a .NET-friendly interface between Visual Studio and LibGit2 and it dramatically simplifies the programming effort required by the Visual Studio development team to establish a communication pipeline to and from the LibGit2 library. LibGit2Sharp is available to you, too, which means that you can use your favorite .NET language to write your own Git tools and utilities. Access more details about LibGit2 and LibGit2Sharp at libgit2.github.com.

In Visual Studio, Team Explorer is the primary GUI conduit through which you ultimately interact with LibGit2—the underlying Git engine. To open it, select the View | Team Explorer menu item or type Ctrl+\ followed by Ctrl+M. Along the top of the Team Explorer window is a toolbar containing blue Back/Forward navigation buttons followed by white Home, green Connect and blue

Refresh buttons. Click the Home button and you'll see a window similar to the one pictured in **Figure 1**.

Below the toolbar is the label "Home" (**Marker 1**). This label has a white down-arrow next to it (**Marker 2**), indicating that it's connected to a dropdown menu. Click anywhere along the label to display the menu (**Marker 4**). Both the Team Explorer toolbar and this context menu let you conveniently switch among the various Team Explorer panels; it's a different kind of tabbed-dialog metaphor: The panel type you're currently viewing (in this case, Home) appears in both the panel label (**Marker 1**) and the Team Explorer title-bar caption (**Marker 3**).

Configuring Git

Before using Git within Visual Studio, you should configure its global settings. To do that, navigate to Team Explorer's Home panel. Its Project section contains a series of buttons for viewing pending changes, managing branches and synchronizing with remote repositories (**Figure 1, Marker 5**). Click Settings to open the Settings panel, and then click Global Settings under the Git section. This presents the Git Settings panel (**Figure 2, Marker 1**). These global settings aren't tied to a particular Git repository; rather, they supply default values as you create new repos (you can later override those defaults on a per-repo basis). Specify your User Name (this should be your full name—spaces are allowed); your e-mail address and the default repo location, which is the default folder where you want newly created Git repos to be stored by Visual Studio (**Marker 2**).

Also, specify whether to associate TFS or Gravatar author images with Git activities. If you select Gravatar, be aware that the way this feature works is to send the e-mail address associated with each Git commit to Gravatar as a lookup-key. Gravatar then returns an image associated with that e-mail address. Thus, ultimately, this seemingly innocuous feature shares contact information about everyone on your team with a third-party entity—something you might want to prevent. Finally, select whether to commit changes after a merge by default (**Marker 3**). If you make any changes to these fields, click Update to save them (**Marker 4**).

In a separate section of the panel, you can set which Diff Tool and Merge Tool to use; currently, these values default to Visual Studio's own tools. If you want to further customize these selections, then you might need to manually edit the configuration file to which this Window writes. That file is .gitconfig, and it's located in your homepath folder.

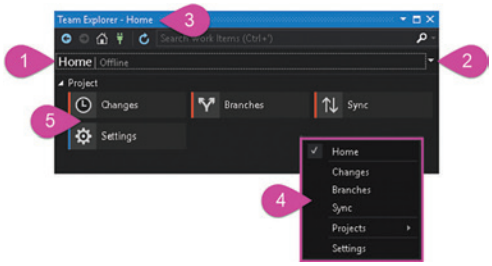

Figure 1 **The Team Explorer Window Home Panel (Offline)**

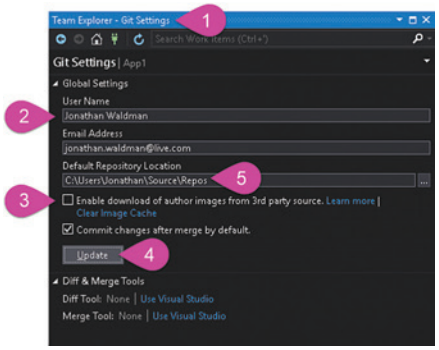

Figure 2 **The Team Explorer Git Settings Panel**

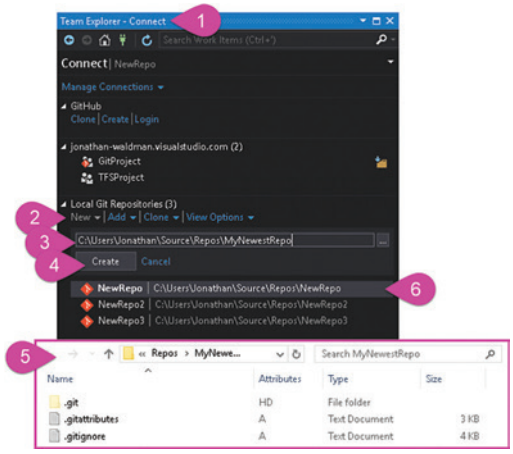

Figure 3 **The Team Explorer Connect Panel**

Working Against a Local Repo

When you work on your own projects as a solo developer and you've made the good decision to place your code under source control, you can start by working offline against a local Git repo and then scale up to a connected, remote repo later, if warranted.

To create an empty repo, go to the Team Explorer Connect panel (**Figure 3, Marker 1**) and click New under Local Git Repositories (**Marker 2**; New is grayed out because I already clicked it). Enter a local path and repo name, such as your default source path followed by \MyNewestRepo (**Marker 3**), then click Create (**Marker 4**). This creates a folder called MyNewestRepo (this is your working directory) that contains a .git folder along with two files, .gitignore and .gitattributes. Although I show it in the screen image, .git is a hidden folder: It contains the actual Git repo (Git's backing database and housekeeping files) and usually shouldn't be touched. But because it contains your entire Git repo, you might want to back it up, so it's important to know that it exists. The .gitattributes file specifies how Git should handle line endings and which programs to launch when diffing a file within the current repo; .gitignore specifies that Git shouldn't track files with certain extensions or in certain folders (by default, it specifies .suo, .user, .pdb, and .tmp file extensions and all of the files in the debug and release folders). Add other file extensions and folders as needed to keep the size of your Git repo as small as possible.

After creating the new repository, you'll see it appear under the Local Git Repositories section. Double-click any repo that appears in the list (**Figure 3, Marker 6**) to connect to it; this highlights the repo using a boldface font before taking you to the Home panel, which confirms that you successfully connected to the repo you selected (**Figure 4, Marker 2**).

If you click Settings now, you'll see that you have access to repo-specific settings. Access those settings if you want to override the values inherited from Git's global settings. For example, it's quite common to customize the e-mail address for the current repo if you're working on a project for a particular client and want to use a work-specific e-mail address. Additionally, you can click provided links to directly edit the .gitignore and .gitattribute files; specify which Diff & Merge tools to use; add remotes and view other attributes related to the current repo.

Recall that Git's working directory is the parent folder that contains the .git directory. Once you've created and

configured the empty repo, the way to add files to it is to first add files to the working directory. Git will see those files but won't incorporate them into the Git repo until you stage and commit them. Armed with this knowledge, simply use the working directory as you want and engage in a Git-commit workflow once you're ready.

While starting with an empty repo and then adding files is one option, you also can start with solution files. To create a new solution along with a Git repo, select the File | New Project menu item. You'll see the New Project dialog that includes a "Create new Git repository" checkbox. If checked, Visual Studio creates a new solution and a new Git repo—along with the two .gitattributes and .gitignore configuration files—in the new project's working directory. Alternatively, if you have an existing solution and you want to place it under Git source control, open the solution and then select the Visual Studio File | Add to the Source Control menu item. Both procedures create a new Git repo along with .gitattributes and .gitignore configuration files.

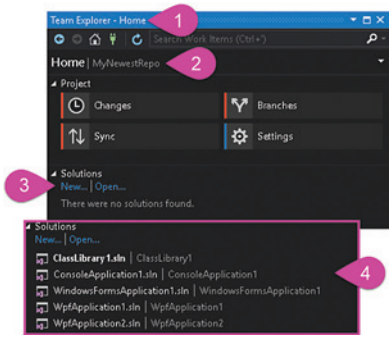

Figure 4 **The Team Explorer Home Panel, Connected to a Repo**

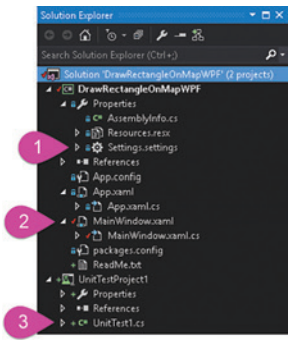

Figure 5 **Solution Explorer with Icons Indicating Source Control States**

Whenever you open a solution that's under Git source control, Visual Studio automatically connects to the repo in that solution's working folder. Likewise, whenever you use the Team Explorer Connect panel to connect to an existing repo, Visual Studio dynamically scans all of the folders in that repo's working directory for .sln files and lists them in the Home panel's Solutions section. For example, if you connect to the MyNewestRepo repo, you might see a list of solutions that looks something like the callout image shown in **Figure 4, Marker 4**. When Visual Studio identifies such solutions associated with a repo, double-click an entry if you wish to open that solution within the IDE.

Making Changes

When you use Visual Studio to open a solution that's under Git source control, Solution Explorer displays informative icons next to items in its treeview control. The icons indicate the state of items in your working directory as compared to items that exist in the Git repo to which you're currently connected. For example, in **Figure 5** you can see a blue lock icon next to checked-in items (**Marker 1**), a red check mark next to changed items (**Marker 2**) and a green plus sign next to added items (**Marker 3**). If you encounter an icon you don't recognize, hover the mouse directly over it to see a helpful tooltip. While these icons usually are accurate, if you make changes to items outside of the Visual Studio IDE, then it might be necessary to click the Solution Explorer Refresh toolbar button in order to update the view.

After working with items in your solution, you'll probably want to stage then commit changes to the Git repo, or possibly even undo some changes. To begin managing the changes you've made, navigate to Team Explorer | Home | Changes. In the Changes panel (**Figure 6, Marker 1**), you'll see all detected changes (**Marker 2**). Click the plus icon (**Marker 12**) to stage all changed items or the minus icon to unstage all items (**Marker 13**). You can also drag and drop items between the Changes (**Marker 2**) and Staged Changes (**Marker 3**) sections.

Right-click a changed item to view a menu that lets you open the file, view its history, compare it with its unmodified version, open the source file and show an informative annotations pane adjacent to it, stage and undo its changes (**Marker 14**). If you want to compare a change with the unchanged version of the file, double-click a changed item to launch a diff window (**Figure 7**). The diff window has two panes: The left pane shows the unmodified version in the local Git repo and the right shows the version in your working directory; the right-most edge visually shows you where there are differences between the files (**Marker 1**)—red indicates a removal while green indicates an addition; the panes show a red highlight over the entire line of code that has a removal (**Marker 2**) and a green highlight over the entire line of code that has an addition (**Marker 3**), and the diff tool draws a red or green box within that line around removed or added text, respectively. Additionally, helpful dropdowns flank the top of each pane (**Marker 4**)—these let you navigate quickly to code sections.

When you're ready to commit your changes, add a commit message (**Figure 6, Marker 4**), then click the multi-mode Commit button (**Marker 5**). This multi-mode button defaults to Commit Staged, but it also can push and sync (this makes sense only in the context of being connected to a remote repository). When the commit operation succeeds, Team Explorer reports the commit ID (**Marker 15**).

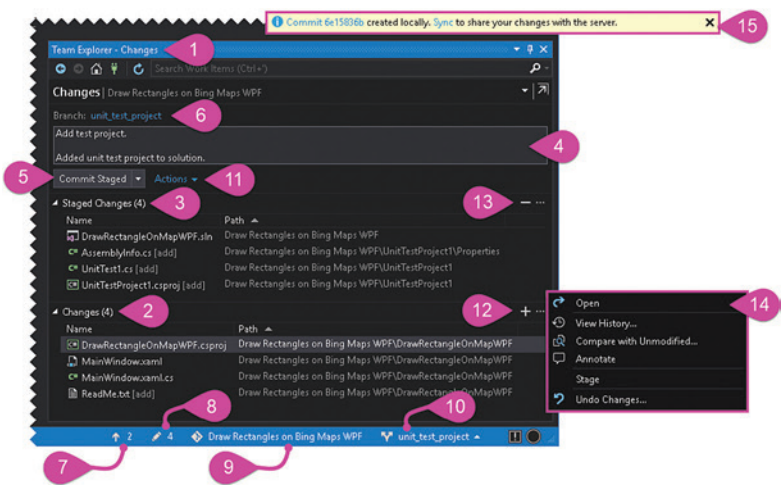

Figure 6 **The Team Explorer Changes Panel**

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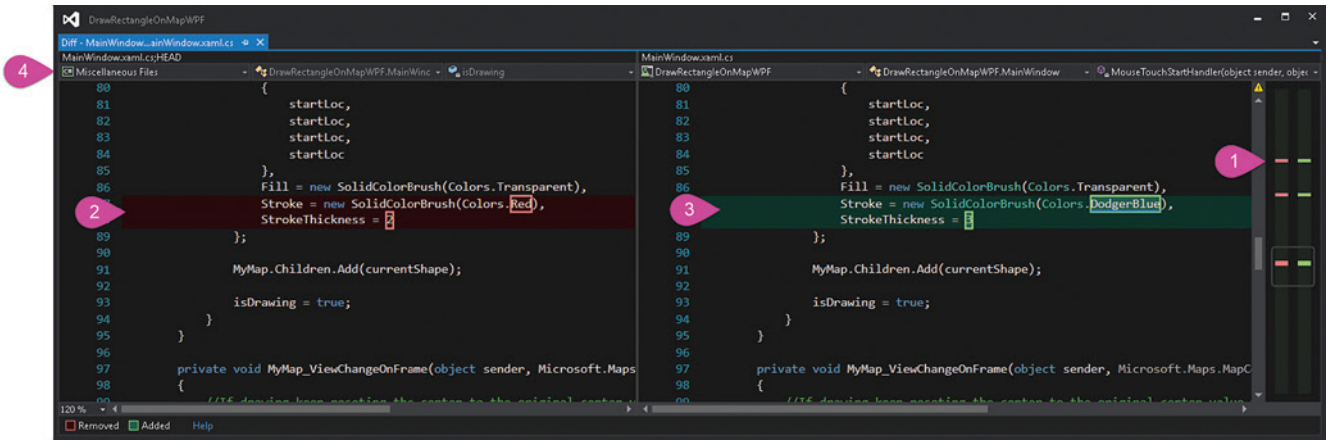

Figure 7 **The Visual Studio Default Diff Tool**

Notice that the Changes panel informs you that it's working against a local branch called unit_test_project (**Figure 6, Marker 6**). The Visual Studio status bar also reports which branch you're working on (**Marker 10**) and it displays other useful, real-time information related to the current Git repo. For instance, it shows the number of unpublished changes—that is, how many changes have not yet been pushed to a remote repo (**Marker 7**); the number of staged changes (**Marker 8**); the name of the current repo (**Marker 9**); and the name of the current branch (**Marker 10**). Furthermore, these status-bar sections act like buttons. For example, if you click the current repo, Visual Studio opens the Team Explorer Connect pane, showing you details regarding the current repo; if you click the current branch, a popup menu offers branching options.

As with any source control system, when you commit changes to the repo, you're adding to the repo's commit history. Those history entries include the user name and e-mail address you provided in Git Settings so that anyone who has access to the history data can view who did "what" and "when." Not only that, when you push your local changes to a remote repo, the history goes along with it. When other members of the team synchronize their local repo with the remote, they'll be able to see the history your changes generated.

Managing Branches

Visual Studio supports basic and advanced Git branching features. When you want to manage branches, open the Branches panel by navigating to Team Explorer | Home | Branches (**Figure 8, Marker 1**). Along the top, you'll see quick links to merge, rebase and other actions (**Marker 2**). Below that, you'll see a section called Active Git Repositories (**Marker 3**) and a list of branches each contains; the current branch is in boldface type (**Marker 4**). To switch to another branch, double-click it. Visual Studio then performs a checkout on the selected branch.

Right-click a particular branch to see a menu of available actions (**Marker 5**). You can check out the selected branch, create a new local branch from an existing local branch, merge from an existing local branch into the selected branch, rebase from the selected local branch onto another existing local branch, perform a hard or mixed reset on the selected branch, cherry-pick the selected branch or delete the current branch. If you choose to merge, Visual Studio offers full support for detecting merge conflicts, and it presents a conflict editor you can use to manually resolve those conflicts.

You also can view the history for any listed branch and, from that history view, you can right-click an entry to see a menu that lets you view commit details, make a new branch, create tags, revert, reset, cherry-pick and navigate to parent/child branches. The history view shows the Commit ID, author, date and commit message.

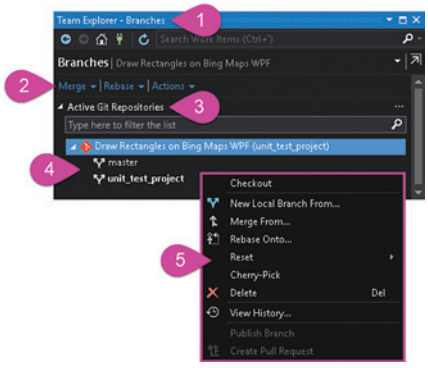

Figure 8 **The Team Explorer Branches Panel**

Connecting to a Remote Repo

So far, I've limited my discussion to working offline against a local Git repo. A local repo is generally all you need if you're working on your own and you have a reliable way to back up your working directory's .git folder. However, when you want to work with other developers on a team project or when you want to use a hosted service as a backup, you'll need to connect to a remote repo.

If you want to have full control of your repo or you're a bit uncomfortable putting the code for the world's next killer app on a hosted server, then you should consider hosting your repo using a file share on your own network. Next, you can increase reliability and file-transfer speeds to and from your repo by installing a Windows-based Git server, such as the Bonobo Git Server (bonobogitserver.com), which is free, or GitStack (gitstack.com), which is free for up to two users. Next, you can download and install Visual Studio Team Foundation Server Express 2015 on a server located on your network and support up to five named users for free; or, if you or anyone on your team has an active MSDN license, you can download and install the full version of Visual Studio Team Foundation Server 2015 on your own server and keep it there for eternity while supporting up to five named users for free. Finally, you can purchase and install Visual Studio Team Foundation Server 2015 along with the client-access licenses (CALs) you need for your team.

If you're willing and able to use an off-site Git-hosting service, your options expand to

include Visual Studio Team Services (previously called Visual Studio Online), as well as such popular options as GitHub, BitBucket and GitLab. The free hosting options always have some restrictions. The Git wiki Web site (bit.ly/10ym3F9) strives to keep current with the many Git hosting options and features.

To show how to connect to remotes and clone repos they host, you'll first clone a repo that's hosted somewhere on your network. Next, you'll connect to and clone a simple Visual Studio Team Services repo hosted on the Web. Finally, I'll show how to connect to and clone a GitHub-hosted repo for a famous project.

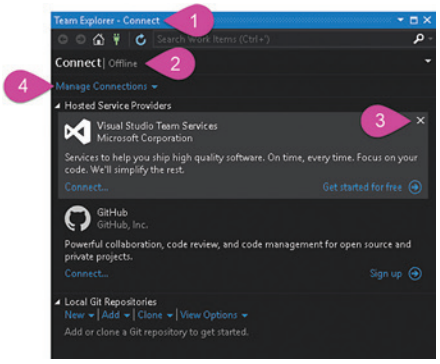

Figure 9 **The Team Explorer Connect Panel Service Provider Options**

To manage remotes, navigate to Team Explorer | Home | Connect (**Figure 9, Marker 1**). The Connect panel displays a blue Manage Connections link menu under the panel menu (**Marker 2**), followed by a section containing a vertical list of Hosted Service Providers (the individual Visual Studio Team Services and GitHub windows are called Service Invitations).

If you happen to close a service invitation (by clicking its X, indicated by **Marker 3**), you won't be able to get it back unless you modify the registry. If this happens, you can instead access the service using the Manage Connections dropdown menu (**Marker 4**). Other information within the Team Explorer Connect panel is also stored in the registry, such as recently used Git repository information. If you want to inspect that registry key, it's located at HKCU\Software\Microsoft\VisualStudio\14.0\TeamFoundation (pay attention to the GitSourceControl and TeamExplorer branches below that).

Recall that one reason you can work offline so productively against a Git repo is that when you clone a remote repo to a local repo, you obtain that repo's entire history, which includes the details for every commit, branch and merge operation. When you go back online, Git determines how your local repo has changed when compared to the remote repo and this is important when it comes to being able to successfully carry out fetch, pull, push and sync operations.

To clone a repo from a local network share, go to the Local Git Repositories section and click the Clone link. You'll be asked to "Enter URL of a Git repo to clone," but the process is actually far more forgiving. You can also enter any valid path to a location on your current workstation (such as c:\Repos\FinancialWizardApp), a UNC path to a network share (\\1.2.3.4\Repos\FinancialWizardApp) or a mapped-drive path (\\computername\Repos\FinancialWizardApp). Just be sure that there's a .git folder at the specified location and that Visual Studio can read it.

In **Figure 10** (**Marker 1**), I've entered a mapped-drive letter to refer to the location on my network that contains my remote repo, and other developers who work on my network can do the same. After providing the location of the remote repo, specify the local path for the cloned repo (**Marker 2**). Next, decide whether to recursively clone submodules, then click Clone.

It's important to note that when you connect to a remote repo on a file server, you won't have the ability to issue pull requests. This feature requires a Git server (such as Team Foundation Server or GitHub). You can, however, create, merge and manage branches and view history and sync changes (by fetching, pulling and pushing).

When you want to clone a repo from Visual Studio Team Services, you first need to log onto a Team Foundation Server. To start, select the Visual Studio Team | Manage menu item, or go to Team Explorer's Connect panel and click Manage Connections, then choose Connect to Team Project. You'll see a Connection to Team Foundation Server dialog appear. Click Servers and you'll see a dialog such as the one shown in **Figure 10, Marker 4**. Notice that you can use this dialog to connect to any available Team Foundation Server, but if you want to connect to a Visual Studio Team Services account, enter the URL for it. When you click OK, you'll need to sign in; once you do that, your server will be listed and you can close the dialog. You'll then see a dialog that shows you two panes: the left pane displays your Team Project Collections and the right pane displays Team Projects in that collection. Check the checkbox next to those team projects you want to appear in Visual Studio, then click Connect. Now navigate to the Team Explorer Connect panel and you'll see your repos listed (**Figure 10, Marker 3**).

