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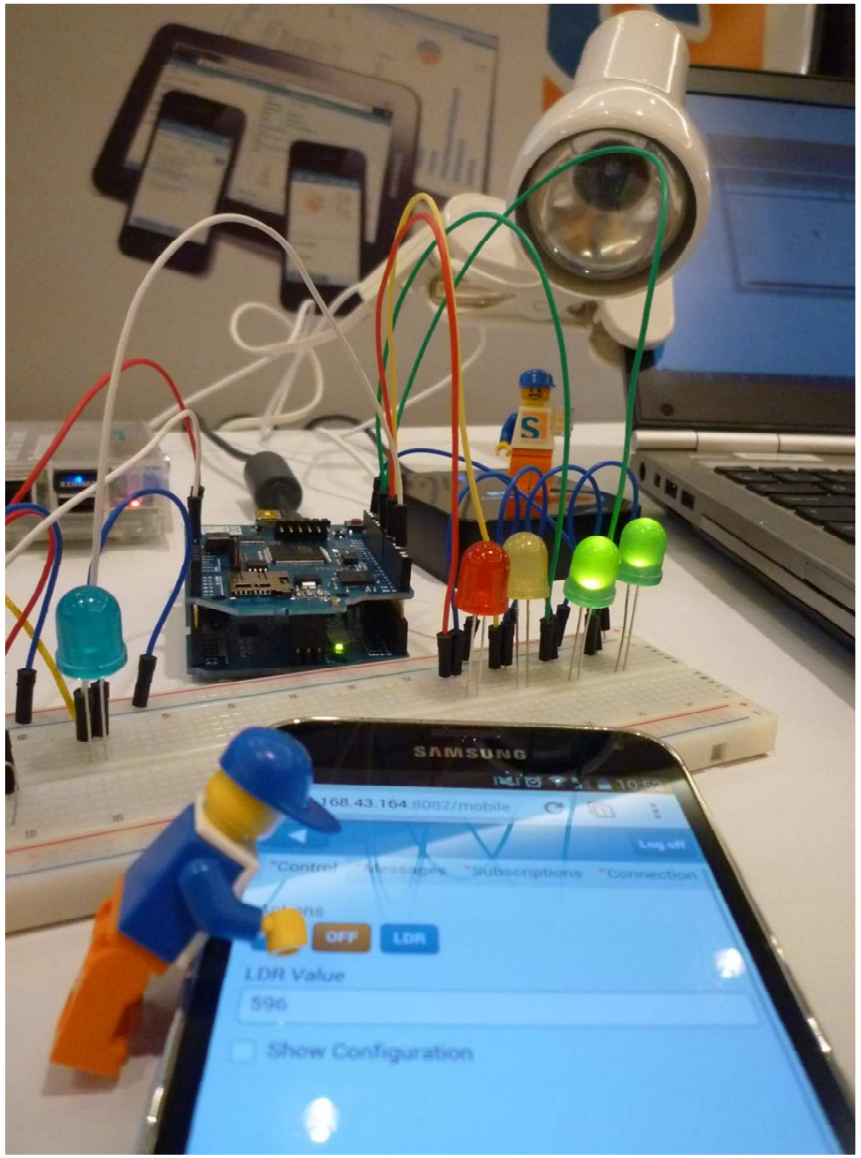
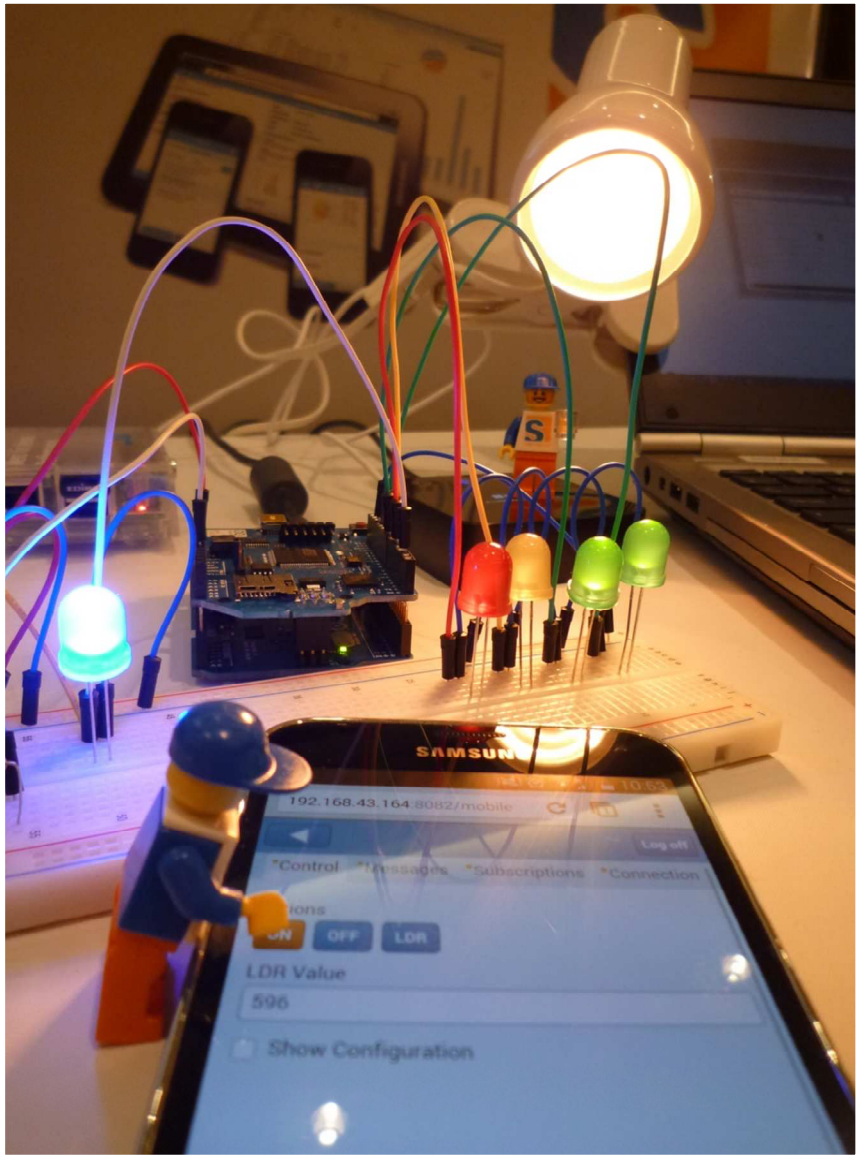
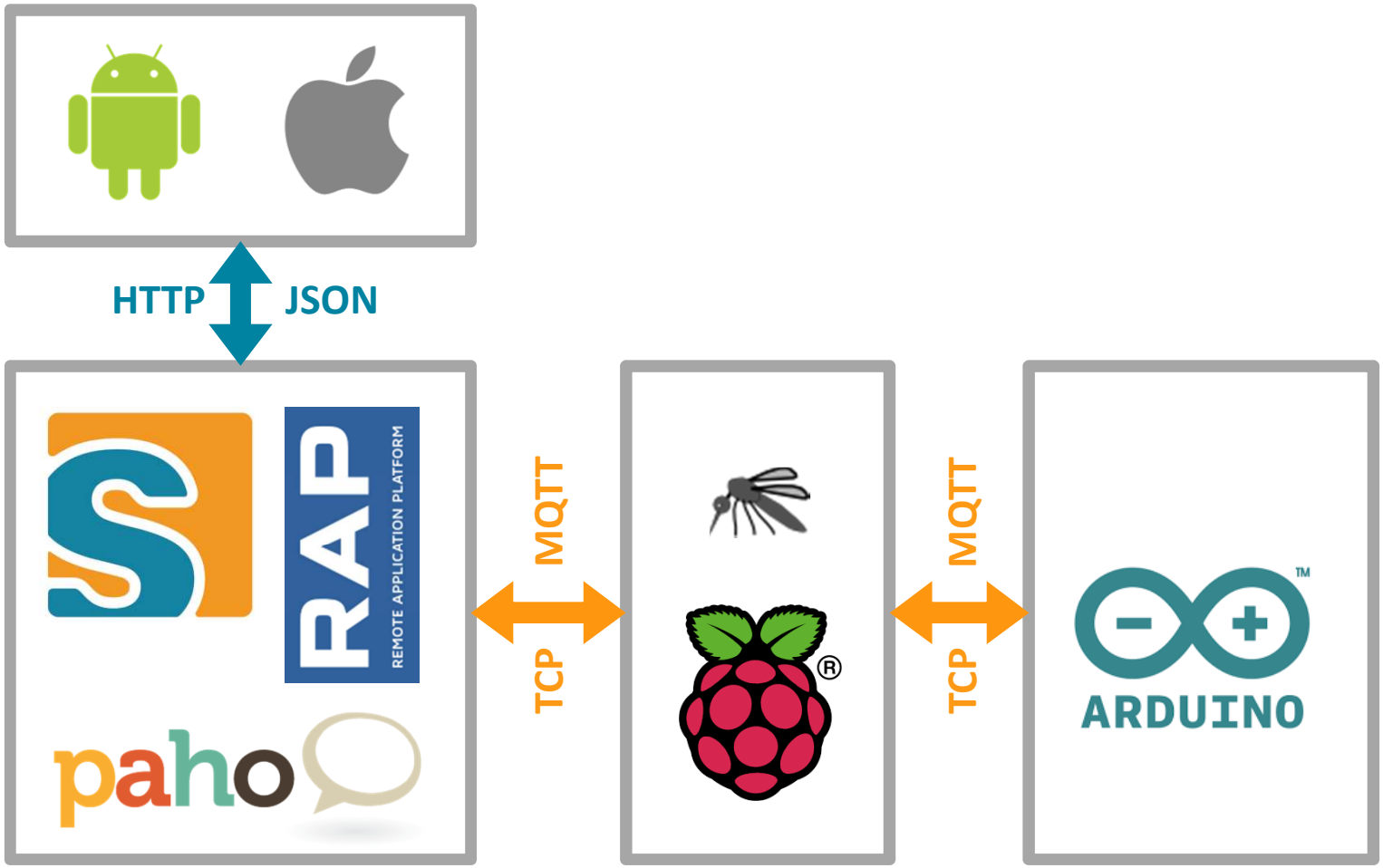
Build your own Open Source IoT Project From A to Z

