MQ Telemetry Transport (MQTT) Programming

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IBM WebSphere MQ Telemetry

- WebSphere MQ Telemetry component is known as MQXR ('eXtended Reach')
- MQTT was added as an installable feature of IBM WebSphere MQ 7.0.1 before being fully integrated into WebSphere MQ version 7.1.
- MQTT is a feature of WebSphere MQ that extends the universal messaging backbone with the MQTT protocol to a wide range of remote sensors, actuators and telemetry devices.

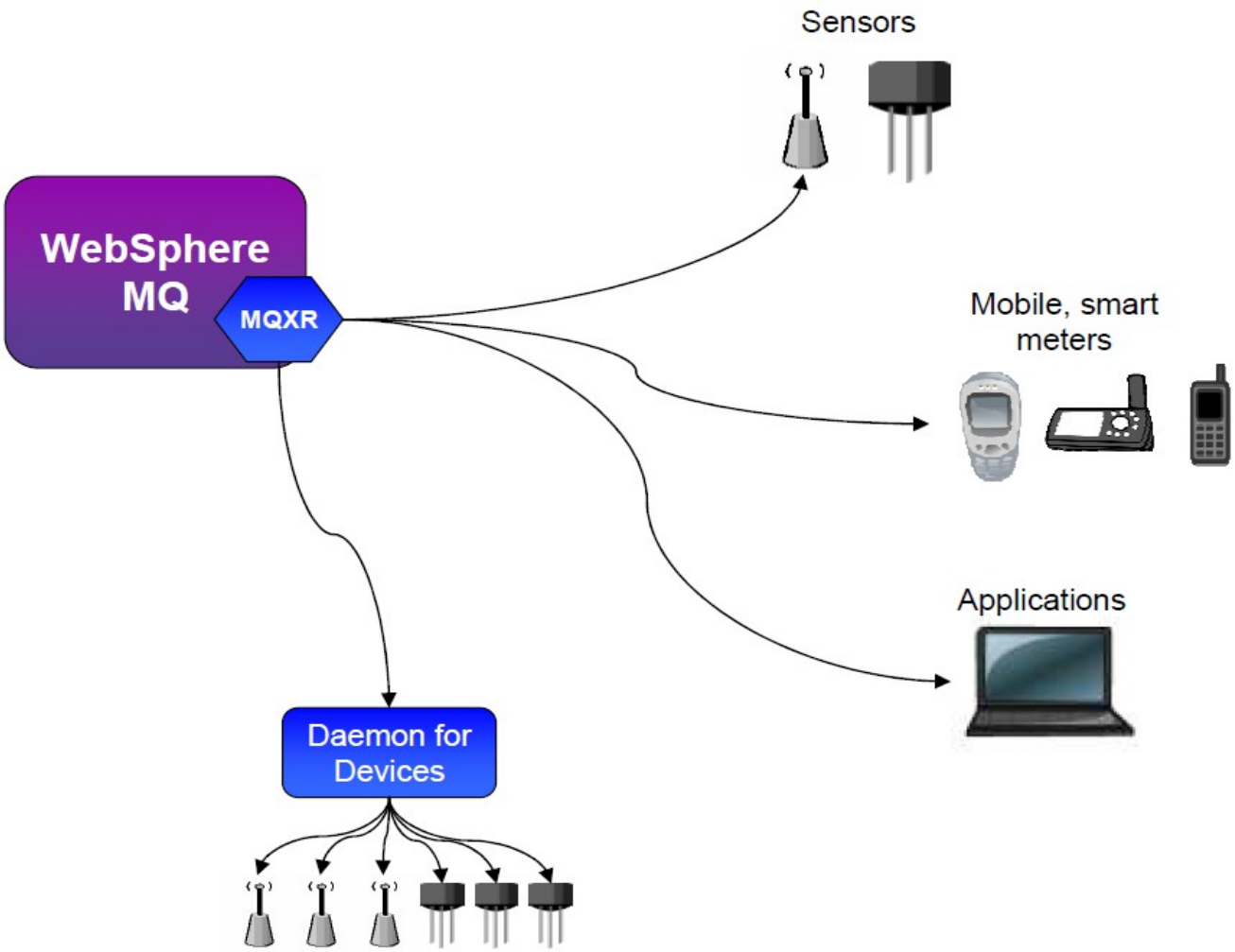
IBM WebSphere MQ Telemetry

- Fully integrated / interoperable with WMQ
  - MQTT messages translated to standard WMQ messages
  - Administration included as part of WebSphere MQ Explorer
- Telemetry channels enable MQTT connections to the queue manager
  - Supports MQTTv3 protocol (most common in use)
- Scalability
  - 100,000+ clients
- Security
  - SSL channels
  - JAAS authentication
- Ships with reference Java (for MIDP upwards) and C clients
  - Small footprint clients
  - other APIs and implementations of MQTT available via 3rd parties