While GitHub offers only Git as a version control system (VCS), Visual Studio Team Services offers decentralized Git by default and centralized TFVC as an alternative. These two VCSes work quite differently and require different IDE tooling. Fortunately, the Team Explorer window was specifically designed to recognize and handle both VCS types. In fact, when you connect to your Visual Studio Team Services server and add projects, Team Explorer shows which projects are under Git version control by using a red Git icon (**Figure 10, Marker 3**); projects unadorned with the Git icon are under TFS version control.

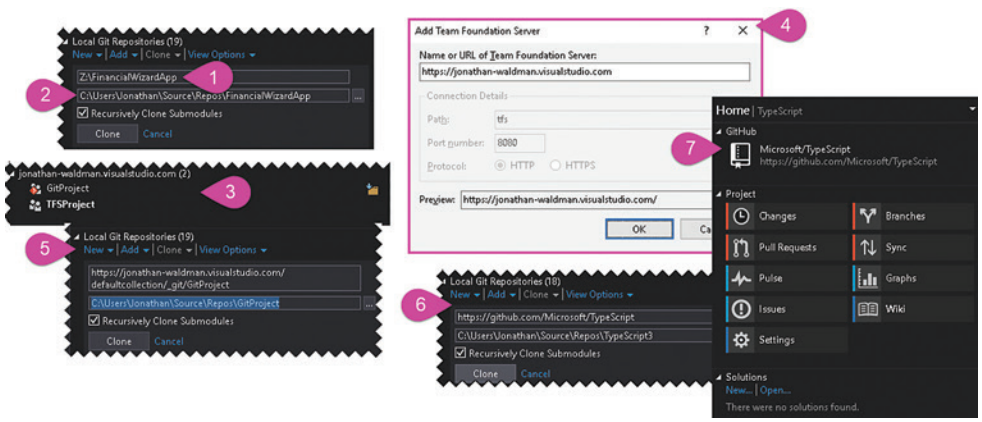

Figure 10 **Working with Various Remote Repo Locations**

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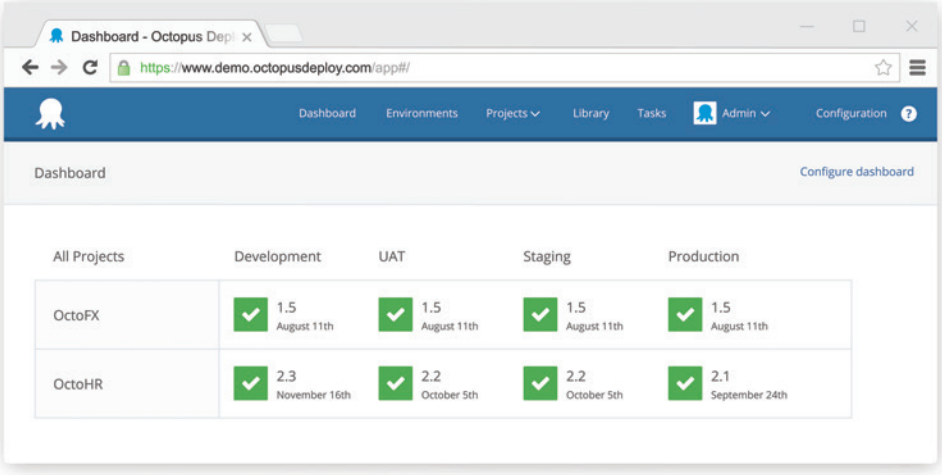

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So in order to clone a Visual Studio Team Services remote repo, it must be a Git repo. You can right-click any Git repo in the list and choose Clone. I chose to clone the GitProject project, which brought me to the Local Git Repositories section with the remote repo information populated, along with a default local repo path (**Figure 10, Marker 5**). Once cloned, the repo appears in the Local Git Repositories list. Double-click to open it and you'll be taken to the Team Explorer Home panel. There you'll see buttons designed to work with Visual Studio Team Services repos, such as Pull Requests, Work Items and Builds.

The process of cloning a remote repo is very similar if you're cloning from GitHub. If you have a private repo hosted on GitHub, then you'll need to log onto your GitHub account to clone it. Otherwise, you can clone public repos straightaway without having an account.

In general, you can clone a remote repo as long as it's on a network share or available from an HTTP/HTTPS server. At this time, Visual Studio does not support SSH for communicating with remote Git repos.

Working with Remote Repos

Once you're connected to a remote repo, you can go back to Team Explorer | Home | Settings and click its Repository Settings link. There, you can view information about the remotes your current repo is connected to (this is especially helpful if you're working against more than one remote). Back on the Settings panel, you'll also see new links if you're connected to a service such as Team Foundation Server or GitHub. Those links let you configure security, group membership, portal settings and so on, for the service.

On the Team Explorer | Home panel, you'll see new buttons related to options your remote service offers. If you're connected to a remote repo hosted by Visual Studio Team Services, you'll see buttons for Pull Requests, Work Items and Builds. If you click Sync, you'll get to the Team Explorer Synchronization panel where you can choose to sync, fetch, pull, publish and push. If there are merge conflicts that can't be resolved automatically, Visual Studio presents the selected Merge Tool so that you can manually choose how to resolve those conflicts.

To conclude, I'll clone Microsoft's open source TypeScript 3 project, which is located at bit.ly/1o2weYt. Because this is a public Git repo, I can clone it directly using the Local Git Repositories section Clone link (**Figure 10, Marker 6**). As of this writing, this repo is about 350MB, so it contains a lot of history and branches and might take a while to download.

Once the local repo has fully downloaded, you'll see it listed under the Local Git Repositories section. If you double-click it, it will open in the Team Explorer Home panel (**Figure 10, Marker 7**). Under the Project section, you'll see buttons designed to work with GitHub repos such as Pull Requests, Sync, Pulse and Graphs. Some of these buttons will take you to the GitHub Web site to complete the requested action.

If you click Branches, you'll be taken to the Team Explorer Branches panel. Once there, you'll see the master branch. If you right-click that, you can view history for the entire project, starting with the initial commit made on July 7, 2014, through to the current date. The view history window lets you view its data using a number of different presentations, depending on the options you choose in the window's toolbar (**Figure 11, Marker 1**). The view I chose to show is referred to as the Detailed View. It shows a graph of branches (**Marker 2**)—merge commits are in gray (**Marker 3**) while non-merge commits are in blue (**Marker 4**)—including the commit ID, the author's user ID, the date of the commit, the commit message and any tags that might be present.

This display makes it easy to navigate to the branch's parent or child. Just select a commit and use the toolbar's Go to Child/Go to Parent navigation buttons (the third and fourth buttons shown). In those cases, where a branch ends with an arrowhead (**Marker 5**), click that commit (see the highlighted row) and the line connecting parent and child will be drawn (**Marker 6**).

Wrapping Up

Visual Studio 2015 provides convenient GUI access to common and many advanced Git features, and is able to do so thanks to the underlying LibGit2 Git engine. Although it offers nearly full support for Git, there are still some less-popular operations, such as stashing, that require interaction with a Git command-line interface. Because the Visual Studio Git tooling is so extensive, it's possible to remain shielded from Git's command-line interface and yet accomplish most Git tasks with little friction. Curious or advanced Git users undoubtedly will, at some point, crave access to bare-metal Git. Those users can assuage themselves by launching a PowerShell Interactive Window and interacting with the official Git for Windows command-line interface, which also is included with Visual Studio. With GUI and command-line options, Visual Studio provides satisfying and ready access to Git, no matter what your skill level. ■

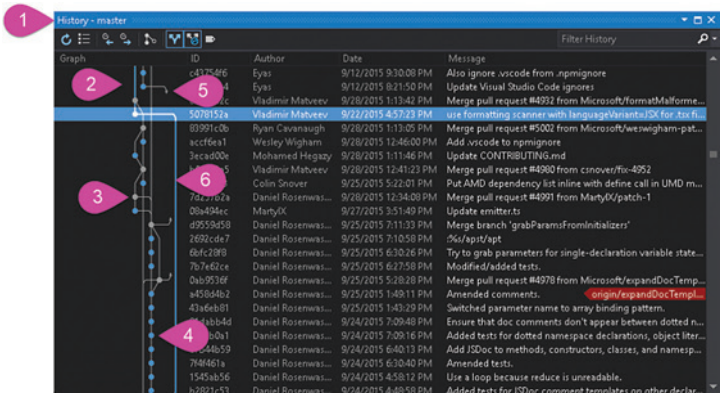

Figure 11 **Viewing History Provides Detail About Branches, Commits and Merges**

Jonathan Waldman *is a Microsoft Certified Professional who specializes in Microsoft technologies and software ergonomics. He has worked with the Microsoft technology stack since its inception and has held lead roles on several highly visible institutional, government and private-sector projects. Waldman is a member of the Pluralsight technical team and authored its video training course on the commercial Wijmo library of enhanced JQuery UI widgets. He can be reached at jonathan.waldman@live.com.*

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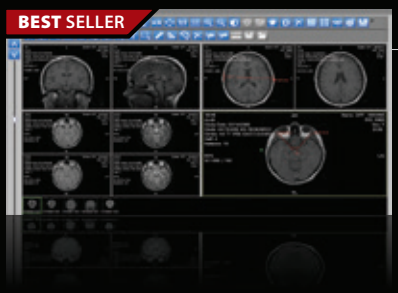

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Write Apps with Visual Studio Code and Entity Framework

Alessandro Del Sole

Open source and cross-platform development are crucial for Microsoft's current and future strategies. Many building blocks of the .NET stack have been open sourced, while others have been developed to embrace and support the new strategy. ASP.NET Core 1.0, currently in Release Candidate (RC) mode, is the most recent open source technology for building cross-platform applications for the Web and cloud, running on Linux, Mac OS X and Windows.

ASP.NET Core lets you write Model-View-Controller (MVC) applications with C# and relies on .NET Core (dotnet.github.io), the new open source and cross-platform modular set of runtimes, libraries and compilers—in RC, too. The biggest benefit of ASP.NET Core is that it's completely independent from any proprietary project system or integrated development environment, which means you can also build an ASP.NET Core application outside of Microsoft Visual Studio, and on OSes different than Windows.

To accomplish this, you use a number of command-line tools to scaffold, build and run applications, while you can use Visual Studio Code for editing. There's a lot of work in progress yet, so some features might change until it reaches the Release-to-Manufacturing (RTM) milestone. For instance, ASP.NET Core used to rely on the .NET Execution Environment (DNX) and its command-line interface (CLI) to build and manage applications; because ASP.NET Core is built upon .NET Core, DNX will be retired and its CLI will switch to the .NET Core command-line tools for future releases, so keep this in mind if you want to start writing cross-platform Web apps with ASP.NET Core and C#.

This article explains how to create a cross-platform ASP.NET Core Web application that leverages Entity Framework 7 to execute data operations against a database, and how to write code in Visual Studio Code (code.visualstudio.com), which you use on Linux, OS X and Windows. Because the focus is on data, I recommend you read the ".NET Core and Visual Studio Code" document on the official Web site (bit.ly/1PhzoC7). You'll write several commands based on the DNX environment for consistency with the current RC; keep in mind this will be replaced with commands from the .NET Core CLI once ASP.NET Core turns into RTM.

I'll point out commands that'll be replaced where appropriate. I'll create my sample application using the new Visual Studio

This article discusses:

- Enhanced editing experience in Visual Studio Code
- Scaffolding an ASP.NET Core application
- Implementing data models with EF 7
- Installing VS Code extensions

Technologies discussed:

.NET Core, ASP.NETMVC, Entity Framework, SQL Server

Figure 1 **Creating a Sample Table**

```
CREATE TABLE [dbo].[Cars](
  [id] [int] IDENTITY(1,1) NOT NULL,
  [CarModel] [nvarchar](max) NOT NULL,
  [Brand] [nvarchar](max) NOT NULL,
CONSTRAINT [PK_Cars] PRIMARY KEY CLUSTERED
(
  [id] ASC
)WITH (PAD_INDEX = OFF, STATISTICS_NORECOMPUTE = OFF, IGNORE_DUP_KEY =
OFF,
  ALLOW_ROW_LOCKS = ON, ALLOW_PAGE_LOCKS = ON) ON [PRIMARY]
) ON [PRIMARY] TEXTIMAGE_ON [PRIMARY]

GO
SET IDENTITY_INSERT [dbo].[Cars] ON

GO
INSERT [dbo].[Cars] ([id], [CarModel], [Brand]) VALUES (1, N'Mustang', N'Ford')
GO
INSERT [dbo].[Cars] ([id], [CarModel], [Brand]) VALUES (2, N'500', N'Fiat')
GO
INSERT [dbo].[Cars] ([id], [CarModel], [Brand]) VALUES (3, N'Giulia', N'Alfa Romeo')
GO
SET IDENTITY_INSERT [dbo].[Cars] OFF
GO
USE [master]
GO
ALTER DATABASE [CARS] SET  READ_WRITE
GO
```

Code tool. Visual Studio Code is a sophisticated, multi-language and cross-platform development tool that puts writing code at its center and that has hooks so you can issue build commands. I'm assuming you already have installed Visual Studio Code, Node.js (nodejs.org), SQL Server Express Edition (bit.ly/1PhzoC7) and ASP.NET Core 1.0 RC (get.asp.net/OtherDownloads).

Creating a Sample Database

First, create a database with which to work. You might use an existing database, or you could also define the data model with the Entity Framework Code First approach, but support for code migrations in ASP.NET Core is still in progress and not stable at this time. So you'll simply create a new database that stores a list of car models and their manufacturers' names. In SQL Server Management Studio, create a new database called Cars, then write and execute the query shown in **Figure 1**, which defines a table called Cars, with three columns: Id (primary key and auto-increment), CarModel (of type NVarChar(Max)) and Manufacturer (of type NVarChar(Max)).

Depending on your scenario, you might also want to consider a column of type bit that you use to mark an item as deleted but that actually is never removed from the data store physically.

Ensure the database, the table and sample data are properly shown in the Management Studio Object Explorer.

Installing C# for Visual Studio Code

In Visual Studio Code, the C# language support has recently moved to an extension that you must download and install separately. It is strongly recommended you install the C# extension to get all the evolved editing features such as syntax colorization, IntelliSense, code issue detection as you type and much more. In order to install C#, run Visual Studio Code, open the Command Palette (F1), then type "ext install" and press Enter. From the list of extensions, double-click C# and wait for the installation to complete. When prompted, accept to restart Visual Studio Code.

Scaffolding an ASP.NET Core Application

Visual Studio Code has no built-in commands that automate the generation of an ASP.NET Core project and creating a project manually requires some effort. With the current RC of ASP.NET Core, you can use a command-line tool called Yeoman (yeoman.io), a popular scaffolding tool that provides, among other things, an option to generate an ASP.NET Core app skeleton. Yeoman relies on Node.js and must be installed from the command line using the Node.js package manager (npm). That said, open a command prompt and type the following line:

```
> npm install -g yo generator-aspnet gulp bower
```

That will install Yeoman (represented by "yo") in the global location (-g) together with gulp (a tool for task automation) and bower (a client-side library manager). Notice that Yeoman ships with a number of generators, including the ASP.NET generator and the Visual Studio Code extension generator. The generator-aspnet option in the previous command line will download and install the ASP.NET Core generator that will simplify your work. When ready, using the cd (or chdir) command, move into a folder where you want to create a new application (cd C:\temp). At this point, type the following command line:

```
> yo aspnet
```

This will open the Yeoman ASP.NET generator, as you can see in **Figure 2**.

Select the Web Application template and press Enter. In the next screen, enter CarModels as the application name and press Enter. The generator defines the application's root namespace based on the app name casing. As a consequence,

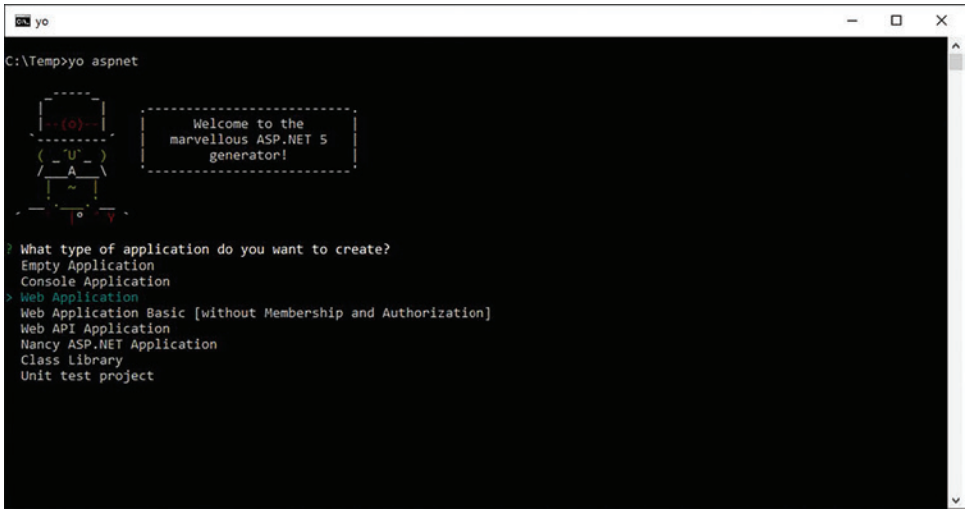

Figure 2 **Starting the Yeoman Generator**

if CarModels is the application name, then the root namespace will also be CarModels; but if you enter carmodels or carModels as the app's name, then your root namespace will be carmodels or carModels, respectively. Take care of this when specifying the application name. After a few seconds, Yeoman completes generating a new ASP.NET Core application into a subfolder called CarModels. With future ASP.NET Core releases, you also will be able to use the .NET Core CLI for scaffolding a Web application. The command line you'll use will look like this:

```
> dotnet new
```

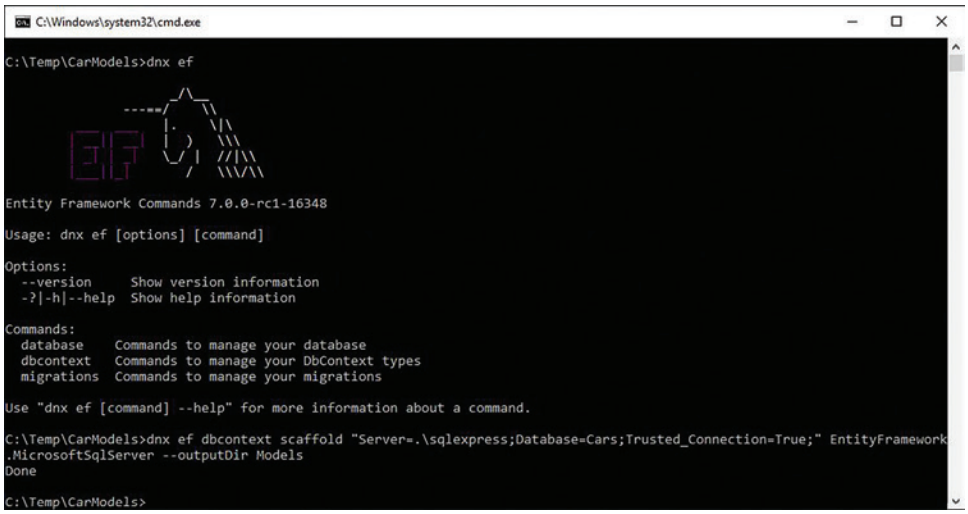

Figure 3 **List of Available Entity Framework Commands**

The current version of the CLI doesn't support scaffolding a Web application, yet; rather, it generates an empty Console application, so this is another reason why you see Yeoman in action here. Enter the CarModels folder by writing "cd CarModels" and then type "code," so that Visual Studio Code will start up, opening the current folder and its contents. When Visual Studio Code opens a folder, it scans for known project file names, such as project.json, package.json or .sln MSBuild solution files. In the case of an ASP.NET Core project, Visual Studio Code finds project.json, collects dependency information, and organizes code files and subfolders in a proper way. The first time the project is open, Visual Studio Code detects missing NuGet packages and offers to make a Restore for you.

Click Restore on the informational bar and wait for the NuGet packages to be downloaded. When finished, you can leverage all the advanced code-editing features of Visual Studio Code to write and edit code files and reuse most of your existing skills with ASP.NET MVC. In fact, Visual Studio Code not only supports C#, but it also offers syntax colorization and other advanced features for all the file types that compose an ASP.NET Core application, including .cshtml, CSS style sheets, JavaScript and .json files.

