**Create serverless applications**

**Choose the best Azure service to automate your business processes**

* Logic Apps
* Microsoft Power Automate
* WebJobs
* Azure Functions

**Design-first technologies**

They both include user interfaces in which you can draw out the workflow

* **Logic Apps** is a service within Azure that you can use to automate, orchestrate, and integrate disparate components of a distributed application. By using the design-first approach in Logic Apps, you can draw out complex workflows that model complex business processes.

You can create or edit a workflow in JSON

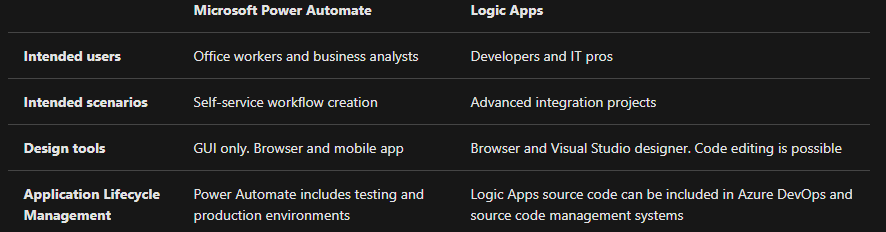
One reason why Logic Apps is so good at integration is that over 200 connectors are included. You can create your own connector if your system exposes a REST API.

* **Microsoft Power Automate** is a service that you can use to create workflows even when you have no development or IT Pro experience. You can create workflows that integrate and orchestrate many different components by using the website or the Microsoft Power Automate mobile app.

There are four different types of flow that you can create:

* + **Automated** a flow that is started by a trigger from some event.
  + **Button**
  + **Scheduled**
  + **Business process** a flow that models a business process such as the stock ordering process or the complaints procedure. The flow process can have: notification to required people; with their approval recorded; calendar dates for steps; and recorded time of flow steps.

*Under the hood, Microsoft Power Automate is built on Logic Apps. This fact means that Power Automate supports the same range of connectors and actions*



**Code-first technologies**

This is the case when you need more control over the performance of your workflow or need to write custom code as part of the business process.

* **WebJobs and the WebJobs SDK** WebJobs are a part of the Azure App Service that you can use to run a program or script automatically.  
  There are two kinds of WebJob:
  + **Continuous** run in a continuous loop. For example, you could use a continuous WebJob to check a shared folder for a new photo.
  + **Triggered** run when you manually start them or on a schedule.

The SDK includes a range of classes, such as **JobHostConfiguration** and **HostBuilder**, which   
reduce the amount of code required to interact with the Azure App Service. The WebJobs SDK only supports C# and the NuGet package manager.

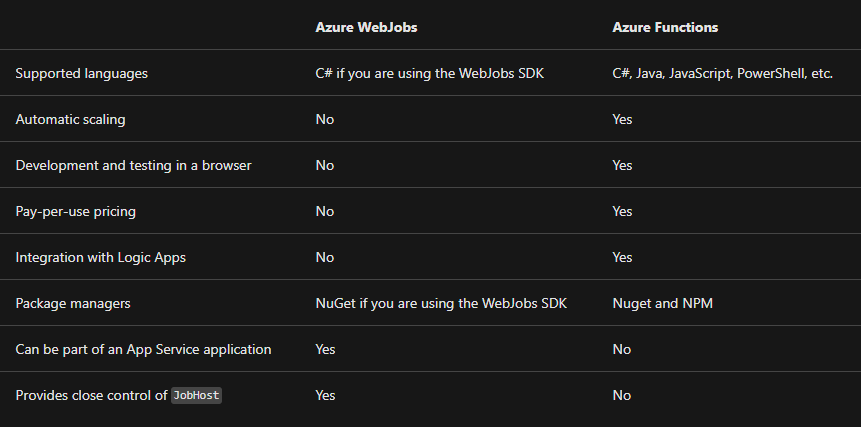
* **Azure Functions** is a simple way for you to run small pieces of code in the cloud, without having to worry about the infrastructure required to host that code.

