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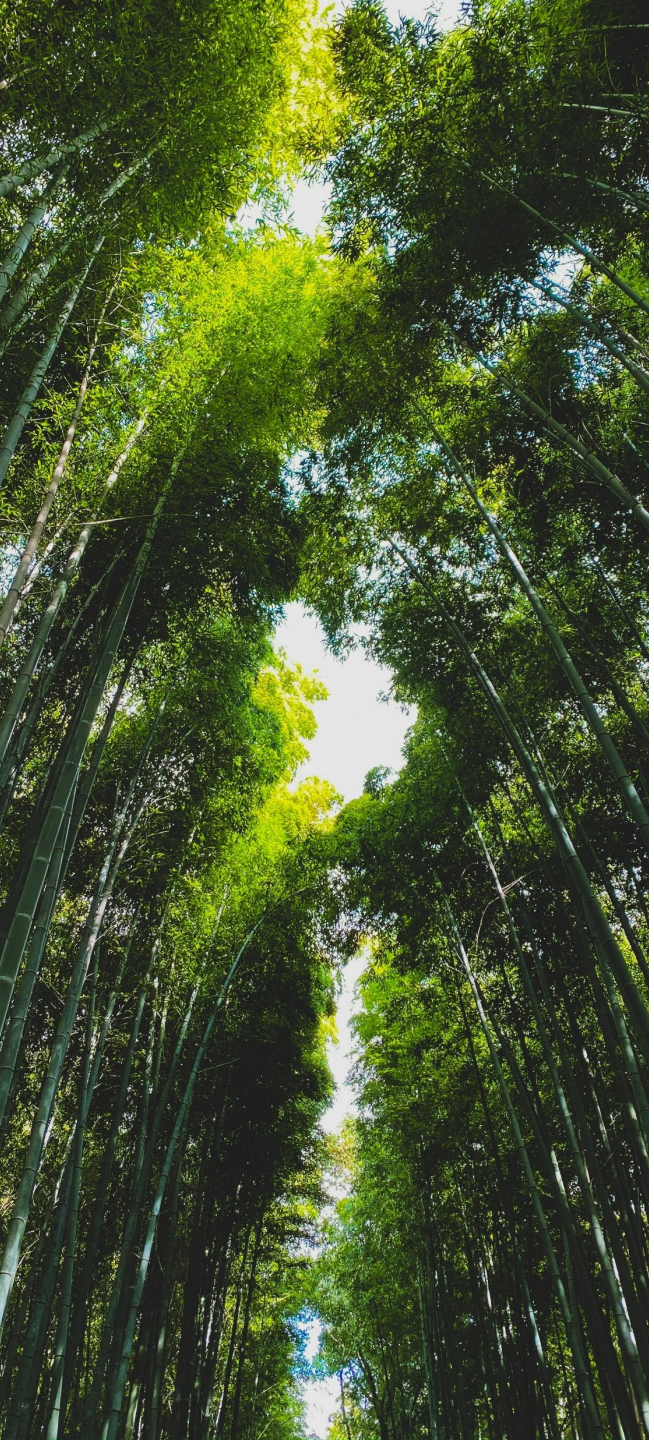
The first Hub for Developers

