RabbitMQ .NET Client Library User Guide


Table of Contents

1. UserGuide .........................................................................................................................4
   1.1. Introduction ..................................................................................................................4
   1.2. AMQP dialects implemented ......................................................................................4

2. ApiOverview .......................................................................................................................4
   2.1. Major namespaces, interfaces and classes .................................................................4
   2.2. Multi-protocol support ..............................................................................................5
   2.3. Connecting to a broker ..............................................................................................6
   2.4. Disconnecting from a broker ....................................................................................7
   2.5. Using exchanges and queues ...................................................................................7
   2.6. Publishing messages .................................................................................................8
   2.7. Retrieving individual messages ................................................................................9
   2.8. Retrieving messages by subscription .......................................................................9
   2.9. Threading, deadlocks, and associated restrictions on consumers .........................10
   2.10. IModel should not be shared between threads ......................................................11
   2.11. Handling unroutable or undelivered messages ......................................................11
   2.12. QPid-compatible JMS BytesMessage, StreamMessage, and MapMessage codecs ...12

3. MessagingPatterns .............................................................................................................13
   3.1. Common ways of working with AMQP .................................................................13
   3.2. Point-to-point messaging .........................................................................................13
      3.2.1. Synchronous, client-server remote procedure call (RPC) .................................14
      3.2.2. Asynchronous, one-way messaging ..............................................................16
      3.2.3. Acknowledgment modes for point-to-point ..................................................16
      3.2.4. Library support for point-to-point messaging ..............................................17
   3.3. Event broadcasting .................................................................................................19
      3.3.1. Publishing events ............................................................................................19
      3.3.2. Subscription ....................................................................................................20
      3.3.3. Retrieving events - low-level approach .........................................................20
      3.3.4. Acknowledgment modes for event broadcasting ........................................21
   3.4. Responsibility transfer ............................................................................................21
   3.5. Reliable message transfer .......................................................................................22
      3.5.1. At-least-once delivery ....................................................................................22
      3.5.2. At-most-once delivery ...................................................................................23
      3.5.3. Exactly-once delivery ...................................................................................23
   3.6. Coding with high-availability AMQP server pairs ...............................................24
   3.7. Interacting with external resources ........................................................................25
4. ShutdownProtocols ......................................................................................................................................26
   4.1. General pattern of AMQP client shutdown ..................................................................................26
   4.2. Information about the circumstances of a shutdown .................................................................26
      4.2.1. ShutdownInitiator ............................................................................................................26
      4.2.2. ShutdownEventArgs ......................................................................................................27
   4.3. The CloseReason properties, and idempotency of Close() calls ..............................................27
   4.4. Atomicity, and use of the IsOpen flags .......................................................................................27
   4.5. Specific shutdown protocols .....................................................................................................28
      4.5.1. IModel ..........................................................................................................................28
      4.5.2. IConnection ..................................................................................................................29
      4.5.3. ISession .......................................................................................................................29

5. TroubleShooting .....................................................................................................................................29
   5.1. Heartbeat issue with Mono 1.1.17.1 on Redhat FC6/x86-64 ....................................................30

6. Examples ..................................................................................................................................................30
   6.1. How to run examples ..................................................................................................................30
   6.2. Examples overview ....................................................................................................................30
      6.2.1. AddClient .....................................................................................................................31
      6.2.2. AddServer .....................................................................................................................31
      6.2.3. DeclareQueue ...............................................................................................................31
      6.2.4. ExceptionTest ...............................................................................................................31
      6.2.5. LogTail .........................................................................................................................31
      6.2.6. SendMap .......................................................................................................................31
      6.2.7. SendString ....................................................................................................................32
      6.2.8. SingleGet ......................................................................................................................32

7. BuildingTheClient ................................................................................................................................32
   7.1. Source Tree Layout ...................................................................................................................32
   7.2. Build Prerequisites ....................................................................................................................33
   7.3. Configuring Your Tree ..............................................................................................................33
   7.4. Building .....................................................................................................................................33
      7.4.1. On Windows, with Visual Studio .................................................................................33
      7.4.2. On Windows, without Visual Studio ............................................................................34
      7.4.3. On Linux, using Mono .................................................................................................34
   7.5. Building the WCF binding ........................................................................................................34
   7.6. Build Products ...........................................................................................................................34

8. ImplementationGuide ................................................................................................................................35
   8.1. Connections, Channels, Sessions and Models ..........................................................................35
   8.2. Channel zero ............................................................................................................................36
   8.3. Information dataflow from the server to the client ....................................................................36
   8.4. Information dataflow from the client to the server ....................................................................37
   8.5. Client-to-server AMQP RPC ....................................................................................................38
   8.6. Constants from the specification ..............................................................................................39
9. ApiGen

9.1. Compilation Process Overview
9.2. Invoking Apigen
9.3. Generated Classes
9.4. The Common Model
  9.4.1. The main model interface
  9.4.2. Content header interfaces
  9.4.3. Mapping methods to RPC requests
  9.4.4. Mapping method parameters to RPC request fields
  9.4.5. Mapping RPC responses to return values
  9.4.6. Mapping asynchronous events
  9.4.7. Overriding behaviour for particular specification versions
1. UserGuide

1.1. Introduction

The RabbitMQ .NET client is an implementation of an AMQP client library for C# (and, implicitly, other .NET languages), and a binding exposing AMQP services via Microsoft’s Windows Communication Foundation (WCF).

This is the User Guide for the RabbitMQ .NET client library. It provides an overview of the codebase and the implemented API.

The full details of the API are documented separately, in the NDocProc-generated javadoc-like HTML documentation.

1.2. AMQP dialects implemented

The client library implements AMQP specifications version 0-8, 0-8bis (0-8 as modified by QPid for their M2 release), 0-9 (omitting sections of the specification marked "work in progress", i.e. the Message content-class) and 0-9-1. The ApiGen tool processes the specification XML files in conjunction with certain C# interfaces, generating C# code directly, which is compiled into the final assembly.

2. ApiOverview

This section gives an overview of the RabbitMQ .NET client API.

Only the basics of using the library are covered: for full detail, please see the javadoc-like API documentation generated from the source code.

2.1. Major namespaces, interfaces and classes

The API is closely modelled on the AMQP protocol specification, with little additional abstraction.

The core API interfaces and classes are defined in the RabbitMQ.Client namespace:

```csharp
using RabbitMQ.Client;
```

The core API interfaces and classes are
• **IModel**: represents an AMQP data channel, and provides most of the AMQP operations
• **IConnection**: represents an AMQP connection
• **ConnectionFactory**: constructs **IConnection** instances

Other useful interfaces and classes include:
• **QueueingBasicConsumer**: receives messages delivered from the server
• **Protocols**: support class for choosing an AMQP protocol variant

Public namespaces other than **RabbitMQ.Client** include:
• **RabbitMQ.Client.Content**: construction and analysis of messages that are binary-compatible with messages produced and consumed by QPid’s JMS compatibility layer.
• **RabbitMQ.Client.Events**: various events and event handlers that are part of the AMQP client library.
• **RabbitMQ.Client.Exceptions**: exceptions visible to the user of the AMQP client library.

All other namespaces are reserved for private implementation detail of the library, although members of private namespaces are usually made available to applications using the library in order to permit developers to implement workarounds for faults or design mistakes they discover in the library implementation. Applications cannot rely on any classes, interfaces, member variables etc. that appear within private namespaces remaining stable across releases of the library.

### 2.2. Multi-protocol support

Class **RabbitMQ.Client.Protocols** contains convenient predefined **IProtocol** instances that permit selection of a supported protocol variant. At the time of writing, the library supports:

• **Protocols.DefaultProtocol**: An alias to one of the other protocols. At the time of writing, the default protocol is **AMQP_0_9_1**.
• **Protocols.AMQP_0_8**: Standard AMQP 0-8 protocol, including **access.request**, **basic.recover-async** and **queue.unbind**.
• **Protocols.AMQP_0_8_QPID**: AMQP 0-8 as extended by QPid’s 0-8 M1 release, without **access.request** and with extra parameters available on certain methods.
• **Protocols.AMQP_0_9**: Standard AMQP 0-9 protocol, including **access.request** and **basic.recover-async**, but excluding the **Message content-class** and other areas of the specification marked “work in progress”.
• **Protocols.AMQP_0_9_1**: Standard AMQP 0-9-1 protocol.

The **Protocols** class also contains some convenience functions for retrieving an **IProtocol** from a string, from the environment or from a .NET XML configuration file. The protocol names permitted are
the same as the static instance variables on class Protocols, that is, AMQP_0_8, AMQP_0_8_QPID, AMQP_0_9, AMQP_0_9_1 and DefaultProtocol.

The following code binds p to the Protocols.AMQP_0_9 instance by looking it up dynamically:

IProtocol p = Protocols.SafeLookup("AMQP_0_9");

Given the following App.config snippet,

```xml
<appSettings>
  <add key="my-protocol" value="AMQP_0_9"/>
</appSettings>
```

the following code will also bind p to the 0-9 IProtocol implementation:

IProtocol p = Protocols.FromConfiguration("my-protocol");

An alternative is Protocols.FromEnvironmentVariable(), which reads the name of the protocol variant to return from the shell environment variable named by Protocols.EnvironmentVariable (at the time of writing, AMQP_PROTOCOL).

Finally, Protocols.FromEnvironment() tries FromConfiguration() first, and if no setting is found, falls back to FromEnvironmentVariable().

If no argument is passed to FromEnvironment() or FromConfiguration(), the value of Protocols.DefaultAppSettingsKey is used. (At the time of writing, the default appSettings key is AMQP_PROTOCOL, the same as the name of the shell environment variable scanned.)