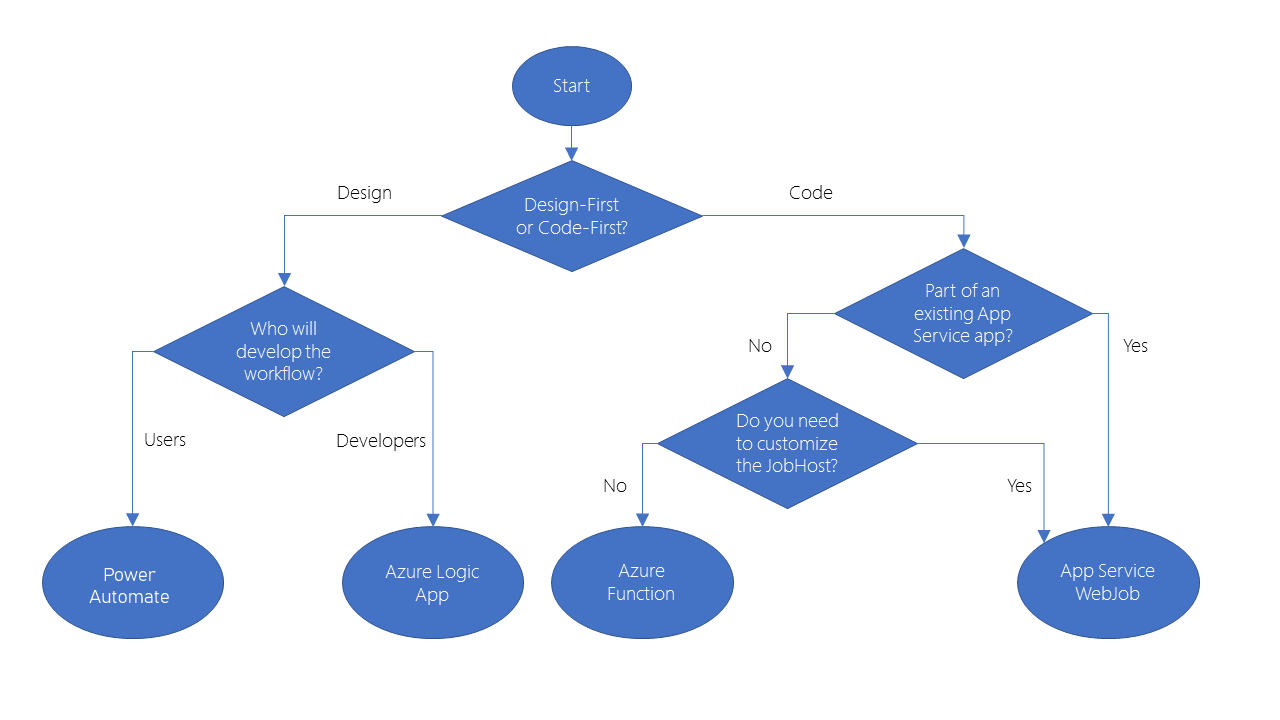
*In addition, with the consumption plan option, you only pay for the time when the code runs.* Azure automatically scales your function in response to the demand from users.

When you create an Azure Function, you can start by writing the code for it in the portal.

Alternatively, if you need source code management, you can use GitHub or Azure DevOps Services.

* + **HTTPTrigger**
  + **TimerTrigger**
  + **BlobTrigger**
  + **CosmosDBTrigger**



**How to choose a service**

**Create serverless logic with Azure Functions  
  
Execution time**

By default, functions have a timeout of 5 minutes. This timeout is configurable to a maximum of 10 minutes. If your function requires more than 10 minutes to execute, you can host it on a VM.   
If your service is initiated through an HTTP request and you expect that value as an HTTP response, the timeout is further restricted to 2.5 minutes. Finally, there's also an option called **Durable Functions** that allows you to orchestrate the executions of multiple functions without any timeout.

**Execution frequency**

If you expect your function to be executed continuously by multiple clients, it would be prudent to estimate the usage and calculate the cost of using functions accordingly. It might be cheaper to host your service on a VM.  
While scaling, only one function app instance can be created every 10 seconds, for up to 200 total instances. Keep in mind, each instance can service multiple concurrent executions, so there is no set limit on how much traffic a single instance can handle. Different types of triggers have different scaling requirements, so research your choice of trigger and investigate its limits.

**What is a function app?**

Functions are hosted in an execution context called a function app. You define function apps to logically group and structure your functions and a compute resource in Azure.

**Choose a service plan**

Function apps may use one of two types of service plans. The first service plan is the **Consumption service plan.**The plan that you choose when using the Azure serverless application platform. The Consumption service plan provides automatic scaling and bills you when your functions are running. The Consumption plan comes with a configurable timeout period for the execution of a function. By default, it is 5 minutes, but may be configured to have a timeout as long as 10 minutes.  
**Azure App Service plan** allows you to avoid timeout periods by having your function run continuously on a VM that you define. When using an App Service plan, you are responsible for managing the app resources the function runs on, so this is technically not a serverless plan. However, it may be a better choice if your functions are used continuously or if your functions require more processing power or execution time than the Consumption plan can provide.

