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Windows on Arm

Building a Native Windows on Arm App with WinUI 3

Non-Confidential

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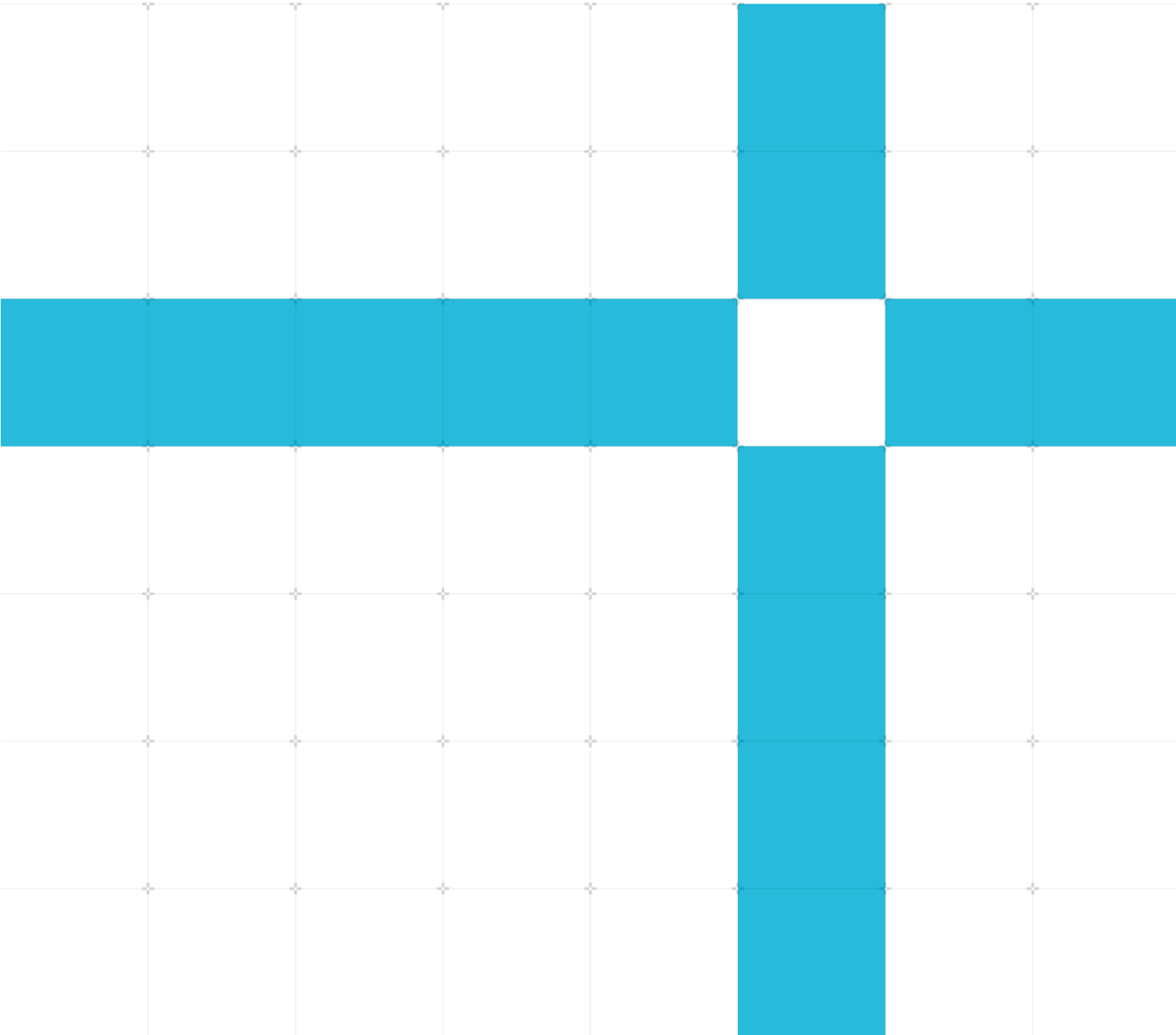

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Contents

1 Overview

In this guide, you can learn how to create a simple but complete WoA-native WinUI 3 application.

Microsoft recently released WinUI 3.0, which runs on .NET 5.0, on machines with AArch64 processors (Arm 64), Intel, and AMD. WinUI 3.0 also runs on .NET 5.0.8, Windows forms, UWP, and WPF **already have native Arm support**. As seen in the **Best Practices for Migrating Windows apps to Windows on Arm**, applications on an AArch64 device can run in x86 emulation mode. Running in emulation mode is fine for applications that do not require high performance. Sometimes, it can be more than ten times slower than running in native mode. Therefore, to really take advantage of the power of the new platform, you want to create native apps.

This guide describes how to develop a simple graphical application for a device with an AArch64 processor. The device we are using to test the app is a Microsoft surface pro X device with an AArch64 processor. I call this device the two in one laptop.

1.1 Before you begin

To work through in this guide, you need visual studio 2019 (VS2019) as an Integrated Development Environment (IDE), with C#. Developing WinUI 3.0 applications involves minimal knowledge of XAML and WPF.

You can find the code for this article on **GitHub**.

1.2 Prepare the development PC

Detailed instructions to install the right components can be found **Windows app development site**. If you have not installed VS2019, you can use the download link the page provides. While you can complete the exercise on VS2022, it is still in preview, so proceed with caution.

If you already have VS2019, open the visual studio installer to add any necessary workloads.

1.3 Prepare the target device

To prepare your AArch64 PC, follow the instructions to **enable your device for development**. Then:

- Download **.NET 5.0 (Linux, macOS, and Windows)**
- Install **.NET 5.0 x86**
- Install **.NET 5.0 Arm64.**

Install the x86 version to contrast the x86 emulated mode with the AArch64 native mode.