### 2.3. Connecting to a broker

The following two code snippets connect to an AMQP broker:

```csharp
ConnectionFactory factory = new ConnectionFactory();
factory.UserName = user;
factory.Password = pass;
factory.VirtualHost = vhost;
factory.Protocol = Protocols.FromEnvironment();
factory.HostName = hostName;
factory.Port = AmqpTcpEndpoint.UseDefaultPort;
IConnection conn = factory.CreateConnection();
```

```csharp
ConnectionFactory factory = new ConnectionFactory();
factory.Uri = "amqp://user:pass@hostName:port/vhost";
IConnection conn = factory.CreateConnection();
```
Since the .NET client uses a stricter interpretation of the AMQP URI spec than the other clients, care must be taken when using URIs. In particular, the host part must not be omitted and virtual hosts with empty names are not addressable.

All factory properties have default values. The default value for a property will be used if the property remains unassigned prior to creating a connection:

- **username**: "guest"
- **password**: "guest"
- **virtual-host**: "/"
- **protocol**: AMQP 0-9-1
- **hostname**: localhost
- **port**: 5672

The IConnection interface can then be used to open a channel:

```csharp
IModel channel = conn.CreateCommand();
```

The channel can now be used to send and receive messages, as described in subsequent sections.

### 2.4. Disconnecting from a broker

To disconnect, simply close the channel and the connection:

```csharp
channel.Close(200, "Goodbye");
conn.Close();
```

Note that closing the channel is considered good practice, but isn’t strictly necessary - it will be done automatically anyway when the underlying connection is closed.

In some situations, you may want the connection to close automatically once the last open channel on the connection closes. To achieve this, set the `IConnection.AutoClose` property to true, but only after creating the first channel:

```csharp
IConnection conn = factory.CreateConnection(...);
IModel channel = conn.CreateCommand();
conn.AutoClose = true;
```

When `AutoClose` is true, the last channel to close will also cause the connection to close. If it is set to true before any channel is created, the connection will close then and there.
2.5. Using exchanges and queues

Client applications work with exchanges and queues, the high-level building blocks of AMQP. These must be "declared" before they can be used. Declaring either type of object simply ensures that one of that name exists, creating it if necessary.

Continuing the previous example, the following code declares an exchange and a queue, then binds them together.

```csharp
code
channel.ExchangeDeclare(exchangeName, ExchangeType.Direct);
channel.QueueDeclare(queueName, false, false, false, null);
channel.QueueBind(queueName, exchangeName, routingKey, null);
```

This will actively declare the following objects:

1. a non-durable, non-autodelete exchange of "direct" type
2. a non-durable, non-exclusive, non-autodelete queue

The exchange can be customised by using additional parameters. The above code then binds the queue to the exchange with the given routing key.

Note that many Channel API methods are overloaded. The convenient short form of ExchangeDeclare uses sensible defaults. There are also longer forms with more parameters, to let you override these defaults as necessary, giving full control where needed.

This "short version, long version" pattern is used throughout the API.

2.6. Publishing messages

To publish a message to an exchange, use IModel.BasicPublish as follows:

```csharp
channel.BasicPublish(exchangeName, routingKey, null, messageBodyBytes);
```

For fine control, you can use overloaded variants to specify the mandatory flag, or send messages with basic-class header properties:

```csharp
IBasicProperties props = channel.CreateBasicProperties();
props.ContentType = "text/plain";
props.DeliveryMode = 2;
channel.BasicPublish(exchangeName, routingKey, props, messageBodyBytes);
```
This sends a message with delivery mode 2 (persistent) and content-type "text/plain". See the definition of the IBasicProperties interface for more information about the available header properties.

2.7. Retrieving individual messages

To retrieve individual messages, use IModel.BasicGet. The returned value is an instance of BasicGetResult, from which the header information (properties) and message body can be extracted:

```csharp
bool noAck = false;
BasicGetResult result = channel.BasicGet(queueName, noAck);
if (result == null) {
    // No message available at this time.
} else {
    IBasicProperties props = result.BasicProperties;
    byte[] body = result.Body;
    ...
}
```

Since noAck = false above, you must also call IModel.BasicAck to acknowledge that you have successfully received and processed the message:

```csharp
...
// acknowledge receipt of the message
channel.BasicAck(result.DeliveryTag, false);
```

2.8. Retrieving messages by subscription

Another way to receive messages is to set up a subscription using the IBasicConsumer interface. The messages will then be delivered automatically as they arrive, rather than having to be requested proactively.

The easiest and safest way to implement a consumer is to use the convenience class QueueingBasicConsumer, and retrieve deliveries from the SharedQueue instance contained therein:

```csharp
QueueingBasicConsumer consumer = new QueueingBasicConsumer(channel);
String consumerTag = channel.BasicConsume(queueName, false, consumer);
while (true) {
    try {
        RabbitMQ.Client.Events.BasicDeliverEventArgs e =
            (RabbitMQ.Client.Events.BasicDeliverEventArgs)
                consumer.Queue.Dequeue();
        IBasicProperties props = e.BasicProperties;
        byte[] body = e.Body;
        // ... process the message
        channel.BasicAck(e.DeliveryTag, false);
    }
```
Another alternative is to subclass `DefaultBasicConsumer`, overriding methods as necessary, or implement `IBasicConsumer` directly. You will generally want to implement the core method `HandleBasicDeliver`.

More sophisticated consumers will need to implement further methods. In particular, `HandleModelShutdown` traps channel/connection closure. Consumers can also implement `HandleBasicCancelOk` to be notified of cancellations.

The `ConsumerTag` property of `DefaultBasicConsumer` can be used to retrieve the server-generated consumer tag, in cases where none was supplied to the original `IModel.BasicConsume` call.

You can cancel an active consumer with `IModel.BasicCancel`:

```csharp
channel.BasicCancel(consumerTag);
```

When calling the API methods, you always refer to consumers by their consumer tags, which can be either client- or server-generated as explained in the AMQP specification document.

### 2.9. Threading, deadlocks, and associated restrictions on consumers

Each `IConnection` instance is, in the current implementation, backed by a single background thread that reads from the socket and dispatches the resulting events to the application. Additionally there are two threads responsible for `Heartbeat` support, if connection negotiation turned it on.

Usually, therefore, there will be four threads active in an application using this library:

- the application thread: contains the application logic, and makes calls on `IModel` methods to perform AMQP operations.
- the connection thread: hidden away and completely managed by the `IConnection` instance.
- the heartbeat read thread: continuously checking if `IConnection` instance has not missed too many `Heartbeat` frames from the broker
- the heartbeat write thread: continuously checking if `IConnection` instance should send `Heartbeat` frame to the broker
The one place where the nature of the threading model is visible to the application is in any callback the application registers with the library. Such callbacks include:

- any IBasicConsumer method
- the BasicReturn event on IModel
- any of the various shutdown events on IConnection, IModel etc.

Application callback handlers must not invoke blocking AMQP operations (such as IModel.QueueDeclare, IModel.BasicCancel or IModel.BasicPublish). If they do, the channel will deadlock.

Only asynchronous AMQP operations without content are safe for use within callbacks, such as IModel.BasicAck. It is not safe to use IModel.BasicPublish in callbacks, because channel flow could block publication.

For this reason, QueueingBasicConsumer is the safest way of subscribing to a queue, because its implementation uses RabbitMQ.Util.SharedQueue to pass deliveries over to the application thread, where all processing of received deliveries is done, and where any AMQP IModel operation is safe.

### 2.10. IModel should not be shared between threads

In general, IModel instances should not be used by more than one thread simultaneously: application code should maintain a clear notion of thread ownership for IModel instances.

If more than one thread needs to access a particular IModel instances, the application should enforce mutual exclusion itself. One way of achieving this is for all users of an IModel to lock the instance itself:

```csharp
IModel ch = RetrieveSomeSharedIModelInstance();
lock (ch) {
    ch.BasicPublish(...);
}
```

Symptoms of incorrect serialisation of IModel operations include, but are not limited to,

- invalid frame sequences being sent on the wire (which occurs, for example, if more than one BasicPublish operation is run simultaneously), and/or
- NotSupportedExceptions being thrown from a method in class RpcContinuationQueue complaining about "Pipelining of requests forbidden" (which occurs in situations where more than one AMQP RPC, such as ExchangeDeclare, is run simultaneously).
2.11. Handling unroutable or undelivered messages

If a message is published with the "mandatory" or "immediate" flags set, but cannot be delivered, the broker will return it to the sending client (via a basic.return AMQP command).

To be notified of such returns, clients can subscribe to the IModel.BasicReturn event. If there are no listeners attached to the event, then returned messages will be silently dropped.

```csharp
channel.BasicReturn +=
    new RabbitMQ.Client.Events.BasicReturnEventHandler(...);
```

The BasicReturn event will fire, for example, if the client publishes a message with the "mandatory" flag set to an exchange of "direct" type which is not bound to a queue.

2.12. QPid-compatible JMS BytesMessage, StreamMessage, and MapMessage codecs

The RabbitMQ.Client.Content namespace contains classes and interfaces that implement QPid-compatible JMS BytesMessage, StreamMessage and MapMessage encoders and decoders.