**Storage account requirements**

When you create a function app, it must be linked to a storage account. You can select an existing account or create a new one. The function app uses this storage account for internal operations such as logging function executions and managing execution triggers.

**Triggers**

Functions are event driven, which means they run in response to an event.  
Azure supports triggers for the following services.

| **Service** | **Trigger description** |
| --- | --- |
| Blob storage | Starts a function when a new or updated blob is detected. |
| Azure Cosmos DB | Start a function when inserts and updates are detected. |
| Event Grid | Starts a function when an event is received from Event Grid. |
| HTTP | Starts a function with an HTTP request. |
| Microsoft Graph Events | Starts a function in response to an incoming webhook from the Microsoft Graph. Each instance of this trigger can react to one Microsoft Graph resource type. |
| Queue storage | Starts a function when a new item is received on a queue. The queue message is provided as input to the function. |
| Service Bus | Starts a function in response to messages from a Service Bus queue. |
| Timer | Starts a function on a schedule. |

### Bindings

Bindings are a declarative way to connect data and services to your function. Bindings know how to talk to different services, which means you don't have to write code in your function to connect to data sources and manage connections. The platform takes care of that complexity for you as part of the binding code. Each binding has a direction - your code reads data from input bindings, and writes data to output bindings. Each function can have zero or more bindings to manage the input and output data processed by the function.

A trigger is a special type of input binding that has the additional capability of initiating execution.

### Secure HTTP triggers

HTTP triggers let you use API keys to block unknown callers by requiring the key to be present on each request. When you create a function, you select the authorization level. By default, it's set to Function, which requires a function-specific API key, but it can also be set to Admin to use a global "master" key, or Anonymous to indicate that no key is required.

Because we specified Function when we created this function, we will need to supply the key when we send the HTTP request. You can send it as a query string parameter named code, or as an HTTP header (preferred) named x-functions-key.

**Execute an Azure Function with triggers**

**What is a timer trigger?**

A timer trigger is a trigger that executes a function at a consistent interval. To create a timer trigger, you need to supply two pieces of information.

* **A Timestamp** parameter name, which is simply an identifier to access the trigger in code.
* **A Schedule**, which is a CRON expression that sets the interval for the timer.

**What is a CRON expression?**

A CRON expression is a string that consists of six fields that represent a set of times. The order of the six fields in Azure is: {second} {minute} {hour} {day} {month} {day of the week}.

For example, a CRON expression to create a trigger that executes every five minutes looks like:

0 \*/5 \* \* \* \*

| **To build a CRON expression, you need to have a basic understanding of some of the special characters.** | | |
| --- | --- | --- |
| **Special character** | **Meaning** | **Example** |
| \* | Selects every value in a field | An asterisk "\*" in the day of the week field means *every* day. |
| , | Separates items in a list | A comma "1,3" in the day of the week field means just Mondays (day 1) and Wednesdays (day 3). |
| - | Specifies a range | A hyphen "10-12" in the hour field means a range that includes the hours 10, 11, and 12. |
| / | Specifies an increment | A slash "\*/10" in the minutes field means an increment of every 10 minutes. |

When you put all the fields together, the expression is read as "on the first second, of every fifth minute of every hour, of every day, of every month".

**Execute an Azure function with an HTTP request**

**What is an HTTP trigger Authorization level?**

An HTTP triggerAuthorization level is a flag that indicates if an incoming HTTP request needs an API key for authentication reasons.

**There are three Authorization levels:**

* Function
* Anonymous
* Admin

The Function and Admin levels are "key" based. To send an HTTP request, you must supply a key for authentication. There are two types of keys: function and host. The difference between the two keys is their scope. **Function keys are specific to a function. Host keys apply to all functions inside the function app.** If your Authorization level is set to Function, you can use either a function or a host key. If your Authorization level is set to Admin, you must supply a host key.  
The Anonymous level means that there's no authentication required. We use this level in our exercise.

**Execute an Azure function when a blob is created**

**What is Azure Blob storage?**

Azure Blob storage is an object storage solution that's designed to store large amounts of unstructured data. For example, Azure Blob storage is great at doing things like:

* Storing files
* Serving files
* Streaming video and audio
* Logging data

There are three types of blobs: block blobs, append blobs, and page blobs.

* **Block blobs** are the most common type. They allow you to store text or binary data efficiently.
* **Append blobs** are like block blobs, but they're designed more for append operations like creating a log file that's being constantly updated.
* **Page blobs** are made up of pages and are designed for frequent random read and write operations.