Creating the Data Model with Entity Framework 7

Now that you have an empty ASP.NET Core application, the next step is to create a data model with Entity Framework 7, the new version of the popular object-relational mapper from Microsoft, which offers support for ASP.NET Core. At the time of this writing, Entity Framework 7 is in RC1. Creating the model will be accomplished running the proper dnx commands from the command prompt and involves a couple of NuGet packages. The first NuGet package is called EntityFramework.MicrosoftSqlServer and is automatically referenced by the newly created project. The second NuGet package is called EntityFramework.MicrosoftSqlServer.Design and must be added manually to the project dependencies. To do this, in Visual Studio Code open the project.json file and locate the following line within the dependencies node:

```
"EntityFramework.MicrosoftSqlServer": "7.0.0-rc1-final",
```

After this line, add this:

```
"EntityFramework.MicrosoftSqlServer.Design": "7.0.0-rc1-final",
```

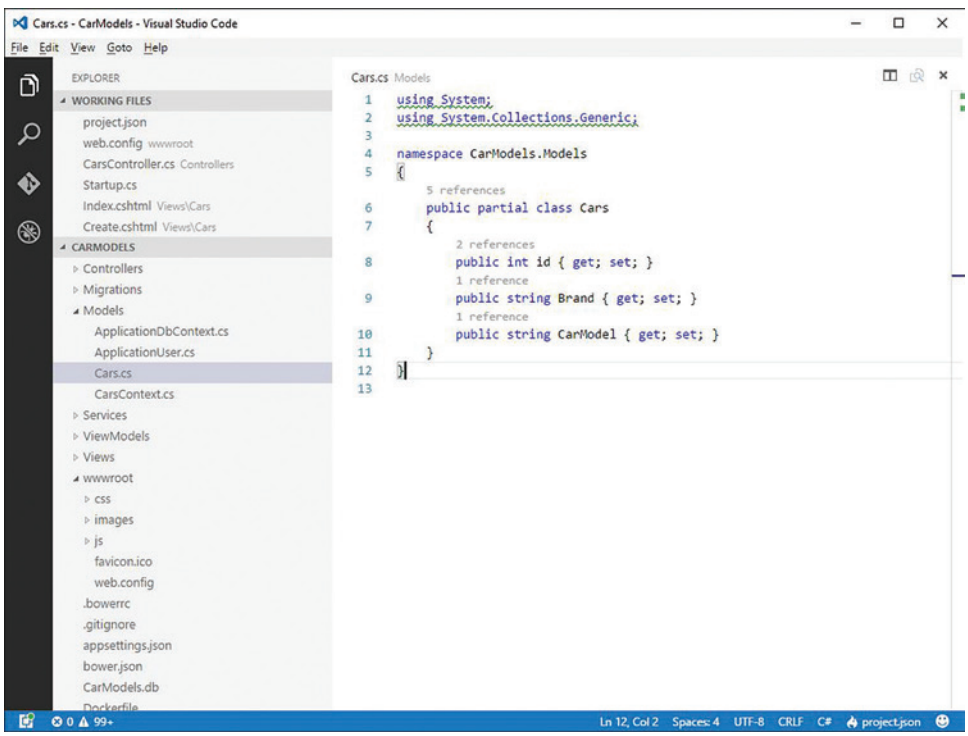

Figure 4 **Cars Model Class in the Code Editor**

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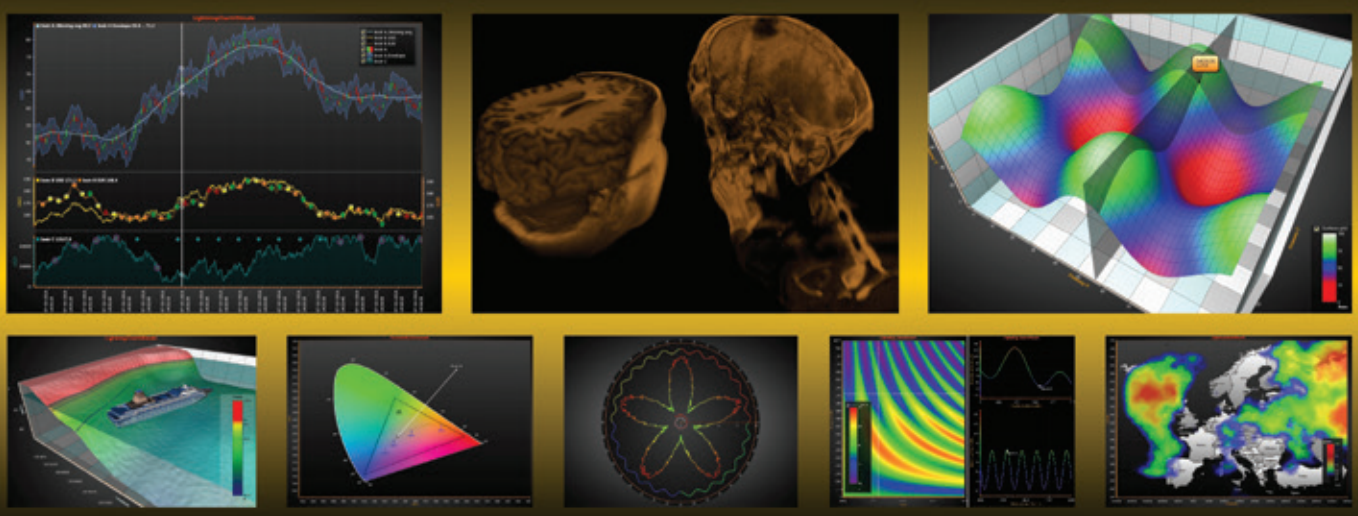

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Figure 5 **Registering the DbContext Class for Dependency Injection**

```
public void ConfigureServices(IServiceCollection services)
{
  // Add framework services
  var connection = @"Server=.\sqlexpress;Database=Cars;Trusted_Connection=True;";

  services.AddEntityFramework()
    .AddSqlServer()
    .AddDbContext<CarsContext>(options => options.UseSqlServer(
      connection));

  services.AddEntityFramework()
    .AddSqlite()
    .AddDbContext<ApplicationDbContext>(options => options.UseSqlite(
      Configuration["Data:DefaultConnection:ConnectionString"]));

  services.AddIdentity<ApplicationUser, IdentityRole>()
    .AddEntityFrameworkStores<ApplicationDbContext>()
    .AddDefaultTokenProviders();

  services.AddMvc();

  // Add application services
  services.AddTransient<IEmailSender, AuthMessageSender>();
  services.AddTransient<ISmsSender, AuthMessageSender>();
}
```

Notice that both packages must have the same version number, which will change in future releases. Save project.json. Visual Studio Code will detect a missing NuGet package and will prompt again for a package Restore. As usual, accept its offer.

Now open a command prompt over the folder that contains the ASP.NET Core project. The dnx environment provides the ef command, which lets you generate entity data models from the command line. This command offers additional commands, such as database, dbcontext and migrations. The database command lets you manage a database, dbcontext lets you scaffold a DbContext type and entities, and migrations lets you work with code migrations. You'll use the dbcontext command to generate a DbContext class and the necessary entities. You can write dnx ef to view the list of available commands (see **Figure 3**) or type a complete command directly.

When ready, write the following command line:

```
> dnx ef dbcontext scaffold "Server=.\sqlexpress;Database=Cars;Trusted_
Connection=True;" EntityFramework.MicrosoftSqlServer --outputDir Models
```

The dbcontext command takes an option called scaffold, which generates the proper DbContext and entities from the database specified in the supplied connection string. Of course, you'll need to replace the server name with yours. EntityFramework.MicrosoftSqlServer specifies the data provider that'll be used for scaffolding. Notice how you can specify an output directory for your data model via the --outputDir option, which is case-sensitive. In this case, the output directory is a folder called Models, which already exists in the project and is the proper, logical place for the DbContext class and entities. After the completion message, you'll see how the Models folder contains a class file called CarsContext.cs, which contains the CarsContext class that inherits from DbContext, and a file called Cars.cs, which defines a class called Cars

Figure 6 **Implementing an MVC Controller That Works Against Data**

```
using System.Linq;
using Microsoft.AspNet.Mvc;
using CarModels.Models;

namespace CarModels.Controllers
{
  public class CarsController : Controller
  {

    // Declares the DbContext class
    private CarsContext dataContext;

    // The instance of DbContext is passed via dependency injection
    public CarsController(CarsContext context)
    {
      this.dataContext=context;
    }

    // GET: /<controller>/
    // Return the list of cars to the caller view
    public IActionResult Index()
    {
      return View(this.dataContext.Cars.ToList());
    }

    public IActionResult Create()
    {
      return View();
    }

    // Add a new object via a POST request
    [HttpPost]
    [ValidateAntiForgeryToken]
    public IActionResult Create(Cars car)
    {
      // If the data model is in a valid state ...
      if (ModelState.IsValid)
      {
        // ... add the new object to the collection
        dataContext.Cars.Add(car);
        // Save changes and return to the Index method
        dataContext.SaveChanges();
        return RedirectToAction("Index");
      }

      return View(car);
    }


    [ActionName("Delete")]
    public IActionResult Delete(int? id)
    {
      if (id == null)
      {
        return HttpNotFound();
      }

      Cars car = dataContext.Cars.Single(m => m.id == id);
      if (car == null)
      {
        return HttpNotFound();
      }

      return View(car);
    }

    // POST: Cars/Delete/5
    // Delete an object via a POST request
    [HttpPost, ActionName("Delete")]
    [ValidateAntiForgeryToken]
    public IActionResult DeleteConfirmed(int id)
    {
      Cars car = dataContext.Cars.SingleOrDefault(m => m.id == id);
      // Remove the car from the collection and save changes
      dataContext.Cars.Remove(car);
      dataContext.SaveChanges();
      return RedirectToAction("Index");
    }

  }
}
```

and that exposes the properties that map columns from the Cars table in the database (see **Figure 4**). Notice that there's no option to control the pluralization of entity names, so this should be managed manually and is beyond the scope of this article.

At this point you must supply the connection string that the application will use to connect to the database. Instead of placing the connection string into the Web.config file, this can be done in the Startup class. This declares a method called ConfigureServices, which is invoked by the runtime to configure the necessary services via dependency injection (DI), and is the recommended place for supplying the connection string. ConfigureServices takes an argument called services, of type Microsoft.Extensions.DependencyInjection.IServiceCollection, which stores a list of services that will be injected. Consider these lines of code:

```
var connection = @"Server=.\sqlexpress;Database=Cars;Trusted_Connection=True;";

services.AddEntityFramework()
  .AddSqlServer()
  .AddDbContext<CarsContext>(options => options.UseSqlServer(connection));
```

What the second line does is register the necessary Entity Framework and SQL Server services for DI and registers the DbContext class as a service. The AddDbContext method lets you specify the connection string via the DbContextBuilder.UseSqlServer method, invoked through a delegate called options. Both lines must be placed at the very beginning of the ConfigureServices method, whose complete code is shown in **Figure 5**.

Figure 7 **Creating an Index View**

```
@model IEnumerable<CarModels.Models.Cars>

@{
  ViewBag.Title = "Cars";
}

<h2>Car models</h2>

<p>
  <a asp-controller="Cars" asp-action="Create">Add New</a>
</p>

<table class="table">
  <tr>
    <th>Car Model</th>
    <th>Brand</th>
  </tr>

  @foreach (var item in Model)
  {
    <tr>
      <td>
        @Html.DisplayFor(modelItem => item.CarModel)
      </td>
      <td>
        @Html.DisplayFor(modelItem => item.Brand)
      </td>
      <td>
        <a asp-controller="Cars" asp-action="Delete"
          asp-route-id="@item.id">Delete</a>
      </td>
    </tr>
  }
</table>
```

Figure 8 **Defining a Create View**

```
@model CarModels.Models.Cars

@{
  ViewBag.Title = "New car";
}

<h2>@ViewData["Title"]</h2>

<form asp-controller="Cars" asp-action="Create" method="post"
  class="form-horizontal" role="form">
  <div class="form-horizontal">
    <div asp-validation-summary="ValidationSummary.All" class="text-danger"></div>
    <div class="form-group">
      <label asp-for="CarModel" class="col-md-2 control-label"></label>
      <div class="col-md-10">
        <input asp-for="CarModel" class="form-control" />
        <span asp-validation-for="CarModel" class="text-danger"></span>
      </div>

      <label asp-for="Brand" class="col-md-2 control-label"></label>
      <div class="col-md-10">
        <input asp-for="Brand" class="form-control" />
        <span asp-validation-for="Brand" class="text-danger"></span>
      </div>
    </div>
    <div class="form-group">
      <div class="col-md-offset-2 col-md-10">
        <input type="submit" value="Create" class="btn btn-default" />
      </div>
    </div>
  </div>
</form>
```

ASP.NET Core supports both Web API services and MVC applications.

So far, you've implemented your data model. Now you need a way to expose actions that the UI will invoke to work against data.

Implementing MVC Controllers

ASP.NET Core supports both Web API services and MVC applications. Web API is the preferred approach if you're building a RESTful service; the current example is instead a Web application with a UI, so you'll use MVC. You can implement MVC controllers and views as you would in any ASP.NET MVC application. A controller is a class that inherits from Microsoft.AspNet.Mvc.Controller and exposes actions that the UI (or other clients) can invoke to work against data. To add a controller, in Visual Studio Code right-click the Controllers folder and select New File. When the text box appears, enter CarsController.cs as the new file name. This will add a new C# file that will also open in the code editor. What the new controller needs to implement are methods that let you query, add and delete data. The full listing for the controller is shown in **Figure 6** (with comments). Though the code might seem a bit long, IntelliSense will help you write code faster and efficiently.

In summary, you have four actions: Index, which returns the list of cars to the caller view; Create, which adds a new car via an HTTP POST request; and Delete and DeleteConfirmed, which wait for user confirmation and remove a car via an HTTP POST request, respectively. With About Index, you could also write a LINQ query to return a filtered list.

Adding and Designing MVC Views

In MVC, views are data-bound Web pages that compose the application's UI. In this example, you need three views: an Index page that

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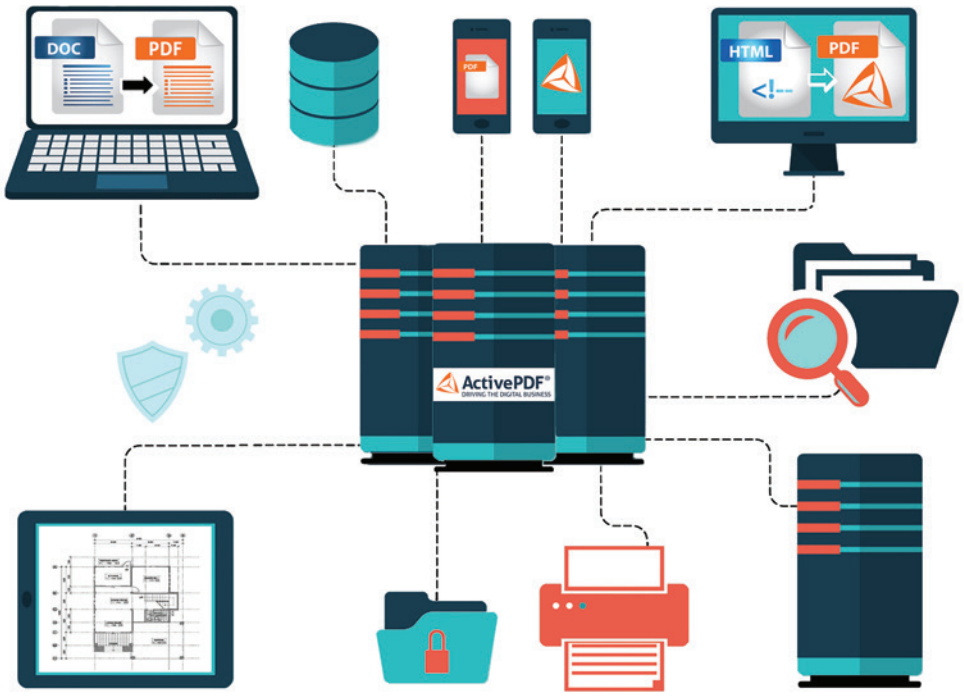

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Figure 9 **Creating a Delete View**

```
@model CarModels.Models.Cars

@{
  ViewData["Title"] = "Delete";
}

<h2>Delete</h2>

<h3>Are you sure you? The operation cannot be undone.</h3>
<div>
  <h4>Cars</h4>
  <hr />
  <dl class="dl-horizontal">
    <dt>
      @Html.DisplayNameFor(model => model.Brand)
    </dt>
    <dd>
      @Html.DisplayFor(model => model.Brand)
    </dd>
    <dt>
      @Html.DisplayNameFor(model => model.CarModel)
    </dt>
    <dd>
      @Html.DisplayFor(model => model.CarModel)
    </dd>
  </dl>

  <form asp-action="Delete">
    <div class="form-actions no-color">
      <input type="submit" value="Delete" class="btn btn-default" /> |
      <a asp-action="Index">Back to List</a>
    </div>
  </form>
</div>
```

shows the list of cars; a Create page that lets users add new cars; and a Delete page that asks confirmation before deleting a car from the database. Views must be organized into subfolders residing in the Views folder, whose name is used by the application to route Web requests. For instance, if you create a folder called Cars, all the views inside this folder will be opened through the ApplicationName/Cars routing convention. Assuming you've created a folder called Cars under Views, right-click it and select New File. Enter Index.cshtml as the file name and press Enter, so that the new file is immediately available in the code editor; based on its extension, Visual Studio Code recognizes it as a Razor file. This view is used to display the full list of items through a table; each row shows the car model, the manufacturer's name, and a hyperlink that users can click to delete an item. **Figure 7** shows the full code for the Index.cshtml page.

Notice how the markup leverages the so-called model binding to specify the .NET type for the model class and to invoke and bind its properties for each row. Also, notice how the Delete link points to the same-named action in the Cars controller, supplying the item id via model binding. Similarly, an action called Create points to the Create action in the Cars controller and opens a new view that lets you add new objects. This view is called Create, and you can create one by performing the same steps you did previously with the Index view, which means adding a Create.cshtml file into the Views\Cars subfolder. In this new view, you basically create a data form where users can write information based on the model properties, providing a button that submits information to the bound controller. **Figure 8** shows how to accomplish this.

The last step is adding a new view called Delete.cshtml into the Views\Cars subfolder. When added, type the code shown in **Figure 9**, which shows detailed information about the item that will be deleted and provides an option to submit or cancel changes.

At this point you have data model, actions and UI. This means you're ready to start to test the sample application.

Running the Application

You can run an ASP.NET Core application from Visual Studio Code directly. To accomplish this, open the Command Palette, type dnx and press Enter. Next, select dnx: Run Command and press Enter. Then click dnx web. This is the equivalent of typing dnx web in a command prompt. In future releases, you'll write dotnet run from the command line. At this point, Visual Studio Code starts Kestrel, an open source Web server for ASP.NET Core applications (bit.ly/1rdEfxV), to host your Web app. In Visual Studio Code, you'll also see a Console window where Kestrel redirects its output and any messages the runtime sends, including the stack trace in case of exceptions, which is particularly useful for debugging purposes. By default, Kestrel starts listening to port 5000, which means that you can open your favorite browser and type http://localhost:5000 to start the application. **Figure 10** shows the application running.

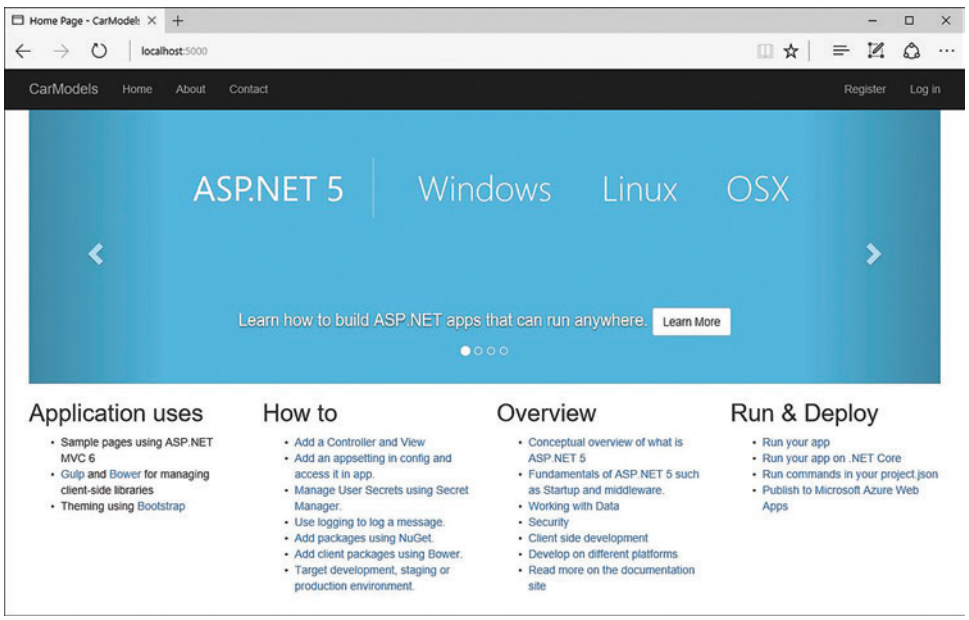
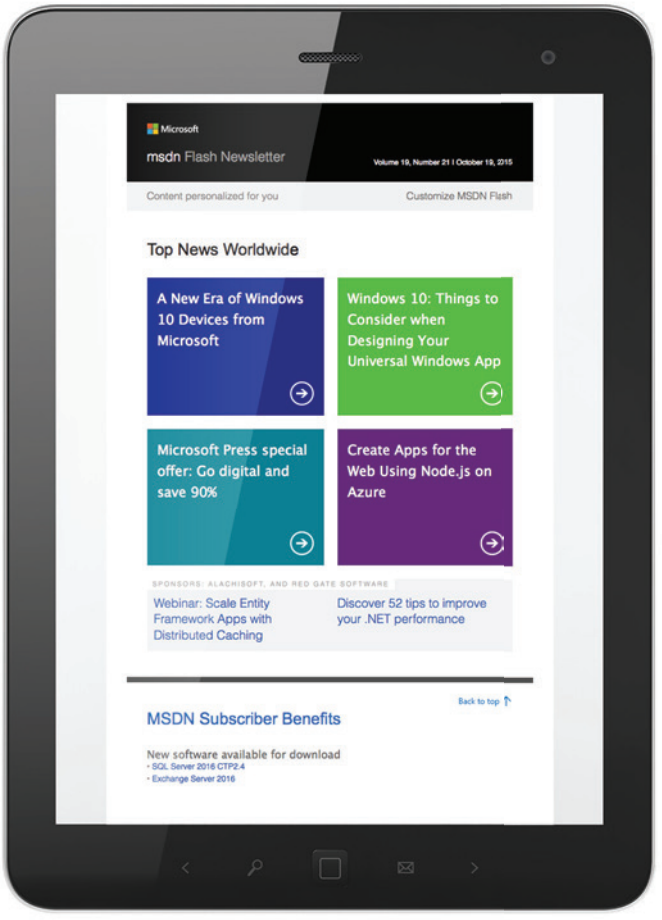


Figure 10 **The Application Running**

In the browser's Web address bar, type localhost:5000/Cars to open the default view for the Cars controller. As you can see in **Figure 11**, the application shows the list of cars, as expected.