For example, to construct (and send) a MapMessage:

```csharp
IModel channel = ...;

IMapMessageBuilder b = new MapMessageBuilder(channel);
b.Headers["header1"] = "some@random.string";
b.Body["field1"] = 123.45;
b.Body["field2"] = new byte[] { 1, 2, 3 };

channel.BasicPublish(exchange, routingKey,
    (IBasicProperties) b.GetContentHeader(),
    b.GetContentBody());
```

A StreamMessage is similar (and BytesMessages are so similar to StreamMessages that I shan’t demonstrate them here):

```csharp
IStreamMessageBuilder b = new StreamMessageBuilder(channel);
b.Headers["header1"] = "some@random.string";
b.WriteDouble(123.45);
b.WriteByte(new byte[] { 1, 2, 3 });
```

Given a received message in the form of an IBasicProperties header and a byte[] body, reading the message as a MapMessage is done with IMapMessageReader:

```csharp
IBasicProperties props = ...;
```
byte[] receivedBody = ...;
IMapMessageReader r = new MapMessageReader(props, receivedBody);
Console.Out.WriteLine("Header1: {0}", r.Headers["header1"]);
Console.Out.WriteLine("Field1: {0}", r.Body["field1"]);
Console.Out.WriteLine("Field2: {0}", r.Body["field2"]);

StreamMessages (and BytesMessages) are similar:

IStreamMessageReader r = new StreamMessageReader(props, receivedBody);
Console.Out.WriteLine("Header1: {0}", r.Headers["header1"]);
Console.Out.WriteLine("First value: {0}", r.ReadDouble());
Console.Out.WriteLine("Second value: {0}", r.ReadByte());

3. MessagingPatterns

3.1. Common ways of working with AMQP

When building distributed systems with AMQP, there are a number of different messaging patterns that
crop up over and over again. In this section, we cover some of the most common coding patterns and
interaction styles:

• Point-to-point messaging: both remote procedure call (RPC), and asynchronous messages directed
toward a particular receiver
• Event broadcasting: one-to-many interactions; transmission of messages directed implicitly to a set of
interested receivers, with collection of zero or more possible responses
• Responsibility transfer: choosing which piece of the network is responsible for any given message
• Reliable message transfer: at-least-once, at-most-once and exactly-once message delivery guarantees
• Coding with high-availability AMQP server pairs
• Preserving atomicity and idempotence when interacting with external resources

Limited library support is also available for working with these patterns, in the
RabbitMQ.Client.MessagePatterns namespace:

• Subscription provides a high-level interface to receiving messages from the server
• SimpleRpcServer builds on Subscription to implement an RPC or one-way service
• SimpleRpcClient builds on Subscription to interact with remote services

Future releases of the RabbitMQ .NET client library will include improved high-level support for the
most common messaging patterns and their variations.
3.2. Point-to-point messaging

The point-to-point messaging pattern occurs when the publisher of a message has a particular receiving application in mind - for instance, when a RPC-style service is made available via the AMQP server, or when an application in a workflow chain receives a work item from its predecessor and sends the transformed work item to its successor.

3.2.1. Synchronous, client-server remote procedure call (RPC)

In order to perform request/response RPC,

- some means of addressing the service must be available
- some means of receiving a reply must be available
- some means of correlating the request message to the reply message must be available

3.2.1.1. Addressing the service

Since AMQP messages are published using a pair of an exchange name and a routing key, this is sufficient for addressing a service. Using a simple exchange-name/routing-key combination permits a number of different ways to implement the service while presenting the same interface to clients. For instance, the service could be implemented as a single process consuming from a queue, and load-balancing internally, or it could be multiple processes consuming from a single queue, being handed requests round-robin style, thereby load balancing without special coding in the service logic.

Messages can be addressed to the service request queue either

- directly, using the AMQP default exchange (""'); or
- indirectly, by using a service-specific exchange, which leaves the routing-key free for such purposes as method selection or additional service-specific addressing information; or
- indirectly, by using an exchange shared by multiple services, with the service name encoded in the routing key.

Using an exchange other than the default exchange permits other applications to receive copies of each request message, which can be useful for monitoring, auditing, logging and debugging.

3.2.1.2. Ensuring a service instance is listening

AMQP's Basic-class publish operation (IModel.BasicPublish) provides two delivery flags, "mandatory" and "immediate", which can be used to ensure various kinds of service availability at the time a request is sent by a client.
Setting the "mandatory" flag causes a request to be returned if it cannot be routed to a queue, and setting the "immediate" flag causes a request to be returned if there is no service instance ready to receive (and, implicitly, process) the message at the time of publication. Returned messages appear as basic.return AMQP commands, which are made visible to the application via the IModel.BasicReturn event on the IModel that was used to publish the message.

Since published messages are returned to clients via AMQP’s basic.return method, and basic.return is an asynchronous negative-acknowledgement event, the absence of a basic.return for a particular message cannot be taken as a confirmation of delivery: the use of delivery flags only provides a way of raising the bar, rather than eliminating failure entirely.

When using delivery flags it is important to be aware that different AMQP servers implement the flags in different ways. For example, the RabbitMQ server does not support the "immediate" flag. Furthermore, depending on the degree of internal asynchrony and distribution that those servers exhibit. In particular, the interpretation of "mandatory" and "immediate" in situations where Tx-class transactions are active is underspecified in both versions 0-8 and 0-9 of the AMQP specification, and different server implementations behave in different ways.

Additionally, the fact that a message was flagged "mandatory", and successfully enqueued on one or more queues, is no guarantee of its eventual receipt: most trivially, the queue could be deleted before the message is processed, but other situations, like the use of the noAck flag by a message consumer, can also make the guarantees provided by "mandatory" and "immediate" conditional.

Alternatively, one could use Publisher Confirms. Setting a channel into confirm mode by calling IModel.ConfirmSelect causes the broker to send a Basic.Ack after each message is processed by delivering to a ready consumer or by persisting to disk.

Once a successfully processed message has been confirmed via the IModel.BasicAcks event handler, the broker has assumed responsibility for the message and the client may consider the message handled.

Note that the broker may also negatively acknowledge a message by sending back a Basic.Nack. In this case, if a message is rejected via the IModel.BasicNacks event handler, the client should assume that the message was lost or otherwise undeliverable. Also, note that unroutable messages - mandatory or immediate messages published to non-existing queues or queues without consumers - are both Basic.Return’ed and Basic.Ack’ed.

3.2.1.3. Receiving replies

AMQP’s Basic-class content header (IBasicProperties) contains a field called ReplyTo, which in AMQP 0-8 and 0-9 is an unstructured string that can be used to tell the service where to post a reply to a received RPC request. Across current AMQP client libraries, there are two widely-used formats for the string in the ReplyTo header:

- a simple queue name; or
• a URI-like string (take care - it is not a URI, it merely shares certain superficial characteristics with URIs) of the form

```
exchangeType://exchangeName/routingKey
```

where `exchangeType` is one of `fanout`, `direct` or `topic`, and both `exchangeName` and `routingKey` may be empty strings.

The service instance will post its reply to the named destination, and the requesting client should arrange to receive messages so addressed, using either `BasicGet` or `BasicConsume` on an appropriately-bound queue.

### 3.2.1.4. Correlating a received reply to a transmitted request

AMQP’s Basic-class content header (`IBasicProperties`) contains a field called `CorrelationId`, which in AMQP 0-8 and 0-9 is an unstructured string that can be used to match a request to a reply. A reply message should have the same `CorrelationId` as the one that was attached to the request message.

### 3.2.2. Asynchronous, one-way messaging

In some situations, a simple request-reply interaction pattern is inappropriate for your application. In these cases, the interaction pattern of interest can be constructed from asynchronous, one-way, point-to-point messages.

If an application is to respond to both synchronous, RPC-style requests, and asynchronous one-way requests, it should use the value of `ReplyTo` to decide which interaction style is being requested of it: if `ReplyTo` is present and non-empty, the request can be assumed to be an RPC-style call; otherwise, it should be assumed to be a one-way message.

The `CorrelationId` field can be used to group together a number of related messages, just as for the RPC-style case, but more generally tying together an arbitrary number of messages.

### 3.2.3. Acknowledgment modes for point-to-point

AMQP can operate in one of two modes, when receiving messages from the server:

- auto-acknowledgement mode (when the `noAck` flag has been set on `BasicGet`, `BasicConsume`, or the `Subscription` constructor), or
- manual-acknowledgement mode. Choosing the right acknowledgement mode is important for your application:
• auto-acknowledgement mode means that the server will internally mark a message as successfully
delivered as it transmits it across the network. Messages delivered in auto-acknowledgement mode
will not generally be re-delivered to any other receiver.

• manual-acknowledgement mode means that the server will wait for positive confirmation of receipt
before marking a message as successfully delivered. Messages delivered in manual-acknowledgement
mode may be re-delivered arbitrarily often3 until a receiver takes responsibility for a message by
sending an acknowledgement for it.

In general,

• if a service is in manual-acknowledgement mode, it should not acknowledge the request message until
it has replied to it; see the section below on interaction with external resources.

• a client may use auto-acknowledgement mode, depending on the consequences of a retransmission of
the request message.

3.2.4. Library support for point-to-point messaging

The RabbitMQ .NET client library includes basic support for common tasks involving point-to-point
messaging.

3.2.4.1. SimpleRpcServer

The class RabbitMQ.Client.MessagePatterns.SimpleRpcServer implements synchronous
RPC-style request handling as well as asynchronous message handling. Users should subclass
SimpleRpcServer, overriding one or more of the methods with names beginning with "Handle".

SimpleRpcServer instances have a request-dispatching loop, MainLoop, which interprets a request as
an RPC-style request needing a reply if the ReplyTo field of the request’s IBasicProperties is
non-null and non-empty. Requests with absent or empty ReplyTo fields are treated as one-way.

When an RPC-style request has been processed, the reply is sent to the ReplyTo address. The reply
address is first matched against a regular-expression describing the URI-like syntax given above; if it
matches, the components of the URI-like syntax are used as the reply address, and if it does not, the
whole string is used as a simple queue name, and the reply is sent to the default exchange ("") with a
routing-key equal to the ReplyTo string.

After a reply message, including possible IBasicProperties headers, is produced by the service
logic, the reply’s CorrelationId is set to be equal to the CorrelationId of the request, if any, before
transmission.

For very basic or unusual asynchronous point-to-point messaging tasks, a Subscription may be used
instead of SimpleRpcServer - please see the section below on Subscriptions.
The basic pattern for implementing a service using SimpleRpcServer is as follows (assuming a class MySimpleRpcServerSubclass extending SimpleRpcServer):

```csharp
using (IConnection conn = new ConnectionFactory()
    .CreateConnection(serverAddress)) {
    using (IModel ch = conn.CreateModel()) {
        Subscription subscription =
            new Subscription(ch, /* ... */);
        // in the line above, the "..." indicates the parameters
        // used to specify the address to use to route messages
        // to the subscription. This subscription will be used
        // to read service request messages, so the "..." effectively
        // specifies the service address.

        new MySimpleRpcServerSubclass(subscription).MainLoop();
    }
}
```

The service logic would be implemented in an override of one of the HandleCall or HandleCast overloads on MySimpleRpcServerSubclass. For full details, please see the code documentation for SimpleRpcServer.

