IoT Engineering
10: Rule-based Integration of IoT Devices

Slides: tmb.gr/iot-10

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Overview

These slides introduce *integration of IoT devices*.

How a sensor can trigger a (remote) actuator.

How multiple devices can be combined.

How to talk to third party products.

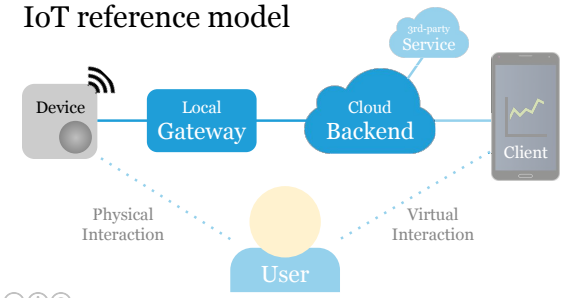
Prerequisites

The Raspberry Pi with Node-RED will be our gateway.

We use curl and the mqtt CLI tool to emulate devices.

And the Feather Huzzah ESP8266 as a real device.

IoT reference model



Remote sensing

Sensor → Device → Gateway → Backend → Client

Data is sent from a device, to a client, via a backend.

E.g. air quality sensor measurements sent to a map.

A → *B* means data flows from A to B.

Remote control

Client → Backend → Gateway → Device → Actuator

Control data is sent to a device and on to an actuator.

E.g. app sends command via backend to dim a light.

Or a stormy weather service triggers a blind to go up.

Remote sensing and control can be integrated.

Levels of control

Thin API, providing detailed access to the hardware:
`PUT https://MY_HOUSE/room/lamp?color=0xffffff`

Simple, easy to use API, lamp chooses color settings:
`PUT https://MY_HOUSE/room/lamp?state=on`

Semantically rich API, involving multiple devices:
`PUT https://MY_HOUSE/room?scene=relax`

HTTP is an implementation detail here.

Hands-on, 5': Where is the logic?

Who decides what a scene means in terms of color, the lamp/device, a room/gateway or the backend?

Which information is required to make a decision?

Which devices are affected by changing a scene?

Which trade-offs does placing the logic involve?

Logic trade-offs

Logic on the backend or client, "in the cloud" — one central place to change functionality for all devices.

Logic on the gateway, "at the edge" — less latency, adapted to local topology, but local information only.

Logic on the device — works when a device is offline, but requires per device firmware update for changes.

Rule-based integration

Control data is sent based on sensor measurements.

Rules describe the conditions which trigger events.

Integrating sensors & actuators of separate devices.

Integration can happen at different levels.

Integration on the backend

Client ← Backend ← Gateway ← Device ← Sensor
→ Gateway → Device → Actuator

Rules on backend integrate 2..n devices in n locations.

E.g. Nest thermostat, learning based on global data.

Integration on the gateway

Client ← Backend ← Gateway ← Device ← Sensor
→ Device → Actuator

Rules on gateway integrate 2..n devices in 1 location.

E.g. a building automation system controlling heat.

Message brokers

A simple way to integrate devices is through a broker.

E.g. a button can publish its state (*on* or *off*) to a topic.

And a lamp device can subscribe to the button's topic.

Or a 3rd party can create the link, to keep them apart:

Subscribe to the button, publish to the lamp's topic.

Glue code

Glue code works well to integrate devices and services.

E.g. as the 3rd party in the previous (broker) example.

Or as a bridge from a local broker to a cloud backend.

The code can inspect and transform messages.

Node-RED

Node-RED enables flow-based programming for IoT.

The tool/service runs on a gateway or "in the cloud".

A Web UI allows users to connect devices & services.

Program flows can be exported/imported as JSON.

Modular nodes allow using 3rd-party functionality.

Installing Node-RED

To install & run Node-RED on the Raspberry Pi, type:

```
$ sudo apt-get install build-essential
$ bash <(curl -sL https://raw.githubusercont\
ent.com/node-red/linux-installers/master/deb\
/update-nodejs-and-nodered)
```

To enable autostart of Node-RED on reboot, type:

```
$ sudo systemctl enable nodered.service
```


Securing Node-RED

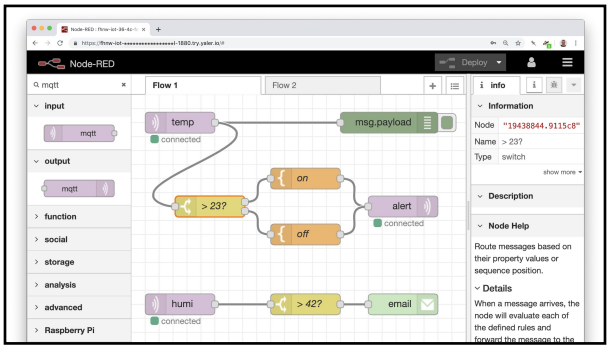
To hash and set the password for your Node-RED user:

```
$ sudo npm install -g node-red-admin
$ node-red-admin hash-pw
$ nano .node-red/settings.js
adminAuth: { // TODO: find, uncomment this part
  type: "credentials",
  users: [{ username: "USERNAME", // TODO
    password: "PASSWORD_HASH", // TODO
    permissions: "*"}]},
```


Accessing Node-RED

To access Node-RED on the Raspberry Pi, either:

- Connect to the same network, then access the Node-RED Web UI at `http://RASPI_IP:1880/`
- Make 127.0.0.1 port 1880 of the Pi accessible via a relay service like Ngrok, PageKite or Yaler.



How Node-RED works

Node-RED maps inputs to outputs with functions.