**How to create a blob trigger**

One setting that you'll want to look at is the Path. The Path tells the blob trigger where to monitor to see if a blob is uploaded or updated. By default, the Path value is:

samples-workitems/{name}

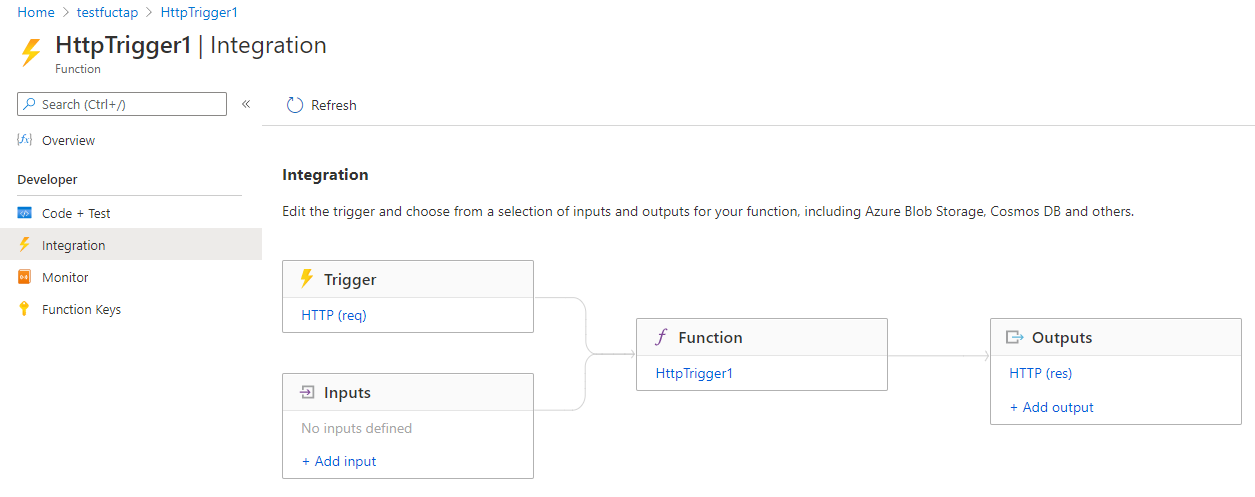
Let's break down this concept into two pieces: samples-workitems and {name}. The first part, samples-workitems, represents the blob container that the trigger monitors. The second part, {name} means that every type of file will cause the trigger to invoke the function. The function is invoked because there's no filter. For example, we could make the trigger invoke the function only when a PNG file is added by using syntax like:

samples-workitems/{name}.png

The last significant piece of information with this concept is the text name. The name represents a parameter in your Azure function that receives the name of the added file.

**True or false: an Azure Function can have multiple triggers associated with it?  
R:** *Every Azure Function must have exactly one trigger associated with it. If you want to use multiple triggers, you must create multiple functions.*

**Chain Azure Functions together using input and output bindings**



*You can see that we can't add more than one trigger. In fact, to change the trigger for our function, we would have to first delete the trigger, and create a new one. However, the Inputs and Outputs sections of this page display a plus sign (+) to add more bindings so we can accept more than one input value, and emit more than one output value.*

**What is a binding?**

Provide a declarative way to connect to data from within your code.   
This is powerful because you can connect to your data sources without having to code specific connection logic (like database connections or web API interfaces).

**Types of bindings**

* **Input binding** - An input binding is a connection to a data source. Our function can read data from these inputs.
* **Output binding** - An output binding is a connection to a data destination. Our function can write data to these destinations.

**Types of supported bindings**

* Blob Storage
* Azure Service Bus Queues
* Azure Cosmos DB
* Azure Event Hubs
* External Files
* External Tables
* HTTP endpoints

*A binding type can be used as an input, an output or both.*

**Binding properties**

Three properties are required in all bindings. You may have to supply additional properties based on the type of binding and storage you are using.

* **Name** - Defines the function parameter through which you access the data. For example, in a queue input binding, this is the name of the function parameter that receives the queue message content.
* **Type** - Identifies the type of binding, i.e., the type of data or service we want to interact with.
* **Direction** - Indicates the direction data is flowing, i.e., is it an input or output binding?

Additionally, most binding types also need a fourth property:

* **Connection** - Provides the name of an app setting key that contains the connection string. Bindings use connection strings stored in app settings to keep secrets out of the function code. This makes your code more configurable and secure.

{  
 "name": "headshotBlob",  
 "type": "blob",  
 "path": "thumbnail-images/{filename}",  
 "connection": "HeadshotStorageConnection",  
 "direction": "in"  
 }

The path property is required when using the Blob trigger, and should be provided in the style shown here, with curly braces around the filename portion of the path. This creates a **binding expression** that allows you to reference the blob's name in other bindings and in your function's code.