### 3.2.4.2. SimpleRpcClient

The class RabbitMQ.Client.MessagePatterns.SimpleRpcClient implements code for interacting with SimpleRpcServers or similar.

RPC-style interactions are performed with the Call methods. A (private) Subscription is set up to receive replies from the service, and the ReplyTo field is set to point to the subscription. The CorrelationId field of the request is initialised to a fresh GUID. Asynchronous/one-way interactions are simply passed on to IModel.BasicPublish without modification: it is up to the caller to set CorrelationId in the asynchronous case.

The class currently has no support for setting the "mandatory" or "immediate" flags on a published request message, nor for handling any BasicReturn events that might arise from setting either flag.

The code that retrieves replies from the internal Subscription currently cannot deal with multiple simultaneously outstanding RPC requests, because it requires that replies arrive in the same order as the requests were sent out. Do not attempt to pipeline requests sent through a single instance of SimpleRpcClient until this restriction has been lifted. See also the overridable protected method SimpleRpcClient.RetrieveReply.

The basic pattern for using SimpleRpcClient is as follows:

```csharp
using (IConnection conn = new ConnectionFactory())
```
using (IModel ch = conn.CreateModel()) {
  SimpleRpcClient client = new SimpleRpcClient(ch, /* ... */);
  // in the line above, the "..." indicates the parameters
  // used to specify the address to use to route messages
  // to the service.

  // The next three lines are optional:
  client.TimeoutMilliseconds = 5000; // defaults to infinity
  client.TimedOut += new EventHandler(TimedOutHandler);
  client.Disconnected += new EventHandler(DisconnectedHandler);

  byte[] replyMessageBytes = client.Call(requestMessageBytes);
  // other useful overloads of Call() and Cast() are
  // available. See the code documentation of SimpleRpcClient
  // for full details.
}

Note that a single SimpleRpcClient instance can perform many (sequential) Call() and Cast() requests! It is recommended that a single SimpleRpcClient be reused for multiple service requests, so long as the requests are strictly sequential.

### 3.3. Event broadcasting

The event broadcasting pattern occurs when an application wishes to indicate a state change or other notification to a pool of applications without knowing precisely the addresses of each interested party. Applications interested in a certain subset of events use AMQP’s exchanges and queue-bindings to configure which events are routed to their own private queues.

Generally, events will be broadcast through topic exchanges, although direct exchanges, while less flexible, can sometimes perform better for applications where their limited pattern-matching capability is sufficient.

#### 3.3.1. Publishing events

To publish an event,

1. ensure the exchange exists
2. determine an appropriate routing key (for stocks, a key such as STOCK.IBM.NYSE might be appropriate; for other applications, other topic hierarchies will naturally arise. See the definition of the topic and direct exchange types in the AMQP specification)
3. publish the message
For example:

```csharp
using (IConnection conn = new ConnectionFactory()
    .CreateConnection(args[0])) {
    using (IModel ch = conn.CreateModel()) {

        IBasicProperties props = ch.CreateBasicProperties();
        FillInHeaders(props); // or similar
        byte[] body = ComputeBody(props); // or similar

        ch.BasicPublish("exchangeName",
            "chosen.routing.key",
            props,
            body);
    }
}
```

See the documentation for the various overloads of `BasicPublish` on class `RabbitMQ.Client.IModel`.

### 3.3.2. Subscription

The class `RabbitMQ.Client.MessagePatterns.Subscription` implements most of the boilerplate of receiving messages (including, in particular, broadcast events) for you, including consumer declaration and management, but excluding queue and exchange declaration and queue binding. For example,

```csharp
// "IModel ch" in scope.
Subscription sub = new Subscription(ch, "STOCK.IBM.#");
foreach (BasicDeliverEventArgs e in sub) {
    // handle the message contained in e ...
    // ... and finally acknowledge it
    sub.Ack(e);
}
```

will start a consumer on the queue using `IModel.BasicConsume`. It is assumed that the queue and any bindings have been previously declared.

`Subscription.Ack()` should be called for each received event, whether or not auto-acknowledgement mode is used, because `Subscription` internally knows whether an actual network message for acknowledgement is required, and will take care of it for you in an efficient way so long as `Ack()` is always called in your code.

For full details, please see the code documentation for the `Subscription` class.
3.3.3. Retrieving events - low-level approach

Usually, the high-level approach using Subscription is sufficient. Occasionally, however, there is a need to use the low-level AMQP primitives. The low-level approach to retrieving events is to bind a queue to the exchange concerned with an appropriate routing-key pattern specification. For instance, assuming that our application wanted to retrieve all prices regarding IBM on queue "MyApplicationQueue":

```csharp
// "IModel ch" in scope.
ch.ExchangeDeclare("prices", "topic");
ch.QueueDeclare("MyApplicationQueue", false, true, true, null);
ch.QueueBind("MyApplicationQueue", "prices",
             "STOCK.IBM.#", false, null);
```

... followed by consumption of messages from "MyApplicationQueue" using BasicGet or BasicConsume. A more full example is given in the ApiOverview chapter.

3.3.4. Acknowledgment modes for event broadcasting

The same auto-acknowledgement/manual-acknowledgement decision as for point-to-point messaging is available for consumers of broadcast events, but the pattern of interaction introduces different tradeoffs:

- for high-volume messaging where it is occasionally acceptable to not receive one of the messages one is interested in, auto-acknowledgement mode makes sense
- for scenarios where every message matching our subscription needs to be delivered, manual-acknowledgement is appropriate

For more information, see the section on reliable message transfer below.

Note also that class Subscription takes care of acknowledgement and the various acknowledgement modes for you, so long as Subscription.Ack() is called for each received message.

3.4. Responsibility transfer

In cases where either

- a non durable exchange and/or queue is used, or
- a message is published with its IBasicProperties.DeliveryMode set to any value other than 2

the message is considered transient, and will not (usually) be written to disk as part of the interaction between the AMQP server and the various AMQP clients publishing and consuming messages.
When a message is transient, it means that the responsibility for ultimate processing of the message resides with the endpoints - the two AMQP clients involved: the publisher, and the consumer.

Responsibility can be partially transferred to the broker by using durable queues, durable exchanges, persistent-mode delivered messages (with DeliveryMode set equal to 2), and Publisher Confirms:

- ensure (ahead of time) that the target queue is durable,
- select Confirm mode using IModel.ConfirmSelect,
- publish the message with "mandatory" flag set and DeliveryMode set equal to 2,
- listen for acknowledgements and negative acknowledgments by setting the IModel.BasicAcks and BasicNacks event handlers.

Once a broker acknowledges a message via the BasicAcks handler, it has taken responsibility for keeping the message on disk and on the target queue until some other application retrieves and acknowledges the message.

If a broker rejects a message via the BasicNacks handler, the publisher may assume that the message was lost or otherwise undeliverable.

Note that for unroutable messages are not considered failures and are both Basic.Return’ed and Basic.Ack’ed. So, if the "mandatory" or "immediate" are used, the client must also listen for returns by setting the IModel.BasicReturn handler.

Responsibility can also be placed with an external database, even further along the chain - see the section on interaction with external resources below.

### 3.5. Reliable message transfer

Messages can be transported between endpoints with different quality-of-service (QoS) levels. In general, failure cannot be completely ruled out, but it is important to understand the various delivery failure modes to understand the kinds of recovery from failure that are required, and the kinds of situation for which recovery is possible.

To reiterate: it is not possible to completely rule out failure. The best that can be done is to narrow the conditions in which failure can occur, and to notify a system operator when failure is detected.

#### 3.5.1. At-least-once delivery

This QoS level assures that a message is delivered to its ultimate destination at least once. That is, a receiver may receive multiple copies of the message. If it is important that a side-effect only occur once for a given message, either at-most-once or exactly-once QoS levels should be used instead.
To implement at-least-once delivery:

- publish the message as usual, with some correlation identifier and reply-to address on it so that the receiver can acknowledge receipt to the sender
- when receiving a message, send an acknowledgement message back to the sender. If the message is an RPC request, then the RPC reply message is implicitly an acknowledgement of receipt of the request.

To reduce the need for resends of a message when publishing using an at-least-once QoS level, it can sometimes be appropriate to use Confirm-class, as described above in the section on responsibility transfer. Of course, if a confirmation from the broker is lost, then a resend will have to be done, since the sending client doesn’t know whether the server actually saw the message or not unless the Basic.Nack arrives.

Alternatively, rather than implement the round-trip logic manually, a client may use Publisher Confirms. By enabling Confirm mode on a channel, a client is requesting that the broker acknowledge or negatively acknowledge all messages sent on the channel from that point on. See the instructions from Responsibility Transfer on how to use confirms.

Deciding on a message-resend policy can be difficult. Some simple resend strategies are:

- resend if your connection is lost or some other crash occurs before you receive confirmation of receipt
- timeout and resend if you do not receive a confirmation within a few seconds. Make sure to double the timeout for each resend, to help avoid retry-related denial-of-service and network congestion.

### 3.5.2. At-most-once delivery

For at-most-once delivery, simply

- publish the message, once, as usual. No correlation identifier is required.
- receive the message in the consuming application, paying attention to the Redelivered flag on the delivery. The Redelivered flag will only be clear when the server believes that it is offering a message for consumption for the very first time. If any attempt at delivery has been made before, the Redelivered flag will be set.

The Redelivered flag is a very limited piece of information, giving only at-most-once QoS. In particular, it cannot be used for exactly-once QoS.