Javaland 2015, Matthias Zimmermann


SAMSUNG
Log off
OFF
LDR
LDR Value
596
Show Configuration


SAMSUNG
192.168.43.164:8082/mobile
Log off
*Control
*Messages
*Subscriptions
*Connection
OFF
LDR
LDR Value
596
Show Configuration

Complete Setup



Why IoT?
Why Open Source?
Why your Project?

Why IoT?

«The IoT can potentially transform nearly every industry to change the way we live and work, locally and globally. »

www.cisco.com

Why Open Source?

- ➔ Faster Innovation
- ➔ Better Quality / Security
- ➔ Lower Business Risk
- ➔ Lower Costs

Why your own IoT Project?

MQTT Protocol

What is MQTT?

MQTT is a Protocol for the IoT

- ➔ Publish Subscribe
- ➔ Open and Standardized
- ➔ Simple
- ➔ Efficient
- ➔ Robust

MQTT is Open and Standardized

Open

- ➔ Vendor Neutral, tons of Implementations
- ➔ ~ 20 Brokers: Mosquitto, Apache ActiveMQ, …
- ➔ ~ 60 Clients: Arduino, C/C++, Java, Objective C, …

Standardized

- ➔ MQTT v3.1.1 is an OASIS Standard

MQTT is Simple

5 Protocol Verbs

- ➔ connect
- ➔ publish
- ➔ subscribe
- ➔ unsubscribe
- ➔ disconnect

3 Callbacks

- ➔ deliveryComplete
- ➔ messageArrived
- ➔ connectionLost

MQTT is Efficient

Broker

➔ Can handle many 10k clients

Client

➔ Small footprint (e.g. Java 147KB without JRE)

Receiving Messages (compared to HTTPS)