2 Create a WinUI 3.0 application

The **Windows UI library** (WinUI) contains the documentation for WinUI 3.0, and the following diagram. The diagram highlights the purpose of WinUI 3, which enables you to use one framework to create applications for all possible Windows platforms.

The following diagram shows the support for the AArch64 processor:

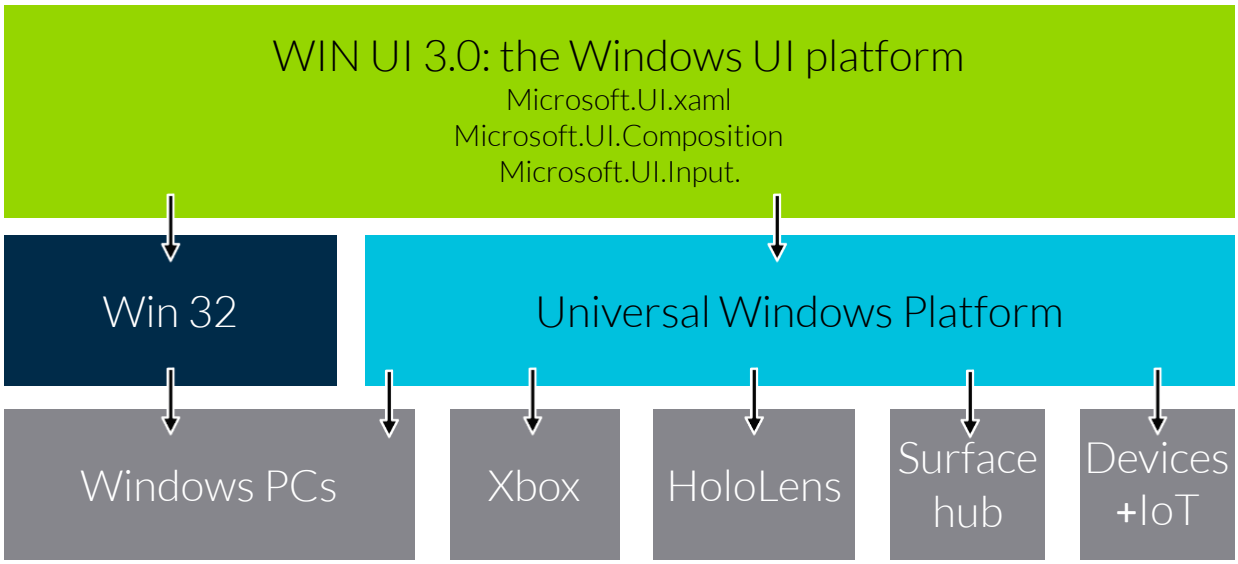

Figure 1: Creating applications with WinUi3 for Windows platforms

First, we create a small application that allows you to reduce the resolution of a user-loaded image. The resolution is downgraded by selecting squares of 20 x 20 pixels and replacing the color of each selected square with the average color of its pixels.

This example is just a demo application, so there are not many options. But it is enough to perform some benchmarks. Detailed instructions for creating Windows app SDK projects can be found on the **Windows app development site**.

In the next chapter, we create the downgrade picture application.

2.1 Create the WinUI 3.0 desktop project

Open VS2019 and follow the instructions:

