

November 9-11, 2021
www.dotnetconf.net

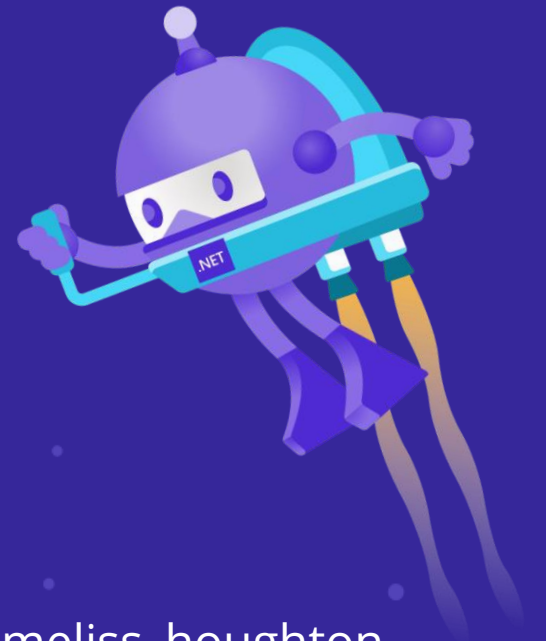
.NET Conf

Discover the world of .NET



.NET Internet of Things

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About Me



azenix



Lead Software Engineer Developer Technologies

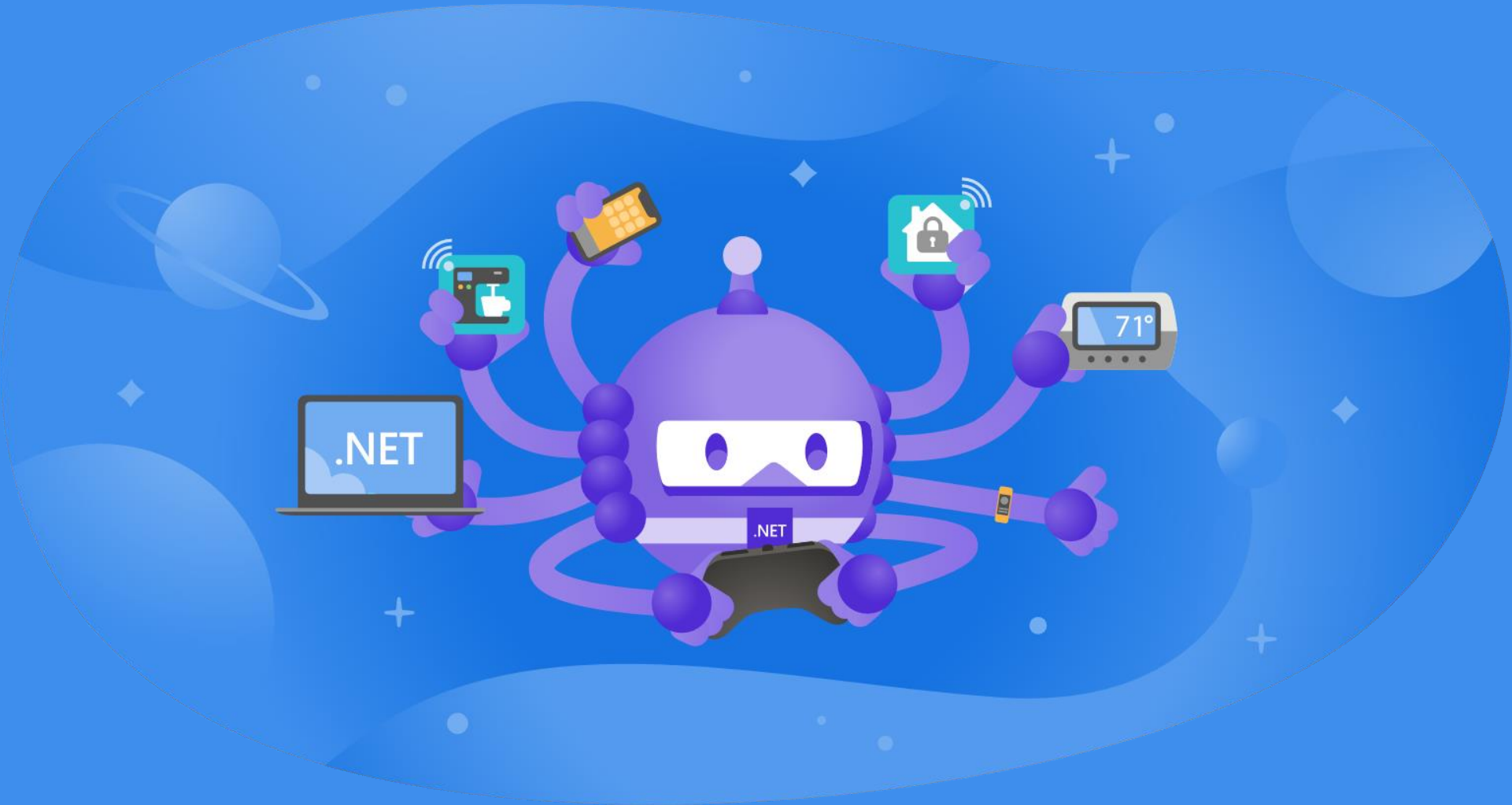
 melissahoughton.dev

 [melissahoughton](https://github.com/melissahoughton)