Microservices With .NET
Asynchronous Communication with RabbitMQ

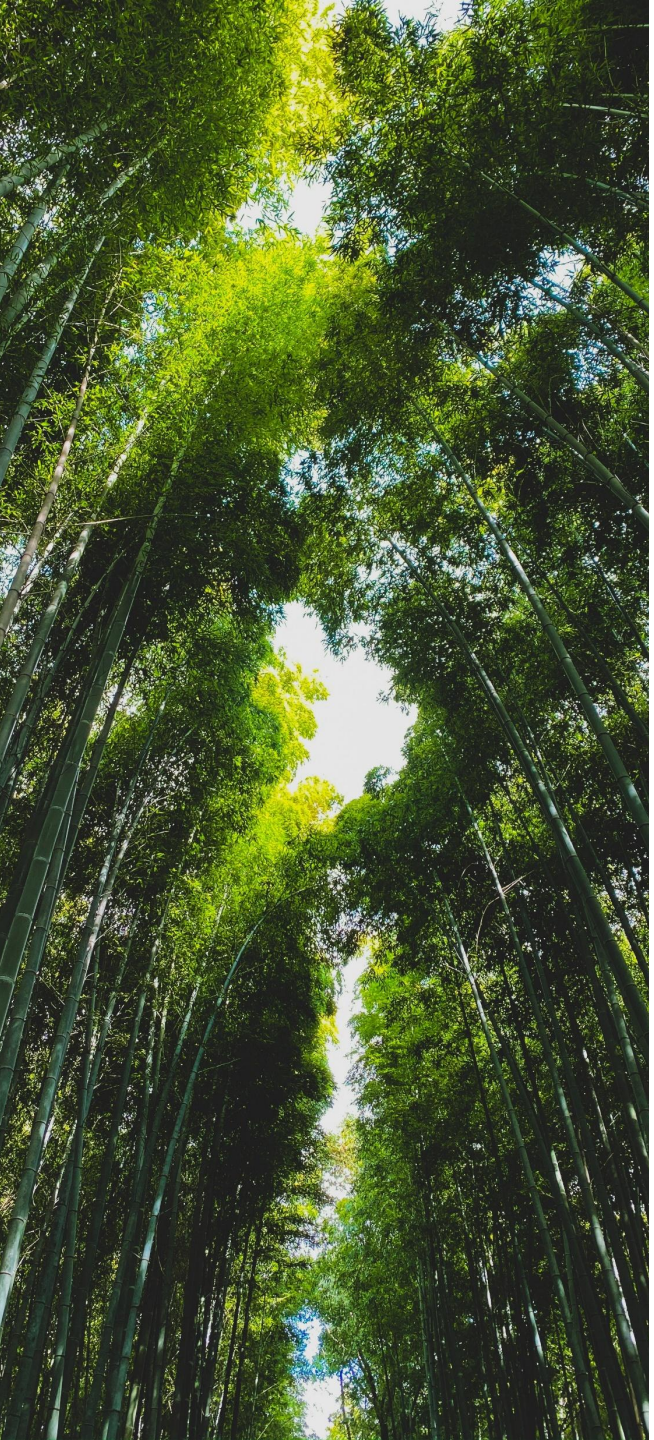


Introduction

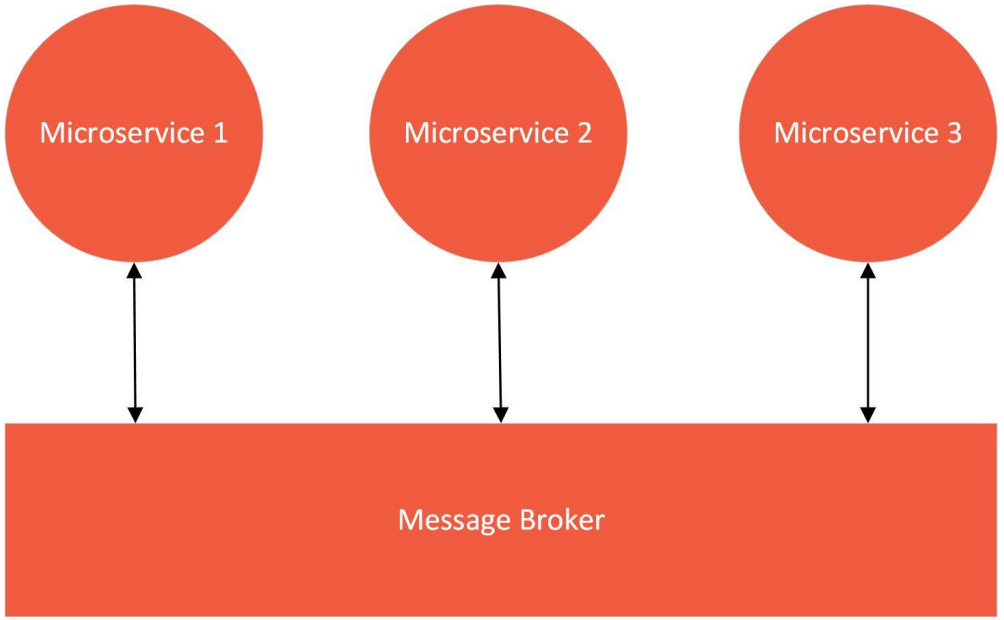
- **Asynchronous Communication** enables microservices to communicate through **messages** traded via a central broker.

- Unlike synchronous communication which follows a **request-reply** pattern, in asynchronous communication, publishers produce messages without expecting an immediate response from the receiver.

- This **significantly** improves message throughput and helps avoid the creation of bottlenecks in the system.



Message Brokers



- **Asynchronous communication is usually facilitated through a Message Broker,** a server application that acts as an intermediary to which messages can be sent and received from.

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RabbitMQ

- **RabbitMQ** is an open-source message broker maintained by *VMWare Tanzu Labs* and available under the *Mozilla Public License*.

- It is written in Erlang, but **clients** are available for a **wide variety of platforms**, including C#, Java, Python, PHP, C/C++, and JavaScript.

- It provides a **rich feature set** such as reliability, performance, and flexible routing.

Installing RabbitMQ (Docker)

- RabbitMQ can be installed through the Docker image, or locally.

- To create a Docker container:
  - Pull the *RabbitMQ:Management* image with `docker image pull rabbitmq:management`

  - Create a container from the image with `docker container run -p 15672:15672 -p 5672:5672 -d rabbitmq:management`

Installing RabbitMQ (Local)

- To install RabbitMQ locally (Windows):
  - First download and install the latest 64-bit Erlang **binary** from https://www.erlang.org/downloads
  - Then download and install the RabitMQ **exe installer** from: https://github.com/rabbitmq/rabbitmq-server/releases
  - Finally, enable the management interface by running the following on a terminal:

```
rabbitmq-plugins enable rabbitmq_management
```

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RabbitMQ Basics

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1. Accessing RabbitMQ
2. Exchanges and Queues
3. Role of Exchanges
4. Exchange Attributes
5. Queue Attributes
6. Exchange Types
7. Message States

RabbitMQ Basics

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Accessing RabbitMQ

- RabbitMQ is based on the AMQP 0-9-1 protocol (although it can also support other protocols via plugins).
- The default port **for the protocol** in RabbitMQ is port `5672`. The **management interface** is available through port `15672`.
- The default credentials are `guest` for **both username and password** (restricted to local host access).

Exchanges and Queues

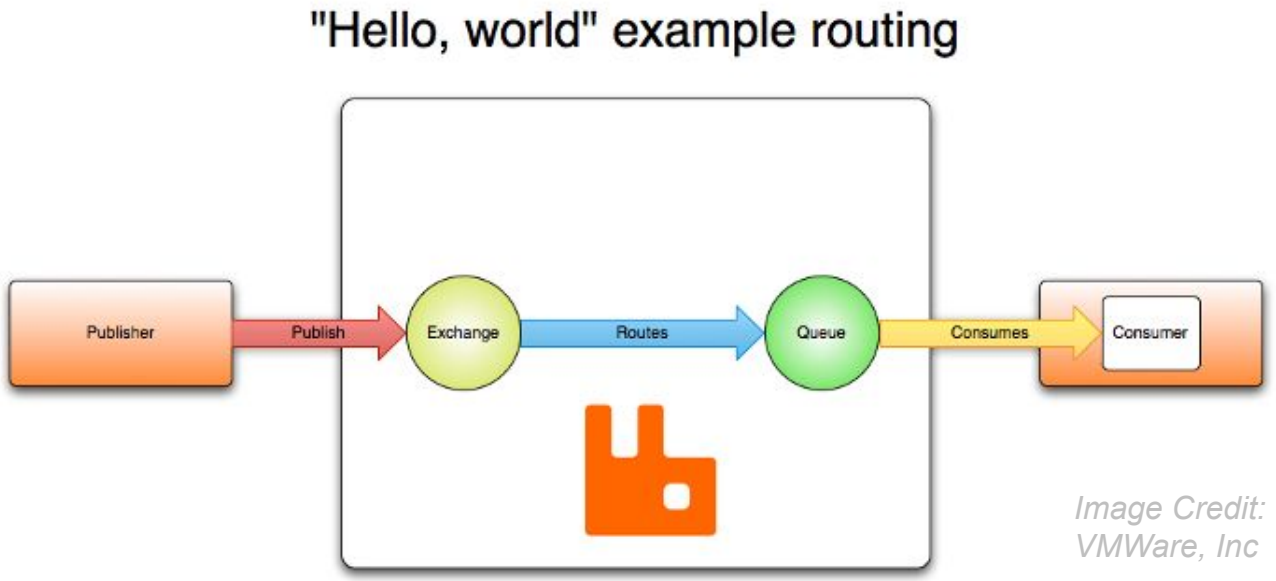

Image Credit: VMWare, Inc

- In the AMPQ protocol, **publishers** create messages that are **pushed to exchanges and stored in queues**. Consumers (receiving applications) can then retrieve messages from the queue.

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Role of Exchanges

- Exchanges are responsible for routing messages to the appropriate queue.
- When needed, messages include a **routing key** based on which the exchange can discern to which queue(s) to push the messages.
- All queues are binded to an exchange. If a queue is not **explicitly** binded to a queue, it is automatically binded to the default exchange.