### 3.5.3. Exactly-once delivery

Exactly-once QoS is an extension of at-least-once QoS, with the addition of a barrier on the receiving side to ensure that a given message is never processed more than once, even if it is received more than once:
• publish the message as usual, with some correlation identifier and reply-to address on it so that the receiver can acknowledge receipt to the sender
• when receiving a message, keep a record of the messages that have been processed, and only process a received message if it has not been seen before.
• always send an acknowledgement message back to the sender, even if the message has been seen before.
• if the message is an RPC request, then the RPC reply message is implicitly an acknowledgement of receipt of the request. The RPC reply message must not change, even if it is sent a second time: it is important that even if one or more copies of the request or the reply message is lost or duplicated that the original requestor receives consistent information back from the requestee.

An interesting challenge in implementing the record of processed messages is deciding when it is acceptable to remove entries from the table (equivalent to being confident that no duplicates of those messages will appear in future). One option is to use the message expiry header in the IBasicProperties structure, but be warned: versions of AMQP up to and including 0-9 do not specify the syntax or semantics of this field! Another option is to have a three-way exchange between the sender and recipient in which the sender promises not to send any further duplicates on the third leg of the interaction.

Still another option (perhaps the most elegant and space-efficient) is to use message identifiers that are strictly increasing as time goes by, so that a single "high water mark" can serve as a record of not only that message, but of all other messages preceding it, without taking up any additional space. Care must be taken when using this last option to account for request messages that arrive out-of-order or that go missing.

### 3.6. Coding with high-availability AMQP server pairs

In situations where continuous AMQP service is desired, the possibility of a server failure can be hedged against with some careful programming and the availability of a warm-standby AMQP server for failover.

The current version of the RabbitMQ .NET client library does not include any special support for failing over to a standby broker.

The main concerns when failing over are

• atomicity of published/acknowledged work units, and
• availability of configured resources on the backup server

Message producers should take care to use transactions in order to receive positive confirmation of receipt of a group of messages from a server, and should keep a record of the exchanges, queues and
bindings they need to have available in order to perform their work, so that on failover, the appropriate resources can be declared before replaying the most recent transactions to recover.

Message consumers should be aware of the possibility of missing or duplicate messages when failing over: a publisher may decide to resend a transaction whose outcome is in doubt, or a transaction the publisher considered complete could disappear entirely due to failure of the primary AMQP server.

### 3.7. Interacting with external resources

A common pattern for an AMQP-connected service is to

1. receive a service request via an AMQP queue
2. update some external resource, such as a file or database
3. reply via AMQP, or at a minimum, acknowledge to the AMQP server that the message triggering the action has been completed

Often elements of the at-least-once or exactly-once patterns appear in conjunction with the external-resource pattern - specifically, the side-effects discussed in the section on reliable message transfer above are often effects on an external resource.

In cases where the exactly-once pattern appears in conjunction with an external resource, it’s important to write code that is able at each step to determine whether the step has already been taken in some previous attempt at completing the whole transaction, and if it has, to be able to omit it in this attempt and proceed to the next step. For example:

- If a work-triggering request went missing, another copy will (eventually) arrive from the ultimate requestor.
- If the work was already performed, for instance a database table was updated, in a previous receipt of the work item in question, the service needs to keep a record of completion of the external work that is atomic with respect to the atomic work itself: for instance, within the same database transaction, some log of honoured requests could be updated, or the row being modified could be updated to include the ID of the request that caused the modification, as well as previous request-IDs that modified the row in question.

This makes it important to be able to compress request IDs so that they do not take unbounded space in the log of performed work, and so that we do not need to introduce a full distributed garbage-collection protocol with the ultimate requestor. One way of doing this is to choose to use request IDs that are strictly increasing, so that a “high water mark” can be used; see also the section on exactly-once delivery above.

- Once the work is known to have been performed, and a reply has been produced (if there is one), the reply can be sent back to the requestor as many times as necessary. The requestor knows which replies it is expecting, and can discard unwanted duplicates. So long as duplicates of the same request always...
receive identical reply messages, the replier need not be careful about sending too many copies of the reply.

- Once the reply has been sent to the AMQP server, the request message can be acknowledged as received and processed with the AMQP server. In cases where there is no reply to a request, the acknowledgement is still useful to ensure that requests are not lost.

### 4. ShutdownProtocols

#### 4.1. General pattern of AMQP client shutdown

AMQP connection, model, channel and session objects share the same general approach to managing network failure, internal failure, and explicit local shutdown.

Each object has a lifecycle state, which can be one of

- **open**: the object is ready for use
- **closing**: the object has been explicitly shut down locally, has issued a shutdown request to any supporting lower-layer objects, and is waiting for the lower layer’s shutdown-complete notification
- **closed**: the object has received a shutdown-complete notification from a lower layer, and has shut itself down in response.

Objects always end up in the closed state, without regard for whether the closure was triggered by a local application request, by an internal client library failure, or by a remote network request or network failure.

In general, objects possess the following shutdown-related members:

- a **shutdown event handler** `MulticastDelegate`, which will be fired when the object transitions to closed state
- a **close reason** property, to allow callers to inspect information about the circumstances that led to the object’s shutdown
- a convenience property, useful for debugging, for testing whether the object is in an open state
- a **close** method that triggers the shutdown machinery for the object

#### 4.2. Information about the circumstances of a shutdown

One class, `ShutdownEventArgs`, and one enumeration, `ShutdownInitiator`, are provided for applications to query objects about the circumstances of their shutdown.
4.2.1. ShutdownInitiator

ShutdownInitiator contains values representing the originator of a shutdown event. The three values are

- **Application**, for shutdown events that originated due to local application action (i.e. an explicit call to a Close() method)
- **Library**, for shutdowns caused by events originating within the RabbitMQ .NET client library itself, such as internal errors
- **Peer**, for shutdowns triggered by the peer, either through network failure or through explicit peer request (i.e. a received channel.close or connection.close method).

4.2.2. ShutdownEventArgs

The ShutdownEventArgs class is used to carry the full circumstances of a shutdown, including a ShutdownInitiator value and any relevant reply code and/or text, AMQP class and/or method ID, and possible "cause" object (usually an Exception).

A ShutdownEventArgs instance is carried as the argument to various shutdown event handler delegates used in the system, and one is also carried by AlreadyClosedException and OperationInterruptedException.

4.3. The CloseReason properties, and idempotency of Close() calls

Closable AMQP objects generally have a CloseReason property, of type ShutdownEventArgs, which can be used to determine the situation in which the object was shut down. A null value for the property indicates that no close reason is available, because the object is not yet shut down. Once the close reason is set for an object, it will not change.

A Close() method on an object, with the exception of IConnection, can be called several times without penalty. Since a close reason can only be set once per object, calls after the first are effectively ignored.

Calls to Close() will not return to the caller until the full shutdown procedure is completed for the object concerned.
4.4. Atomicity, and use of the IsOpen flags

Use of the various IsOpen properties is not recommended for production code, since the property may change value between the time that you look at it and the time you use the object. For example, the following code contains a race condition:

```csharp
public void BrokenMethod(IModel model) {
    // RACE CONDITION
    if (model.IsOpen) {
        // The following method call depends on the model being in open state.
        // The state may change between the IsOpen call and the BasicQos call!
        model.BasicQos(0, 1, false);
    }
}
```

The pattern that should be used is to ignore the IsOpen property, and instead simply attempt the action desired. An OperationInterruptedException will be thrown in cases where the object is in an invalid state:

```csharp
public void BetterMethod(IModel model) {
    try {
        ...
        model.BasicQos(0, 1, false);
    } catch (OperationInterruptedException ope) {
        // Handle one of the many possible reasons why the BasicQos or any
        // other operation before it couldn’t be handled
    } catch (IOException ioe) {
        // Check why socket was closed
    }
}
```

In the above pattern we also catch IOExceptions caused by a SocketException. Such exceptions may be raised when the broker closes the connection unexpectedly.

4.5. Specific shutdown protocols

4.5.1. IModel

In the current version of the RabbitMQ .NET client library, supporting AMQP specification versions 0-8 and 0-9, IModel encapsulates both a session and a channel layered on top of a connection. Shutting down an IModel instance causes the underlying session and channel to be closed, but does not close the underlying IConnection.

```csharp
delegate ModelShutdownEventHandler(IModel model, ShutdownEventArgs reason);
event ModelShutdownEventHandler ModelShutdown;
ShutdownEventArgs CloseReason { get; }
bool IsOpen { get; }
```
void Close(ushort replyCode, string replyText);

Any time an AMQP operation is invoked on an IModel that is not in the opened state, an AlreadyClosedException is thrown.

### 4.5.2. IConnection

IConnection encapsulates an AMQP connection. When the connection shuts down, either through explicit user action or through network failure or similar, all associated channels, sessions, and models are shut down. Connection can be gracefully closed using Close() or forced to close using Abort() methods. Close(int timeout) and Abort(int timeout) methods allow for specifying timeout for underlying connection close operations to finish. If such timeout is reached we force the socket to close and exit. Default value is Timeout.Infinite. A call on Close() method on IConnection object which was previously closed, will throw AlreadyClosedException and new close reason will be ignored. Abort() can be called several times, since any attempt to abort closed connection will be ignored. ShutdownReport property returns any errors that occurred during connection close operations as a list of ShutdownReportEntry objects.

delegate ConnectionShutdownEventHandler(IConnection connection, ShutdownEventArgs reason);

event ConnectionShutdownEventHandler ConnectionShutdown;

ShutdownEventArgs CloseReason { get; }
bool IsOpen { get; }
void Close();
void Close(int timeout);
void Abort();
void Abort(int timeout);
IList ShutdownReport { get; }

### 4.5.3. ISession

Sessions are currently an internal, implementation-only concept, and should not be used by applications, as they are not part of the public API.

delegate SessionShutdownEventHandler(ISession session, ShutdownEventArgs reason);

event SessionShutdownEventHandler SessionShutdown;

ShutdownEventArgs CloseReason { get; }
bool IsOpen { get; }
void Close(ShutdownEventArgs reason);
5. TroubleShooting

5.1. Heartbeat issue with Mono 1.1.17.1 on Redhat FC6/x86-64

Fix: Upgrade Mono to 1.2.x.

