New Visual Studio 2013 Diagnostic Tools

Overview

In this lab, you will learn about some of the new diagnostic tools that were introduced with Visual Studio 2012 updates, as well as the new diagnostic tools introduced in Visual Studio 2013. You will also be introduced to the enhanced asynchronous debugging features found in Visual Studio 2013.

Objectives

In this hands-on lab, you will learn how to do the following:

- Use the Performance and Diagnostics Hub
- Use the UI Responsiveness Tools for JavaScript and XAML Windows Store applications
- Use the Energy Consumption Tool
- Analyze JavaScript Memory Usage
- Create and Analyze Managed Memory Dumps
- Use the enhanced asynchronous debugging features in Visual Studio 2013

Prerequisites

The following are required to complete this hands-on lab:

- Windows 8.1
- Microsoft Visual Studio 2013(with Update 2 RC applied)

Notes

Estimated time to complete this lab: **60** minutes.

Note: You can log into the virtual machine with user name “**User**” and password “**P2ssw0rd**”.

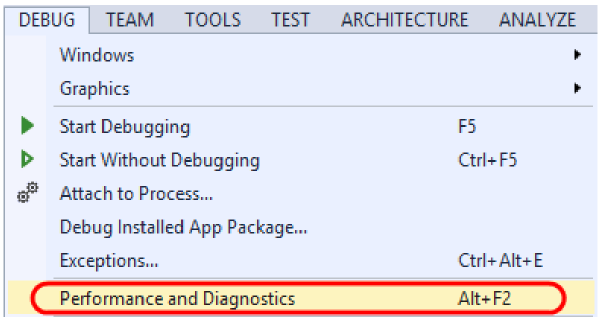
Note: This lab may make references to code and other assets that are needed to complete the exercises. You can find these assets on the desktop in a folder named **TechEd 2014**. Within that folder, you will find additional folders that match the name of the lab you are working on.

Exercise 1: Introduction to Performance and Diagnostics Hub

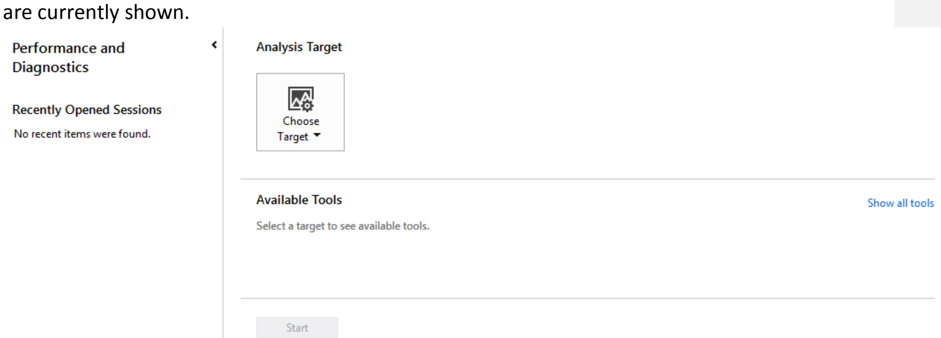
In this exercise, you will you will learn about the new Performance and Diagnostics Hub in Visual Studio 2013. The new hub brings together existing tools into one location, and makes it easier to see what tools are available for the current project based on the current language, application type, or platform. Future updates will also be surfaced here, increasing the discoverability for developers.

Task 1: Introduction to Performance and Diagnostics Hub

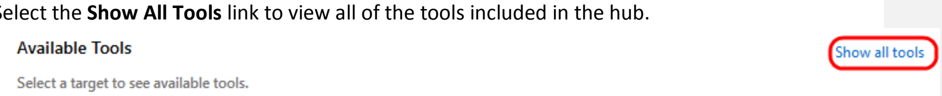
1. Open **Visual Studio 2013**.
2. To open the **Performance and Diagnostics hub**, you can either select it from the **Debug** menu or by pressing the **Alt+F2** shortcut.



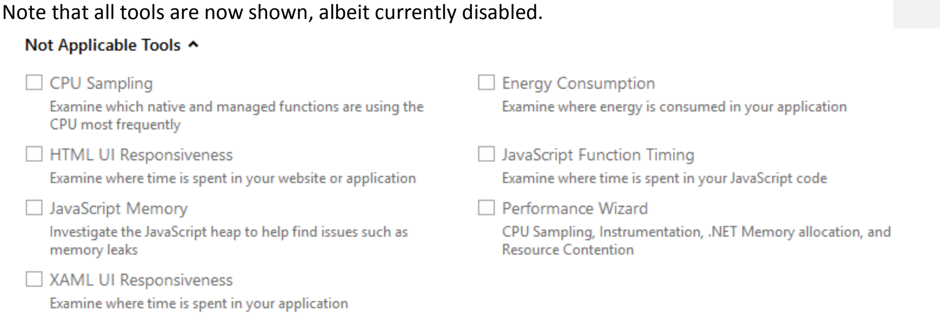
3. By default, the hub will only show you the tools that are available for the target based on language, application type, or platform. Since you don't have an analysis target chosen, no tools are currently shown.



4. Select the **Show All Tools** link to view all of the tools included in the hub.



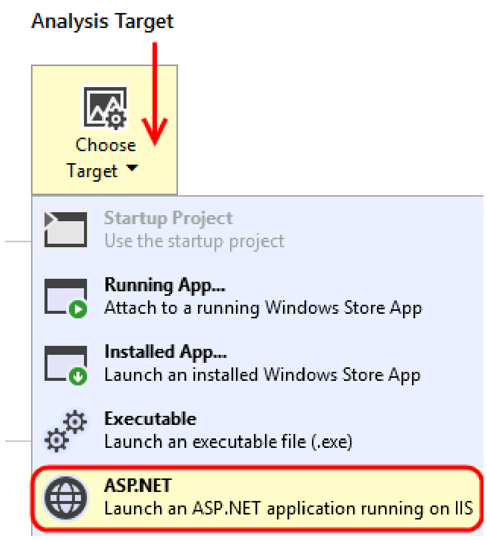
5. Note that all tools are now shown, albeit currently disabled.



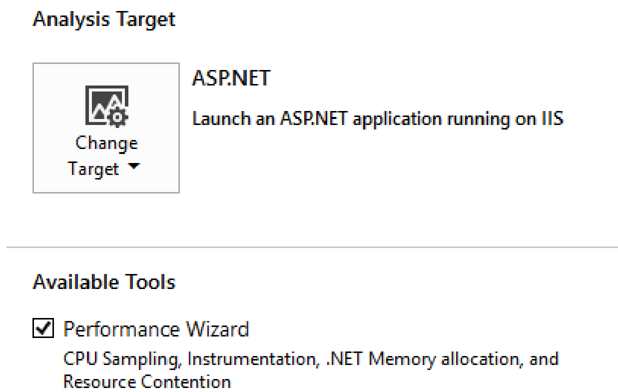
Note: Some of the tools shown here are not new in Visual Studio 2012 and 2013, but have simply been moved into the hub. These include the **Performance Wizard** and **JavaScript Function Timing** tools. New tools since Visual Studio 2012 include **CPU Sampling**, **JavaScript Memory**, and **HTML UI Responsiveness** (some were introduced in product updates). New tools since Visual Studio 2013 include **XAML UI Responsiveness** and **Energy Consumption**.

6. Select the "**Show target specific tools**" link to return to the default hub view.

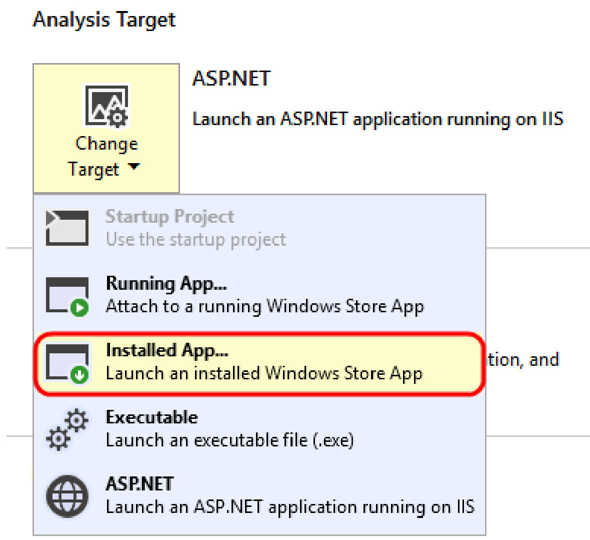
7. Select the **Choose Target** dropdown and select the **ASP.NET** option.



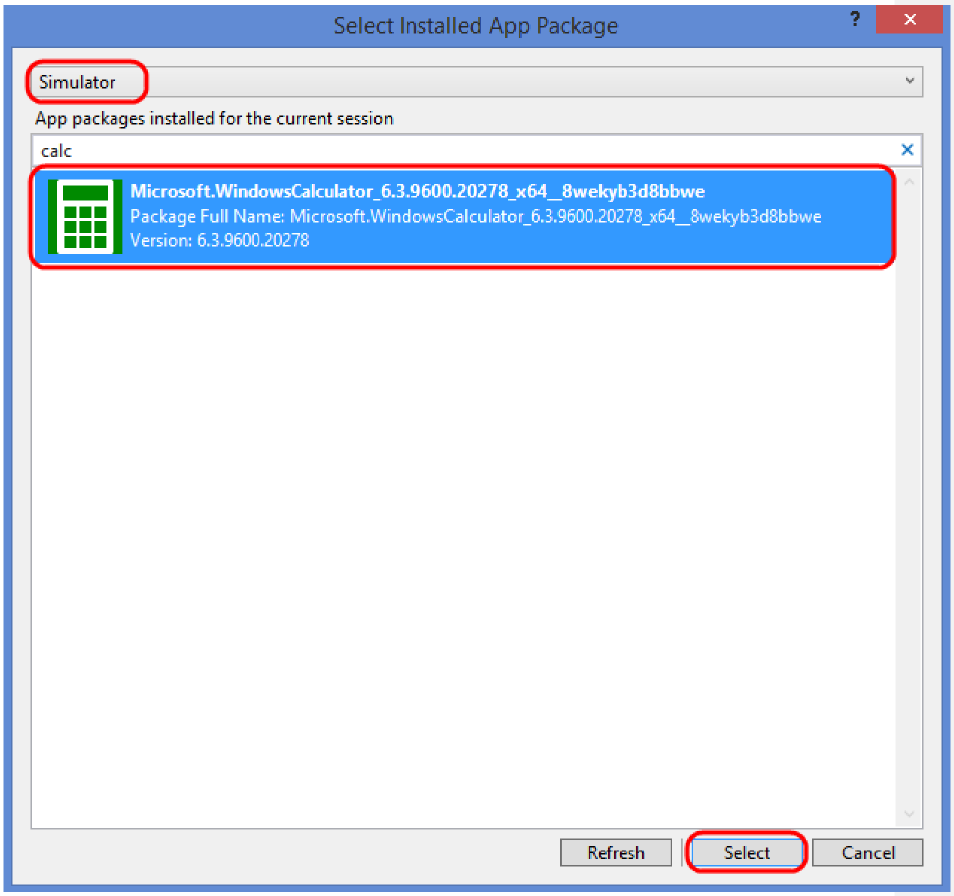
8. Note that the hub now shows the Performance Wizard as being the only available tool, and therefore automatically selects it. If you were to instead select the Executable analysis target, you would see the same thing.



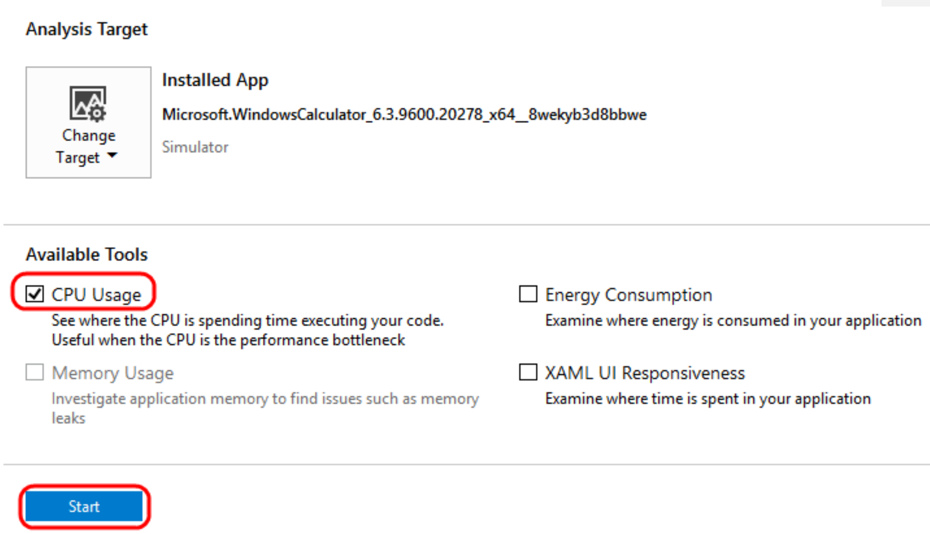
9. Select the **Change Target** dropdown (the name changed after selecting the first target) and then select the **Installed App...** option.



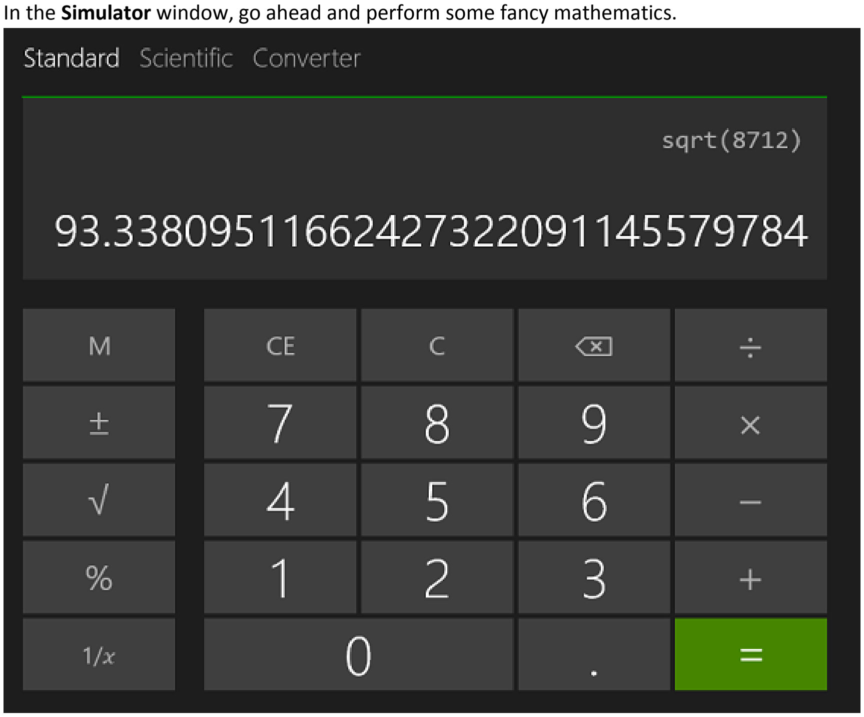
10. In the **Select Installed App Package** window, select the **Simulator** option from the dropdown, and then search for (type **'calc'** into the search box) and select the **Windows Calculator** app package. Click the **Select** button to continue.



