Building IoT systems with openHAB

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Overview

- Timeline
- Frameworks and Protocols
- openHAB architecture
- openHAB features
- openHAB configuration
- openHAB examples
- Demo

IoT Timeline

- ARPANET online in 1969 with “things” talking Network Control Program (NCP)
- Internet born in 1983: ARPANET “things” start talking TCP/IP
- Trojan Room Coffee Pot goes on Internet in 1993
  - http://en.wikipedia.org/wiki/Trojan_Room_coffee_pot
- Kevin Ashton (Auto-ID) coins “IoT” in 1999
- Media goes into a frenzy about IoT that just won’t quit.
- openHAB started in 2010
- Thomas Ruecker’s Tweeting Toilet goes online, ushering in the Internet of Toilets (IoT) era in 2014
  - http://www.computerworld.com/article/2605093/laid-off-from-job-man-builds-tweeting-toilet.html

Frameworks

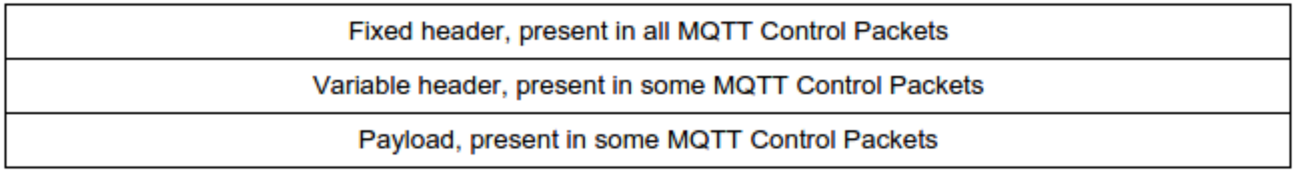
- AllJoyn - framework for distributed applications
  - https://allseenalliance.org/developers/learn/architecture
- IOTivity - framework for Machine to Machine(M2M) communication
  - https://www.iotivity.org/
- Kura - OSGi-based framework for M2M applications
  - https://eclipse.org/kura/
- Mihini - Lua-based M2M framework
  - https://eclipse.org/mihini/
- openHAB - Home Automation and IoT gateway framework
  - http://openhab.org
- ...

Protocols

- CoAP (Constrained Application Protocol)
  - request/response, low overhead, translates to HTTP
- MQTT
  - pub/sub, low overhead
- RESTful HTTP
  - request/response, one way from devices to service
- XMPP (Extensible Messaging and Presence Protocol)
  - pub/sub, built in authentication
- ...

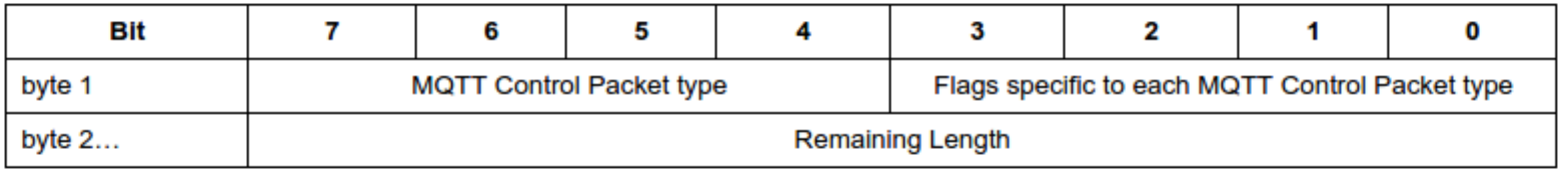
MQTT

- OASIS standard: MQTT v3.1.1
- Publish/Subscribe and hub/spoke model
  - MQTT brokers provides the communication hub
- Mosquitto 1.3.4 broker supports MQTT v3.1.1
- Fixed header required, variable header and payload optional



Fixed header, present in all MQTT Control Packets
Variable header, present in some MQTT Control Packets
Payload, present in some MQTT Control Packets