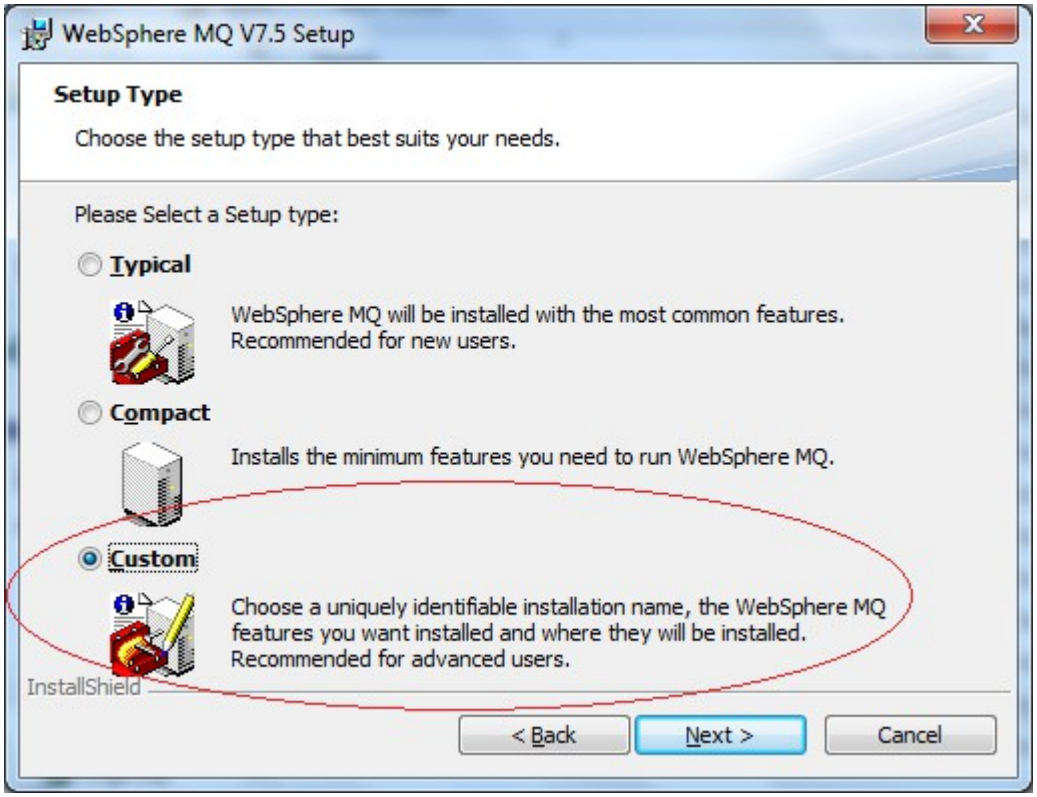
IBM WebSphere MQ Telemetry

- MQ applications use Publish/Subscribe to communicate with MQTT client applications.
- MQ applications can use Point-To-Point messaging to send a message directly to an MQTT client application (Note: This is one-way!!)
  - Connect to your queue manager
  - On the MQOPEN API call:
    - Set the QMgr Name to the MQTT Client Id
    - Set the Queue Name to the Topic
  - Use MQPUT to send messages directly to a particular MQTT client application

WebSphere MQ Telemetry Topology



WebSphere MQ Installation on Windows



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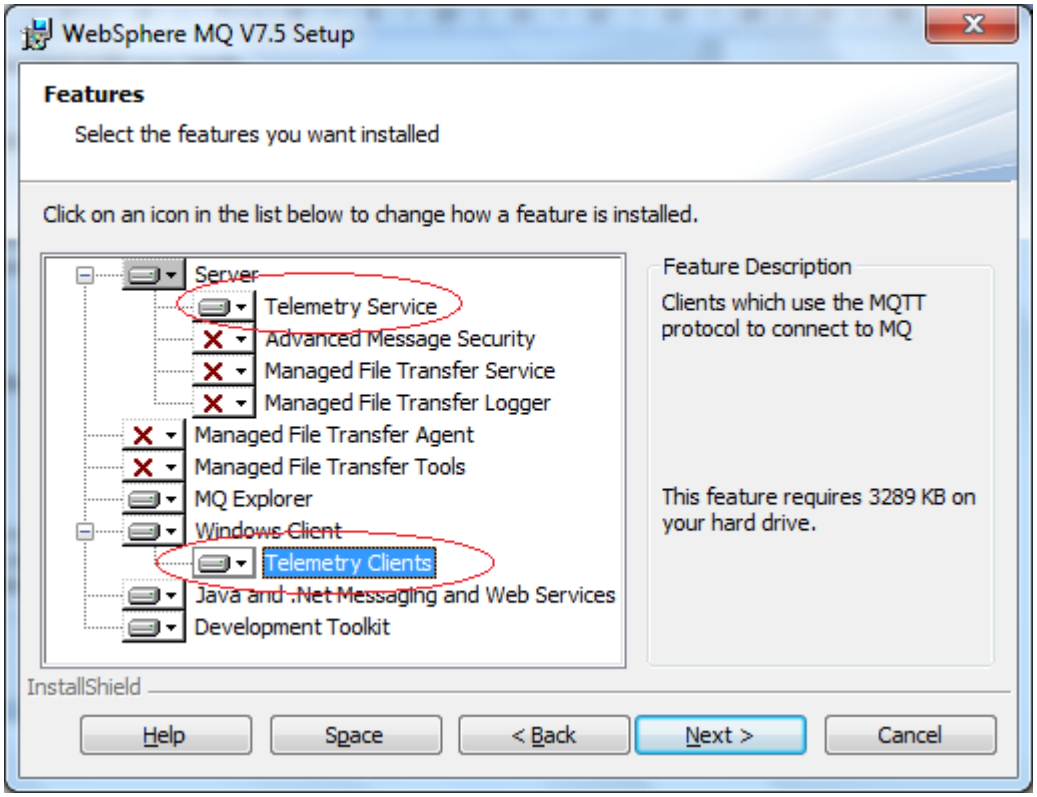
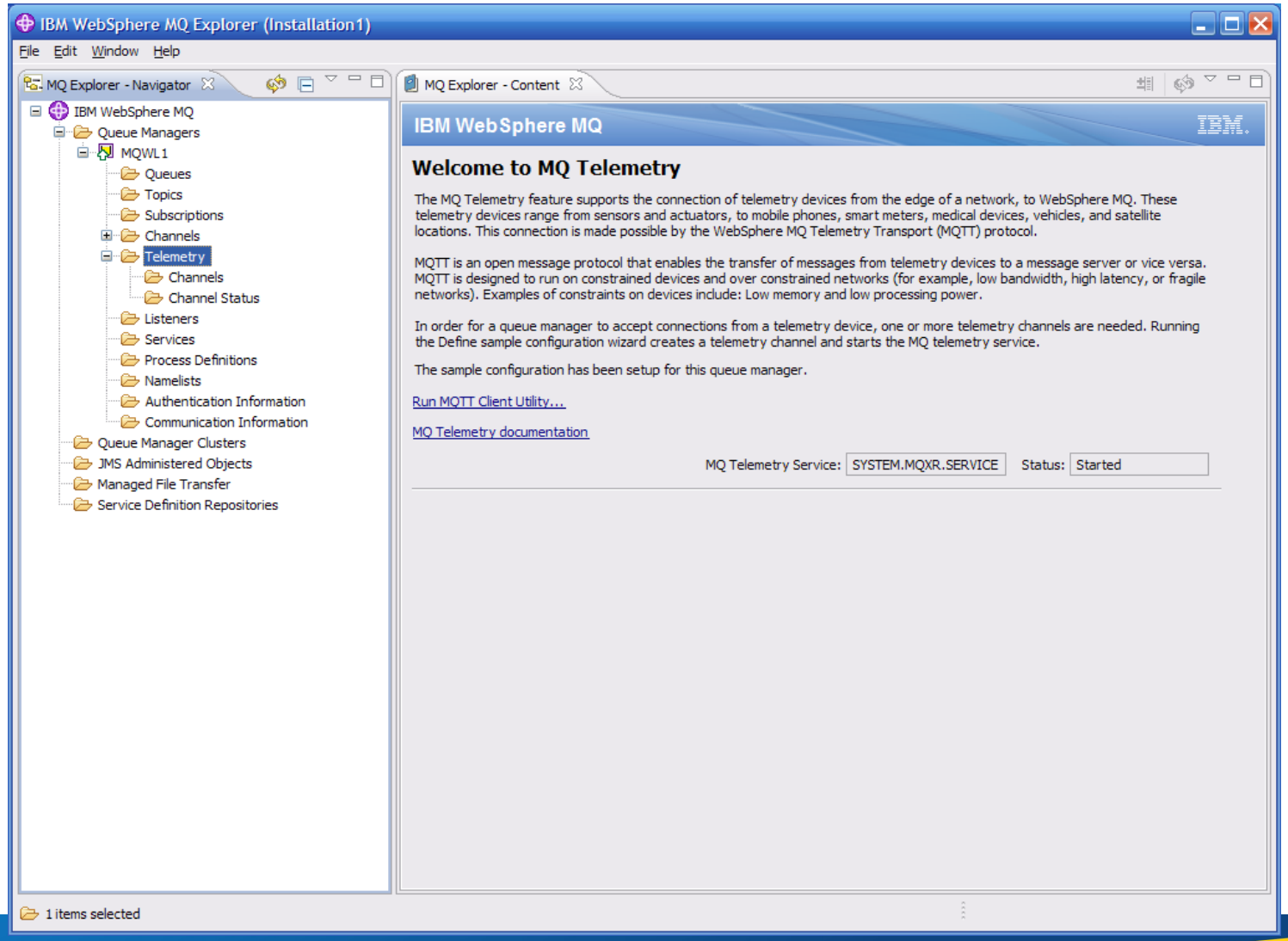