➔ 100x more messages

➔ 100x less energy

Sending Messages

➔ 10x more messages

➔ 10x less energy

MQTT is Robust

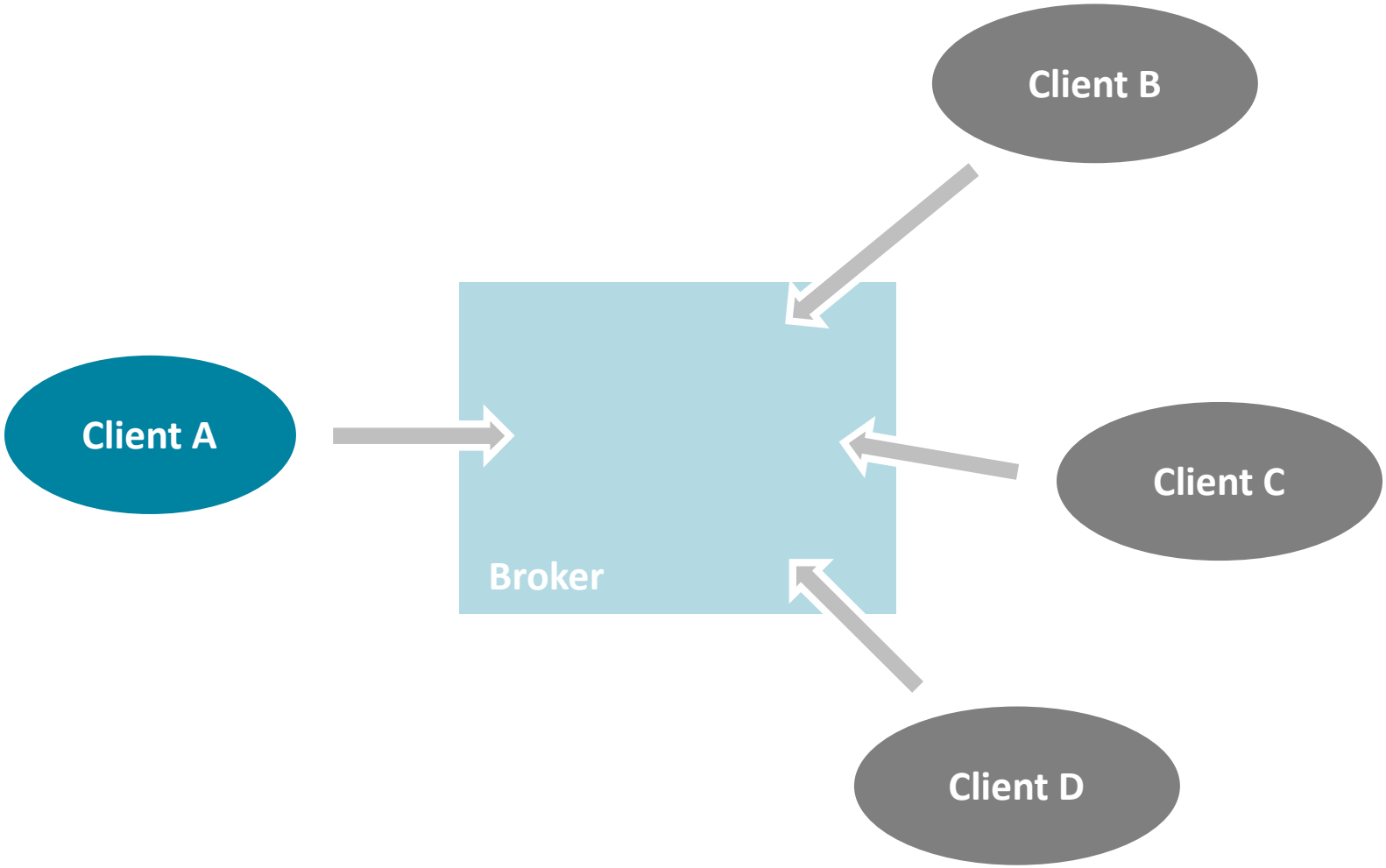
MQTT works for Networks with

- ➔ Low bandwith
- ➔ High latency
- ➔ Unreliable
- ➔ High cost per byte

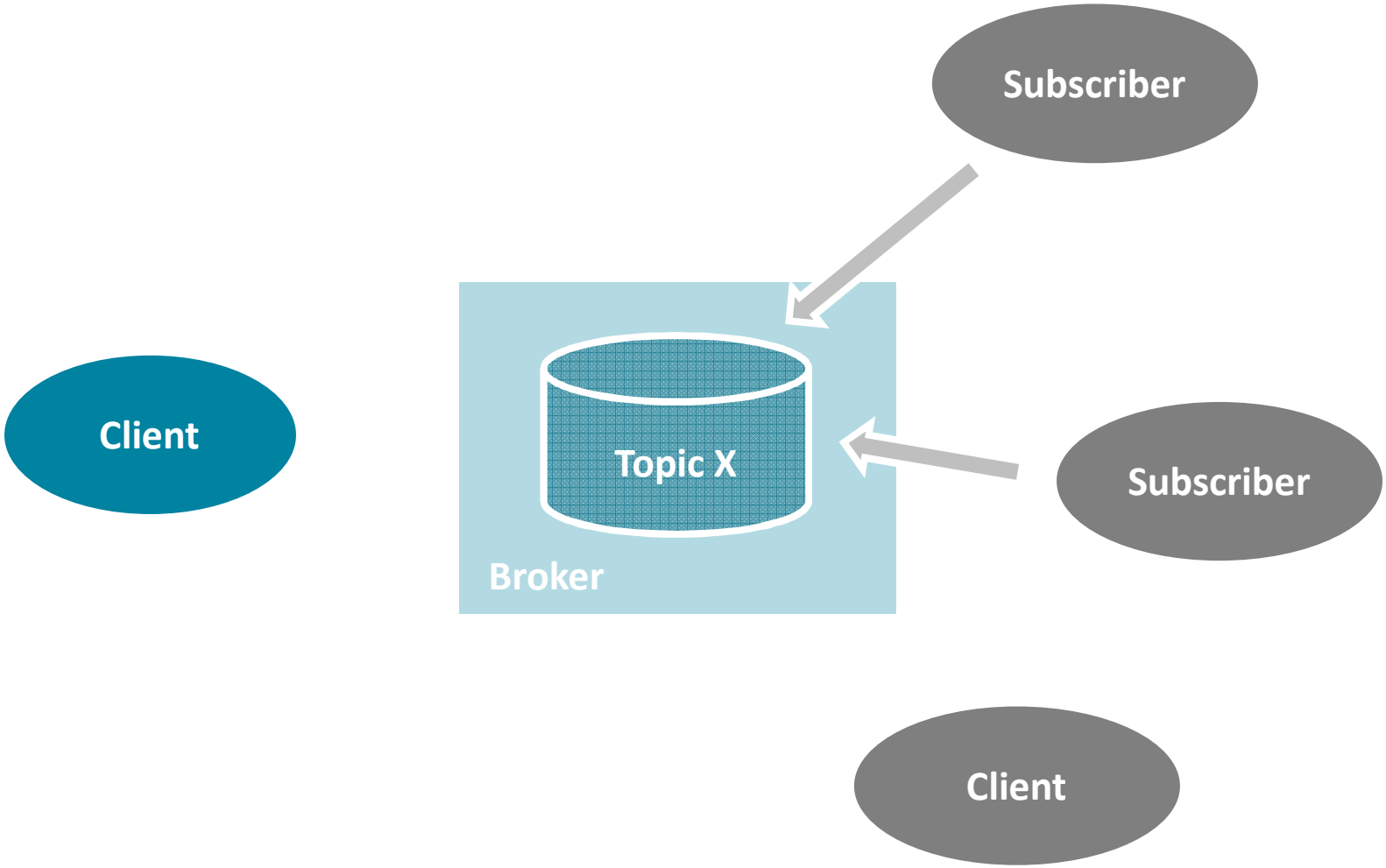
Networks

- ➔ Typically TCP
- ➔ But also VSAT, GPRS, 2G….