Exchange Attributes

- Exchanges are declared with several attributes that control their behavior:

Attribute	Function
Name	The name of the exchange.
Durable	If true, the exchange will be stored in the disk drive, and can survive a broker restart.
Auto-delete	If true, the exchange will automatically be deleted when all queues are unbounded from it.
Arguments	Optional arguments used mostly by plugins.

Queue Attributes

- Queues include the following attributes:

Attribute	Function
Name	The name of the queue.
Durable	If true, the queue will be stored in the disk drive, and can survive a broker restart.
Exclusive	If true, the queue can only be used by one connection and will be deleted when the connection closes.
Auto-delete	If true, the queue will automatically be deleted when all consumers unsubscribe.
Arguments	Optional arguments used mostly by plugins.

Exchange Types

Direct	Messages are routed to the **matching exchange** according to the routing key.
Fanout	Messages are always routed to **all queues** binded to the exchange.
Topic	Messages are routed to **one or multiple** queues according to a **structured** routing key.
Headers	Similar to Topic, but routing is based on a **collection of headers** rather than the routing key.

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Message States

Ready

Messages that reach a queue are initially set to read. They will be delivered when a subscriber accesses the queue.

Unacknowledged

Messages that have been delivered to a subscriber but have not been acknowledged as processed are marked us *Unacked*. If the connection to the subscriber is lost, the messages will be moved back to the *Ready* state.

Acknowledged

Messages marked as *Acked* are removed from the queue and are considered by the broker as safe to delete.

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Fanout Exchange

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1. Fanout Exchange Introduction
2. Importing the Client Library
3. Creating an AMQP Connection
4. Declaring a Fanout Exhange
5. Declaring and Binding a Queue
6. Creating a Publisher
7. Publising in Fanout Exchanges
8. Consuming Messages
9. Creating an Eventing Consumer
10. Creating a Subscriber

Fanout Exchange

Introduction

Fanout exchange routing

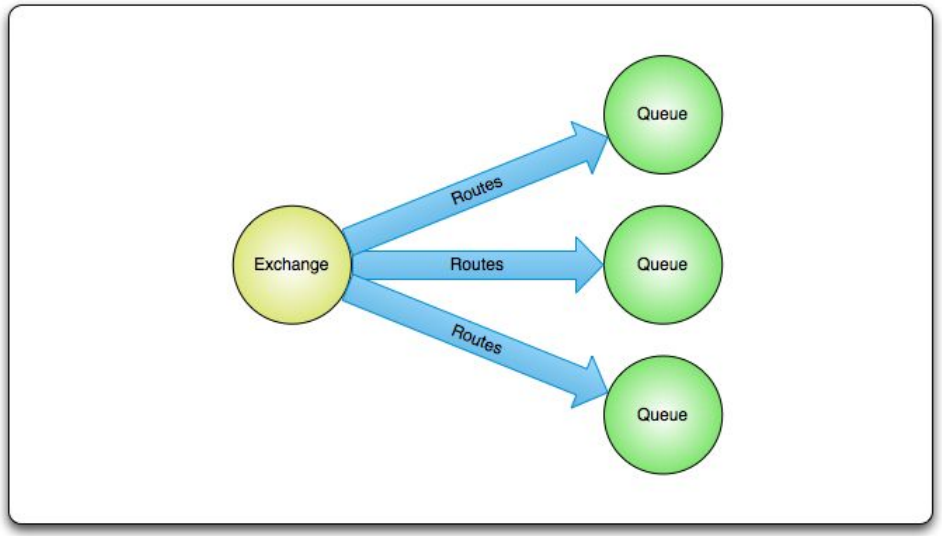

Image Credit: VMWare, Inc

- A **Fanout Exchange** ignores the routing key and rather delivers a copy of the message to **all queues** binded to the exchange.
- It is frequently used to broadcast **information of wide interest to a large number of recipients** such as news for aggregators or scores for a leaderboard.

Important Client Library Types

- The client provides three important types defined in the `RabitMQ.Client` namespace:
  - The `IConnection` type represents a connection to the AMQP 0-9-1 broker server.
  - The `IConnectionFactory` type is used to create instances of `IConnection`.
  - The `IModel` type represents represents an AMQP channel through which most protocol operations can be accessed.

Declaring Exchanges/Queues

- Exchanges and queues can be declared through the management plugin or directly in the code.
- Declaration operators are **transient**. If the exchange or queue already exists, it will be used.
- In order to declare an exchange or queue, a connection must be first established.

Creating an AMPQ Connection

The displayed code presents the creation of a connection.

- First a `ConnectionFactory` is created and UserName, Password as well as HostName provided **through its properties**.
- Then, an **`IConnection` instance is created from the factory** and an **`IModel` instance** is created based on the `IConnection` instance.

```
ConnectionFactory factory = new()
        {
            UserName = "guest",
            Password = "guest",
            HostName = "localhost"
        };

using IConnection connection = factory.CreateConnection();
using IModel channel = connection.CreateModel();
```

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Declaring an Exchange

- Through an `IModel` instance, an exchange or queue can be declared.
- When declaring an exchange, both a **name string** as well as a **type** (through the `ExchangeType` enum) must be specified.
- channel.ExchangeDeclare("CS1225_FanoutEx", ExchangeType.Fanout);

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Declaring a Queue

- When declaring a queue the following parameters are given:
  - *queue* (Queue name, `Boolean`)
  - *durable* (`Boolean`)
  - *exclusive* (`Boolean`)
  - *autoDelete* (`Boolean`)
  - *arguments* (`IDictionaty<string, object>`)

- ```
  channel.QueueDeclare("FanoutEx_Q1",
  false, false, false, null);
  ```
  ```

Binding a Queue

- With both the exchange and the queue declared, the queue can now be binded to the exchange. This can be achived with `IModel`'s `QueueBind()` method. It accepts three arguemtns:
  - *queue* (Queue name, `string`)
  - *exchange* (Exchange name, `string`)
  - *routingKey* (`string`)

- channel.QueueBind("FanoutEx_Q1", "CS1225_FanoutEx", "");

Creating a Publisher

- Messages can be published using `IModel`'s `BasicPublish()` extension method. It accepts four arguments:
  - *exchange* (Exchange name, `string`)
  - *routingKey* (`string`)
  - *basicProperties* (`IBasicProperties`)
  - *body* (`Byte[]`)

- ```
  string message = "Hello World";
  var body = Encoding.UTF8.GetBytes(message);
  channel.BasicPublish("CS1225_FanoutEx", "",
  null, body);
  ```

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  ```

```
static void Main(string[] args)
        {
            ConnectionFactory factory = new()
            {
                UserName = "guest",
                Password = "guest",
                HostName = "localhost"
            };

            using IConnection connection = factory.CreateConnection();
            using IModel channel = connection.CreateModel();

            channel.ExchangeDeclare("CS1225_FanoutEx",
ExchangeType.Fanout);
            channel.QueueDeclare("FanoutEx_Q1", false, false, false,null);

            channel.QueueBind(« FanoutEx_Q1", "CS1225_FanoutEx", "");

            string message = "Hello World";
            var body = Encoding.UTF8.GetBytes(message);

            channel.BasicPublish("CS1225_FanoutEx", "", null, body);

            Console.WriteLine(" FanoutEx.Publisher Sent {0}", message);
}
```

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Publishing in Fanout Exchanges

Received messages can be seen in the queues section of the management portal. In fanout exchanges, the routing key is always ignored and a copy of all messages is delivered to all binded queues.