- Fixed header just 2 bytes



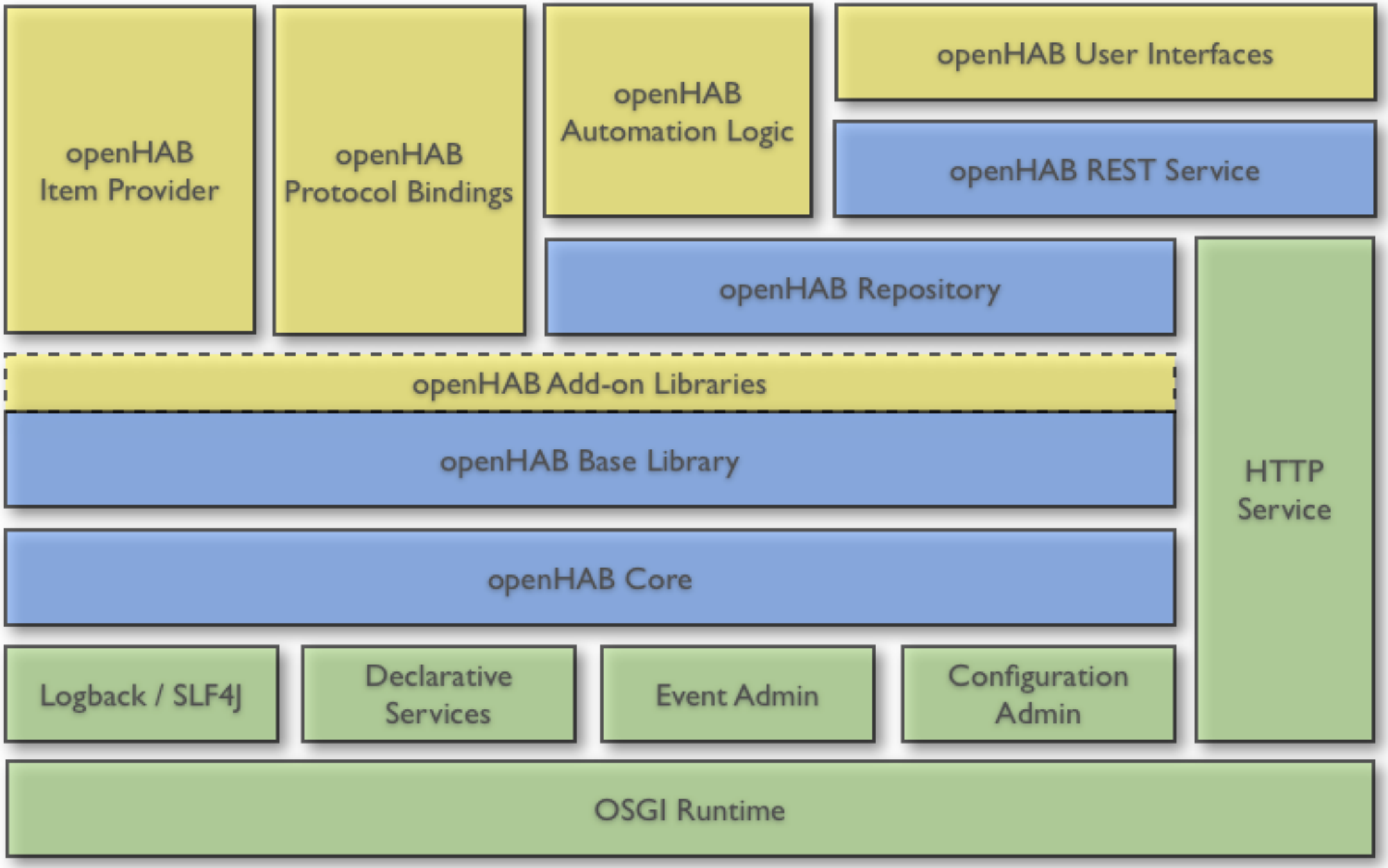
Bit	7	6	5	4	3	2	1	0
byte 1	MQTT Control Packet type				Flags specific to each MQTT Control Packet type			
byte 2…	Remaining Length							