1. Click File > New > Project, to create a new project and then select C#, Windows, and WinUI:

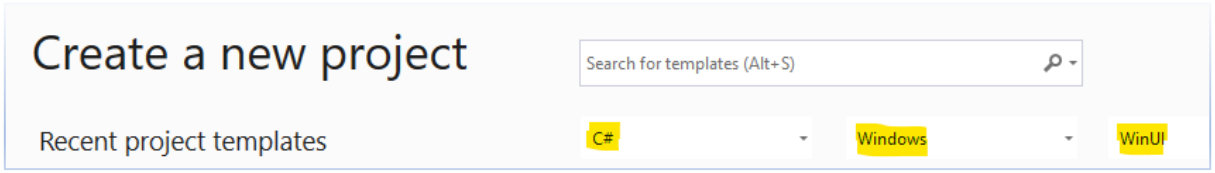

Figure: Creating new project

2. Select Blank App, Packaged (WinUI 3 in Desktop):

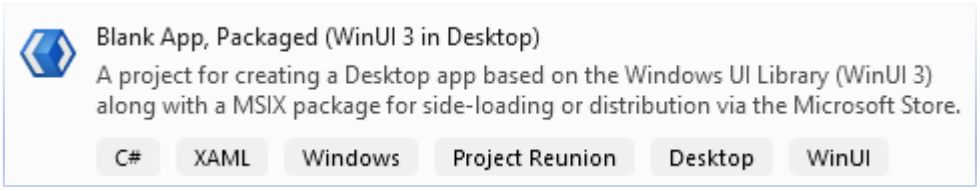

Figure: Selecting blank app, packaged

3. Name the app to DowngradePicture, then choose a location, and click create:

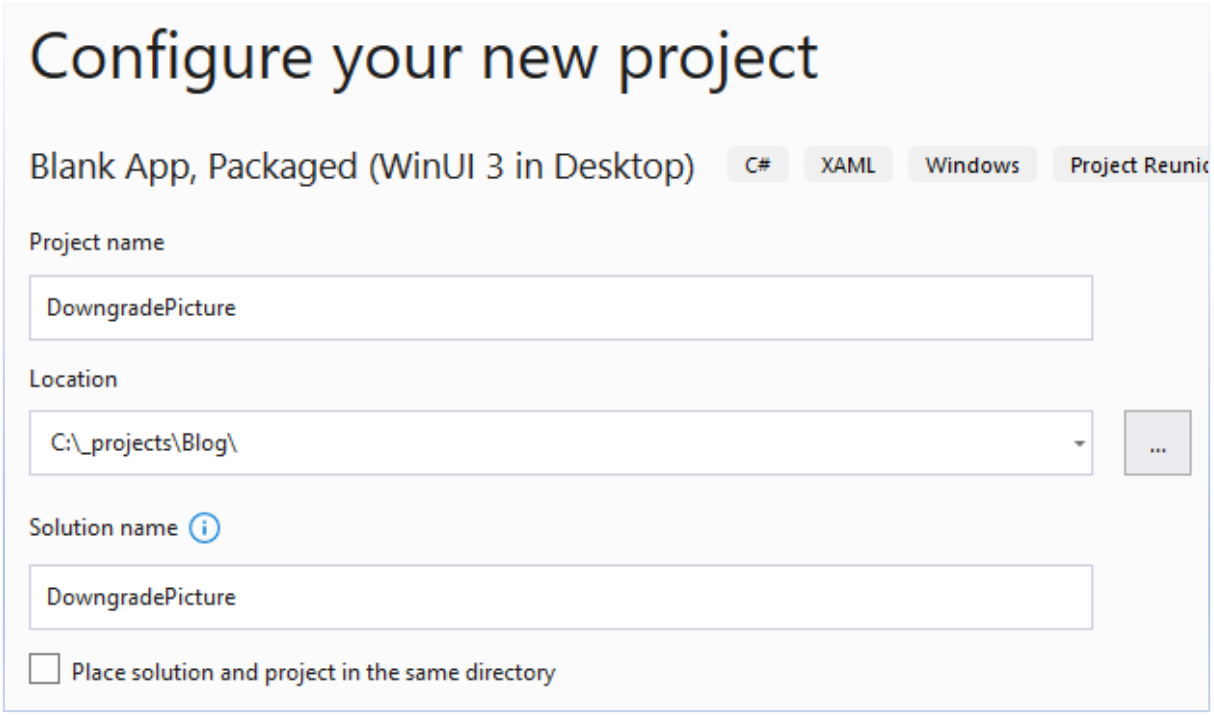

Figure: Naming the app, selecting the location

4. Select the target and minimum versions of Windows on the appearing dialog box. Leave the default values and click OK:

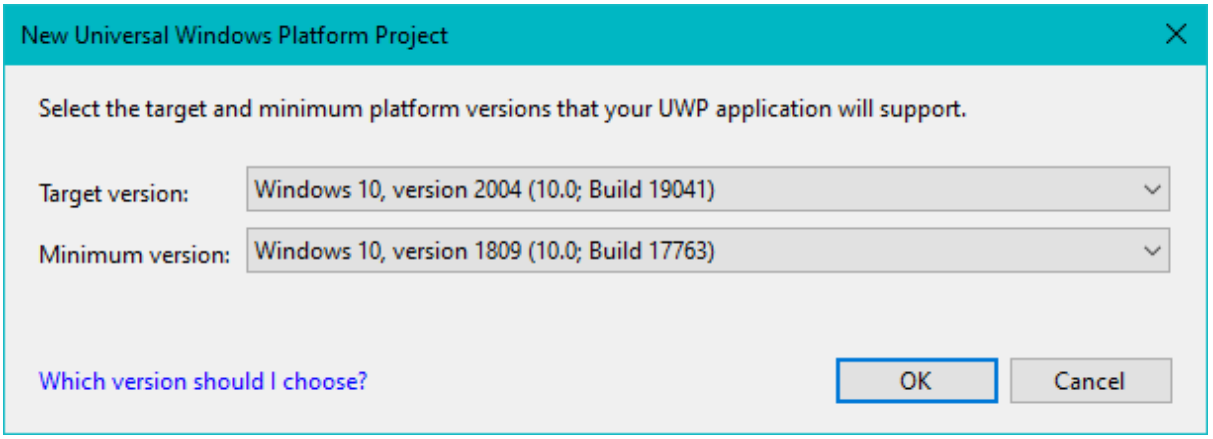

Figure: Platform version dialog box

The settings seen on the previous figure, also work in Windows 11.

After a few seconds, the solution explorer and an overview page will appear. We now have an application that can run on our machine. It does not do much yet, but it is the beginning of your first WinUI 3.0 application.

In the Solution Explorer, there are two projects:

- DowngradePicture contains the code and resources for the project. Here we publish the application for different versions (x86 and AArch64).
- DowngradePicture (Package) contains the manifest file of the application. This file contains all the information that our application must run. Notice that this is a startup project. The manifest file allows for setting the icons and capabilities of the application.

If you are familiar with Windows Presentation Foundation, you can recognize the MainWindow.xaml file. This file is where we add the code to load and display the image file.

2.2 Add controls to the main window

If you prefer not to type from blank, you can find the necessary code on **GitHub**.

On the main window, we want to show the original and downgraded pictures with some controls. Also, we would like a text block to display the time taken to downgrade the image.

