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# Factory Automation Transport

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### DOCUMENT ACCESS

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# Factory Automation Transport

*Estimated time to read: 31 minutes*

The goal of this tutorial is introduce one of the more common scenarios of the use of the Factory Automation module, which is the coordination of Fleet Managers. Out of the box, Factory Automation already provides support for the use and implementation of this scenario.

## Note

This tutorial will assume the user already has some familiarity with Factory Automation and has finished the tutorial for Factory Automation and all tutorials for Connect IoT.

## Note

During this tutorial, the **Automation Manager** will run in console mode to highlight the most important events as they take place.

## Overview

In this example, we will model a machine that will have a dependency to one fleet manager, which will be responsible for feeding raw materials to the machine.

This example is focused on showing how Factory Automation module behaves, so details about the MES model used and custom logic in MES are purely for demonstration purposes and do not serve as examples to be replicated on productive environments.

## Overview of MES Model

In this example, the goal will be to have a material that symbolizes a batch of cookies being processed in a **Resource** that will be an Oven, with a `Resource LoadPort` to receive the container dock/undock and a feeder for the raw material coal. It will also require a `Resource LoadPort` that will be the AGV.

## Note

Some details, for example, on lookup table names are omitted feel free to add the names that make more sense to your model.

## Creating a Simple MES model

1. Create a **Calendar**
2. Create a **Facility**
3. Create an **Area**
4. Create a **Step** - `Oven`
5. Create a **Flow** with the **Step** - `Oven`
6. Create a **Resource** - `Oven`

7. Create a **Service** that will link the **Resource** `Oven` to the **Step** `Oven`
8. Create a **Step** - `Coal Feed`
9. Create a **Flow** for the **Step** - `Coal Feed`
10. Create a **Resource Consumable Feed** - `Coal Feeder`
11. Create a **Service** that links the **Resource** `Coal Feeder` with the **Step** `Coal Feed`
12. In the `Oven` **Resource**, Manage Consumable Feeds and add the `Coal Feeder`
13. Create a **Resource LoadPort** - `Coal LoadPort`
14. Add **Resource** - `Coal LoadPort` as **SubResource** of the **Resource** - `Oven`

At the end of these steps, the system will have a **Resource** - `Oven` with a **Resource LoadPort** - `Coal LoadPort` and a **Resource Consumable Feed** - `Coal Feeder`. It will also have the necessary flows, steps and the services to link them both.

## Creating Materials

1. Create a **Product** - `Cookies`
2. With the `Default Start Flow Path` the **Flow** for the **Step** - `Oven`
3. Create a **Product** - `Coal`
4. With the `Default Start Flow Path` the **Flow** for the **Step** - `Coal`
5. Create a **Material** - `CookieBatch`
6. With **Product** - `Cookie` and **Quantity** - `100`
7. Create a **Material** - `Material Coal`
8. With the **Product** - `Coal` and **Quantity** - `100`
9. Create a **Container** - `CoalContainer001`
10. Manage Positions of the **Container** and add to the `CoalContainer001` the **Material** `Material Coal`
11. Create **BOM** - `BOM Cookies`
12. **BOM Item**
  - a. **Product** - `Coal`
    - i. **Quantity** - `0.3` and **Source Step** - `Coal Feed`
13. In the **Step** - `Oven` add the **BOM Context** with the `BOM Cookies` and **Assembly Type** - `Automatic at Track`  
In (this assembly type will consume automatically according to the **BOM** when the **Material** is tracked in a **Resource**)

The model now has a **Material** - `CookieBatch` ready to be dispatched to the **Resource** - `Oven`. The `Oven` has an empty LoadPort and an empty Feeder.

## Use Case - Raw Material Replenishing

### Overview

The use case of the replenishing will consist on checking if there is any material in the consumable feed when the material is dispatched. If there is no material in the feeder, request material from the fleet manager of the raw materials. This a very simple use case, since in real scenarios typically there needs to be more resolution on when to refill and what product will refill which consumable feed.

After the job is created, the fleet manager will assign a robot to the job created. It will then pick the **Container** - `CoalContainer001` with the **Material** - `Material Coal`. Next step it will dock the **Container** in the

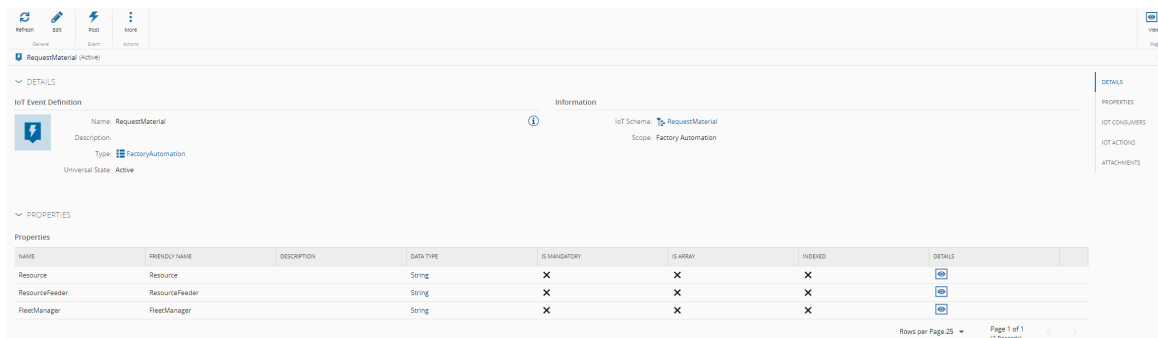
load port and then attach the material to the `Coal Feeder`. The last step will be for the robot to finish the job, by returning to a default position.

## Request Material

This is the first step in the replenishing lifecycle. We will create a `DEE Action`, that is appended on the `Post` of the `Dispatch Materials` to create a new request material job.

### Create Request Material - IoTEventDefinition

Create an **IoT Event Definition** - `Request Material` to define the structure of the job. It will have the Scope set to `Factory Automation` and the properties `FleetManager`, `Resource` and `ResourceFeeder` all defined as string. Notice that here is where we will define all the context the job requires to be able to execute. The required context to execute will depend on the particular case that is being addressed.



The screenshot shows the configuration page for an IoT Event Definition named 'RequestMaterial'. The 'Details' section shows the Name as 'RequestMaterial', Description as 'RequestMaterial', Type as 'FactoryAutomation', and Universal State as 'Active'. The 'Properties' section contains a table with the following data:

NAME	FRIENDLY NAME	DESCRIPTION	DATA TYPE	IS MANDATORY	IS ARRAY	INDEXED	DETAILS
Resource	Resource		String	X	X	X	[Details]
ResourceFeeder	ResourceFeeder		String	X	X	X	[Details]
FleetManager	FleetManager		String	X	X	X	[Details]

### Create a DEE Action - Check If Materials On Feeder On Dispatch

**DEE Actions** are the mechanism in the `MES` where we can add customization hooks to default system functionality. These hooks can be on the beginning of the execution `Pre` or in the end `Post`. In this particular case, we will append in the `Post` of the service `DispatchMaterials`.

#### Note

It's a good practice to add a prefix for DEEs that are not system made to make it distinguishable (i.e Custom).

1. Go to `Administration > DEE Actions`
2. Select `New`
3. Give as Name `CheckIfMaterialsOnFeedOnDispatch`, for now the classification and action group is not important

The `DEE` code is split between two important sections: the **condition phase** and the **execution phase**. Only if the condition phase returns with true, will the execution phase be invoked. In the history of an action (i.e TrackIn) in the `MES`, it will be explicit if a `DEE` was evaluated and eventually if it was executed. For more information on DEEs, see [DEE Actions](#).

The context of the `DEE` is present on the Inputs dictionary. This context will depend on to what service the `DEE` is appended. The system provides helpful information on what is in the context by expanding the left pane after adding the action group.

Let's add the Action Group to our `DEE`.

1. Go to the `Details` tab
2. select `Add` on the Action Group
3. Search for `MaterialManagement.MaterialManagementOrchestration.DispatchMaterials.Post`. If the action group is not present:

4. Go to Administration > DEE Actions
5. Select the Settings (three vertical dots) next to the Action Groups
6. Select Add new Action Group
7. Give as Name - MaterialManagement.MaterialManagementOrchestration.DispatchMaterials.Post
8. Select Create
9. Check it and select Add

In order to find the action group where we want to append our DEE, you can consult the [API documentation](#), or analyze the history whenever the action that you are interested is executed and it will be apparent what are multiple sub-actions that you can append your business logic. Note also that in the DEE in the code view, in the right pane it `Input Parameters`, it will now show all available parameters.

Starting on the code for the `Test Condition Code`. We want to validate that the Inputs that we are interested are correct, to validate we should process and then pass that value to our DEE context.

TestCondition Code:

```

/// <summary>
/// Summary text: Request Material if Feeder has no consumables
/// Actions groups:
///     * MaterialManagement.MaterialManagementOrchestration.DispatchMaterials.Post
/// Depends On:
/// Is Dependency For:
/// Exceptions:
/// </summary>

var serviceProvider = (IServiceProvider)Input["ServiceProvider"];
var utilitiesDEEContext = serviceProvider.GetService<IDeeContextUtilities>();

// Validate input
if (Input["DispatchMaterialsInput"] is not DispatchMaterialsInput dispatchMaterialsInput)
{
    throw new ArgumentNullException("DispatchMaterialsInput");
}

// Retrieve resource
var resource = dispatchMaterialsInput.Materials.FirstOrDefault().Value.Resource;

utilitiesDEEContext.SetContextParameter("CheckIfMaterialsOnFeedOnDispatch_Inputs", new
Dictionary<string, object>()
{
    { "CheckIfMaterialsOnFeedOnDispatch_Resource", resource },
});
return true;

```

Execution Code:

```

// System
UseReference("", "System.Linq");
UseReference("", "System.Data");

// CMF
UseReference("Cmf.Navigo.BusinessOrchestration.dll",
"Cmf.Navigo.BusinessOrchestration.MaterialManagement.InputObjects");
UseReference("Cmf.Navigo.BusinessOrchestration.dll",
"Cmf.Navigo.BusinessOrchestration.Abstractions");
UseReference("Cmf.Foundation.BusinessObjects.dll",
"Cmf.Foundation.BusinessOrchestration.DataPlatform.InputObjects");
UseReference("Cmf.Foundation.BusinessObjects.dll",
"Cmf.Foundation.BusinessOrchestration.DataPlatform.OutputObjects");
UseReference("Cmf.Foundation.BusinessOrchestration.dll",
"Cmf.Foundation.BusinessOrchestration.DataPlatform.Domain");
UseReference("Cmf.Foundation.BusinessOrchestration.dll",
"Cmf.Foundation.BusinessOrchestration.Abstractions");

```

```

// Common
UseReference("Cmf.Common.CustomActionUtilities.dll", "Cmf.Common.CustomActionUtilities");
UseReference("Cmf.Common.CustomActionUtilities.dll",
"Cmf.Common.CustomActionUtilities.Abstractions");
UseReference("Newtonsoft.Json.dll", "Newtonsoft.Json");

var serviceProvider = (IServiceProvider)Input["ServiceProvider"];
var deeUtilities = serviceProvider.GetService<IDeeContextUtilities>();
var entityFactory = serviceProvider.GetService<IEntityFactory>();

var inputs = deeUtilities.GetContextParameter("CheckIfMaterialsOnFeedOnDispatch_Inputs") as
Dictionary<string, object>;
var resource = inputs["CheckIfMaterialsOnFeedOnDispatch_Resource"] as IResource;

// Retrieve Consumable Feeders for the Table for Resource
INgpDataSet feedersResult = resource.GetConsumableFeeds(null, out _);
DataSet feedersList = NgpDataSet.ToDataSet(feedersResult);
IResourceCollection feeders = entityFactory.CreateCollection<IResourceCollection>();

// Validate Resource has Feeders
if (feedersList.HasData())
{
    // Iterate Consumable Feeders for the Resource and Retrieve the Entity values
    foreach (DataRow dataRow in feedersList.Tables[0].Rows)
    {
        string subResourceName = dataRow["SubResourceTargetEntityName"].ToString();
        if (!string.IsNullOrEmpty(subResourceName))
        {
            IResource feeder = entityFactory.Create<IResource>();
            feeder.Name = subResourceName;

            feeders.Add(feeder);
        }
    }

    if (feeders.Any())
    {
        // Load Feeders of the Resource
        feeders.Load();
        // Load Relation between Resource Feeders and Materials
        feeders.LoadRelations("MaterialResource");

        // Retrieve empty feeders
        feeders.Where(feeder =>
!feeder.RelationCollection.ContainsKey("MaterialResource")).ToList().ForEach(feeder => {
            // Post a new Job if Feeder has no Consumables
            // Will create the Request Material Job
            var dataPlatform = serviceProvider.GetService<IDataPlatformManagementOrchestration>
());

            AppProperties appProperties = new AppProperties()
            {
                ApplicationContext = "Transport Request from MES for Request Raw Material",
                ApplicationName = "FleetManager-RawMaterial",
                EventDefinition = "RequestMaterial",
                EventTime = DateTime.Now
            };

            Dictionary<string, object> dataToSend = new Dictionary<string, object>();
            dataToSend.Add("Resource", resource.Name);
            dataToSend.Add("ResourceFeeder", feeder.Name);
            dataToSend.Add("FleetManager", "FleetManager-RawMaterial");

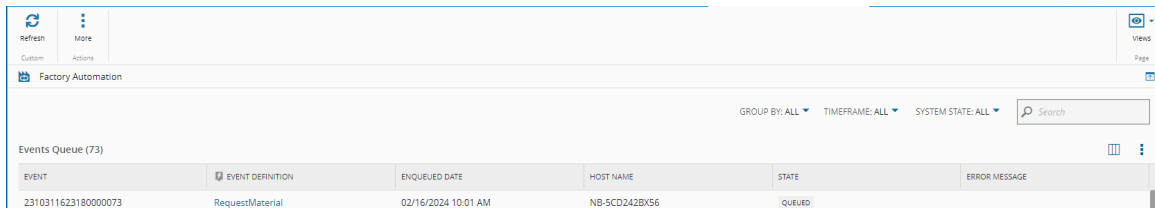
            PostEventInput postEventInput = new PostEventInput
            {
                AppProperties = appProperties,
                Data =
Newtonsoft.Json.Linq.JObject.Parse(JsonConvert.SerializeObject(dataToSend)),
            };
            PostEventOutput postEventOutput = dataPlatform.PostEvent(postEventInput);
        });
    }
}

```

The goal is to check if there are feeders without materials attached, then create a new request material job for each feeder without material.