openHAB basics

- FOSS automation software
- http://www.openhab.org
  - Eclipse Public License 1.0
- Written mostly in Java
  - *Java, UGH!*
- Central automation hub
- Hardware/protocol agnostic
  - Many bindings http://www.openhab.org/features-tech.html
- Component-based architecture
  - Each component is an OSGi bundle

openHAB Architecture Overview

- 🟨 openHAB Add-ons
- 🟦 openHAB Core Components
- 🟩 OSGi Framework



openHAB Item Provider

openHAB Protocol Bindings

openHAB Automation Logic

openHAB User Interfaces

openHAB REST Service

openHAB Repository

HTTP Service

openHAB Add-on Libraries

openHAB Base Library

openHAB Core

Logback / SLF4J

Declarative Services

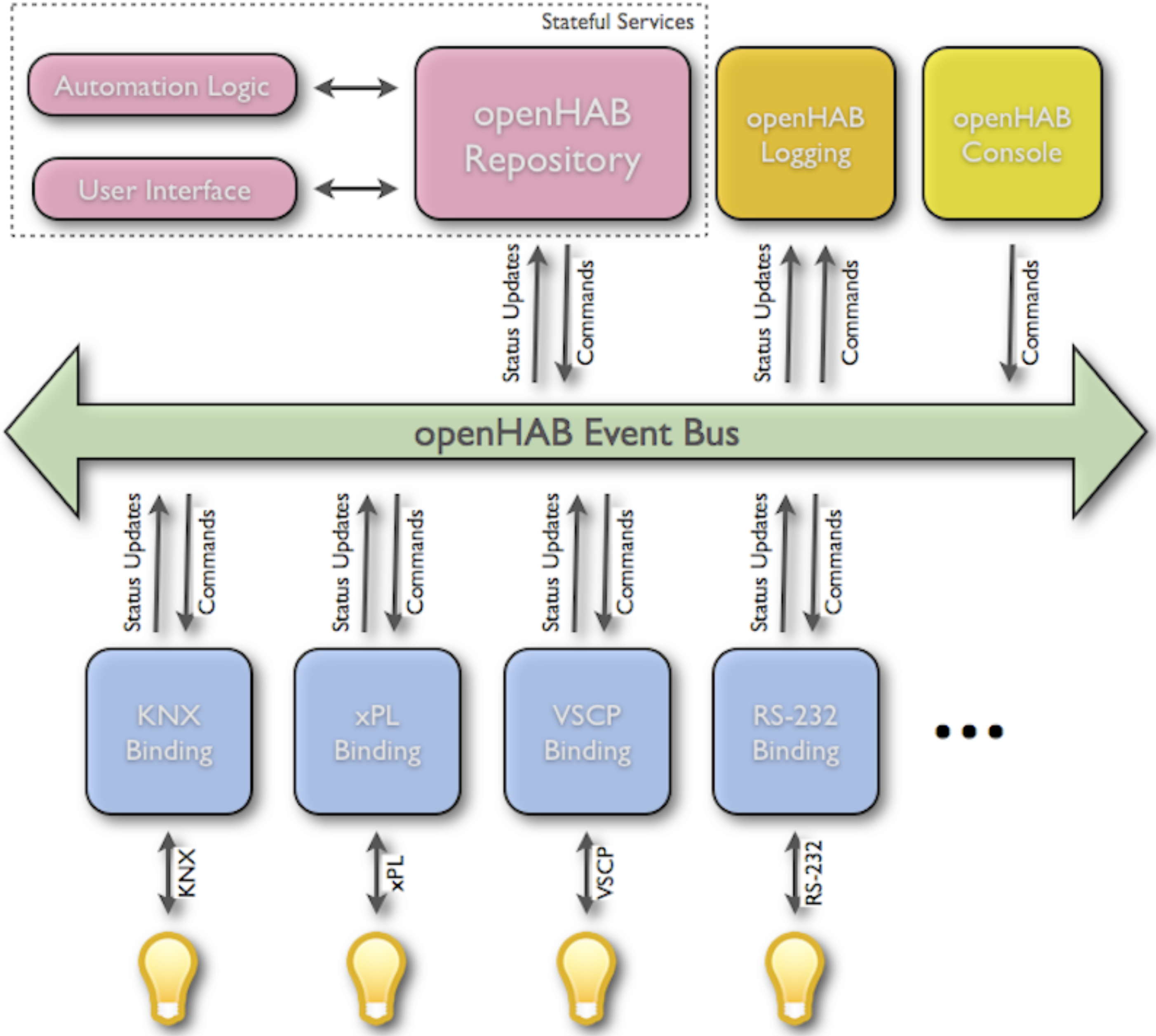
Event Admin

Configuration Admin

OSGI Runtime

openHAB architecture

- Event bus
  - Asynchronous communication bus
- Repository
  - Persistent storage
- Items
  - Objects that can be read or written
  - Have a type and state
- Bindings
  - Translate event bus events to/from external system
- Actions
  - Programmatic methods available for use by scripts/rules



Stateful Services

Automation Logic

User Interface

openHAB Repository

openHAB Logging

openHAB Console

Status Updates

Commands

openHAB Event Bus

KNX Binding

xPL Binding

VSCP Binding

RS-232 Binding

KNX

xPL

VSCP

RS-232

openHAB features

- Plugin framework
- Rules engine
- Logging mechanism
- UI abstraction
  - Sitemap - Tree structure of UI widgets
  - Item UI Providers - Dynamic UI configuration
- UI implementations
  - Web
  - Android
  - iOS
- Designer tool - graphic configuration of runtime

openHAB add-ons

- Actions
  - HTTP - access URL on event
  - Mail - ancient notification technology
  - Pushover/Prowl - notifications
  - Twitter - Tweet that your toilet flushed
- Bindings
  - Bluetooth - device proximity events
  - GPIO - Linux sysfs-based GPIO events
  - KNX - home automation events
  - MQTT - raw protocol support
  - OneWire - various sensor events
  - Serial - RS-232 will never die
  - ZWave - home automation events