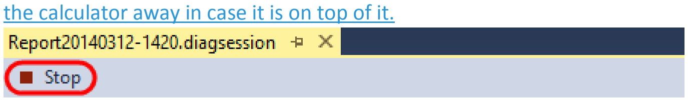
11. The available tools now include only those that can be used to analyze a XAML-based Windows Store application, which include CPU ~~Sampling~~Usage, XAML UI Responsiveness, and Energy Consumption.
12. Select the **CPU Usage** tool and then click **Start**.

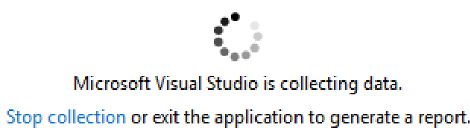


13. In the **Simulator** window, go ahead and perform some fancy mathematics.



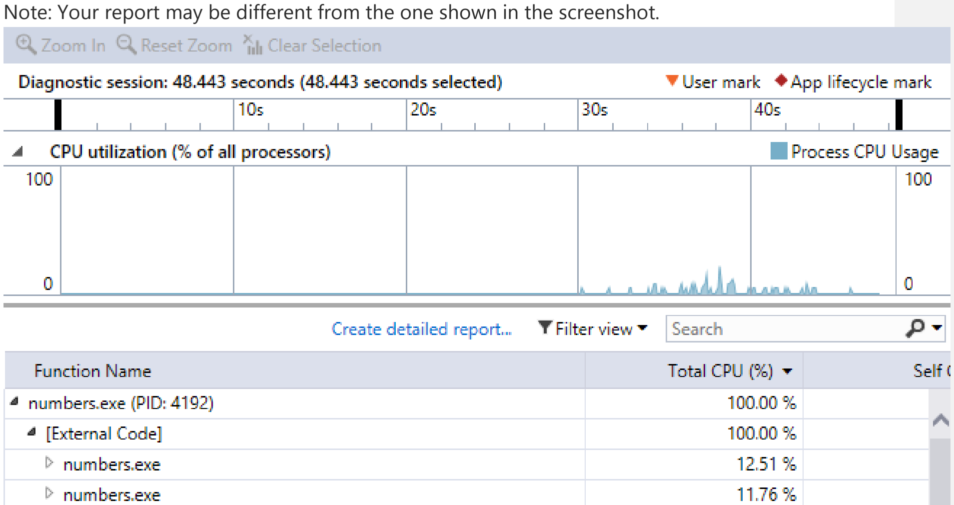
14. Return to Visual Studio and click the **Stop** button on the left corner on the Report's tab.. Move the calculator away in case it is on top of it.





15. After the report is generated, you should see the report opened in **Summary** view. This view is a starting point in your investigation into performance issues. From each line in the Summary view, you can move to more detailed views by right-clicking the function or module name.

    Note: Your report may be different from the one shown in the screenshot.



16. Although analyzing applications using the CPU Usage tool is not the focus of this lab, you can learn more about using the tool with Windows 8 and Windows Server 2012 applications (and above) in this MSDN article. The purpose of this task was to introduce the Performance and Diagnostics hub as a central starting point to access most performance and diagnostic tools from within Visual Studio 2013.
17. Close the profiling report but keep Visual Studio open.

Exercise 2: UI Responsiveness and Energy Consumption Tools

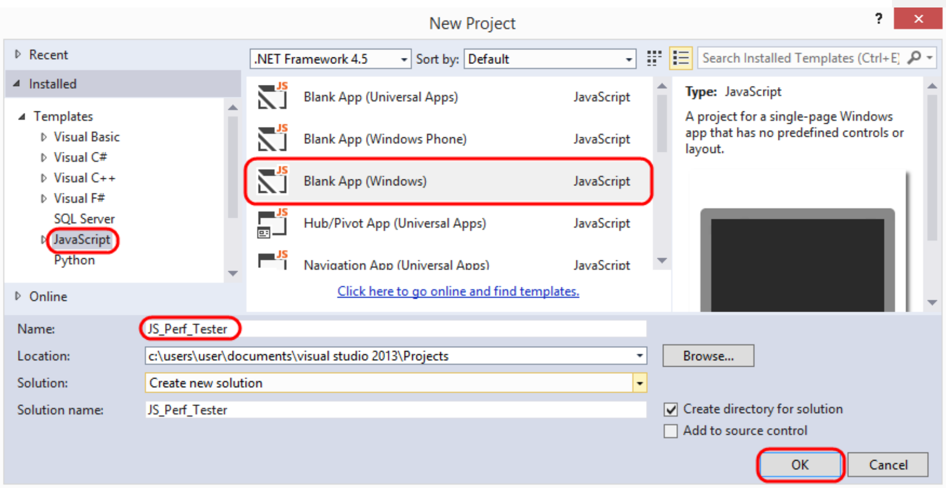
In this exercise, you will take a look at the diagnostic data that is collected when using the UI Responsiveness tools for Windows Store apps and then use that data to help create a fix that will improve a sample application. The key to maintaining a responsive app is keeping the UI thread as free as possible. After that, you will see what diagnostic data the Energy Consumption tool provides.

Note: Some of the new tools being shown in this lab are also available using the F12 developer tools in Internet Explorer 11.

Task 1: Create a JavaScript Windows Store Application for Testing

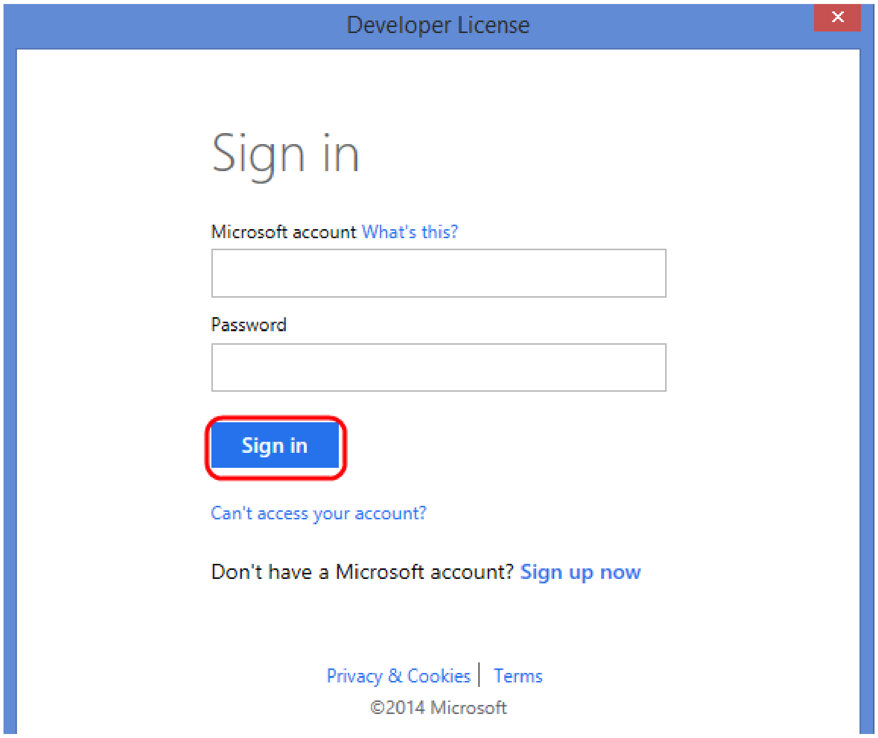
In this task, you will create a JavaScript Windows Store app that will be used for testing in the next task.

1. Select **File | New | Project**.
2. Under **Templates | JavaScript**, select the **Blank App (Windows)** template, enter **JS_Perf_Tester** in the **Name** field and then click the **OK** button to create the solution.

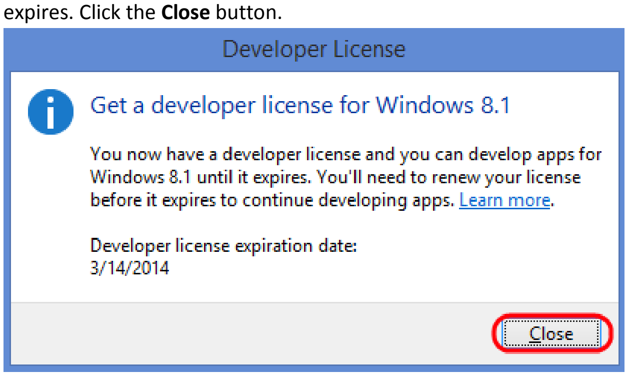


3. If you do not have a developer license for Windows 8.1 installed yet, you will be prompted to agree to the terms and then install a license. Click the "**I Agree**" button if you agree with the terms. You will also need to click **Yes** in the User Account Control dialog box that appears.

4. If you are installing a developer license, you may also need to sign in with your Microsoft account. Go ahead and sign in to finish the developer license installation.



5. After installing a developer license using a Microsoft account, you will be given 30 days before it expires. Click the **Close** button.



6. Open **default.html** and replace the existing contents of the **body** with the following markup.

HTML
```
<div class="wrapper">
```

```
    <button id="content">Waiting for values</button>
</div>
```

7. Open **default.css** and add the following CSS to the end.

```
HTML
#content {
    margin-left: 200px;
    margin-top: 200px;
}
```

8. Open **default.js** and replace the entire existing contents with the following code.

```
JavaScript
(function () {
    "use strict";

    var app = WinJS.Application;
    var activation = Windows.ApplicationModel.Activation;

    var content;
    var wrapper;

    app.onactivated = function (args) {
        if (args.detail.kind === activation.ActivationKind.launch) {
            if (args.detail.previousExecutionState !==
activation.ApplicationExecutionState.terminated) {

                content = document.getElementById("content");
                wrapper = document.querySelector(".wrapper");

                content.addEventListener("click", handler);

            } else {
            }

            args.setPromise(WinJS.UI.processAll());
        }
    };

    app.oncheckpoint = function (args) {
    };

    app.start();

    var idx = 0;
    var count = 0;
    var max = 5000;
    var text = ["eenie", "meenie", "minie", "moe"];
    var color = ["red", "crimson", "maroon", "purple"];
```

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```
    function increment() {

        setTimeout(function () {

            idx++;
            count++;

            if (idx > 3) { idx = 0; }
            if (count < max) { increment(); }

        }, 1000);
    }

    function setValues() {

        content = document.getElementById("content");
        content.removeNode(true);

        var newNode = document.createElement("button");
        newNode.id = "content";
        newNode.textContent = text[idx];
        newNode.style.backgroundColor = color[idx];

        wrapper.appendChild(newNode);
    }

    function update() {

        setTimeout(function () {

            setValues();
            if (count < max) { update(); }
        });
    }

    function handler(args) {
        performance.mark("Click");
        content.textContent = "eenie";
        increment();
        update();
    }