Symptom: Exception while connecting. Appears immediately, not after the expected 3 or 6 seconds.

Example symptom trace:

Unexpected connection Connection(d49c7727-3d56-4101-909e-5a7ff17b5647, amqp-0-9://127.0.0.1:5672) closure: AMQP close-reason, initiated by Library, code=0, text="End of stream", classId=0, methodId=0, cause=System.IO.EndOfStreamException: Heartbeat missing with heartbeat == 3 seconds
at RabbitMQ.Client.Impl.ConnectionBase.HandleSocketTimeout () [0x00000]
at RabbitMQ.Client.Impl.ConnectionBase.MainLoopIteration () [0x00000]
at RabbitMQ.Client.Impl.ConnectionBase.MainLoop () [0x00000]

Problematic Mono version:

$ mono --version
Mono JIT compiler version 1.1.17.1, (C) 2002-2006 Novell, Inc and Contributors.
    www.mono-project.com
    TLS: __thread
    GC: Included Boehm (with typed GC)
    SIGSEGV: normal
    Disabled: none

6. Examples

This section gives an overview of the simple examples provided with .Net client distribution.

6.1. How to run examples

From the command line go to the directory where RabbitMQ .Net/C# client is installed, and then to the bin directory. All of the examples require additional arguments to run. Typing the name of the example, e.g. SendString.exe will print the list of required and optional arguments to the program.
6.2. Examples overview

6.2.1. AddClient

Example that illustrates the usage of remote procedure calls. The client sends a list of numbers (given in the program’s arguments) using the ’AddServer’ routing key. The message is then read by the client which performs the function of the server, namely AddServer. The sum is calculated and the result is sent back to AddClient via an acknowledgement.

6.2.2. AddServer

AddServer performs the function of the remote procedure call server. On the lower level it uses the Subscription pattern that reads messages from the queue, calculates the sum of the numbers included in the body of the message and sends an acknowledgement with the result.

6.2.3. DeclareQueue

This example creates a queue (if it does not exist yet) and binds it to multiple exchanges using the exchange name and routing key tuple.

6.2.4. ExceptionTest

ExceptionTest allows to see the usage of Shutdown protocols in a real scenario. We attach three event handlers to both the connection and the model, which then print information messages in an order defined in the shutdown protocol.

6.2.5. LogTail

The LogTail example makes use of the Subscription pattern described in the MessagingPatterns section. When the exchange name is empty, it declares a named queue, otherwise it declares an exchange of the specified type and a temporary queue from which it will consume messages. LogTail quietly consumes messages until it receives a message with only ’quit’ in the body.

6.2.6. SendMap

SendMap publishes a single message to the exchange which is constructed from key/value pairs given as arguments. Keys that start with ’+’ are placed in the body of the message, whereas those starting with ’-’ go to the header. Supported values’ types are: string/byte array, byte array (base-64), boolean, 32-bit integer, double precision float and fixed-point decimal. Refer to the info printed in the command line for detailed information on how to specify values with particular types.
6.2.7. SendString

The SendString example performs a single message publish, according to the given routing key. If the exchange name is not empty it declares an exchange with the given name and type. Otherwise it declares a queue with the name given in the routing key.

6.2.8. SingleGet

SingleGet will try to retrieve a message from the queue, the name of which is given in the command line. If there is no message in the queue it will close the connection and exit.

7. BuildingTheClient

7.1. Source Tree Layout

The source tree is laid out as follows:

- docs - Contains the AMQP specification XML files, used to generate code in projects/client/ApiGen project
- lib - Third-party libraries and programs referenced by the code or used during the build
- projects - Source code to the various parts of the system
  - client - Source code and project files for building the client
    - ApiGen - Project for the XML specification parser and code generator application
    - ApiGenBootstrap - Project for creating a library out of some parts of RabbitMQ.Client’s source code that are used in ApiGen
    - RabbitMQ.Client - The client library project
    - Unit - Unit tests for the client library
  - wcf - WCF binding source code and project files
    - RabbitMQ.ServiceModel - The WCF binding project
- examples - Example projects
  - client - Example code and projects for using the client library
  - wcf - Example code and projects for using the WCF binding
7.2. Build Prerequisites

To compile the RabbitMQ .NET client library, you will need

- a .NET development environment:
  - Microsoft .NET 2.0 (or later)
  - Microsoft .NET 3.0 (or later) if you want to build the WCF binding too

- Microsoft Visual Studio 2005 or later (optional)

To run the unit tests, you will need

- NUnit 2.5 or later; included in the lib directory

7.3. Configuring Your Tree

Copy Local.props.example to Local.props, and edit it if necessary (the properties in this file have suggestive names). Set PropTargetFramework to v1.1, v2.0, v3.0 or v3.5. If you would like to build under Mono, only v1.1 and v2.0 are supported; also set PropUsingMono to true in this case.

7.4. Building

7.4.1. On Windows, with Visual Studio

Simply open RabbitMQDotNetClient.sln with Visual Studio and build.

If you are using a version of Visual Studio later than Visual Studio 2005, you will have to convert the solution to make it compatible with your version of Visual Studio. This process is automated and you are presented with a wizard when you first open the solution file.

The projects in the RabbitMQ .NET client contain some customizations in order to allow generating source files and running NUnit tests as part of the build process. You might be presented with warnings
claiming that the projects might be unsafe. You will have to instruct Visual Studio to open all projects
normally.

To skip running the NUnit tests as part of the build, select the DebugNoTest build configuration.

Note: If you change a property in Local.props while the solution is loaded in Visual Studio, you will
have to close the solution and reopen it, for the changes to take effect.

### 7.4.2. On Windows, without Visual Studio

To build the client library without Visual Studio, first you need to make sure you have the .NET’s
framework directory in your PATH environment variable. The .NET framework directory can usually be
found at %WINDIR%\Microsoft.NET\Framework\v2.0.50727 for .NET 2.0 or
%WINDIR%\Microsoft.NET\Framework\v3.0 for .NET 3.0.

Open the Command Prompt (Start -> Run -> cmd) or Cygwin (if you have it installed) and change to the
client’s directory. Now type msbuild.exe and hit return to start building the solution.

Refer to MSBuild’s documentation for information on valid command line switches for msbuild.exe.

### 7.4.3. On Linux, using Mono

For building under Mono, please refer to

### 7.5. Building the WCF binding

Building the WCF binding is enabled by default in Local.props if the target framework is v3.0 or
later (only on Windows).

To disable building the WCF binding, set PropBuildWcf to false.

Building the WCF binding under Mono is currently unsupported due to limitations of Mono.

### 7.6. Build Products

The build products available after a successful build are:
If building the WCF binding is enabled, there will also be:

- projects/wcf/RabbitMQ.ServiceModel/build/bin/RabbitMQ.ServiceModel.dll - The WCF binding library
- Example programs for the WCF binding, like
  projects/examples/wcf/Test/build/bin/RabbitMQ.ServiceModel.Test.exe

Other build products:

- gensrc/RabbitMQ.Client/autogenerated-api-*.cs - Protocol-specific autogenerated code, produced by Apigen
- projects/client/RabbitMQ.Client/build/bin/RabbitMQ.Client.xml - csc-generated XML documentation of the client assembly
- projects/wcf/RabbitMQ.ServiceModel/build/bin/RabbitMQ.ServiceModel.xml - csc-generated XML documentation of the WCF binding

8. ImplementationGuide

The internals of the RabbitMQ .NET AMQP client library implementation live in src/client/impl, in C# namespace RabbitMQ.Client.Impl. Most of the classes mentioned below are in this namespace, modulo conspicuous exceptions such as IModel and IProtocol, which are instead in namespace RabbitMQ.Client.

8.1. Connections, Channels, Sessions and Models

Each AMQP connection is represented by an instance of ConnectionBase. Each connection has one thread running in the background, which reads and dispatches frames from the connection socket, as well as acting as a serialization point for outbound AMQP commands. There may also be two additional threads responsible for Heartbeat support (In and Outbound), if it was negotiated during the connection open process.

Each ConnectionBase instance has an instance of SessionManager, which is responsible for allocation of channel numbers, and maintenance of the map from channel numbers to ISession instances.
Each AMQP channel, that is, an uninterpreted, independent stream of commands, is represented by an instance of ISession. There are three implementations of this interface at the time of writing: Session, which provides the normal operation of a channel, QuiescingSession, which represents a channel in the process of an abnormal shutdown, and MainSession which controls special channel zero responsible for sending/receiving frames and used in ConnectionBase. The ISession instances do not interpret the commands that travel across them.

Interpretation of AMQP commands sent and received is done by the “model” code, implemented for the most part in ModelBase. This is the class that contains the majority of the implementation of the public AMQP API from IModel, as well as the private AMQP operations from IFullModel. It is also ModelBase that provides the request/response correlation during an AMQP RPC-style synchronous operation, in conjunction with RpcContinuationQueue.

8.2. Channel zero

Channel zero is a special connection-management channel, and is implemented using field ConnectionBase.m_model0. See also field ModelBase.m_connectionStartCell and methods ModelBase.HandleConnectionMethodName, all of which are an awkward part of ModelBase only relevant to operations on channel zero. MainSession implements the special behaviour of the channel zero.

8.3. Information dataflow from the server to the client
AMQP commands transmitted from the server to the client are processed by each ConnectionBase’s connection thread, which runs ConnectionBase.MainLoop until the connection is terminated.

MainLoop reads a frame from the connection’s socket, blocking until either some traffic arrives or the socket’s read-timeout exception fires. A timeout in .Net means that the socket is in an unusable state, hence the whole Connection needs to be closed. If Heartbeat support is active then two additional loops run in separate threads: ConnectionBase.HeartbeatReadLoop and ConnectionBase.HeartbeatWriteLoop.

HeartbeatReadLoop continuously checks if our connection was inactive for too long and we missed too many Heartbeat frames the broker. In such case EndOfStreamException occurs and the connection is closed.

