RabbitMQ tutorial - Work Queues

Work Queues

(using the .NET Client)

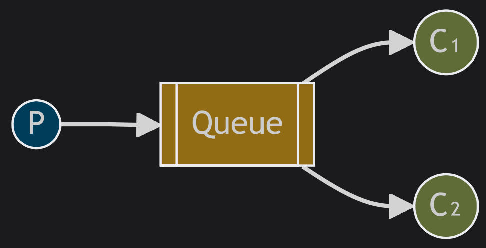
INFO

Prerequisites

This tutorial assumes RabbitMQ is installed and running on `localhost` on the standard port (5672). In case you use a different host, port or credentials, connections settings would require adjusting.

Where to get help

If you're having trouble going through this tutorial you can contact us through GitHub Discussions or RabbitMQ community Discord.



In the first tutorial we wrote programs to send and receive messages from a named queue. In this one we'll create a *Work Queue* that will be used to distribute time-consuming tasks among multiple workers.

The main idea behind Work Queues (aka: *Task Queues*) is to avoid doing a resource-intensive task immediately and having to wait for it to complete. Instead we schedule the task to be done later. We encapsulate a *task* as a message and send it to a queue. A worker process running in the background will pop the tasks and eventually execute the job. When you run many workers the tasks will be shared between them.

This concept is especially useful in web applications where it's impossible to handle a complex task during a short HTTP request window.

Preparation

In the previous part of this tutorial we sent a message containing "Hello World!". Now we'll be sending strings that stand for complex tasks. We don't have a real-world task, like images to be resized or pdf files to be rendered, so let's fake it by just pretending we're busy - by using the `Thread.Sleep()` function (you will need to add `using System.Threading;` near the top of the file to get access to the threading APIs). We'll take the number of dots in the string as its complexity; every dot will account for one second of "work". For example, a fake task described by `Hello...` will take three seconds.

We will slightly modify the *Send* program from our previous example, to allow arbitrary messages to be sent from the command line. This program will schedule tasks to our work queue, so let's name it `NewTask`:

Like tutorial one we need to generate two projects.

```
dotnet new console --name NewTask
mv NewTask/Program.cs NewTask/NewTask.cs
dotnet new console --name Worker
mv Worker/Program.cs Worker/Worker.cs
cd NewTask
dotnet add package RabbitMQ.Client
cd ../Worker
dotnet add package RabbitMQ.Client
```

Copy the code from our old *Send.cs* to *NewTask.cs* and make the following modifications.

Update the initialization of the *message* variable:

```
var message = GetMessage(args);
```

Add the *GetMessage* method to the end of the *NewTask* class:

```
static string GetMessage(string[] args)
{
    return ((args.Length > 0) ? string.Join(" ", args) : "Hello World!");
}
```

Our old *Receive.cs* script also requires some changes to fake a second of work for every dot in the message body. It will handle messages delivered by RabbitMQ and perform the task, so let's copy it to *Worker.cs* and modify it as follows.

After our existing *WriteLine* for receiving the message, add the fake task to simulate execution time:

```
Console.WriteLine($" [x] Received {message}");

int dots = message.Split('.').Length - 1;
Thread.Sleep(dots * 1000);

Console.WriteLine(" [x] Done");
```

Round-robin dispatching

One of the advantages of using a Task Queue is the ability to easily parallelise work. If we are building up a backlog of work, we can just add more workers and that way, scale easily.

First, let's try to run two `Worker` instances at the same time. They will both get messages from the queue, but how exactly? Let's see.

You need three consoles open. Two will run the `Worker` program. These consoles will be our two consumers - C1 and C2.

```
# shell 1
cd Worker
dotnet run
# => Press [enter] to exit.
```

```
# shell 2
cd Worker
dotnet run
# => Press [enter] to exit.
```

In the third one we'll publish new tasks. Once you've started the consumers you can publish a few messages:

```
# shell 3
cd NewTask
dotnet run "First message."
dotnet run "Second message.."
dotnet run "Third message..."
dotnet run "Fourth message...."
dotnet run "Fifth message....."
```

Let's see what is delivered to our workers:

```
# shell 1
# => Press [enter] to exit.
# => [x] Received First message.
# => [x] Done
# => [x] Received Third message...
# => [x] Done
# => [x] Received Fifth message.....
# => [x] Done
```

```
# shell 2
# => Press [enter] to exit.
# => [x] Received Second message..
# => [x] Done
# => [x] Received Fourth message....
# => [x] Done
```

By default, RabbitMQ will send each message to the next consumer, in sequence. On average every consumer will get the same number of messages. This way of distributing messages is called round-robin. Try this out with three or more workers.