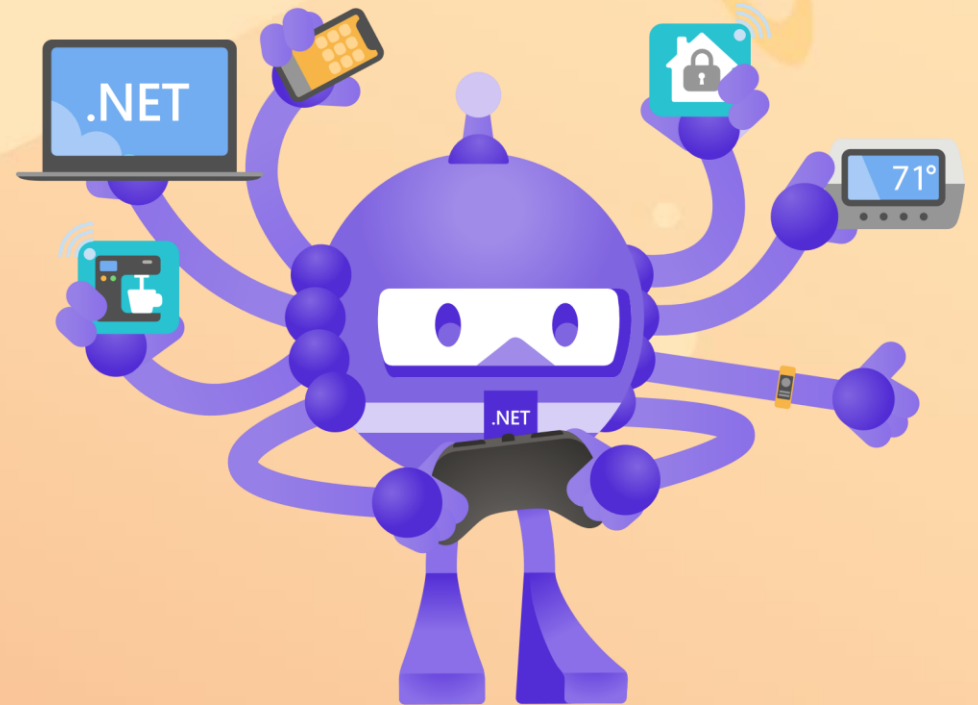
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 [meliss_houghton](https://twitter.com/meliss_houghton)

What is IoT?



How can you use .NET for IoT



.NET IoT Libraries

Libraries	Device Bindings <ul style="list-style-type: none">• Analog Converters• Digital Logic• Display Controller• I/O Expanders• Sensors• LED Drivers• Memory• Motor Drivers• Real Time Clocks	Tooling <ul style="list-style-type: none">• CLI• Docker• Templates• Testing
Core APIs	System.Device.Gpio <ul style="list-style-type: none">• ADC• CAN• GPIO• I2C• PWM• SPI	Futures <ul style="list-style-type: none">• System.Device.*
Platform	Windows 10 IoT / Linux <ul style="list-style-type: none">• X86• X64• ARM32• ARM64	
Hardware	Maker Boards <ul style="list-style-type: none">• Raspberry Pi• HummingBoard• BeagleBone Black• Custom Hardware	

System.Device.Gpio



Protocols Including:

- General-purpose I/O (GPIO)
- Inter-Integrated Circuit (I2C)
- Serial Peripheral Interface (SPI)
- Pulse Width Modulation (PWM)
- Serial port

IoT.Device.Bindings

<https://github.com/dotnet/iot/tree/main/src/devices>



A vibrant space-themed background featuring a large, textured planet in the upper left, a smaller planet in the lower right, and a field of stars. A soft, colorful nebula in shades of purple and blue is visible in the center-right. The word "Demo" is written in a large, white, sans-serif font on the left side.

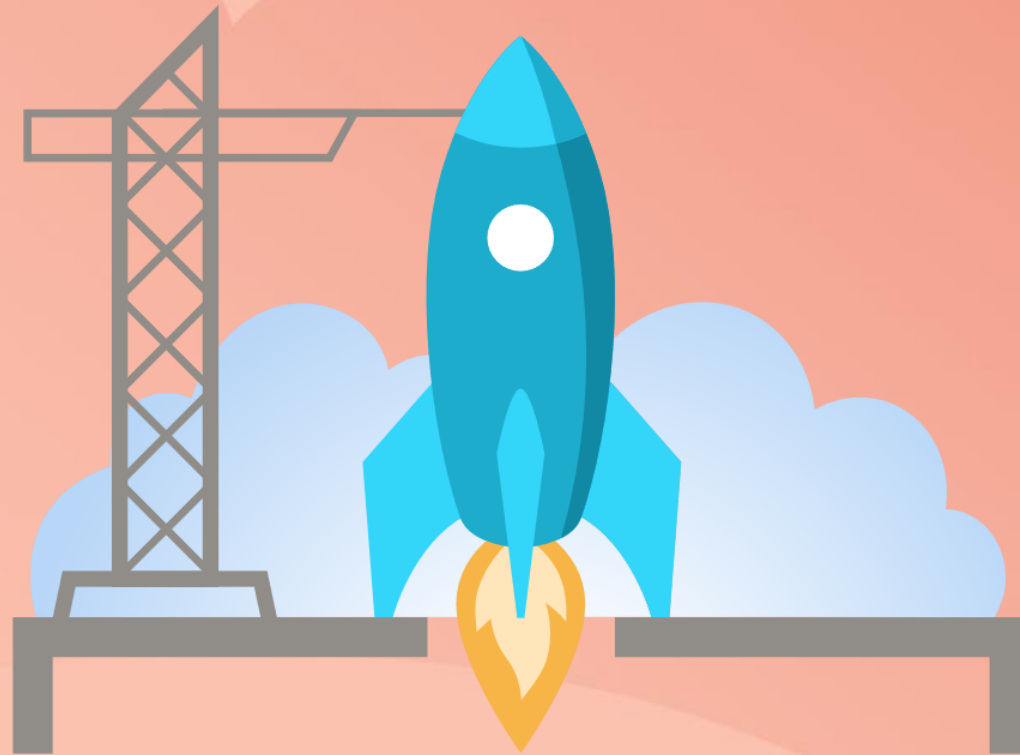
Demo

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Tools



Deployment



Framework-dependent

```
# Install .NET on the device
curl -sSL https://dot.net/v1/dotnet-install.sh | bash /dev/stdin --channel Current

# Publish the app with Deployment mode = Framework-dependent and Target runtime = Portable
dotnet publish

# Copy the files from the computer to the device
scp -r /publish-location/* pi@raspberrypi:/home/pi/deployment-location/

# Run the app on the device
dotnet HelloWorld.dll
```

Self-contained

```
# Publish the app with Deployment mode = Self-contained and Target runtime = linux-arm
dotnet publish -r linux-arm

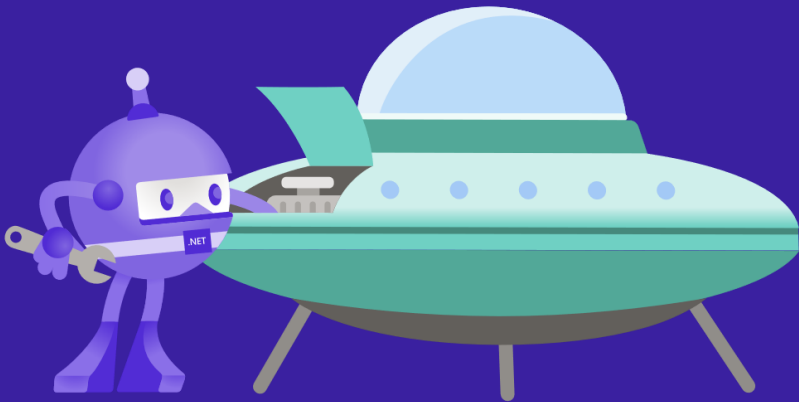
# Copy the files from the computer to the device
scp -r /publish-location/* pi@raspberrypi:/home/pi/deployment-location/

# Run the app on the device
chmod +x HelloWorld
./HelloWorld
```

Debugging

⚠ Required assets to build and debug are missing from 'dotnet.iot'. Add them?