```
channel.ExchangeDeclare("CS1225_FanoutEx", ExchangeType.Fanout);
channel.QueueDeclare("FanoutEx_Q1",false, false, false, null);
channel.QueueDeclare("FanoutEx_Q2",false, false, false, null);


channel.QueueBind("FanoutEx_Q1", "CS1225_FanoutEx", "");
channel.QueueBind("FanoutEx_Q2", "CS1225_FanoutEx", "q2");
//^ The routing key is ignored in Fanout Exchanges


string message = "Hello World";
var body = Encoding.UTF8.GetBytes(message);

channel.BasicPublish("CS1225_FanoutEx", "", null, body);
channel.BasicPublish("CS1225_FanoutEx", "q2", null, body);
//^ Both messages are received by both queues
```

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Consuming Messages

- Messages can be received using a **Consumer**. The consumer maintains an active connection to the broker, which can **notify the consumer** when new messages are available.

- Using consumers, it not necessary for the subscriber to actively check the server for messages (unlike AMQP's `get` method which necessitates an exchange).

- This significantly improves performance and reduces load.

Consuming Messages

- Messages can be received using a **Consumer**. The consumer maintains an active connection to the broker, which can **notify the consumer** when new messages are available.

- Using consumers, it not necessary for the subscriber to actively check the server for messages (unlike AMQP's `get` method which necessitates an exchange).

- This significantly improves performance. In a **new project** named `FanoutEx.Subsriber`, messages can be consumed.

Eventing Consumer

The `EventingBasicConsumer` class allows the instantiation of a **message consumer** that will raise **events** whenever a message is received.

Methods can then be added to the consumer's `Received` **delegate** in order to **handle any incoming messages**.

```
var consumer = new EventingBasicConsumer(channel);

    consumer.Received += (model, ea) =>

    {

    var body = ea.Body.ToArray();

    var message = Encoding.UTF8.GetString(body);

    Console.WriteLine($"FanoutEx.Subscriber received
{message}");

     };
```

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Starting the Consumer

- The consumer is now defined but is **not yet started** and listening for messages.

- A consumer can be started by using the `BasicConsume()` method, which accepts three arguments:
  - `queue` (Name of the queue, String)
  - `autoAck` (If true an ack is automatically sent when the message is received, Boolean)
  - `consumer` (The consumer instance, IBasicConsumer)

Producing a Subscriber

- When `BasicConsume()` is called, the consumer will start and the application will continue to listen for messages until it terminates or until `BasicCanel()` is called.

- A `ReadLine()` statement can be used to prevent the application from automatically exiting.

- ```
  channel.BasicConsume("FanoutEx_Q1",  true,
  consumer);
  Console.WriteLine("Listening for messages.
  Press ENTER anytime to quit...");
  Console.ReadLine();
  ```

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  ```

```
static void Main(string[] args)
{
    ConnectionFactory factory = new()
    {
        UserName = "guest", Password = "guest", HostName = "localhost"
    };

    using IConnection connection = factory.CreateConnection();
    using IModel channel = connection.CreateModel();

    channel.ExchangeDeclare("CS1225_FanoutEx", ExchangeType.Fanout);
    channel.QueueDeclare("FanoutEx_Q1", false, false, false, null);
    channel.QueueBind("FanoutEx_Q1", "CS1225_FanoutEx", "");

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

    channel.BasicConsume("FanoutEx_Q1",  true, consumer);