The following image shows how the reduced image must looks like compared to the original:

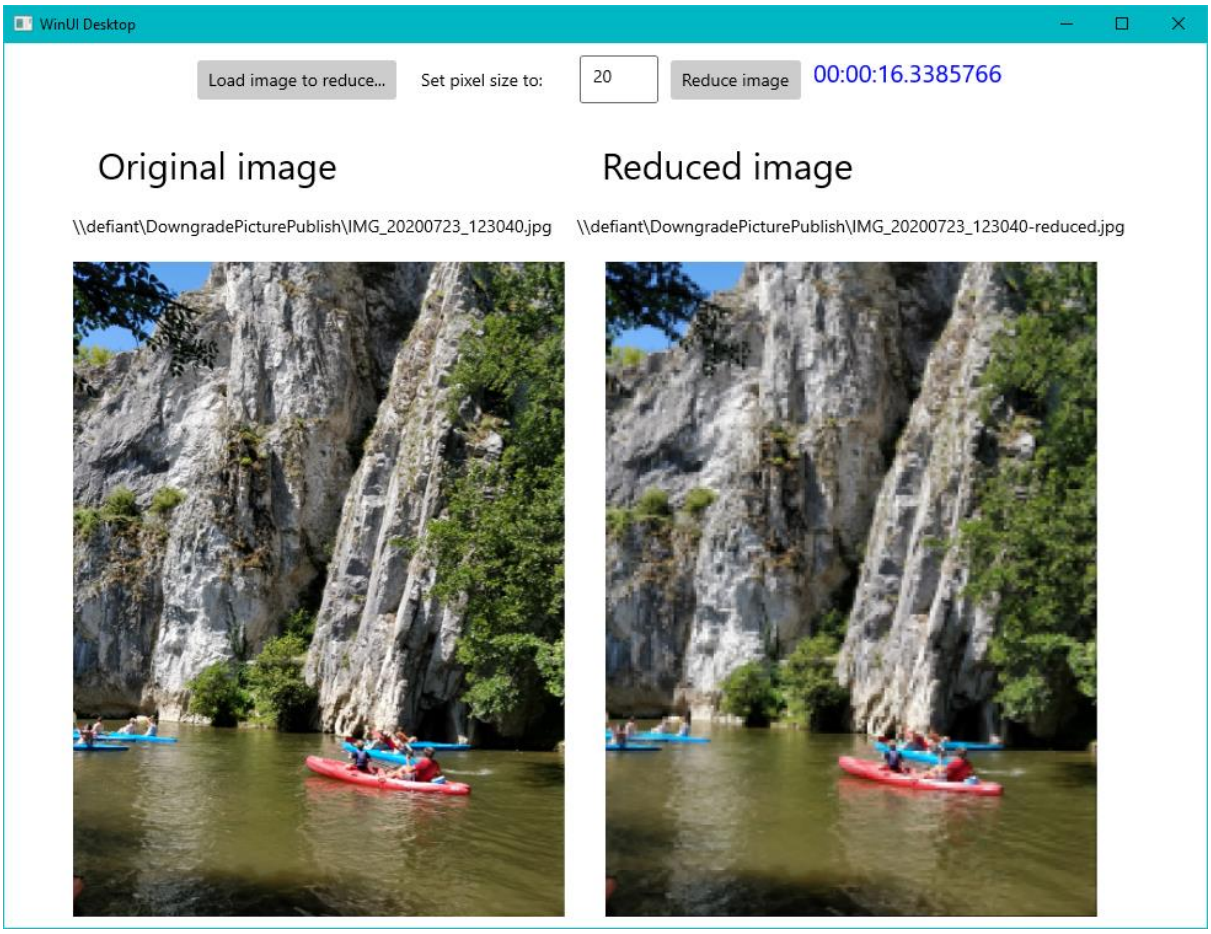

Figure: Original and downgraded image comparison

The following XAML code to accomplish the task, can be found on **GitHub**:

```
<Window
    x:Class="Downgrade Aarch64 Picture.MainWindow"
    xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
    xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
    xmlns:local="using:DowngradePicture"
    xmlns:d="http://schemas.microsoft.com/expression/blend/2008"
    xmlns:mc="http://schemas.openxmlformats.org/markup-compatibility/2006"
    mc:Ignorable="d">

    <StackPanel Orientation="Vertical" HorizontalAlignment="Center" >
        <StackPanel Orientation="Horizontal" HorizontalAlignment="Center" >
            <Button Click="OnLoadClicked">Load image to reduce...</Button>
            <TextBlock Margin="20" Text="Set pixel size to: " />
```

```
            <TextBox Margin="10" Text="20" x:Name="pixelSize" TextChanged="PixelSize_Te
xtChanged" />
            <Button x:Name="reduceButton" Click="OnReduceClicked" IsEnabled="False">Red
uce image</Button>
            <TextBlock Margin="10" FontSize="20" x:Name="txtDuration" Foreground="Blue"
/>
        </StackPanel>
        <StackPanel Orientation="Horizontal" HorizontalAlignment="Center" >
            <StackPanel Orientation="Vertical" HorizontalAlignment="Center" >
                <TextBlock Margin="20" Text="Original image" FontSize="30" />
                <TextBlock x:Name="txtPath" Text="" />
                <Image x:Name="originalImage" Width="400" ImageOpened="OnImageOpened" M
argin="0,20" />
            </StackPanel>
            <StackPanel Orientation="Vertical" HorizontalAlignment="Center" Margin="10,
 0"  >
                <TextBlock Margin="20" Text="Reduced image" FontSize="30" />
                <TextBlock x:Name="txtReducedPath" Text="" />
                <Image x:Name="reducedImage" Width="400"  Margin="0,20" />
            </StackPanel>
        </StackPanel>
    </StackPanel>
</Window>
```

The code to handle the events, and to reduce the bitmap is in the **MainWindow.xaml.cs** file.

The `OnLoadClicked` function allows you to select an image file and load it into `originalImage.`

The `OnReduceClicked` function calls the `ReduceBitmap` function and saves the result on the file system.

The `ReduceBitmap` function uses the value of `pixelSize` to reduce the bitmap quality.