WebSphere MQ Installation on Linux

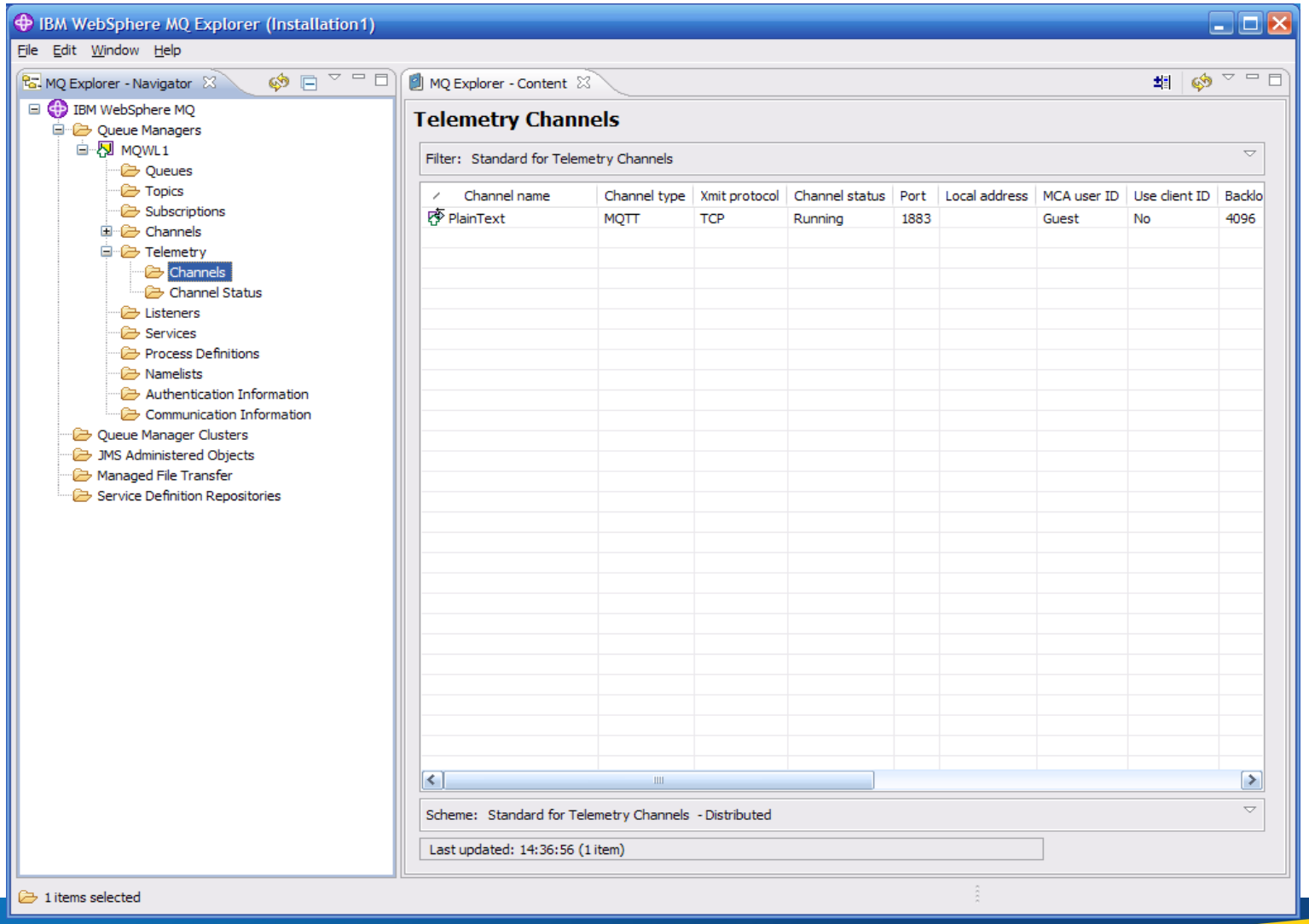
rpm -ivh MQSeriesXRService-7.5.0-0.x86_64.rpm