Now we can dispatch the **Material** - `Cookie Batch` and see if there is any job created. In order to check the Job Queue:

1. Go to the `Automation` left pane
2. Select `Factory Automation`
3. Select `Views > IoT Events Queue`



EVENT	EVENT DEFINITION	ENQUEUED DATE	HOST NAME	STATE	ERROR MESSAGE
2310311623180000073	RequestMaterial	02/16/2024 10:01 AM	NB-SCD242BX56	QUEUED	

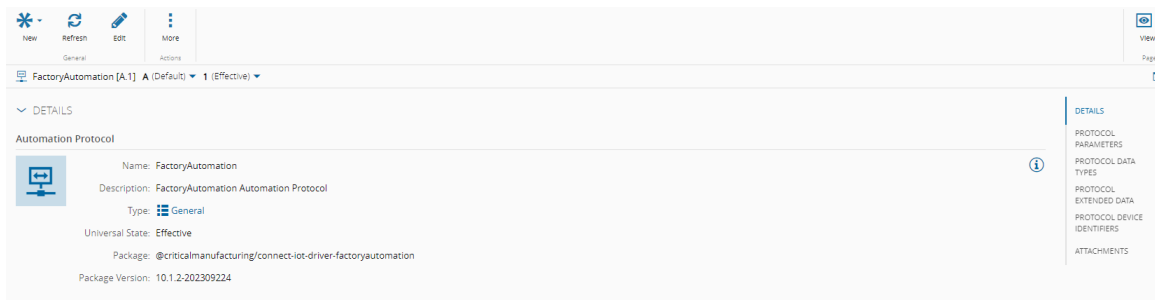
A job has been created, but it has not been processed. This is expected as currently we have no Factory Automation worker running and processing jobs and we have no definition of what Factory Automation should do with the request material job.

### Create a Factory Automation Worker

The Factory Automation worker will be responsible for consuming and executing jobs from the queue. The worker will have a limit on how many concurrent jobs can be executed at any given time. It is also important to understand that jobs assigned to a worker in case of the worker process failing will be invalidated. It is then a good practice to balance the amount of controllers with workers in your Factory Automation to mitigate risk.

### Create a Factory Automation - Protocol

1. Go to `Business Data > Automation Protocol`
2. Create `New`
3. Name `FactoryAutomation`
4. Select `Package` for the driver of Factory Automation
5. Select the version available
6. In the Parameters
7. Notice that the maximum concurrent jobs is of `10`
8. select `Next` and `Create`



DETAILS	
<b>Automation Protocol</b>	
Name: <code>FactoryAutomation</code>	
Description: <code>FactoryAutomation Automation Protocol</code>	
Type: <code>General</code>	
Universal State: <code>Effective</code>	
Package: <code>@criticalmanufacturing/connect-iot-driver-factoryautomation</code>	
Package Version: <code>10.1.2-202309224</code>	

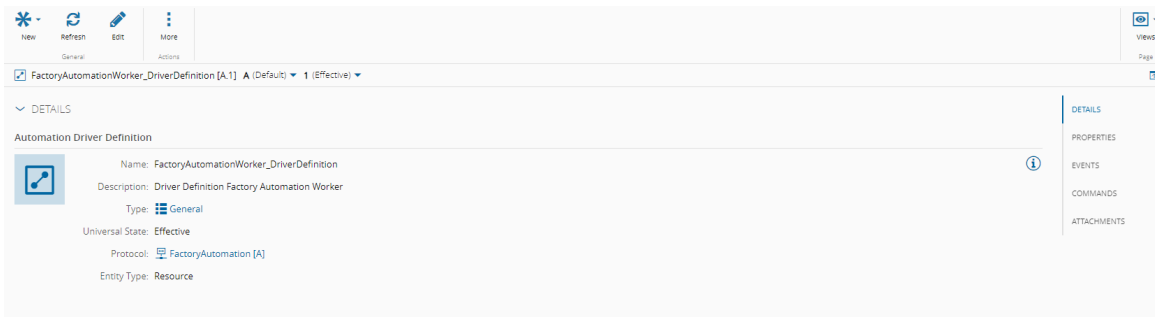
### Create a Factory Automation - Driver Definition

1. Go to `Business Data > Automation Driver Definition`
2. Create `New`
3. Name `FactoryAutomationWorker_DriverDefinition`

4. Select Automation Protocol `FactoryAutomation`

5. Entity Type **Resource**

6. select `Next` and `Create`



The Factory Automation driver is a particular case where it does not need any further definitions on the driver definition.

### Create a Factory Automation - Controller

1. Go to `Business Data > Automation Controller`

2. Create `New`

3. Name `FactoryAutomationWorker_Controller`

4. Select Version

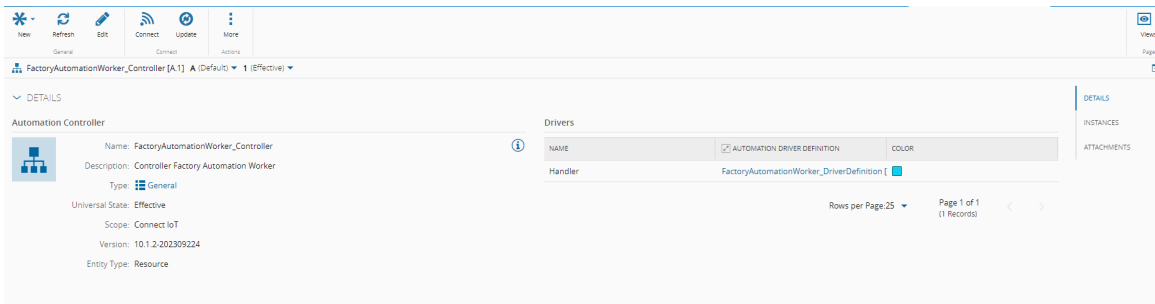
5. Entity Type **Resource**

6. Add Driver Definition

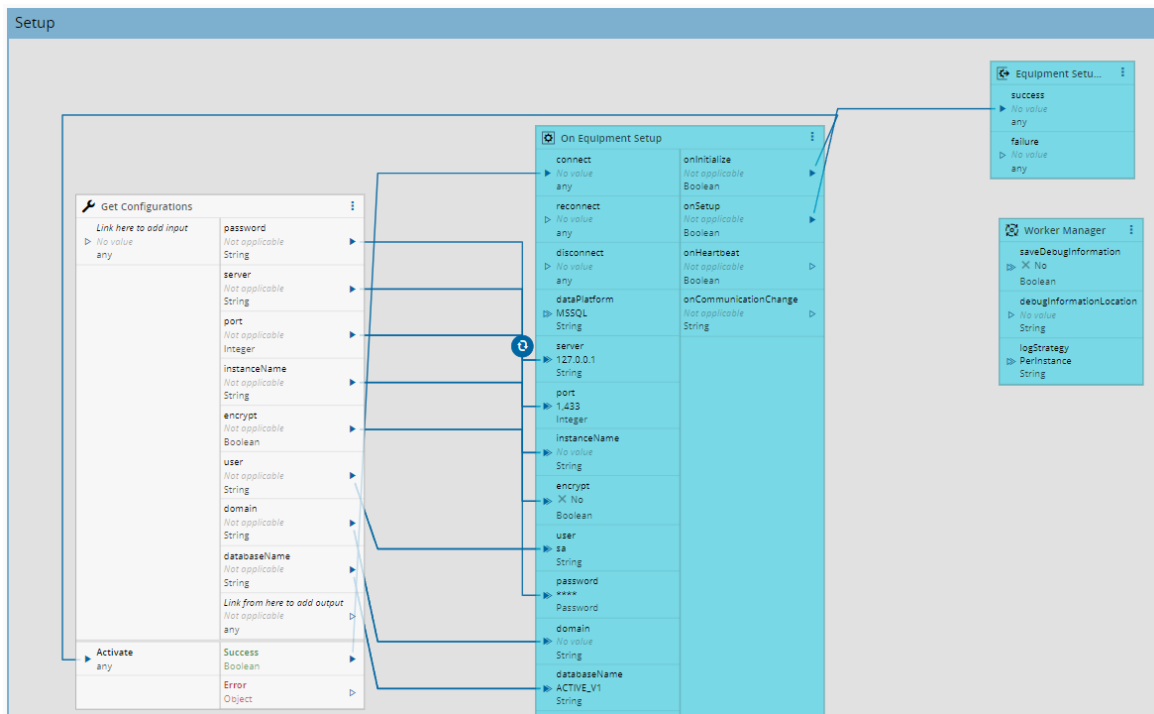
7. Name `Handler`

8. Driver Definition - `FactoryAutomationWorker_DriverDefinition`

9. select `Next` and `Create`

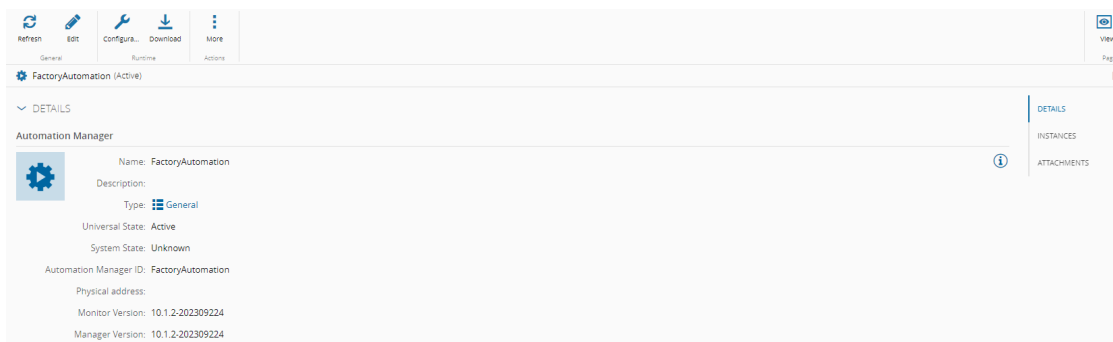


Factory Automation requires access to the database, the recommended way to store passwords in the system is by using secure strings in the `Configuration Entries`. For the tutorial either add directly in the settings the configurations of your database or create configuration entries for each setting and populate them in the configurations. For more information, go to the [Get Configurations](#) task.



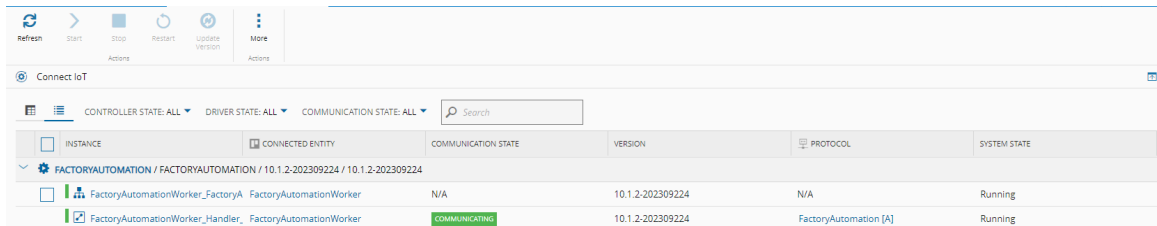
## Create a Factory Automation - Controller Instance

1. Create a **Resource** FactoryAutomationWorker with ProcessingType Component
2. Go to Business Data > Automation Manager
3. Create New
4. Name FactoryAutomation
5. Logical Address FactoryAutomation
6. Select Version

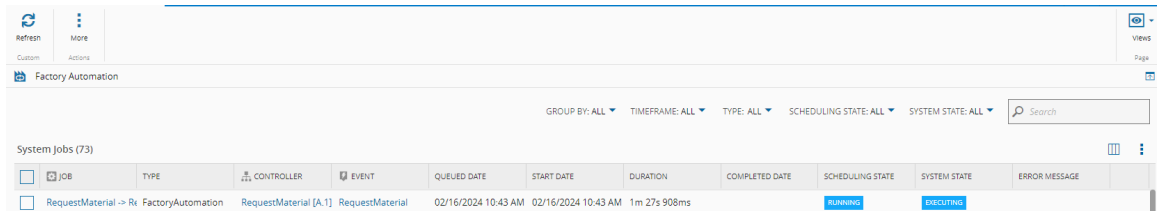


7. Go to Business Data > Automation Controller > FactoryAutomationWorker\_Controller
8. select Connect
9. Select the **Resource** FactoryAutomationWorker and **Automation Manager** FactoryAutomation
10. In the Drivers also select the **Resource** FactoryAutomationWorker
11. Go to Business Data > Automation Manager > FactoryAutomation
12. Click Download
13. Run the **Automation Manager**
  - a. Unzip the **Automation Manager**
  - b. Go to scripts
  - c. Run StartConsole.bat

In the MES system we can see that the Factory Automation Worker is **Communicating** and that our job is now on the **Job List**.