Running openHAB

- Runs “well” on any x86 or ARM board with 512MB+ RAM
  - A resource hog like any other Java/Jetty/OSGi application
- OpenJDK or Oracle JREs are supported
  - Some bindings may not work on OpenJDK on ARM
- Packaged on some distros
  - Debian Cloudbees repository has the core and all bindings packaged
    - openhab-runtime
    - openhab-addon-*

    -
      ```
      $ cat /etc/apt/sources.list.d/openhab.list
      deb http://repository-openhab.forge.cloudbees.com/release/1.6.1/apt-repo/ /
      ```

openHAB configuration

```
$(openhab)/configurations/
                           openhab.cfg
                           items/*.items
                           persistence/*.persist
                           rules/*.rules
                           scripts/*.script
                           sitemaps/*.sitemap
                           transform/*.map
```

openhab.cfg

```
######################## Mail Action configuration
####################################
#
# The SMTP server hostname, e.g. "smtp.gmail.com"
mail:hostname=smtp.gmail.com

# the SMTP port to use (optional, defaults to 25 (resp. 587 for TLS))
mail:port=587

# the username and password if the SMTP server requires
authentication
mail:username=torvalds
mail:password=linux1991

# The email address to use for sending mails
mail:from=Not Really Linus <torvalds@gmail.com>

# set to "true", if TLS should be used for the connection
# (optional, defaults to false)
mail:tls=true
```

Global settings are in this config file

home.items

```
Contact FrontDoor "Front Door [MAP(en.map):%s]" {mqtt="<[openhab:
/house/frontdoor:state:default]"}

Contact GarageDoor "Garage Door [MAP(en.map):%s]" {zwave="3:
command=sensor_binary"}
```

openHAB rules

- Java-like
  - Imports
  - Variable declarations
  - Rules

```
var VarType var1

rule “rule name”
when
     <trigger1> or <trigger2>
then
     <execute_actions>
end
```

openHAB triggers

- Item/Event-based

```
Item <item> received command [<command>]
Item <item> changed [from <state>] [to <state>]
```