Message acknowledgment

Doing a task can take a few seconds. You may wonder what happens if one of the consumers starts a long task and dies with it only partly done. With our current code, once RabbitMQ delivers a message to the consumer it immediately marks it for deletion. In this case, if you terminate a worker we will lose the message it was just processing. We'll also lose all the messages that were dispatched to this particular worker but were not yet handled.

But we don't want to lose any tasks. If a worker dies, we'd like the task to be delivered to another worker.

In order to make sure a message is never lost, RabbitMQ supports message *acknowledgments*. An ack(nowledgement) is sent back by the consumer to tell RabbitMQ that a particular message has been received, processed and that RabbitMQ is free to delete it.

If a consumer dies (its channel is closed, connection is closed, or TCP connection is lost) without sending an ack, RabbitMQ will understand that a message wasn't processed fully and will re-queue it. If there are other consumers online at the same time, it will then quickly redeliver it to another consumer. That way you can be sure that no message is lost, even if the workers occasionally die.

A timeout (30 minutes by default) is enforced on consumer delivery acknowledgement. This helps detect buggy (stuck) consumers that never acknowledge deliveries. You can increase this timeout as described in Delivery Acknowledgement Timeout.

Manual message acknowledgments are turned on by default. In previous examples we explicitly turned them off by setting the autoAck ("automatic acknowledgement mode") parameter to true. It's time to remove this flag and manually send a proper acknowledgment from the worker, once we're done with a task.

After the existing *WriteLine*, add a call to *BasicAck* and update *BasicConsume* with *autoAck:false*:

```
    Console.WriteLine(" [x] Done");

    // here channel could also be accessed as
((EventingBasicConsumer)sender).Model
    channel.BasicAck(deliveryTag: ea.DeliveryTag, multiple: false);
```

```
};
channel.BasicConsume(queue: "hello",
                     autoAck: false,
                     consumer: consumer);
```

Using this code, you can ensure that even if you terminate a worker node using CTRL+C while it was processing a message, nothing is lost. Soon after the worker node is terminated, all unacknowledged messages will be redelivered.

Acknowledgement must be sent on the same channel that received the delivery. Attempts to acknowledge using a different channel will result in a channel-level protocol exception. See the doc guide on confirmations to learn more.

> **Forgotten acknowledgment**
>
> It's a common mistake to miss the `BasicAck`. It's an easy error, but the consequences are serious. Messages will be redelivered when your client quits (which may look like random redelivery), but RabbitMQ will eat more and more memory as it won't be able to release any unacked messages.
>
> In order to debug this kind of mistake you can use `rabbitmqctl` to print the `messages_unacknowledged` field:
>
> ```
> sudo rabbitmqctl list_queues name messages_ready messages_unacknowledged
> ```
>
> On Windows, drop the sudo:
>
> ```
> rabbitmqctl.bat list_queues name messages_ready messages_unacknowledged
> ```

Message durability

We have learned how to make sure that even if the consumer dies, the task isn't lost. But our tasks will still be lost if RabbitMQ server stops.

When RabbitMQ quits or crashes it will forget the queues and messages unless you tell it not to. Two things are required to make sure that messages aren't lost: we need to mark both the queue and messages as durable.

First, we need to make sure that the queue will survive a RabbitMQ node restart. In order to do so, we need to declare it as *durable*:

```
channel.QueueDeclare(queue: "hello",
                     durable: true,
                     exclusive: false,
                     autoDelete: false,
                     arguments: null);
```

Although this command is correct by itself, it won't work in our present setup. That's because we've already defined a queue called `hello` which is not durable. RabbitMQ doesn't allow you to redefine an existing queue with different parameters and will return an error to any program that tries to do that. But there is a quick workaround - let's declare a queue with different name, for example `task_queue`:

```
channel.QueueDeclare(queue: "task_queue",
                     durable: true,
                     exclusive: false,
                     autoDelete: false,
                     arguments: null);
```

This `QueueDeclare` change needs to be applied to both the producer and consumer code. You also need to change the name of the queue for `BasicConsume` and `BasicPublish`.

At this point we're sure that the `task_queue` queue won't be lost even if RabbitMQ restarts. Now we need to mark our messages as persistent.