INSTANCE	CONNECTED ENTITY	COMMUNICATION STATE	VERSION	PROTOCOL	SYSTEM STATE	
FACTORYAUTOMATION / FACTORYAUTOMATION / 10.1.2-202309224 / 10.1.2-202309224						
<input type="checkbox"/>	FactoryAutomationWorker_FactoryA	FactoryAutomationWorker	N/A	10.1.2-202309224	N/A	Running
<input checked="" type="checkbox"/>	FactoryAutomationWorker_Handler	FactoryAutomationWorker	<b>COMMUNICATING</b>	10.1.2-202309224	FactoryAutomation [A]	Running



JOB	TYPE	CONTROLLER	EVENT	QUEUED DATE	START DATE	DURATION	COMPLETED DATE	SCHEDULING STATE	SYSTEM STATE	ERROR MESSAGE
<input type="checkbox"/>	RequestMaterial - Rr	FactoryAutomation	RequestMaterial [A.1]	RequestMaterial	02/16/2024 10:43 AM	02/16/2024 10:43 AM	1m 27s 908ms	<b>RUNNING</b>	<b>EXECUTING</b>	

In the **Job List**, let's stop the job for now, as we still need the workflow for the job itself. Select the job and select **Stop**.

### Request Material - Create Job Workflow - Main

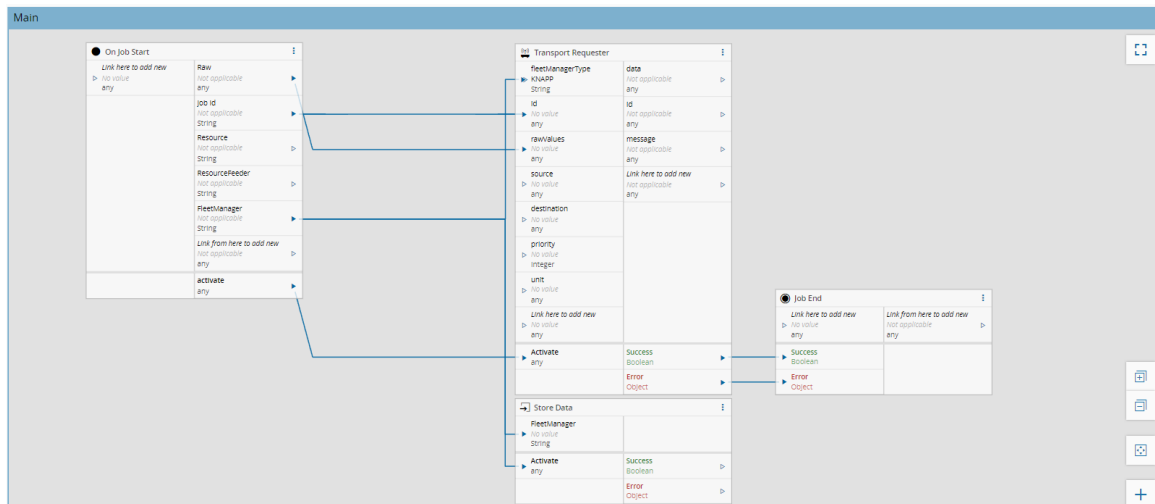
1. Go to **Business Data > Automation Controller**
2. Create **New**
3. Select Scope **FactoryAutomation**
4. Add IoTEventDefinition **RequestMaterial**

The workflow for a job must have a **start** and an **end**. The workflow created by default will already place the tasks **On Job Start** and **JobEnd** to signal this requirement. The job is agnostic to any particular driver and does not communicate to a machine but serves as a lifecycle of actions. The first action that we will perform is notifying whomever is serving the fleet manager.

The **Transport Requester** task will provide the beginning and the end of the transport. It will notify the listener of the new job and will wait for a **Transport Reply** to notify it that the job has finished. We will drag and drop the **Transport Requester** this task will passthrough the job context and give the success or error of the job. We will also store the FleetManager of the job.

#### Note

In the scope of this tutorial we will have just the beginning of the transport as a **Transport Requester** and then receive information that comes to the fleet manager for the rest of the lifecycle, but depending on your scenario, you can have as much bi-directional communication as needed.



**Note**

In order for the jobs to be restartable, you can add a [Checkpoint](#) task, with the job context.

### Request Material - Create Job Workflow - Transport Interactions

There are four different actions in the job lifecycle that apply to this use case:

1. `Robot Assigned` - when the fleet manager assigns a robot
2. `Picked Container` - when the robot picks a filled container
3. `Drop Container` - when the robot docks a container
4. `Drop Material` - when the material is attached to the feeder

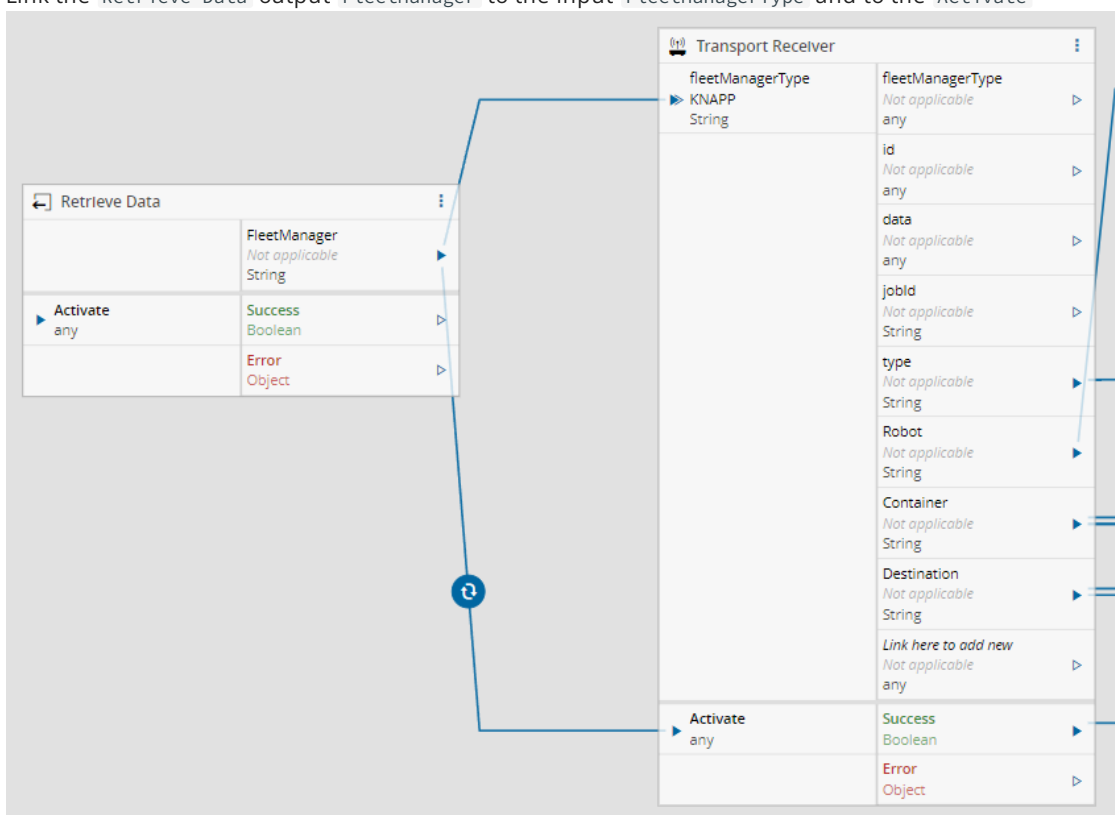
Factory Automation provides an easy way to have touch points between the fleet manager and the job execution with the task `Transport Receiver`. Using the `Transport Receiver` with command `Status Update` and the flag `Include Id in Command` as `true`, we receive information and parse it as outputs, for only our job. The `Status Update` will be a notification, whereas an `Interaction` will register a callback. The interactions are dependent on the fleet manager, so we will have to activate the receiver only when we know the fleet manager, this is why we stored the fleet manager in the `Main` workflow. We will also want to store which robot is being used in the job execution so we can pass along that context for the other actions.

**Note**

The flag `Include Id in Command` is very important. If the flag is set as `false` it means it will be a broadcast to all. If the flag is `true` and the context is inside a controller of `scope` - Factory Automation, it will not be mandatory to provide an id, it will inherit it from the job context. If, like the images in this tutorial the `id` or the setting is not available, it means you are currently in a version that does not support this feature and the controller will have to manage this mechanism.

1. Create new page `Transport Interactions`
2. Use the `Retrieve Data`
3. Settings
  - a. Trigger on Store - `true`
4. Outputs
  - a. Add

- i. Name - FleetManager
  - ii. Identifier - FleetManager
  - iii. Type - String
- 5. Drag and Drop the Transport Receiver task
- 6. Settings
  - a. Auto-Activate - False
  - b. Command - Status Update
- 7. Outputs
  - a. Name - Robot with type String
  - b. Name - Container with type String
  - c. Name - Destination with type String
- 8. Link the Retrieve Data output FleetManager to the input FleetManagerType and to the Activate



- 9. Now use the Switch task to control the flow by type
- 10. Input
  - a. Name Type
  - b. Type - String
- 11. Outputs (the settings pattern is the same for all outputs)
  - a. RobotAssigned
    - i. Equals - RobotAssigned
    - ii. Type - Boolean
    - iii. Value - true
  - b. PickedContainer
  - c. DropContainer

d. DropMaterial

Now depending on the type of interaction, the job will perform different actions.

For the `RobotAssigned`, the job will persist internally that information.

1. Use the `Store Data` task to store the `RobotAssigned`

2. Settings

a. Working Mode - `StoreOnActive`

3. Inputs

a. Add

i. Name - `RobotAssigned`

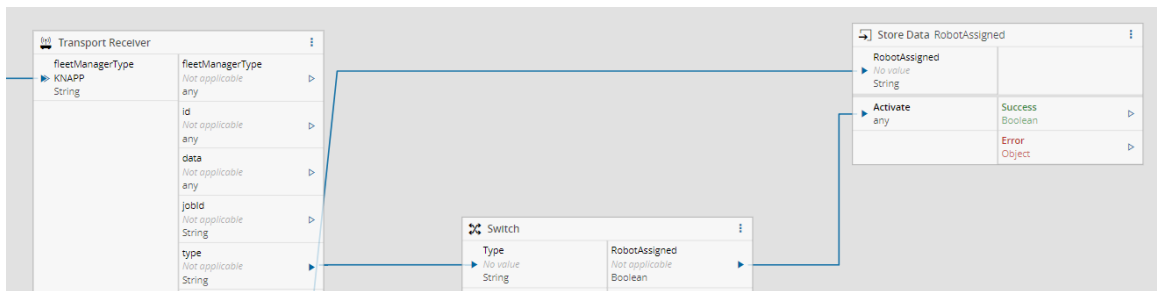
ii. Identifier - `RobotAssigned`

iii. Type - `String`

iv. Storage - `Temporary`

4. Link the `Robot` output from the task `Transport Receiver` to the input `Robot Assigned` of the `Store Data` task

5. Link the `RobotAssigned` output from the task `Switch` to the input `Activate` of the `Store Data` task



For the next actions we will require integration with the `MES`.

**Create a DEE Action - `RobotPickedContainer`**

The `DEE Action` will be responsible for docking the container selected by the fleet manager in the AGV.

**Note**

It's a good practice to add a prefix for DEEs that are not system made to differentiate (i.e Custom).

1. Go to `Administration > DEE Actions`

2. Select `New`

3. Give as Name `RobotPickedContainer`

4. Classification `ConnectIoT`

In this case we will not require an action group, this `DEE` will not be appended to a system service but will be execute directly via a business **Rule**.

Execution Code:

```
var serviceProvider = (IServiceProvider)Input["ServiceProvider"];
var entityFactory = serviceProvider.GetService<IEntityFactory>();

IContainer container = entityFactory.Create<IContainer>();
container.Name = Input["Container"] as string;
```

```

IResource robot = entityFactory.Create<IResource>();
robot.Name = Input["Robot"] as string;

container.Load();
// Load the relation between the Container and the Materials in the Container
container.LoadRelations("MaterialContainer");
robot.Load();

// Validate: Only Pick filled containers
if(!container.ContainerMaterials.Any()) {
    throw new Exception("Container must have Materials");
}

// If container is docked, undock it
if(container.ResourceAssociationType == ContainerResourceAssociationType.DockedContainer){
    container.Undock();
}

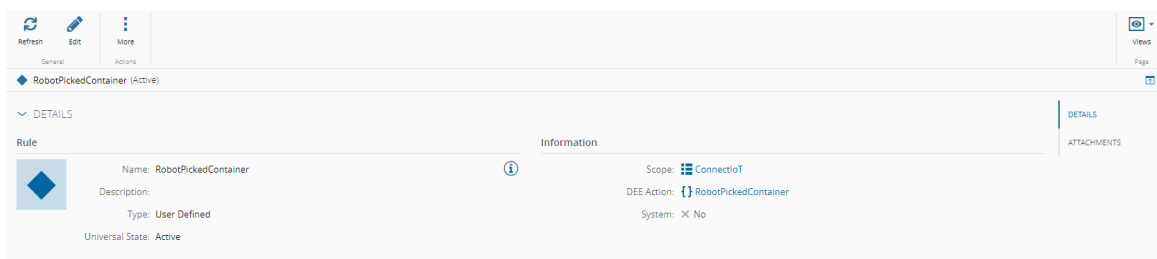
// Dock on Robot
container.Dock(robot);

```

The code is very simple, we validate the container has materials and then dock it in the robot. If the container is already docked somewhere else, we will undock it.