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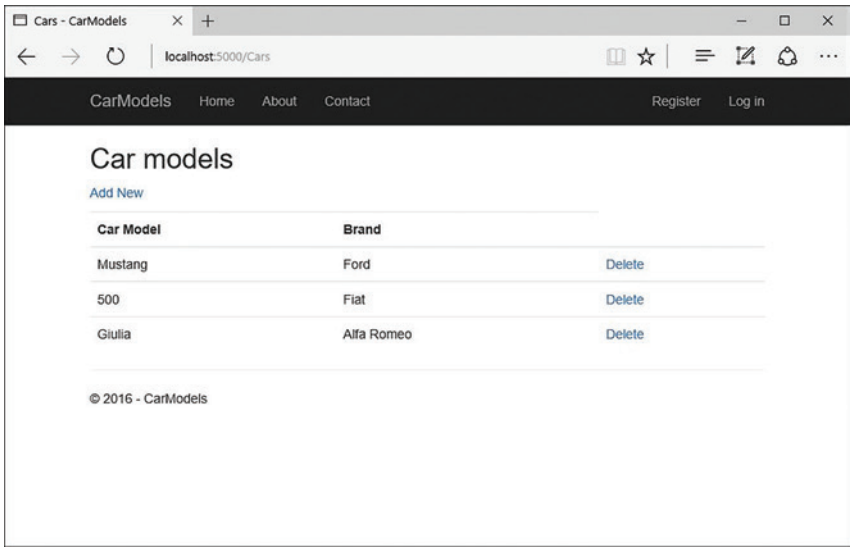

Figure 11 **Application Showing the List of Cars in the Database**

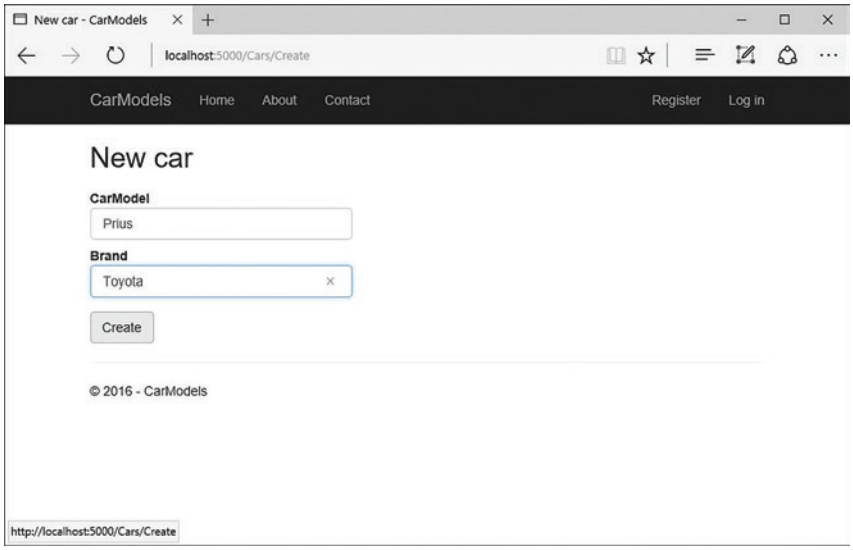

Figure 12 **Adding a New Item**

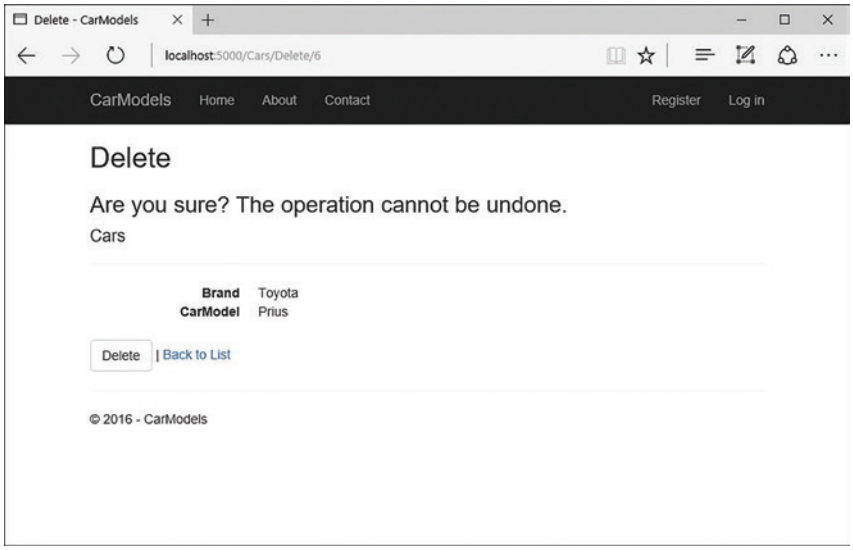

Figure 13 **Deleting an Item**

Click Add New, so that you have an option to add a new item (see **Figure 12**). When you click Create, the new item is saved into the database and the application will navigate back to the previous view, where you'll see the updated list of cars.

Now, click the Delete hyperlink near the car you added previously. The Delete view appears, showing the selected item's details and asking for the user's confirmation (see **Figure 13**). Simply click Delete to remove the item and return to the index. Remember that this is a cross-platform Web application, so it can be published to Linux, OS X and Windows.

Hints About Publishing Your Application

You have alternatives to publishing your ASP.NET Core application, including (but not limited to) Microsoft Azure and IIS. The first option involves enabling Git integration, whereas the second one currently involves the DNX Utility (dnu) and the dnu publish command line and will involve the dotnet publish command line in future releases. Publishing has been discussed on Microsoft resources. Publishing to Azure is discussed at bit.ly/22QXTh6, whereas using dnu is discussed at bit.ly/1TWvfWh.

Wrapping Up

Visual Studio Code lets you write ASP.NET Core applications by leveraging all of the evolved editing features available to C# and to the other file types in the project. Being a cross-platform itself, it's the perfect companion to start writing MVC applications for Linux, OS X and Windows. The availability of the Entity Framework to different platforms and the opportunity of reusing your existing C# and MVC skills make writing data-centric Web applications an even more amazing experience. Don't forget to check out the ASP.NET Core and .NET Core documentation for updates about the .NET Core CLI. ■

Alessandro Del Sole *has been a Microsoft MVP since 2008. Awarded MVP of the Year five times, he has authored many books, eBooks, instructional videos and articles about .NET development with Visual Studio. Del Sole works as a solution developer expert for Brain-Sys (www.brain-sys.it), focusing on .NET development, training and consulting. You can follow him on Twitter: @progalex.*

Thanks to the following Microsoft technical expert for reviewing this article: *James McCaffrey*

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ALM / DevOps	ASP.NET	Cloud Computing	Database and Analytics	JavaScript / HTML5 Client	Mobile Client	Software Practices	Visual Studio / .NET Framework	Windows Client

START TIME	END TIME	Visual Studio Live! Pre-Conference Workshops: Monday, September 26, 2016 *(Separate entry fee required)*			
7:30 AM	9:00 AM	Pre-Conference Workshop Registration - Coffee and Morning Pastries			
9:00 AM	6:00 PM	**M01** Workshop: Building for the Internet of Things: Hardware, Sensors & the Cloud - *Nick Landry*	**M02** Workshop: Developer Dive into SQL Server 2016 - *Leonard Lobel*	**M03** Workshop: Distributed Cross-Platform Application Architecture - *Rockford Lhotka & Jason Bock*	**M04** Workshop: Creating Awesome 2D & 3D Games and Experiences with Unity - *Adam Tuliper*
6:45 PM	9:00 PM	Dine-A-Round			

START TIME	END TIME	Visual Studio Live! Day 1: Tuesday, September 27, 2016			
7:00 AM	8:00 AM	Registration - Coffee and Morning Pastries			
8:00 AM	9:00 AM	Keynote: To Be Announced			
9:15 AM	10:30 AM	**T01** Angular 2 101 - *Deborah Kurata*	**T02** Developing Universal Windows Platform (UWP) Applications - *Scott Golightly*	**T03** Developer Productivity in Visual Studio 2015 - *Robert Green*	**T04** This session is sequestered, details will be released soon
10:45 AM	12:00 PM	**T05** ASP.NET MVC6—What You Need to Know - *Philip Japikse*	**T06** Building Connected and Disconnected Mobile Applications - *James Montemagno*	**T07** Professional Scrum Development Using Visual Studio 2015 - *Richard Hundhausen*	**T08** This session is sequestered, details will be released soon
12:00 PM	1:30 PM	Lunch - Visit Exhibitors			
1:30 PM	2:45 PM	**T09** Angular 2 Forms and Validation - *Deborah Kurata*	**T10** New SQL Server 2016 Security Features for Developers - *Leonard Lobel*	**T11** Use Visual Studio to Scale Agile in Your Enterprise - *Richard Hundhausen*	**T12** Windows for Makers: Raspberry Pi, Arduino & IoT - *Nick Landry*
3:00 PM	4:15 PM	**T13** Introduction to ASP.NET Core 1.0 - *Scott Golightly*	**T14** Cross-platform Mobile Development for the C# Developer - *James Montemagno*	**T15** This session is sequestered, details will be released soon	**T16** Cloud Enable .NET Client LOB Applications - *Robert Green*
4:15 PM	5:30 PM	Welcome Reception			

START TIME	END TIME	Visual Studio Live! Day 2: Wednesday, September 28, 2016			
7:00 AM	8:00 AM	Registration - Coffee and Morning Pastries			
8:00 AM	9:15 AM	**W01** JavaScript Patterns for the C# Developer - *Ben Hoelting*	**W02** Implementing the MvvM Pattern in Your Xamarin Apps - *Kevin Ford*	**W03** VSTS and Azure: Cloud DevOps 101 - *Mike Benkovich*	**W04** Introduction to Next Generation of Azure PaaS—Service Fabric and Containers - *Vishwas Lele*
9:30 AM	10:45 AM	**W05** Busy Developer's Guide to TypeScript - *Ted Neward*	**W06** This session is sequestered, details will be released soon	**W07** User Story Mapping - *Philip Japikse*	**W08** Cloud Oriented Programming - *Vishwas Lele*
11:00 AM	12:00 PM	**GENERAL SESSION: FAST, EASY, AND FUN—MOBILE DEVELOPMENT FOR EVERYONE WITH XAMARIN** - *James Montemagno, Developer Evangelist, Xamarin Team, Microsoft*			
12:00 PM	1:30 PM	Birds-of-a-Feather Lunch - Visit Exhibitors			
1:30 PM	2:45 PM	**W09** Getting Started with ASP.NET Core 1 Web API and Entity Framework Core 1 - *Philip Japikse*	**W10** Using Visual Studio Tools for Apache Cordova to Create MultiPlatform Applications - *Kevin Ford*	**W11** Exploring C# 7 New Features - *Adam Tuliper*	**W12** Lock the Doors, Secure the Valuables, and Set the Alarm - *Eric D. Boyd*
3:00 PM	4:15 PM	**W13** Angular 2 and ASP.NET Core—A Perfect Match! - *Dan Wahlin*	**W14** Busy .NET Developer's Guide to Swift - *Ted Neward*	**W15** I'm Emotional - Using Microsoft Cognitive Services to Understand the World Around You - *Adam Tuliper*	**W16** App Services: The New PaaS - *Mike Benkovich*
4:30 PM	5:45 PM	**W17** Increase Website Performance and Search with Lucene.Net Indexing - *Ben Hoelting*	**W18** Reusing Business Logic in Cross-Platform .NET - *Rockford Lhotka*	**W19** Database Development with SQL Server Data Tools - *Leonard Lobel*	**W20** Breaking Down Walls with Modern Identity - *Eric D. Boyd*
7:00 PM	9:00 PM	Evening Event			

START TIME	END TIME	Visual Studio Live! Day 3: Thursday, September 29, 2016			
7:00 AM	8:00 AM	Registration - Coffee and Morning Pastries			
8:00 AM	9:15 AM	**TH01** Building Data-Centric Apps with Angular 2 and Breeze - *Brian Noyes*	**TH02** Building Business Apps on the Universal Windows Platform - *Billy Hollis*	**TH03** Using Your SQL Skills to Become a Big Data Developer - *Omid Afnan*	**TH04** Docker: Creating the Ultimate Development Environment - *Dan Wahlin*
9:30 AM	10:45 AM	**TH05** Getting Started with Aurelia - *Brian Noyes*	**TH06** HoloLens - *Billy Hollis*	**TH07** Data Anlytics with Azure Data Lake: U-SQL In Depth - *Omid Afnan*	**H08** DevOps for Developers - *Brian Randell*
11:00 AM	12:15 PM	**TH09** Pretty, Yet Powerful. How Data Visualization Transforms the Way We Comprehend Information - *Walt Ritscher*	**TH10** Dependencies Demystified - *Jason Bock*	**TH11** Predicting the Future Using Azure Machine Learning - *Eric D. Boyd*	**TH12** PowerShell for Developers - *Brian Randell*
12:15 PM	1:30 PM	Lunch			
1:30 PM	2:45 PM	**TH13** Building Rich UI with ASP.NET MVC and Bootstrap - *Walt Ritscher*	**TH14** What's the Problem?!?: How to Resolve Conflict - *Robert Bogue*	**TH15** Exploratory Data Analysis with R Tools for Visual Studio - *Matthew Renze*	**TH16** Developing Awesome 3D Apps with Unity and C# - *Adam Tuliper*
3:00 PM	4:15 PM	**TH17** Assembling the Web - A Tour of WebAssembly - *Jason Bock*	**TH18** Hack Proof: Software Design for a Hostile Internet - *Robert Bogue*	**TH19** Data Visualization with R Tools for Visual Studio - *Matthew Renze*	**TH20** Technical Debt - Fight It with Science and Rigor - *Brian Randell*

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START TIME	END TIME	Visual Studio Live! Pre-Conference Workshops: Monday, October 3, 2016 *(Separate entry fee required)*			
7:30 AM	9:00 AM	Pre-Conference Workshop Registration • Coffee and Morning Pastries			
9:00 AM	6:00 PM	**M01** Workshop: DevOps in a Day *- Brian Randell*	**M02** Workshop: SQL Server for Developers *- Andrew Brust and Leonard Lobel*	**M03** Workshop: Distributed Cross-Platform Application Architecture *- Rockford Lhotka & Jason Bock*	
6:45 PM	9:00 PM	Dine-A-Round			

START TIME	END TIME	Visual Studio Live! Day 1: Tuesday, October 4, 2016			
7:00 AM	8:00 AM	Registration - Coffee and Morning Pastries			
8:00 AM	9:00 AM	Keynote: To Be Announced			
9:15 AM	10:30 AM	**T01** AngularJS2 in 75 Minutes *- Sahil Malik*	**T02** This session is sequestered, details will be released soon	**T03** Developer Productivity in Visual Studio 2015 *- Robert Green*	**T04** Cloud Oriented Programming *- Vishwas Lele*
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4:15 PM	5:30 PM	Welcome Reception			

START TIME	END TIME	Visual Studio Live! Day 2: Wednesday, October 5, 2016			
7:00 AM	8:00 AM	Registration - Coffee and Morning Pastries			
8:00 AM	9:15 AM	**W01** JavaScript Patterns for the C# Developer *- Ben Hoelting*	**W02** Implementing the MvvM Pattern in Your Xamarin Apps *- Kevin Ford*	**W03** Developing Awesome 3D Apps with Unity and C# *- Adam Tuliper*	**W04** Introduction to Next Generation of Azure PaaS—Service Fabric and Containers *- Vishwas Lele*
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4:30 PM	5:45 PM	**W17** Increase Website Performance and Search with Lucene.Net Indexing *- Ben Hoelting*	**W18** Reusing Business Logic in Cross-Platform .NET *- Rockford Lhotka*	**W19** Implementing Data Protection and Security in SQL Server 2016 *- Steve Jones*	**W20** Build Real-Time Websites and Apps with SignalR and Azure *- Rachel Appel*
6:45 PM	10:30 PM	Visual Studio Live! Monuments by Moonlight Tour			

START TIME	END TIME	Visual Studio Live! Day 3: Thursday, October 6, 2016			
7:00 AM	8:00 AM	Registration - Coffee and Morning Pastries			
8:00 AM	9:15 AM	**TH01** Building Data-Centric Apps with Angular 2 and Breeze *- Brian Noyes*	**TH02** Moving from WPF to Windows 10 and Universal Apps *- Billy Hollis*	**TH03** Test Drive Automated GUI Testing with WebDriver *- Rachel Appel*	**TH04** Big Data and Hadoop with Azure HDInsight *- Andrew Brust*
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Real-World ASP.NET Core MVC Filters

Steve Smith

Filters are a great, often underutilized feature of ASP.NET MVC and ASP.NET Core MVC. They provide a way to hook into the MVC action invocation pipeline, which makes them great for pulling common repetitive tasks out of your actions. Often, an app will have a standard policy that it applies to how it handles certain conditions, especially those that might generate particular HTTP status codes. Or it might perform error handling or application-level logging in a specific fashion, in every action. These kinds of policies represent cross-cutting concerns, and if possible, you want to follow the Don't Repeat Yourself (DRY) principle and pull them out into a common abstraction. Then, you can apply this abstraction globally or wherever appropriate within your application. Filters provide a great way to achieve this.

What About Middleware?

In the June 2016 issue, I described how ASP.NET Core middleware allows you to control the request pipeline in your apps (msdn.magazine.com/mt707525). That sounds suspiciously like what filters can do in your ASP.NET Core MVC app. The difference between the two is context. ASP.NET Core MVC is implemented via middleware. (MVC itself isn't middleware, but it configures itself to be the default destination for the routing middleware). ASP.NET Core MVC includes many features like Model Binding, Content Negotiation, and Response Formatting. Filters exist within the context of MVC, so they have access to these MVC-level features and abstractions. Middleware, in contrast, exists at a lower level and doesn't have any direct knowledge of MVC or its features.

If you have functionality you want to run at a lower level, and it doesn't depend on MVC-level context, consider using middleware. If you tend to have a lot of common logic in your controller actions, filters might provide a way for you to DRY them up to make them easier to maintain and test.

This article discusses:

- Kinds of filters
- Filter scoping
- A sample MVC Controller, with and without filters
- Testing your filters

Technologies discussed:

ASP.NET Core MVC

Code download available at:

bit.ly/1sJruw6

Kinds of Filters

Once the MVC middleware takes over, it calls into a variety of filters at different points within its action invocation pipeline.

The first filters that execute are authorization filters. If the request isn't authorized, the filter short-circuits the rest of the pipeline immediately.

Next in line are resource filters, which (after authorization) are both the first and last filter to handle a request. Resource filters can run code at the very beginning of a request, as well as at the very end, just before it leaves the MVC pipeline. One good use case for a resource filter is output caching. The filter can check the cache and return the cached result at the beginning of the pipeline. If the cache isn't yet populated, the filter can add the response from the action to the cache at the end of the pipeline.

Action filters run just before and after actions are executed. They run after model binding takes place, so they have access to the model-bound parameters that will be sent to the action, as well as the model validation status.

Actions return results. Result filters run just before and after results are executed. They can add behavior to view or formatter execution.

Finally, exception filters are used to handle uncaught exceptions and apply global policies to these exceptions within the app.

In this article, I'll focus on action filters.

Filter Scoping

Filters can be applied globally, or at the individual controller or action level. Filters that are implemented as attributes can typically be added at any level, with global filters affecting all actions, controller attribute filters affecting all actions within that controller, and action attribute filters applying to just that action. When

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DevExpress®

Be Remarkable: Your Talent, Our Tools

Q&A with Julian Bucknall, Chief Technical Officer, DevExpress

Q How does DevExpress help developers be remarkable?
A DevExpress has been assisting developers for over 15 years to create stunning applications for their customers. Whether building dashboard applications for better data clarity, creating cross-platform solutions for Windows, Web and Mobile, or leveraging existing knowledge to deliver touch-enabled solutions, developers have everything they need to build their best without limits or compromise.

Q What type of products does DevExpress offer?
A The product range that DevExpress offers spans presentation controls, enterprise-ready reporting systems, IDE productivity tools, and data analysis and visualization libraries for Visual Studio. The technologies aim to help build the best by increasing productivity, getting greater clarity from complex software, and creating rich, highly-visual applications for Windows, Web, and Mobile.

Q What technologies and platforms are the primary focus for DevExpress?
A DevExpress can be trusted to continue to support older platforms, like WinForms or ASP.NET WebForms. We pride ourselves in letting our customers leverage existing knowledge in older platforms to create modern, touch-enabled, applications. Just as important to us are the new technologies; like WPF and HTML5, we always strive for feature parity between all our product lines. For example, our new controls—Diagram and TreeMap—have been released for multiple platforms. There is so much available for all of our platforms, we encourage devs to download the trial to see for themselves!

Q For Web Technologies and Open Source, what is DevExpress doing in those areas?
A Wow! Now that is a big topic! I can only touch briefly on what we are doing in each. DevExpress continues to create and improve for ASP.NET WebForms and MVC and our support for the new ASP.NET Core is up on GitHub. Additionally, we have open-sourced our support for Bootstrap and Angular2 with our DevExtreme product.

multiple filters apply to an action, their order is determined first by an Order property and second by how they're scoped to the action in question. Filters with the same Order run outside-in, meaning first global, then controller and then action-level filters are run. After the action runs, the order is reversed, so the action-level filter runs, then the controller-level filter, then the global filter.

Filters that aren't implemented as attributes can still be applied to controllers or actions by using the TypeFilterAttribute type. This attribute accepts the type of the filter to run as a constructor parameter. For example, to apply the CustomActionFilter to a single action method, you'd write:

```
[TypeFilter(typeof(CustomActionFilter))]
public IActionResult SomeAction()
{
  return View();
}
```

The TypeFilterAttribute works with the app's built-in services container to ensure any dependencies exposed by the CustomActionFilter are populated at run time.

A DRY API

To demonstrate a few examples where filters can improve the design of an ASP.NET MVC Core app, I've built a simple API that provides basic create, read, update, delete (CRUD) functionality and follows a few standard rules for handling invalid requests. Because securing APIs is its own topic, I'm intentionally leaving that outside the scope of this sample.

My sample app exposes an API for managing authors, which are simple types with just a couple of properties. The API uses the standard HTTP verb-based conventions to get all authors, get one author by ID, create a new author, edit an author and delete an author. It accepts an IAuthorRepository through dependency injection (DI) to abstract the data access. (See my May article at msdn.com/magazine/mt703433 for more on DI.) Both the controller implementation and the repository are implemented asynchronously.

The API follows two policies:

1. API requests that specify a particular author ID will get a 404 response if that ID doesn't exist.
2. API requests that provide an invalid Author model instance (ModelState.IsValid == false) will return a BadRequest with the model errors listed.

Figure 1 shows the implementation of this API with these rules in place.