})();
```

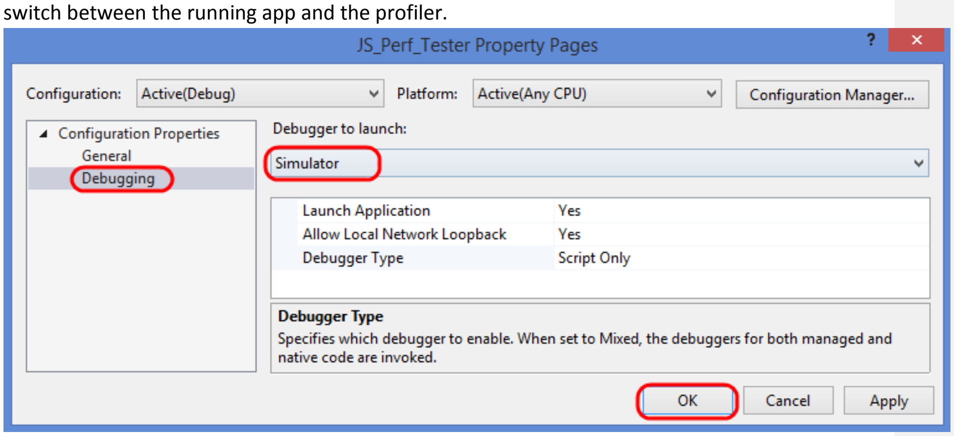
9. Press **F5** to compile the application and start debugging.
10. Click the “**Waiting for values**” button and verify that the button text and color are updated approximately once per second. This is by design.

11. Close the app by pressing **Alt+F4**. To return to the Desktop, either press **Win+D** or select the **Desktop** tile on the Start screen.

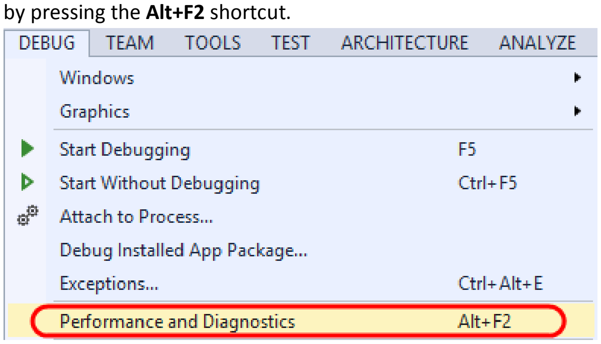
Task 2: Using the HTML UI Responsiveness Tool

In this task, you will use the HTML UI Responsiveness Tool to profile the Windows Store application you created in the previous task, and then use that data to help locate a performance problem and fix it.

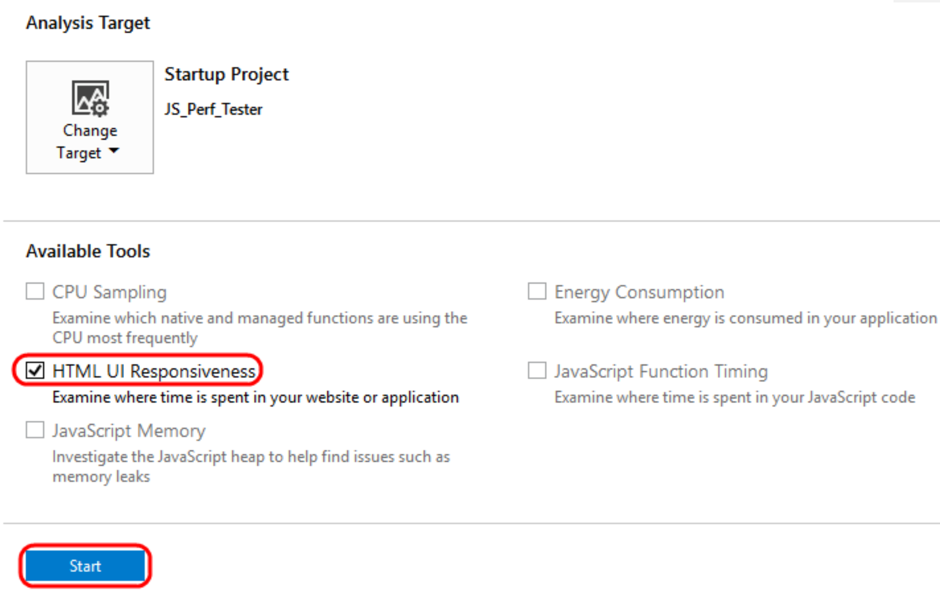
1. Before we start using the HTML UI Responsiveness tool, let's configure the application to use the Windows Simulator. In **Solution Explorer**, select the project node and press **Alt+Enter** to open the project properties window.
2. Select the **Debugging** page, select the **Simulator** debugger option and then click **OK**. One advantage of using the simulator here is that you can place it next to Visual Studio and easily switch between the running app and the profiler.



3. To open the **Performance and Diagnostics hub**, you can either select it from the **Debug** menu or by pressing the **Alt+F2** shortcut.

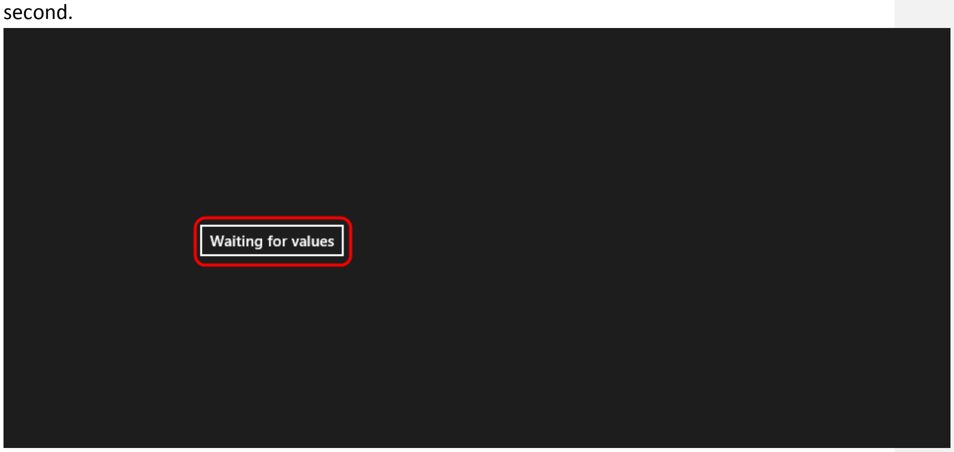


4. Select the **HTML UI Responsiveness** tool from the list of available tools and then click **Start**. In this case, you are using the default analysis target which is the startup project.



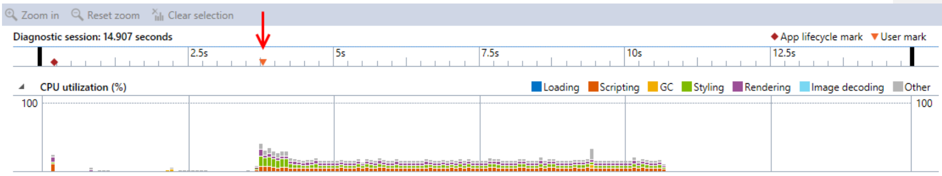
Note: When you start the profiler, you may see a User Account Control prompt requesting permission to run VsEtwCollector.exe. Click **Yes**.

5. In the simulator that is now running your app, click the "**Waiting for values**" button and then let it run for about **10** seconds. You should see the button text and color update about once per second.

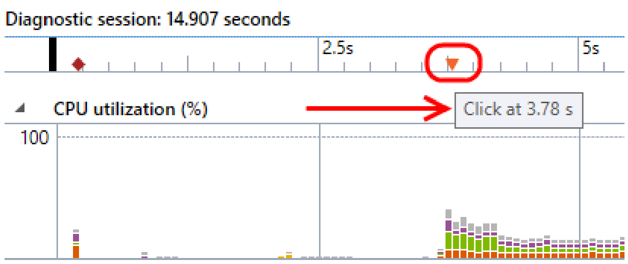


6. Switch back to **Visual Studio** and click the **Stop** button to stop the profiler.

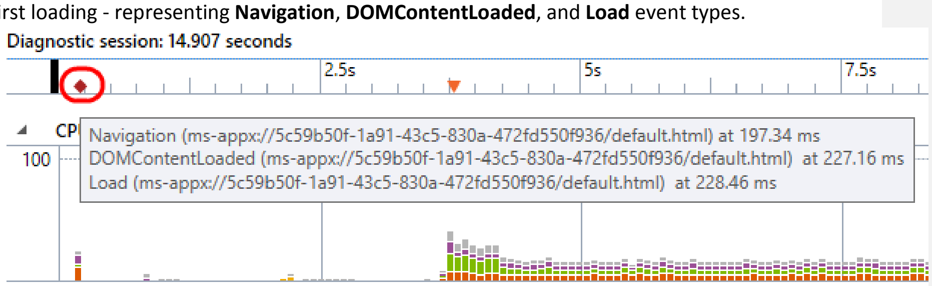
7. After the diagnostic session report is shown, take a look at the **CPU utilization** graph and note that it increases dramatically after a few seconds (at the point in time where you clicked the button).



8. The timeline bar at the top also shows various app lifecycle and user marks. If you hold the mouse cursor over the **user mark** (orange triangle) you should see the text "Click" with a time appended. This was recorded by the application using JavaScript in the button click handler.

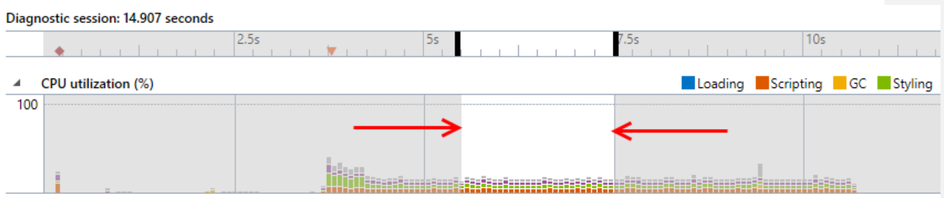


9. Hold the mouse cursor over the **app lifecycle mark** near the beginning of the timeline, and take note of the different events that were recorded around this time period as the application was first loading - representing **Navigation**, **DOMContentLoaded**, and **Load** event types.

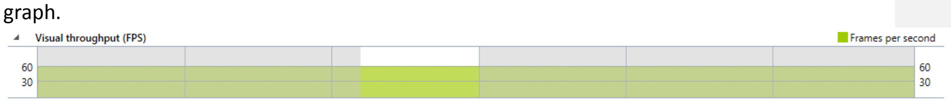


10. By default, you will be viewing data for the entire length of the diagnostic session. Select a couple seconds from the middle portion of the CPU utilization graph using a **click-and-drag** selection technique, after the point where the button was clicked.

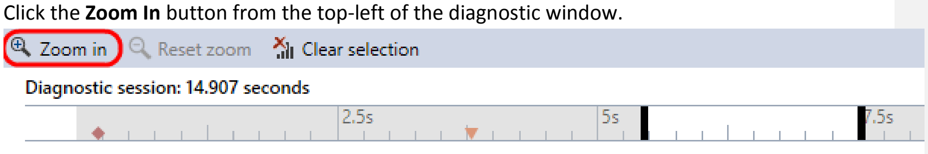
    Note: the non-shaded area represents the selection.



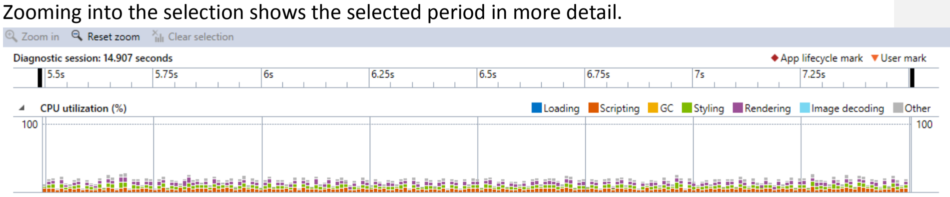
11. Also take note of the **Visual throughput (FPS)** graph. In this case, the FPS remains at 60 throughout the diagnostic session, therefore there are no dropped frames. Periods of excessive CPU utilization can result in low or inconsistent frame rates. If you develop rich media apps and games, the visual throughput graph may provide more important data than the CPU utilization graph.



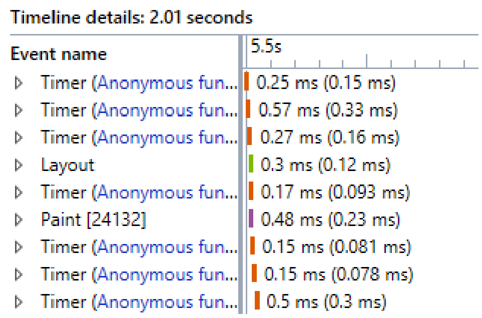
12. Click the **Zoom In** button from the top-left of the diagnostic window.



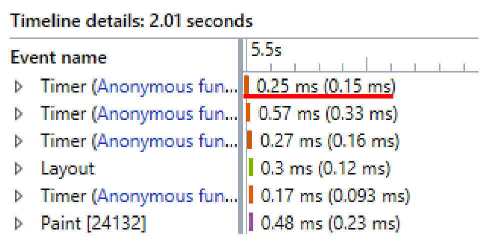
13. Zooming into the selection shows the selected period in more detail.



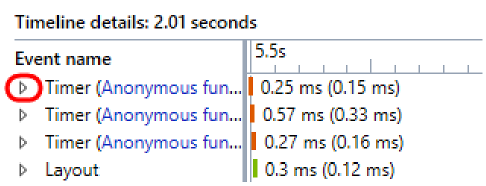
14. The **Timeline Details** section shows the filtered events for the selected period. By default, the timeline is sorted sequentially, meaning that events that occurred earlier in time will appear higher (and to the left) than events which occurred later. These events confirm the visible trends that you saw in the CPU utilization graph, in that there are many events taking place over short periods of time.



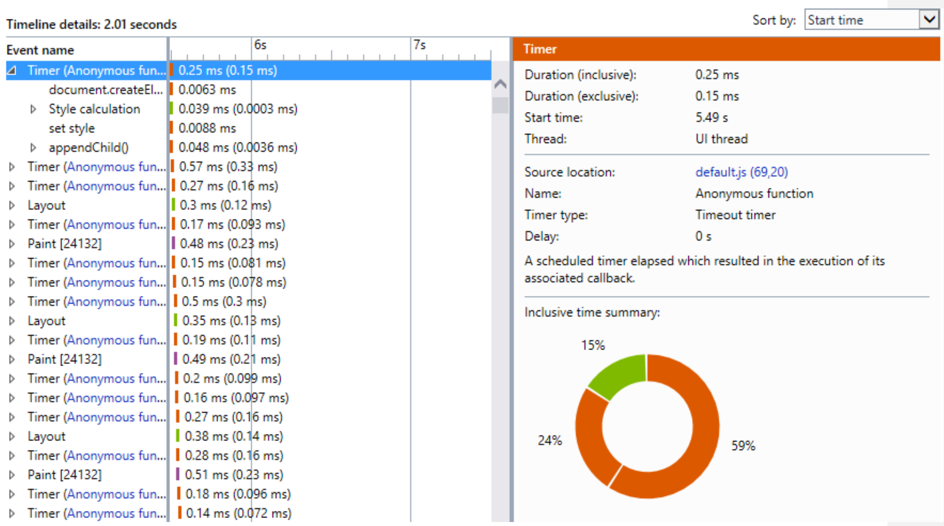
15. As is the case with the CPU utilization graph, the colors next to each event correspond to categories such as Loading, Scripting, Styling, Rendering, and so on. The first number next to each event corresponds to the **inclusive duration** time, and the second number to the **exclusive duration** time.



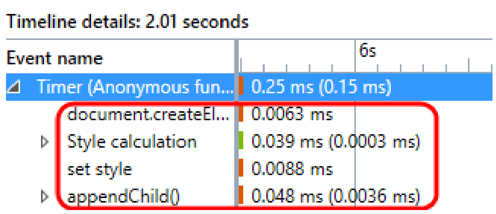
16. Select and expand the first **Timer** event.



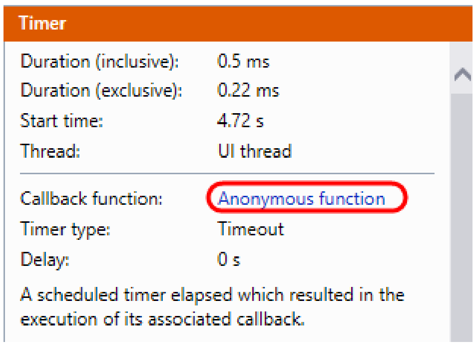
17. Selecting an event will show a details pane to the right. This shows us that this Timer event executed an anonymous function in default.js and kicked off a number of other processes as a result (represented by the child events). Note that the **Delay** property for the timer is **0**, meaning no delay.



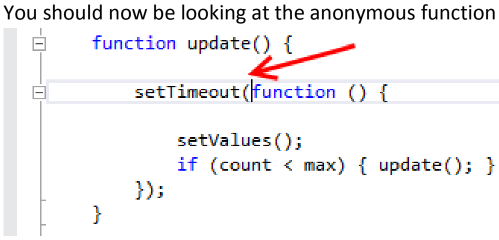
18. Take a look through the various child events recorded for the same timer event. This shows that there is a call to document.createElement(), followed by a style calculation, and finally a call to appendChild().



19. In the short time span selected (approximately one to two seconds), there are a great number of Timer, Layout, and Paint events taking place. **Timer** events occur most frequently, far more frequently than the one update per second that is visibly apparent after you run the app and click the button.
20. Click the **Source Location** link to navigate to **default.js** and the location of the anonymous function that was called.



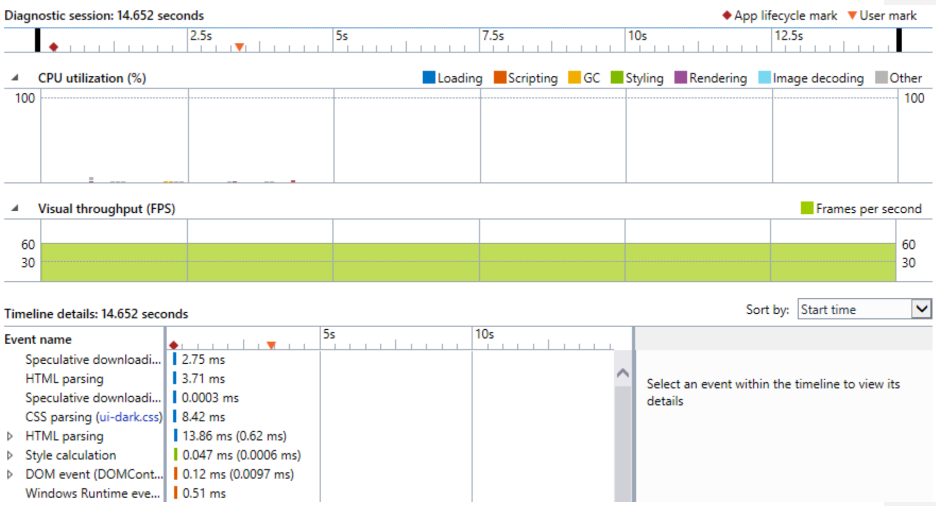
21. You should now be looking at the anonymous function definition.



22. As you can see, this anonymous function calls **setValues()**, which updates the button in the UI. Unfortunately, it appears that this function is running too frequently (as you just saw quite a few associated Timer events), and is therefore updating the UI when it isn’t necessary. This is due to the use of a default timeout value of 0 in the call to **setTimeout()**.
23. To fix the problem, add a second parameter to the setTimeout() call that specifies a 1000 millisecond delay. You can do this by replacing the **update()** function with the following. This will fix the issue with the excessive Timer events.