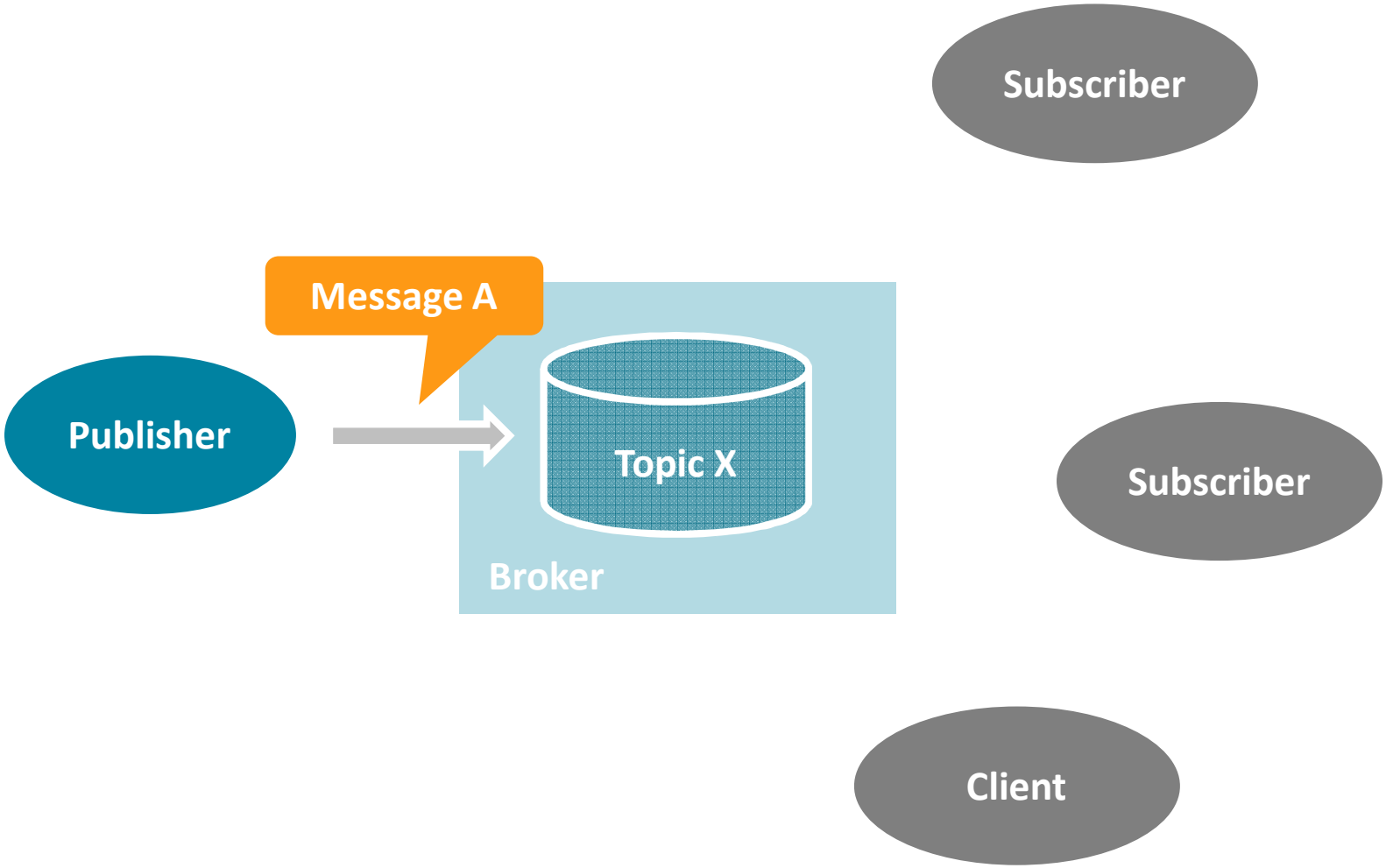
Connect to Broker



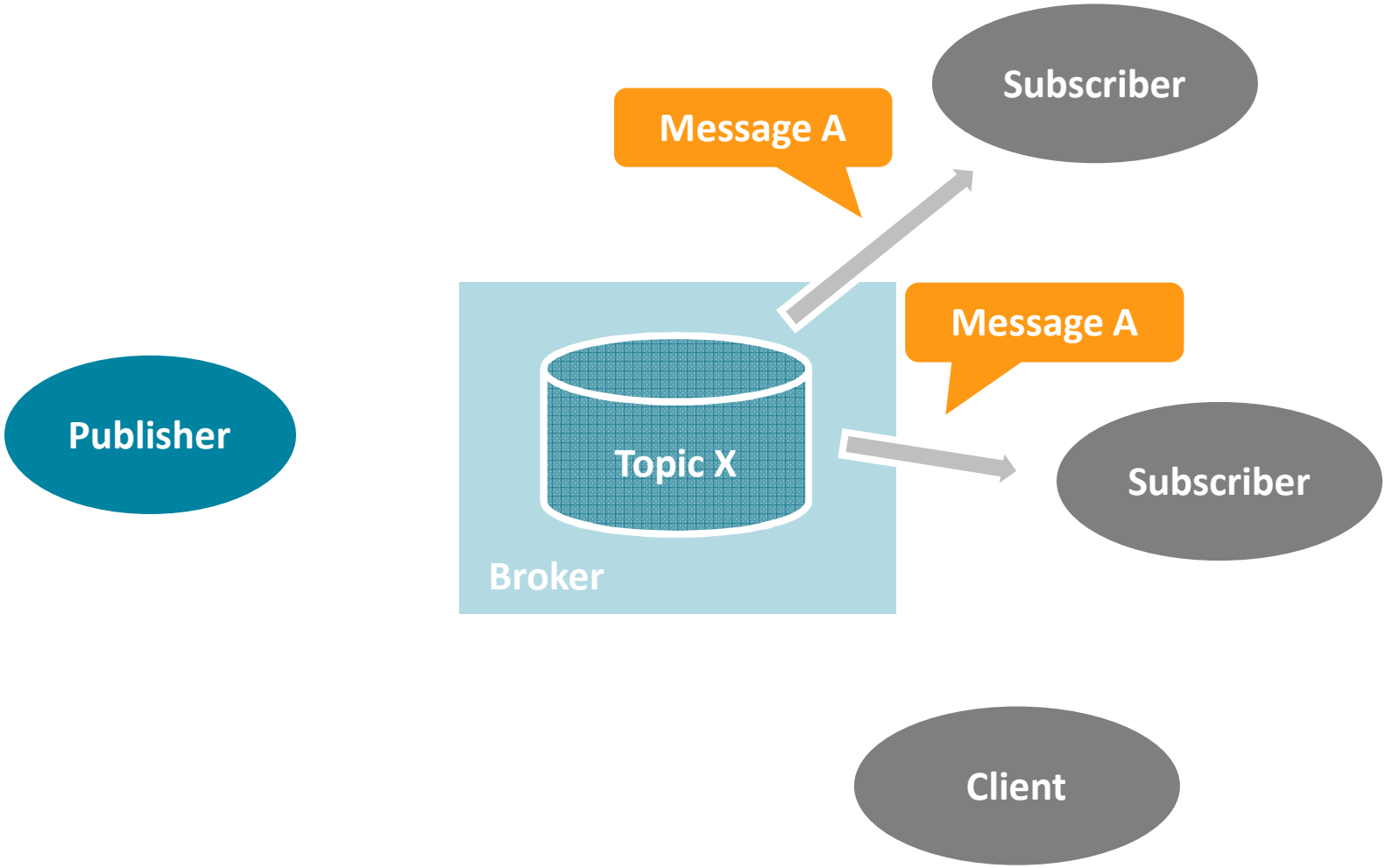
Subscribe to Topic «X»



Publish «A» to Topic «X»



Broker forwards «A» to Subscribers of «X»



MQTT Topics

Needed to Publish and Subscribe

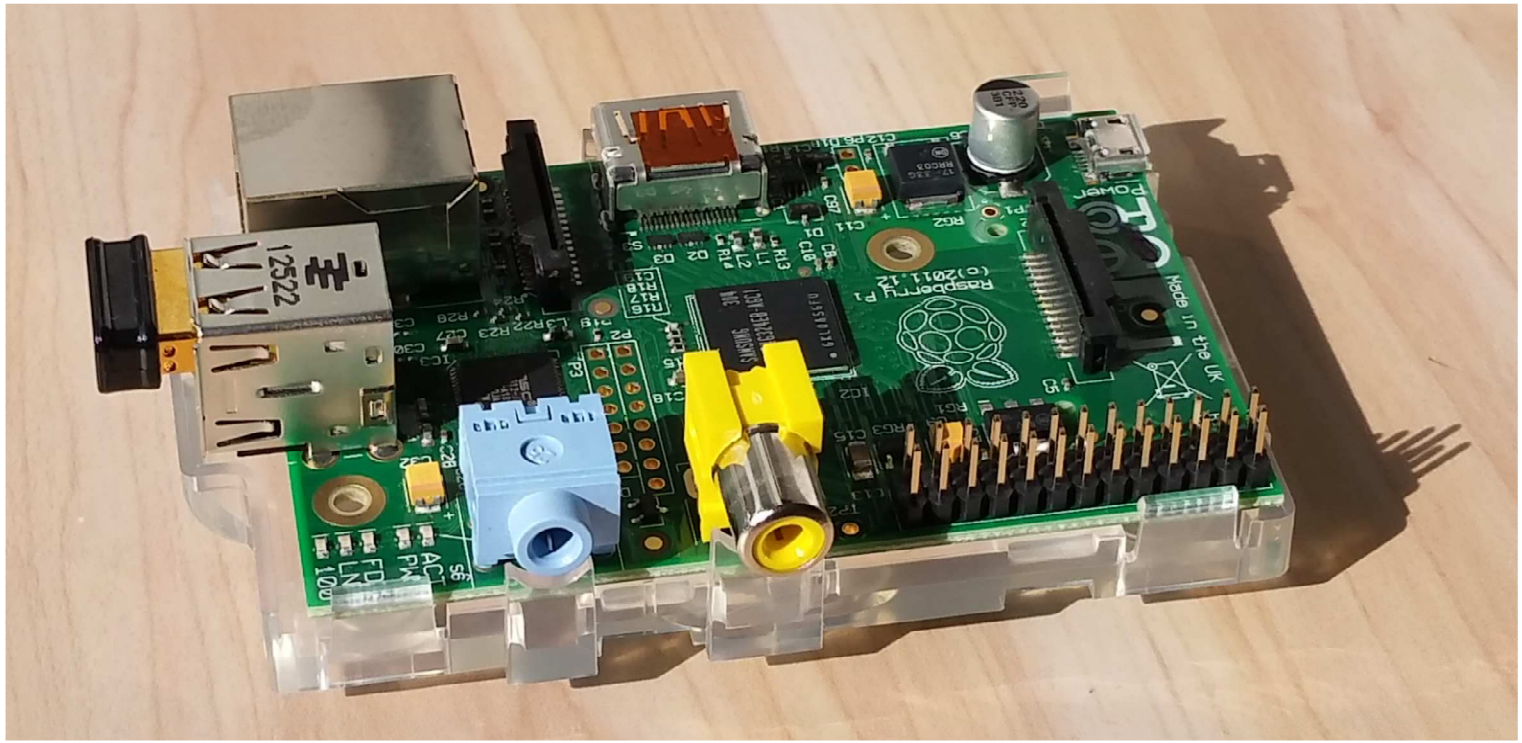
- ➔ Publish Message to a Topic
- ➔ Subscribe a Topic (-Filter)