rpm -ivh MQSeriesXRClients-7.5.0-0.x86_64.rpm

MQ Explorer on Windows



MQ Explorer on Windows



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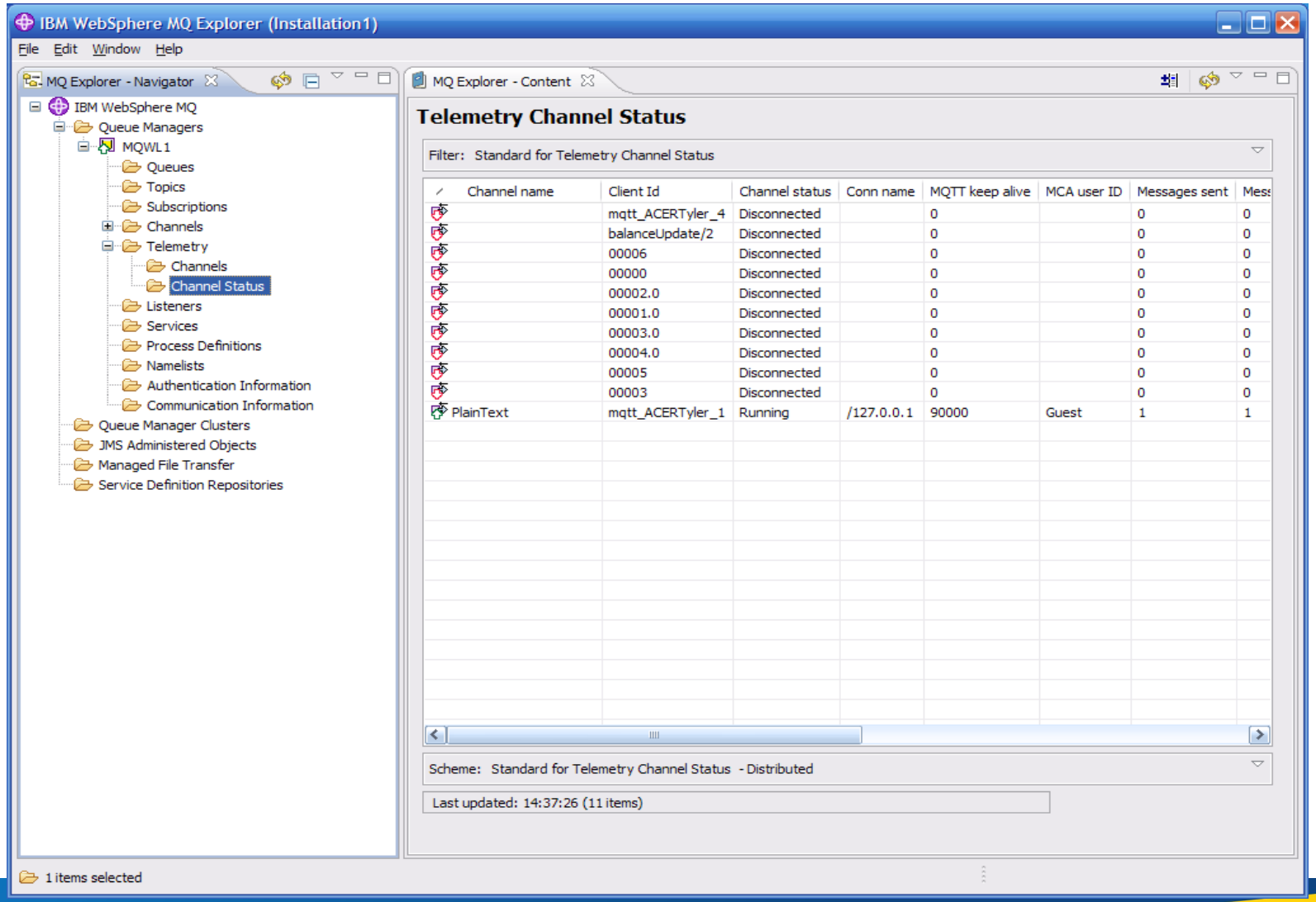
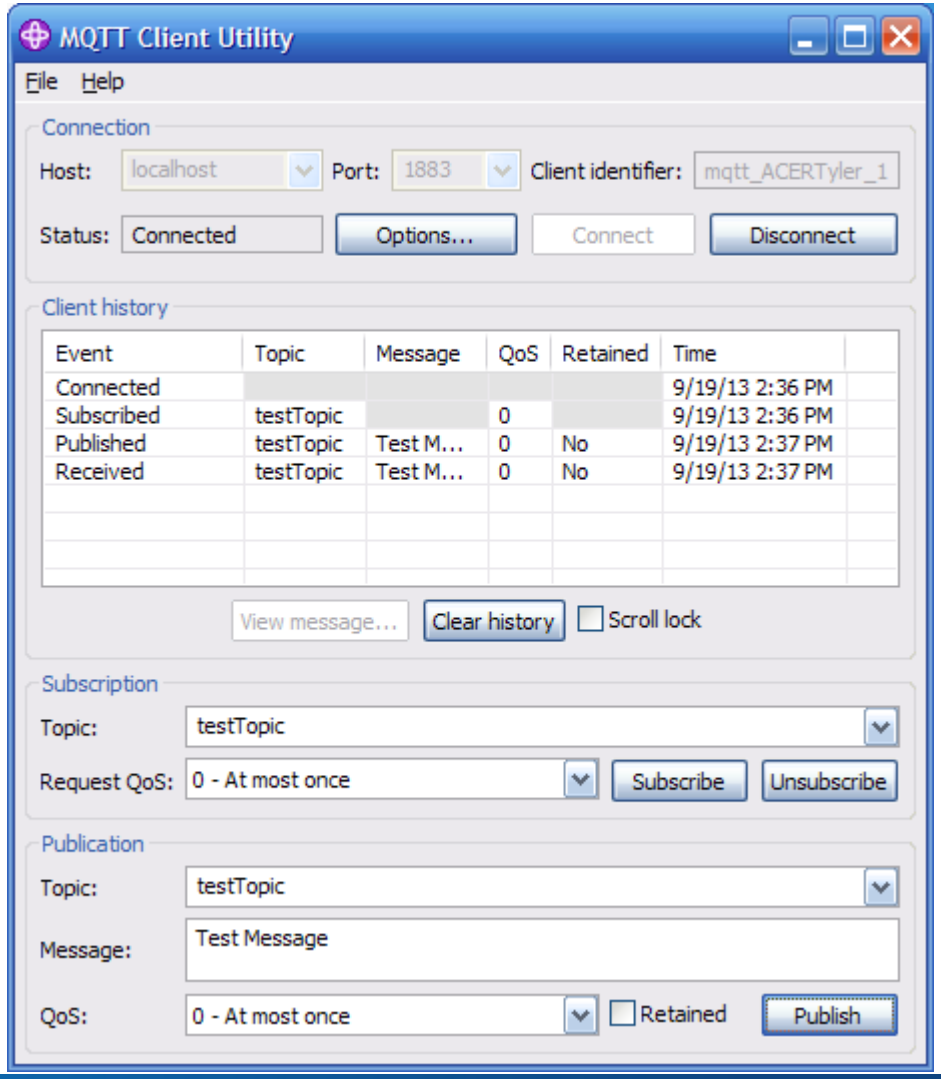