Create a **Rule** to encapsulate the DEE Action:

1. Go to Business Data > Rule
2. Create New
3. Name - RobotPickedContainer
4. Scope - ConnectIoT
5. DEE Action - RobotPickedContainer
6. select Create



### Create a DEE Action - RobotDroppedContainer

The DEE Action will be responsible for undocking the container of the AGV and docking to the load port of the resource. This DEE Action is very similar to what was done previously, nevertheless it was decided to not merge both to provide clear different hooks. This means that if any further logic is needed we already have entry points available

1. Go to Administration > DEE Actions
2. Select New
3. Give as Name RobotDroppedContainer
4. Classification ConnectIoT

In this case we will not require an action group, this DEE will not be appended to a system service but will be execute directly via a business **Rule**.

Execution Code:



```

var serviceProvider = (IServiceProvider)Input["ServiceProvider"];
var entityFactory = serviceProvider.GetService<IEntityFactory>();

IContainer container = entityFactory.Create<IContainer>();
container.Name = Input["Container"] as string;

IResource robot = entityFactory.Create<IResource>();
robot.Name = Input["Robot"] as string;

IResource destinationResource = entityFactory.Create<IResource>();
destinationResource.Name = Input["Destination"] as string;

container.Load();
// Load the relation between the Container and the Materials in the Container
container.LoadRelations("MaterialContainer");
destinationResource.Load();

// Validate: Only Drop filled containers
if(!container.ContainerMaterials.Any()) {
    throw new Exception("Container must have Materials");
}

// Undock from Robot
if(container.ResourceAssociationType == ContainerResourceAssociationType.DockedContainer) {
    container.Undock();
}

// Dock on Load Port
container.Dock(destinationResource);

```

The code is analogous to the RobotPickedContainer, but in this case the container is moved from the robot in to the Resource Load Port.

Create a **Rule** to encapsulate the DEE Action:

1. Go to Business Data > Rule
2. Create New
3. Name - RobotDroppedContainer
4. Scope - ConnectIoT
5. DEE Action - RobotDroppedContainer
6. Select Create

#### Create a DEE Action - RobotDropMaterial

The DEE Action will be responsible for attaching the **Material** in the **Container** to the **Resource** Feeder of the main resource.

1. Go to Administration > DEE Actions
2. Select New
3. Give as Name RobotDropMaterial
4. Classification ConnectIoT

In this case we will not require an action group, this DEE will not be appended to a system service but will be execute directly via a business **Rule**.

Execution Code:

```

var serviceProvider = (IServiceProvider)Input["ServiceProvider"];
var entityFactory = serviceProvider.GetService<IEntityFactory>();

IContainer container = entityFactory.Create<IContainer>();
container.Name = Input["Container"] as string;

```

```

IResource robot = entityFactory.Create<IResource>();
robot.Name = Input["Robot"] as string;

IResource destinationFeeder = entityFactory.Create<IResource>();
destinationFeeder.Name = Input["Destination"] as string;

container.Load();
// Load the relation between the Container and the Materials in the Container
container.LoadRelations("MaterialContainer");
destinationFeeder.Load();

if(!container.ContainerMaterials.Any()) {
    throw new Exception("Container must have Materials");
} else {

    // Create Input for AttachConsumables
    Dictionary<IMaterial, IAttachConsumableParameters> materialsToAttach = new
Dictionary<IMaterial, IAttachConsumableParameters>();
    foreach(var containerMaterial in container.ContainerMaterials) {
        materialsToAttach.Add(containerMaterial.SourceEntity, new AttachConsumableParameters());
    }

    // Attach Container Materials to the Feeder
    destinationFeeder.AttachConsumables(materialsToAttach);
}

```

The code is similar to what we saw in the other actions, but in this action we don't want to perform dock or undock, but we want to retrieve the **Materials** in the **Container** and attach them to the Resource Feeder.

Create a **Rule** to encapsulate the **DEE** Action:

1. Go to Business Data > Rule
2. Create New
3. Name - RobotDropMaterial
4. Scope - ConnectIoT
5. **DEE** Action - RobotDropMaterial
6. select Create

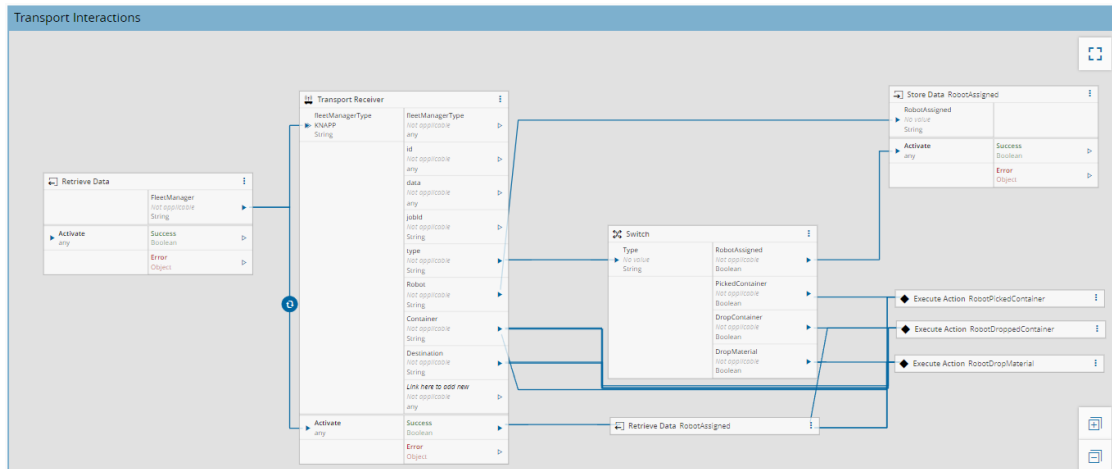
### Request Material - Create Job Workflow - Transport Interactions - Actions

Now we can use the **DEE** **Actions** in the workflow of the Job. Going back to the workflow of the Request Material Controller in the page Transport Interactions.

1. Drag and drop task Execute Action
2. Description - RobotPickedContainer
3. Settings
  - a. Rule - RobotPickedContainer
4. Inputs
  - a. Add
    - i. Name - Container
    - ii. Type - String
  - b. Add
    - i. Name - Robot
    - ii. Type - String
5. Link the output **Container** of the Transport Receiver to the input **Container** of the Execute Action RobotPickedContainer

6. Link the output `Robot` of the `Retrieve Data` to the input `Robot` of the `Execute Action RobotDroppedContainer`
7. Link the output `PickedContainer` to the input `Activate` of the `Execute Action RobotPickedContainer`
8. Drag and drop task `Execute Action`
9. Description - `RobotDroppedContainer`
10. Settings
  - a. Rule - `RobotDroppedContainer`
11. Inputs
  - a. Add
    - i. Name - `Container`
    - ii. Type - `String`
  - b. Add
    - i. Name - `Robot`
    - ii. Type - `String`
  - c. Add
    - i. Name - `Destination`
    - ii. Type - `String`
12. Link the output **Container** of the `Transport Receiver` to the input **Container** of the `Execute Action RobotDroppedContainer`
13. Link the output `Destination` of the `Transport Receiver` to the input **Container** of the `Execute Action RobotDroppedContainer`
14. Link the output `Robot` of the `Retrieve Data` to the input `Robot` of the `Execute Action RobotDroppedContainer`
15. Link the output `DroppedContainer` to the input `Activate` of the `Execute Action RobotDroppedContainer`
16. Drag and drop task `Execute Action`
  - a. Description - `RobotDropMaterial`
  - b. Settings
  - c. Rule - `RobotDropMaterial`
  - d. Inputs
  - e. Add
    - i. Name - `Container`
    - ii. Type - `String`
  - f. Add
    - i. Name - `Robot`
    - ii. Type - `String`
  - g. Add
    - i. Name - `Destination`
    - ii. Type - `String`
17. Link the output **Container** of the `Transport Receiver` to the input **Container** of the `Execute Action RobotDropMaterial`
18. Link the output `Destination` of the `Transport Receiver` to the input **Container** of the `Execute Action RobotDropMaterial`

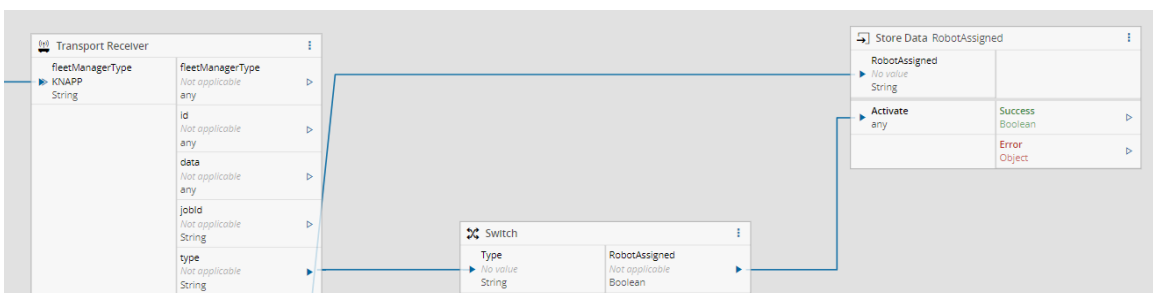
19. Link the output `Robot` of the `Retrieve Data` to the input `Robot` of the `Execute Action RobotDropMaterial`
20. Link the output `PickedContainer` to the input `Activate` of the `Execute Action RobotDropMaterial`



21. Use the `Store Data` task to store the `RobotAssigned`
  - a. Settings
  - b. Working Mode - `StoreOnActive`
  - c. Inputs
  - d. Add
    - i. Name - `RobotAssigned`
    - ii. Identifier - `RobotAssigned`
    - iii. Type - `String`
    - iv. Storage - `Temporary`

22. Link the `Robot` output from the task `Transport Receiver` to the input `Robot Assigned` of the `Store Data` task

23. Link the `RobotAssigned` output from the task `Switch` to the input `Activate` of the `Store Data` task



### Fleet-Manager - Raw Material

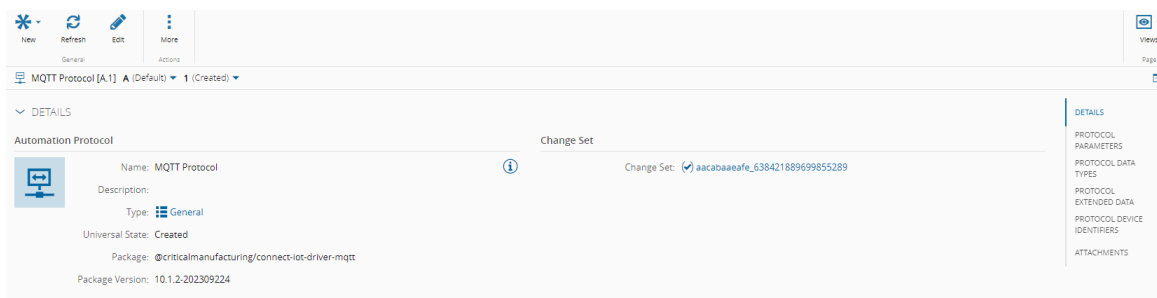
At this moment we have a consumer for the jobs and we have a workflow with the lifecycle of the job. Now we require the integration to the Fleet Manager. For this example we will assume that the fleet manager runs on `MQTT` and has the following topics:

1. Topic - `FleetManager.Robot.Assign`
2. Payload - `{"JobId": "<jobID>", "Robot": "<robot>"}`
3. Topic - `FleetManager.Robot.PickContainer`
4. Payload - `{"JobId": "<jobID>", "Container": "<container>"}`
5. Topic - `FleetManager.Robot.DropContainer`

6. Payload - {"JobId":"<jobID>","Container":"<container>","Destination":"\<destination>"}
7. Topic - FleetManager.Robot.PickContainer
8. Payload - {"JobId":"<jobID>","Container":"<container>","Destination":"<destination>"}
9. Topic - FleetManager.Robot.ArrivedAtDestination
10. Payload - {"JobId":"<jobID>","Container":"<container>"}