Topic Organization

- ➔ String of one or more UTF-8 chars
- ➔ Topic separator *“/“* used to seprate topic into levels
- ➔ Examples
  - *bsiag.com/munich/4thfloor/temperature/last*
  - */Bundesliga/Game/BER/BAY*
  - *262a1843-589e-4067-a773-03fbe663bc5e*

The MQTT Broker

The MQTT Broker

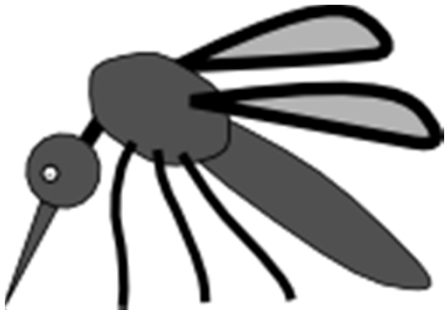


Raspberry Pi with Mosquitto and a USB WiFi Adapter

Mosquitto

Open Source MQTT Broker

- ➔ Eclipse IoT Project
- ➔ Lightweight
- ➔ Written in C
- ➔ Executables for Windows, OSX, Linux, and Raspberry Pi

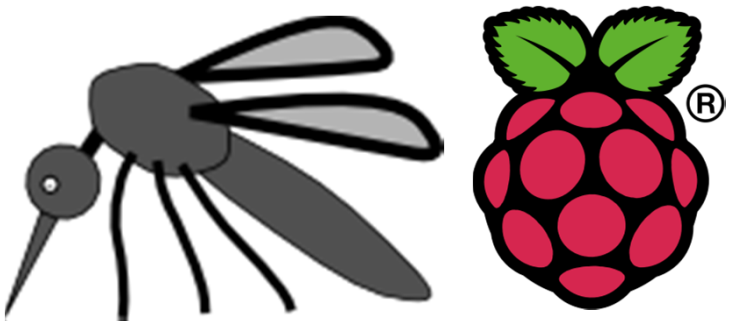


https://www.eclipse.org/mosquitto/
http://mosquitto.org/

Mosquitto on Raspberry Pi

Step-by-Step

1. Prepare SD Card
2. Download and Copy Noobs to SD Card
3. Connect Raspberry to Keyboard, Screen, Mouse, Power
4. Configure Raspberry
5. Add USB WiFi dongle and connection
6. Add Mosquitto Broker
7. Reboot frequently ☺

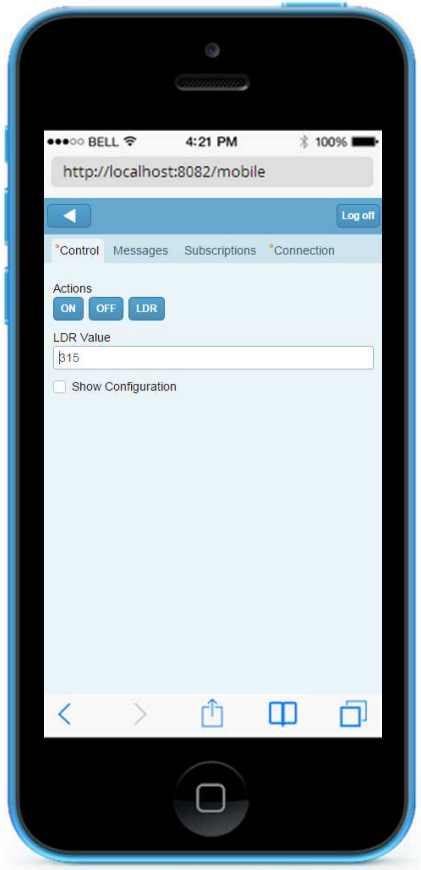


Links that helped

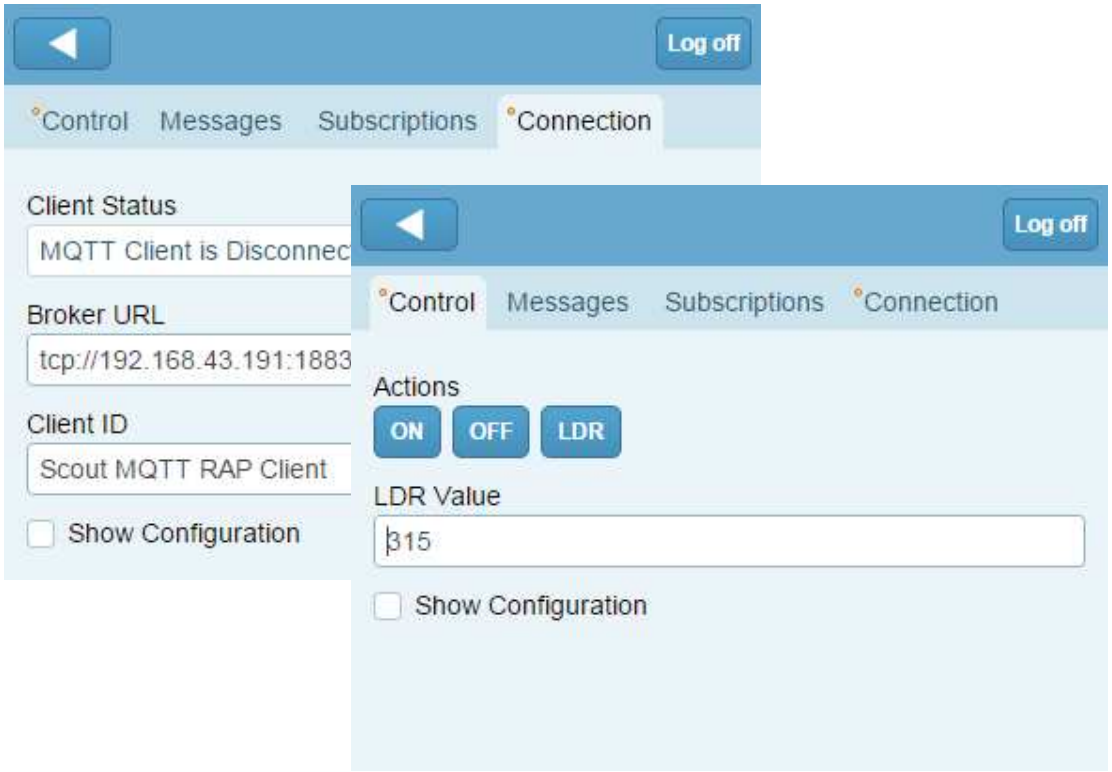
- **SD Card**
  http://www.raspberrypi.org/help/noobs-setup/
- **Noobs**
  http://www.raspberrypi.org/downloads/
- **Add WiFi**
  http://weworkweplay.com/play/automatically-connect-a-raspberry-pi-to-a-wifi-network/
- **WiFi USB Dongle**
  Go for the **Edimax EW-7811Un**
- **Mosquitto**
  http://jpmens.net/2013/09/01/installing-mosquitto-on-a-raspberry-pi/