As you can see, there's a fair bit of duplicate logic in this code, especially in the way NotFound and BadRequest results are

Figure 1 **AuthorsController**

```
[Route("api/[controller]")]
public class AuthorsController : Controller
{
  private readonly IAuthorRepository _authorRepository;

  public AuthorsController(IAuthorRepository authorRepository)
  {
    _authorRepository = authorRepository;
  }

  // GET: api/authors
  [HttpGet]
  public async Task<List<Author>> Get()
  {
    return await _authorRepository.ListAsync();
  }

  // GET api/authors/5
  [HttpGet("{id}")]
  public async Task<IActionResult> Get(int id)
  {
    if ((await _authorRepository.ListAsync()).All(a => a.Id != id))
    {
      return NotFound(id);
    }
    return Ok(await _authorRepository.GetByIdAsync(id));
  }

  // POST api/authors
  [HttpPost]
  public async Task<IActionResult> Post([FromBody]Author author)
  {
    if (!ModelState.IsValid)
    {
      return BadRequest(ModelState);
    }
    await _authorRepository.AddAsync(author);
    return Ok(author);
  }

  // PUT api/authors/5
  [HttpPut("{id}")]
  public async Task<IActionResult> Put(int id, [FromBody]Author author)
  {
    if ((await _authorRepository.ListAsync()).All(a => a.Id != id))
    {
      return NotFound(id);
    }
    if (!ModelState.IsValid)
    {
      return BadRequest(ModelState);
    }
    author.Id = id;
    await _authorRepository.UpdateAsync(author);
    return Ok();
  }

  // DELETE api/values/5
  [HttpDelete("{id}")]
  public async Task<IActionResult> Delete(int id)
  {
    if ((await _authorRepository.ListAsync()).All(a => a.Id != id))
    {
      return NotFound(id);
    }
    await _authorRepository.DeleteAsync(id);
    return Ok();
  }

  // GET: api/authors/populate
  [HttpGet("Populate")]
  public async Task<IActionResult> Populate()
  {
    if (!(await _authorRepository.ListAsync()).Any())
    {
      await _authorRepository.AddAsync(new Author()
      {
        Id = 1,
        FullName = "Steve Smith",
        TwitterAlias = "ardalis"
      });
      await _authorRepository.AddAsync(new Author()
      {
        Id = 2,
        FullName = "Neil Gaiman",
        TwitterAlias = "neilhimself"
      });
    }
    return Ok();
  }
}
```

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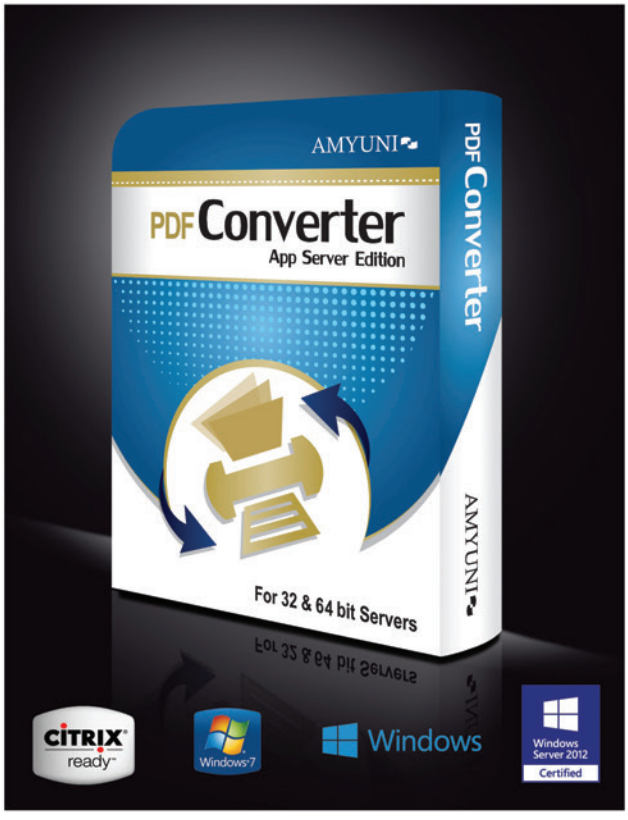

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Figure 2 **ValidateAuthorExistsAttribute**

```
public class ValidateAuthorExistsAttribute : TypeFilterAttribute
{
  public ValidateAuthorExistsAttribute():base(typeof
    (ValidateAuthorExistsFilterImpl))
  {
  }

  private class ValidateAuthorExistsFilterImpl : IAsyncActionFilter
  {
    private readonly IAuthorRepository _authorRepository;

    public ValidateAuthorExistsFilterImpl(IAuthorRepository authorRepository)
    {
      _authorRepository = authorRepository;
    }

    public async Task OnActionExecutionAsync(ActionExecutingContext context,
      ActionExecutionDelegate next)
    {
      if (context.ActionArguments.ContainsKey("id"))
      {
        var id = context.ActionArguments["id"] as int?;
        if (id.HasValue)
        {
          if ((await _authorRepository.ListAsync()).All(a => a.Id != id.Value))
          {
            context.Result = new NotFoundObjectResult(id.Value);
            return;
          }
        }
      }
      await next();
    }
  }
}
```

returned. I can quickly replace the model validation/BadRequest checks with a simple action filter:

```
public class ValidateModelAttribute : ActionFilterAttribute
{
  public override void OnActionExecuting(ActionExecutingContext context)
    {
    if (!context.ModelState.IsValid)
    {
      context.Result = new BadRequestObjectResult(context.ModelState);
    }
  }
}
```

This attribute can then be applied to those actions that need to perform model validation by adding [ValidateModel] to the action method. Note that setting the Result property on the ActionExecutingContext will short-circuit the request. In this case, there's no reason not to apply the attribute to every action, so I'll add it to the controller rather than to every action.

Checking to see if the author exists is a bit trickier, because this relies on the IAuthorRepository that's passed into the controller through DI. It's simple enough to create an action filter attribute that takes a constructor parameter, but, unfortunately, attributes expect these parameters to be supplied where they're declared. I can't provide the repository instance where the attribute is applied; I want it to be injected at run time by the services container.

Fortunately, the TypeFilter attribute will provide the DI support this filter requires. I can simply apply the TypeFilter attribute to the actions, and specify the ValidateAuthorExistsFilter type:

```
[TypeFilter(typeof(ValidateAuthorExistsFilter))]
```

While this works, it's not my preferred approach, because it's less readable and developers looking to apply one of several common attribute filters will not find the ValidateAuthorExistsAttribute through IntelliSense. An approach I favor is to subclass the TypeFilterAttribute, give it an appropriate name, and put the filter implementation in a private class inside of this attribute. **Figure 2** demonstrates this approach. The actual work is performed by the private ValidateAuthorExistsFilterImpl class, whose type is passed into the TypeFilterAttribute's constructor.

Note that the attribute has access to the arguments being passed to the action, as part of the ActionExecutingContext parameter. This allows the filter to check whether an id parameter is present and get its value before checking to see if an Author exists with that Id. You should also notice that the private ValidateAuthorExistsFilterImpl is an async filter. With this pattern, there's just one method to implement, and work can be done before or after the action is executed by running it before or after the call to next. However, if you're short-circuiting the filter by setting a context.Result, you need to return without calling next (otherwise you'll get an exception).

Another thing to remember about filters is that they shouldn't include any object-level state, such as a field on an IActionFilter (in particular one implemented as an attribute) that's set during OnActionExecuting and then read or modified in OnActionExecuted. If you find the need

Figure 3 **Authors2Controller**

```
[Route("api/[controller]")]
[ValidateModel]
public class Authors2Controller : Controller
{
  private readonly IAuthorRepository _authorRepository;

  public Authors2Controller(IAuthorRepository authorRepository)
  {
    _authorRepository = authorRepository;
  }

  // GET: api/authors2
  [HttpGet]
  public async Task<List<Author>> Get()
  {
    return await _authorRepository.ListAsync();
  }

  // GET api/authors2/5
  [HttpGet("{id}")]
  [ValidateAuthorExists]
  public async Task<IActionResult> Get(int id)
  {
    return Ok(await _authorRepository.GetByIdAsync(id));
  }

  // POST api/authors2
  [HttpPost]
  public async Task<IActionResult> Post([FromBody]Author author)
  {
    await _authorRepository.AddAsync(author);
    return Ok(author);
  }

  // PUT api/authors2/5
  [HttpPut("{id}")]
  [ValidateAuthorExists]
  public async Task<IActionResult> Put(int id, [FromBody]Author author)
  {
    await _authorRepository.UpdateAsync(author);
    return Ok();
  }

  // DELETE api/authors2/5
  [HttpDelete("{id}")]
  [ValidateAuthorExists]
  public async Task<IActionResult> Delete(int id)
  {
    await _authorRepository.DeleteAsync(id);
    return Ok();
  }
}
```

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Conclusion

If you are a software developer working on a mobile app, you simply cannot overlook LEADTOOLS. Its award-winning imaging technology will go a long way in enhancing the quality and boosting the development speed of your image-enabled mobile apps.

to do this sort of logic, you can avoid that kind of state by switching to an IAsyncActionFilter, which can simply use local variables within the OnActionExecutionAsync method.

After shifting model validation and checking for the existence of records from within the controller actions to common filters, what has been the effect on my controller? For comparison, **Figure 3** shows Authors2Controller, which performs the same logic as AuthorsController, but leverages these two filters for its common policy behavior.

Notice two things about this refactored controller. First, it's shorter and clearer. Second, there are no conditionals in any of the methods. The common logic of the API has been completely pulled into filters, which are applied where appropriate, so that the work of the controller is as straightforward as possible.

But Can You Test It?

Moving logic from your controller into attributes is great for reducing code complexity and enforcing consistent runtime behavior. Unfortunately, if you run unit tests directly against your action methods, your tests aren't going to have the attribute or filter behavior applied to them. This is by design, and of course you can unit test your filters independent of individual action methods to ensure they work as designed. But what if you need to ensure not only that your filters work, but that they're properly set up and applied to individual action methods? What if you want to refactor some API code you already have to take advantage of the filters I just showed, and you want to be sure the API still behaves correctly when you're finished? That calls for integration testing. Fortunately, ASP.NET Core includes some great support for fast, easy integration testing.

Figure 4 **Authors Put Tests**

```
[Theory]
[InlineData("authors")]
[InlineData("authors2")]
public async Task ReturnsNotFoundForId0(string controllerName)
{
  var authorToPost = new Author() { Id = 0, FullName = "test",
    TwitterAlias = "test" };
  var jsonContent = new StringContent(JsonConvert.SerializeObject(authorToPost),
    Encoding.UTF8, "application/json");
  var response = await _client.PutAsync($"/api/{controllerName}/0", jsonContent);

  Assert.Equal(HttpStatusCode.NotFound, response.StatusCode);
  var stringResponse = await response.Content.ReadAsStringAsync();

  Assert.Equal("0", stringResponse);
}

[Theory]
[InlineData("authors")]
[InlineData("authors2")]
public async Task ReturnsBadRequestGivenNoAuthorName(string controllerName)
{
  var authorToPost = new Author() {Id=1, FullName = "", TwitterAlias = "test"};
  var jsonContent = new StringContent(
    JsonConvert.SerializeObject(authorToPost),
    Encoding.UTF8, "application/json");
  var response = await _client.PutAsync($"/api/{controllerName}/1", jsonContent);

  Assert.Equal(HttpStatusCode.BadRequest, response.StatusCode);

  var stringResponse = await response.Content.ReadAsStringAsync();
  Assert.Contains("FullName", stringResponse);
  Assert.Contains("The FullName field is required.", stringResponse);
}

[Theory]
[InlineData("authors")]
[InlineData("authors2")]
public async Task ReturnsOkGivenValidAuthorData(string controllerName)
{
  var authorToPost = new Author() { Id=1,FullName = "John Doe",
    TwitterAlias = "johndoe" };
  var jsonContent = new StringContent(JsonConvert.SerializeObject(authorToPost),
    Encoding.UTF8, "application/json");
  var response = await _client.PutAsync($"/api/{controllerName}/1", jsonContent);
  response.EnsureSuccessStatusCode();
}
```

My sample application is configured to use an in-memory Entity Framework Core DbContext, but even if it were using SQL Server, I could easily switch to using an in-memory store for my integration tests. This is important, because it dramatically improves the speed of such tests, and makes it much easier to set them up, because no infrastructure is required.

The class that does most of the heavy lifting for integration testing in ASP.NET Core is the TestServer class, available in the Microsoft.AspNetCore.TestHost package. You configure the TestServer identically to how you configure your Web app in the Program.cs entry point, using a WebHostBuilder. In my tests, I'm choosing to use the same Startup class as in my sample Web app, and I'm specifying that it runs in the Testing environment. This will trigger some sample data when the site starts up:

```
var builder = new WebHostBuilder()
  .UseStartup<Startup>()
  .UseEnvironment("Testing");
var server = new TestServer(builder);
var client = server.CreateClient();
```

The client in this case is a standard System.Net.Http.HttpClient, which you use to make requests to the server just as if it were over the network. But because all of the requests are made in memory, the tests are extremely fast and robust.

For my tests, I'm using xUnit, which includes the ability to run multiple tests with different data sets for a given test method. To confirm that my AuthorsController and Authors2Controller classes both behave identically, I'm using this feature to specify both controllers to each test. **Figure 4** shows several tests of the Put method.

Notice that these integration tests don't require a database or an Internet connection or a running Web server. They're almost as fast and simple as unit tests, but, most important, they allow you to test your ASP.NET apps through the entire request pipeline, not just as an isolated method within a controller class. I still recommend writing unit tests where you can, and falling back to integration tests for behavior you can't unit test, but it's great to have such a high-performance way to run integration tests in ASP.NET Core.

Next Steps

Filters are a big topic—I only had room for a couple of examples in this article. You can check out the official documentation on docs.asp.net to learn more about filters and testing ASP.NET Core apps.

The source code for this sample is available at bit.ly/1sJruw6. ■

Steve Smith *is an independent trainer, mentor and consultant, as well as an ASP.NET MVP. He has contributed dozens of articles to the official ASP.NET Core documentation (docs.asp.net), and helps teams quickly get up to speed with ASP.NET Core. Contact him at ardalis.com and follow him on Twitter: aka @ardalis.*

Thanks to the following Microsoft technical expert for reviewing this article: *Doug Bunting*

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JAMES MCCAFFREY

Lightweight Random Number Generation

Random numbers are used in many machine learning algorithms. For example, a common task is to select a random row of a matrix. In C# the code might resemble:

```
double[][] matrix = new double[20][];  // 20 rows
matrix = LoadData("C:\\Somewhere\\SomeFile.txt");
int lo = 0;
int hi = 20;
Random rnd = new Random(0);  // Create generator, seed = 0
x = rnd.NextDouble();  // [0.0, 1.0)
int randomRow = (int)((hi - lo) * x + lo);  // [0, 19]
// Do something with randomRow
```

In this article I'll show you how to generate random numbers using four different algorithms: the Lehmer algorithm, the linear congruential algorithm, the Wichmann-Hill algorithm and the lagged Fibonacci algorithm.

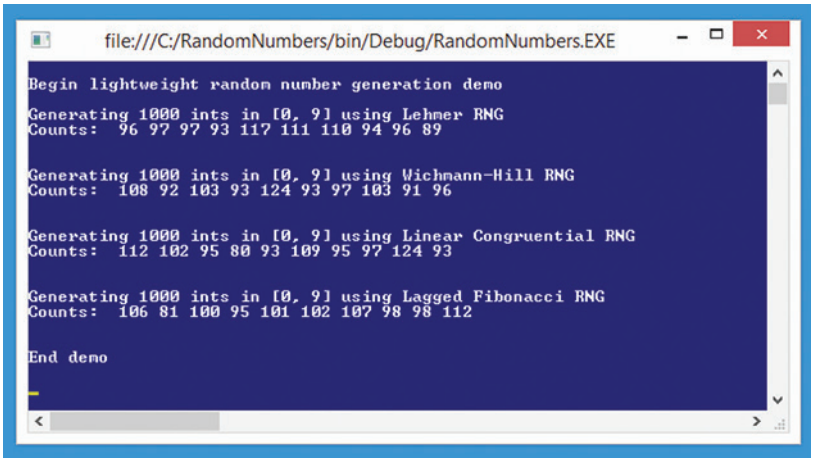

Figure 1 **Lightweight Random Number Generation Demo**

But why go to the trouble of creating your own random number generator (RNG) when the Microsoft .NET Framework already has an effective and easy-to-use Random class? There are two scenarios where you might want to create your own RNG. First, because different programming languages have different built-in random number generation algorithms, if you're writing code you want to port to multiple languages, you can write your own RNG so you can implement it across different languages. Second, some languages, notably R, have only a global RNG, so if you want to create multiple generators you must write your own RNG.

A good way to see where this article is headed is to take a look at the demo program in **Figure 1**. The demo program begins by creating a very simple RNG using the Lehmer algorithm. Then the RNG is used to generate 1,000 random integers between 0 and 9 inclusive. Behind the scenes, the count of each generated integer is recorded, then the demo displays the counts. This process is repeated for the linear congruential algorithm, the Wichmann-Hill algorithm and the lagged Fibonacci algorithm.

This article assumes you have at least intermediate programming skills, but doesn't assume you know anything about random number generation. The demo code is written in C#, but because one of the main scenarios to use custom random number generation is when writing portable code, the demo code is designed to be easily translatable to other languages.

Code download available at msdn.com/magazine/0816magcode.

The Lehmer Algorithm

The simplest reasonable random number generation technique is the Lehmer algorithm. (I use the term "random number generation" rather than the more accurate "pseudo-random number generation" for simplicity.) Expressed symbolically, the Lehmer algorithm is:

```
X(i) = a * X(i-1) mod m
```

In words, "the new random number is the old random number times a constant a, modulo a constant m." For example, suppose at some point the current random number is 104, and a = 3, and m = 100. Then the new random number would be 3 * 104 mod 100 = 312 mod 100 = 12. Simple, but there are many tricky implementation details.

To create the demo program, I launched Visual Studio and created a new C# console application project named RandomNumbers. The demo program has no significant .NET dependencies so any version of Visual Studio will work.

After the template code loaded, in the Solution Explorer window I right-clicked on file Program.cs and renamed it to the more descriptive RandomNumbersProgram.cs and Visual Studio then automatically renamed class Program for me. At the top of the code in the editor window I deleted all the using statements except for the ones referencing the top-level System and the Collections.Generic namespaces.

Next, I added a class named LehmerRng to implement the Lehmer RNG algorithm. The code is shown in **Figure 2**. The 1988 version of the Lehmer algorithm uses a = 16807 and m = 2147483647 (which is int.MaxValue). A later, 1993 version of Lehmer suggests a = 48271 as a slightly superior alternative. These values come from math theory. The

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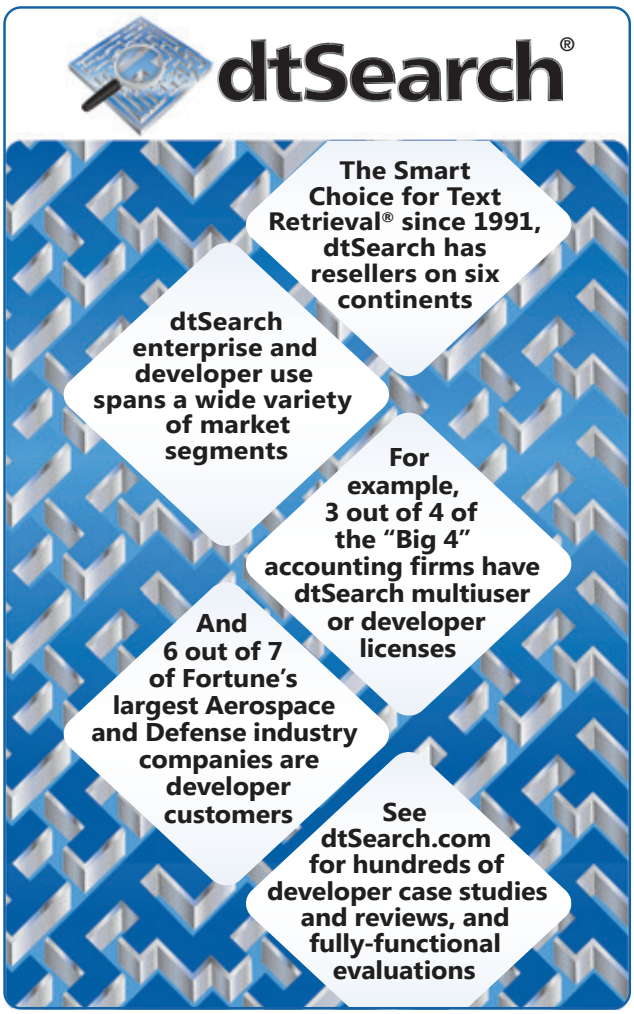

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Figure 2 **The Lehmer Algorithm Implementation**

```
public class LehmerRng
{
  private const int a = 16807;
  private const int m = 2147483647;
  private const int q = 127773;
  private const int r = 2836;
  private int seed;

  public LehmerRng(int seed)
  {
    if (seed <= 0 || seed == int.MaxValue)
      throw new Exception("Bad seed");
    this.seed = seed;
  }

  public double Next()
  {
    int hi = seed / q;
    int lo = seed % q;
    seed = (a * lo) - (r * hi);
    if (seed <= 0)
      seed = seed + m;
    return (seed * 1.0) / m;
  }
}
```

demo code is based on the famous paper, "Random Number Generators: Good Ones Are Hard to Find," by S. K. Park and K. W. Miller.

An implementation problem is avoiding arithmetic overflow. The Lehmer algorithm uses a clever algebra trick. The value of q is m / a (integer division) and the value of r is m % a (m modulo a).

When initializing the Lehmer RNG with a seed value, you can use any integer in the range [1, int.MaxValue - 1]. Many RNGs have a no-parameter constructor that grabs the system date-time and converts it to an integer and uses that as the seed.

The Lehmer RNG is called in the Main method of the demo program, like so:

```
int hi = 10;
int lo = 0;
int[] counts = new int[10];
LehmerRng lehmer = new LehmerRng(1);
for (int i = 0; i < 1000; ++i) {
  double x = lehmer.Next();
  int ri = (int)((hi - lo) * x + lo); // 0 to 9
  ++counts[ri];
}
```

Each call to the Next method returns a value in [0.0, 1.0)—greater than or equal to 0.0 and strictly less than 1.0. The pattern (int)(hi - lo) * Next + lo) will return an integer in the range [lo, hi-1].

The Lehmer algorithm is reasonably effective and is my usual technique of choice for simple scenarios. However, note that none of the algorithms presented in this article are cryptographically secure and they should be used only in situations where statistical rigor isn't required.