HeartbeatWriteLoop continuously checks the activity of the connection and forces Heartbeat frame to be sent to the broker if it was idle for too long.

Once a complete frame has been read from the socket, it is dispatched with a call to ISession.HandleFrame to the ISession object responsible for the channel number carried within the frame.

In the normal case, the ISession implementation will be Session, whose HandleFrame method makes use of an instance of CommandAssembler to stitch sequentially-received frames together into whole AMQP commands. As soon as a complete command is available, it is sent through the CommandReceived event handler on Session, which in the usual case will result in an invocation of ModelBase.HandleCommand.

ModelBase.HandleCommand uses DispatchAsynchronous, which is part of the automatically-generated code produced by Apigen, to decide whether the received command is an asynchronous event (including RPC responses that have been marked in IModel as AmqpForceOneWay etc) or an RPC response that should release a waiting IRpcContinuation, about which more below.

8.4. Information dataflow from the client to the server

There are two styles of interaction available to ModelBase:

- synchronous, RPC-style interaction, e.g. ExchangeDeclare, BasicGet and BasicConsume.
- asynchronous, event-style interaction, e.g. BasicAck, BasicPublish.

Sometimes, what would normally be an RPC-style interaction must, for implementation reasons, instead be treated as two loosely associated asynchronous messages, for instance when nowait=true on methods like ExchangeDeclare, or in the case of methods like BasicConsume. For more information, see the section on AmqpForceOneWay in the section on ApiGen.
The `ModelBase` implementation does not directly choose which alternative to use: instead, the autogenerated code makes calls to `ModelBase.ModelRpc` and `ModelBase.ModelSend` as directed by the annotations on `IFullModel` (again, see the section on `ApiGen` for more details).

`ModelSend` is the simpler of the two, as no record of an awaited reply is required: the command is simply formatted and sent down the socket (via `Command.Transmit`, via `SessionBase.Transmit`).

`ModelRpc` is more involved. Calls to `IModel` methods that (indirectly) invoke `ModelRpc` should only occur in the application’s thread, and should never occur in the connection’s thread (see also the section on threading issues and deadlock in the `ApiOverview`).

## 8.5. Client-to-server AMQP RPC

When an application thread calls an `IModel` method that in turn calls `ModelBase.ModelRpc`, the application thread is suspended, the request is sent to the server, and when the response arrives, the suspended application thread is awakened. The interface between the application thread and the connection thread is usually an instance of `SimpleBlockingRpcContinuation`, the methods of which are called from the connection thread when a reply or exceptional condition arrives.

If `SimpleBlockingRpcContinuation.HandleCommand` is called, the reply `Command` is handed back to `ModelRpc`, which then hands it back through the autogenerated code to the application. Otherwise, `SimpleBlockingRpcContinuation.HandleModelShutdown` will be called due to some error condition on the channel, in which case `OperationInterruptedException` will be thrown from `SimpleBlockingRpcContinuation.GetReply`, through `ModelRpc`, and out to the application.
8.6. Constants from the specification

From numerous places in the implementation source code:

```csharp
// We use spec version 0-9 for common constants such as frame types,
// error codes, and the frame end byte, since they don’t vary *within
// the versions we support*. Obviously we may need to revisit this if
// that ever changes.
using CommonFraming = RabbitMQ.Client.Framing.v0_9;
```

If this needs revisiting, a good place to start would be extending `IProtocol` to cover the variation.

9. ApiGen

Apigen is the program that reads the AMQP XML specification documents, and autogenerates the code found after a build in the `build/gensrc/autogenerated-api-*.cs` files.
It is automatically invoked as part of the NAnt default.build script.

### 9.1. Compilation Process Overview

Apigen uses the `IModel` interface definition to guide its code generation process in conjunction with the particular XML specification file chosen.

First, `IModel` and a minimal number of its supporting classes and interfaces are compiled together using the C# compiler, resulting in `build/bin/apigen-bootstrap.dll`.

Apigen then uses .NET reflection while reading the XML specification file (from `docs/specs/amqp*.xml`), and finally generates the output C# code.
The generated code is then compiled with all the C# API and implementation classes, resulting in build/bin/RabbitMQ.Client.dll.

9.2. Invoking Apigen

Usage: Apigen.exe [options ...] <input-spec-xml> <output-csharp-file>
Options include:
    /apiName:<identifier>
    /n:<name.space.prefix>
    /v:<majorversion>-<minorversion>

The apiName option is required.

The <input-spec-xml> parameter should be the path to the AMQP specification file to digest. The <output-csharp-file> should be the location of the output file to generate.

The available options are:

- **apiName:<identifier>** - Specifies the identifier that will be used to represent the generated IProtocol in the RabbitMQ.Client.Protocols class.
- **n:<name.space.prefix>** - Supplying a namespace prefix of, for instance, foo, will cause the generated code to be placed in RabbitMQ.Client.Framing.foo and RabbitMQ.Client.Framing.Impl.foo. If this parameter is not supplied, a default will be constructed from the version (either the /v: command-line option, or the version specified in the spec XML): if the version is N-M, for instance 0-8, then the effect is as if /n:vN_M was supplied (e.g. /n:v0_8).
- **v:<majorversion>-<minorversion>** - Overrides the version numbers found in the spec XML file. Used as part of the namespaces for generated code if no /n: option is supplied.
9.3. Generated Classes

Generated classes are placed in namespaces

- RabbitMQ.Client.Framing.VersionSpecificPart

The generated classes include, in the semi-public namespace:

- class RabbitMQ.Client.Framing.VersionSpecificPart.Constants
- interface RabbitMQ.Client.Framing.VersionSpecificPart.ClassnameMethodname, one per AMQP XML specification method
- class RabbitMQ.Client.Framing.VersionSpecificPart.ClassnameProperties, one per AMQP XML content-bearing class

and in the private/implementation-specific namespace:

- class RabbitMQ.Client.Framing.Impl.VersionSpecificPart.Model
- class RabbitMQ.Client.Framing.Impl.VersionSpecificPart.ClassnameMethodname, one per AMQP XML specification method

The Protocol class implements IProtocol. Its most important generated methods are DecodeMethodFrom and DecodeContentHeaderFrom.

The Constants class collects the various numeric constants defined in the XML specification file.
Each `ClassnameMethodname` interface represents a protocol-specific variant of a single AMQP method, and its corresponding Impl-namespaced `ClassnameMethodname` class is the implementation of the interface.

Each `ClassnameProperties` class is a protocol-specific implementation of a common content header interface.

The `Model` class implements the autogenerated methods from the `IFullModel` definition (about which much more below, in the "The Common Model" section), as well as implementing the `DispatchAsynchronous` method used to decide if an incoming command is an asynchronous event or a reply to a synchronous RPC request.

The inheritance relationships are as follows (for specification version 0-9; other versions follow, *mutatis mutandis*):

for Protocol:

- `RabbitMQ.Client.Framing.v0_9.Protocol`
  - is autogenerated
  - is protocol-specific

  - is written by hand
  - is very short
  - is protocol-specific
  - is implemented in file `src/client/impl/v0_9/ProtocolBase.cs`
  - extends `RabbitMQ.Client.Impl.AbstractProtocolBase`

- `RabbitMQ.Client.Impl.AbstractProtocolBase`
  - is written by hand
  - is protocol-neutral
  - implements `RabbitMQ.Client.IProtocol`

- `RabbitMQ.Client.IProtocol`
  - is protocol-neutral
  - is public API.
for *Model*:

- RabbitMQ.Client.Framing.Impl.v0_9.Model
  - is autogenerated
  - is protocol-specific
  - extends RabbitMQ.Client.Impl.ModelBase

- RabbitMQ.Client.Impl.ModelBase
  - is written by hand
  - is long and complex
  - is protocol-neutral
  - is implemented in file src/client/impl/ModelBase.cs
  - implements RabbitMQ.Client.Impl.IFullModel

- RabbitMQ.Client.Impl.IFullModel
  - is written by hand
  - is protocol-neutral
  - is compiled in to Apigen and used to guide the compilation process
  - extends RabbitMQ.Client.IModel

- RabbitMQ.Client.IModel
  - is written by hand
  - is protocol-neutral
  - contains the main public API for performing AMQP operations.

for *BasicProperties*:

- RabbitMQ.Client.Framing.v0_9.BasicProperties
  - is autogenerated
  - is protocol- and content-class-specific
  - extends RabbitMQ.Client.Impl.BasicProperties

- RabbitMQ.Client.Impl.BasicProperties
  - is written by hand
  - is protocol-neutral, but content-class-specific
  - extends RabbitMQ.Client.Impl.ContentHeaderBase
• implements RabbitMQ.Client.IBasicProperties

• RabbitMQ.Client.Impl.ContentHeaderBase
  • is written by hand
  • is protocol- and content-class-neutral
  • implements RabbitMQ.Client.IContentHeader

• RabbitMQ.Client.IBasicProperties
  • is written by hand
  • is protocol-neutral, but content-class-specific
  • is public API.

9.4. The Common Model

In order to accommodate differences in broker implementations, we supply a common interface that all supported protocol variants must implement. The common interface is in two pieces:

• RabbitMQ.Client.IModel - the public API
• RabbitMQ.Client.Impl.IFullModel - internal, implementation-specific pieces of the protocol; extends the IModel interface.

Apigen is linked with these interfaces, and at runtime uses reflection to look for the IFullModel interface (see definition of Apigen.m_modelType).

The definitions in IFullModel, taken together with the class and method definitions in the AMQP specification XML, guide the code generation process.

9.4.1. The main model interface

The interface itself contains both

• members that should be autogenerated, and
• members that must not be autogenerated, that will be supplied by hand-written code.
9.4.2. Content header interfaces

```csharp
[AmqpContentHeaderFactory("basic")]
IBasicProperties CreateBasicProperties();

[AmqpContentHeaderFactory("file")]
IFileProperties CreateFileProperties();

// etc.
```

Use the `AmqpContentHeaderFactory` attribute to specify that a particular method is to be implemented by constructing an instance of a protocol-specific implementation of a common, protocol-neutral interface.