Source: C# (Extension) Don't Ask Again Not Now Yes



Start debugging (points to 'Publish, Launch, and Attach Debugger' button)

Debugger (points to the debugger icon in the toolbar)

Set breakpoint (points to the breakpoint icon on line 15)

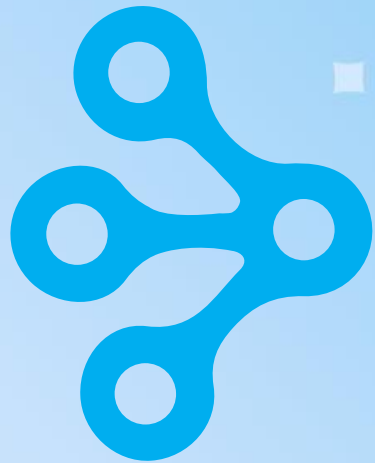
Start debugging shortcut (points to the 'Start Debugging' button in the toolbar)

Pause, step over, step in/out, restart, stop (points to the toolbar icons for pausing and stepping through code)

```
1 using System;
2 using Iot.Device;
3 using Iot.Device.CpuTemperature;
4 using System.Threading;
5
6 namespace dotnet.core.iot
7 {
8     0 references
9     class Program
10    {
11        2 references
12        static CpuTemperature temperature = new CpuTemperature();
13        0 references
14        static void Main(string[] args)
15        {
16            while (true)
17            {
18                if (temperature.IsAvailable)
19                {
20                    Console.WriteLine($"The CPU temperature is {temperature.Temperature.Celsius}");
21                }
22                Thread.Sleep(2000); // sleep for 2000 milliseconds
23            }
24        }
25    }
26 }
```

Demo

.NET nanoFramework



nano
Framework

Demo

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.NET IoT

Powerful boards

All .NET core libraries

IoT.Device.Bindings and
System.Device.Gpio

Manual deployment setup

Manual remote debugging

Deploy the code via SSH
connection

nanoFramework

Low-level microcontrollers

Specific .NET libraries

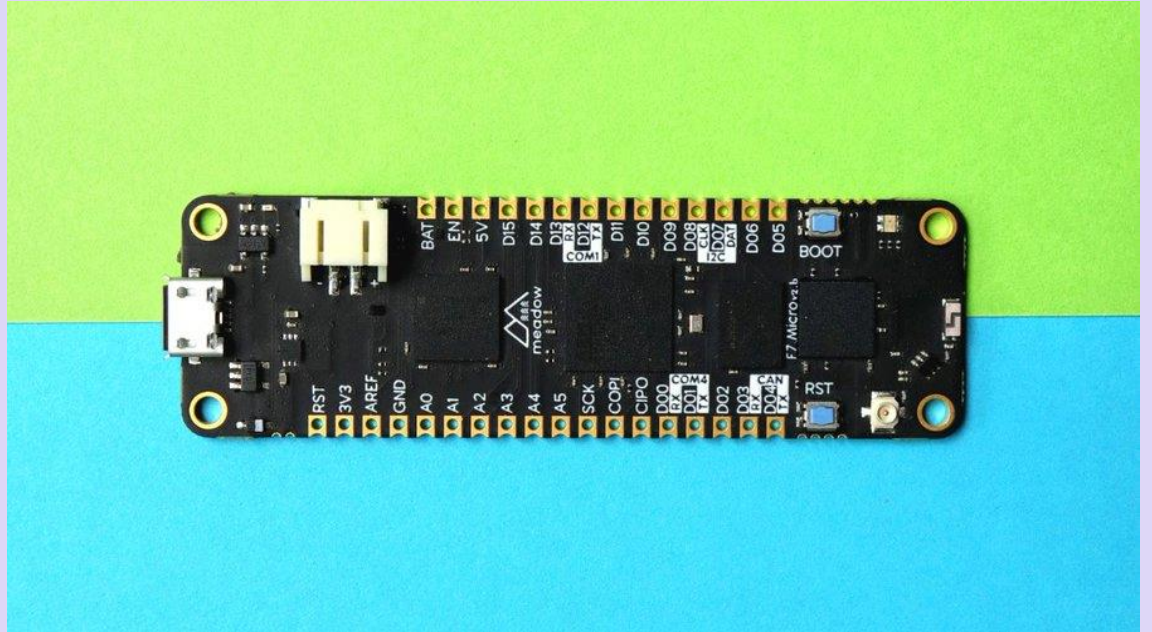
Specific packages per sensor

Built-in deployment

Remote debugging experience

Deploy via wired connection

Meadow



Why use Meadow

- Enterprise IoT
- Full .NET on embeddable microcontrollers
- Plug and Play IoT Library
- Focused on Security
- Cloud agnostic

Program.cs

```
using Meadow;
using System.Threading;

namespace HelloMeadow
{
    class Program
    {
        static IApp app;
        public static void Main(string[] args)
        {
            // instantiate & run new meadow app
            app = new MeadowApp();
            Thread.Sleep(Timeout.Infinite);
        }
    }
}
```