```
JavaScript
function update() {

    setTimeout(function () {

        setValues();
        if (count < max) { update(); }
    }, 1000);
}
```

24. Run the HTML UI Responsiveness tool again, click the button, and then check the CPU utilization graph to verify that this reduces utilization as expected. Also note that the excessive Timer events are now gone.

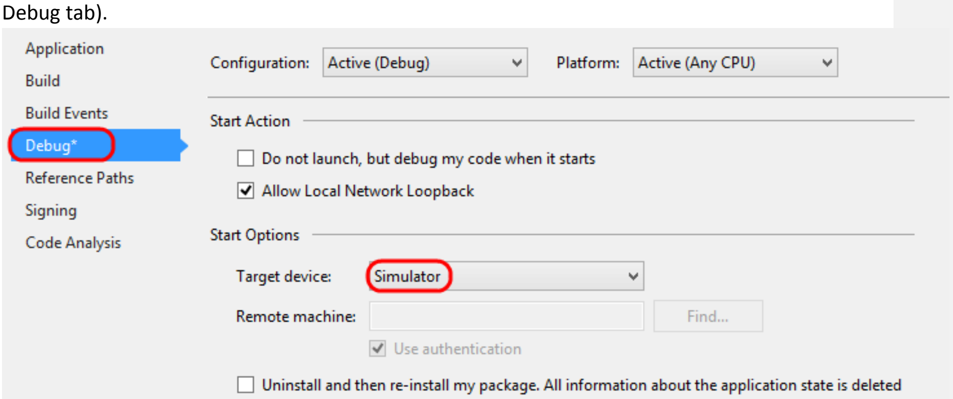


25. If you are interested in learning more about analyzing UI responsiveness in JavaScript applications, you can take a look at this MSDN article.

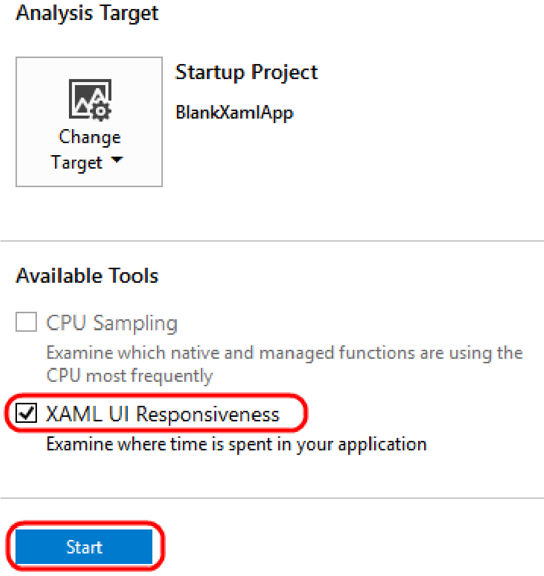
Task 3: Using the XAML UI Responsiveness Tool

In this task, you will use the XAML UI Responsiveness Tool to profile a XAML Windows Store application, and then use that data to help locate a performance problem and fix it.

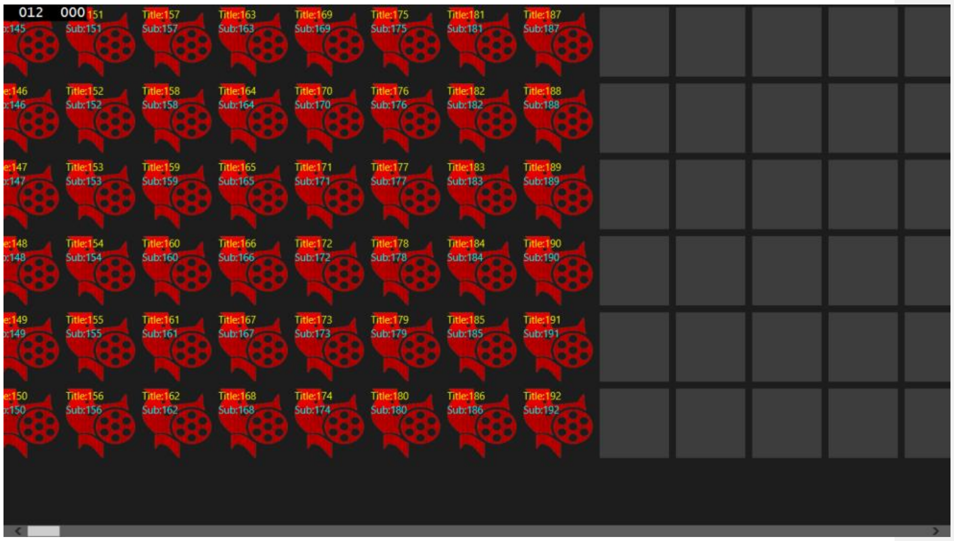
1. Open the **BlankXamlApp.sln** solution file found in the lab's **Source\BlankXamlApp** folder.
2. Configure the project to use the **Windows Simulator** when debugging as you did at the beginning of the previous exercise (although this time look for the Target Device setting on the Debug tab).



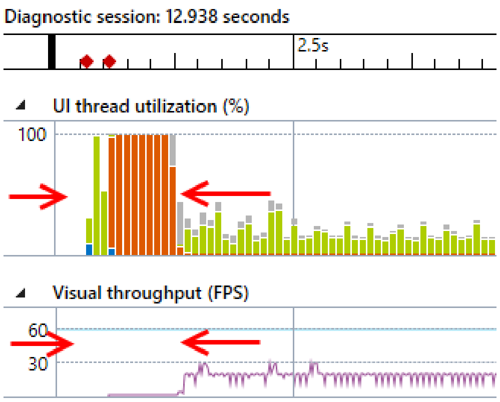
3. Open the **Performance and Diagnostics hub**, select the **XAML UI Responsiveness** tool, and then click **Start**.



4. The application simply shows a grid view with a bunch of data items. Each data item shows a few lines of data-bound text and contains a background image. As you scroll to the right, you should notice that the animation is not very smooth and that it can take quite a while before new tiles are shown. The app does not feel very responsive.

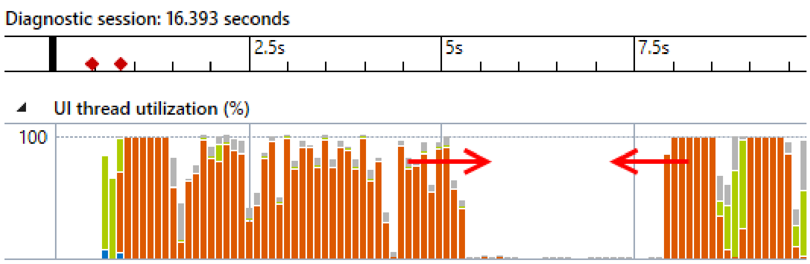


5. Switch back to **Visual Studio** and click the **Stop** button to stop the profiler.
6. After the diagnostic session report is shown, take a look at the **UI thread utilization (%)** graph. This shows that it took quite a while and required quite a bit of layout work before the initial tiles were visible. The **Visual throughput** graph also bears this out as the FPS was close to zero during this time period.

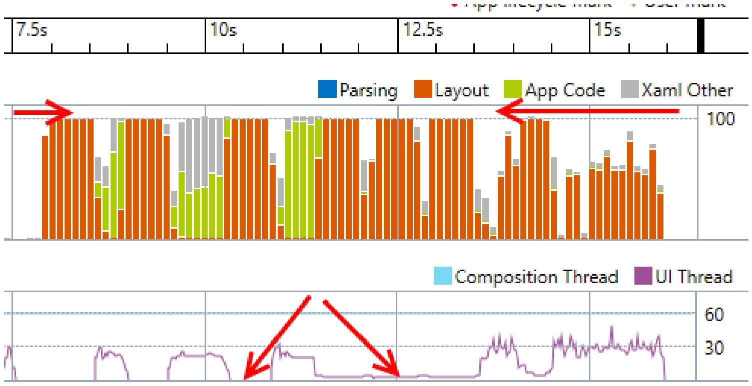


Note: You can also add user marks to XAML-based Windows Store applications, although we will not do so in this lab.

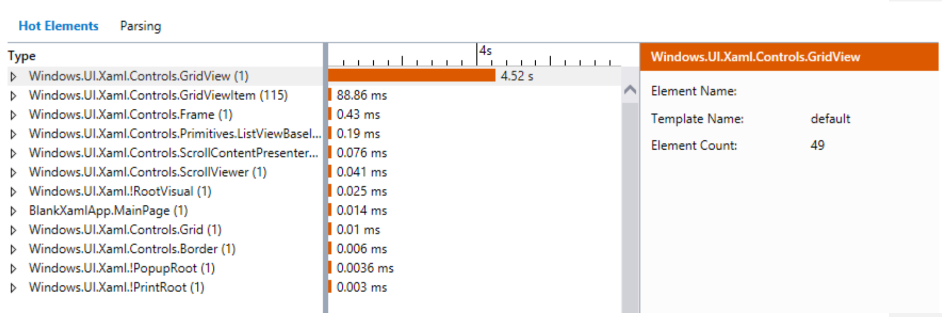
7. Looking further down the UI thread utilization graph, there may be a period where no layout was occurring before you started scrolling through more items.



8. Looking further down the UI thread utilization graph, note that layout code starts to dominate the UI thread once again, and the visual throughput drops significantly.

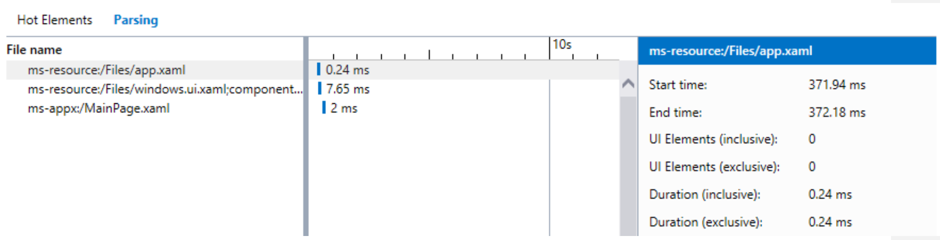


9. The XAML UI Responsiveness tool shows two detailed views below the graphs. The first view is named **Hot Elements**, and this contains a horizontal bar graph that represents all of the elements that participated in layout during the selected portion of the diagnostics session. They are grouped by their template and sorted in descending order by the time they took for layout. Note that the **GridView** control and its children were responsible for a large portion of the layout time.



10. Select the **Parsing** link tab.

11. The parsing view doesn't indicate that parsing is a significant contributor to overall UI thread utilization as it only took a few milliseconds.



12. Switch back to the **Hot Elements** tab.
13. Leave the diagnostic session window open, as you can compare this baseline to future runs.
14. Open **MainPage.xaml** and take a look at the XAML.

```
<GridView x:Name="myGridView"
          ItemsSource="{Binding}"
          SelectionChanged="myGridView_SelectionChanged"
          Background="{StaticResource ApplicationPageBackgroundThemeBrush}"
          ContainerContentChanging="MyGridView_ContainerContentChanging"
          >
    <GridView.ItemTemplate>
        <DataTemplate>
            <StackPanel Height="100"
                        Width="100" Background="{StaticResource ImageBrush1}"
                        >
                <Rectangle x:Name="placeholderRectangle"
                           Fill="Red"
                           Opacity="0"/>
                <TextBlock x:Name="titleTextBlock"
                           Text="{Binding Title}"
                           Foreground="Yellow"/>
                <TextBlock x:Name="subtitleTextBlock"
                           Text="{Binding Subtitle}"
                           Foreground="Aqua"/>
                <TextBlock x:Name="descriptionTextBlock"
                           Text="{Binding Description}"
                           Foreground="Gray"/>
            </StackPanel>
        </DataTemplate>
    </GridView.ItemTemplate>
```

15. The **GridView** is ultimately bound to a list of data items in code, and it uses a data template definition to display each item. In an attempt to improve UI responsiveness, the developer of the application tried to take advantage of the new ContainerContentChanging event, but unfortunately it appears that the code added to the handler is quite expensive.

16. Place the cursor anywhere on the event handler assignment for the ContainerContentChanging event (**MyGridView_ContainerContentChanging**) and then press **F12** to go to the definition in the code behind.