The parameter to the attribute specifies the content class that should be used. It may not be null.

9.4.3. Mapping methods to RPC requests

The name of the AMQP method to associate with a given `IFullModel` method is derived by analysing the name of the C# method:

- `ExchangeDeclare` --> (split by CamelCasing)
- `Exchange Declare` --> (lookup each piece in the XML file)
  - class=exchange, method=declare

9.4.3.1. AmqpMethodMapping

If the name of the method does not match any AMQP name, a mapping must be explicitly provided:

```csharp
[AmqpMethodMapping(null, "channel", "open")]
void _Private_ChannelOpen(string outOfBand);
```

The first parameter to the attribute specifies the specification version to which the attribute should apply, or null if it should apply to any and all specification versions.

The second and third parameters are the AMQP specification class and method names, respectively, to use when building a mapping for this C# method.

9.4.3.2. AmqpMethodDoNotImplement

The `AmqpMethodDoNotImplement` attribute can be used on any method to cause code-generation to skip that method.

```csharp
[AmqpMethodDoNotImplement(null)]
```
void ExchangeDeclare(string exchange, string type);

It should be used to mark interface methods that are backed by hand-written code: for example, the
ExchangeDeclare overload above is a convenience method, backed by hand-written code that invokes
a different overload of ExchangeDeclare with all the missing parameters filled in with sensible
defaults.

Another case in which hand-written code is required is when non-standard RPC processing is needed, for
instance in the cases of BasicConsume and BasicCancel. These delegate (in hand-written code) to the
automatically-generated _Private_BasicConsume and _Private_BasicCancel methods. This
pattern provides an opportunity to combine automatically-generated marshalling code with other
concerns not related to the framing or transmission of a request.

The parameter to the attribute specifies the specification version to which the attribute should apply, or
null if it should apply to any and all specification versions.

9.4.4. Mapping method parameters to RPC request fields

Parameters in a mapped method call are matched to the corresponding fields in an AMQP command by
analysing the parameter name:

prefetchCount --> (split on CamelCasing)
"prefetch count"
<-- "prefetch count" (in AMQP specification 0-8)
<-- "prefetch-count" (in AMQP specification 0-9)

9.4.4.1. AmqpFieldMapping

If the name of the parameter to a method call does not fit such an analysis, the AmqpFieldMapping
attribute should be used on the parameter concerned:

void _Private_BasicConsume(...,
    bool exclusive,
    bool nowait,
    [AmqpFieldMapping("RabbitMQ.Client.Framing.v0_9",
       "filter")]
    IDictionary arguments);

The parameter to the attribute specifies the specification version to which the attribute should apply, or
null if it should apply to any and all specification versions.

The second parameter is the AMQP XML field name to match to the parameter.
9.4.4.2. AmqpNowaitArgument

Some AMQP command requests have a “nowait” boolean field, which affects the interaction style of the command, turning it from a synchronous RPC request into an asynchronous command request. In order to generate the correct workflow code, Apigen needs to know which (if any) of a method’s parameters will change the server’s interpretation of the interaction style of the command. The AmqpNowaitArgument attribute should be used for this purpose:

```csharp
void _Private_ExchangeDelete(string exchange,
    bool ifUnused,
    [AmqpNowaitArgument(null)]
    bool nowait);
```

When AmqpNowaitArgument decorates a particular parameter, if that parameter is true at runtime, the generated code will send the request asynchronously; otherwise it will send it synchronously.

It is an error to apply AmqpNowaitArgument to methods mapped to commands that are not synchronous.

The first parameter to the attribute specifies the specification version to which the attribute should apply, or null if it should apply to any and all specification versions.

The second, optional, parameter to the attribute specifies the value to return from the method in cases where the server’s reply is not waited for. It can be safely omitted for methods returning void, or methods returning a reference type (in which case null is returned). For other methods, it should be a string containing a C# code fragment to place in the generated code.

9.4.4.3. AmqpContentHeaderMapping and AmqpContentBodyMapping

Some methods take AMQP content, in the form of subsequent frames to be sent on the wire: content headers followed by content body. The AmqpContentHeaderMapping and AmqpContentBodyMapping attributes mark the parameters of a method that should be sent as the content header and content body frames, respectively:

```csharp
void _Private_BasicPublish(ushort ticket,
    string exchange,
    string routingKey,
    bool mandatory,
    bool immediate,
    [AmqpContentHeaderMapping]
    IBasicProperties basicProperties,
    [AmqpContentBodyMapping]
    byte[] body);
```

Parameters so marked will not be mapped to fields in the command request.
9.4.5. Mapping RPC responses to return values

Commands mapped to methods on IFullModel may have a response command that contains useful information that should be exposed as the return value of the C# method. If the C# method returns void, no information will be returned, but the method will not return until the response has arrived from the server.

9.4.5.1. AmqpMethodMapping

If AmqpMethodMapping is applied to the return value of a mapped C# method, it causes the generation of code that will wait for the named reply method instead of whatever default could be gleaned from reading the specification XML:

```
[return: AmqpMethodMapping(null, "connection", "tune")]
ConnectionTuneDetails ConnectionStartOk(IDictionary clientProperties,
                                          string mechanism,
                                          byte[] response,
                                          string locale);
```

In the example above, the XML specification talks about request-reply pairs involving connection.start and connection.start-ok, and connection.tune and connection.tune-ok. Because these are seen from the server's perspective, and we are implementing a client, we need to talk about a request-reply pair involving connection.start-ok and connection.tune instead.

9.4.5.2. AmqpFieldMapping

If AmqpFieldMapping is applied to the return value of a mapped C# method, it causes a single field to be extracted from the reply command and returned.

If it is not applied, however, then if the method does not return void, the return type is assumed to be valuetype (a.k.a. struct) with annotations specifying how to map AMQP reply method fields onto fields of the returned struct.

```
[return: AmqpFieldMapping(null, "messageCount")]
uint QueuePurge(...);
```

The above example extracts and returns just the "message-count" field of the queue.purge-ok reply.

```
[return: AmqpMethodMapping(null, "connection", "tune")]
ConnectionTuneDetails ConnectionStartOk(IDictionary clientProperties,
                                          string mechanism,
                                          byte[] response,
                                          string locale);

public struct ConnectionTuneDetails
```
The above example extracts the "channel-max", "frame-max" and "heartbeat" fields of the reply, and inserts them into a fresh ConnectionTuneDetails structure. The definitions of the fields may have AmqpFieldMapping attributes applied to them if their names do not match the names given in the specification XML.

9.4.5.3. AmqpForceOneWay

In some cases where a method mapping would otherwise be generated as a synchronous RPC, we need to send it instead as an asynchronous command, decoupling the request from the response and permitting the weaving of non-framing-related concerns into the workflow. In these cases, applying AmqpForceOneWay to the method causes it to always be sent as an asynchronous request. Methods so marked must return void.

```
[AmqpForceOneWay]
[AmqpMethodMapping(null, "basic", "get")]
void _Private_BasicGet(ushort ticket,
                        string queue,
                        bool noAck);
```

void HandleBasicGetOk(...);

void HandleBasicGetEmpty();

The example above has been marked AmqpForceOneWay because the specification XML supplies two possible responses, basic.get-ok and basic.get-empty, which does not fit the simple RPC request-reply pattern implemented for many of the other commands.

Since basic.get will always result in one or the other of the mentioned result methods, it’s important to handle these methods as if they were asynchronous events from the broker, matching up the request and response in hand-written code.

9.4.6. Mapping asynchronous events

Methods which have a name starting with the string "Handle" are assumed by Apigen to be event handlers for responding to asynchronous events.

```
void HandleBasicDeliver(string consumerTag,
                        ulong deliveryTag,
                        bool redelivered,
```
In the example above, whenever a `basic.deliver` method arrives, it will be dispatched, as it arrives, to the hand-written implementation of `HandleBasicDeliver`, and will not be assumed to be the reply to an earlier RPC-style request.

Note that `AmqpContentHeaderMapping` and `AmqpContentBodyMapping` are permitted on the arguments of an asynchronous event handler.

### 9.4.7. Overriding behaviour for particular specification versions

In some versions of the specification, a particular field, method or content header may not be supported. Methods and parameters can be marked to cause particular implementations to complain if these features are used by applications:

```csharp
[AmqpUnsupported("RabbitMQ.Client.Framing.v0_8qpid")] void QueueUnbind(string queue,
    string exchange,
    string routingKey,
    IDictionary arguments);
```

In the example above, `queue.unbind` is marked as unsupported by the QPid-specific variant of the 0-8 protocol. Clients using the QPid-specific 0-8 IProtocol implementation will, at runtime, receive a thrown `UnsupportedMethodException` if they call `QueueUnbind`.

```csharp
[AmqpForceOneWay]
[AmqpMethodMapping(null, "basic", "consume")]
void _Private_BasicConsume(ushort ticket,
    string queue,
    string consumerTag,
    bool noLocal,
    bool noAck,
    bool exclusive,
    bool nowait,
    [AmqpUnsupported("RabbitMQ.Client.Framing.v0_8")]
    [AmqpFieldMapping("RabbitMQ.Client.Framing.v0_9",
        "filter")]
    IDictionary arguments);
```

In the example above, the "arguments" parameter is unsupported in standard 0-8, and in 0-9 it is named "filter" instead of "arguments". In all other implementations, it is assumed to be supported and named "arguments".
The parameter to the attribute specifies the specification version to which the attribute should apply, or null if it should apply to any and all specification versions.

Notes

1. See RabbitMQ.Client.Impl.SessionManager.CheckAutoClose() for the implementation of this feature.

2. The underlying implementation reason is that the IBasicConsumer callbacks are invoked in the connection’s thread rather than in the application’s thread.

3. Within limits - please see the AMQP specification for precise details of when redelivery is permitted and when and how it is mandated.

4. See the AMQP specification for full details of the meaning of "durable" here

5. Submissions welcome!