The Wichmann-Hill Algorithm

The Wichmann-Hill algorithm dates from 1982. The idea of Wichmann-Hill is to generate three preliminary results and then combine those results into a single, final result. The code that implements Wichmann-Hill is presented in **Figure 3**. The demo code is based on the paper, "Algorithm AS 183: An Efficient and Portable Pseudo-Random Number Generator," by B. A. Wichmann and I. D. Hill.

Because the Wichmann-Hill algorithm uses three different generating equations, it requires three seed values. The three m values

Figure 3 **Wichmann-Hill Algorithm Implementation**

```
public class WichmannRng
{
  private int s1, s2, s3;

  public WichmannRng(int seed)
  {
    if (seed <= 0 || seed > 30000)
      throw new Exception("Bad seed");
    s3 = seed;
    s2 = s3 / 2;
    s1 = s2 / 2;
  }

  public double Next()
  {
    s1 = 171 * (s1 % 177) - 2 * (s1 / 177);
    if (s1 < 0) { s1 += 30269; }

    s2 = 172 * (s2 % 176) - 35 * (s2 / 176);
    if (s2 < 0) { s2 += 30307; }

    s3 = 170 * (s3 % 178) - 63 * (s3 / 178);
    if (s3 < 0) { s3 += 30323; }

    double r = (s1 * 1.0) / 30269 + (s2 * 1.0) / 30307 + (s3 * 1.0) / 30323;
    return r - Math.Truncate(r);  // orig uses % 1.0
  }
}
```

in Wichmann-Hill are 30269, 30307 and 30323, so you need three seed values in the range [1, 30000]. You could write a constructor that requires three values, but that's a somewhat annoying programming interface. The demo uses a single seed parameter value to generate the three working seeds.

Calling the Wichmann-Hill RNG uses the same pattern as the other demo RNGs:

```
WichmannRng wich = new WichmannRng(1);
for (int i = 0; i < 1000; ++i) {
  double x = wich.Next();
  int ri = (int)((hi - lo) * x + lo); // 0 to 9
  ++counts[ri];
}
```

The Wichmann-Hill algorithm is only marginally more difficult to implement than the Lehmer algorithm. An advantage of Wichmann-Hill over Lehmer is that Wichmann-Hill generates a longer pattern (more than 6,000,000,000,000 values) before beginning to repeat itself.

Figure 4 **Linear Congruential Algorithm Implementation**

```
public class LinearConRng
{
  private const long a = 25214903917;
  private const long c = 11;
  private long seed;

  public LinearConRng(long seed)
  {
    if (seed < 0)
      throw new Exception("Bad seed");
    this.seed = seed;
  }

  private int next(int bits) // helper
  {
    seed = (seed * a + c) & ((1L << 48) - 1);
    return (int)(seed >> (48 - bits));
  }

  public double Next()
  {
    return (((long)next(26) << 27) + next(27)) / (double)(1L << 53);
  }
}
```

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The Linear Congruential Algorithm

As it turns out, both the Lehmer algorithm and the Wichmann-Hill algorithm can be considered special cases of what's called the linear congruential (LC) algorithm. Expressed as an equation, LC is:

```
X(i) = (a * X(i-1) + c) mod m
```

This is exactly like the Lehmer algorithm with the inclusion of an additional constant, c. Adding c gives the general LC algorithm slightly better statistical properties than the Lehmer algorithm. The demo implementation of the LC algorithm is presented in **Figure 4**. The code is based on the Portable Operating System Interface (POSIX) standard.

The LC algorithm uses several bit operations. The idea here is that instead of working with type integer (32 bits), the basic math calculations are done using type long (64 bits). When finished, 32 of those bits, from positions 16 through 47 inclusive, are extracted and converted to an integer. This approach gives better results than taking either the low order 32 bits or the high order 32 bits, at the expense of some coding complexity.

The demo calls the LC random number generator, like so:

```
LinearConRng lincon = new LinearConRng(0);
for (int i = 0; i < 1000; ++i) {
  double x = lincon.Next();
  int ri = (int)((hi - lo) * x + lo); // 0 to 9
  ++counts[ri];
}
```

Notice that unlike the Lehmer and Wichmann-Hill generators, the LC generator can accept a seed value of 0. The demo LC constructor copies the input seed parameter value directly to the class member seed variable. Many common LC implementations perform a preliminary manipulation of the input seed in order to avoid emitting a well-known series of starting values.

The Lagged Fibonacci Algorithm

The lagged Fibonacci algorithm, expressed as an equation, is:

```
X(i) = X(i-7) + X(i-10) mod m
```

In words, the new random number is the random number generated 7 times ago, plus the random number generated 10 times ago, modulo some large value m. The values (7, 10) can be changed, as I'll explain shortly.

Suppose at some point in time, the sequence of generated random values is:

```
... 123  072  409  660  915  358  224  707  834  561  ??
```

where 561 is the most recently generated value. If m = 100, then the next random number would be:

```
(660 + 123) % 100 = 783 % 100 = 83
```

Notice that at any point you always need the 10 most recently generated values. So, the key task with lagged Fibonacci is to generate initial values to get the process started. The demo implementation of lagged Fibonacci is presented in **Figure 5**.

The demo code uses the X(i-7) and X(i-10) previous random numbers to generate the next random number. The values (7, 10) are usually called (j, k) in the research literature on this topic. There are other (j, k) pairs you can use for lagged Fibonacci. A few of the values recommended by the well-known "Art of Computer Programming" (Addison-Wesley, 1968) are (24,55), (38,89), (37,100), (30,127), (83,258), (107,378).

To initialize a (j, k) lagged Fibonacci RNG, you must prepopulate a list with k values. There are several ways to do this. However, it's required that at least one of the initial k values be odd. The demo uses the crude technique of copying the seed parameter value as all k initial values, then burning away the first 1,000 generated values. If the initial seed parameter value is even, then the first of the k values is set to 11 (an arbitrary odd number).

Figure 5 **Lagged Fibonacci Implementation**

```
public class LaggedFibRng
{
  private const int k = 10; // Largest magnitude"-index"
  private const int j = 7; // Other "-index"
  private const int m = 2147483647;  // 2^31 - 1 = maxint

  private List<int> vals = null;
  private int seed;

  public LaggedFibRng(int seed)
  {
    vals = new List<int>();
    for (int i = 0; i < k + 1; ++i)
      vals.Add(seed);
    if (seed % 2 == 0) vals[0] = 11;

    // Burn some values away
    for (int ct = 0; ct < 1000; ++ct) {
      double dummy = this.Next();
    }
  }  // ctor

  public double Next()
  {
    // (a + b) mod n = [(a mod n) + (b mod n)] mod n
    int left = vals[0] % m;    // [x-big]
    int right = vals[k - j] % m; // [x-other]
    long sum = (long)left + (long)right;  // prevent overflow

    seed = (int)(sum % m);  // Because m is int, result has int range
    vals.Insert(k + 1, seed);  // Add new val at end
    vals.RemoveAt(0);  // Delete now irrelevant [0] val
    return (1.0 * seed) / m;
  }
}
```

To prevent arithmetic overflow, the Next method uses type long for calculations and the mathematical property that (a + b) mod n = [(a mod n) + (b mod n)] mod n.

Wrapping Up

Let me emphasize that the four RNGs presented in this article are intended only for non-critical scenarios. That said, I did run the four RNGs through a set of well-known baseline tests for randomness, and they did pass those tests. Even so, RNGs are notoriously tricky and time and time again standard RNGs have been found to be defective, sometimes only after they've been in use for years. For example, in the 1960s IBM distributed a linear congruential algorithm implementation called RANDU that has incredibly poor properties. And, there are research reports that Microsoft Excel 2008 had a horrendously flawed Wichmann-Hill implementation.

The current state of the art in random number generation is an algorithm named Fortuna (after the Roman goddess of chance). The Fortuna algorithm was published in 2003 and is based on mathematical entropy plus sophisticated cryptographic techniques such as the Advanced Encryption System. ■

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Thanks to the following Microsoft technical experts who reviewed this article: *Chris Lee and Kirk Olynyk*

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How To Be MEAN: Exploring ECMAScript

Welcome back, MEANers.

We're in the middle of 2016. What you might not realize is that JavaScript (which is actually officially known as ECMAScript) has a new version of the language, ECMAScript 2015. If your JavaScript code isn't starting to use it, then it's high time to start. Fortunately, it's trivial to do so, because there are good reasons to do so. In this installment, I'll go over some of the more interesting and important features of ECMAScript 2015, and in a future piece, I'll look at what using MEAN in the more modern style would be like (essentially, now that you've got a firm footing on how MEAN applications operate, I'll reboot the code base completely; more on that then).

Simple Changes

Some of the simplest changes to the language simply embrace modes of programming that have been widespread convention in the ecosystem and community for some time now.

One of these conventions is that of immutability, which ECMAScript 2015 embodies through use of a const declaration:

```
const firstName = "Ted";
```

This, like the C++ declaration of the same name, declares that the reference name ("firstName") can never point anywhere else; it doesn't insist that the object to which the reference points cannot change. ECMAScript 2015 also has a new form of mutable reference declaration, let, which is essentially a drop-in replacement for var; I advise to embrace it at any opportunity.

A more "convenience"-type change is to add string interpolation to the language using backticks (the leftward-leaning single quote that usually appears underneath the tilde on U.S. keyboards) instead of single-quotes or double-quotes:

```
const speaker = { name: "Brian Randell", rating: 5 };
console.log(`Speaker ${speaker.name} got a rating of ${speaker.rating}`);
```

Like C#-style string interpolation, ECMAScript 2015 will interpret the expression inside the braces, attempting to convert it to a string and inserting it into the resulting string.

One of the more important changes to the language has been to embrace "block-scoping"; previously, within JavaScript, variables scoped to functions, not to arbitrary code blocks. This meant that any variable declared anywhere inside of a function was accessible throughout the entire function, not just the block in which it was declared, which was confusing and a subtle source of bugs.

An interesting side effect of this block scoping is that ECMAScript now gains locally declared functions, similar to that proposed for C# 7:

```
{
  function foo () { return 1 }
  foo() === 1
  {
    function foo () { return 2 }
    foo() === 2
  }
  foo() === 1
}
```

Here, I define a function foo in the block, to return the value 1. Then, for no particular reason, I introduce a new scope block, define a new definition of foo, and demonstrate that when that scope block closes, the definition of foo returns to the previous version—which is exactly what almost every other language on the face of the planet does already.

> This explains the name—the Promise object is, in effect, promising to invoke the then function when the initial code is complete.

However, idiomatically, ECMAScript doesn't use locally nested functions; instead, it prefers a more functional-style programming idiom, defining a variable reference to point to an anonymous function definition, and use that. In support of that, ECMAScript 2015 now supports arrow functions, which use a syntax almost identical to that of C#:

```
const nums = [1, 2, 3, 4, 5];
nums.forEach(v => {
  if (v % 2 == 0)
    console.log(v);
});
```

(Remember that you added the function forEach to arrays as part of the previous ECMAScript standard.) This will, as assumed, print out the even numbers in the array. If, on the other hand, I want to construct even numbers out of the source array, I can use the built-in "map" and an arrow function to do essentially the same thing:

```
const nums = [1, 2, 3, 4, 5];
const evens = nums.map(v => v * 2);
```

Arrow functions are a long-awaited change and it's reasonable to expect that most JavaScript-based code will adopt them aggressively.

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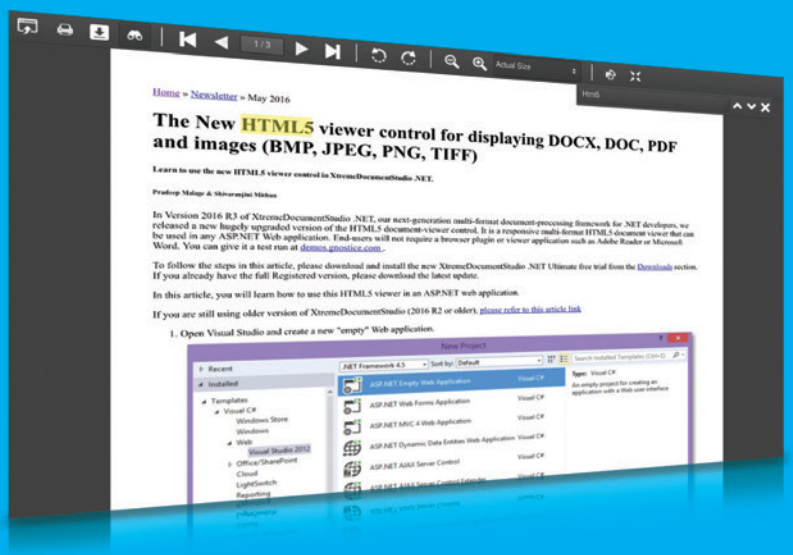

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Promises

Of the many solutions that were floated through the ECMAScript community to help address some of the complexity around the Node.js callback-style of programming, one of the recurring themes was that of "promises"—essentially, a library-based approach that transforms the callbacks into something that looked more serial in nature. Several different promises-based libraries were popular within the community, and the ECMAScript committee eventually chose to standardize on one, which it now simply refers to as "Promises." (Note the uppercase in the name; this is also the name of the principal object used to implement them.) Using ECMAScript 2015 Promises can look a little weird at first, compared to standard synchronous programming, but for the most part, it makes sense.

> Probably one of the most significant changes, at least from the perspective of building a MEAN-based application, is the adoption of a formal module system.

Consider, for a moment, application code that wants to invoke a library routine that uses a Promise to be able to do some things in the background:

```
msgAfterTimeout("Foo", 100).then(() =>
  msgAfterTimeout("Bar", 200);
).then(() => {
  console.log(`done after 300ms`);
});
```

Here, the idea is that msgAfterTimeout is going to print "Hello, Foo" after a 100 ms timeout, and afterward, do the same thing again ("Hello, Bar" after 200 ms), and after that, simply print a message to the console. Notice how the steps are connected using then function calls—the returned object from msgAfterTimeout is a Promise object and then defines the function invoked when the initial Promise has completed execution. This explains the name—the Promise object is, in effect, promising to invoke the then function when the initial code is complete. (In addition, what happens if an exception is thrown from within the function? The Promise allows you to specify a function executed in that case, using the catch method).

In the case where you want to run several functions simultaneously and then execute a function after all have finished, you can use Promise.all:

```
const fetchPromised = (url, timeout) => { /* ... */ }
Promise.all([
  fetchPromised("http://backend/foo.txt", 500),
  fetchPromised("http://backend/bar.txt", 500),
  fetchPromised("http://backend/baz.txt", 500)
]).then((data) => {
  let [ foo, bar, baz ] = data;
  console.log(`success: foo=${foo} bar=${bar} baz=${baz}`);
}, (err) => {
  console.log(`error: ${err}`);
});
```

As you can see, the results of each asynchronously executed function will be collected and assembled into an array, which is then passed as the first parameter to the (first) function given to then. (The let statement is an example of "destructuring assignment" in ECMAScript 2015, another new feature; essentially, each element of the data array is assigned to each of those three declared variables and the remainder, if any, thrown away.) Notice, as well, that then is passed a second function, which is used in the event that there's an error in executing any of the async functions.

It's definitely a different style of programming, but not unusual for anyone who's spent time working with the various C# asynchronous mechanisms, a la PLINQ or TPL.

Library

ECMAScript 2015 has added a few important things to the standard library (which all ECMAScript environments are supposed to provide, be they browser or server) beyond the Promise. In particular, they've added a Map (key/value store, similar to the .NET Dictionary<K,V> type) and a Set (a no-duplicates "bag" of values), both of which are available without requiring any sort of import:

```
const m = new Map();
m.set("Brian", 5);
m.set("Rachel", 5);
console.log(`Brian scored a ${m.get("Brian")} on his talk`);

const s = new Set();
s.add("one");
s.add("one"); // duplicate
s.add("one"); // duplicate
console.log(`s holds ${s.size} elements`);
  // Prints "1"
```

In addition, several more standard functions are being added to various object prototypes already in the ECMAScript environment, such as find on Arrays, and some numeric valuation methods (such as isNAN or isFinite) to the Number prototype. For the most part, both these and the earlier Map and Set types were already present in the community as third-party packages, but bringing them in to the standard ECMAScript library will help cut down on some of the package-dependencies that litter the ECMAScript landscape.

Modules

Probably one of the most significant changes, at least from the perspective of building a MEAN-based application, is the adoption of a formal module system. Previously, as I discussed almost a year ago, a MEAN-based application used the Node.js require function to "import" (interpret/execute) another JavaScript file and return an object for use. This meant that when a MEAN developer wrote the following line, the express object returned by evaluating a JavaScript file stored in a subdirectory inside of node_modules, which was installed via the use of npm:

```
var express = require('express');
```

To make this work, several conventions had to be in place, and it worked, but the lack of formality distinctly hindered the language and ecosystem's forward progress. In ECMAScript 2015 new keywords were introduced to formalize much of this.

It's a bit circular to explain, so let's start with a simple example: two files, one called app.js, and the library it wants to use, called math. The math library will be a non-npm library (for simplicity),

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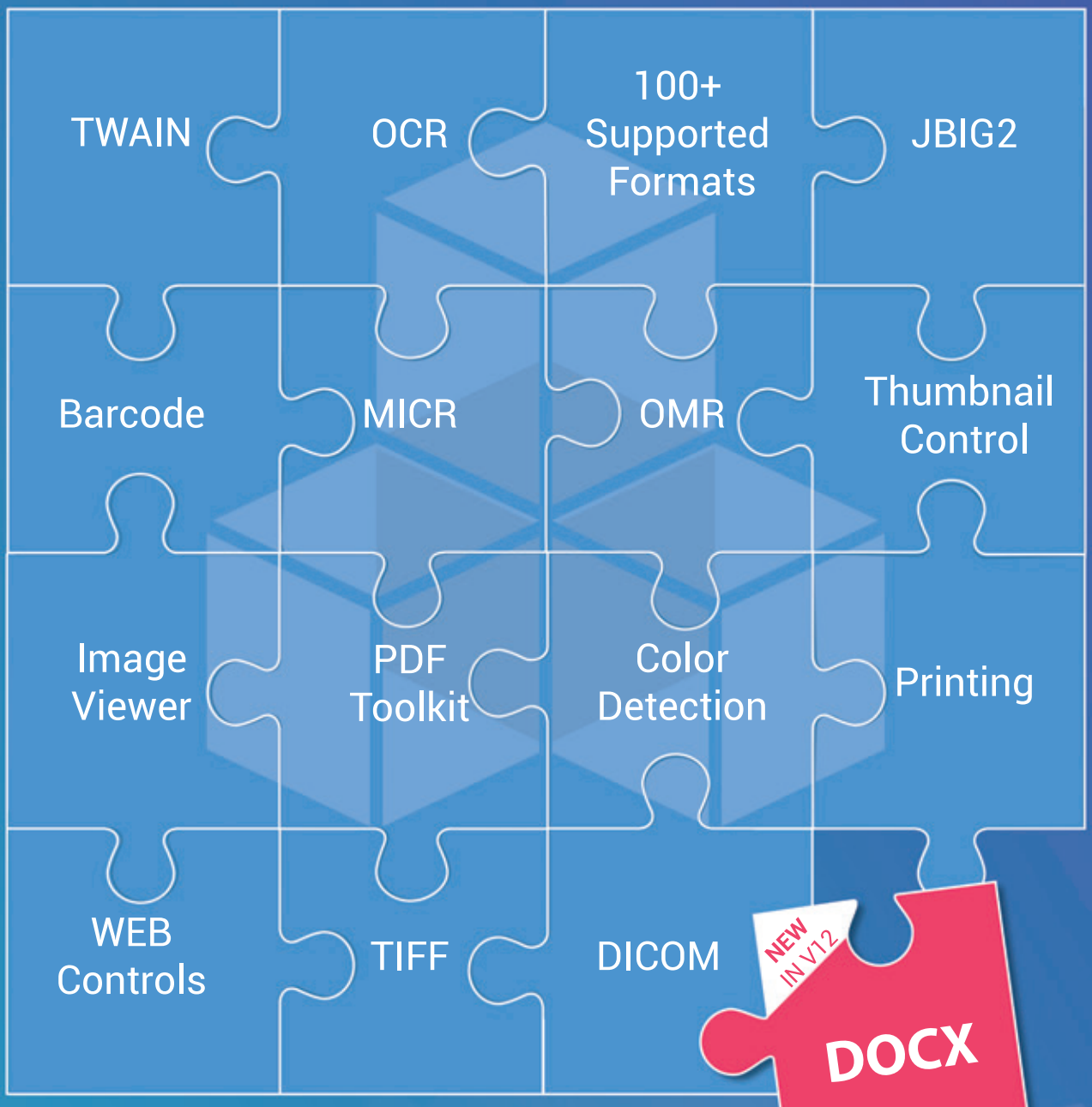

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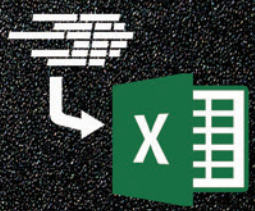

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and will have two values it exports: the value of pi (3.14), called PI, and a function to sum up an array of numbers, called sum:

```
//  lib/math.js
export function sum (x, y) { return x + y };
export var pi = 3.141593;

//  app.js
import * as math from "lib/math";
console.log("2PI = " + math.sum(math.pi, math.pi));
```

Notice that in the library, the symbols made accessible to clients are declared with the "export" keyword, and when referencing the library, you use the keyword "import." More commonly, however, you want to import the symbols from the library as top-level elements themselves (rather than as members), so the more common usage will likely be this:

```
//  app.js
import {sum, pi} from "lib/math"
console.log("2π = " + sum(pi, pi));
```

This way, the imported symbols can be used directly, rather than in their member-scoped form.

Wrapping Up

There's a great deal more hiding in the ECMAScript 2015 standard; readers who haven't seen any of these features before now should definitely check out any of the (ever-growing list of) resources describing the new standard found on the Internet. The official ECMA standard is available at bit.ly/1xxQKpl (it lists the current specification as 7th edition, called ECMAScript 2016, largely because ECMA has decided to go to a yearly cadence on new changes to the language). However, for a less "formal" description of the language, readers are encouraged to check out es6-features.org, which provides a list of the new language features and their comparison to what was present before within the language.

In addition, while Node.js is almost entirely compliant with the feature set of ECMAScript 2015, other environments aren't, or are in various states of support. For those environments, that aren't quite up to a complete level of support, there are two "transpiler" tools—the Google-sponsored Traceur compiler and the Babel compiler. (Both are, of course, just an npm away.) Of course, Microsoft's own TypeScript is amazingly close to what ECMAScript 2015 ended up being, meaning that one could adopt TypeScript today and be almost line-for-line compliant with ECMAScript 2015 if/when converting to ECMAScript 2015 is needed or desirable.