Functions can aggregate, switch, transform, etc.

The basic unit of information is a message.

A message has a payload and metadata.

For details, see Node-RED docs.

Node-RED MQTT client

Use the *mqtt* node to act as a publisher or subscriber.

Subscribe to messages, publish alerts to another topic.

Subscribe to local messages, publish them to the cloud.

Act depending on the value of the message payload.

Node-RED HTTP Web service

Make a Web service with *http* & *http-response* nodes.

Receive Webhook calls, transform the body payload.

Forward HTTP Webhook data to an MQTT broker.

Or use the *http request* node to (also) be a client.

Hands-on, 15': Node-RED

Install Node-RED on the Raspberry Pi or your laptop.

Create a new flow or import & analyse one from here.

Use the *debug* node to build your flow step-by-step.

Integration on a 3rd party service

Service* ← Backend_1 ← Gateway ← Device ← Sensor
→ Backend_n → Gateway → Device → Actuator

3rd party integrates 2..n devices/connected products.

Integration is done via product specific backend APIs.

Rules specify how a sensor input triggers actuators.

A typical example for this is IFTTT, see next slide.

IFTTT

IFTTT enables the integration of devices and services.

"if this then that" *applets* connect *triggers* to *actions*.

Devices trigger *events* or are controlled by an action.

Many connected products have IFTTT integrations*.

*Hue, Nest, Netatmo, Oticon, Ring, Withings, ...

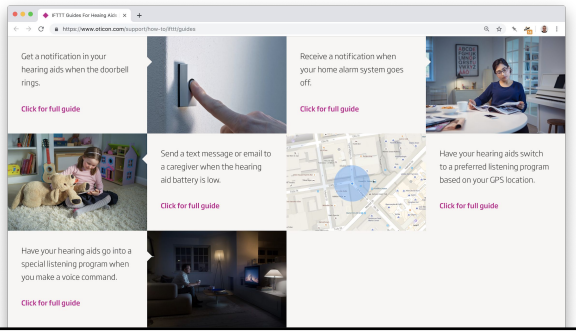
IFTTT applets

End-users can create an IFTTT applet themselves.

Each product or service has to be *connected* once.

Connecting here means getting API permissions.

After this setup step IFTTT keeps track of events.



IFTTT Webhooks

IFTTT Webhooks is a simple way to integrate devices.

It enables triggers and actions for quick prototyping*.

"Webhook" includes incoming and outgoing calls.

IFTTT sends or receives HTTP Web requests.

*Real products use the IFTTT platform API.

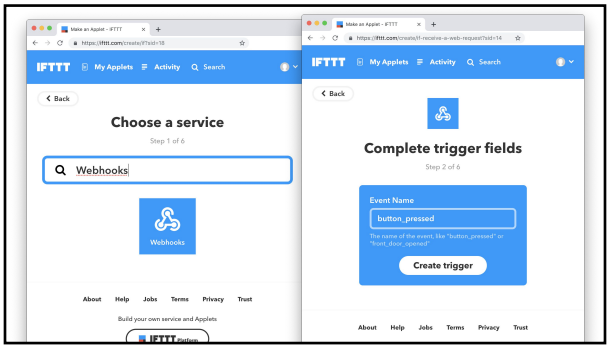
IFTTT Webhook trigger

IFTTT can receive Web requests to *trigger* an *event*.

To get a *key*, see IFTTT Webhooks > *Documentation*.

```
$ curl -X -H "Content-Type: application/json"
-d '{"value1":"23","value2":"42"}'
https://maker.ifttt.com/trigger/MY_EVENT/with/
key/IFTTT_API_KEY
```

The POST request body and values are optional.



Hands-on, 15': IFTTT Webhook trigger

Imagine an IFTTT Webhook enabled button device.

Create an applet to send SMS if the button is pressed.

Emulate the *button_pressed* event using the curl tool.

Sketch the hardware and code to build such a button.

If time permits, implement your connected button.

IFTTT Webhook action

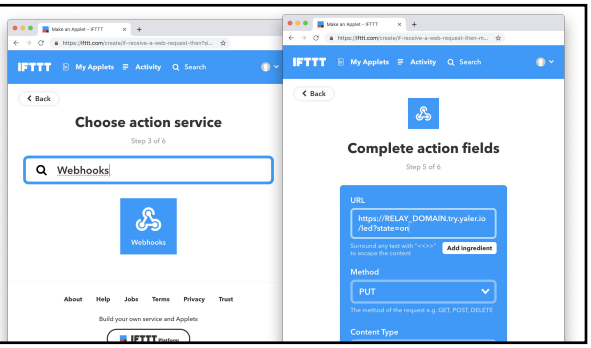
IFTTT can make a Web request as a resulting *action*.

The outgoing Webhook API calls a URL you provide.

It supports PUT and POST methods, among others.

The body can be JSON, URL-encoded or plain text.

Variable *ingredients* depend on the chosen trigger.



Hands-on, 15': IFTTT Webhook action

Create an IFTTT applet to show the weather on a LED.

Design a Web API* to set weather conditions or colors.

Where would you map weather conditions to colors?

Create a Postb.in to test the IFTTT Webhook call.

*Which would run e.g. on the ESP8266 or a Pi.

Summary

We've seen on which level integration can happen.

How integration is done with glue code or services.

On the gateway we used Node-RED to implement it.

In the backend we integrated products with IFTTT.

Next: Voice Control for Connected Products.

Feedback or questions?

Write me on https://fhnw-iot.slack.com/

Or email thomas.amberg@fhnw.ch

Thanks for your time.