**Write data with output bindings**

As with input bindings, there are multiple types of output bindings. However not all types support both input and output. You'll use them anytime you want to send or store data. Here, we'll look at the types that support output bindings and when to use them.

**Output binding types**[**https://docs.microsoft.com/en-us/learn/modules/chain-azure-functions-data-using-bindings/6-write-data-with-output-bindings-portal-lesson**](https://docs.microsoft.com/en-us/learn/modules/chain-azure-functions-data-using-bindings/6-write-data-with-output-bindings-portal-lesson)

**Combining input and output bindings**

It's possible to apply multiple bindings to a single function. This allows you to define both input and output bindings, and the input and output can even be the same binding type.

**Input binding types**[**https://docs.microsoft.com/en-us/azure/azure-functions/functions-triggers-bindings?tabs=csharp#supported-bindings**](https://docs.microsoft.com/en-us/azure/azure-functions/functions-triggers-bindings?tabs=csharp#supported-bindings)

**What is a binding expression?**

A binding expression is specialized text in function.json, function parameters, or code that is evaluated when the function is invoked to yield a value. For example, if you have a Service Bus Queue binding, you could use a binding expression to get the name of the queue from App Settings.

**Types of binding expressions**

* App settings
* Trigger file name
* Trigger metadata
* JSON payloads
* New GUID
* Current date and time

Most expressions are identified by wrapping them in curly braces. However, app setting binding expressions are wrapped in percent signs rather than curly braces. For example if the blob output binding path is %Environment%/newblob.txt and the Environment app setting value is Development, a blob will be created in the Development container.

**Add an Azure Cosmos DB input binding**

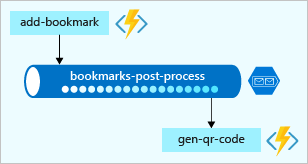
In the Document ID field, enter {id}.

This syntax is known as a binding expression. The function is triggered by an HTTP request that uses a query string to specify the ID to look up.

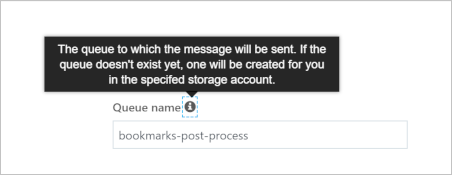
An incoming HTTP request triggers the function, and an id query parameter is passed to the Azure Cosmos DB input binding. If the database finds a document that matches this ID, the bookmark parameter will be set to the located document. In that case, you construct a response that contains the URL value found in the bookmarked document. If no document is found matching this key, you would respond with a payload and status code that tells the user the bad news.

**Add an Azure Queue Storage output binding**

Azure Queue storage is a service for storing messages that can be accessed from anywhere in the world. The size of a single message can be as much as 64 KB, and a queue can contain millions of messages - up to the total capacity of the storage account in which it is defined. T



*The only task you performed was to create a queue binding. You never created the queue explicitly. You are witnessing the power of bindings! As the following notification declares, the queue is automatically created for you if it doesn't exist.*



In this exercise, we expanded your knowledge of bindings to output bindings, writing data to your Azure Cosmos DB. We went further and added another output binding to post messages to an Azure queue. This demonstrates the true power of bindings to help you shape and move data from incoming sources to a variety of destinations. We haven't written any database code or had to manage connection strings ourselves. Instead, we configured bindings declaratively and let the platform take care of securing connections, scaling our function, and scaling our connections.

**Create a long-running serverless workflow with Durable Functions**

**Durable Functions**

Is an extension of Azure Functions that enables you to perform long-lasting, stateful operations in Azure. Azure provides the infrastructure for maintaining state information. You can use Durable Functions to orchestrate a long-running workflow. Using this approach, you get all the benefits of a serverless hosting model, while letting the Durable Functions framework take care of activity monitoring, synchronization, and runtime concerns.

*Durable Functions is an extension of Azure Functions****. Whereas Azure Functions operate in a stateless environment, Durable Functions can retain state between function calls****. This approach enables you to simplify complex stateful executions in a serverless-environment.*

***Some benefits of using Durable Functions include:***

* They enable you to write event driven code. A durable function can wait asynchronously for one or more external events, and then perform a series of tasks in response to these events.
* You can chain functions together. You can implement common patterns such as fan-out/fan-in, which uses one function to invoke others in parallel, and then accumulate the results.
* You can orchestrate and coordinate functions, and specify the order in which functions should execute.
* The state is managed for you. You don't have to write your own code to save state information for a long-running function.