All these features will become more obvious as you start working with MEAN tools that make use of them, so don't stress for now if they don't make sense yet. In the meantime … happy coding! ■

Ted Neward *is a Seattle-based polytechnology consultant, speaker and mentor. He has written more than 100 articles, is an F# MVP and has authored and coauthored a dozen books. Reach him at ted@tedneward.com if you're interested in having him come work with your team, or read his blog at blogs.tedneward.com.*

Thanks to the following technical expert for reviewing this article: *Shawn Wildermuth*

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START TIME	END TIME		
5:00 PM	8:00 PM	Pre-Conference Registration - Royal Pacific Resort Conference Center	
6:00 PM	9:00 PM	Dine-A-Round Dinner @ Universal CityWalk	
START TIME	**END TIME**		
8:00 AM	5:00 PM	**VSM01** Workshop: Distributed Cross-Platform Application Architecture - *Rockford Lhotka & Jason Bock*	
12:00 PM	1:00 PM	Lunch	
1:00 PM	5:00 PM	**VSM1** Workshop Continues	
5:00 PM	6:00 PM	EXPO Preview	
6:00 PM	7:00 PM	Live! 360 Keynote: To Be Announced	
START TIME	**END TIME**		
8:00 AM	9:00 AM	Visual Studio Live! Keynote: To Be Announced	
9:00 AM	9:30 AM	Networking Break • Visit the EXPO	
9:30 AM	10:45 AM	**VST01** Building Applications with ASP.NET Core - *Scott Allen*	**VST02** Busy .NET Developer's Guide to Swift - *Ted Neward*
11:00 AM	12:15 PM	**VST05** Richer MVC Sites with Knockout JS - *Miguel Castro*	**VST06** Busy .NET Developer's Guide to Native iOS - *Ted Neward*
12:15 PM	2:00 PM	Lunch • Visit the EXPO	
2:00 PM	3:15 PM	**VST09** WCF & Web API: Can We All Just Get Along?!? - *Miguel Castro*	**VST10** Creating Great Looking Android Applications Using Material Design - *Kevin Ford*
3:15 PM	4:15 PM	Networking Break • Visit the EXPO	
4:15 PM	5:30 PM	**VST13** Busy Developer's Guide to Chrome Development - *Ted Neward*	**VST14** Using Visual Studio Tools for Apache Cordova to Create MultiPlatform Applications - *Kevin Ford*
5:30 PM	7:30 PM	Exhibitor Reception	
START TIME	**END TIME**		
8:00 AM	9:15 AM	**VSW01** Moving from Angular 1 to Angular 2 - *Ben Dewey*	**VSW02** The Future of Mobile Application Search - *James Montemagno*
9:30 AM	10:45 AM	**VSW05** Getting Started with Aurelia - *Brian Noyes*	**VSW06** Building Connected and Disconnected Mobile Applications - *James Montemagno*
10:45 AM	11:15 AM	Networking Break • Visit the EXPO	
11:15 AM	12:15 PM	Live! 360 Keynote: To Be Announced	
12:15 PM	1:45 PM	Birds-of-a-Feather Lunch • Visit the EXPO	
1:45 PM	3:00 PM	**VSW09** Living in a Command Line Web Development World (NPM, Bower, Gulp, and More) - *Ben Dewey*	**VSW10** Understanding the Windows Desktop App Development Landscape - *Brian Noyes*
3:00 PM	4:00 PM	Networking Break • Visit the EXPO • Expo Raffle @ 3:30 p.m.	
4:00 PM	5:15 PM	**VSW13** Securing Client JavaScript Apps - *Brian Noyes*	**VSW14** Let's Write a Windows 10 App: A Basic Introduction to Universal Apps - *Billy Hollis*
8:00 PM	10:00 PM	Live! 360 Dessert Luau - *Wantilan Pavilion*	
START TIME	**END TIME**		
8:00 AM	9:15 AM	**VSH01** Build Real-Time Websites and Apps with SignalR - *Rachel Appel*	**VSH02** Cognitive Services: Building Smart Applications with Computer Vision - *Nick Landry*
9:30 AM	10:45 AM	**VSH05** HTTP/2: What You Need to Know - *Robert Boedigheimer*	**VSH06** Building Business Apps on the Universal Windows Platform - *Billy Hollis*
11:00 AM	12:15 PM	**VSH09** TypeScript and ES2015 JumpStart - *John Papa*	**VSH10** A Developers Introduction to HoloLens - *Billy Hollis & Brian Randell*
12:15 PM	1:30 PM	Lunch on the Lanai	
1:30 PM	2:45 PM	**VSH13** All Your Tests Are Belong To Us - *Rachel Appel*	**VSH14** Developing Awesome 3D Apps with Unity and C# - *Adam Tuliper*
3:00 PM	4:15 PM	**VSH17** SASS and CSS for Developers - *Robert Boedigheimer*	**VSH18** From Oculus to HoloLens: Building Virtual & Mixed Reality Apps & Games - *Nick Landry*
4:30 PM	5:30 PM	Live! 360 Conference Wrap-Up - *Pacifica 6 - Andrew Brust (Moderator),*	
START TIME	**END TIME**		
8:00 AM	5:00 PM	**VSF01** Workshop: Angular 2 Bootcamp - *John Papa*	
12:00 PM	1:00 PM	Lunch	
1:00 PM	5:00 PM	**VSF01** Session Continues	

Speakers and sessions subject to change

AGENDAS AT-A-GLANCE

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Pre-Conference: Sunday, December 4, 2016

Pre-Conference Workshops: Monday, December 5, 2016

VSM02 Workshop: Service Oriented Technologies - Designing, Developing, & Implementing WCF and the Web API - *Miguel Castro*	**VSM03** Workshop: DevOps in a Day - *Brian Randell*	**MAM01** Workshop: Building Modern Mobile Apps - *Brent Edwards & Kevin Ford*	**ADM01** Workshop: Building Teams - *Steve Green*	**ADM02** Workshop: One Codebase to Rule Them All: Xamarin - *Fabian Williams*
VSM2 Workshop Continues	**VSM3** Workshop Continues	**MAM01** Workshop Continues	**ADM01** Workshop Continues	**ADM02** Workshop Continues

Day 1: Tuesday, December 6, 2016

VST03 What's New in Azure v2 - *Eric D. Boyd*	**VST04** Real World Scrum with Team Foundation Server 2015 & Visual Studio Team Services - *Benjamin Day*	**MAT01** Modern App Development: Transform How You Build Web and Mobile Software - *Rockford Lhotka*	**ADT01** Hacking Technical Debt - *Steve Green*	**ADT02** Java 8 Lambdas and the Streaming API - *Michael Remijan*
VST07 Overview of Power Apps - *Nick Pinheiro*	**VST08** Get Good at DevOps: Feature Flag Deployments with ASP.NET, WebAPI, & JavaScript - *Benjamin Day*	**MAT02** Architecture: The Key to Modern App Success - *Brent Edwards*	**ADT03** Are You A SOLID Coder? - *Steve Green*	**ADT04** PrimeFaces 5: Modern UI Widgets for Java EE - *Kito Mann*
VST11 Introduction to Next Generation of Azure PaaS – Service Fabric and Containers - *Vishwas Lele*	**VST12** To Be Announced	**MAT03** Manage Distributed Teams with Visual Studio Team Services and Git - *Brian Randell*	**ADT05** Agile Architecture - *Steve Green*	**ADT06** Full Stack Java with JSweet, Angular 2, PrimeNG, and JAX-RS - *Kito Mann*
VST15 Cloud Oriented Programming - *Vishwas Lele*	**VST16** Bringing DevOps to the Database - *Steve Jones*	**MAT04** Focus on the User Experience #FTW - *Anthony Handley*	**ADT07** Crafting Innovation - *Steve Green*	**ADT08** Who's Taking Out the Garbage? How Garbage Collection Works in the VM - *Kito Mann*

Day 2: Wednesday, December 7, 2016

VSW03 Managing Enterprise and Consumer Identity with Azure Active Directory - *Nick Pinheiro*	**VSW04** Improving Performance in .NET Applications - *Jason Bock*	**MAW01** DevOps, Continuous Integration, the Cloud, and Docker - *Dan Nordquist*	**ADW01** Stop Killing Requirements! - *Melissa Green*	**ADW02** Migrating Customers to Microsoft Azure: Lessons Learned From the Field - *Ido Flatow*
VSW07 Practical Internet of Things for the Microsoft Developer - *Eric D. Boyd*	**VSW08** I'll Get Back to You: Understanding Task, Await, and Asynchronous Methods - *Jeremy Clark*	**MAW02** Mobile Panel - *Kevin Ford, Rockford Lhotka, James Montemagno, & Ryan J. Salva*	**ADW03** Meeting-Free Software Development in Distributed Teams - *Yegor Bugayenk*	**ADW04** The Essentials of Building Cloud-Based Web Apps with Azure - *Ido Flatow*
VSW11 To Be Announced	**VSW12** Learn to Love Lambdas (and LINQ, Too) - *Jeremy Clark*	**MAW03** C# Everywhere: How CSLA .NET Enables Amazing Cross-Platform Code Reuse - *Rockford Lhotka*	**ADW05** Introduction to Microsoft Office Graph - *Fabian Williams*	**ADW06** Building IoT and Big Data Solutions on Azure - *Ido Flatow*
VSW15 ARM Yourself for Azure Success - *Esteban Garcia*	**VSW16** Continuous Delivery on Azure: A/B Testing, Canary Releases, and Dark Launching - *Marcel de Vries*	**MAW04** Coding for Quality and Maintainability - *Jason Bock*	**ADW07** As You Think About Azure Databases, Think About DocumentDb - *Fabian Williams*	**ADW08** Where Does JavaScript Belong in the App Store? - *Jordan Matthiesen*

Day 3: Thursday, December 8, 2016

VSH03 C# Best Practices - *Scott Allen*	**VSH04** Application Insights: Measure Your Way to Success - *Esteban Garcia*	**MAH01** Modern Mobile Development: Build a Single App For iOS & Android with Xamarin Forms - *Kevin Ford*	**ADH01** From VMs to Containers: Introducing Docker Containers for Linux and Windows Server - *Ido Flatow*	**ADH02** Continuous Testing in a DevOps World - *Wayne Ariola*
VSH07 Debugging Your Way Through .NET with Visual Studio 2015 - *Ido Flatow*	**VSH08** The Ultimate Intro to Docker for Developers - *Adam Tuliper*	**MAH02** Universal Windows Development: UWP for PC, Tablet & Phone - *Brent Edwards*	**ADH03** CQRS 2.0 - Commands, Actors, and Events...Oh My! - *David Hoerster*	**DH04** Microservices as Chat Bots Are the Future - *Yegor Bugayenk*
VSH11 Exploring Microservices in a Microsoft Landscape - *Marcel de Vries*	**VSH12** Automated UI Testing for iOS and Android Mobile Apps - *James Montemagno*	**MAH03** Modern Web Development: ASP.NET MVC and Web API - *Allen Conway*	**ADH05** The Curious Case for the Immutable Object - *David Hoerster*	**ADH06** Continuous Integration May Have Negative Effects - *Yegor Bugayenk*
VSH15 Unit Testing Makes Me Faster: Convincing Your Boss, Your Co-Workers, and Yourself - *Jeremy Clark*	**VSH16** Writing Maintainable, X-Browser Automated Tests - *Marcel de Vries*	**MAH04** Modern Web Development: Building a Smart Web Client with TypeScript and Angular2 - *Allen Conway*	**ADH07** To Be Announced	**ADH08** Mobile DevOps Demystified with Xamarin, VSTS and HockeyApp - *Roy Cornelissen*
VSH19 User Experience Case Studies - Good and Bad - *Billy Hollis*	**VSH20** Debugging the Web with Fiddler - *Ido Flatow*	**MAH05** Using All That Data: Power BI to the Rescue - *Scott Diehl*	**ADH09** Get Started with Microsoft PowerApps - *Fabian Williams*	**ADH10** Overcoming the Challenges of Mobile Development in the Enterprise - *Roy Cornelissen*

Andrew Connell, Don Jones, Rockford Lhotka, Matthew McDermott, Brian Randell, & John K. Waters

Post-Conference Workshops: Friday, December 9, 2016

VSF02 Workshop: Building Modern Web Apps with Azure - *Eric D. Boyd & Brian Randell*	**MAF01** Workshop: Modern App Deep Dive: Xamarin, Responsive Web, UWP, CSLA .NET - *Jason Bock, Allen Conway, Brent Edwards & Kevin Ford*	**ADF01** Workshop: To Be Announced
VSF02 Session Continues	**MAF01** Session Continues	**ADF01** Session Continues

Sing a Song of Silicon

I cannot get my sleep to-night; old bones are hard to please;
I'll stand the middle watch up here - alone wi' God an' these
My engines, after ninety days o' race an' rack an' strain
Through all the seas of all Thy world, slam-bangin' home again.

This excerpt comes from my favorite poet, Rudyard Kipling, from my favorite poem, "McAndrew's Hymn." Speaking through the old Scottish marine engineer, Kipling marvels at the greatest technological accomplishment of his day (1894), the coal-fired steamship, and honors those who designed and built and ran them. I briefly mentioned this poem in my April 2012 column ("Poetry of the Geeks", msdn.com/magazine/hh882456), but I will now dive deeply into it with you. I encourage you to read the whole thing, online at bit.ly/29eDxvf.

Speaking through the old Scottish marine engineer, Kipling marvels at the greatest technological accomplishment of his day (1894), the coal-fired steamship, and honors those who designed and built and ran them.

While much has changed since Kipling's time, I find that many of his observations on engineering and innovation resonate with me today. For example, consider how fast our hardware improves. Kipling noticed this 100 years ago, long before some plagiarist stuck Moore's name on the idea and called it a law. I hear McAndrew as I contemplate the original 4.77 MHz IBM PC (with two floppy drives and 256KB of memory) that I use as a planter:

[I] started as a boiler-whelp when steam and [I] were low.
I mind the time we used to serve a broken pipe wi' tow.
Ten pound was all the pressure then - Eh! Eh! - a man wad drive;
An' here, our workin' gauges give one hunder' fifty-five!

Kipling writes of the difficulties of integrating disparate components into a working whole, and the beauty of the final accomplishment:

Lord, send a man like Robbie Burns to sing the Song o' Steam!
To match wi' Scotia's noblest speech yon orchestra sublime
Whaurto-uplifted like the Just—the tail-rods mark the time.
The Crank-throws give the double-bass; the feed-pump sobs an' heaves:
An' now the main eccentrics start their quarrel on the sheaves.
Her time, her own appointed time, the rocking link-head bides,
Till-hear that note?—the rod's return whings glimmerin' through the guides.

McAndrew had the same problem finding good helpers that we have today. Think about his words the next time you hire IT grunts:

Below there! Oiler! What's your wark? Ye find her runnin' hard?
Ye needn't swill the cap wi' oil—this isn't the Cunard.
Ye thought? Ye are not paid to think. Go, sweat that off again!
Tck! Tck! It's deeficult to sweer nor tak' The Name in vain!

As I've written many times, we software geeks hold much more responsibility than we did a decade or two ago. A player losing his high score in Solitaire wasn't so bad, but it's a whole lot worse if he loses his prescription records, and way, way worse if his medical records get mixed in with someone else's. It's not the users's job to keep his programs secure and working, it's ours. We're just starting to get this through our heads, but McAndrew knew. He says of his passengers:

Maybe they steam from grace to wrath - to sin by folly led -
It isna mine to judge their path - their lives are on my head.
Mine at the last - when all is done it all comes back to me,
The fault that leaves six thousand ton a log upon the sea.

Above all, we geeks feel the thrill of creating in our own image, which nothing else can ever match. McAndrew felt that too, as he says to God:

Uplift am I? When first in store the new-made beasties stood,
Were Ye cast down that breathed the Word declarin' all things good?

That's why we entered this crazy profession, and that's why we stay. Read what Kipling wrote about McAndrew 100 years ago. For "first-class passengers," put in your own trochaic description of an idiot—perhaps "bone-head manager." For "horse-power," substitute "megaflops" or whatever your performance metric is. And tell me this isn't how you feel when your system goes live:

Oh for a man to weld it then, in one trip-hammer strain,
Till even first-class passengers could tell the meanin' plain!
But no one cares except mysel' that serve an' understand
My seven thousand horse-power here. Eh, Lord! They're grand, they're grand! ■

DAVID S. PLATT *teaches programming .NET at Harvard University Extension School and at companies all over the world. He's the author of 11 programming books, including "Why Software Sucks" (Addison-Wesley Professional, 2006) and "Introducing Microsoft .NET" (Microsoft Press, 2002). Microsoft named him a Software Legend in 2002. He wonders whether he should tape down two of his daughter's fingers so she learns how to count in octal. You can contact him at rollthunder.com.*

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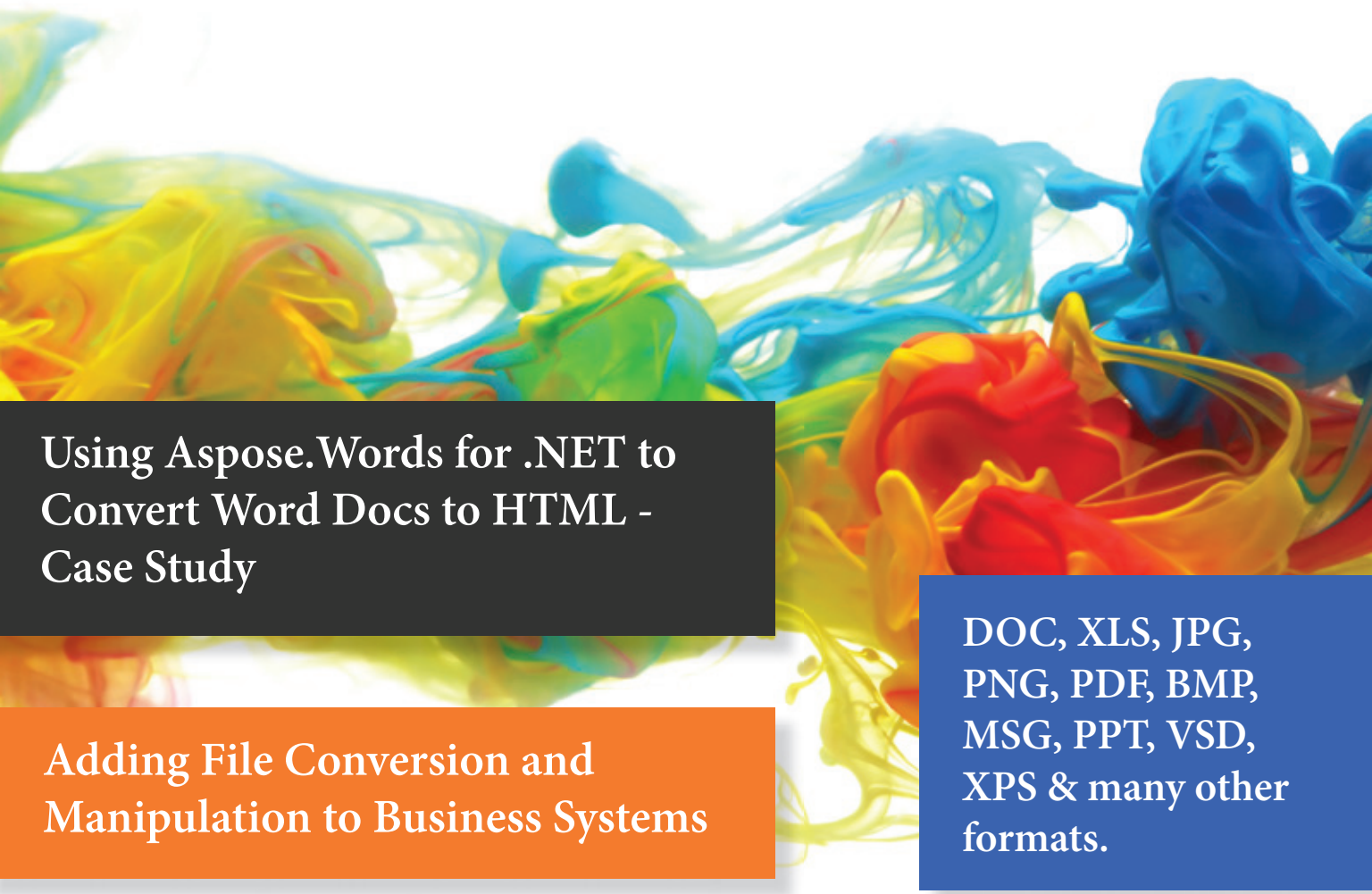

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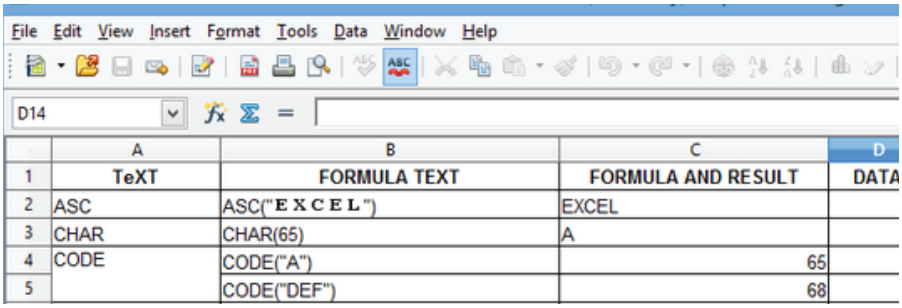

	A	B	C	D
1	TeXT	FORMULA TEXT	FORMULA AND RESULT	DATA
2	ASC	ASC("EXCEL")	EXCEL	
3	CHAR	CHAR(65)	A	
4	CODE	CODE("A")	65	
5		CODE("DEF")	68	

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	Table			
	Column 1	**Column 2**	**Column 3**	**Column 4**
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Row 2	Cell 1	Cell 2	Cell 3	
Row 3	Cell 1	Cell 2		

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Format support varies across platforms.

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	Standard	Enhanced		Standard	Enhanced
Developer Small Business	$999	$1498	Site Small Business	$4995	$7490
Developer OEM	$2997	$4494	Site OEM	$13986	$20972

The pricing info above is for .NET: prices for other platforms may differ. For the latest, contact sales.