The MQTT Scout Client

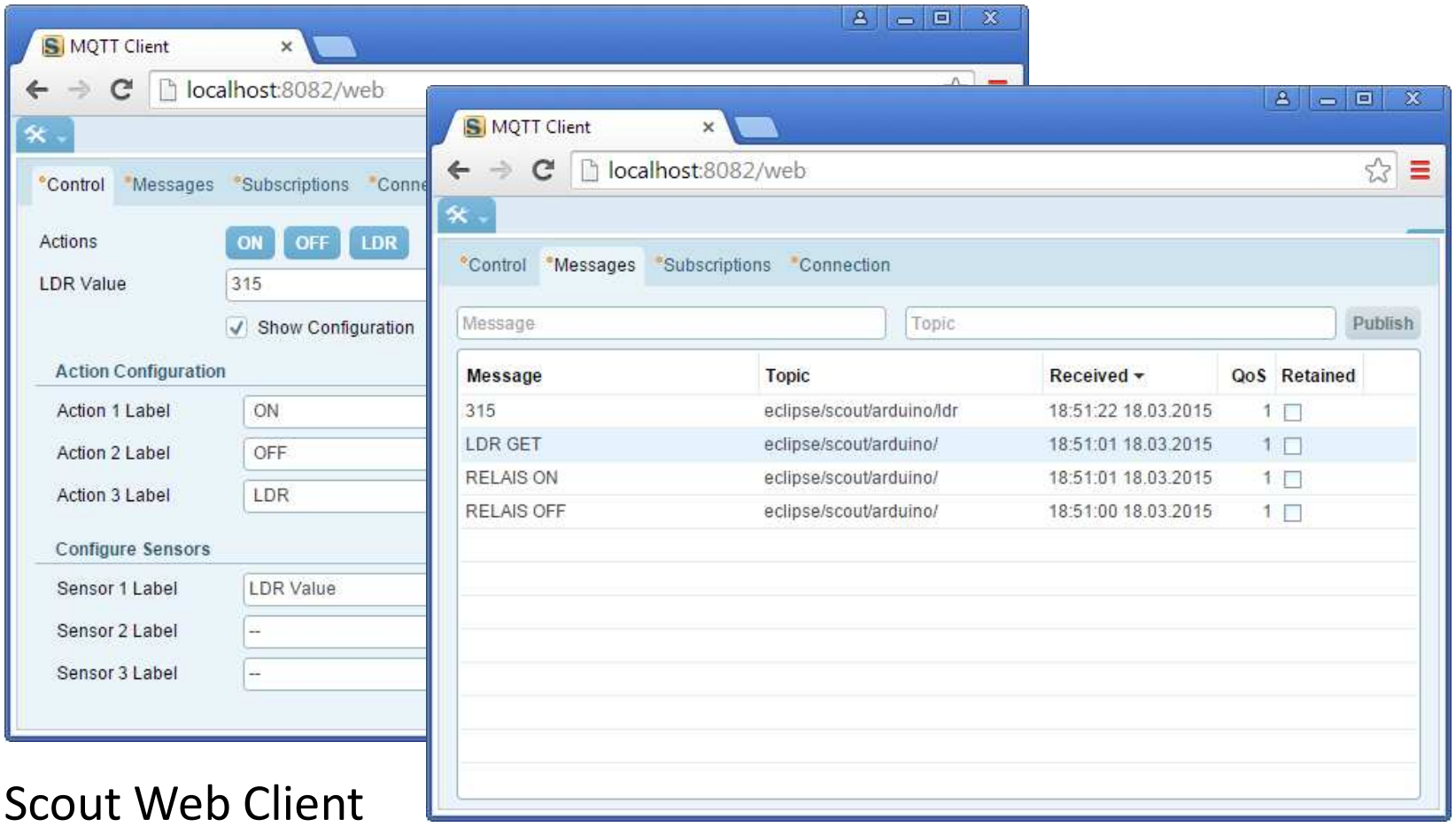
The MQTT Scout Client



Scout Mobile Client



The MQTT Scout Client



Scout Web Client

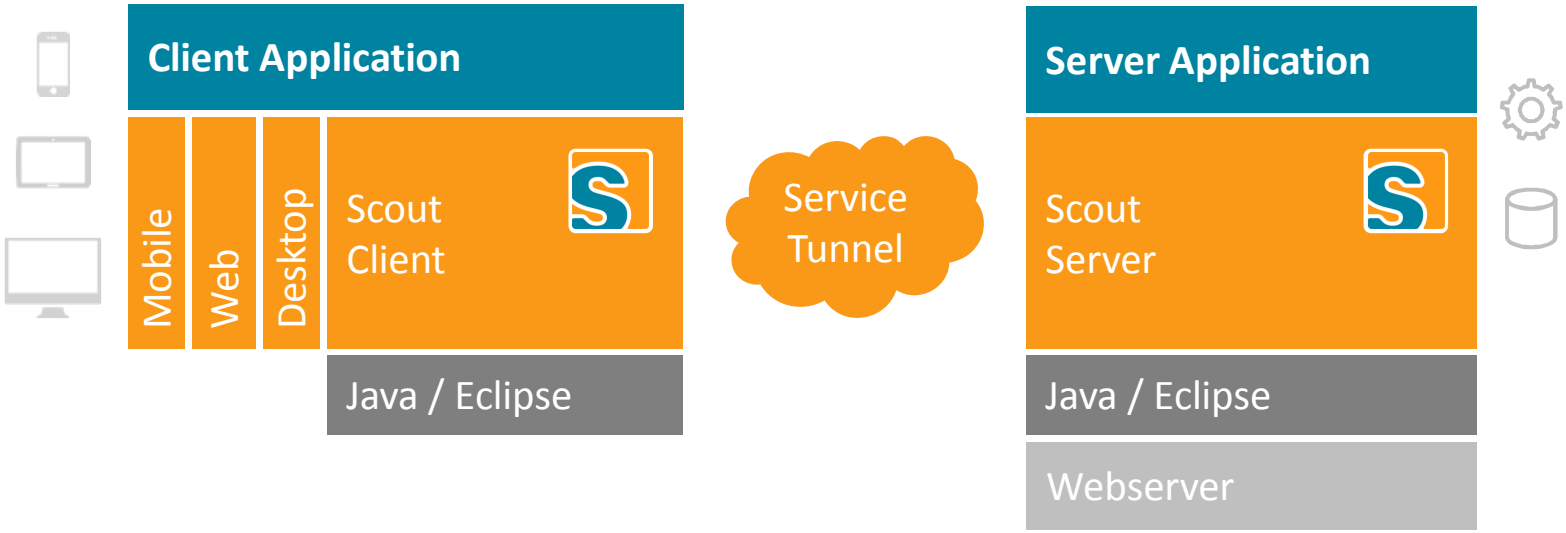
Eclipse Scout

Open Source Application Framework

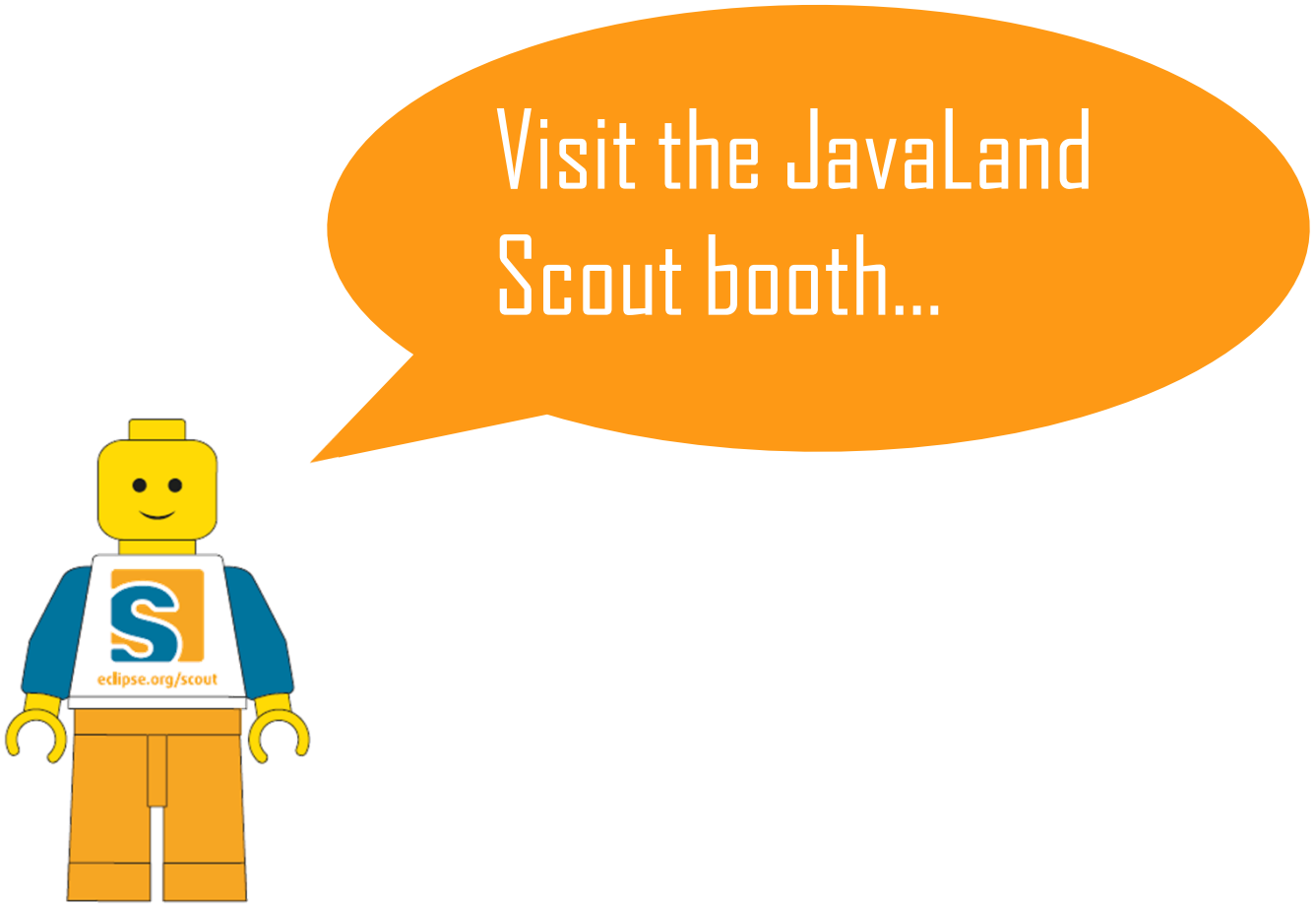
- Eclipse Technology Project
- Multi Device Support (Desktop, Web, Mobile)
- Client Server Architecture
- Scales well for large Applications
- Simple to learn
- Based on Java / Eclipse
  → 2016 pure Java Framework

https://www.eclipse.org/scout

Scout Architecture



Learn more about Scout