The following function shows that the parameter `step` corresponds to the value of `pixelSize`:

```
private static Bitmap ReduceBitmap(Bitmap bitmap, int step)
{
    for (int x = 0; x < bitmap.Width; x += step)
    {
        for (int y = 0; y < bitmap.Height; y += step)
        {
            int r = 0;
            int g = 0;
            int b = 0;
```

```
            for (int i = 0; i < step && x + i < bitmap.Width; i++)
            {
                for (int j = 0; j < step && y + j < bitmap.Height; j++)
                {
                    Color c = bitmap.GetPixel(x + i, y + j);
                    r += c.R;
                    g += c.G;
                    b += c.B;
                }
            }
            Color avg = Color.FromArgb(r / (step * step), g / (step * step), b / (step
* step));

            for (int i = 0; i < step && x + i < bitmap.Width; i++)
            {
                for (int j = 0; j < step && y + j < bitmap.Height; j++)
                {
                    bitmap.SetPixel(x + i, y + j, avg);
                }
            }
        }
    }

    return bitmap;
}
```

The code uses `GetPixel` to get all pixel colors for each block. The code then calculates the average color for that block and uses `SetPixel` to set all the pixels to that color. Setting all pixels takes longer with large pictures. This difference allows us to contrast the performance between x86 and AArch64 modes.

3 Deploy the application on the two in one laptop

Now that the application runs on our development PC, we can deploy it to the two in one laptop. This process is less straightforward than needed, but the following walkthrough must help. The official documentation is on **package and deploy page** for Windows apps.

3.1 Publishing the binaries for each mode

With the following instructions publish the binaries for each mode:

1. Hit right-click DowngradePicture project in Solution Explorer and select Publish from the context menu. The publish window opens. In this window we can create multiple profiles. In our case, we need two profiles, one for x86 and one for arm64.

Visual Studio refers to AArch64 as arm64.

2. Click the New button to create a profile.
   The following profile settings appear for win10-x86:

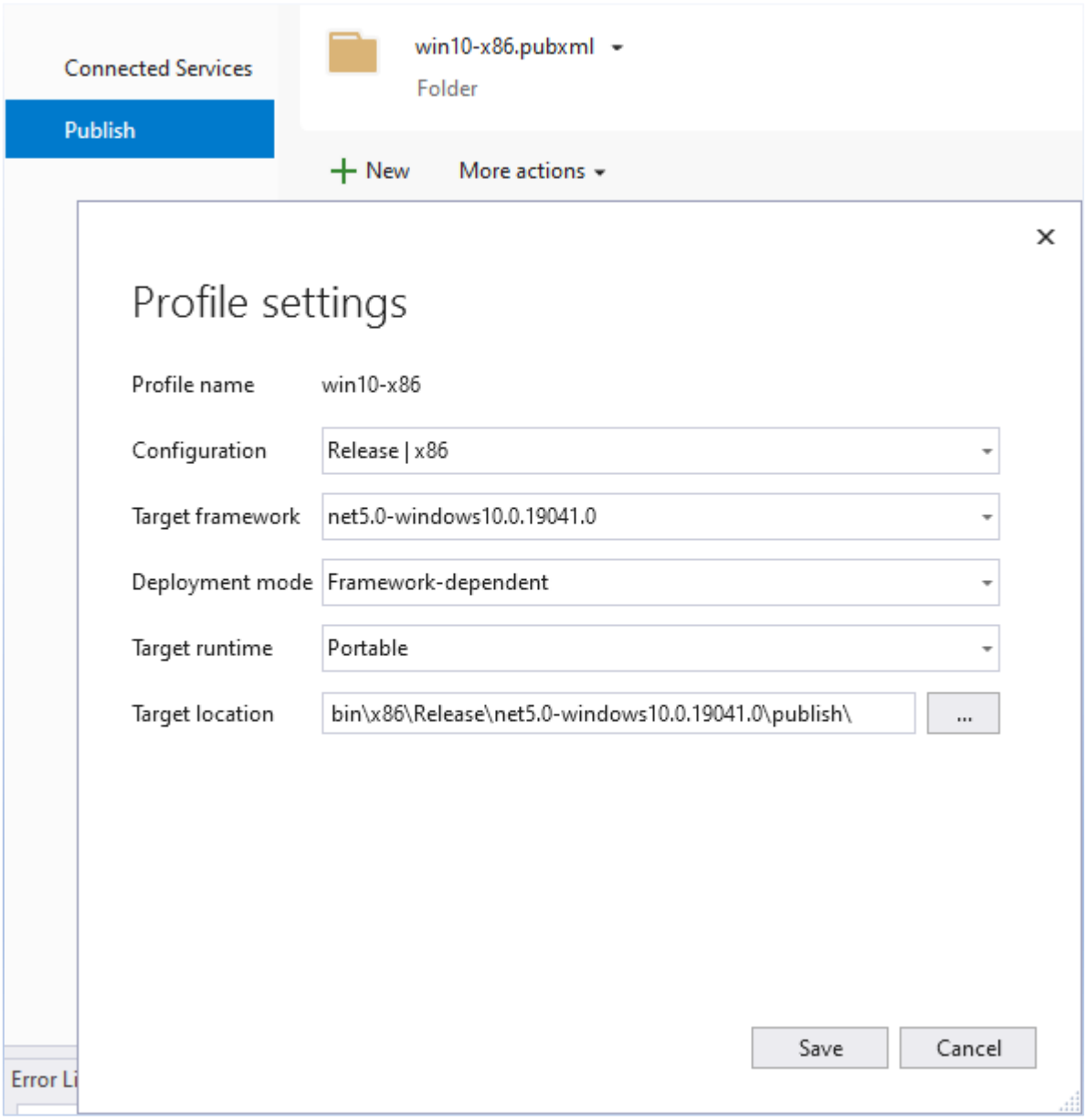

Figure: Win 10 x86 profile.