```
<GridView x:Name="myGridView"
          ItemsSource="{Binding}"
          SelectionChanged="myGridView_SelectionChanged"
          Background="{StaticResource ApplicationPageBackgroundThemeBrush}"
          ContainerContentChanging="MyGridView_ContainerContentChanging"
          >
    <GridView.ItemTemplate>
```

17. The first line of the event handler makes a call to a long running operation, and is likely to be a major contributor to the poor responsiveness that you just experienced.

```
// Display each item incrementally to improve performance.
1 reference
private void MyGridView_ContainerContentChanging(
        ListViewBase sender,
        ContainerContentChangingEventArgs args)
{
    LongOperation(939391);

    args.Handled = true;
```

18. For the purposes of this lab, assume the following about the long running operation:

- It needs to be performed here and can't be optimized significantly

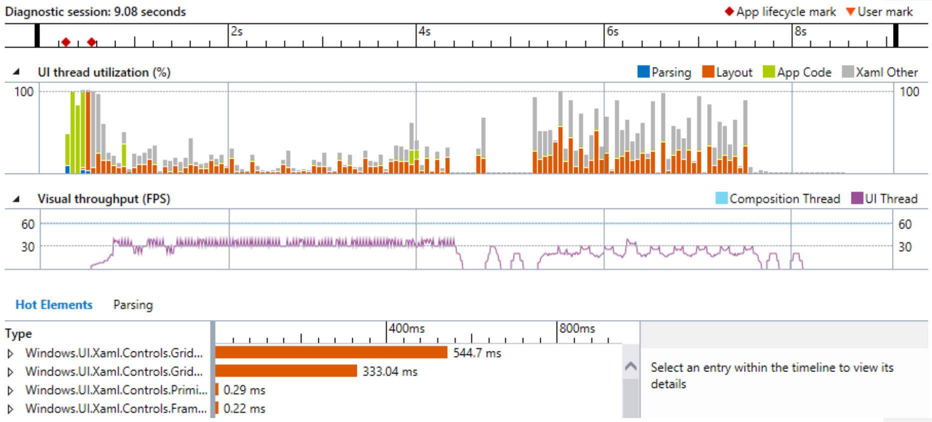
- It can be performed asynchronously (code later in the handler is not dependent on the result)

19. Wrap the line of code representing the long running operation by using **Task.Run()** to offload the operation from the UI thread.

```
// Display each item incrementally to improve performance.
1 reference
private void MyGridView_ContainerContentChanging(
        ListViewBase sender,
        ContainerContentChangingEventArgs args)
{
    Task.Run(() =>
    {
        LongOperation(939391);
    });

    args.Handled = true;
```

20. Run the **XAML UI Responsiveness** tool once again, performing a similar test that you previously did including scrolling through the items. You should notice a marked improvement in responsiveness as you scroll. Note that the third line of text, which is meant to be a description, still takes a significant amount of time to render.
21. **Stop** the profiler to view the report.

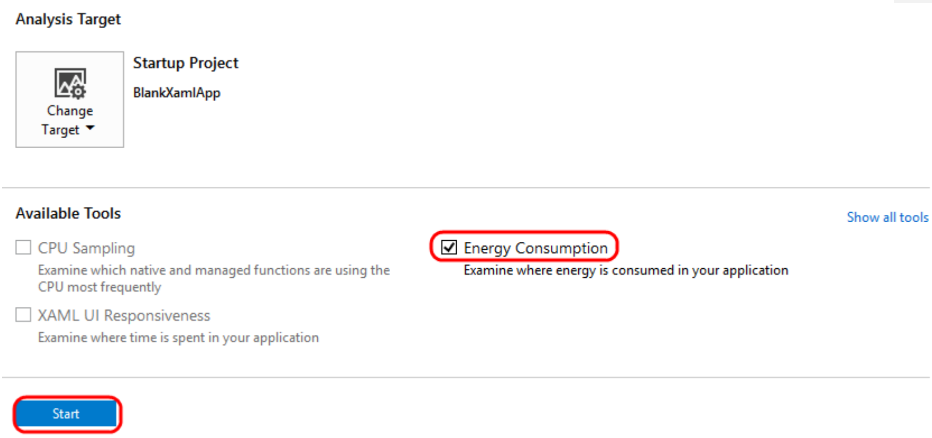
22. Note that the UI thread utilization percentage is much less than it was before. You can switch between the before and after reports to see this.



Task 4: Using the Energy Consumption Tool

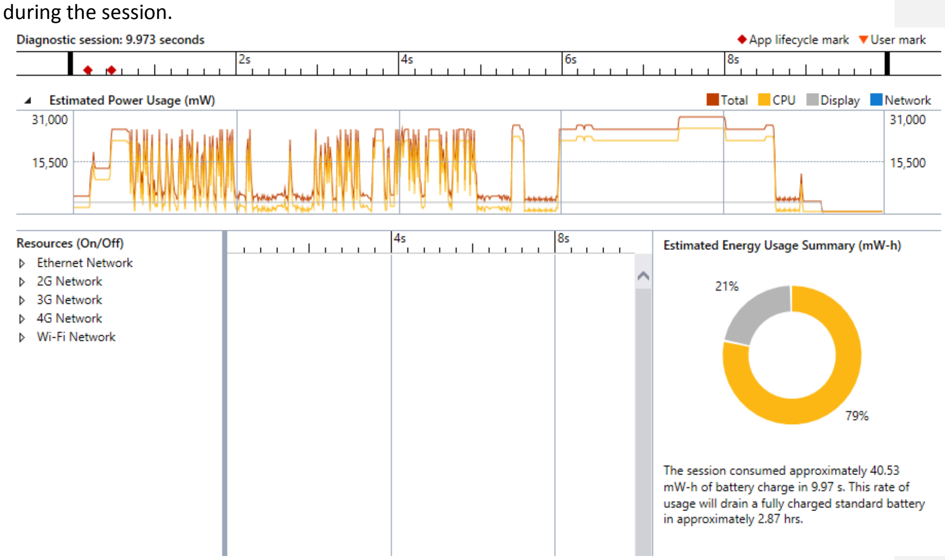
In this task, you will use the Energy Consumption Tool to profile a XAML Windows Store application, and then use that data to help give you an idea of the energy requirements. This profiler helps you analyze the power and energy consumption of Windows Store apps on low-power tablet devices that run all or part of the time on their own batteries. On a battery-powered device, an app that uses too much energy can cause so much customer dissatisfaction that, eventually, customers might even uninstall it. Optimizing energy use can increase your app's adoption and use by customers.

1. Open the **Performance and Diagnostics hub**, select the **Energy Consumption** tool, and then click **Start**.

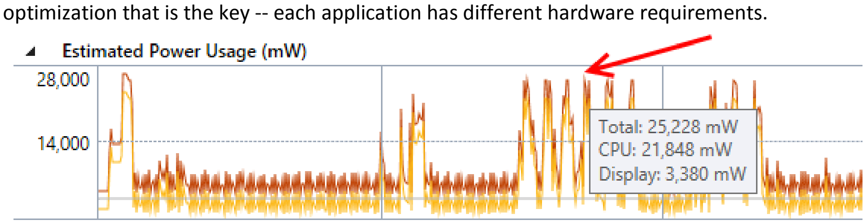


Note: Energy profiling using the Windows Store simulator or on the same computer as Visual Studio is running on is not generally recommended, as profiling on the actual device provides far more realistic data. The energy profiler **estimates** power and energy use by using a software model of standard reference device hardware that is representative of the low powered tablet devices your application might run on.

2. Scroll through the application for a few seconds and then Switch back to **Visual Studio** and click the **Stop** button.
3. The diagnostic session report for the **Energy Consumption** tool shows the activity level of the display, CPU, and network connections and shows estimates of the power and total energy used during the session.

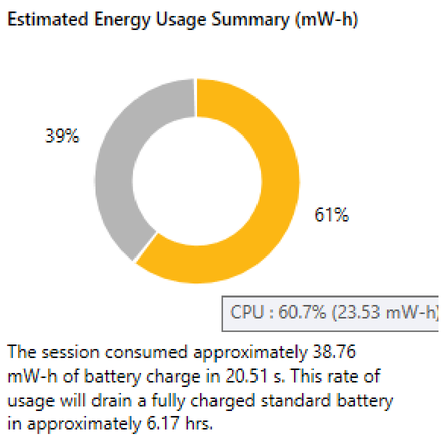


4. If you hold the mouse cursor over areas of **peak power** usage (associated with your scrolling), you'll note that the CPU energy usage spikes, but the estimated display power usage remains constant. Looking for spikes in power usage can help you identify potential areas for further optimization. Although the magnitude of the power usage numbers can be useful (if collected from a real device), it's the relative measure of any savings that you can produce through optimization that is the key -- each application has different hardware requirements.



Note: **Power** measures the rate that force is used to perform work that is done in a period of time. In electrical science, the standard unit of power is a watt, which is defined as the rate at which work is done when one ampere of current flows through an electrical potential difference of one volt. In the **Power Usage** graph, the units are displayed as milliwatts (**mW**) which are one thousandth of a watt.

5. If you hold the mouse cursor over the total energy use summary pie graph, you can see the estimate for each category. This shows that it is estimated that the CPU consumes most of the energy over the profiling period, with the remainder going to the display.



Note: **Energy** measures the total amount of power, either as a capacity or potential, as in the power capacity of a battery, or as the total amounted of power expended over a period of time. The unit of energy is a watt-hour, the amount of power of one watt constantly applied for one hour. In the **Energy Summary**, the units are displayed as milliwatt-hours (**mW-h**).

Note: To obtain the good estimates, you'll want to profile the energy use of the app on a low-powered device that is being powered by its batteries. Because Visual Studio does not run on most of these devices, you'll need to connect your Visual Studio computer to the device using the Visual Studio remote tools. To connect to a remote device, you need to configure both the Visual Studio project and the remote device.

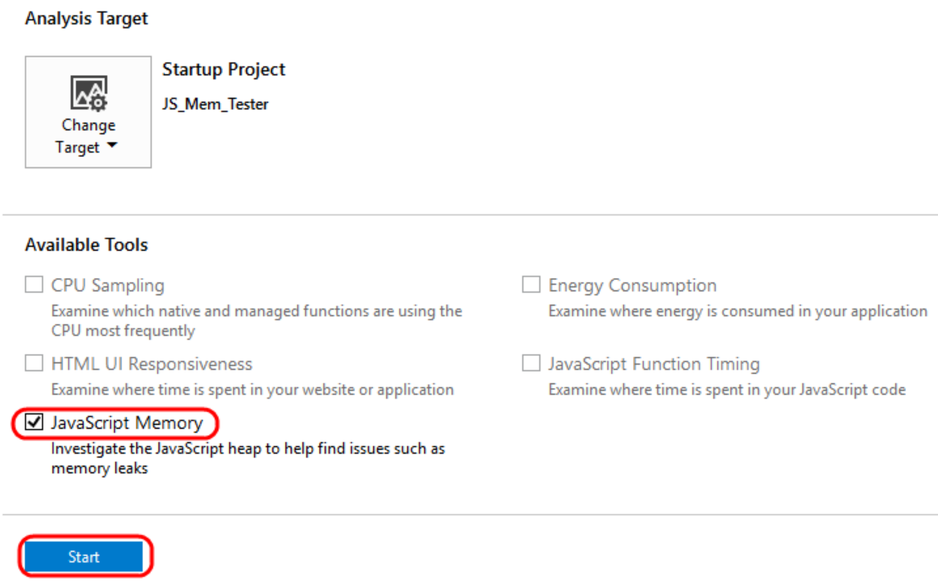
Exercise 3: Memory Tools and Diagnostics

In this exercise, you will learn how to analyze JavaScript Windows Store applications for memory leaks and analyze managed memory dump files.

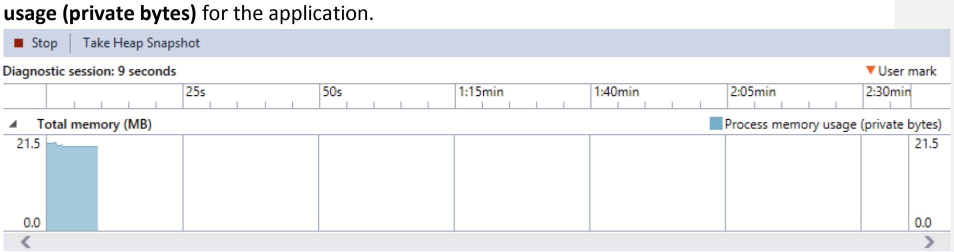
Task 1: Analyze JavaScript Memory Usage

In this task, you will use the JavaScript memory analyzer to help identify a simple memory issue in a Windows Store application.

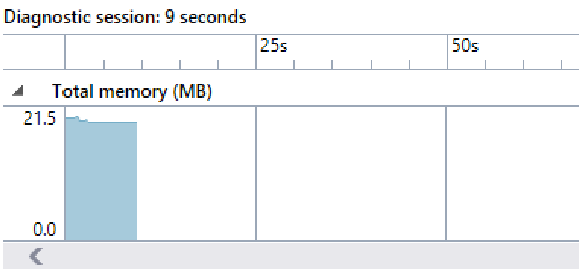
1. Open the **JS_Mem_Tester.sln** solution file found in the lab's **Source\JS_Mem_Tester** folder.
2. Configure the project to use the **Windows Simulator**.
3. Open the **Performance and Diagnostics hub**, select the **JavaScript Memory** tool, and then click **Start**.

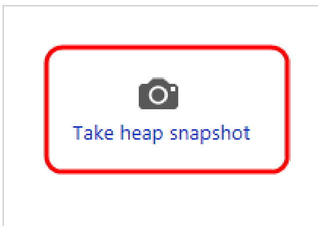


4. After the app is launched in the simulator, you should see a button named **Leak Memory**.
5. In Visual Studio, the diagnostic session window shows the JavaScript memory analyzer information. The **Total memory** graph is updated regularly to show the current **process memory usage (private bytes)** for the application.



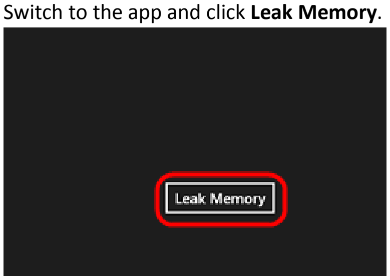
6. Click the **Take heap snapshot** button. This represents your baseline snapshot.





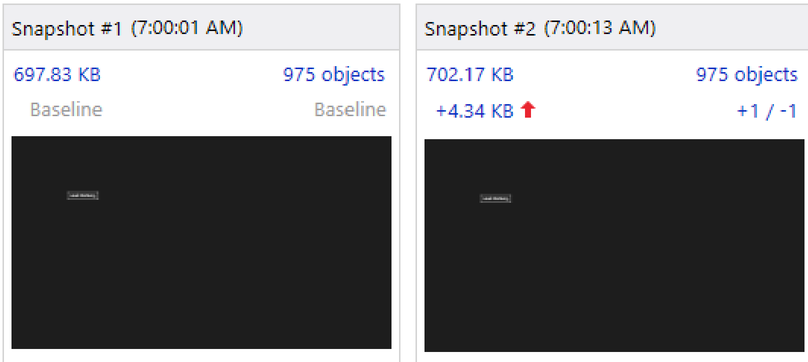
Note: In your own scenarios, take your first snapshot just before a suspected memory leak, if possible.

7. Switch to the app and click **Leak Memory**.

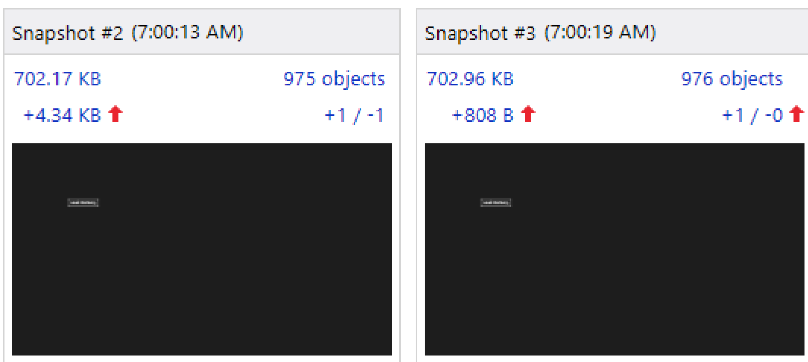


8. In this scenario, you suspect that you just performed an action that may result in a memory leak. Switch to Visual Studio and click **Take heap snapshot** again.
9. Switch to the app and click **Leak Memory** again.
10. Switch to Visual Studio and click **Take heap snapshot** for the third time. By taking a third snapshot in this workflow, you can filter out changes from the baseline snapshot to the second snapshot that aren't associated with memory leaks. For example, there may be expected changes such as updating headers and footers on a page, which will generate some changes in memory usage but may be unrelated to memory leaks.
11. In Visual Studio, click the **Stop** button to stop profiling.
12. Start analyzing the snapshots by comparing the first two. **Snapshot #2** shows that the heap size (shown by the red up arrow on the left) has increased by more than 4 KB compared to the

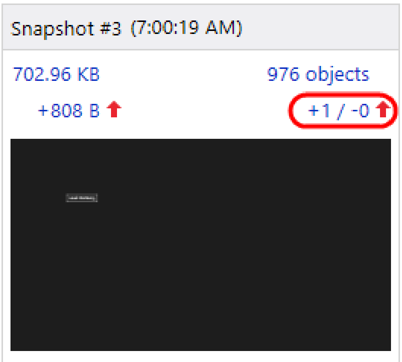
baseline snapshot. In addition, the number of objects on the heap (shown by the red up arrow on the right) has increased compared to the baseline, with one object added and one removed.



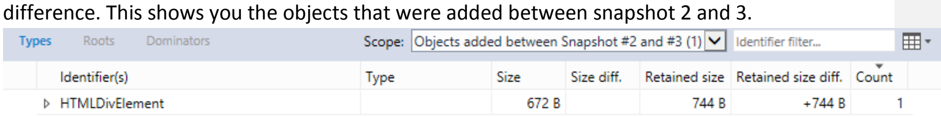
13. **Snapshot #3** shows that the heap size has increased again compared to the previous snapshot, with one object added and no objects removed.



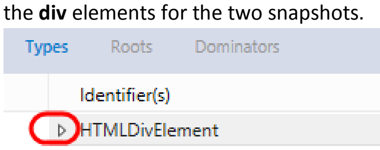
14. In **Snapshot #3**, select the "**+1 / -0**" link to view a differential view of the objects on the heap compared to Snapshot #2.



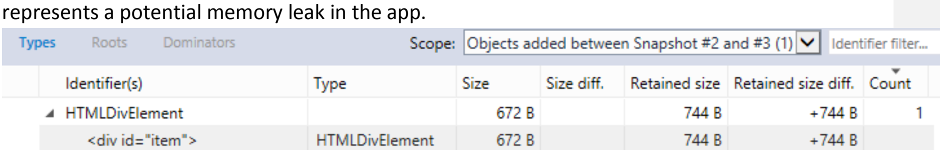
15. The differential view of heap objects shows the **Types** view by default, sorted by object count difference. This shows you the objects that were added between snapshot 2 and 3.



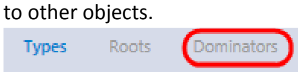
16. Expand the **HTMLDivElement** group at the top of the list to view additional information about the **div** elements for the two snapshots.

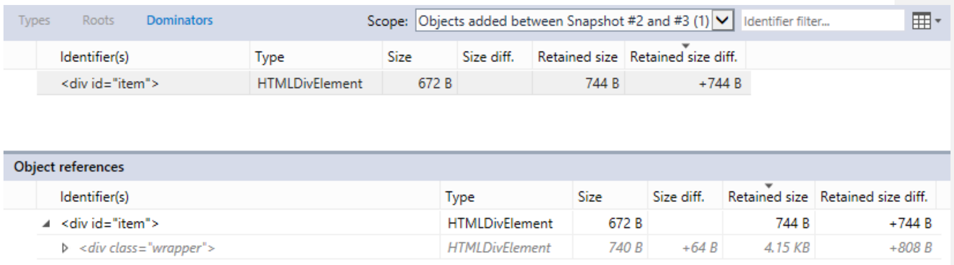


17. The div element that has been added to the heap between Snapshot #2 and Snapshot #3 represents a potential memory leak in the app.



18. Select the **Dominators** tab. This view shows a list of heap objects that have exclusive references to other objects.





19. In this scenario, the **Dominators** view shows similar information to the Types view, but the information is sorted by retained size instead of object count. When you remove a dominator from memory, you reclaim all memory that the object retains. A diff view of the dominators can be helpful to quickly identify the objects that consume the most memory.
20. Some knowledge of the app helps at this point; choosing the Leak Memory button should remove a DIV element as well as add an element, so the code doesn't seem to be working right (that is, it leaks memory). The next task shows how to fix that.

Task 2: Fixing the JavaScript Memory Leak

In this task, you will fix the memory leak.

1. From the analysis of the JavaScript memory usage, you determined that div elements with an ID of "item" may be leaking. Open the **default.js** script file from the **js** folder for the project.
2. Scroll down and locate the **initialize** function. This is called each time the **run** function is called, which is on first load of the app and each time the button is clicked. It appears that it is attempting to remove a cached div element with a call to **removeNode**, so that doesn't explain why a leak is occurring.