- Time-based

```
Time is midnight
```

- System-based

```
System started
```

openHAB actions

- Actions used in rules engine to accomplish a task
- Core actions

```
sendCommand()
postUpdate()
logInfo()
```

- Binding actions

```
sendMail()
pushNotification()
sendTweet()
sendXbmcNotification()
```

home.rules

If the state of the door item changes, send a notification indicating the state of the door.

```
rule "Notify Front Door"
when
        Item FrontDoor changed
then
        pushover("Front door is " + FrontDoor.state.toString)
end

rule "Notify Garage Door"
when
        Item GarageDoor changed
then
        pushover("Garage door is " + GarageDoor.state.toString)
end
```

en.map

```
CLOSED=closed
OPEN=open
-=unknown
```

A contact item has the state of CLOSED, OPEN, or - (undefined). These are too shouty to print out as is, so transform to lower case before sending to the action.

default.sitemap

```
sitemap default label="Home"
{
    Frame label="House" {
        Text item=FrontDoor
    }

    Frame label="Garage" {
        Text item=GarageDoor
    }
}
```

The sitemap defines Items to be displayed in the UI, grouping, and layout.

scripts and persistence

- Scripts are another tool useful for reuse of code blocks between rules
  - Java syntax like Xtend language is used
- Persistence allows multiple methods for state to be save
  - Each Item may specify a persistence strategy
  - Addons
    - db4o
    - mysql
    - mongodb
    - Logback

ESP8266-based door sensor

- $2-3 WiFi SoC module with Tensilica core and GNU toolchain
  - http://www.esp8266.com
- NodeMcu - FOSS firmware with lua interpreter for ESP8266
  - http://www.nodemcu.com
  - Full I/O library including MQTT v3.1.1 client compatible with openHAB
- Reed switch interfaced to GPIO on ESP8266
- Just 28 lines of lua
  - Configure WiFi
  - Handle GPIO/switch interrupts
  - Publish MQTT “open”/”closed” messages

Door sensor code fragment

```
-- Door switch contact interrupt callback
function switchcb(level)
  if level == 1 then
    state = "CLOSED"
  else
    state = "OPEN"
  end

  -- Publish a message on each change in state
  tmr.alarm(2, 1000, 0, function() m:publish(topic, state, 0, 0,
function(conn) print("sent") end) end)
end

-- Create an MQTT client instance and connect to the broker
m = mqtt.Client(clientid, keepalive, username, password)
m:connect(broker, port, 0, function(conn) print("connected") end)

-- Configure GPIO2 as an interrupt with a pullup
gpio.mode(gpio2, gpio.INT, gpio.PULLUP)
-- Set GPIO2 to call our handler on both edges
gpio.trig(gpio2, "both", switchcb)
```

ZWave Tilt Sensor

- Zwave is a proprietary mesh network
  - Controllers and common sensors have open protocols
  - Fully supported in openHAB
- ZWave products are easy to purchase in U.S. at any home improvement store
  - Cheap off the shelf sensors
- AEON Labs Z-Stick USB controller
  - http://aeotec.com/z-wave-usb-stick
  - Push button inclusion of ZWave device to mesh network
  - Works out of the box with openHAB
- EcoLink garage door tilt sensor
  - Battery powered tilt sensor suitable for overhead doors
  - Works out of the box with openHAB

openHAB future

- More bindings, of course
- openHAB2 is coming
  - optimize for embedded (hub with 256MB RAM)
  - Minimal runtime
  - Switch to Concierge OSGi?
  - New binding API incorporate concept of “Things”
  - “Things” will be discoverable (IP addresses, etc.)
  - New UI based on material design

Q&A

References

- https://github.com/konsulko/iot-openhab
- http://www.openhab.org
- https://github.com/openhab/openhab/wiki/MQTT-Binding
- https://github.com/openhab/openhab/wiki/Z-Wave-Binding
- http://nodemcu.com/
- http://esp8266.com
- http://www.openzwave.com/