MQTT Client Utility



What is MQ Telemetry Transport (MQTT)?

- MQ Telemetry Transport (MQTT) is a simple publish/subscribe lightweight messaging protocol.
- It is open source and royalty-free, allowing easy adaptation for a wide variety of devices.
- Ideal for constrained environments where network bandwidth is low and when remote devices may have limited processing capabilities. This design allows thousands of remote clients to be interconnected, resulting in “Internet of Things”.

What is MQ Telemetry Transport (MQTT)?

Open

- Open published spec designed for the world of “devices”
  - Invented by IBM and Eurotech
  - MQTT client code (C and Java) donated to the Eclipse "Paho" M2M project

Lean

- Minimized on-the-wire format
  - Smallest possible packet size is 2 bytes
  - No application message headers
- Reduced complexity/footprint
  - Clients: C=30Kb; Java=100Kb

Reliable

- Three qualities of service:
  - 0 – at most once delivery
  - 1 – assured delivery but may be duplicated
  - 2 – once and once only delivery
- In-built constructs to support loss of contact between client and server.
  - “Last will and testament” to publish a message if the client goes offline.
- Stateful “roll-forward” semantics and “durable” subscriptions.

Simple

- Simple / minimal pub/sub messaging semantics
  - Asynchronous (“push”) delivery
  - Simple set of verbs -- connect, publish, subscribe and disconnect.

MQTT Concept: Publish/Subscribe

- The MQTT protocol is based on the principle of publishing messages and subscribing to topics, which is typically referred to as a PUBLISH/SUBSCRIBE model. Clients can subscribe to topics and thereby receive whatever messages are published to those topics. Or clients can publish messages to topics, thus making them available to all subscribers to those topics.

MQTT Concept: Topics & Subscriptions

- Messages in MQTT are published to topics, which can be thought of as subject areas. Clients, in turn, sign up to receive particular messages by subscribing to a topic. Subscriptions can be explicit, which limits the messages received to the specific topic at hand, or use wildcard designators (+ and #) to receive messages across a variety of related topics.

MQTT Concept: Clean sessions & durable connections

- When an MQTT client connects to the server, it sets the clean session flag. If the flag is set to true, then all of the client's subscriptions are removed when it disconnects from the server. If the flag is set to false, then the connection is treated as durable, and the client's subscriptions remain in effect after any disconnection. In this event, subsequent messages that arrive carrying a high QoS designation are stored for delivery once the connection is reestablished. Also note that this an optional behavior, and that messages may get lost. Even with QoS=2 messages may get lost because all of the server state is purged on reconnect.

MQTT Concept: Retained messages

- With MQTT, the server keeps the message even after sending it to all current subscribers. If a **new** subscription is submitted for the same topic, any retained messages are then sent to the new subscribing client.

MQTT Concept: Wills

- When a client connects to a server, it can inform the server that it has a will, or a message that should be be published to a specific topic or topics in the event of an unexpected disconnection. This is particularly useful in alarm or security settings where system managers must know immediately when a remote sensor has lost contact with the network.

MQTT Concept: Qualities of Service

MQTT defines three Quality of Service (QoS) levels for message delivery:

- QoS = 0 "At most once", messages are delivered according to the best efforts of TCP/IP network. Message loss or duplication can occur. A response is not expected and no retry defined in the protocol
- QoS = 1 "At least once", where messages are assured to arrive but duplicates may occur.
- QoS = 2 "Exactly once", where message are assured to arrive exactly once.