    Console.WriteLine("Listening for messages. Press ENTER anytime to quit...");
    Console.ReadLine();
}
```

Direct Exchange

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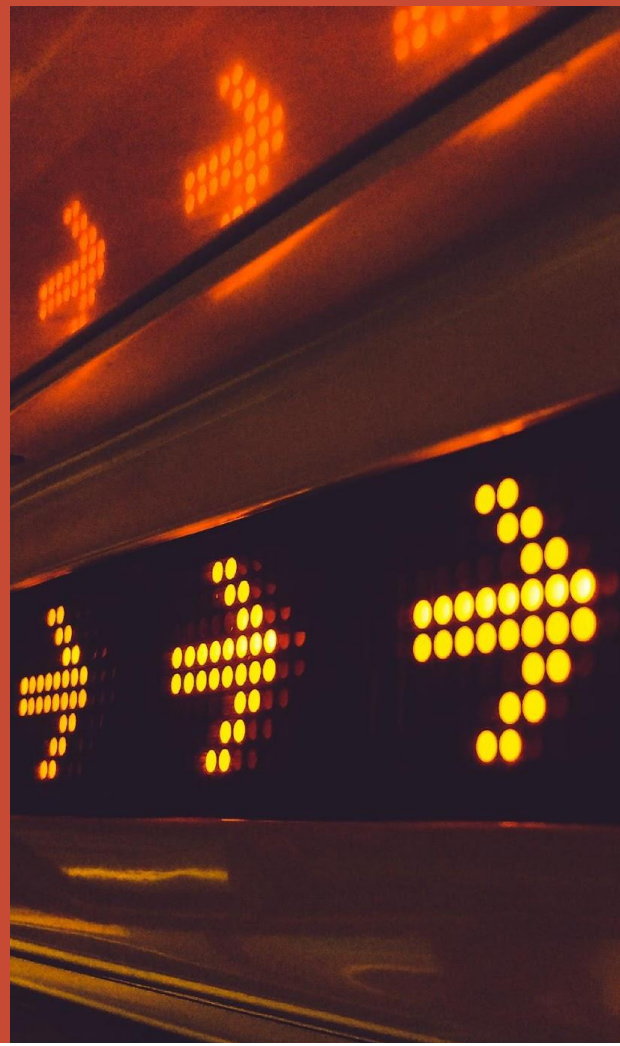
1. Direct Exchange Introduction
2. Binding Queues With a Routing Key
3. Publishing to a Direct Exchange
4. Subscribing to a Direct Exchange
5. Configuring Persistence
6. Declaring a Durable Queue
7. Sending Persistent Messages



Direct Exchange

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Introduction

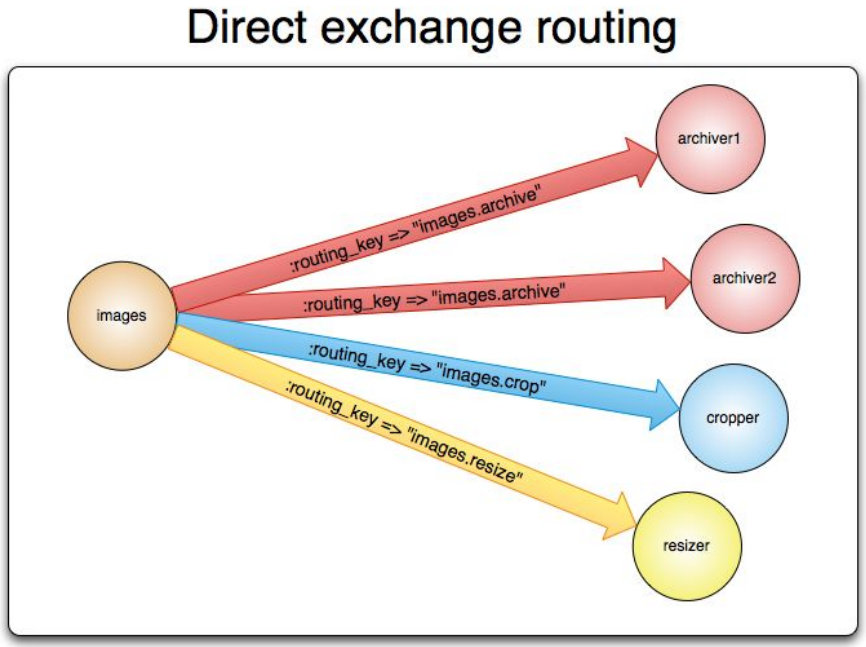

Image Credit: VMWare, Inc

- A **Direct Exchange** routes messages to one or more queues based on the **routing key**.
- Queues bind to the exchange with a routing key. Messages arriving at the exchange will only be routed to the queue(s) with a matching routing key.

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Binding With Routing Key

- Binding a queue to a Direct Exchange, is done in the same manner as in a Fanout Exchange, but a routing key is specified:

```
ConnectionFactory factory = new()
{UserName = "guest", Password = "guest“, HostName = "localhost"};

using IConnection connection = factory.CreateConnection();
using IModel channel = connection.CreateModel();
channel.ExchangeDeclare("CS1225_DirectEx", ExchangeType.Direct);

channel.QueueDeclare(queue: "Green", false, false, false,null);
channel.QueueBind("Green", "CS1225_DirectEx", "green");

channel.QueueDeclare(queue: "Red", false, false, false, null);
channel.QueueBind("Red", "CS1225_DirectEx", "red");
```

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Publishing

- When publishing to a direct exchange the routing key determines which queue(s) will receive the message.
- The following message will only be pushed to any queues banded to the *CS1225_DirectEx* exchange with the routing key *green*:

```
string message = "Hello World to Green!!!";
var body = Encoding.UTF8.GetBytes(message);

channel.BasicPublish( "CS1225_DirectEx", "green",
null, body);
```

```
static void Main(string[] args)
        {
            ConnectionFactory factory = new()
            {
                UserName = "guest",
                Password = "guest",
                HostName = "localhost"
            };

            using IConnection connection = factory.CreateConnection();
            using IModel channel = connection.CreateModel();

            channel.ExchangeDeclare("CS1225_DirectEx", ExchangeType.Direct);

            channel.QueueDeclare(queue: "Green", false, false, false,null);
            channel.QueueBind("Green", "CS1225_DirectEx", "green");

            channel.QueueDeclare(queue: "Red", false, false, false, null);
            channel.QueueBind("Red", "CS1225_DirectEx", "red");

            string message = "Hello World to Green!!!";
            var body = Encoding.UTF8.GetBytes(message);

            channel.BasicPublish( "CS1225_DirectEx", "green", null, body);

            Console.WriteLine($"DirectEx.Publisher sent {message}");
        }
```

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Receiving

- Receiving messages from a *Direct* exchange is similar to receiving from a *Fanout.*
- The queue is specified using the queue name, not the routing key. Remember that values are case sensitive.

```
var consumer = new EventingBasicConsumer(channel);
consumer.Received += (model, ea) =>
{
    var body = ea.Body.ToArray();
    var message = Encoding.UTF8.GetString(body);
    Console.WriteLine(" [x] Received {0}", message);
};

channel.BasicConsume(queue: "Green", true, consumer);
```

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```
static void Main(string[] args)
        {
            ConnectionFactory factory = new()
            {
                UserName = "guest",
                Password = "guest",
                HostName = "localhost"
            };

            using IConnection connection =
factory.CreateConnection();
            using IModel channel = connection.CreateModel();

            channel.ExchangeDeclare("CS1225_DirectEx",
ExchangeType.Direct);
            channel.QueueDeclare( "green", false, false, false,
null);

            var consumer = new EventingBasicConsumer(channel);
            consumer.Received += (model, ea) =>
            {
                var body = ea.Body.ToArray();
                var message = Encoding.UTF8.GetString(body);
                Console.WriteLine(" [x] Received {0}", message);
            };

            channel.BasicConsume(queue: "Green", true, consumer);

            Console.WriteLine("Listening for messages. Press ENTER
anytime to quit...");
            Console.ReadLine();
        }
```

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Durable Queue

- Queues declared as `durable` will be recorded to disk and will **survive a broker restart**.
- The existing *green* queue can be changed to be declared as durable, after deleting the existing instance.
- Trying to **re-declare an existing queue with different properties** will produce an **exception**.

```
channel.QueueDeclare("green", true, false,
false, null);
```

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Implementing Persistence

- In order for messages to be **persisted** and survive a broker restart, their properties must include the property `delivery_mode` with the value of `2`.

- In order to send a message that will persist a broker restart:
  - It must be sent on a **durable** queue.
  - An `IBasicProperties` object with the Persistent property set to **`true`** must be `created`.
  - The `IBasicProperties` object must be passed as the `properties` argument to the publishing method.