3. Click Save.

The following profile settings appear for win10-arm64:

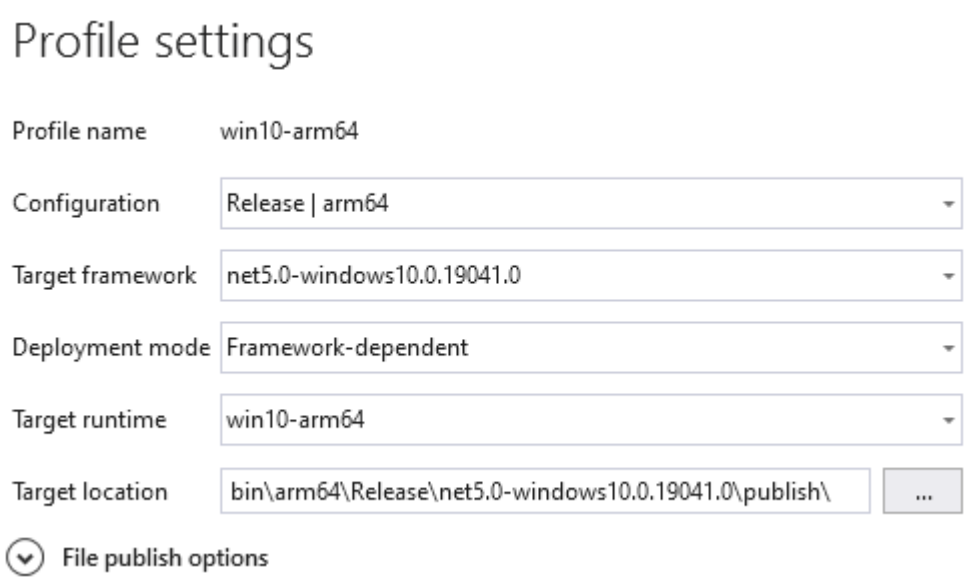

Figure: Win 10 x64 profile.

4. Click Save.
5. Click Publish, once both profiles are created.

3.2 Create the app packages

Use the following instructions to create the app packages:

1. Right-click DowngradePicture (Package) project and select Publish from the context menu.
2. Finally, click Create app package.

A wizard opens with options for distribution as you can see in the following screenshot:

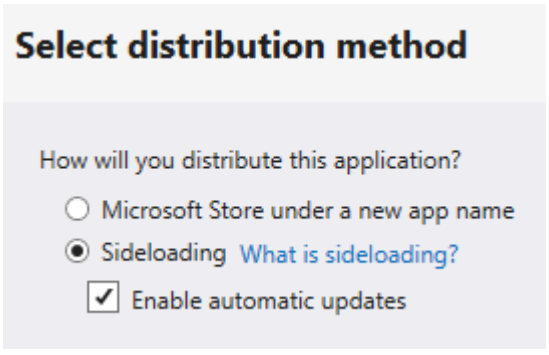

Figure: App distribution methods

3. Choose Sideloading to enable package deployment without passing through the Microsoft store. This selection is preferable for testing purposes. Sideloading is also a good option when the application is an in-house application that you do not want to make publicly available.

4. Select Yes, select a certificate:

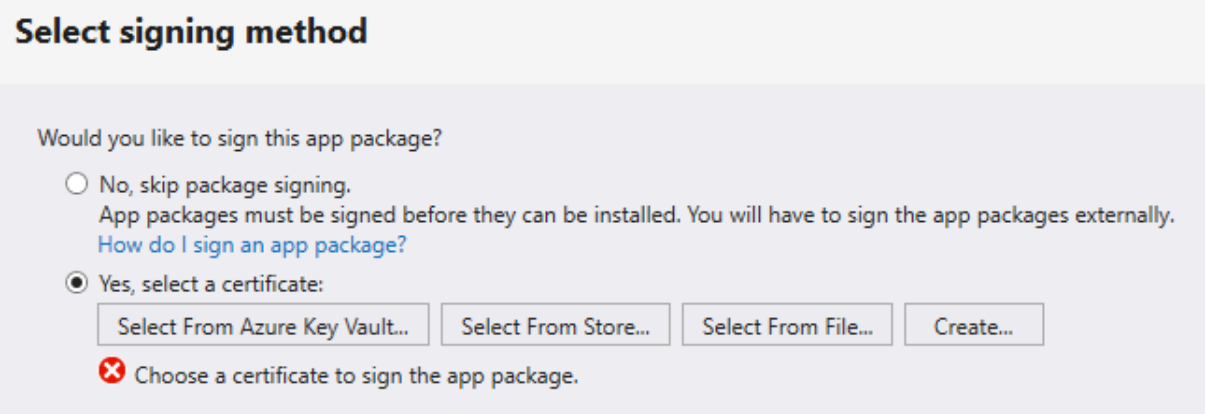

Figure: Select signing method.