MQTT Concept: Security

- You can pass a username and password with an MQTT connect packet in V3.1 of the protocol.
- Encryption across the network can be handled with SSL, independently of the MQTT protocol itself (it is worth noting that SSL is not the lightest of protocols, and does add significant network overhead).
- Additional security can be added by an application encrypting data that it sends and receives, but this is not something built-in to the protocol, in order to keep it simple and lightweight.

Some C Code

Some code... Using Paho Asynchronous MQTT client library for C

```
#include "MQTTAsync.h"

#include "MQTTClientPersistence.h"
```

C Code: Connecting to MQTT Server

3 Steps:

1. Create a MQTTAsync
2. Create a MQTTAsync_connectOptions structure and set the options
3. Call MQTTAsync_connect and pass the MQTTAsync object and the MQTTAsync_connectOptions structure

C Code: Connecting to MQTT Server Creating The Client

```
MQTTAsync client;

MQTTAsync_create(&client, "tcp://m2m.eclipse.org:1883",
  "clientId", MQTTCLIENT_PERSISTENCE_NONE, NULL);

MQTTAsync_setCallbacks(client, NULL, connectionLost,
                                     messageArrived, NULL);
```

C Code: Connecting to MQTT Server Setting Connection Options

```
MQTTAsync_connectOptions conn_opts = MQTTAsync_connectOptions_initializer;
conn_opts.keepAliveInterval = 20;
conn_opts.cleansession = 1;
conn_opts.onSuccess = onConnect;
conn_opts.onFailure = onConnectFailure;
conn_opts.context = client;
```

C Code: Connecting to MQTT Server More Connection Options

```
conn_opts.username = "yourUsername";

conn_opts.password =  "yourPassword";

conn_opts.ssl = ssl_structure;

conn_opts.will = will_structure;

conn_opts.context = client;
```

… and more

C Code: Connecting to MQTT Server Connecting

```
MQTTAsync_connect(client, &conn_opts);
```

C Code: Callbacks

```
void onConnect(void* context, MQTTAsync_successData* response) {}

void onConnectFailure(void* context, MQTTAsync_failureData* response){}

void connectionLost(void *context, char *cause) {}
```

C Code: Subscribing to a Topic

2 Steps:

1. Create a MQTTAsync_responseOptions structure and set the options
2. Call MQTTAsync_subscribe and pass the MQTTAsync object and the MQTTAsync_responseOptions structure

C Code: Subscribing to a Topic Setting Subscription Options

```
MQTTAsync_responseOptions opts =
                                MQTTAsync_responseOptions_initializer;

opts.onSuccess = onSubscribe;

opts.onFailure = onSubscribeFailure;

opts.context = client;
```

C Code: Subscribing to a Topic Subscribing

```
int _qos = 0;

MQTTAsync_subscribe(client, "Topic", _qos, &opts);
```

C Code: Sending a Message

3 Steps:

1. Create a MQTTAsync_message
2. Create a MQTTAsync_responseOptions structure and set the options
3. Call MQTTAsync_sendMessage and pass the MQTTAsync_message and the MQTTAsync_responseOptions structure

C Code: Sending a Message
Creating The Message

```
MQTTAsync_message pubmsg = MQTTAsync_message_initializer;


char *message = "this is a test message";
pubmsg.payload = message;
pubmsg.payloadlen = strlen(message);
pubmsg.qos = 0;
pubmsg.retained = 0;
```

C Code: Sending a Message
Sending Options

```
MQTTAsync_responseOptions opts =
                              MQTTAsync_responseOptions_initializer;

opts.onSuccess = onSend;

opts.onFailure = onSendFailure;

opts.context = client;
```

C Code: Sending a Message Sending

```
MQTTAsync_sendMessage(client, "Topic", &pubmsg, &opts);
```

C Code: Receiving Messages

```
int messageArrived(void *context, char *topicName, int  topicLen,
                                MQTTAsync_message *message)
{
  message->payload

  topicName
}
```

Some Java (Android) Code

Some code... Using Paho MQTT Client library for Java

```
import org.eclipse.paho.client.mqttv3
```

Java Code: MQTT

You must have an object thats implements MqttCallback

```
public void connectionLost(Throwable cause)

public void deliveryComplete(IMqttDeliveryToken token)

public void messageArrived(String topic, MqttMessage
                                        message) throws MqttException
```

Java Code: Connecting to MQTT Server

4 Steps:

1. Create a MqttAsyncClient object
2. Create a MqttConnectOptions object and set the options
3. Create a IMqttActionListener listener
4. Call connect method on MqttAsyncClient object and pass the MqttConnectOptions and the IMqttActionListener objects

Java Code: Connecting to MQTT Server Creating The Client

```
MqttAsyncClient client; // Store Globally

try {

client  = new MqttAsyncClient("tcp://m2m.eclipse.org:1883",
"clientId");

client.setCallback(this);//Set Callback to object implementing MqttCallback


} catch (MqttException e) {

// Catch Error

}
```

Java Code: Connecting to MQTT Server Setting Connection Options

```
MqttConnectOptions conOpt = new MqttConnectOptions();


conOpt.setCleanSession(true);
conOpt.setKeepAliveInterval(20);
conOpt.setPassword("password".toCharArray());
conOpt.setUserName("userName");
```

…. And More

Java Code: Connecting to MQTT Server Connection Listener

```
IMqttActionListener conListener = new IMqttActionListener() {
  public void onSuccess(IMqttToken asyncActionToken) {
    //Connected
  }
  public void onFailure(IMqttToken asyncActionToken, Throwable exception) {
    //Failed to Connect
  }
};
```

Java Code: Connecting to MQTT Server Connecting

```
try {
  client.connect(conOpt,"Connect sample context",conListener);
} catch (MqttException e) {
  // Catch Error
}
```