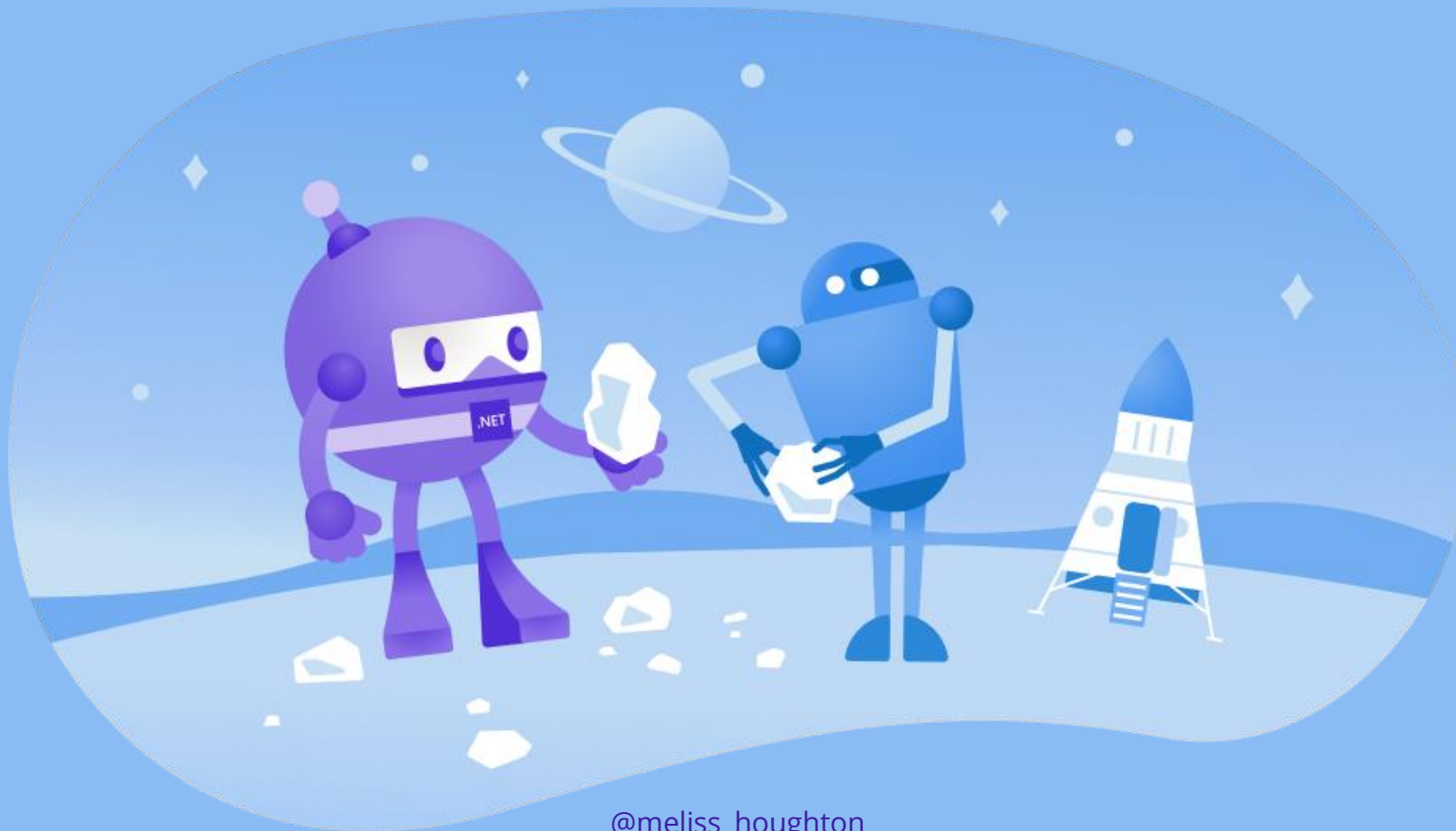
MeadowApp.cs

```
using Meadow;
using Meadow.Devices;
using Meadow.Foundation.Leds;

namespace HelloMeadow
{
    public class MeadowApp : App<F7Micro, MeadowApp>
    {
        public MeadowApp()
        {
            var pwmLed = new PwmLed(
                Device, Device.Pins.D13,
                TypicalForwardVoltage.Blue);
            // pulse the LED
            pwmLed.StartPulse();
        }
    }
}
```

Azure IoT SDK for .NET

<https://github.com/Azure/azure-iot-sdk-csharp>



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Azure IoT Hub

```
// Create device client
// And connect to IoT Hub using MQTT protocol
DeviceClient deviceClient =
    DeviceClient.Create(
        iotHubHostName,
        deviceAuthentication,
        TransportType.Mqtt);

...

// Send the telemetry message.
await deviceClient.SendEventAsync(message);
```

Azure IoT Explorer (preview)

File Edit View Window Help

Azure IoT Explorer (preview) Notifications Settings

Home > MyExampleHub > Devices > mydevice > Telemetry

Stop Show system properties Clear events Simulate a device

Telemetry

Consumer group \$Default

Specify enqueue time No

Use built-in event hub Yes

Receiving events...