**An orchestration function provides these extra benefits:**

* You can define the workflows in code. You don't need to write a JSON description or use a workflow design tool.
* Functions can be called both synchronously and asynchronously. Output from the called functions is saved locally in variables and used in subsequent function calls.
* Azure checkpoints the progress of a function automatically when the function awaits. Azure may choose to dehydrate the function and save its state while the function waits, to preserve resources and reduce costs. When the function starts running again, Azure will rehydrate it and restore its state.

**Function types**

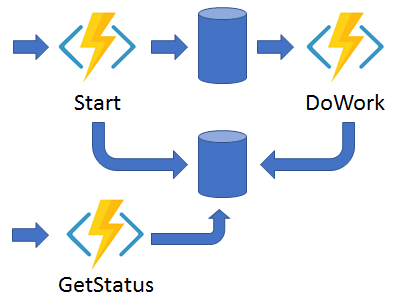
* **Client** functions are the entry point for creating an instance of a Durable Functions orchestration. They can run in response to an event from many sources, such as a new HTTP request arriving, a message being posted to a message queue, an event arriving in an event stream. You can write them in any of the supported languages.
* **Orchestrator** functions describe how actions are executed, and the order in which they are run. You write the orchestration logic in code (C# or JavaScript).
* **Activity** functions are the basic units of work in a durable function orchestration. An activity function contains the actual work performed by the tasks being orchestrated.

**Application patternsApplication patterns**

**Function chaining** - Executes a sequence of functions in a specified order. The output of one function is applied to the input of the next function in the sequence. The output of the final function is used to generate a result.

**Fan out/fan in** - This pattern runs multiple functions in parallel and then waits for all the functions to finish. The results of the parallel executions can be aggregated or used to compute a final result. 

**Async HTTP APIs** - This pattern addresses the problem of coordinating state of long-running operations with external clients. An HTTP call can trigger the long-running action. Then, it can redirect the client to a status endpoint. The client can learn when the operation is finished by polling this endpoint.



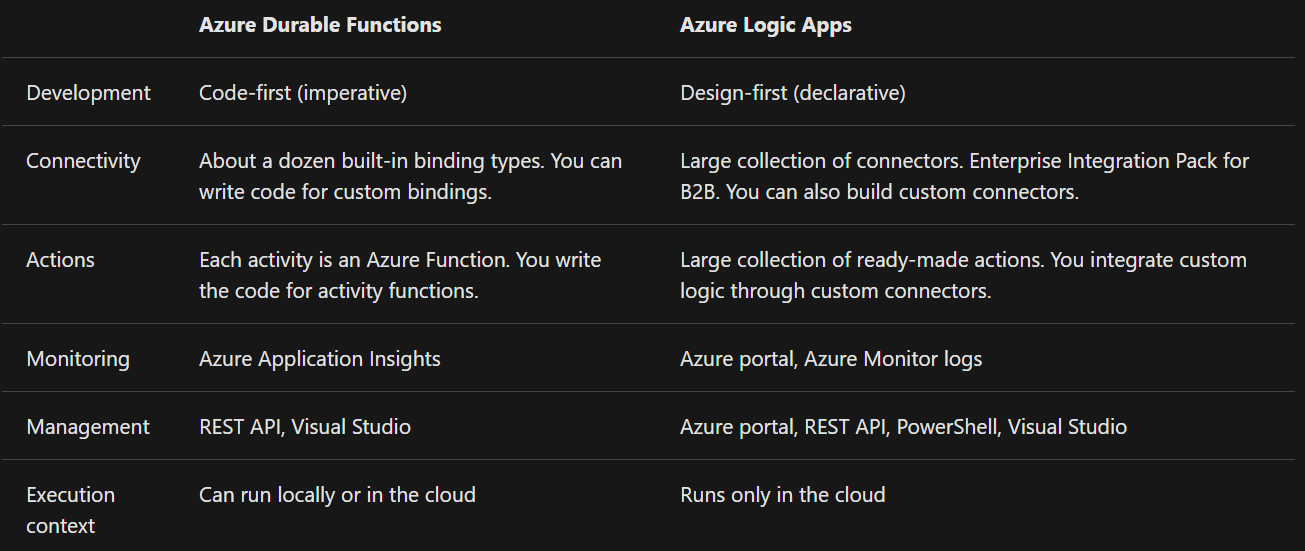
**Monitor -** This pattern implements a recurring process in a workflow, possibly looking for a change in state. For example, you could use this pattern to poll until specific conditions are met.