```
function initialize() {

    if (wrapper != null) {
        elem.removeNode(true);
    }
}
```

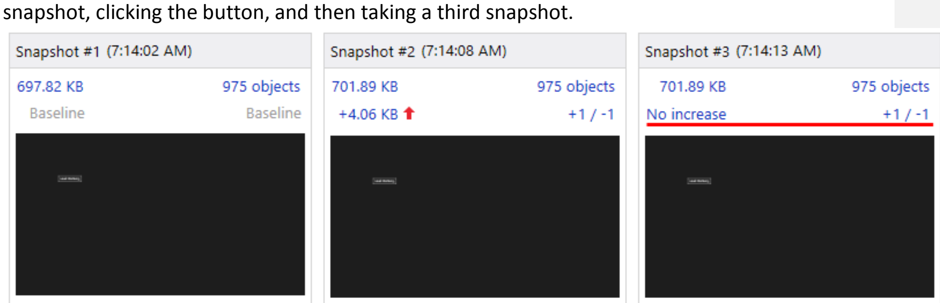
3. Take a look at the load function. In part, it creates a new **div** element and appends it as a child of the **wrapper** div element. However, it doesn't update the cached div element (which the initialize method uses later in an attempt to remove the old div element).

```
function load() {

    wrapper = document.querySelector(".wrapper");

    var newDiv = document.createElement("div");

    var img = new Image();
    img.src = "/images/logo-scale-100.png";
    newDiv.style.backgroundImage = 'url(' + img.src + ')';
    newDiv.style.zIndex = "-1";
    newDiv.id = "item";

    //elem = newDiv;
    wrapper.appendChild(newDiv);
}
```

4. Fix the memory leak by uncommenting the line that assigns the new div element to the cached element reference named “**elem**”.

```
        newDiv.style.zIndex = "-1";
        newDiv.id = "item";