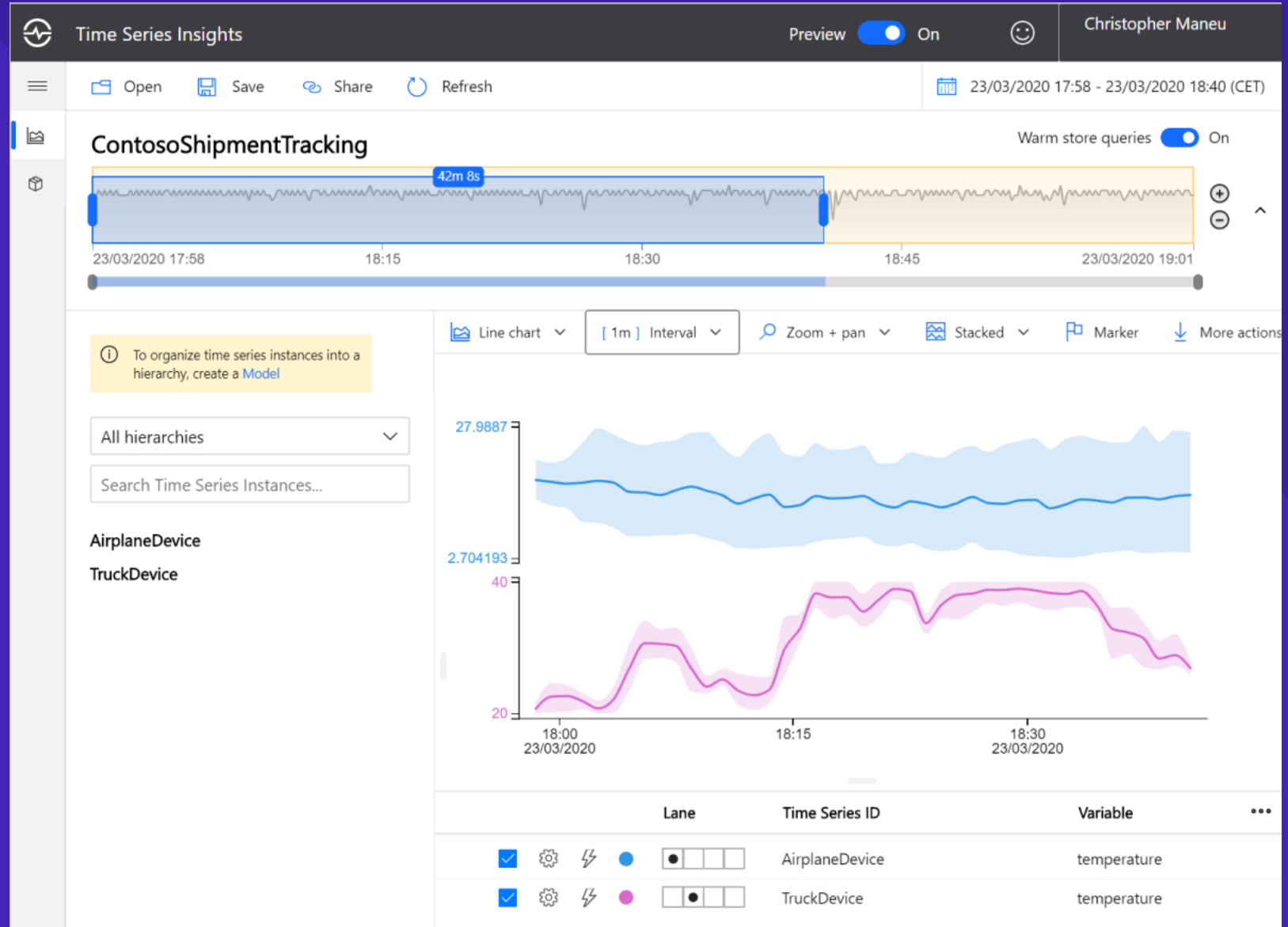
Tue Aug 03 2021 16:03:17 GMT-0700 (Pacific Daylight Time):

```
{
  "body": {
    "workingSet": 27496
  },
  "enqueuedTime": "Tue Aug 03 2021 16:03:17 GMT-0700 (Pacific Daylight Time)",
  "properties": {}
}
```

Tue Aug 03 2021 16:03:17 GMT-0700 (Pacific Daylight Time):

```
{
  "body": {
    "temperature": 21.9
  },
  "enqueuedTime": "Tue Aug 03 2021 16:03:17 GMT-0700 (Pacific Daylight Time)",
  "properties": {}
}
```

Time Series Insights



Digital Twins

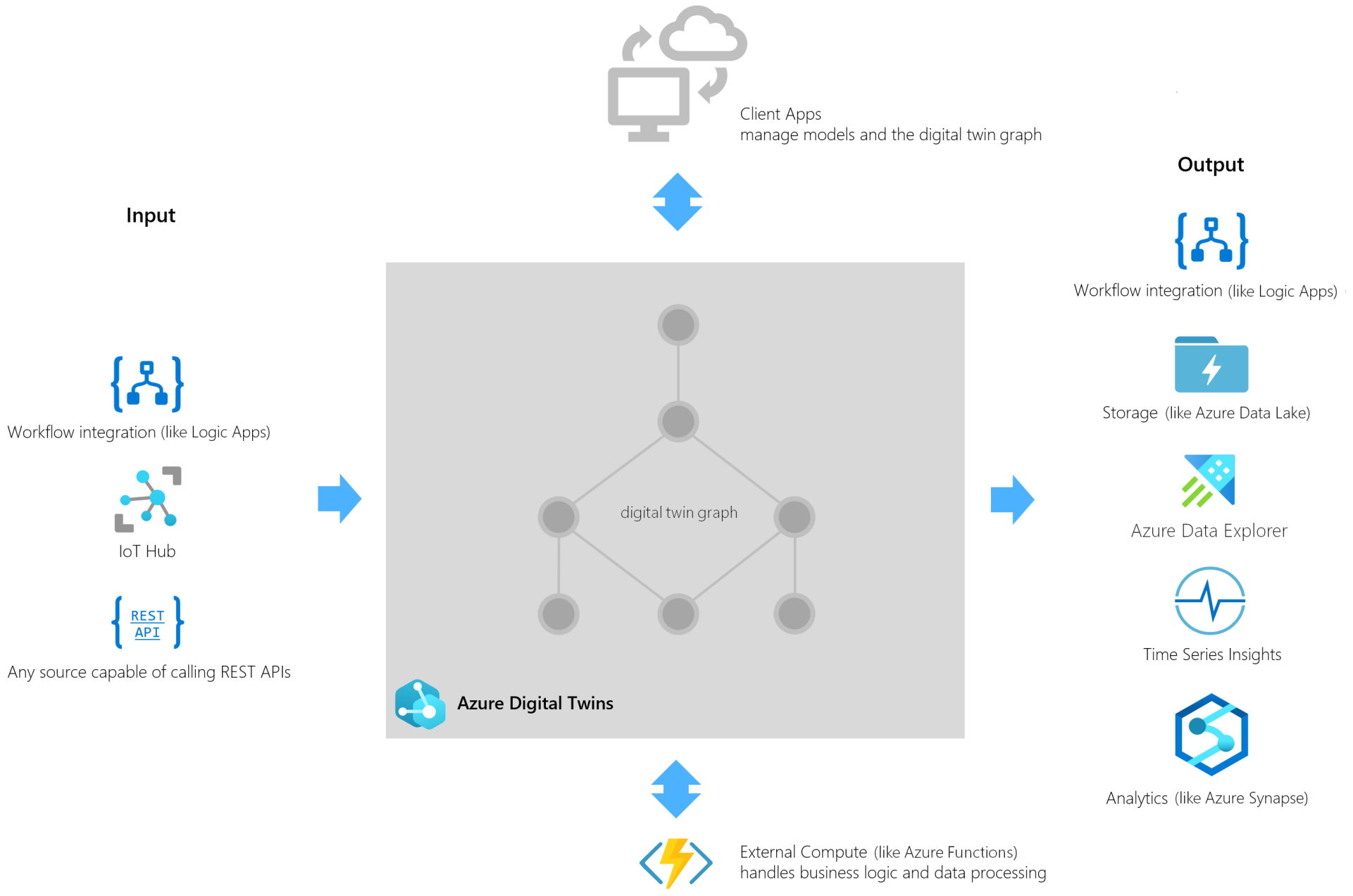
```
dotnet add package Azure.DigitalTwins.Core
dotnet add package Azure.Identity
```

```
string adtInstanceUrl = "https://<your-Azure-Digital-Twins-instance-hostName>";

var credential = new DefaultAzureCredential();
var client = new DigitalTwinsClient(new Uri(adtInstanceUrl), credential);
Console.WriteLine($"Service client created - ready to go");
```

```
var twinData = new BasicDigitalTwin();
twinData.Metadata.ModelId = "dtmi:example:SampleModel;1";
twinData.Contents.Add("data", $"Hello World!");

string prefix = "sampleTwin-";
for (int i = 0; i < 3; i++)
{
    try
    {
        twinData.Id = $"{prefix}{i}";
        await client.CreateOrReplaceDigitalTwinAsync<BasicDigitalTwin>(twinData.Id, twinData);
        Console.WriteLine($"Created twin: {twinData.Id}");
    }
    catch (RequestFailedException e)
    {
        Console.WriteLine($"Create twin error: {e.Status}: {e.Message}");
    }
}
```