**Human interaction** - This pattern combines automated processes that also involve some human interaction. A manual process within an automated process is tricky because people aren't as highly available and as responsive as most computers. Human interaction can be incorporated using timeouts and compensation logic that runs if the human fails to interact correctly within a specified response time. An approval process is an example of a process that involves human interaction.



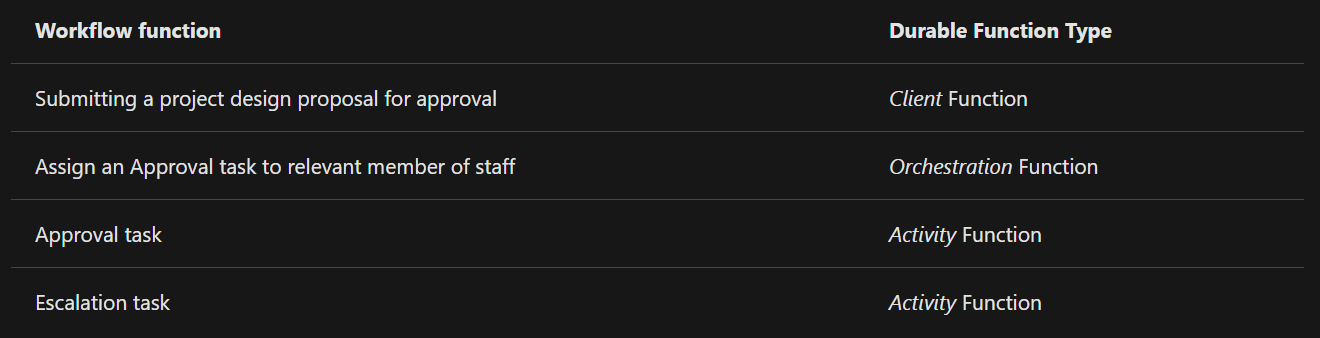
**Comparison with Logic Apps**



**Description of the design approval process**

1. A project design is submitted.
2. An approval task is allocated to a manager, so they can review the project design proposal.
3. The project design proposal is rejected or approved.
4. An escalation task is allocated if the approval task isn't completed within a pre-defined time limit.

**The following table shows how the workflow steps can be mapped to the function types we use in a Durable Functions workflow.**

****

**How to control long running tasks using durable timers & How to add an escalation path based on the timer**

**Timers in Durable Functions**

Durable Functions provides timers for use in the orchestrator functions, which you can use to implement delays or set up timeouts for asynchronous actions. You should use durable timers in orchestrator functions instead of the setTimeout() and setInterval() functions.

You create a durable timer by calling the createTimer() method of the DurableOrchestrationContext. This method returns a task that resumes on a specified date and time.

**Using timers for delay**

*You should always use currentUtcDateTime to obtain the current date and time, instead of Date.now or Date.UTC.*

*Durable Functions enables you to implement long-running workflows without requiring that you maintain state information manually. Azure provides the infrastructure in which Durable Functions run. You focus on the logic for the functions that perform the tasks in your workflow.*

*In this module we learned about Durable Functions and how to orchestrate our simple design proposal approvals process. Using durable timers, we can add an escalation path to our workflows, especially for those long-running, indeterminate tasks.*

**Develop, test, and publish Azure Functions by using Azure Functions Core Tools**

The Azure Functions Core Tools are command-line utilities that enable you to develop and run functions locally and publish them to Azure.

**Create and run Azure Functions locally by using the Core Tools**

The Azure Functions Core Tools let you develop and run functions on your local computer from the command line.

**What are the Azure Functions Core Tools?**

The Azure Functions Core Tools are a set of command-line tools that you can use to develop and test Azure Functions on your local computer.

1. Generate the files and folders you need to develop functions on your local computer
2. Run your functions locally so you can test and debug them
3. Publish your functions to Azure

**Function apps and functions projects**

Every function published to Azure belongs to a function app: a collection of functions that are published together into the same environment. All of the functions in an app share a common set of configuration values, and must all be built for the same language runtime. Each function app is an Azure resource that can be configured and managed independently.

When you develop functions locally, you work within a functions project: a folder that contains the code and configuration files that define your functions. A functions project on your computer is equivalent to a function app in Azure, and can contain multiple functions that use the same language runtime.

To get started developing, you need to create a functions project folder that's organized correctly. Every new function you add to the project requires additional code and configuration that must be complete and correctly structured, or your functions will not be able to run. If you wanted to, you could become familiar with the names and contents of the files needed in a functions project folder and create them yourself, but doing so would be time-consuming and error-prone.