Sending Persistent Messages

- Properties are exposed through an *IBasicProperties* object, which can be instantiated with the `Imodel.CreateBasicProperties()` method.

```
channel.ExchangeDeclare("CS1225_DirectEx",
ExchangeType.Direct);
var properties = channel.CreateBasicProperties();
properties.Persistent = true;
```

- When **creating the publisher** the **`IBasicProperties`** object must be passed to the `BasicPublish()` method.

```
channel.BasicPublish( "CS1225_DirectEx", "green",
properties, body);
```

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```
static void Main(string[] args)
{
    ConnectionFactory factory = new()
    {
        UserName = "guest",
        Password = "guest",
        HostName = "localhost"
    };

    using IConnection connection = factory.CreateConnection();
    using IModel channel = connection.CreateModel();
    var properties = channel.CreateBasicProperties();
    properties.Persistent = true;

    channel.ExchangeDeclare("CS1225_DirectEx", ExchangeType.Direct);

    channel.QueueDeclare(queue: "Green", true, false, false,null);
    channel.QueueBind("Green", "CS1225_DirectEx", "green");

    channel.QueueDeclare(queue: "Red", true, false, false, null);
    channel.QueueBind("Red", "CS1225_DirectEx", "red");

    string message = "Hello World to Green!!!";
    var body = Encoding.UTF8.GetBytes(message);

    channel.BasicPublish( "CS1225_DirectEx", "green", properties, body);

    Console.WriteLine($"DirectEx.Publisher sent {message}");
}
```


```
static void Main(string[] args)
{
    ConnectionFactory factory = new()
    {
        UserName = "guest",
        Password = "guest",
        HostName = "localhost"
    };

    using IConnection connection = factory.CreateConnection();
    using IModel channel = connection.CreateModel();

    channel.ExchangeDeclare("CS1225_DirectEx",  ExchangeType.Direct);
    channel.QueueDeclare( "Green", true, false, false, null);

    var consumer = new EventingBasicConsumer(channel);
    consumer.Received += (model, ea) =>
    {
        var body = ea.Body.ToArray();
        var message = Encoding.UTF8.GetString(body);
        Console.WriteLine(" [x] Received {0}", message);
    };

    channel.BasicConsume(queue: "Green", true, consumer);

    Console.WriteLine("Listening for messages. Press ENTER anytime to
quit...");
    Console.ReadLine();
}
```

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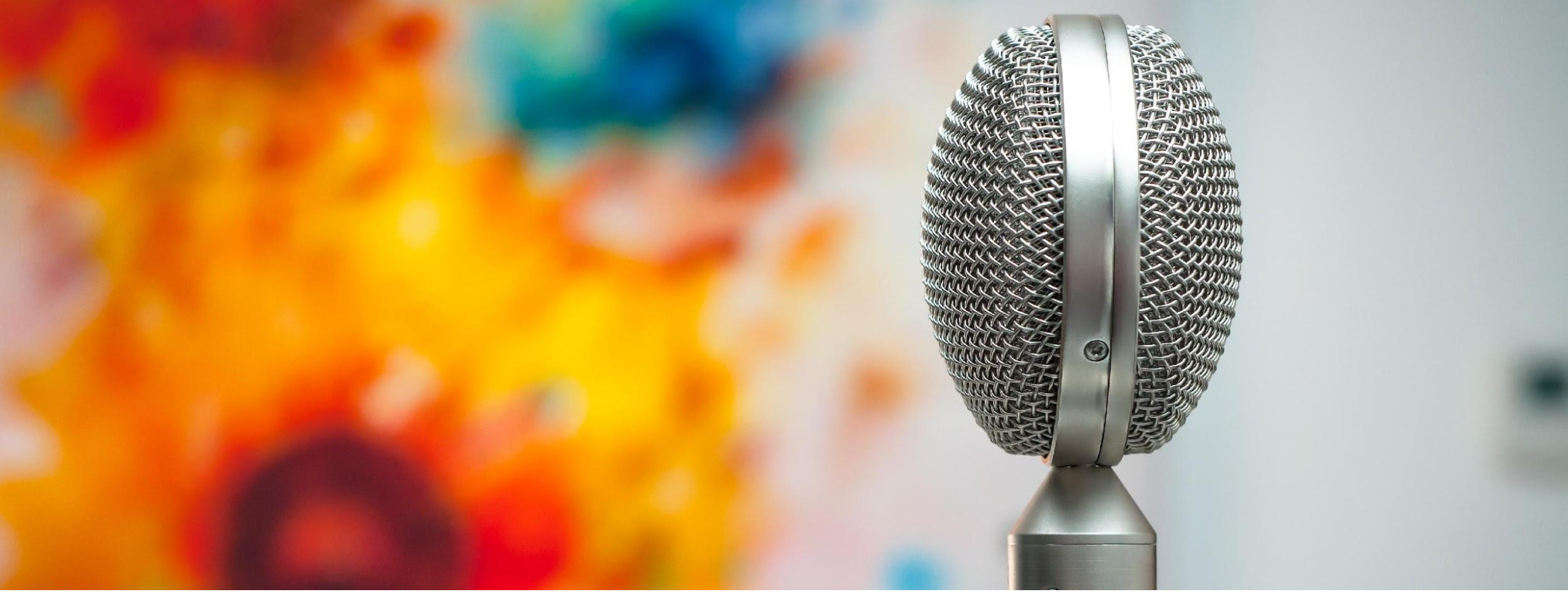

Topic Exchange

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1. Topic Exchange Introduction
2. Defining the Example Queues
3. Publishing to a Topic Exchange
4. Subscribing to a Topic Exchange

Topic Exchange

Code.Hub

Introduction

- A **Topic Exchange** also routes messages to one or more queues based on the **routing key**.
- The key format is specific. Consisting of any number of words separated by dots.
- The key can contain the special * and # symbols, to symbolize any single word or any number of words, at any part of the key.

Example Queues

- For this example, four queues will be created:
  - The *BikesSales* (`CRM.Sales.Bikes`) queue will receive only messages for **Bike sales**.
  - The *Clothing* (`CRM.Sales.Clothing`) queue will receive only messages for **clothing sales**.
  - The *AllSales* (`CRM.Sales.*`) queue will receive only messages for **all sales**.
  - The *AllCRM* (`CRM.#`) queue will receive **all** CRM related messages.

Declaring the Queues

The Publisher will declare a series of queues, as per the presented requirements:

```
channel.ExchangeDeclare("CS1225_TopicEx", ExchangeType.Topic);
channel.QueueDeclare(queue: "BikesSales", false, false, false, null);
channel.QueueBind("BikesSales", "CS1225_TopicEx", "CRM.Sales.Bikes");
channel.QueueDeclare(queue: "ClothingSales", false, false, false, null);
channel.QueueBind("ClothingSales", "CS1225_TopicEx", "CRM.Sales.Clothing");

channel.QueueDeclare(queue: "AllSales", false, false, false, null);
channel.QueueBind("AllSales", "CS1225_TopicEx", "CRM.Sales.*");
channel.QueueDeclare(queue: "AllCRM", false, false, false, null);
channel.QueueBind("AllCRM", "CS1225_TopicEx", "CRM.#");
```

Understanding the Routing

- The first and second queues (`CRM.Sales.`Bikes and `CRM.Sales.Clothing`) will only receive messages that **perfectly match their routing keys**, similarly to direct exchanges.

- The third quue will receive messages from both of the above queues (`CRM.Sales.*`). It would also receive messages from any other queue who matches the routing key format, **regardless of the value of the last word**.

- The foruth queue (`CRM.#`) will receive messages from both queues as well, as it would from **any other queue whose routing key starts with *CRM***.

Publishing a Message

- A message can be published to the exchange using an appropriate routing key. The presented message will be sent to all queues except `CRM.Sales.Clothing`.