AI/ML for IoT with .NET



ML.NET

SentimentModelmbconfig

Scenario Select a scenario

Environment
Data
Train
Evaluate
Consume
Next steps

Train with your data
The following scenarios use Automated ML to train and pick the best model for your data.
[Learn more about training with your own data in Model Builder.](#)

Data classification
Classify tabular data into 2+ categories, e.g. predict if comments are positive or negative sentiments.
Local

Value prediction
Predict a numeric value from your data (regression), e.g. predict the price of a house based on features like size, location, etc.
Local

Image classification
Classify images into 2+ categories, e.g. predict whether an image is of a dog or a cat.
Azure Local

Recommendation
Produce a list of suggested items for a particular user, e.g. recommend products.
Local

Object detection
Detect and identify objects in images, e.g. detect cars in an image and draw bounding boxes around each car.
Azure

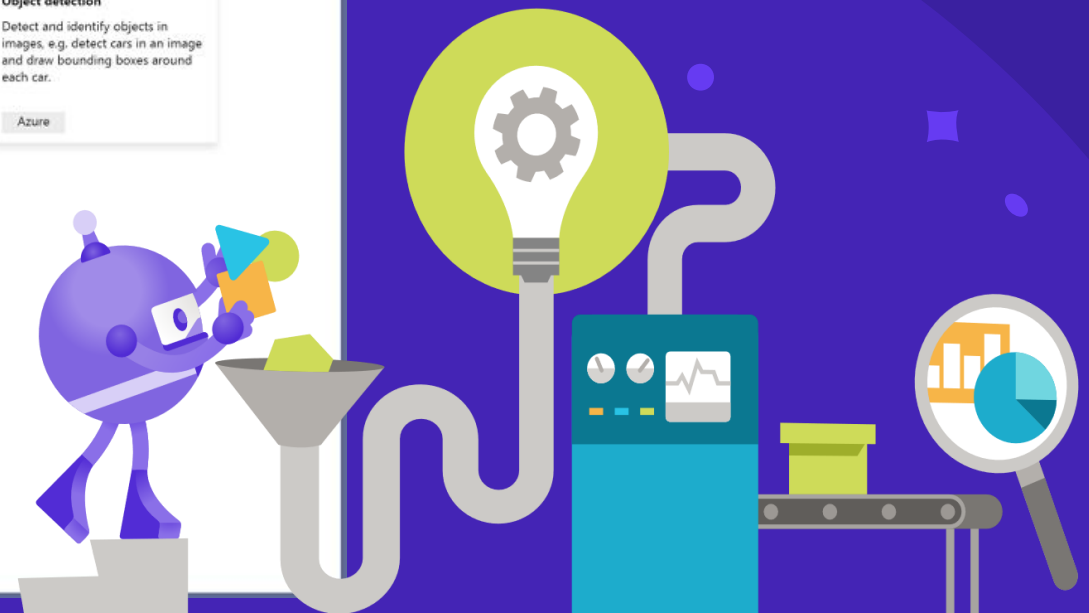
Limited scenarios
The following scenarios are not yet supported by Automated ML, so walkthroughs with an example dataset and pre-defined training code are provided.
[Learn more about examples in Model Builder.](#)

Anomaly detection
Detect abnormalities or outliers in data. This example detects spikes in shampoo sales.
Example

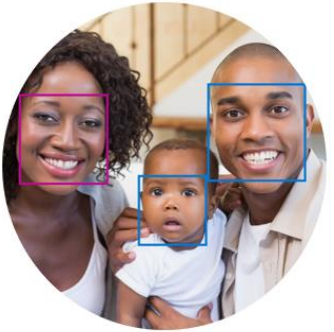

Forecasting
Predict future values based on previously observed time series values. This example predicts bike rental service demand.
Example