Case Study: Aspose.Words for .NET

ProHire Staffing - Using Aspose.Words for .NET to convert Word Docs to HTML

PROHIRE IS THE WORKFORCE SOLUTIONS LEADER IN THE UNITED STATES AND SPECIALIZE IN THE RECRUITMENT OF SALES AND SALES MANGEMENT PROFESSIONALS. We were founded with the goal of becoming the premier provider of executive search and placement services to the Fortune 500 and Inc. 500 Companies.

Problem

ProHire uses Bullhorn ATS as its Application Tracking System to track the electronic handling of its recruitment needs. We wanted to integrate the Bullhorn API with our new website. Our goal was to convert MS Word Documents resumes into a clean and concise HTML format into our existing .Net Stack. The converted HTML resume version needed to look close to the original.

> "The transitions with Aspose. Words for .NET was very painless to do."

Looking for a Solution

We chose the ASPOSE.Words product because it easily integrated into our existing .Net stack, and provided a quality MS Word to HTML conversion. The product was easy to download, and with a few lines of code we were up and running. We found the primary difference between the Aspose. Words and other products was the obvious conversion quality from MS Word to HTML.

Finding a Solution

We had tested other products that converted Word to HTML. Every one we tested had some problem with the conversion. Some of them lost elements of the resume during the conversion. Most of them changed the format of the resume or changed the color of the text unexpectedly. This is unacceptable when you are sending a resume to a hiring manger. We were very satisfied with the results. We did not need any technical support because documentation was sufficient to us.

Implementation

Once we had the Aspose DLL our developer was able to implement Aspose.Words for .NET in a few hours. The transitions with Aspose. Words for .NET was very painless to do.

Outcome

We are very pleased with the success of our Aspose.Words for .NET implementation. Aspose.Words is a very powerful development tool that is well documented and easy to install. The documentation is easy to understand and use. If you want a product to convert Word Docs to HTML look no further. ProHire is happy to recommend Aspose.

This is an extract from a case study on our website. For the full version, go to: www.aspose.com/corporate/customers/case-studies.aspx

The converted HTML resume version needed to look close to the original.

Open, Create, Convert, Print & Save Files

from within your *own* applications.

ASPOSE.TOTAL

allows you to process these file formats:

- Word documents
- Excel spreadsheets
- PowerPoint presentations
- PDF documents
- Project documents
- Visio documents
- Outlook emails
- OneNote documents

DOC XLS PPT PDF EML
PNG XML RTF HTML VSD
BMP & barcode images.

ASPOSE
File Format APIs

Contact Us:
US: +1 903 306 1676
EU: +44 141 628 8900
AU: +61 2 8006 6987
sales@aspose.com

Helped over 11,000 companies and over 300,000 users work with documents in their applications.

File Format APIs

GET STARTED NOW

- Free Trial
- 30 Day Temp License
- Free Support
- Community Forums
- Live Chat
- Blogs
- Examples
- Video Demos

Adding File Conversion and Manipulation to Business Systems

How often do people in your organization complain that they can't get information in the file format and layout they want? Converting documents from one format to another without losing layout and formatting should be simple, but it can be frustrating for both users and developers.

EXTRACTING DATA FROM A DATABASE AND DELIVERING IT TO THE SALES TEAM AS A REPORT, complete with charts and corporate branding, is fine. Until the sales team says that they want it as a Microsoft Excel file, and could you add a dashboard?

Using information from online forms in letters that can are printed and posted is easy. But what if you also want to add tracking barcodes and archive a digital copy as a PDF?

> Aspose creates APIs that work independently of Microsoft Office Automation.

Ensuring that your business system supports all the different Microsoft Office file formats your users want can be difficult. Sometimes the native file format support of your system lets you down. When that is the case, use tools that extend that capability. A good tool can save you time and effort.

Document Conversion Options

Building your own solution: Time-consuming and costly, this option is only sensible if the solution you develop is central to your business.

Using Microsoft Office Automation: Microsoft Office Automation lets you use Microsoft Office programs server-side. It is not how the Office products were designed to be used. It can work well but you might notice issues with the stability, security and speed of the system, as well as cost.

Using an API: The API market has lots of free and commercial solutions, some very focused, some feature-rich. An API integrates with your code and gives you access to a range of new features.

Look to Aspose

Aspose are API experts. We create APIs, components and extensions that work independently of Microsoft Automation to extend a platform's native file format manipulation capabilities.

Aspose have developed APIs for .NET, Java, Cloud and Android that lets developers convert, create and manipulate Microsoft Office files – Microsoft Word, Excel, PowerPoint, Visio and Project – and other popular business formats, from PDFs and images to emails. We also have APIs for working with images, barcodes and OCR. The APIs are optimised for stability, speed and ease of use. Our APIs save users weeks, sometimes months, of effort.

Finding the Right Tool

To find the product that's right for you, take a systematic approach:

- List must-have and nice-to-have features.
- Research the market.
- Ask for recommendations.
- Select a few candidates .
- Run trials.
- Evaluate
  - ease of use,
  - support and documentation,
  - performance, and
  - current and future needs.

Aspose.BarCode

A complete toolkit for barcode generation and recognition

- Generate barcodes with customer defined size and color.
- Recognize a large number of barcode types from images.

ASPOSE.BARCODE IS A ROBUST AND RELIABLE BARCODE GENERATION AND RECOGNITION API that allows developers to add barcode generation and recognition functionality to their applications quickly and easily.

Aspose.BarCode supports most established barcode specifications. It can export generated barcodes to multiple image formats, including BMP, GIF, JPED, PNG and TIFF.

Aspose.BarCode gives you full control over every aspect of the barcode image, from background and bar color, through image quality, rotation angle, X-dimension, captions, and resolution.

> Robust and reliable barcode generation and recognition.

Aspose.BarCode can read and recognize most common 1D and 2D barcodes from any image and at any angle. Filters help developers clean up difficult to read images to improve recognition.

Aspose.BarCode offers a large number of symbologies and formatting options.

Common Uses

- Generating and recognizing barcode images.
- Printing barcode labels.
- Enhancing workflow by adding barcode functionality.
- Using recognition functions to drive real-life work processes.

Key Features

- Barcode generation and recognition.
- Comprehensive support for 1D and 2D symbologies.
- Image processing for improved recognition.

Supported File Formats

JPG, TIFF, PNG, BMP, GIF, EMF, WMF, EXIP and ICON.

Format support varies across platforms.

Supported Barcodes

Linear: EAN13, EAN8, UPCA, UPCE, Interleaved2of5, Standard2of5, MSI, Code11, Codabar, EAN14(SCC14), SSCC18, ITF14, Matrix 2 of 5, PZN, Code128, Code39 Extended, Code39 Standard, OPC, Code93 Extended, Code93 Standard, IATA 2 of 5, GS1Code128, ISBN, ISMN, ISSN, ITF6, Pharmacode, DatabarOmniDirectional, VIN, DatabarTruncated, DatabarLimited, DatabarExpanded, PatchCode, Supplement **2D**: PDF417, MacroPDF417, DataMatrix, Aztec, QR, Italian Post 25, Code16K, GS1DataMatrix **Postal**: Postnet, Planet, USPS OneCode, Australia Post, Deutsche Post Identcode, AustralianPosteParcel, Deutsche Post Leticode, RM4SCC, SingaporePost, SwissPostParcel

Platforms

Pricing Info					
	Standard	Enhanced		Standard	Enhanced
Developer Small Business	$599	$1098	Site Small Business	$2995	$5490
Developer OEM	$1797	$3294	Site OEM	$8386	$15372

The pricing info above is for .NET: prices for other platforms may differ. For the latest, contact sales.

Aspose *for* Cloud

The easiest API to Create, Convert & Automate Documents in the cloud.

Convert
Create
Render
Combine
Modify

without installing anything!

Aspose.Words for Cloud

Create and convert docs
Manipulate text
Render documents
Annotate

Aspose.Cells for Cloud

Create spreadsheets
Convert spreadsheets
Manipulate cells and formulas
Render spreadsheets

Aspose.Slides for Cloud

Create presentations
Manage slides
Edit text and images
Read and convert

Aspose.Pdf for Cloud

Create and convert PDFs
Manipulate text, images
Add pages, split, encrypt
Manage stamps

Aspose.Email for Cloud

Create, update, and convert messages
Extract attachments
Use with any language

Aspose.BarCode for Cloud

Generate barcodes
Read barcodes
Set attributes
Multiple image formats

Free Evaluation at www.aspose.com

- +44 141 628 8900
- +1 903 306 1676
  sales@aspose.com
- +61 2 8006 6987

Aspose.Email

Work with emails and calendars without Microsoft Outlook

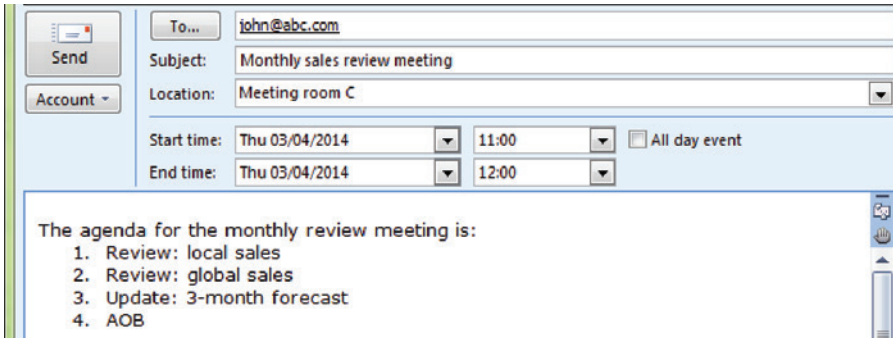
- Complete email processing solution.
- Message file format support.

ASPOSE.EMAIL IS AN EMAIL PROGRAMMING API that allows developers to access and work with PST, EML, MSG and MHT files. It also offers an advanced API for interacting with enterprise mail systems like Exchange and Gmail.

Aspose.Email can work with HTML and plain text emails, attachments and embedded OLE objects. It allows developers to work against SMTP, POP, FTP and Microsoft Exchange servers. It supports mail merge and iCalendar features, customized header and body, searching archives and has many other useful features.

Aspose. Email works with HTML and plain text emails, attachments and embedded OLE objects.

Aspose.Email allows developers to focus on managing email without getting into the core of email and network programming. It gives you the controls you need.



Aspose.Email lets your applications work with emails, attachments, notes and calendars.

Common Uses

- Sending email with HTML formatting and attachments.
- Mail merging and sending mass mail.
- Connecting to POP3 and IMAP mail servers to list and download messages.
- Connecting to Microsoft Exchange Servers to list, download and send messages.
- Create and update tasks using iCalendar.
- Load from and save messages to file or stream (EML, MSG or MHT formats).

Key Features

- A complete email processing solution.
- Support for MSG and PST formats.
- Microsoft Exchange Server support.
- Complete recurrence pattern solution.

Supported File Formats

MSG, MHT, OST, PST, EMLX, TNEF, and EML.

Format support varies across platforms.

Platforms

Pricing Info					
	Standard	Enhanced		Standard	Enhanced
Developer Small Business	$599	$1098	Site Small Business	$2995	$5490
Developer OEM	$1797	$3294	Site OEM	$8386	$15372

The pricing info above is for .NET: prices for other platforms may differ. For the latest, contact sales.

www.aspose.com

EU: +44 141 628 8900

US: +1 903 306 1676
sales@aspose.com

Oceania: +61 2 8006 6987

Aspose.Pdf

Create PDF documents without using Adobe Acrobat

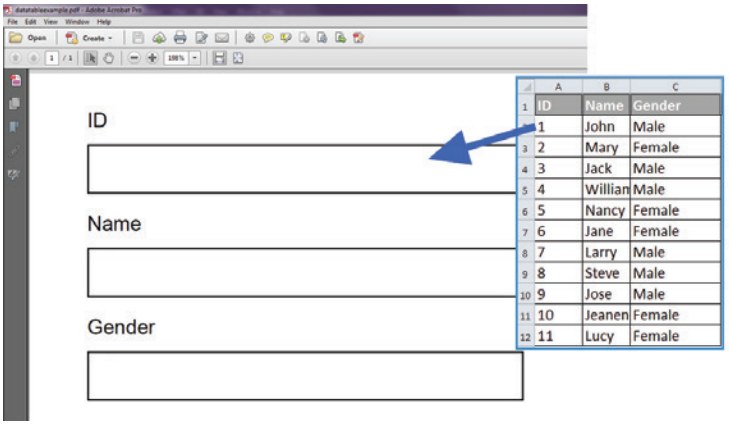
- A complete solution for programming with PDF files.
- Work with PDF forms and form fields.

ASPOSE.PDF IS A PDF DOCUMENT CREATION AND MANIPULATION API that developers use to read, write and manipulate PDF documents without using Adobe Acrobat. Aspose.Pdf is a sophisticated product that integrates with your application to add PDF capabilities.

Aspose.Pdf offers a wealth of features that lets developers compress files, create tables, work with links, add and remove security, handle custom fonts, integrate with external data sources, manage bookmarks, create table of contents, create forms and manage form fields.

> Read, write and manipulate PDF documents independently of Adobe Acrobat.

It helps developers add, work with attachments, annotations and PDF form data, add, replace or remove text and images, split, concatenate, extract or inset pages, and print PDF documents.



Aspose.Pdf can be used to automatically complete PDF forms with external data.

Common Uses

- Creating and editing PDF files.
- Inserting, extracting, appending, concatenating and splitting PDFs.
- Working with text, images, tables, images, headers, and footers.
- Applying security, passwords and signatures.
- Working with forms and form fields.

Key Features

- PDF creation from XML or XSL-FO documents.
- PDF form and field support.
- Advanced security and encryption.
- High-fidelity printing and conversion.
- Supported File Formats
- PDF, PDF/A, PDF/A_1b, PCL, XSL-FO, LaTeX, HTML, XPS, TXT and a range of image formats.

Format support varies across platforms.

Platforms

Pricing Info					
	Standard	Enhanced		Standard	Enhanced
Developer Small Business	$799	$1298	Site Small Business	$3995	$6490
Developer OEM	$2397	$3894	Site OEM	$11186	$18172

The pricing info above is for .NET: prices for other platforms may differ. For the latest, contact sales.

Aspose.Pdf

.Net, Java & Cloud

File Formats

PDF DOC XML XSL-FO XPS HTML BMP JPG PNG ePUB & other image file formats.

Create and Manipulate PDFs

Create new or edit/manipualte existing PDFs.

Form Field Features

Add form fields to your PDFs. Import and export form fields data from select file formats.

Table Features

Add tables to your PDFs with formatting such as table border style, margin and padding info, column width and spanning options, and more.

Get started today at www.aspose.com

Aspose.Note for .NET

Aspose.Note for .NET is an API that lets developers convert Microsoft OneNote pages to a variety of file formats, and extract the text and document information.

Conversion is fast and high-fidelity. The output looks like the OneNote page, no matter how complex the formatting or layout.

Aspose.Note works independently of Office Automation and does not require Microsoft Office or OneNote to be installed.

Modify, convert, render and extract text and images from Microsoft OneNote files without relying on OneNote or other libraries.

Features

File Formats and Conversion		Rendering and Printing	Document Management
Microsoft OneNote 2010, 2010 SP1, 2013	Load, Save	Save as Image (BMP, GIF, JPG, PNG)	• Extract text • Get the number of pages in a document. • Get page information. • Extract images. • Get image information from a document. • Replace text in document.
PDF	Save	Save as PDF	
Images (BMP, GIF, JPG, PNG)	Save		

Aspose.Imaging

Create Images from scratch.

- Load existing images for editing purposes.
- Render to multiple file formats.

ASPOSE.IMAGING IS A CLASS LIBRARY that facilitates the developer to create Image files from scratch or load existing ones for editing purpose. Also, Aspose.Imaging provides the means to save the created or edited Image to a variety of formats. All of the above mentioned can be achieved without the need of an Image Editor. It works independent of other applications and although Aspose.Imaging allows you to save to Adobe PhotoShop® format (PSD), you do not need PhotoShop installed on the machine.

Aspose.Imaging is flexible, stable and powerful. It's many features and image processing routines should meet most imaging requirements. Like all Aspose file format components, Aspose. Imaging introduces support for an advanced set of drawing features along with the core functionality. Developers can draw on Image surface either by manipulating the bitmap information or by using the advanced functionality like Graphics and Paths.

Aspose.Imaging allows creation and manipulation of images.

Create images from scratch. or load existing ones...

Common Uses

- Create images from scratch.
- Load and Edit existing images.
- Export images to a variety of formats.
- Adding watermark to images.
- Export CAD drawings to PDF & raster image formats.
- Crop, resize & RotateFlip images.
- Extract frames from multipage TIFF image.

Key Features

- Create, edit, and save images
- Multiple file formats
- Drawing features
- Export images

Supported File Formats

BMP, JPG, TIFF, GIF, PNG, PSD, DXF, DWG, and PDF.

Platforms

Pricing Info					
	Standard	Enhanced		Standard	Enhanced
Developer Small Business	$399	$898	Site Small Business	$1995	$4490
Developer OEM	$1197	$2694	Site OEM	$5586	$12572

The pricing info above is for .NET.

Aspose.Slides

Work with presentations without using Microsoft PowerPoint

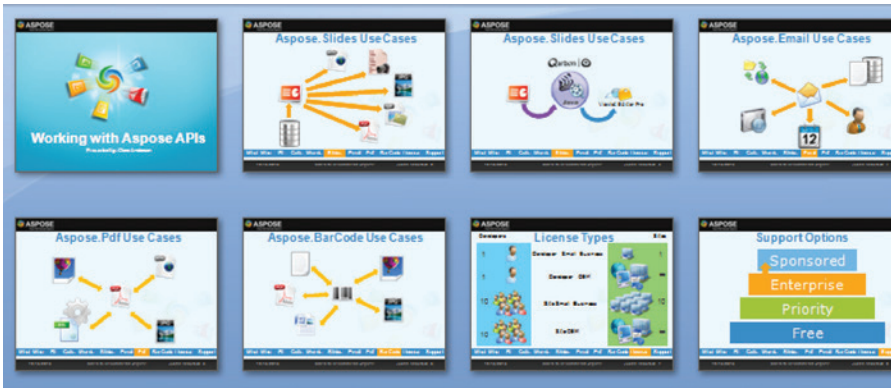
- Complete solution for working with presentation files.
- Export presentations and slides to portable or image formats.

ASPOSE.SLIDES IS A FLEXIBLE PRESENTATION MANAGEMENT API that helps developers read, write and manipulate Microsoft PowerPoint documents. Slides and presentations can be saved to PDF, HTML and image file formats without Microsoft PowerPoint.

Aspose.Slides offers a number of advanced features that make it easy to perform tasks such as rendering slides, exporting presentations, exporting slides to SVG and printing. Developers use Aspose.Slides to build customizable slide decks, add or remove standard graphics and automatically publish presentations to other formats.

> Aspose.Slides gives you the tools you need to work with presentation files.

Aspose.Slides gives developers the tools they need to work with presentation files. It integrates quickly and saves time and money.



Aspose.Slides has advanced features for working with every aspect of a presentation.

Common Uses

- Creating new slides and cloning existing slides from templates.
- Handling text and shape formatting.
- Applying and removing protection.
- Exporting presentations to images and PDF.
- Embedding Excel charts as OLE objects.
- Generate presentations from database.

Key Features

- A complete presentation development solution.
- Control over text, formatting and slide elements.
- OLE integration for embedding external content.
- Wide support for input and output file formats.

Supported File Formats

PPT, HTML, POT, PPS, PPTX, POTX, PPSX, ODP, PresentationML, XPS, PDF and image formats including TIFF and JPG.

Format support varies across platforms.

Platforms

Pricing Info					
	Standard	Enhanced		Standard	Enhanced
Developer Small Business	$799	$1298	Site Small Business	$3995	$6490
Developer OEM	$2397	$3894	Site OEM	$11186	$18172

The pricing info above is for .NET: prices for other platforms may differ. For the latest, contact sales.

Support Services

Get the assistance you need, when you need it, from the people who know our products best.

- Free support for all, even when evaluating
- Get the level of support that suits you and your team

NO ONE KNOWS OUR PRODUCTS AS WELL AS WE DO.
We develop them, support them and use them. Our support is handled through our support forums and is available to all Aspose users.

Support

We are developers ourselves and understand how frustrating it is when a technical issue or a quirk in the software stops you from doing what you need to do. This is why we offer free support. Anyone who uses our product, whether they have bought them or are using an evaluation, deserves our full attention and respect. We have four levels of support that can fit your needs.

> Everyone who uses Aspose products have access to our free support.

Work with the developers that developed and continue to maintain our products.

Support Options

Free

Everyone who uses Aspose products have access to our free support. Our software developers are on stand-by to help you succeed with your project, from the evaluation to roll-out of your solution.

Priority

If you want to know when you'll hear back from us on an issue and know that your issue is prioritized, Priority Support is for you. It provides a more formal support structure and has its own forum that is monitored by our software engineers.

Enterprise

Enterprise customers often have very specific needs. Our Enterprise Support option gives them access to the product development team and influence over the roadmap. Enterprise Support customers have their own, dedicated issue tracking system.

Sponsored

Available to Enterprise customers that would like to request features, this higher prioritized support can ensure your needed features are on our roadmap. A member of our team will produce a feature specification document to capture your requirements and how we intend to fulfill them so the direction development will take is clear up-front.

Pricing Info
To see the Priority and Enterprise support rates, refer to the product price list, or contact our sales team.
Sponsored Support is unique so pricing is specific to each project. Please contact our sales team to discuss.

Aspose has 4 Support Services to best suit your needs

Free Support	Support Forums with no Charge
Priority Support	24 hour response time in the week, issue escalation, dedicated forum
Enterprise Support	Communicate with product managers, influence the roadmap
Sponsored Support	Get the feature you need built now

Technical Support is an issue that Aspose takes very seriously. Software must work quickly and dependably. When problems arise, developers need answers in a hurry. We ensure that our clients receive useful answers and solutions quickly.

Email • Live Chat • Forums

Contact Us

US Sales: +1 903 306 1676
sales@aspose.com
EU Sales: +44 141 628 8900
AU Sales: +61 2 8006 6987

ASPOSE
File Format APIs