### Fleet-Manager - Raw Material - Protocol

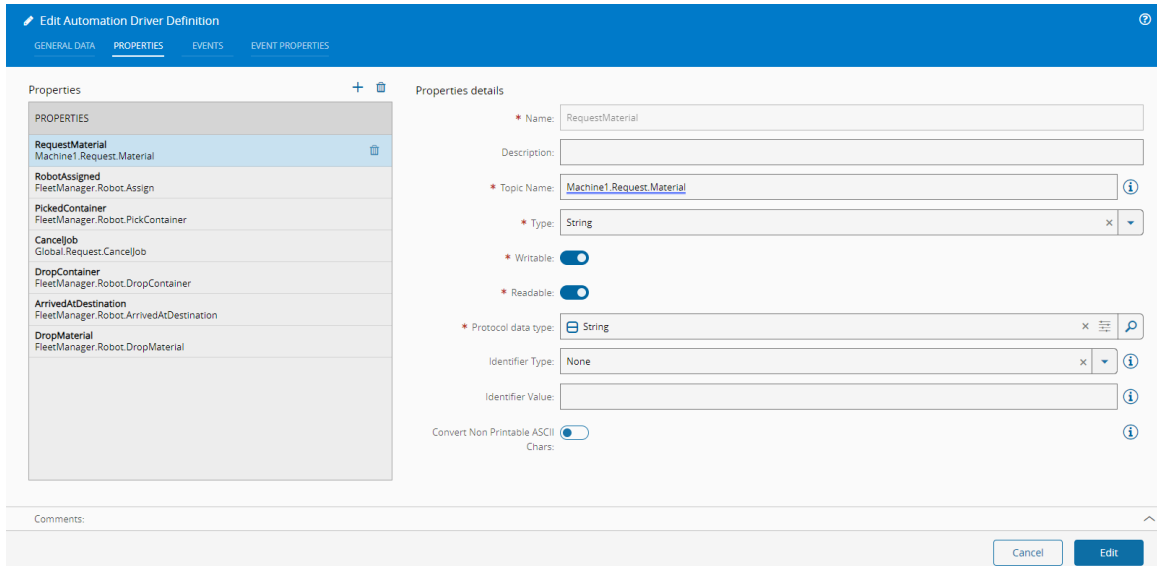
1. Go to Business Data > Automation Protocol
2. Create New
3. Name MQTT Protocol
4. Select Package for the driver of the mqtt driver
5. Select the version available
6. select Next and Create



### Fleet-Manager - Raw Material - Driver Definition

1. Go to Business Data > Automation DriverDefinition
2. Create New
3. Name Fleet-Manager-RawMaterial\_DriverDefinition
4. Select Automation Protocol MQTT Protocol
5. Entity Type **Resource**
6. select Next
7. Add properties (all properties will have the same details, except the one's mentioned otherwise):
8. Name - RequestMaterial
  - a. Topic Name - Machine1.Request.Material
  - b. Type - String
  - c. Protocol Data Type - String
9. Name - RobotAssigned
  - a. Topic Name - FleetManager.Robot.Assign
10. Name - PickedContainer
  - a. Topic Name - FleetManager.Robot.PickContainer
11. Name - DropContainer
  - a. Topic Name - FleetManager.Robot.DropContainer
12. Name - DropMaterial
  - a. Topic Name - FleetManager.Robot.DropMaterial
13. Name - ArrivedAtDestination
  - a. Topic Name - FleetManager.Robot.ArrivedAtDestination

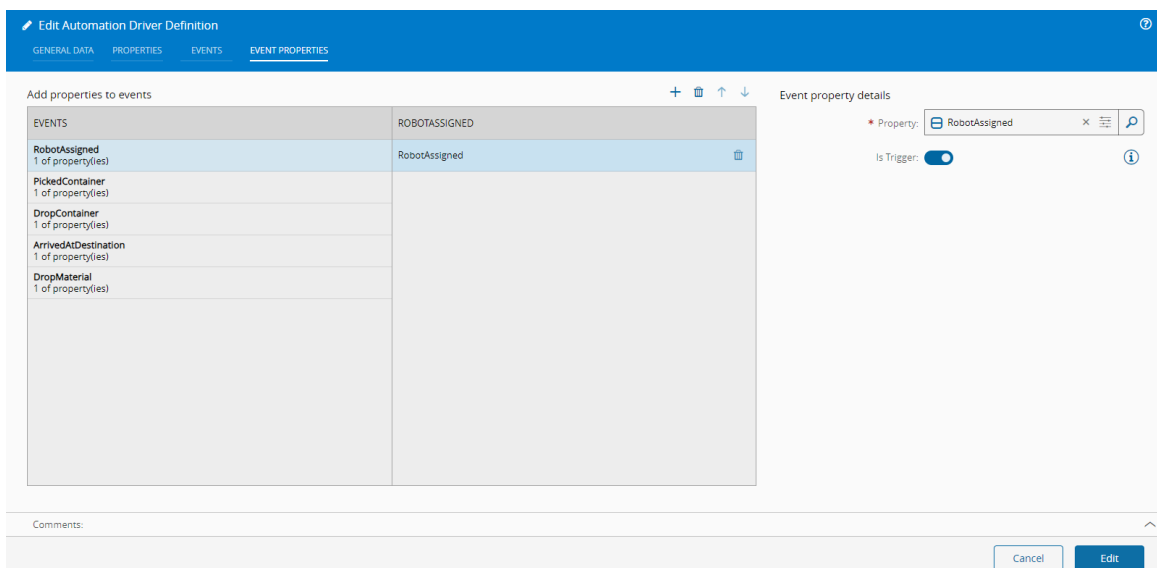
14. Add events
15. Name - RobotAssigned
16. Name - PickedContainer
17. Name - DropContainer
18. Name - DropMaterial
19. Name - ArrivedAtDestination
20. Add event properties with matching properties



The screenshot shows the 'Edit Automation Driver Definition' interface with the 'PROPERTIES' tab selected. On the left, a list of properties is shown, including 'RequestMaterial', 'RobotAssigned', 'PickedContainer', 'CancelJob', 'DropContainer', 'ArrivedAtDestination', and 'DropMaterial'. The 'RequestMaterial' property is selected. The 'Properties details' section on the right shows the following configuration:

- Name: RequestMaterial
- Description: (empty)
- Topic Name: Machine1.Request.Material
- Type: String
- Writable:
- Readable:
- Protocol data type: String
- Identifier Type: None
- Identifier Value: (empty)
- Convert Non Printable ASCII Chars:

At the bottom, there are 'Cancel' and 'Edit' buttons.



The screenshot shows the 'Edit Automation Driver Definition' interface with the 'EVENT PROPERTIES' tab selected. On the left, a table titled 'Add properties to events' is shown:

EVENTS	ROBOTASSIGNED
RobotAssigned 1 of property(ies)	RobotAssigned
PickedContainer 1 of property(ies)	
DropContainer 1 of property(ies)	
ArrivedAtDestination 1 of property(ies)	
DropMaterial 1 of property(ies)	

The 'RobotAssigned' property is selected in the table. The 'Event property details' section on the right shows the following configuration:

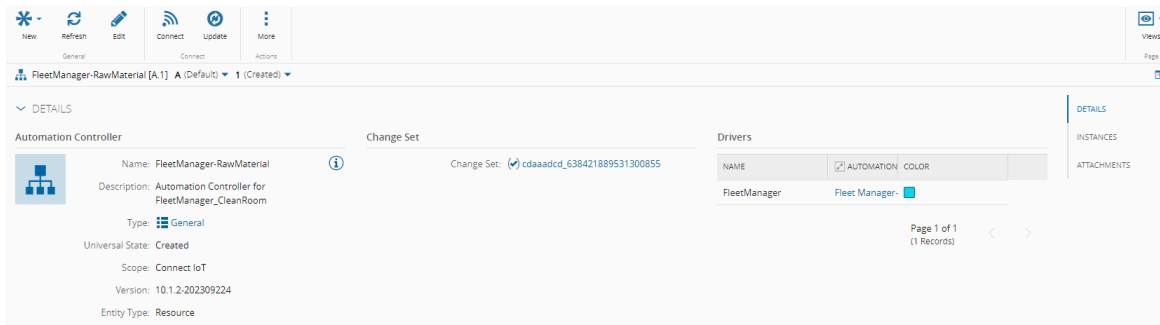
- Property: RobotAssigned
- Is Trigger:

At the bottom, there are 'Cancel' and 'Edit' buttons.

### Fleet-Manager - Raw Material - Controller

1. Go to Business Data > Automation Controller
2. Create New
3. Entity Type **Resource**
4. Add Driver Definition
5. Name Handler
6. Driver Definition - FleetManager-RawMaterial\_DriverDefinition

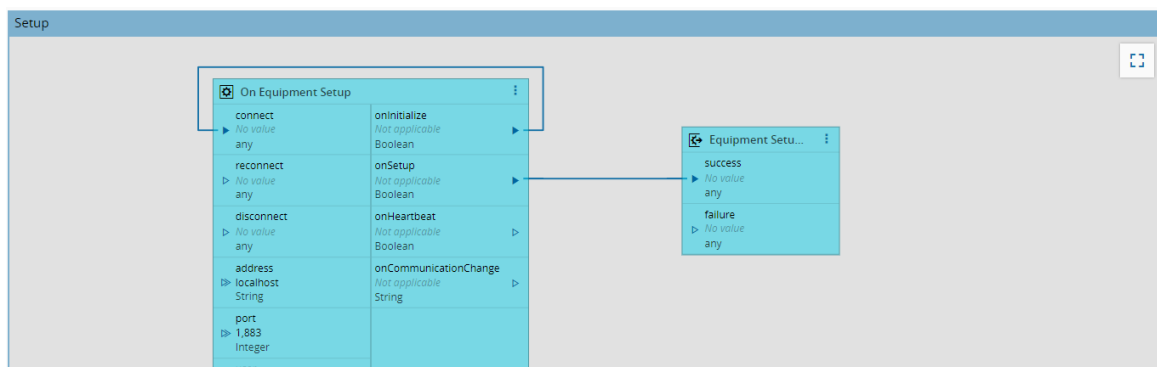
## 7. Select Next and Create



The screenshot shows the configuration page for 'FleetManager-RawMaterial'. The 'Automation Controller' section is expanded, showing details like Name, Description, Type, Universal State, Scope, Version, and Entity Type. The 'Change Set' is set to 'cdaaadcd\_638421889531300855'. The 'Drivers' table shows a single entry for 'FleetManager' with 'Automation' set to 'Fleet Manager' and 'Color' set to a blue square. The page indicates 'Page 1 of 1 (1 Records)'.

### Fleet-Manager - Raw Material - Controller - Setup

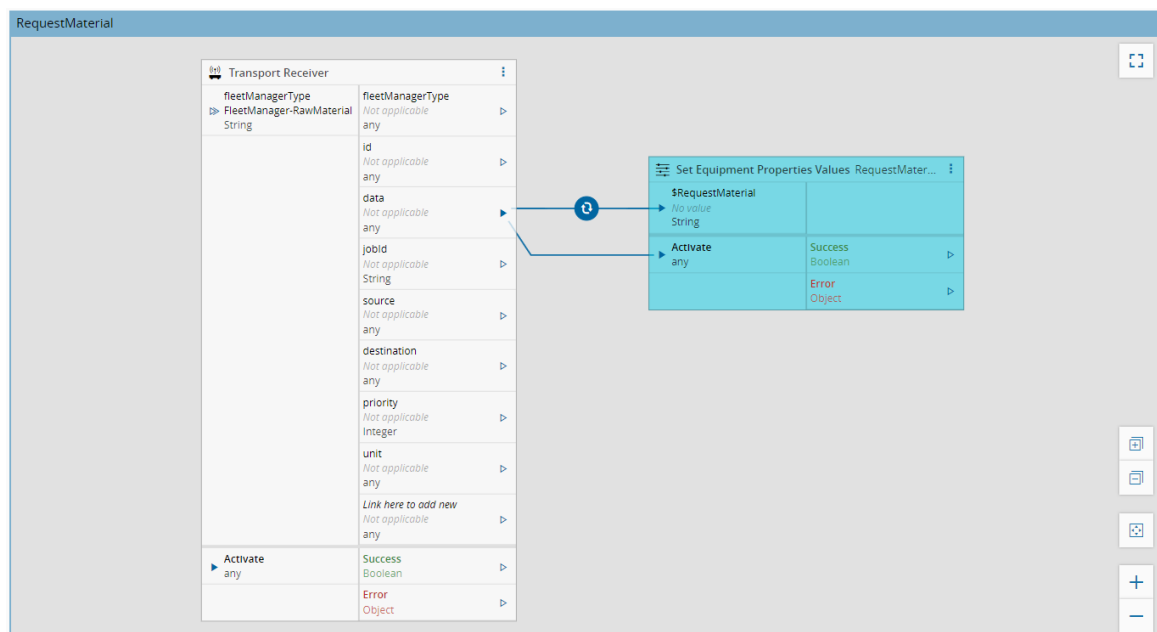
Feel free to use also the `Get Configurations` task to control the settings of the `On Equipment Setup`. This is a simple case so for this case, let's add the address as localhost and keep the default settings.



The screenshot shows the 'Setup' configuration page. The 'On Equipment Setup' task is selected, and its configuration is visible. The 'address' property is set to 'localhost' and the 'port' is set to '1883'. The 'onInitialize' and 'onSetup' tasks are also visible, with 'onSetup' being the active task. The 'Equipment Setup' task is also visible, showing 'success' and 'failure' states.

### Fleet-Manager - Raw Material - Controller - Request Material

Create a new page `Request Material`. The first action in the fleet manager will be to notify the fleet manager of a request material. In this workflow we will add a `Transport Receiver` task for the fleet manager `FleetManager-RawMaterial` with command `Transportation`. This is the task that will be notified by the `Transport Requester` of the `Request Material` job. Then we will publish to an mqtt topic `Machine1.Request.Material` the required payload, this is mapped by executing the `Set Equipment Properties Values RequestMaterial` task for the Automation Property `RequestMaterial`.



The screenshot shows the 'RequestMaterial' configuration page. The 'Transport Receiver' task is selected, and its configuration is visible. The 'fleetManagerType' is set to 'FleetManager-RawMaterial'. The 'data' property is set to '\$RequestMaterial'. The 'Activate' task is also visible, showing 'Success' and 'Error' states.