If you already have a certificate, you can select it here. Otherwise, create a self-signed test certificate to use instead. Take note of the password that you use to create it for later use:

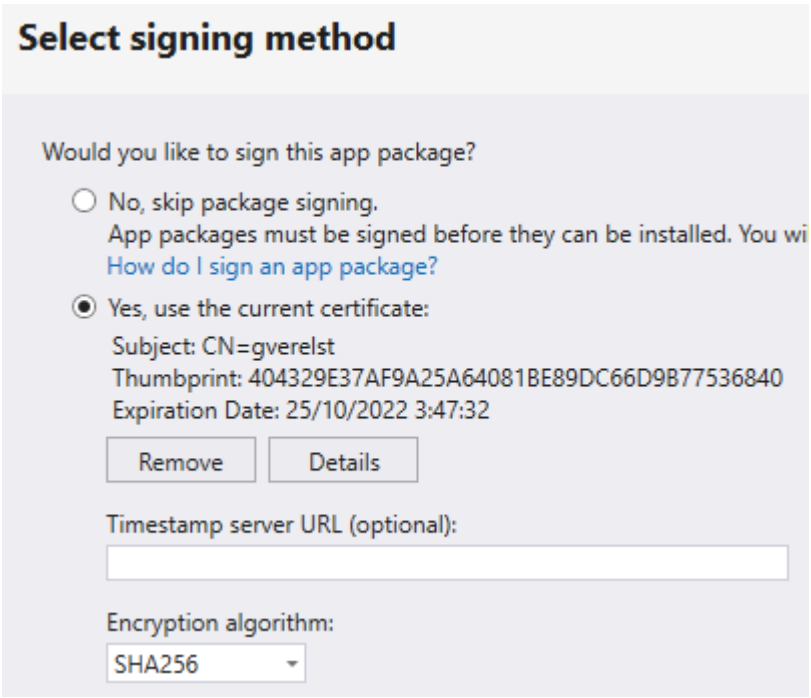

Figure: Certificate selection

On the next page, select the packages to create. Here, we can package the profiles we have published:

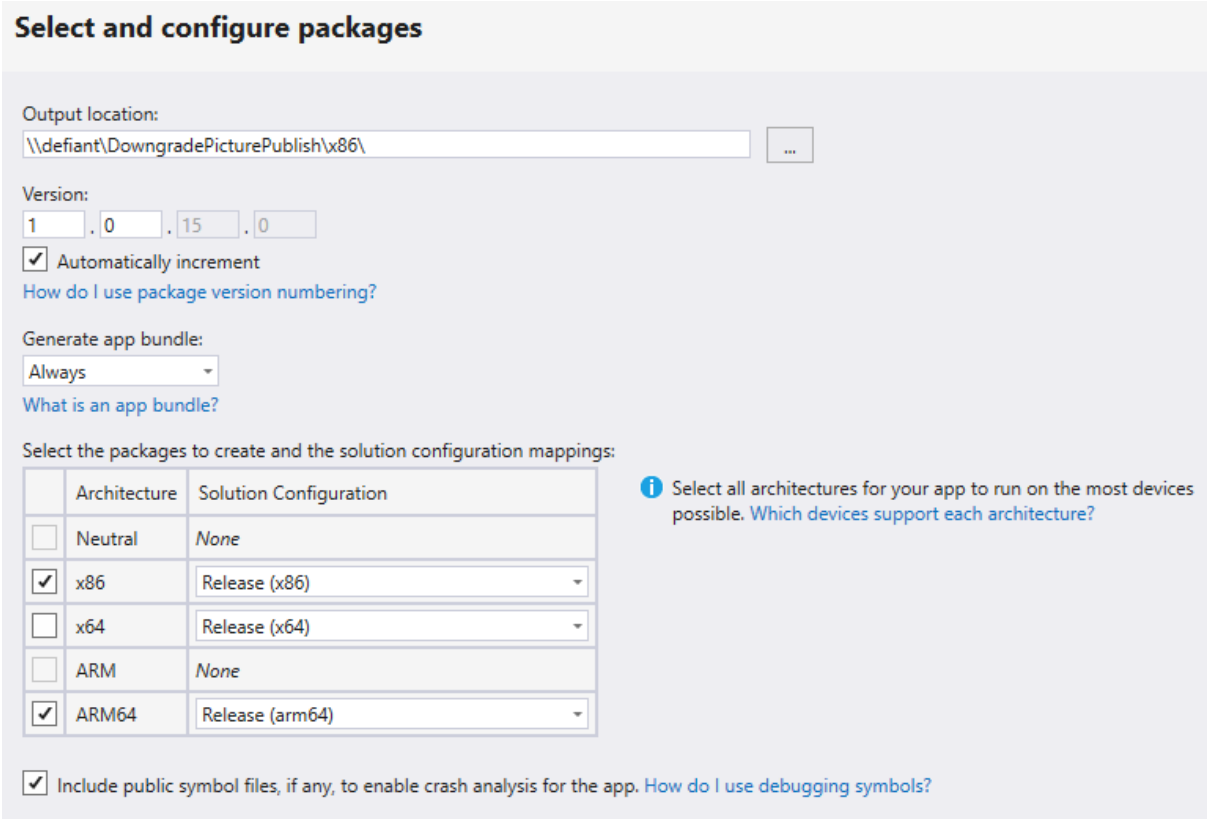

Figure: Select and configure packages.

We cannot select Release (x64) because we did not publish an x64 profile. Choosing the x64 wizard results in a Visual Studio error message. For the output location, we have used a shared folder on the development PC. The two in one laptop can access this folder as well, so we do not need to copy and distribute files.

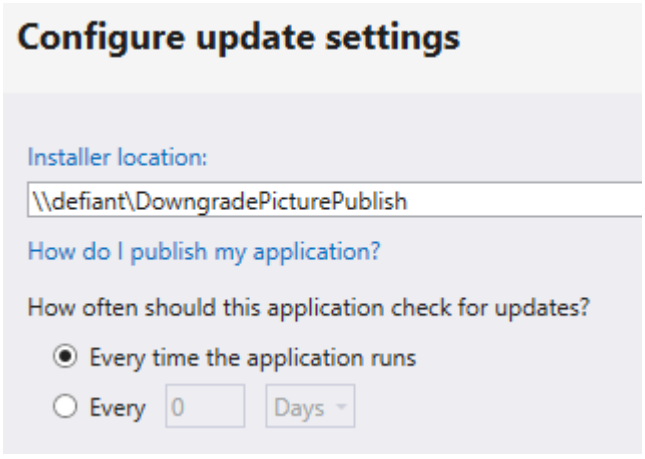

Figure: Configure update settings.