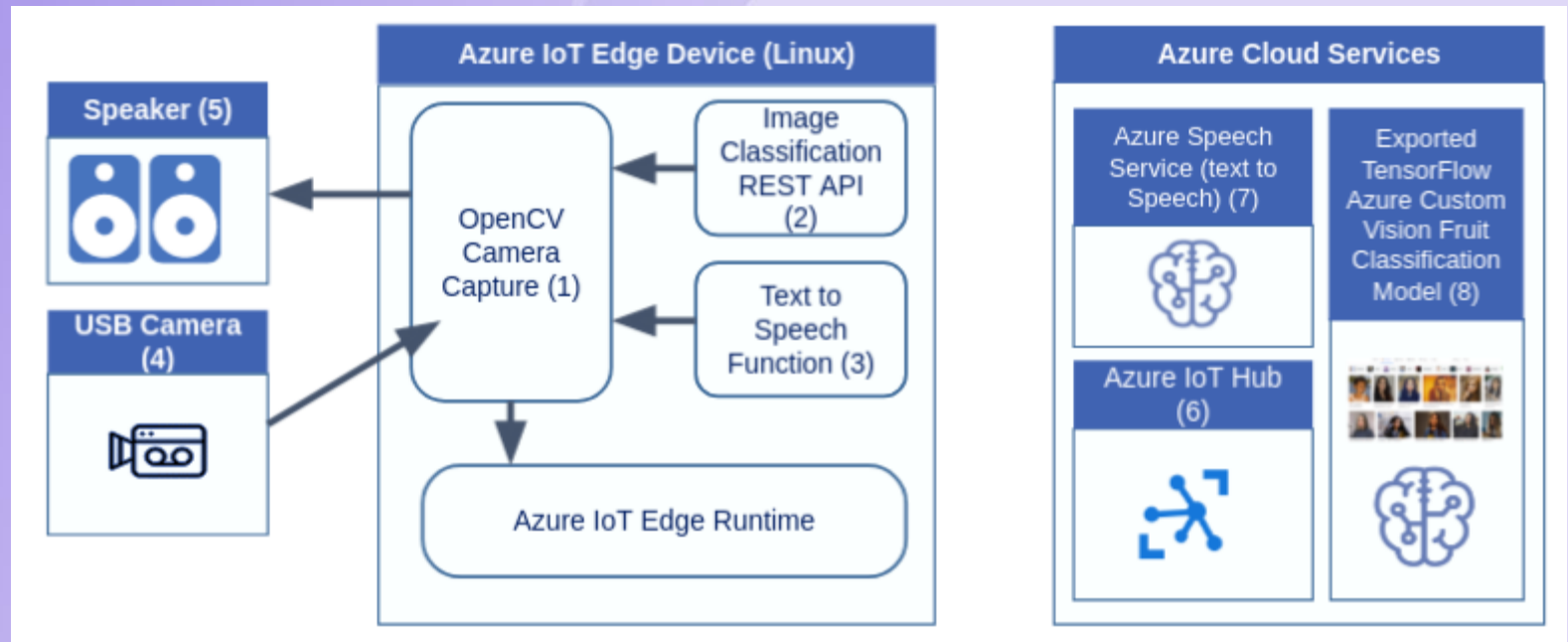
Clustering
Identify groups of related items without any pre-existing labels or categories. This example divides a set of iris flowers into different...
Example

Feedback

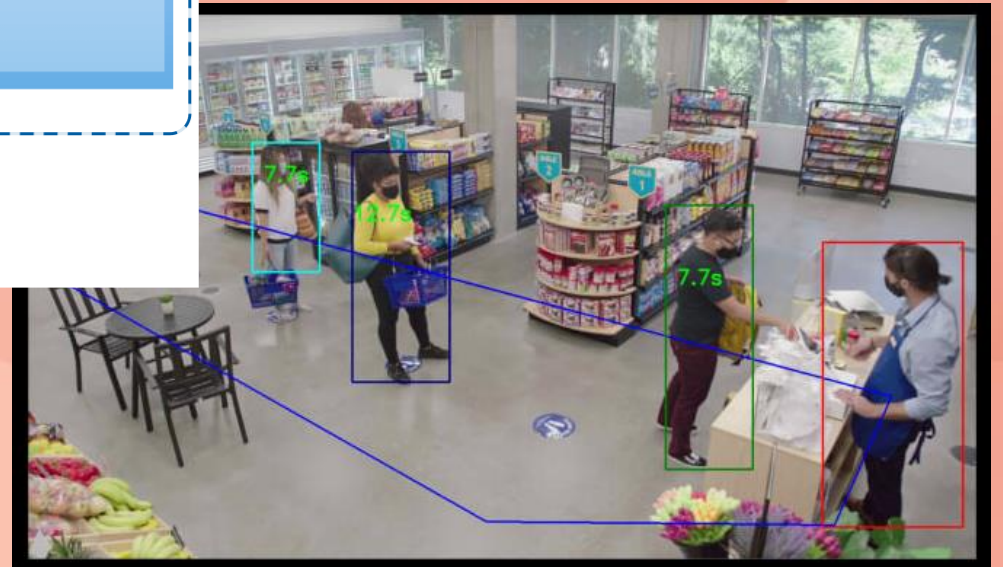
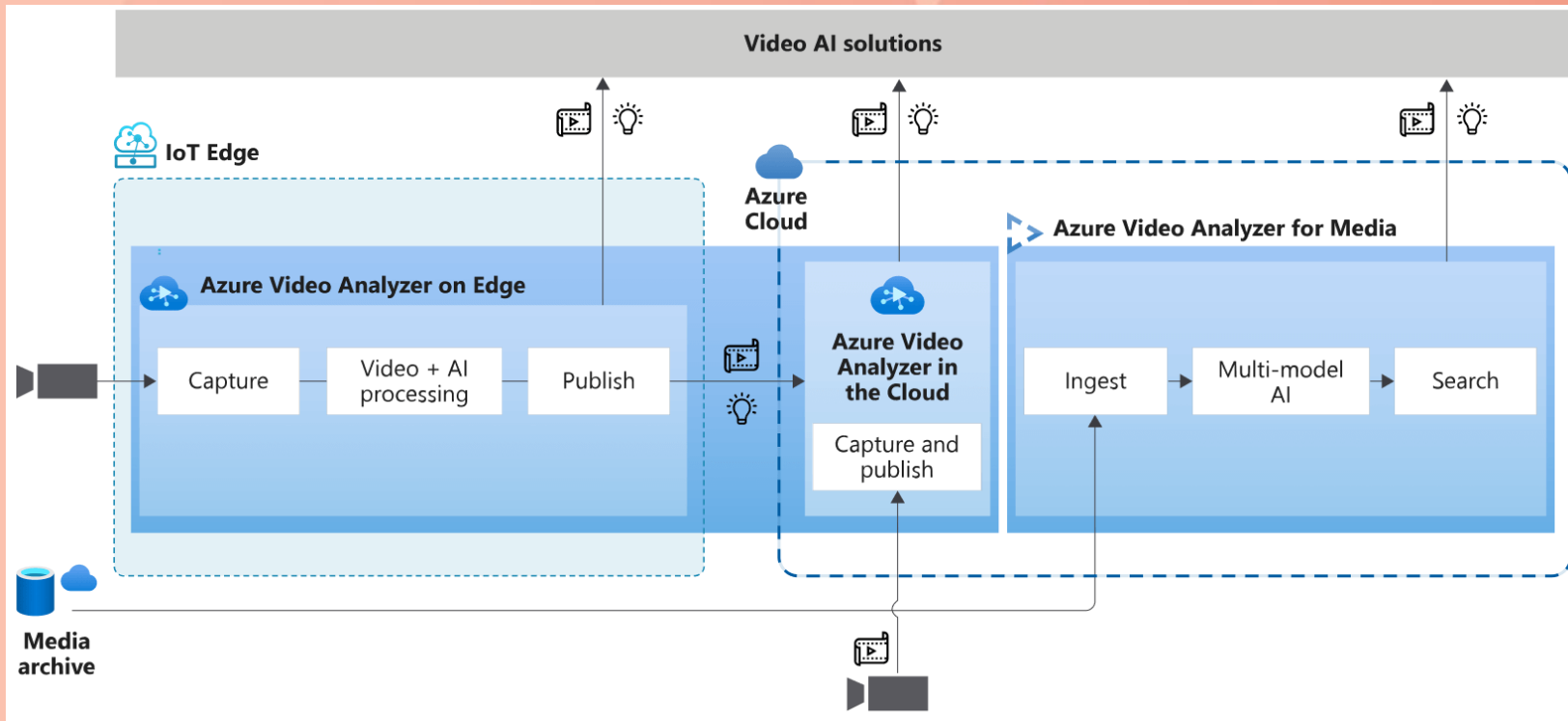