## Fleet-Manager - Raw Material - Controller - RobotAssigned

The next actions will follow a very similar pattern. Create a page `RobotAssigned`. When we receive an `On Equipment Event` task for the Event `RobotAssigned` we will notify our job, using the `Transport Requester` task with command interaction. We want to just notify the job that is managing this lifecycle so add the flag `Include Id in Command` as `true` and we will have to fill the `Id` input. It will also be helpful to add a simple `Code` task, that will transform the string received into a JSON object. We will also apply an `AnyToConstant` converter connecting to the `type` input of the `Transport Requester` task, this converter will apply a string with value `RobotAssigned`. The type will be used in the job to interpret to do with the interaction.

### Note

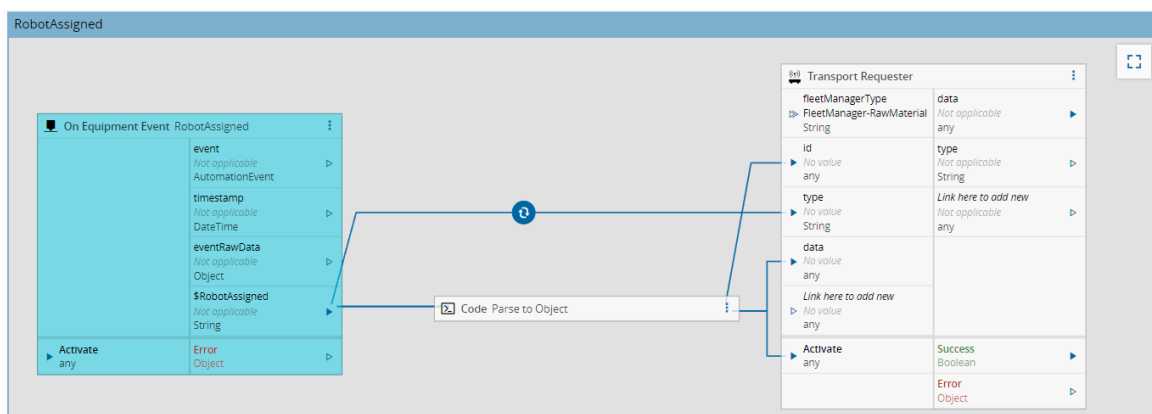
The flag `Include Id in Command` is very important. If the flag is set as `false` it means it will be a broadcast to all. If the task is `true` a job id must be provided. This is different than when we were in the context of the job, if we are in the context of `Connect IoT` we must provide the Id.

Content of the `Code` task:

```
public async main(inputs: any, outputs: any): Promise<any> {
  const data = JSON.parse(inputs.Value);

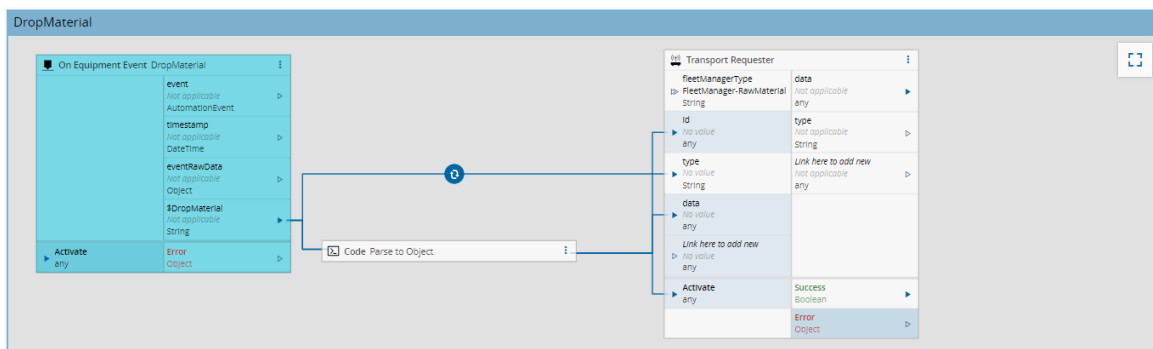
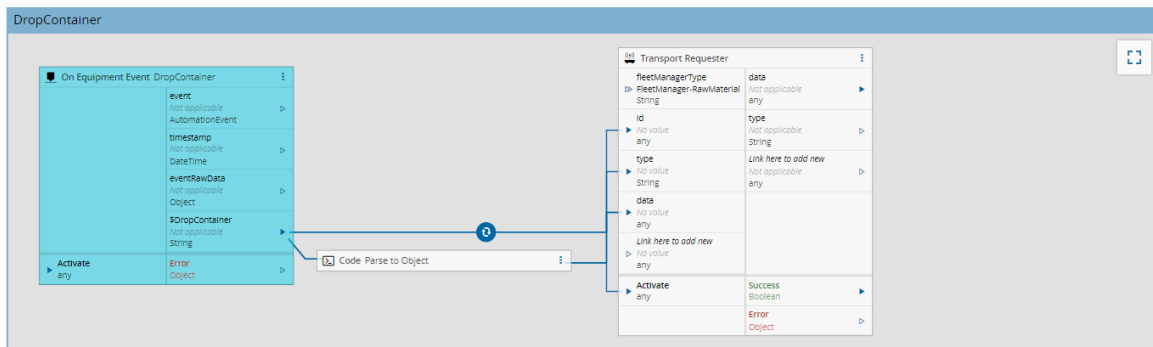
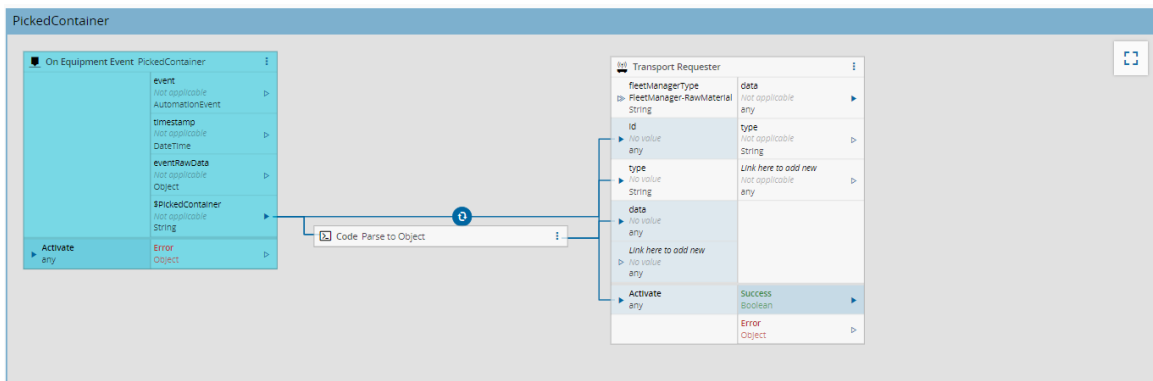
  outputs.jobId.emit(data["JobId"]);
  outputs.data.emit(JSON.parse(inputs.Value))
}
```

The code task will have the string input `Value` and the Output `jobId` and `data`. The `Success` output of the `Code` task will link to the `Activate` of the `Transport Requester`.



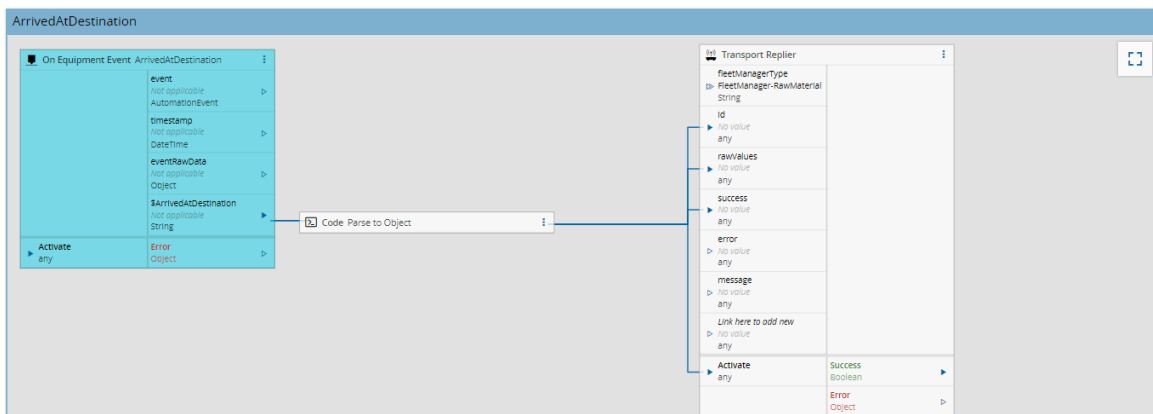
## Fleet-Manager - Raw Material - Controller - Others

The next actions are defined in the same fashion, changing the event that triggers them and changing the converter `AnyToConstant` to feed the different types.



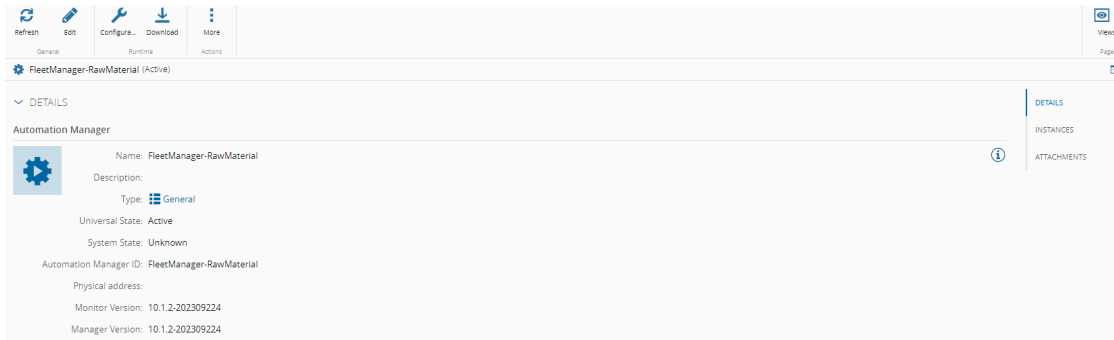
### Fleet-Manager - Raw Material - Controller - Arrived At Destination

The event `ArrivedAtDestination` will mark the end of the job. It will no longer call an interaction, but will call a `Transport Replier`, this task will signal the end of the job to the `Transport Requester` task of the main job.



### Fleet-Manager - Raw Material - Controller Instance

1. Create a Resource `FleetManager-RawMaterial` with ProcessingType Component
2. Go to `Business Data > Automation Manager`
3. Create `New`
4. Name `FleetManager-RawMaterial`
5. Logical Address `FleetManager-RawMaterial`
6. Select Version



7. Go to `Business Data > Automation Controller > FleetManager-RawMaterial_Controller`
8. Select `Connect`
9. Select Resource `FleetManager-RawMaterial` and Automation Manager `FleetManager-RawMaterial`
10. In the Drivers also select the Resource `FleetManager-RawMaterial`
11. Go to `Business Data > Automation Manager > FactoryAutomation`
12. Click `Download`
13. Run the Automation Manager
  - a. Unzip the Automation Manager
  - b. Go to scripts
  - c. Run `StartConsole.bat`

### Start the MQTT Broker

For this implementation we will use an MQTT broker [Mosquitto](#). Download and install mosquitto. In order to start the broker with mosquitto, go to where mosquitto was installed.

#### Note

If the mosquitto was installed as a windows service you won't need to start a console for the mosquitto broker.

To start the broker open a powershell console:

```
cd "C:\Program Files\mosquitto"
.\mosquitto.exe -v
```

Now the system should have the fleet manager and the Factory Automation worker communicating.

INSTANCE	CONNECTED ENTITY	COMMUNICATION STATE	VERSION	PROTOCOL	SYSTEM STATE
FACTORYAUTOMATION / FACTORYAUTOMATION / 10.1.2-202309224 / 10.1.2-202309224					
FactoryAutomationWorker_FactoryA	FactoryAutomationWorker	N/A	10.1.2-202309224	N/A	Running
FactoryAutomationWorker_Handler	FactoryAutomationWorker	COMMUNICATING	10.1.2-202309224	FactoryAutomation [A]	Running
FLEETMANAGER-RAWMATERIAL / FLEETMANAGER-RAWMATERIAL / 10.1.2-202309224 / 10.1.2-202309224					
FleetManager-RawMaterial_FleetMai	FleetManager-RawMaterial	N/A	10.1.2-202309224	N/A	Running
FleetManager-RawMaterial_FleetMai	FleetManager-RawMaterial	COMMUNICATING	10.1.2-202309224	MQTT Protocol [A]	Running

## Executing a Job Lifecycle

All the components have been created so we can perform the full job lifecycle.

Let's subscribe to the topic where we will send the request material, so we can confirm that we will receive the correct payload:

```
cd "C:\Program Files\mosquitto"
.\mosquitto_sub.exe -h localhost -t "Machine1.Request.Material"
```

Dispatch the **Material - Cookie Batch** to the **Oven** Resource. As we have seen previously a job will be created and will be processed.