        elem = newDiv;
        wrapper.appendChild(newDiv);
    }
```

5. Using the same steps as before, use the **JavaScript Memory** tool to analyze the memory usage of the app by taking a baseline snapshot, clicking the Leak Memory button, taking a second snapshot, clicking the button, and then taking a third snapshot.



6. **Snapshot #3** now shows the heap size has no increase over Snapshot #2, and the object count is shown as **+1 / -1**, which indicates that one object was added and one removed. This is the expected behavior for the app, so the memory leak has been fixed.
7. You can close any Visual Studio instances you have open at this point.

Task 3: Debug Managed Memory

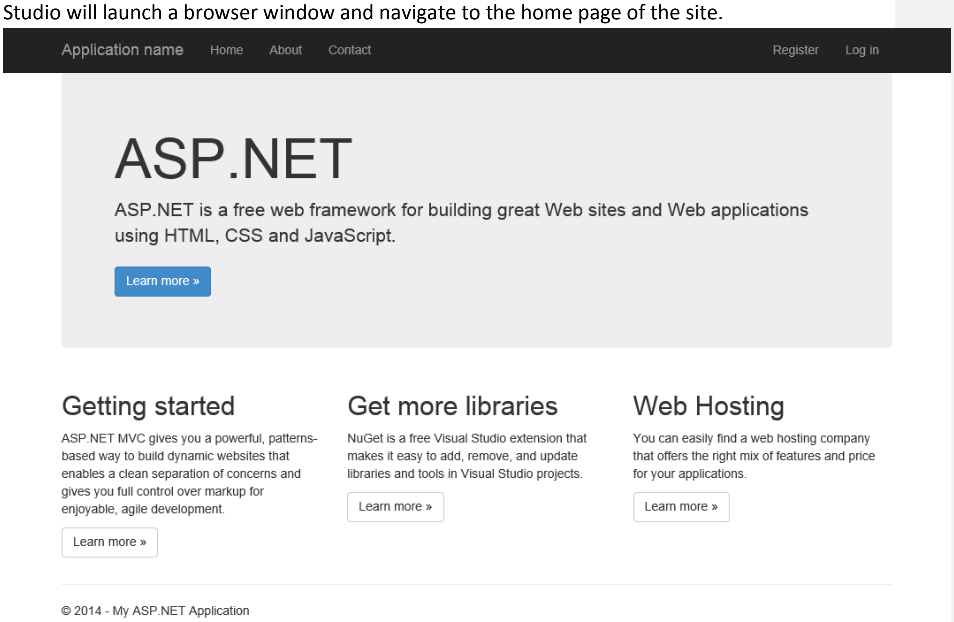
In this task, you will learn how to use the Debug Managed Memory feature found in Visual Studio Ultimate 2013 to help diagnose memory issues from production environments. These memory issues can fit in to a number of categories, including memory leaks, inefficient memory usage, and unnecessary allocations.

Note: this task requires Visual Studio Ultimate 2013.

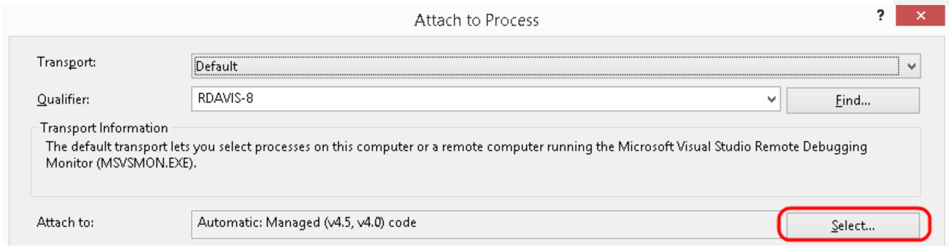
1. Open the **SampleLeak.sln** solution file found in the lab's **Source\SampleLeak** folder. This is just a MVC web application created from the Visual Studio 2013 template, with a memory leak introduced that occurs when loading the home page of the application.
2. Press **Ctrl+F5** to start the web application without attaching the debugger. The project should already be configured to use IIS Express when debugging.

   Note: It will take a moment to restore NuGet packages.

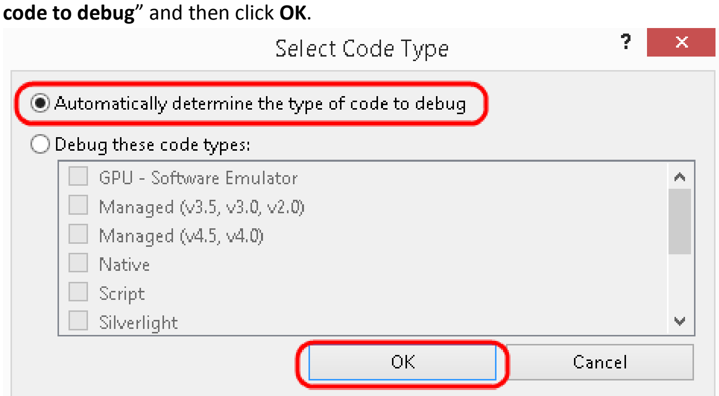
3. After starting the web application, IIS Express will start up and host the application, and Visual Studio will launch a browser window and navigate to the home page of the site.



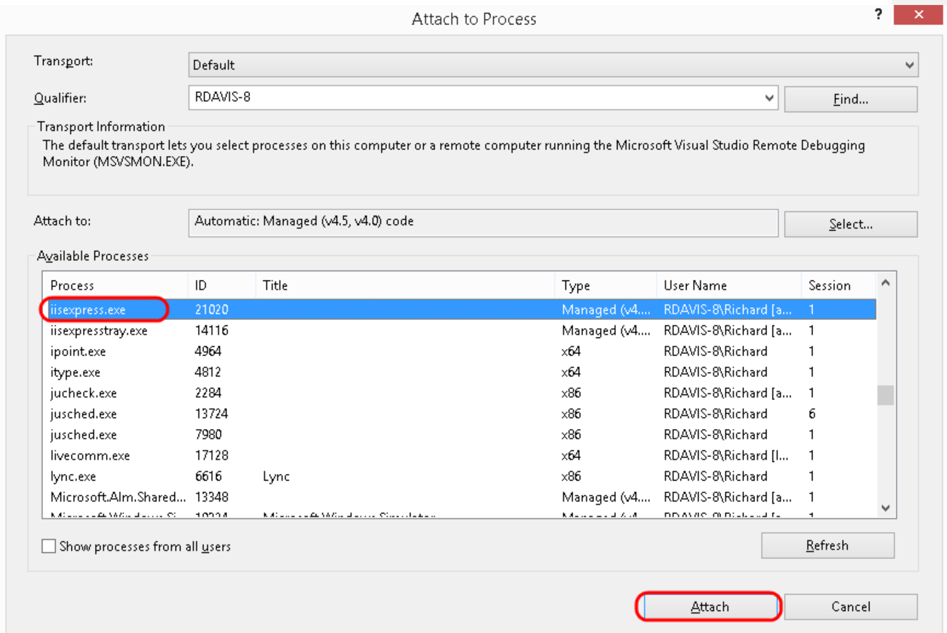
4. In Visual Studio, press **Ctrl+Alt+P** to open the **Attach to Process** window.
5. In the **Attach to Process** window, click the **Select** button to the right of the **Attach To** setting.



6. In the **Select Code Type** window, select the option to "**Automatically determine the type of code to debug**" and then click **OK**.



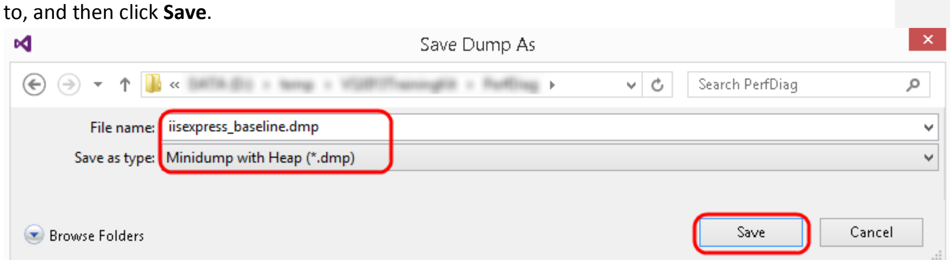
7. Select **iisexpress.exe** from the list of available processes and then click **Attach**.



8. Select **Debug | Break All** from the main menu or by pressing **Ctrl+Alt+Break**.
9. Select **Debug | Save Dump As** from the main menu.

   Note: Although there are caveats to keep in mind, you could create the dump file through other means such as using Task Manager or by using free tools such as ProcDump. Please see this blog post from the Visual Studio Debugger Team Blog for more information if interested.

10. In the **Save Dump As** window, name the file **iisexpress_baseline.dmp**, choose to save the dump file with heap information (this is the default "save as type" option), choose a location to save to, and then click **Save**.

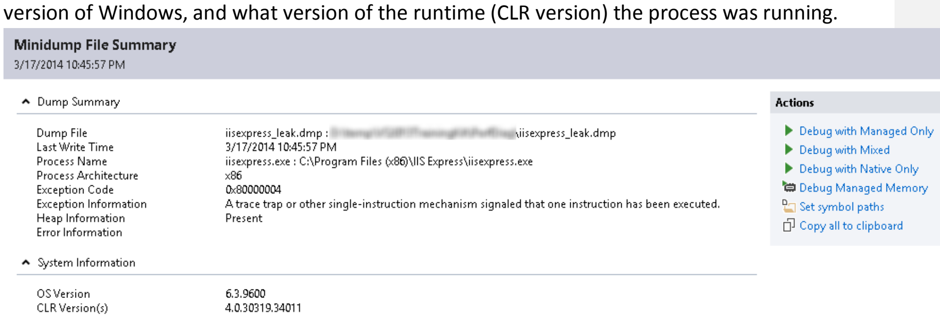


11. In Visual Studio, press **F5** to let the IIS worker process continue running.
12. Return to the browser window and then press **F5** to refresh the page **five** times.

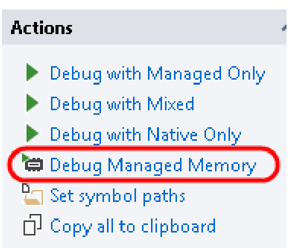
13. In Visual Studio, select **Debug | Break All**.
14. Select **Debug | Save Dump As** to save a dump file to the same location as the first dump, but this time with the name **iisexpress_leak.dmp**.
15. Press **Shift+F5** to stop debugging.
16. In an Explorer window, navigate to the location where the dump files were saved.
17. Double-click on the **iisexpress_leak.dmp** file to open it with Visual Studio Ultimate 2013.

    Note: The process the dump file was collected against must have been running on .NET 4.5 or higher.

18. Once the file is open in Visual Studio Ultimate, you will be presented with the dump file summary page. This shows when the dump was created, the architecture of the process, the version of Windows, and what version of the runtime (CLR version) the process was running.

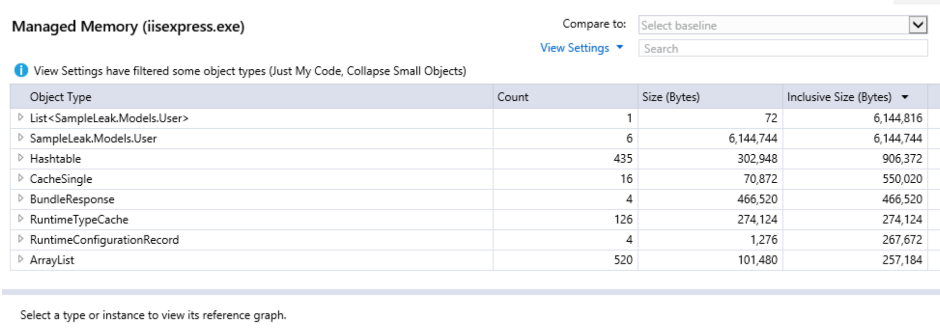


19. Click the **Debug Managed Memory** action link to the right of the dump summary.



20. Once the analysis is complete, you should see the new managed memory analysis view. The top pane contains a list of objects in the heap, grouped by their type name with columns that show you the count and total size. When a type or instance is selected in the top pane, the bottom pane will be updated with objects that are referencing this type or instance which prevent it from being garbage collected (at the time of the snapshot).

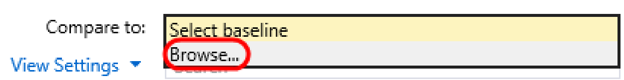
    Note: By default, the view settings are set to show **Just My Code**.



Object Type	Count	Size (Bytes)	Inclusive Size (Bytes)
List<SampleLeak.Models.User>	1	72	6,144,816
SampleLeak.Models.User	6	6,144,744	6,144,744
Hashtable	435	302,948	906,372
CacheSingle	16	70,872	550,020
BundleResponse	4	466,520	466,520
RuntimeTypeCache	126	274,124	274,124
RuntimeConfigurationRecord	4	1,276	267,672
ArrayList	520	101,480	257,184

21. Select the **List<SampleLeak.Models.User>** object from the top of the list.
22. The **Paths to Root** view shows that this list is rooted in the static variable **SampleLeak.Data.UserRepository.m_userCache**.
23. Select the **Referenced Types** tab.
24. Starting with the **List<SampleLeak.Models.User>** object from the References list, expand all child references. With everything expanded, you should be able to see that there were a number of User instances referenced and that byte arrays are taking up most of the memory. Using this information, you could then investigate the code to see why the User instances were using so much memory, perhaps providing a big savings on memory usage.

25. To investigate a potential memory leak, it is useful to compare to a baseline memory dump. Select the dropdown next to the **Compare To** option and then select the **Browse** option.



26. In the **Select File to Compare With** dialog, select the **iisexpress_baseline.dmp** file and then click **Open**.
27. After analysis is complete, you will see a few additional columns that show differences in object counts and sizes. Note that there are more User objects than there were in the baseline dump, and that there was a large increase in memory usage. This is a good indication that the application may be leaking User objects, so you would now be able to raise the issue with the developers who would be able to use the dump files to help pinpoint the issue and create a fix.

Managed Memory (iisexpress.exe)

Compare to: D:\temp\VS2013Tra...ress_baseline.dmp

View Settings ▾ Search

ⓘ View Settings have filtered some object types (Just My Code, Collapse Small Objects)

Object Type	Count	Count Diff.	Size (Bytes)	Size Diff. (B...	Inclusive Size (Bytes)	Inclusive Size Diff. (Bytes)
List<SampleLeak.Models.User>	1	0	104	+32	13,313,716	+5,120,652
SampleLeak.Models.User	13	+5	13,313,612	+5,120,620	13,313,612	+5,120,620
CacheSingle	16	0	116,028	+13,440	641,596	+28,228
Hashtable	518	+1	462,592	+106,840	1,008,492	+10,912
RuntimeType	27,089	0	765,064	+376	765,064	0
BundleResponse	4	0	466,496	0	466,496	0
RuntimeTypeCache	0	-129	0	-277,488	0	-277,488
RuntimeConfigurationRecord	0	-4	0	-1,276	0	-295,776
ArrayList	0	-597	0	-119,992	0	-314,572

28. You can now stop debugging and close Visual Studio.

Exercise 4: Other Debugging Improvements

In this exercise, you will take a quick look at some asynchronous debugging enhancements to Visual Studio 2013, as well as automatic method return value inspection.

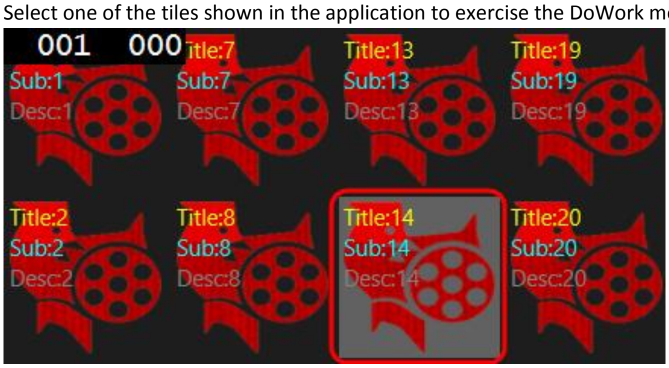
Task 1: Asynchronous Debugging

In this task, you will learn about asynchronous debugging enhancements that have been made in Visual Studio 2013 that make it easier to understand and follow asynchronous tasks.

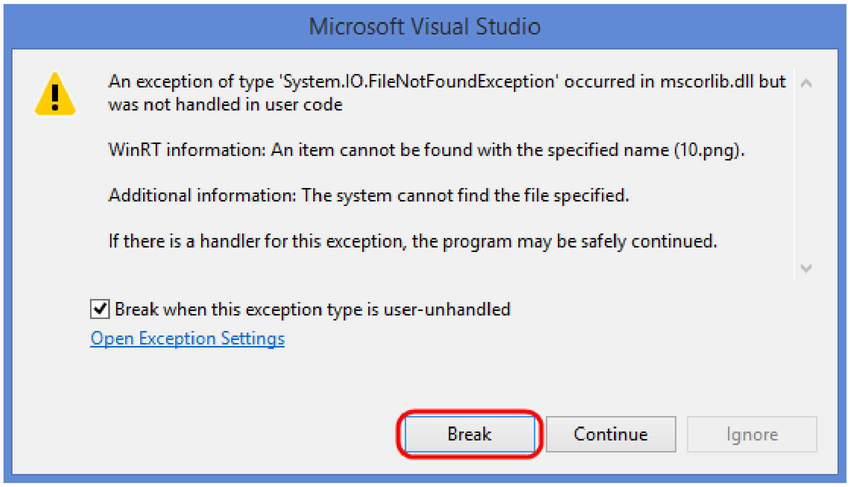
1. Open the **BlankXamlApp.sln** solution file found in the lab's **Source\BlankXamlApp** folder.
2. Open the **MainPage.xaml.cs** code file, locate the **myGridView_SelectionChanged** event handler, and un-comment the line of code that calls the asynchronous **DoWork** method. The DoWork method is an asynchronous method which itself makes use of additional asynchronous code.