Java Code: Subscribing to a Topic

2 Steps:

1. Create a IMqttActionListener listener
2. Call subscribe method on the MqttAsyncClient object and pass the IMqttActionListener object

Java Code: Subscribing to a Topic Subscription Listener

```
IMqttActionListener subListener = new IMqttActionListener() {
  public void onSuccess(IMqttToken asyncActionToken) {
    //Subscription Successful
  }
  public void onFailure(IMqttToken asyncActionToken, Throwable exception) {
    //Subscription Failed
  }
};
```

Java Code: Subscribing to a Topic Subscribing

```
try {

  int qos = 0;

  client.subscribe("testTopic", qos, "Subscribe sample
  context", subListener);

} catch (MqttException e) {

  //Error

}
```

Java Code: Publishing a Message

2 Steps:

1. Create a IMqttActionListener listener
2. Create MqttMessage and call publish method on the MqttAsyncClient object and pass the IMqttActionListener object

Java Code: Publishing a Message Publishing Listener

```
IMqttActionListener pubListener = new IMqttActionListener() {
  public void onSuccess(IMqttToken asyncActionToken) {
    //Publish Successful
  }
  public void onFailure(IMqttToken asyncActionToken, Throwable exception) {
    //Publish Failed
  }
};
```

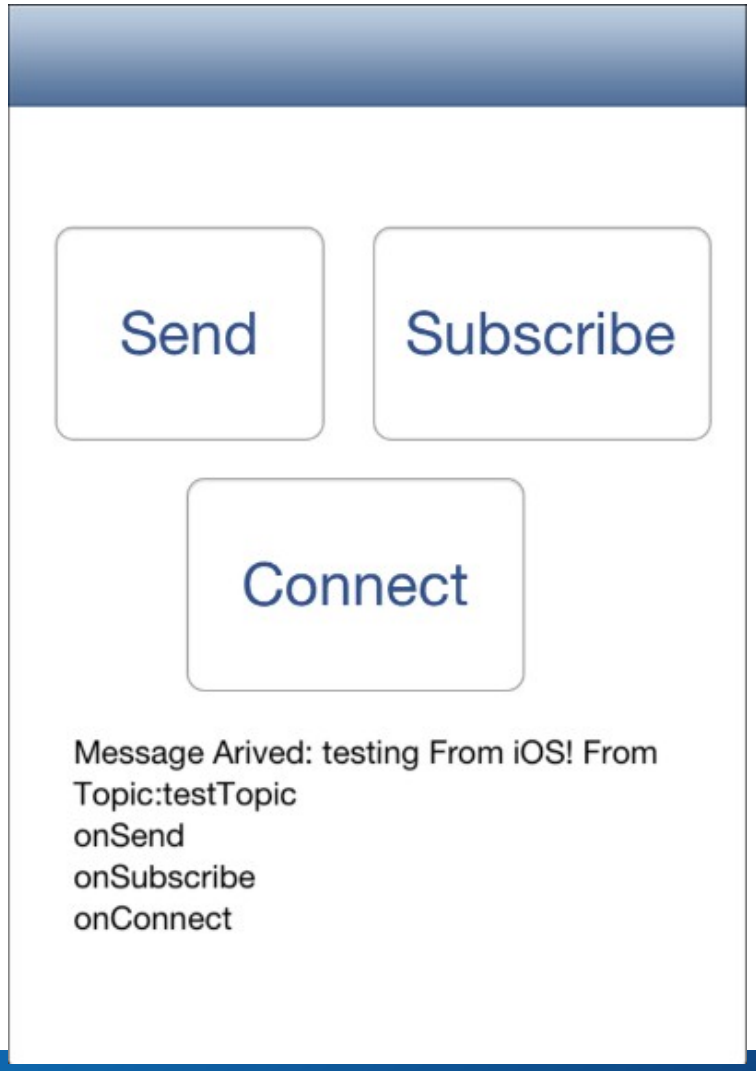
Java Code: Publishing a Message Publishing the Message

```
try {
  MqttMessage message = new MqttMessage("test
                                  message".getBytes());
  message.setQos(0);
  client.publish(topicName, message, "Pub sample
              context", pubListener);
} catch (MqttException e) {
  //Error when trying to send message
}
```

Java Code: Receiving a Message

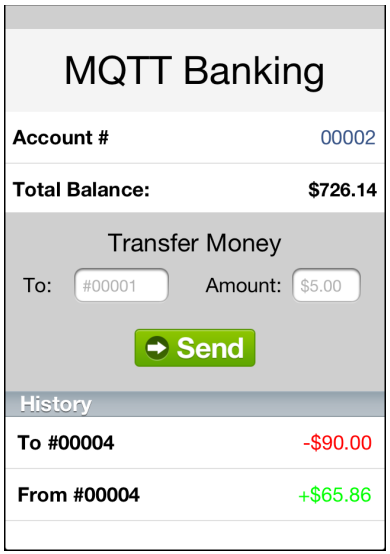
```
public void messageArrived(String topic, MqttMessage message) throws
MqttException {


System.out.println("Message Arrived:" + new String(message.getPayload()) +

                   "At Topic:\t" + topic +

                    "  QoS:\t" + message.getQos());

}
```

Demo 1


Send
Subscribe
Connect
Message Arived: testing From iOS! From Topic:testTopic
onSend
onSubscribe
onConnect