GROUP BY: ALL	TIMEFRAME: ALL	TYPE: ALL	SCHEDULING STATE: ALL	SYSTEM STATE: ALL	SEARCH					
System Jobs (77) / 1 Item Selected										
JOB	TYPE	CONTROLLER	EVENT	QUEUED DATE	START DATE	DURATION	COMPLETED DATE	SCHEDULING STATE	SYSTEM STATE	ERROR MESSAGE
RequestMaterial -> Rr FactoryAutomation	RequestMaterial [A.1]	RequestMaterial		02/17/2024 05:35 PM	02/17/2024 05:19 PM	16m 3s 472ms		RUNNING	EXECUTING	

Now we can see that the worker processed the job.

```
2024-02-17 17:35:16.683 info: [croot>]Setup[task_3666][workerManager] Starting execution for new Job '231031162318000077'
2024-02-17 17:35:16.690 info: Currently running '1' concurrent jobs
2024-02-17 17:35:16.691 info: Starting new Job '231031162318000077'
2024-02-17 17:35:16.694 debug: [croot>]Setup[task_3666][workerManager] Creating execution engine for new Job '231031162318000077'
2024-02-17 17:35:16.696 debug: [croot>]Setup[task_3666][workerManager] Loading entire controller details (including workflows) for controller '2310311623180000238'
2024-02-17 17:35:16.698 debug: [croot>]Setup[task_3666][workerManager] Committing dequeue transaction for Job '231031162318000077'
2024-02-17 17:35:16.683 debug: [croot>]Setup[task_3666][workerManager] Got controller '2310311623180000238' details from system
2024-02-17 17:35:16.693 debug: [croot>]Setup[task_3666][workerManager] Creating DI container for new Job '231031162318000077'
2024-02-17 17:35:16.697 debug: [croot>]Setup[task_3666][workerManager] Creating execution engine for new Job '231031162318000077'
2024-02-17 17:35:16.698 debug: [croot>]Setup[task_3666][workerManager] Creating internal driverProxy and subscribing topics for new Job '231031162318000077'
2024-02-17 17:35:16.699 debug: [croot>]Setup[task_3666][workerManager] Creating execution context and setting the expiration timeout for new Job '231031162318000077'
2024-02-17 17:35:16.691 debug: [croot>]Setup[task_3666][workerManager] Persisting information for new Job '231031162318000077'
2024-02-17 17:35:16.691 debug: [croot>]Setup[task_3666][workerManager] Storing data in 'Persistent' for 'JOB_ID': '231031162318000077'
2024-02-17 17:35:16.693 debug: [croot>]Setup[task_3666][workerManager] Trying to write control persistency data from 'C:\Users\jroque\Downloads\FATutorial\ConnectIoT\FactoryAutomation\Persistency\Controller_AutomationControllerInstance_231031162318000013\connectIoT_ControllerI
le.json'
2024-02-17 17:35:16.694 info: Successfully wrote 'Controller_AutomationControllerInstance_231031162318000013' store
2024-02-17 17:35:16.694 debug: [croot>]Setup[task_3666][workerManager] Storing data in 'Persistent' for 'JOB_ID': '231031162318000077', name='RequestMaterial -> RequestMaterial', type='FactoryAutomation', controllerId='2310311623180000238', timeout='0', data={'Resource':'Oven','ResourceFeeder':'Coal Feeder','FleetManager':'FleetManager-RawMaterial', 'state':'SchedulingState=Running', state='Executing', errorCode='null', errorMessage='null', $id='5', eventDefinition='231031162318000008', name='RequestMaterial', $id='6'}, eventName='RequestMaterial', $id='4'}, resultData[Object: ]
2024-02-17 17:35:16.696 debug: [croot>]Setup[task_3666][workerManager] Trying to write control persistency data from 'C:\Users\jroque\Downloads\FATutorial\ConnectIoT\FactoryAutomation\Persistency\Controller_AutomationControllerInstance_231031162318000013\connectIoT_ControllerI
le.json'
2024-02-17 17:35:17.115 info: Job '231031162318000077' state updated in system: SchedulingState=Running, State=Executing, SubState=undefined, ErrorCode='null', ErrorMessage='null'
2024-02-17 17:35:16.993 info: Successfully wrote 'Controller_AutomationControllerInstance_231031162318000013' store
2024-02-17 17:35:16.994 info: [croot>]Setup[task_3666][workerManager] Starting Engine execution for Job '231031162318000077'
2024-02-17 17:35:16.985 info: [croot>]Setup[task_3666][workerManager] Adding workflow: Name='Main', Id='23103116231800010581', LastServiceHistoryId='2310311623180051394'
2024-02-17 17:35:16.919 info: [croot>]Setup[task_3666][workerManager] Adding workflow: Name='Transport Interactions', Id='23103116231800010582', LastServiceHistoryId='2310311623180051394'
2024-02-17 17:35:16.936 info: [croot>]Setup[task_3666][workerManager] Sending to 'Handler' a message of type 'connect-iot-driver.factoryautomation.Command.JobStatus'
2024-02-17 17:35:17.116 debug: [croot>]Setup[task_3666][workerManager] Job '231031162318000077' status change report was accepted and processed
2024-02-17 17:35:17.116 info: [croot>]Setup[task_3666][workerManager] Triggering OnJobStart for job '231031162318000077' (triggered by event 'RequestMaterial')
2024-02-17 17:35:17.124 debug: [croot>]Setup[task_3666][workerManager] [croot>]Main[task_1898][transportRequester] Emitting RequestMaterial: received from DriverProxy
2024-02-17 17:35:17.122 info: [croot>]Setup[task_3666][workerManager] [croot>]Main[task_1898][transportRequester] Subscribing to 'Cnf.FactoryAutomation.FleetManager.Callback_231031162318000077.Transportation'
2024-02-17 17:35:17.122 debug: [croot>]Setup[task_3666][workerManager] [croot>]Main[task_1898][transportRequester] Sending Command Cnf.FactoryAutomation.FleetManager.FleetManager-RawMaterial.Transportation (231031162318000077)
2024-02-17 17:35:17.124 debug: [croot>]Setup[task_3666][workerManager] [croot>]Main[task_2378][store] Storing 'RequestMaterial' with 'FleetManager-RawMaterial' into temporary store
2024-02-17 17:35:17.125 debug: [croot>]Setup[task_3666][workerManager] [croot>]Transport Interactions[task_2348][retrieval] Retrieved 'FleetManager' with value 'FleetManager-RawMaterial'
2024-02-17 17:35:17.126 debug: [croot>]Setup[task_3666][workerManager] [croot>]Transport Interactions[anyToConstant] Converted to constant value='true'
2024-02-17 17:35:17.129 debug: [croot>]Setup[task_3666][workerManager] [croot>]Transport Interactions[task_2348][transportReceiver] No input Id was provided will try to fallback to context Job Id (only available in a Factory Automation Workflow)
2024-02-17 17:35:17.131 info: [croot>]Setup[task_3666][workerManager] [croot>]Transport Interactions[task_2348][transportReceiver] Subscribing to 'Cnf.FactoryAutomation.FleetManager.FleetManager-RawMaterial.231031162318000077.Interaction'
2024-02-17 17:35:17.144 info: [croot>]Setup[task_3666][workerManager] [croot>]Main[task_1898][transportRequester] Command Cnf.FactoryAutomation.FleetManager.FleetManager-RawMaterial.Transportation (231031162318000077) sent successfully
```

In the worker it logs that the message was sent successfully so let's see the fleet manager.

```
2024-02-17 17:35:17.140 debug: [croot>]RequestMaterial[task_2668][transportReceiver] Request received: subject='Cnf.FactoryAutomation.FleetManager.FleetManager-RawMaterial.Transportation', message='Resource'Oven', ResourceFeeder='Coal Feeder', FleetManager='FleetManager-RawMaterial', $id='231031162318000077', jobId='231031162318000077', $id='1'
2024-02-17 17:35:17.157 info: Setting values for properties
2024-02-17 17:35:17.143 debug: [croot>]RequestMaterial[task_2668][transportReceiver] Notified sender that message 'Cnf.FactoryAutomation.FleetManager.FleetManager-RawMaterial.Transportation' was received and processed
2024-02-17 17:35:17.157 debug: [croot>]RequestMaterial[task_2668][transportReceiver] [croot>]RequestMaterial[task_2668][transportReceiver] value='Resource'Oven', ResourceFeeder='Coal Feeder', FleetManager='FleetManager-RawMaterial', id='231031162318000077', jobId='231031162318000077', $id='1', $id='3'
2024-02-17 17:35:17.155 debug: [croot>]RequestMaterial[task_2668][transportReceiver] [croot>]RequestMaterial[task_2668][transportReceiver] value='Machine1.Request.Material' | value: 'Resource'Oven', ResourceFeeder='Coal Feeder', FleetManager='FleetManager-RawMaterial', id='231031162318000077', jobId='231031162318000077', $id='1'
2024-02-17 17:35:17.159 debug: >> publish: topic=Machine1.Request.Material, messageId=0 qos=0, retain=false, dup=false, payload=Resource'Oven', ResourceFeeder='Coal Feeder', FleetManager='FleetManager-RawMaterial', id='231031162318000077', jobId='231031162318000077', $id='1'
2024-02-17 17:35:17.161 debug: << publish: topic=Machine1.Request.Material, qos=0, retain=false, dup=false, payload=Resource'Oven', ResourceFeeder='Coal Feeder', FleetManager='FleetManager-RawMaterial', id='231031162318000077', jobId='231031162318000077', $id='1'
```

Lastly in the mqtt subscriber we will see that a message arrived as expected.

```
C:\Program Files\mosquitto
➤ .\mosquitto_sub.exe -h localhost -t "Machine1.Request.Material"
Resource='Oven', ResourceFeeder='Coal Feeder', FleetManager='FleetManager-RawMaterial', id='231031162318000077', jobId='231031162318000077', $id='1'
```



```
.\mosquitto_pub.exe -h localhost -t "FleetManager.Robot.DropContainer" -m
'{"JobId":"231031162318000077","Container":"CoalContainer001", "Destination":"Coal LoadPort"}'
```

The fleet manager will forward the message to the job.

```
2024-02-17 18:11:18.378 debug: << publish: topic=FleetManager.Robot.DropContainer, qos=0, retain=false, dup=false, payload={"JobId":"231031162318000077","Container":"CoalContainer001", "Destination":"Coal LoadPort"}
2024-02-17 18:11:18.390 info: Received Event Occurrence: 'Sat Feb 17 2024 18:11:18 GMT+0000', 'DropContainer':
  DropContainer={JobId:"231031162318000077","Container":"CoalContainer001", "Destination":"Coal LoadPort"} || rawType='Buffer', data=[123, 34, 74, 111, 88, 73, 100, 34, 58, 34, 58, 51, 49, 48, 54, 50, 51, 49, 56, 48, 48, 48, 48, 55, 55, 34, 44, 34, 67, 111, 110, 116, 97, 105, 110, 101, 114, 34, 58, 34, 67, 111, 97, 108, 67, 111, 110, 116, 97, 105, 110, 101, 114, 48, 48, 48, 34, 44, 32, 34, 68, 101, 115, 116, 105, 110, 97, 116, 105, 111, 110, 34, 5, 3, 74, 67, 111, 97, 108, 32, 70, 121, 97, 108, 69, 111, 114, 34, 121], side='S'
2024-02-17 18:11:18.379 info: Sending Event Occurrence: 'Sat Feb 17 2024 18:11:18 GMT+0000 (Western European Standard Time)', 'DropContainer (2310311623180000151)':
  DropContainer={JobId:"231031162318000077","Container":"CoalContainer001", "Destination":"Coal LoadPort"} || original=[123, 1434, 274, 3=111, 4=88, 5=73, 6=100, 7=34, 8=58, 9=34, 10=58, 11=51, 12=49, 13=48, 14=51, 15=49, 16=48, 17=3, 18=51, 19=51, 20=49, 21=58, 22=48, 23=48, 24=48, 25=48, 26=48, 27=55, 28=55, 29=34, 30=34, 31=34, 32=67, 33=111, 34=110, 35=116, 36=97, 37=105, 38=110, 39=110, 40=114, 41=34, 42=58, 43=34, 44=67, 45=111, 46=97, 47=108, 48=67, 49=111, 50=116, 51=116, 52=97, 53=105, 54=110, 55=101, 56=114, 57=110, 58=116, 59=116, 60=34, 61=44, 62=32, 63=68, 64=101, 65=115, 66=116, 67=116, 68=105, 69=110, 70=97, 71=116, 72=105, 73=111, 74=110, 75=54, 76=58, 77=34, 78=67, 79=111, 80=97, 81=108, 82=32, 83=70, 84=111, 85=97, 86=108, 87=90, 88=111, 89=114, 90=116, 91=34, 92=121]
2024-02-17 18:11:18.381 debug: [2ae7803f]DropContainer[task_4356[equipmentEvent]] Event 'DropContainer' received from DriverProxy
2024-02-17 18:11:18.381 debug: [2ae7803f]DropContainer[task_4356[equipmentEvent]] Emitting property value 'DropContainer' = {"JobId":"231031162318000077","Container":"CoalContainer001", "Destination":"Coal LoadPort"}
2024-02-17 18:11:18.381 debug: [2ae7803f]DropContainer[anyToConstant] Converted to constant value='DropContainer'
2024-02-17 18:11:18.420 info: [2ae7803f]DropContainer[task_4532[transportRequester]] Subscribing to 'Cnf.FactoryAutomation.FleetManager.Callback.231031162318000077.Interaction'
2024-02-17 18:11:18.420 debug: [2ae7803f]DropContainer[task_4532[transportRequester]] Sending Command Cnf.FactoryAutomation.FleetManager.FleetManager-RawMaterial.231031162318000077.Interaction (231031162318000077)
2024-02-17 18:11:18.423 info: [2ae7803f]DropContainer[task_4532[transportRequester]] Command Cnf.FactoryAutomation.FleetManager.FleetManager-RawMaterial.231031162318000077.Interaction (231031162318000077) sent successfully
```

The worker will receive the message and invoke the execute action for the robot dropped container.

```
2024-02-17 18:11:18.422 debug: [crootto]Setup[task_3666[workerManager]] [crootto]Transport Interactions[task_2340[transportReceiver]] Request received: subject=Cnf.FactoryAutomation.FleetManager.FleetManager-RawMaterial.231031162318000077.Interaction, message=type='DropContainer', JobId='231031162318000077', Container='CoalContainer001', Destination='Coal LoadPort', id='231031162318000077', side='I'
2024-02-17 18:11:18.422 debug: [crootto]Setup[task_3666[workerManager]] [crootto]Transport Interactions[task_2340[transportReceiver]] Notified sender that message 'Cnf.FactoryAutomation.FleetManager.FleetManager-RawMaterial.231031162318000077.Interaction' was received and processed
2024-02-17 18:11:18.450 debug: [8f6efdbb]Setup[task_3666[workerManager]] [8f6efdbb]Transport Interactions[task_2687[switch]] Switch input 'DropMaterial' changed detected to DropContainer. Checking potential matches...
2024-02-17 18:11:18.450 debug: [8f6efdbb]Setup[task_3666[workerManager]] [8f6efdbb]Transport Interactions[task_2687[switch]] Triggering output DropContainer: true
2024-02-17 18:11:18.451 debug: [8f6efdbb]Setup[task_3666[workerManager]] [8f6efdbb]Transport Interactions[task_4634[retrieve]] Retrieving values from store
2024-02-17 18:11:18.481 debug: [8f6efdbb]Setup[task_3666[workerManager]] [8f6efdbb]Transport Interactions[task_7012[executeAction]] Getting ObjectByname: Name='RobotDroppedContainer', Type='Rule'
2024-02-17 18:11:18.484 info: [8f6efdbb]Setup[task_3666[workerManager]] [8f6efdbb]Transport Interactions[task_7012[executeAction]] Resolved Object Id='231031162318000035' from Name='RobotDroppedContainer'
```

In the MES we can now see that the Resource **AGV1** will now have no docked and the container will now be at the Resource **Coal LoadPort**.