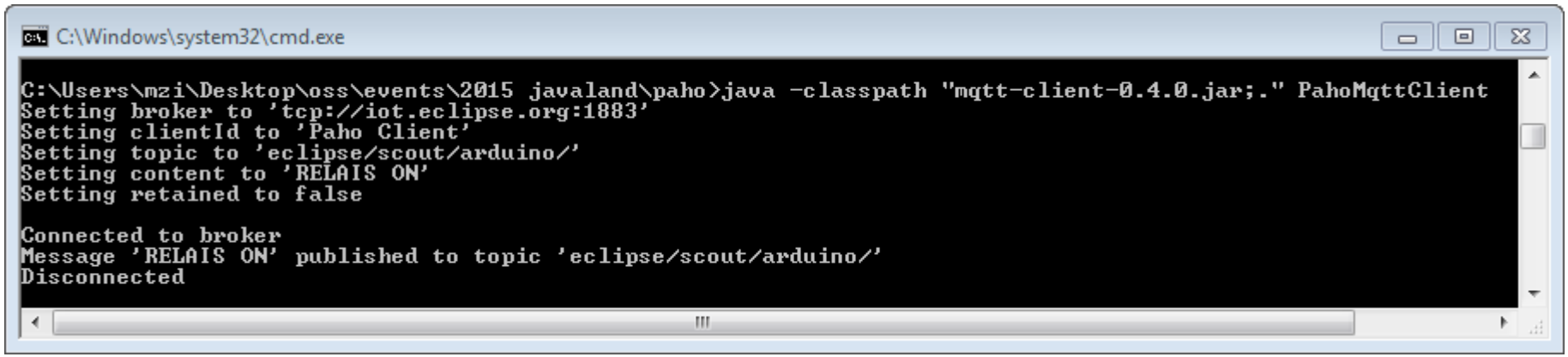
Scout MQTT Client

Step-by-Step

1. Download and Install Eclipse Scout
   https://www.eclipse.org/downloads/
2. Clone the MQTT Scout Github Repo
   https://github.com/BSI-Business-Systems-Integration-AG/mqtt.git
3. Open Scout IDE with empty workspace
4. Import plugins in scout subfolder of cloned project

The MQTT Paho Client

The MQTT Paho Client



Paho Command Line Client

Paho

Open Source MQTT Client Implementations

- ➔ Eclipse IoT Project
- ➔ Client Libraries in C/C++, Java, JavaScript, Python, C#
- ➔ Java Library very simple to learn