After the existing *GetBytes*, set `IBasicProperties.Persistent` to `true`:

```
var body = Encoding.UTF8.GetBytes(message);

var properties = channel.CreateBasicProperties();
properties.Persistent = true;
```

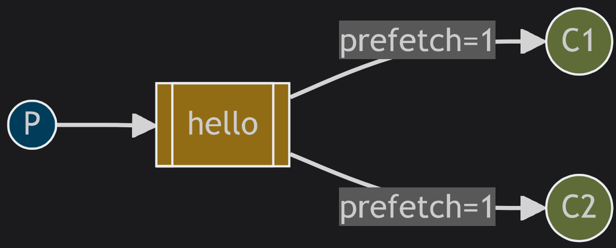
> **Note on Message Persistence**

> Marking messages as persistent doesn't fully guarantee that a message won't be lost. Although it tells RabbitMQ to save the message to disk, there is still a short time window when RabbitMQ has accepted a message and hasn't saved it yet. Also, RabbitMQ doesn't do `fsync(2)` for every message -- it may be just saved to cache and not really written to the disk. The persistence guarantees aren't strong, but it's more than enough for our simple task queue. If you need a stronger guarantee then you can use publisher confirms.

Fair Dispatch

You might have noticed that the dispatching still doesn't work exactly as we want. For example in a situation with two workers, when all odd messages are heavy and even messages are light, one worker will be constantly busy and the other one will do hardly any work. Well, RabbitMQ doesn't know anything about that and will still dispatch messages evenly.

This happens because RabbitMQ just dispatches a message when the message enters the queue. It doesn't look at the number of unacknowledged messages for a consumer. It just blindly dispatches every n-th message to the n-th consumer.



In order to change this behavior we can use the `BasicQos` method with the `prefetchCount` = `1` setting. This tells RabbitMQ not to give more than one message to a worker at a time. Or, in other words, don't dispatch a new message to a worker until it has processed and acknowledged the previous one. Instead, it will dispatch it to the next worker that is not still busy.

After the existing *QueueDeclare* in *Worker.cs* add the call to `BasicQos`:

```
channel.QueueDeclare(queue: "task_queue",
                     durable: true,
                     exclusive: false,
                     autoDelete: false,
                     arguments: null);
```

```
channel.BasicQos(prefetchSize: 0, prefetchCount: 1, global: false);
```

> **Note about queue size**
>
> If all the workers are busy, your queue can fill up. You will want to keep an eye on that, and maybe add more workers, or have some other strategy.

Putting It All Together

Open two terminals.

Run the consumer (worker) first so that the topology (primarily the queue) is in place. Here is its complete code:

```
using System.Text;
using RabbitMQ.Client;
using RabbitMQ.Client.Events;

var factory = new ConnectionFactory { HostName = "localhost" };
using var connection = factory.CreateConnection();
using var channel = connection.CreateModel();

channel.QueueDeclare(queue: "task_queue",
                     durable: true,
                     exclusive: false,
                     autoDelete: false,
                     arguments: null);

channel.BasicQos(prefetchSize: 0, prefetchCount: 1, global: false);

Console.WriteLine(" [*] Waiting for messages.");

var consumer = new EventingBasicConsumer(channel);
consumer.Received += (model, ea) =>
{
    byte[] body = ea.Body.ToArray();
    var message = Encoding.UTF8.GetString(body);
    Console.WriteLine($" [x] Received {message}");

    int dots = message.Split('.').Length - 1;
```

```
    Thread.Sleep(dots * 1000);

    Console.WriteLine(" [x] Done");

    // here channel could also be accessed as
((EventingBasicConsumer)sender).Model
    channel.BasicAck(deliveryTag: ea.DeliveryTag, multiple: false);
};
channel.BasicConsume(queue: "task_queue",
                     autoAck: false,
                     consumer: consumer);

Console.WriteLine(" Press [enter] to exit.");
Console.ReadLine();
```

Now run the task publisher (NewTask). Its final code is:

```
using System.Text;
using RabbitMQ.Client;

var factory = new ConnectionFactory { HostName = "localhost" };
using var connection = factory.CreateConnection();
using var channel = connection.CreateModel();

channel.QueueDeclare(queue: "task_queue",
                     durable: true,
                     exclusive: false,
                     autoDelete: false,
                     arguments: null);

var message = GetMessage(args);
var body = Encoding.UTF8.GetBytes(message);

var properties = channel.CreateBasicProperties();
properties.Persistent = true;

channel.BasicPublish(exchange: string.Empty,
                     routingKey: "task_queue",
                     basicProperties: properties,
                     body: body);
Console.WriteLine($" [x] Sent {message}");

Console.WriteLine(" Press [enter] to exit.");
```

```
Console.ReadLine();

static string GetMessage(string[] args)
{
    return ((args.Length > 0) ? string.Join(" ", args) : "Hello World!");
}
```

(NewTask.cs source)

Using message acknowledgments and `BasicQos` you can set up a work queue. The durability options let the tasks survive even if RabbitMQ is restarted.

For more information on `IModel` methods and `IBasicProperties`, you can browse the RabbitMQ .NET client API reference online.

Now we can move on to tutorial 3 and learn how to deliver the same message to many consumers.