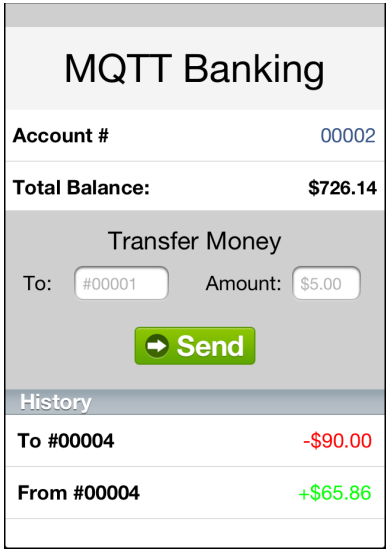
Demo 2

iOS



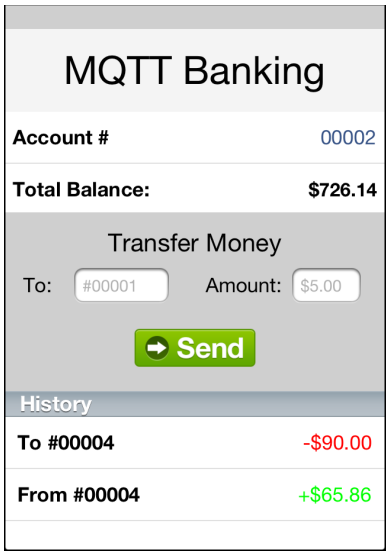
MQTT Server

Android



Demo 2

iOS



MQTT Server

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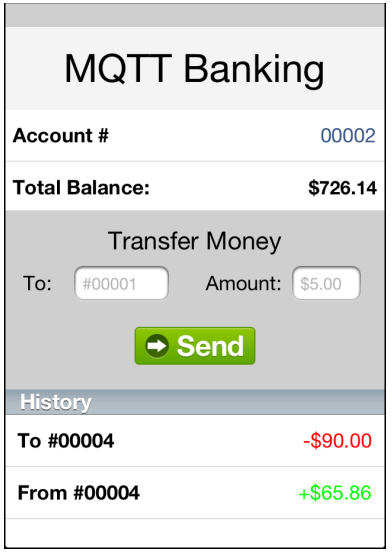

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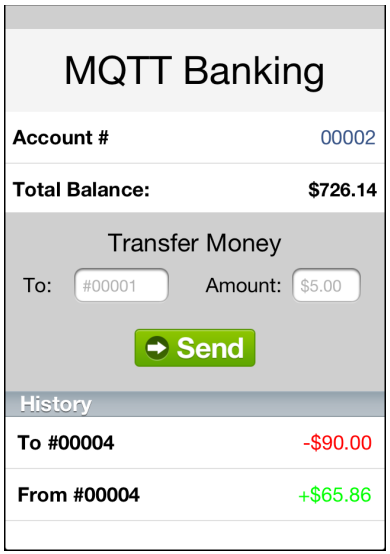

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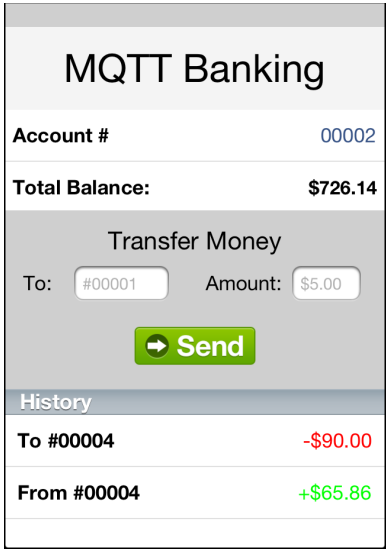
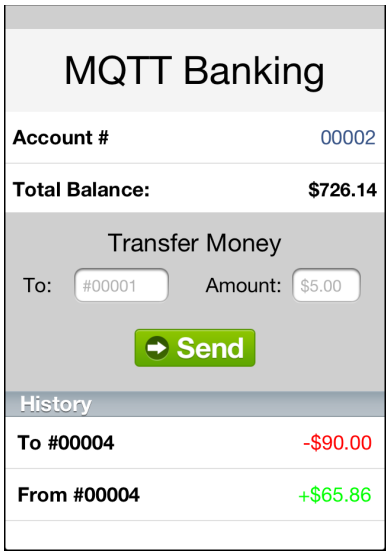


Demo 2

iOS



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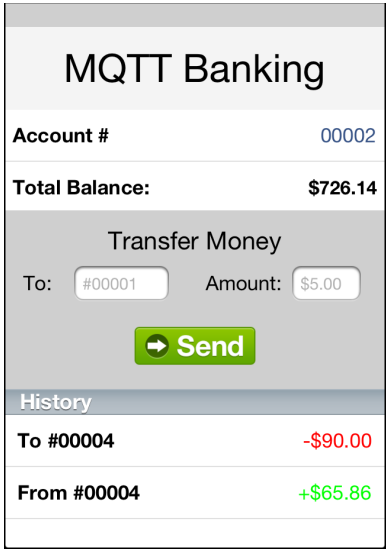

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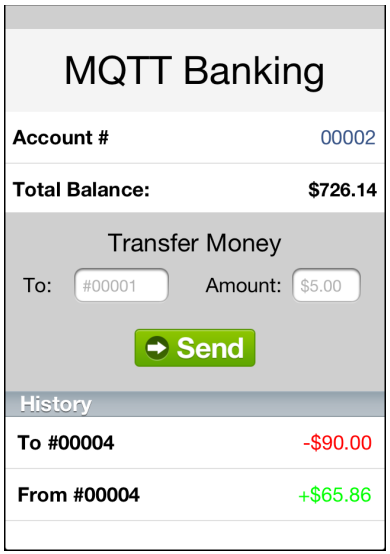

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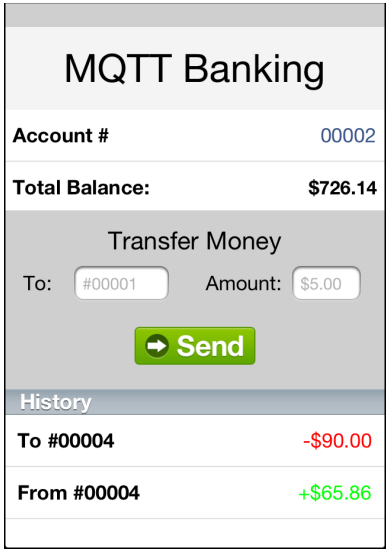

Questions & Answers