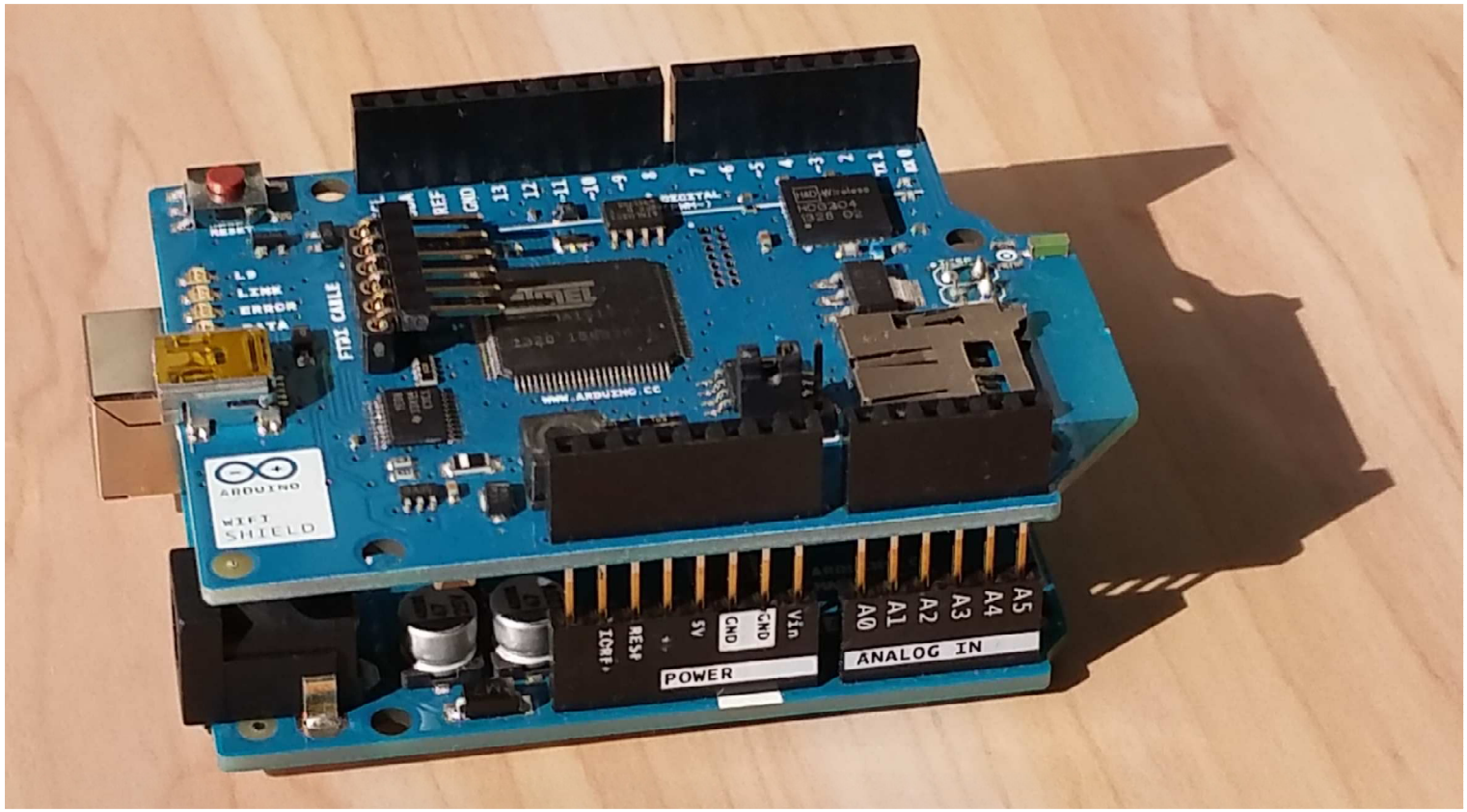
https://www.eclipse.org/paho

Paho

```
 7  public class PahoMqttClient {
 8
 9      static String broker       = "tcp://iot.eclipse.org:1883";
10      static String clientId     = "Paho Client";
11      static String topic        = "eclipse/scout/arduino/";
12      static String content      = "RELAIS ON";
13
14      public static void main(String[] args) {
15          if(args.length == 2) {
16              topic = args[0];
17              content = args[1];
18          }
19
20          printConfiguration();
21
22          try {
23              MemoryPersistence  persistence = new MemoryPersistence();
24              MqttClient         client      = new MqttClient(broker, clientId, persistence);
25              MqttConnectOptions opts        = new MqttConnectOptions();
26              MqttMessage        message     = new MqttMessage(content.getBytes());
27
28              client.connect(opts);            System.out.println("Connected to broker");
29              client.publish(topic, message);  System.out.println("Message '"+content+"' publi
30              client.disconnect();             System.out.println("Disconnected");
31
32              System.exit(0);
33          }
34          catch(MqttException me) {
35              me.printStackTrace();
36          }
37      }
```

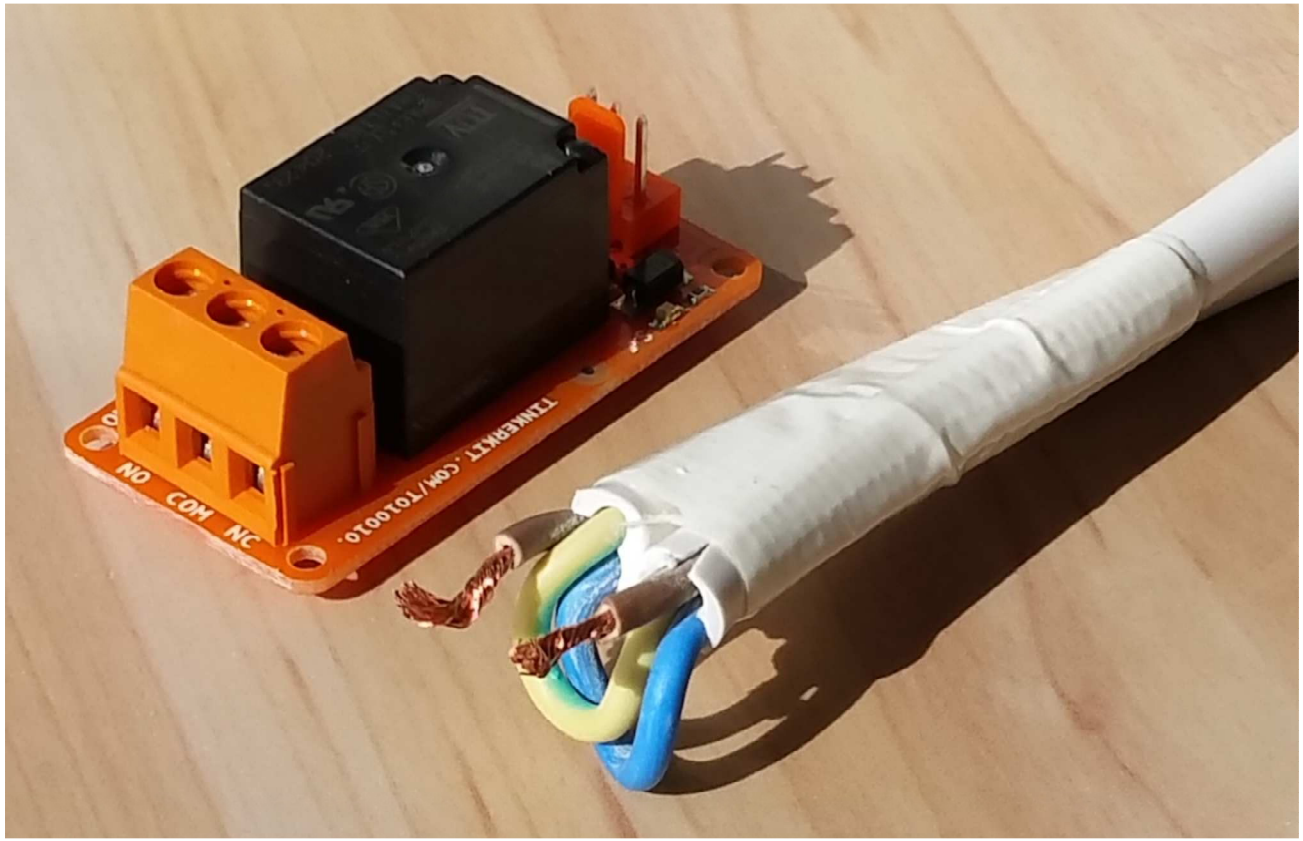
The MQTT Arduino Client

The MQTT Arduino Client



Arduino Uno with the Arduino WiFi Shield

The MQTT Arduino Client



Relay with modified Power Cable

Arduino PubSubClient

Open Source Client Library for the Arduino

- ➔ Works out of the box
- ➔ Very simple to use
- ➔ QOS 1,2 messaging NOT supported

https://github.com/knolleary/pubsubclient
http://knolleary.net/arduino-client-for-mqtt/

Simple Arduino Sketch

mqtt_basic

```
#include <SPI.h>
#include <Ethernet.h>
#include <PubSubClient.h>

// Update these with values suitable for your network.
byte mac[]    = {  0xDE, 0xED, 0xBA, 0xFE, 0xFE, 0xED };
byte ip[]     = { 172, 16, 0, 100 };
byte server[] = { 172, 16, 0, 2 };

void callback(char* topic, byte* payload, unsigned int length) { }
EthernetClient ethClient;
PubSubClient client(server, 1883, callback, ethClient);

void setup() {
  Ethernet.begin(mac, ip);
  if (client.connect("arduinoClient")) {
    client.publish("outTopic","hello world");
    client.subscribe("inTopic");
  }
}

void loop() {
  client.loop();
}
```

Arduino MQTT Client

Step-by-Step

1. Download and Install Arduino IDE
   http://arduino.cc/en/Main/Software
2. Clone the MQTT Scout Github Repo
   https://github.com/BSI-Business-Systems-Integration-AG/mqtt.git
3. Open mqttClient.ino Sketch in Arudino IDE
   And fix WiFi Settings/MQTT Broker for you Setup
4. Put WiFi Shield on Arduino Uno and add Electronics
5. Connect Arduino to Computer
6. Upload Script

The MQTT Arduino Client

What it does

1. Setup Input/Output Pins
2. Finds correct WiFi
3. Connects to WiFi
4. Connects to MQTT Broker
   and subscribes to eclipse/scout/arduino
5. Listens for Commands
   - RELAY ON → Switches Lamp On
   - RELAY OFF → Switches Lamp Off
   - LDR GET → Publishes LDR to eclipse/scout/arduino/ldr

Wrap Up

What have we done?

We learned about a specific IoT project setup

- From Mobile Phone to Arduino and Back
- MQTT Protocol
- Mosquitto Broker
- Paho Client Library
- Eclipse Scout Framework
- Arduino IDE with PubSub Library
- Breadboard with Electronics and AC Relay

What have we missed?

1. Many other IoT Protocols
2. Many other Devices
3. IoT and Cloud
4. Security
5. …

What next?

Thanks !