```
string message = "A Bike Sales Has Occurred!!!";
var body = Encoding.UTF8.GetBytes(message);

channel.BasicPublish("CS1225_TopicEx",
"CRM.Sales.Bikes", null, body);

Console.WriteLine($"TopicEx.Publisher sent
messages to topic exchanges.");
```

```
static void Main(string[] args)
{
    ConnectionFactory factory = new()
    {
        UserName = "guest",
        Password = "guest",
        HostName = "localhost"
    };

    using IConnection connection = factory.CreateConnection();
    using IModel channel = connection.CreateModel();
    channel.ExchangeDeclare("CS1225_TopicEx", ExchangeType.Topic);

    channel.QueueDeclare(queue: "BikesSales", false, false, false, null);
    channel.QueueBind("BikesSales", "CS1225_TopicEx", "CRM.Sales.Bikes");
    channel.QueueDeclare(queue: "ClothingSales", false, false, false, null);
    channel.QueueBind("ClothingSales", "CS1225_TopicEx", "CRM.Sales.Clothing");

    channel.QueueDeclare(queue: "AllSales", false, false, false, null);
    channel.QueueBind("AllSales", "CS1225_TopicEx", "CRM.Sales.*");
    channel.QueueDeclare(queue: "AllCRM", false, false, false, null);
    channel.QueueBind("AllCRM", "CS1225_TopicEx", "CRM.#");


    string message = "A Bike Sales Has Occurred!!!";
    var body = Encoding.UTF8.GetBytes(message);

    channel.BasicPublish("CS1225_TopicEx", "CRM.Sales.Bikes", null, body);
    Console.WriteLine($"TopicEx.Publisher sent messages to topic exchanges.");
}
```

Receiving a Message

- A message can be received by a consumer. The same message may be received by multiple queues.

```
var consumerAll = new EventingBasicConsumer(channel);
consumerAll.Received += (model, ea) =>
{
    var body = ea.Body.ToArray();
    var message = Encoding.UTF8.GetString(body);
    Console.WriteLine($"TopixEx.Subscriber received '{message}' from AllSales Queue");
};
channel.BasicConsume("AllSales", true, consumerAll);

var consumerBikes = new EventingBasicConsumer(channel);
consumerBikes.Received += (model, ea) =>
{
    var body = ea.Body.ToArray();
    var message = Encoding.UTF8.GetString(body);
    Console.WriteLine($"TopixEx.Subscriber received '{message}' from BikesSales Queue");
};
channel.BasicConsume("BikesSales", true, consumerBikes);
```

Code.Hub

```
static void Main(string[] args)
{
    ConnectionFactory factory = new()
    {
        UserName = "guest",
        Password = "guest",
        HostName = "localhost"
    };

    using IConnection connection = factory.CreateConnection();
    using IModel channel = connection.CreateModel();
    channel.ExchangeDeclare("CS1225_TopicEx", ExchangeType.Topic);

    channel.QueueDeclare(queue: "BikesSales", false, false, false, null);
    channel.QueueBind("BikesSales", "CS1225_TopicEx", "CRM.Sales.Bikes");
    channel.QueueDeclare(queue: "ClothingSales", false, false, false, null);
    channel.QueueBind("ClothingSales", "CS1225_TopicEx", "CRM.Sales.Clothing");

    channel.QueueDeclare(queue: "AllSales", false, false, false, null);
    channel.QueueBind("AllSales", "CS1225_TopicEx", "CRM.Sales.*");
    channel.QueueDeclare(queue: "AllCRM", false, false, false, null);
    channel.QueueBind("AllCRM", "CS1225_TopicEx", "CRM.#");

    var consumerAll = new EventingBasicConsumer(channel);
    consumerAll.Received += (model, ea) =>
    {
        var body = ea.Body.ToArray();
        var message = Encoding.UTF8.GetString(body);
        Console.WriteLine($"TopixEx.Subscriber received '{message}' from          AllSales Queue");
    };
    channel.BasicConsume("AllSales", true, consumerAll);

    var consumerBikes = new EventingBasicConsumer(channel);
    consumerBikes.Received += (model, ea) =>
    {
        var body = ea.Body.ToArray();
        var message = Encoding.UTF8.GetString(body);
        Console.WriteLine($"TopixEx.Subscriber received '{message}' from          BikesSales Queue");
    };
    channel.BasicConsume("BikesSales", true, consumerBikes);

    var consumerClothing = new EventingBasicConsumer(channel);
    consumerClothing.Received += (model, ea) =>
    {
        var body = ea.Body.ToArray();
        var message = Encoding.UTF8.GetString(body);
        Console.WriteLine($"TopixEx.Subscriber received '{message}' from          ClothingSales Queue");
    };
    channel.BasicConsume("ClothingSales", true, consumerBikes);

    Console.WriteLine("Listening for messages. Press ENTER anytime to quit...");
    Console.ReadLine();
}
```

Code.Hub

Headers Exchange

Code.Hub

1. Headers Exchange Introduction
2. Binding a Queue With Headers
3. Setting Message Headers
4. Publishing a Message With Headers
5. Subscribing to a Headers Exchange

Topic Exchange

Code.Hub

Introduction

- A **Headers Exchange** is similar to topic and also routes each message to one or more queue, but instead of routing based on the routing key, it routes based on **headers**.
- Headers are specified for a **queue** when it is **bound** to the the headers exchange.
- They specify which messages the queue will receive.
- Headers are also specified when a message is sent.

Binding a Queue

- After declaring an **exchange of headers** type, queues can be bound with headers that specify which messages they will receive.
- The special **`x-match`** header can further specify which messages the queue will receive:
  - **`all`** signifies that the queue should receive messages only when the values **in all headers** match the specified.
  - **any** signifies that queue should match messages when the value in **at least one header** matches the specified.

Binding a Queue