With the Azure Functions Core Tools, you'll never need to do this! You can use the Core Tools to generate function projects and functions from scratch.

**When you create a new functions project two most critical project files are always present:**

* **host.json** stores runtime configuration values, such as logging options, for the function app. The settings stored in this file are used both when running functions locally and in Azure.
* **local.settings.json** stores configuration values that only apply to the function app when it is run locally with the Core Tools. This file contains two kinds of settings:
  + **local runtime settings** used to configure the local functions runtime itself
  + **custom application settings** which you can add and configure based on your app's needs and can be accessed and used by all the functions in the app.

**Run functions locally**

Functions aren't programs that can be run on their own: they must be hosted by the functions host. The host is what powers everything outside of your function code: it loads configuration, listens for triggers and HTTP requests, starts the worker process for the language your functions are written in, writes log output and more. In Azure, function apps run the function host automatically when they

You can use the Core Tools to run your own instance of the functions host and try out your functions locally before you publish them. By running your functions before publishing them, you can make sure your configuration and code loads correctly and test out your functions by making real HTTP calls to them without the need for Azure resources.

**Exercise - Create a function locally by using the Core Tools**

mkdir ~/loan-wizard

cd ~/loan-wizard

func init

func new

code .

***Replace the full contents of index.js***

func start

Ctrl+C

func start &> ~/output.txt &

curl "http://localhost:7071/api/simple-interest" -w "\n"

curl "http://localhost:7071/api/simple-interest?principal=5000&rate=.035&term=36" -w "\n"

pkill func

code ~/output.txt

**Create a function app**

Before you can use the Core Tools to publish a project, you need to create a function app in Azure. This is not a capability of the Core Tools: creating function apps is one of the responsibilities of the Azure management tools, which include the Azure portal, Azure CLI and Azure PowerShell.

*If you already have a local functions project you want to publish, make sure to create the function app with the same language runtime. If you try to deploy a project to an app with a different runtime, publishing will halt with an error.*

**Publish to Azure**

To publish a functions project to Azure, run **func azure functionapp publish <app\_name>** from the functions project folder. **<app\_name>** is the name of the target function app in Azure, not the name of your project folder, which can be different.

*The Core Tools don't ask you to sign in to Azure. Instead, they access your subscriptions and resources by loading your session information from the Azure CLI or Azure PowerShell. If you don't have an active session in one of those tools, publishing will fail. It's possible to publish from the Core Tools without the Azure CLI or Azure PowerShell, but it's much easier if you do have them, and we recommend you install one or the other and log in before trying to publish.*

**Things to know**

* The Core Tools do not validate or test your functions code during publishing.
* When you publish, any functions already present in the target app are stopped and deleted before the contents of your project are deployed. You can't combine functions from multiple projects into one app by publishing them in sequence - all of the functions you want in the app must be in one project.
* Publishing to Azure does not create any kind of relationship between the local project and the target function app. You can publish a single functions project to multiple function apps. You can also re-publish a project to the same app repeatedly as you work on your code.
* The invocation URLs displayed after you publish may include a code parameter in the query string, as in the screenshot above. By default, HTTP functions created by the Core Tools are configured with an authorization level of function, meaning they require callers to provide a secret key in the request headers or query string. The Core Tools includes the key in the query string of the displayed URL for your convenience.

**Publish a function to Azure by using the Core Tools**

RESOURCEGROUP=learn-1a731473-8658-4cd9-b51b-57b5612f8a15

STORAGEACCT=learnstorage$(openssl rand -hex 5)

FUNCTIONAPP=learnfunctions$(openssl rand -hex 5)

az storage account create \

--resource-group "$RESOURCEGROUP" \

--name "$STORAGEACCT" \

--kind StorageV2 \

--location centralus

az functionapp create \

--resource-group "$RESOURCEGROUP" \

--name "$FUNCTIONAPP" \

--storage-account "$STORAGEACCT" \

--runtime node \

--consumption-plan-location centralus \

--functions-version 2

1. The three lines at the top create shell variables with values that we use repeatedly in the following commands. For resource group, we specify the group created for you by the sandbox. The storage account and function app names include $(openssl rand -hex 5), which generates a random 5-character string, to ensure that the names meet the requirement of being globally unique.
2. az storage account create creates an Azure storage account that will be used by the function app. A storage account is a separate Azure resource that needs to be created before the function app can be created.
3. az functionapp create creates the function app. Our new app uses the node (JavaScript) runtime, and runs on the serverless, pay-as-you-go consumption billing plan.

cd ~/loan-wizard

func azure functionapp publish "$FUNCTIONAPP"