Azure Cognitive Services

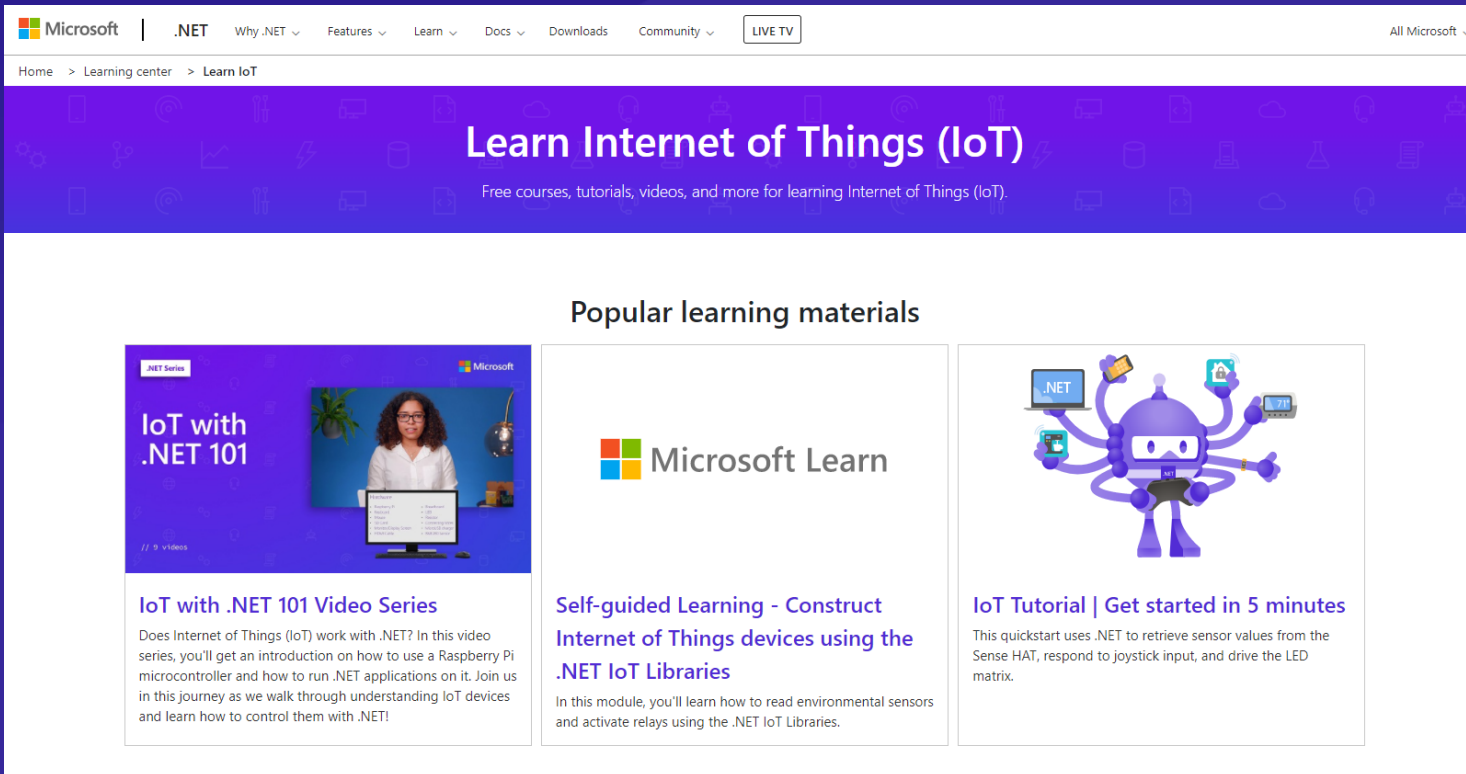
Vision	Language
	
Face Recognition & Identification Recognize Text (OCR)	Language Detection Language Understanding Key phrase extraction Text Sentiment Analysis



Azure Video Analyser



How to get started



The screenshot shows the Microsoft .NET IoT learning page. At the top, there is a navigation bar with the Microsoft logo, ".NET", and various menu items like "Why .NET", "Features", "Learn", "Docs", "Downloads", "Community", and "LIVE TV". Below the navigation bar, there is a breadcrumb trail: "Home > Learning center > Learn IoT". The main heading is "Learn Internet of Things (IoT)" with a sub-heading "Free courses, tutorials, videos, and more for learning Internet of Things (IoT)". Underneath, there is a section titled "Popular learning materials" with three cards. The first card is for the "IoT with .NET 101 Video Series", the second is for "Self-guided Learning - Construct Internet of Things devices using the .NET IoT Libraries", and the third is for "IoT Tutorial | Get started in 5 minutes".


Microsoft | .NET Why .NET Features Learn Docs Downloads Community LIVE TV All Microsoft

Home > Learning center > Learn IoT

Learn Internet of Things (IoT)


Free courses, tutorials, videos, and more for learning Internet of Things (IoT).

Popular learning materials




IoT with .NET 101 Video Series

Does Internet of Things (IoT) work with .NET? In this video series, you'll get an introduction on how to use a Raspberry Pi microcontroller and how to run .NET applications on it. Join us in this journey as we walk through understanding IoT devices and learn how to control them with .NET!



Self-guided Learning - Construct Internet of Things devices using the .NET IoT Libraries

In this module, you'll learn how to read environmental sensors and activate relays using the .NET IoT Libraries.



IoT Tutorial | Get started in 5 minutes

This quickstart uses .NET to retrieve sensor values from the Sense HAT, respond to joystick input, and drive the LED matrix.



Summary



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Thanks for joining!



<https://bit.ly/dotnetconf-iot>



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