```
ConnectionFactory factory = new()
{ UserName = "guest", Password = "guest", HostName = "localhost"};
using IConnection connection = factory.CreateConnection();
using IModel channel = connection.CreateModel();
channel.ExchangeDeclare("CS1225_HeadersEx", ExchangeType.Headers);

Dictionary<string, object> bindHeaders = new()
{
    { "x-match", "all" },
    { "shape", "square" },
    { "color", "black" }
};
channel.QueueDeclare(queue: "BlackSquares", false, false, false, null);
channel.QueueBind("BlackSquares", "CS1225_HeadersEx", "", bindHeaders);
```

Setting Message Headers

- When publishing a message the headers can be specified within the **IBasicProperpties properties** object, passed in the parmaters of the `BasicPublish()` method.
- The properties object can be initialized with the `IModel.CreateBasicProperties()` method.
- Headers can be specified from IBasicProperties' *`Headers`* field

Publishing a Message

```
string message = "A Black Square has been generated!";
var body = Encoding.UTF8.GetBytes(message);

IBasicProperties props = channel.CreateBasicProperties();
Dictionary<string, object> msgHeaders = new()
{
    { "shape", "square" },
    { "color", "black" }
};
props.Headers = msgHeaders;

channel.BasicPublish("CS1225_HeadersEx", "", props, body);
Console.WriteLine($"HeadersEx.Publisher sent message to the headers exchange.");
```

Code.Hub

```
static void Main(string[] args)
{
    ConnectionFactory factory = new()
    {
        UserName = "guest",
        Password = "guest",
        HostName = "localhost"
    };

    using IConnection connection = factory.CreateConnection();
    using IModel channel = connection.CreateModel();
    channel.ExchangeDeclare("CS1225_TopicEx", ExchangeType.Topic);

    channel.QueueDeclare(queue: "BikesSales", false, false, false, null);
    channel.QueueBind("BikesSales", "CS1225_TopicEx", "CRM.Sales.Bikes");
    channel.QueueDeclare(queue: "ClothingSales", false, false, false, null);
    channel.QueueBind("ClothingSales", "CS1225_TopicEx", "CRM.Sales.Clothing");

    channel.QueueDeclare(queue: "AllSales", false, false, false, null);
    channel.QueueBind("AllSales", "CS1225_TopicEx", "CRM.Sales.*");
    channel.QueueDeclare(queue: "AllCRM", false, false, false, null);
    channel.QueueBind("AllCRM", "CS1225_TopicEx", "CRM.#");


    string message = "A Bike Sales Has Occurred!!!";
    var body = Encoding.UTF8.GetBytes(message);

    channel.BasicPublish("CS1225_TopicEx", "CRM.Sales.Bikes", null, body);
    Console.WriteLine($"TopicEx.Publisher sent messages to topic exchanges.");
}
```

Receiving a Message

- Messages can be received by subscribing to the appropriate queue:

```
var consumer = new EventingBasicConsumer(channel);
consumer.Received += (model, ea) =>
{
    var body = ea.Body.ToArray();
    var message = Encoding.UTF8.GetString(body);
    Console.WriteLine($"HeadersEx.Subscriber received '{message}' from BlackSquares Queue");
};
channel.BasicConsume("BlackSquares", true, consumer);

Console.WriteLine("Listening for messages. Press ENTER anytime to quit...");
Console.ReadLine();
```

Code.Hub

```
static void Main(string[] args)
{
    ConnectionFactory factory = new()
    {
        UserName = "guest",
        Password = "guest",
        HostName = "localhost"
    };

    using IConnection connection = factory.CreateConnection();
    using IModel channel = connection.CreateModel();
    channel.ExchangeDeclare("CS1225_HeadersEx", ExchangeType.Headers);

    Dictionary<string, object> bindHeaders = new()
    {
        { "x-match", "all" },
        { "shape", "square" },
        { "color", "black" }
    };
    channel.QueueDeclare(queue: "BlackSquares", false, false, false, null);
    channel.QueueBind("BlackSquares", "CS1225_HeadersEx", "", bindHeaders);

    string message = "A Black Square has been generated!";
    var body = Encoding.UTF8.GetBytes(message);

    IBasicProperties props = channel.CreateBasicProperties();
    Dictionary<string, object> msgHeaders = new()
    {
        { "shape", "square" },
        { "color", "black" }
    };
    props.Headers = msgHeaders;

    channel.BasicPublish("CS1225_HeadersEx", "", props, body);
    Console.WriteLine($"HeadersEx.Publisher sent message to the headers exchange.");
}
```

Worker Service

Code.Hub

1. Worker Service Introduction
2. Background Service Class Methods
3. Creating and Registering the Service

Worker Service

Code.Hub

Introduction

- ASP.NET Core enables **implementation of background tasks** through the `IHostedService` interface and the associated `BackgroudService` base class.
- By creating an extension of *BackgroundService* it is possible to create a background task that will continuously listen for new messages from RabbitMQ while the web application runs.

BackgroundService Methods

- The **BackgroundService** class defines three fundamental methods:
  - `StartAsync()` defines the logic that will be executed when the task is first started. It can be used to initialize properties and open connections.
  - `ExecuteAsync()` defines the main logic that will be executed as the task runs.
  - `StopAsync()` defined the logic that will be used when the task stops gracefully. It can be used to dispose objects and close connections.

```
public class SubscriberService : BackgroundService
{
    private IConnection Connection { get; }
    private IModel Channel { get; }

    public SubscriberService(ILoggerFactory loggerFactory)
    {
        ConnectionFactory factory = new()
        { UserName = "guest", Password = "guest", HostName = "localhost"};

       Connection = factory.CreateConnection();
       Channel = Connection.CreateModel();
    }

    protected override Task ExecuteAsync(CancellationToken stoppingToken)
    {
        stoppingToken.ThrowIfCancellationRequested();

        var consumer = new EventingBasicConsumer(Channel);
        consumer.Received += (ch, ea) =>
        {
            var content = System.Text.Encoding.UTF8.GetString(ea.Body.ToArray());
            Console.WriteLine($"DirectEx.WorkerSubscriber received {content}"); ;
        };

        Channel.BasicConsume("Green", true, consumer);
        return Task.CompletedTask;
    }

    public override void Dispose()
    {
        Channel.Close();
        Connection.Close();
        base.Dispose();
    }
}
```

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Registering the Service

- The presented code allows handling messages while the application is running.
- After the service has been created it can be injected to the **Service Container** by using the `AddHostedService<T>()` method:

```
builder.Services.AddHostedService
    <SubscriberService>();
```

- The written console messages can be seen by running the application directly (not through IIS Express, which will hide console output).

Thank you!

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