BIN/POSITION	CONTAINER	STATUS	TYPE	POSITION UNIT TYPE	USED POSITIONS	TOTAL POSITIONS	ASSOCIATION TYPE
1	CoalContainer001	Available	Production	Material	1	1	DockedContainer

Now the robot will drop the material into the feeder Resource **Coal Feeder**.

```
.\mosquitto_pub.exe -h localhost -t "FleetManager.Robot.DropMaterial" -m
'{"JobId":"231031162318000077","Container":"CoalContainer001", "Destination":"Coal Feeder"}'
```

The fleet manager will forward the message to the job.

```
2024-02-17 18:19:12.470 debug: << publish: topic=FleetManager.Robot.DropMaterial, qos=0, retain=false, dup=false, payload={"JobId":"231031162318000077","Container":"CoalContainer001", "Destination":"Coal Feeder"}
2024-02-17 18:19:12.480 info: Received Event Occurrence: 'Sat Feb 17 2024 18:19:12 GMT+0000', 'DropMaterial':
  DropMaterial={JobId:"231031162318000077","Container":"CoalContainer001", "Destination":"Coal Feeder"} || rawType='Buffer', data=[123, 34, 74, 111, 88, 73, 100, 34, 58, 34, 58, 51, 49, 48, 54, 50, 51, 49, 48, 54, 50, 51, 49, 56, 48, 48, 48, 48, 55, 55, 34, 44, 34, 67, 111, 110, 116, 97, 105, 110, 101, 114, 34, 58, 34, 67, 111, 97, 108, 67, 111, 110, 116, 97, 105, 110, 101, 114, 48, 48, 48, 34, 44, 32, 34, 68, 101, 115, 116, 105, 110, 97, 116, 105, 111, 110, 34, 5, 3, 74, 67, 111, 97, 108, 32, 70, 121, 97, 108, 69, 111, 114, 34, 121], side='S'
2024-02-17 18:19:12.480 info: Sending Event Occurrence: 'Sat Feb 17 2024 18:19:12 GMT+0000 (Western European Standard Time)', 'DropMaterial (2310311623180000151)':
  DropMaterial={JobId:"231031162318000077","Container":"CoalContainer001", "Destination":"Coal Feeder"} || original=[123, 1434, 274, 3=111, 4=88, 5=73, 6=100, 7=34, 8=58, 9=34, 10=58, 11=51, 12=49, 13=48, 14=51, 15=49, 16=48, 17=3, 18=51, 19=51, 20=49, 21=58, 22=48, 23=48, 24=48, 25=48, 26=48, 27=55, 28=55, 29=34, 30=34, 31=34, 32=67, 33=111, 34=110, 35=116, 36=97, 37=105, 38=110, 39=110, 40=114, 41=34, 42=58, 43=34, 44=67, 45=111, 46=97, 47=108, 48=67, 49=111, 50=116, 51=116, 52=97, 53=105, 54=110, 55=101, 56=114, 57=110, 58=116, 59=116, 60=34, 61=44, 62=32, 63=68, 64=101, 65=115, 66=116, 67=116, 68=105, 69=110, 70=97, 71=116, 72=105, 73=111, 74=110, 75=54, 76=58, 77=34, 78=67, 79=111, 80=97, 81=108, 82=32, 83=70, 84=101, 85=101, 86=108, 87=101, 88=114, 89=34, 90=121]
2024-02-17 18:19:12.480 debug: [82f983da]DropMaterial[task_4356[equipmentEvent]] Event 'DropMaterial' received from DriverProxy
2024-02-17 18:19:12.481 debug: [82f983da]DropMaterial[task_4356[equipmentEvent]] Emitting property value 'DropMaterial' = {"JobId":"231031162318000077","Container":"CoalContainer001", "Destination":"Coal Feeder"}
2024-02-17 18:19:12.482 debug: [82f983da]DropMaterial[anyToConstant] Converted to constant value='DropMaterial'
2024-02-17 18:19:12.515 info: [82f983da]DropMaterial[task_4532[transportRequester]] Subscribing to 'Cnf.FactoryAutomation.FleetManager.Callback.231031162318000077.Interaction'
2024-02-17 18:19:12.515 debug: [82f983da]DropMaterial[task_4532[transportRequester]] Sending Command Cnf.FactoryAutomation.FleetManager.FleetManager-RawMaterial.231031162318000077.Interaction (231031162318000077)
2024-02-17 18:19:12.519 info: [82f983da]DropMaterial[task_4532[transportRequester]] Command Cnf.FactoryAutomation.FleetManager.FleetManager-RawMaterial.231031162318000077.Interaction (231031162318000077) sent successfully
```

The worker will receive the message and invoke the execute action for the robot dropped material.

```
2024-02-17 18:19:12.518 debug: [crootto]Setup[task_3666[workerManager]] [crootto]Transport Interactions[task_2340[transportReceiver]] Request received: subject=Cnf.FactoryAutomation.FleetManager.FleetManager-RawMaterial.231031162318000077.Interaction, message=type='DropMaterial', JobId='231031162318000077', Container='CoalContainer001', Destination='Coal Feeder', id='231031162318000077', side='I'
2024-02-17 18:19:12.519 debug: [crootto]Setup[task_3666[workerManager]] [crootto]Transport Interactions[task_2340[transportReceiver]] Notified sender that message 'Cnf.FactoryAutomation.FleetManager.FleetManager-RawMaterial.231031162318000077.Interaction' was received and processed
2024-02-17 18:19:12.532 debug: [6638738c]Setup[task_3666[workerManager]] [6638738c]Transport Interactions[task_2687[switch]] Switch input 'DropMaterial' changed detected to DropMaterial. Checking potential matches...
2024-02-17 18:19:12.533 debug: [6638738c]Setup[task_3666[workerManager]] [6638738c]Transport Interactions[task_2687[switch]] Triggering output DropMaterial: true
2024-02-17 18:19:12.533 debug: [6638738c]Setup[task_3666[workerManager]] [6638738c]Transport Interactions[task_4634[retrieve]] Retrieving values from store
2024-02-17 18:19:12.563 debug: [6638738c]Setup[task_3666[workerManager]] [6638738c]Transport Interactions[task_0103[executeAction]] Getting ObjectByname: Name='RobotDropMaterial', Type='Rule'
2024-02-17 18:19:12.575 info: [6638738c]Setup[task_3666[workerManager]] [6638738c]Transport Interactions[task_0103[executeAction]] Resolved Object Id='231031162318000036' from Name='RobotDropMaterial'
```

In the Resource **Agv1** even if we select **Manage Consumables** we can see that now we have a material in our consumable feed.

Manage Consumables

Oven (Up) / SEMI E10 > Standby

CONSUMABLE FEED	MATERIAL
Coal Feeder Pos: 1	Material Coal Coal [A] / Qty: 97 KG

Consumable Feed Details

Name: Coal Feeder  
Position: 1  
Description:  
Type: Standard

Material Details

Name: Material Coal  
Product: Coal [A]  
Description:  
Primary Qty: 97 KG  
Expiration Date:  
Order: 1

Comments:

Cancel Update

```
.\mosquitto_pub.exe -h localhost -t "FleetManager.Robot.ArrivedAtDestination" -m
'{"JobId":"2310311623180000077","Container":"CoalContainer001"}'
```

The fleet manager will forward the message to the job.

```
2024-02-17 18:23:13.670 debug: << publish: topic=FleetManager.Robot.ArrivedAtDestination, qos=0, retain=false, dup=false, payload={"JobId":"2310311623180000077","Container":"CoalContainer001"}
2024-02-17 18:23:13.671 info: Sending Event Occurrence: Sat Feb 17 2024 18:23:13 GMT+0000 (Western European Standard Time) 'ArrivedAtDestination (2310311623180000152)'
2024-02-17 18:23:13.673 info: Received Event Occurrence: Sat Feb 17 2024 18:23:13 GMT+0000 'ArrivedAtDestination (2310311623180000152)'
2024-02-17 18:23:13.673 debug: [c12e5910]ArrivedAtDestination[task_4618]equipmentEvent Event 'ArrivedAtDestination' received from DriverProxy
2024-02-17 18:23:13.673 debug: [c12e5910]ArrivedAtDestination[task_4618]equipmentEvent omitting property value 'ArrivedAtDestination' of ['JobId': '2310311623180000077', 'Container': 'CoalContainer001']
2024-02-17 18:23:13.727 debug: [c12e5910]ArrivedAtDestination[task_4640]transportReplier Reply to Cnf.FactoryAutomation.FleetManager.Callback.2310311623180000077.Transportation received
```

The job `Transport Requester` will be notified and emit outputs. This will signal the end of the job.

```
2024-02-17 18:23:13.724 info: [c12e5910]Setup[task_3666]workerManager [c12e5910]Main[task_1988]transportRequester Unsubscribing from 'Cnf.FactoryAutomation.FleetManager.Callback.2310311623180000077.Transportation'
2024-02-17 18:23:13.725 debug: [c12e5910]Setup[task_3666]workerManager [c12e5910]Main[task_1988]transportRequester Request received. subject=Cnf.FactoryAutomation.FleetManager.Callback.2310311623180000077.Transportation, message='sa
ccess=true, JobId='2310311623180000077', Container='CoalContainer001', id='2310311623180000077', sid='1'
2024-02-17 18:23:13.725 debug: [c12e5910]Setup[task_3666]workerManager [c12e5910]Main[task_1988]transportRequester Notified sender that message 'Cnf.FactoryAutomation.FleetManager.Callback.2310311623180000077.Transportation' was recei
ved and processed
2024-02-17 18:23:13.752 info: Job '2310311623180000077' was reported as being completed
2024-02-17 18:23:13.751 info: [c12e5910]Setup[task_3666]workerManager Job '2310311623180000077' returned result: {}
2024-02-17 18:23:13.752 info: Sending to 'Handler' a message of type 'connect.iot.driver.factoryautomation.Command.JobStatus'
2024-02-17 18:23:13.754 info: [c12e5910]Setup[task_3666]workerManager [c12e5910]TransportInteraction[task_2340]transportReceiver Unsubscribing from 'Cnf.FactoryAutomation.FleetManager.FleetManager-RawMaterial.2310311623180000077.Int
eraction'
2024-02-17 18:23:14.118 info: Job '2310311623180000077' marked as completed in system
2024-02-17 18:23:14.286 info: Job '2310311623180000077' state updated in system: SchedulingState:'Processed', State:'Completed', SubState:'undefined', ErrorCode:'null', ErrorMessage:'null'
2024-02-17 18:23:14.298 debug: [c12e5910]Setup[task_3666]workerManager Job '2310311623180000077' status change report was accepted and processed
```

In the Factory Automation GUI we can now see that our job is `Processed`

GROUP BY: ALL	TIMEFRAME: ALL	TYPE: ALL	SCHEDULING STATE: ALL	SYSTEM STATE: ALL	Search					
System Jobs (77) / 1 Item Selected										
JOB	TYPE	CONTROLLER	EVENT	QUEUED DATE	START DATE	DURATION	COMPLETED DATE	SCHEDULING STATE	SYSTEM STATE	ERROR MESSAGE
<input type="checkbox"/>	RequestMaterial -> Rr FactoryAutomation	RequestMaterial [A.1]	RequestMaterial	02/17/2024 05:35 PM	02/17/2024 05:19 PM	1h 3m 46s 806ms	02/17/2024 06:23 PM	PROCESSED	COMPLETED	

## Handling Failures

In this tutorial we did not address error scenarios. If the job is canceled, you can use the `Transport Replier` task to signal the end of the job, but with the command `CancelTransportation`. If the job is in error, you can use the `Transport Replier` task with the command `Transportation`, but with the input error filled in. The error messages will then be visible in the Factory Automation GUI.

**Info**

More information on the [Factory Automation](#) section of the User Guide.





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