Click Create to create the packages at the installer location. Ignore warnings about files. Everything works if the previous steps have been followed correctly.

3.3 Install the package on the two in one laptop

Once you have created a developer certificate, you must export it to the target device. You only must do this export the first time:

1. Copy the .pfx file to the shared folder and double-click it.
2. Choose Local machine as the store location and click Next.
3. Click Next after the security confirmation and type the password that you set for the certificate. Leave the other options in their default states.
4. Click Next again and select Trusted Root Certification Authorities.

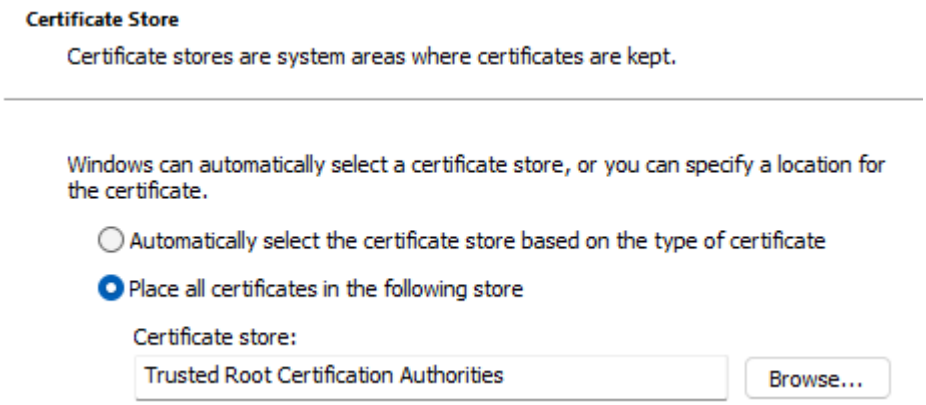

Figure: Certificate store

5. Click Next once more to see the overview and click Finish to import the certificate.

Now we are ready to install the application on the target PC.

6. Open the index.html file in the publish folder and click Get the app to install and run it.

We have now successfully created a WinUI 3.0 application and installed it on the target device for testing.

4 Benchmark the app

We created the application to run in either x86 (emulation) mode or AArch64 (native) mode on the two in one laptop. Having used the same picture in both modes, we can compare the results.

4.1 Benchmark X86 emulation

Downgrading the picture in x86 emulation mode took 47.39 seconds. Note that the left-hand side of the following image shows that this mode is running as a 32-bit process (x86):

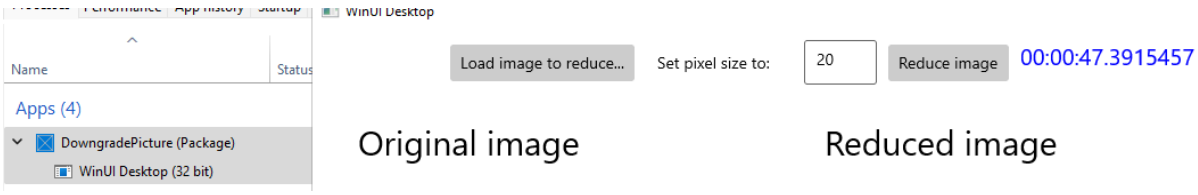

Figure: Downgrading time in x86

4.2 Benchmark AArch64 native

In native mode, downgrading the picture takes approximately 24 seconds, nearly twice as fast as in x86 emulation mode. Although this application uses integer-based calculations, we can still appreciate this boost in performance. When **working with floating-point operations,** the improvements are even better, up to 10 times faster as the following screenshot shows:

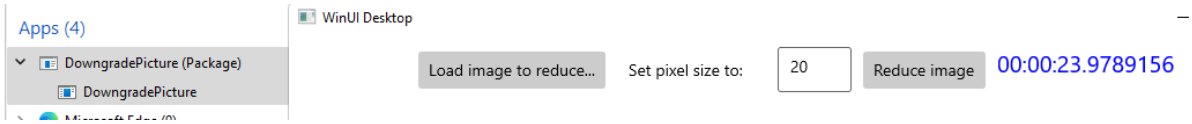

Figure: Downgrading time in x64

5 Summary

WinUI 3 has solid support for the AArch64 processor. Visual Studio allows for easy creation of the AArch64 package, which we can deploy on a two in one laptop. Achieving a 100 percent performance gain is especially impressive, considering that we only had to create a win10-arm64 profile in Visual Studio to accomplish it.

As a bonus, this building works on Windows 11 too, without any modification.

6 Related Information

Here are some resources related to material discussed in this guide:

Microsoft docs:

- **Build desktop Windows apps with the Windows App SDK - Windows apps | Microsoft docs**
- **Create your first WinUI 3 app - Windows apps | Microsoft docs**
- **Install tools for Windows app development - Windows apps | Microsoft docs**
- **Stable release channel for the Windows App SDK - Windows apps | Microsoft docs**
- **Windows UI library (WinUI) - Windows apps | Microsoft docs**

GitHub.com:

- **Microsoft/WinUI-3-Demos (github.com)**

7 Next steps

This guide has introduced how to build a native Windows on Arm app with WinUI 3. With this knowledge you can fork this application and make something out of it. Let us know what you have done in the comment section on **CodeProject**. You can also publish your application on the Microsoft store.