```
1 reference
private async void myGridView_SelectionChanged(object sender, SelectionChangedEventArgs e)
{
    await DoWork(10);
}
```

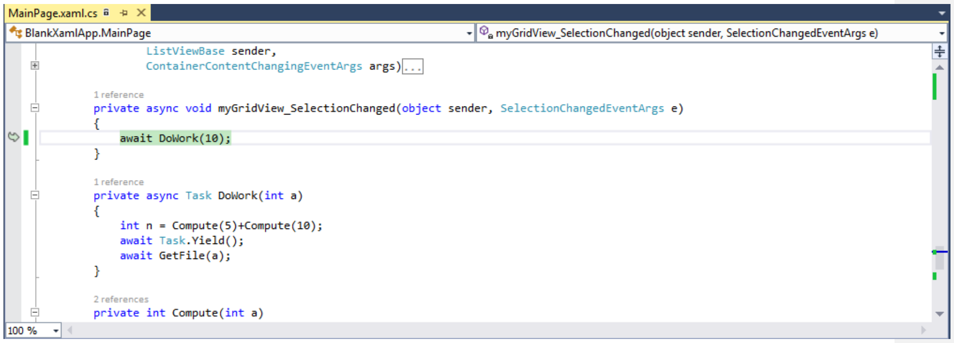
3. Press **F5** to start debugging the application.
4. Select one of the tiles shown in the application to exercise the DoWork method.



5. Visual Studio should show a dialog window describing an unhandled exception in the application. This shows that the application tried to access a file named **10.png**, but that it was not found. Click the **Break** button.

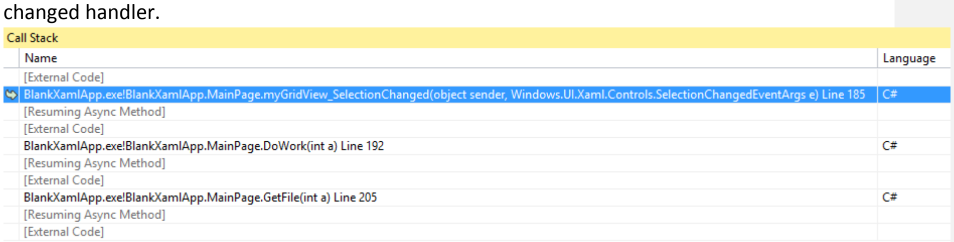


6. After breaking into the debugger, you should see that Visual Studio has opened **MainPage.xaml.cs** and highlighted the call to **DoWork**.



7. Developers typically rely on the **Call Stack** window to tell them how their application got to their current location, but this was not the case for asynchronous calls prior to Visual Studio 2013 and Windows 8.1. The latest enhancements made to the call stack window for asynchronous debugging provides additional stack frames to aid in understanding how the program reached a location inside an asynchronous call. These enhancements work across all of the languages that Visual Studio supports for Windows app development (C++, JavaScript, C#/VB).

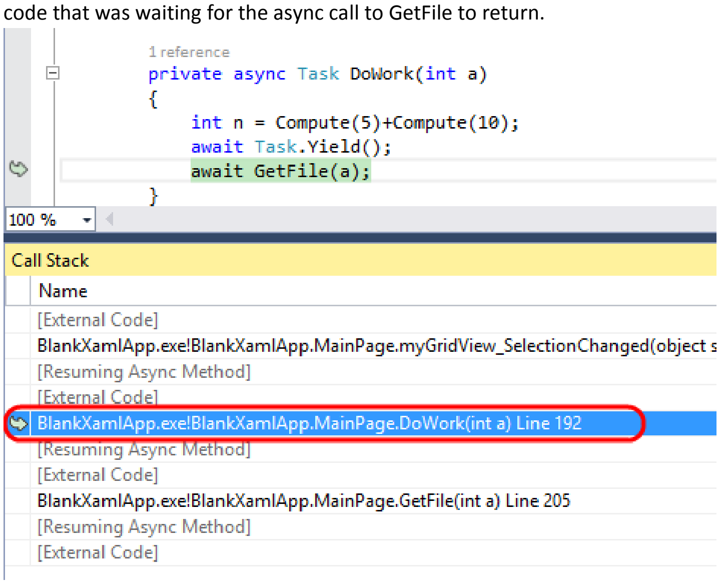
8. In managed code, the **async** and **await** pattern to asynchronous programming created situations where you had asynchronous methods awaiting other asynchronous methods to return, but call stack information was not made available until now.
9. In the **Call Stack** window (**Debug | Windows | Call Stack**), you can see that the debugger is currently set to the call stack where the async **DoWork** method is called, within the selection changed handler.



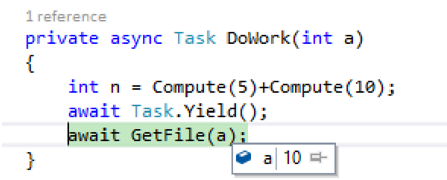
10. Also note that the additional call stack frames that have been added to the Call Stack window, namely the **DoWork** and **GetFile** methods. In managed code, Visual Studio shows the asynchronous methods that are awaiting the current asynchronous method, rather than the call stack when the task was created, as is the case for [C++](C++) and JavaScript debugging.

    Note: The call stack from the screenshot above is showing 'Just My Code'. If you see a lot of additional external code in the Call Stack window, you can right-click on the window and **de-select** the **Show External Code** option to get a cleaner view.

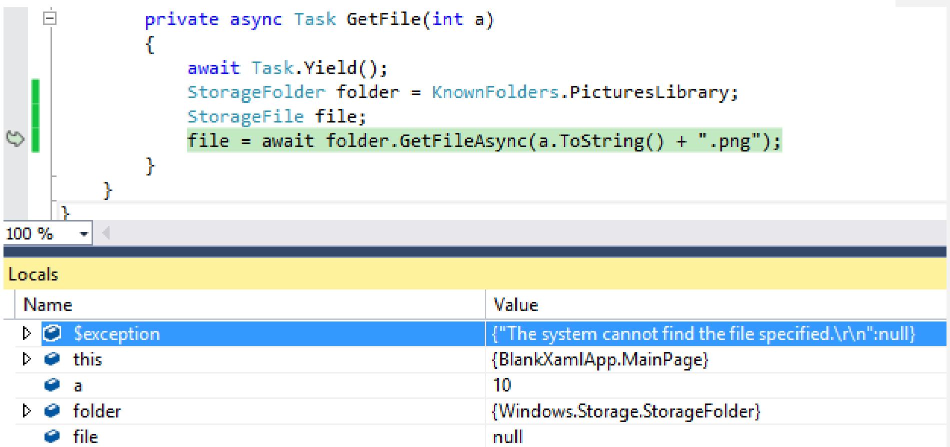
11. **Double-click** on the **DoWork** call stack frame. Note that Visual Studio takes you to the line of code that was waiting for the async call to GetFile to return.



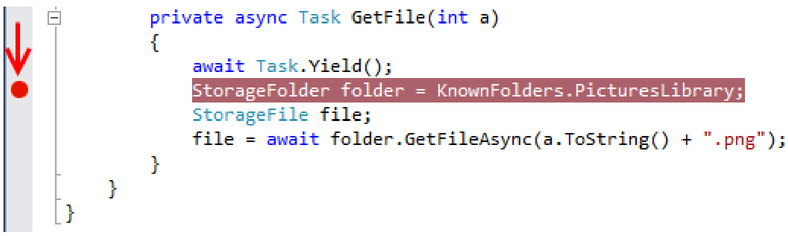
12. Hold the mouse cursor over the parameter sent to the **GetFile** method. This confirms that the filename requested from the GetFile method was ‘**10**’.



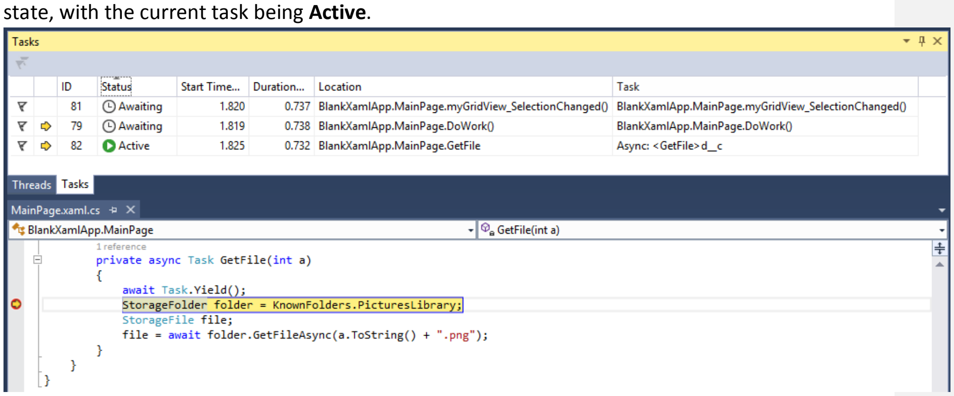
13. **Double-click** on the **GetFile** call stack frame. This shows how the final folder and path were constructed and the location where the exception originated. You can view additional diagnostic information in the **Locals** window.



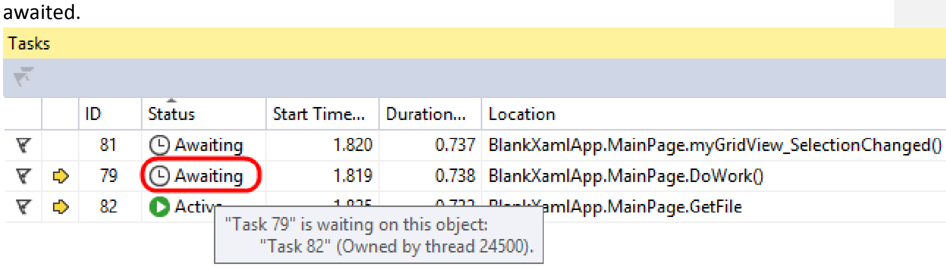
14. Select **Debug | Stop Debugging**.
15. Now you will take a quick tour of the asynchronous debugging improvements through the **Tasks** window. The Parallel Tasks window was introduced in Visual Studio 2010, but has been enhanced and renamed to be just the Tasks window in Visual Studio 2013. This can be useful for debugging hung and excessively long tasks, and like the upgraded call stacks, this is supported for all languages that are supported in Visual Studio for developing Windows Store apps.
16. Set a **breakpoint** on the second line of the **GetFile** method.



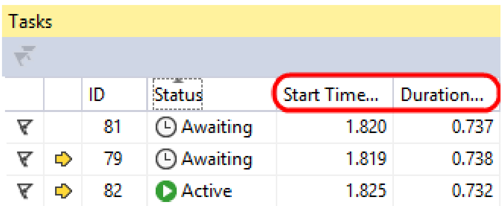
17. Press **F5** to start debugging and then select one of the tiles once again.
18. The breakpoint should be hit and Visual Studio will break into the debugger.
19. The **Tasks** window (**Debug | Windows | Tasks**) should show two tasks that are in the **Awaiting** state, with the current task being **Active**.



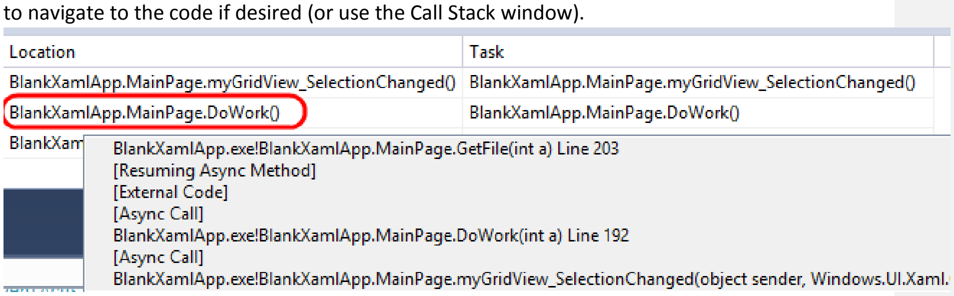
20. Hold the mouse cursor over one of the tasks in the **Awaiting** state to see which task is being awaited.



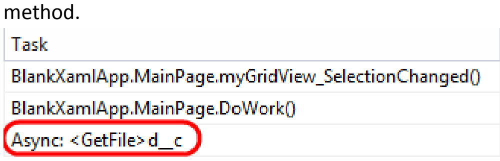
21. The **Start Time** represents the time when the task was created relative to the time that you started debugging. The **Duration** is how long that the task has been running for. This information can help you understand the execution order of your asynchronous tasks and to find which ones may have been running for longer than expected.



22. The **Location** column shows the current location in code. By hovering over the location, you will see a call stack including the asynchronous calls. You can double-click on the individual frames to navigate to the code if desired (or use the Call Stack window).



23. The **Task** column helps you identify and distinguish between different tasks. For example, "Async: <GetFile> d_c" is the lambda function in the continuation of the GetFile asyncronous method.



24. Select **Debug | Stop Debugging**.

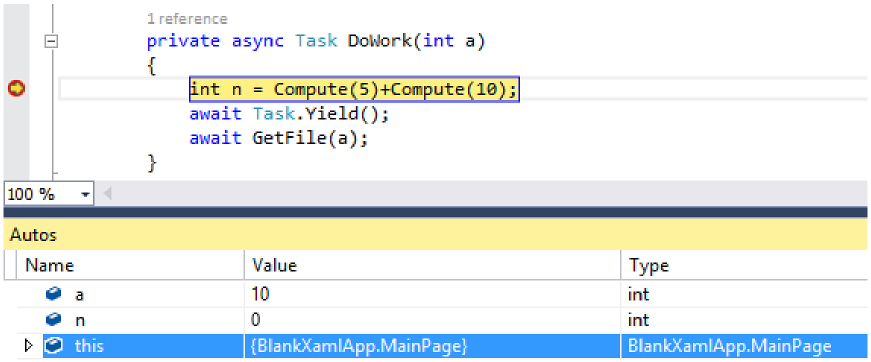
Task 2: Method Return Value Inspection

In this task, you will take a look at an enhancement added to the Autos window in Visual Studio 2013 that enables you to quickly determine the return values for functions. This is particularly useful for situations where the return values are not stored in local variables or you are using nested function calls.

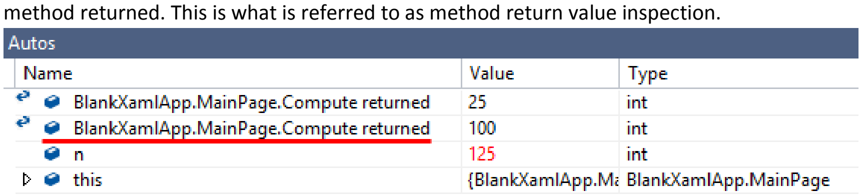
1. Set a breakpoint on the **first** line of the **DoWork** method.

```
1 reference
private async Task DoWork(int a)
{
    int n = Compute(5)+Compute(10);
    await Task.Yield();
    await GetFile(a);
}
```

2. Press **F5** to start debugging and then select one of the tiles once again.
3. In the **Autos** window (**Debug | Windows | Autos**), note that everything appears as expected with local variables and the current class instance.



4. Press **F10** once to step over the line that computes a value and assigns the result to the local variable '**n**'.
5. Note that the **Autos** window now automatically shows what the two calls to the Compute method returned. This is what is referred to as method return value inspection.



6. Stop debugging and close Visual Studio.