ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

Department of Computer Science and Engineering, ARCES

WoT Store:

a Thing and Application Management Ecosystem for the W3C Web of Things

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Outline

- WoT Store: features, architecture, implementation
- Use Cases: Industry 4.0, Smart Agriculture, Home automation
- Conclusions and future works

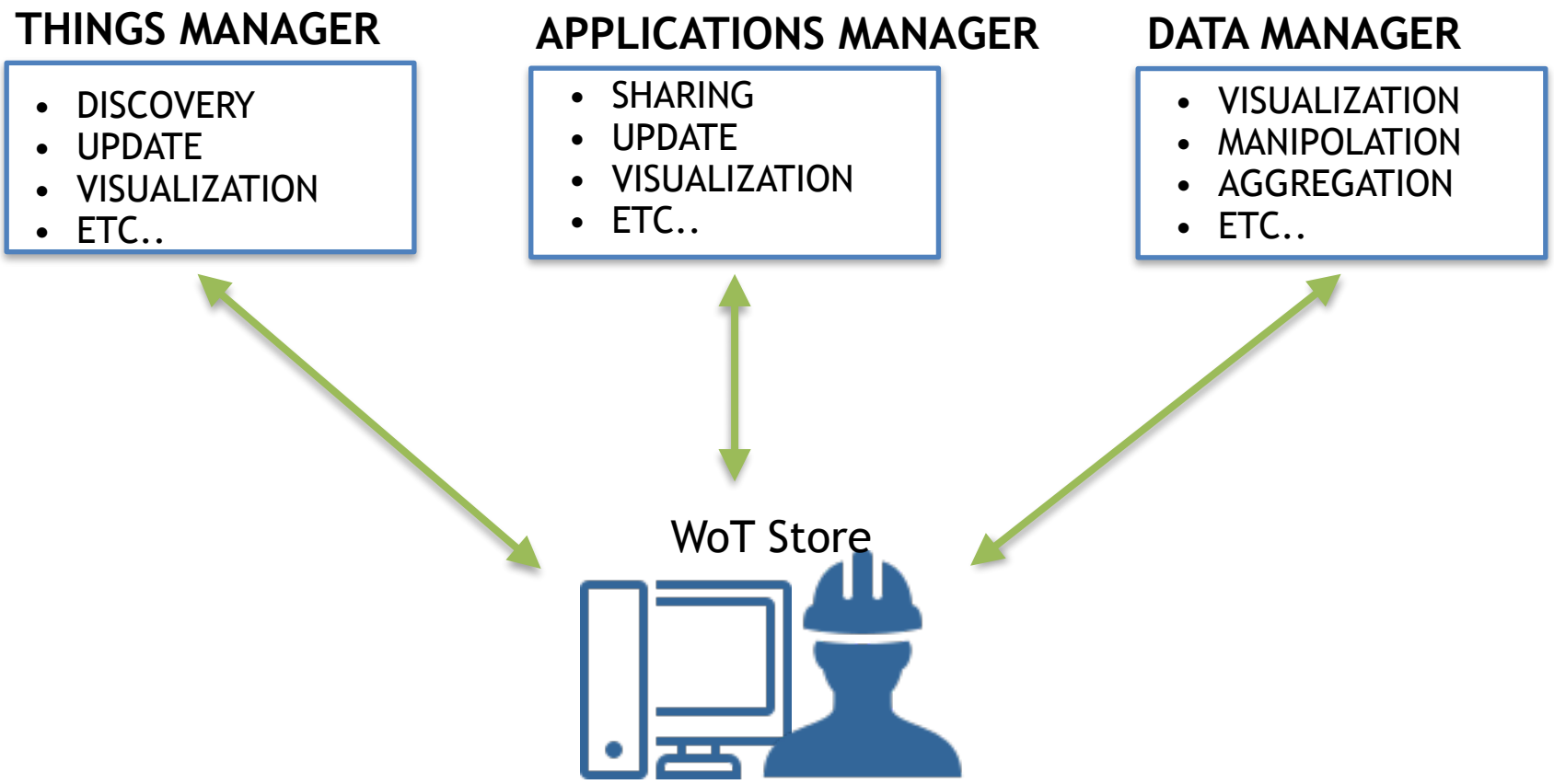
WoT Store

W3C Web of Things (WoT) represents a reference solution toward the deployment of fully interoperable systems. Its worldwide adoption depends also on the availability of support tools that might facilitate the deployment of novel WoT applications or the integration with traditional IoT systems

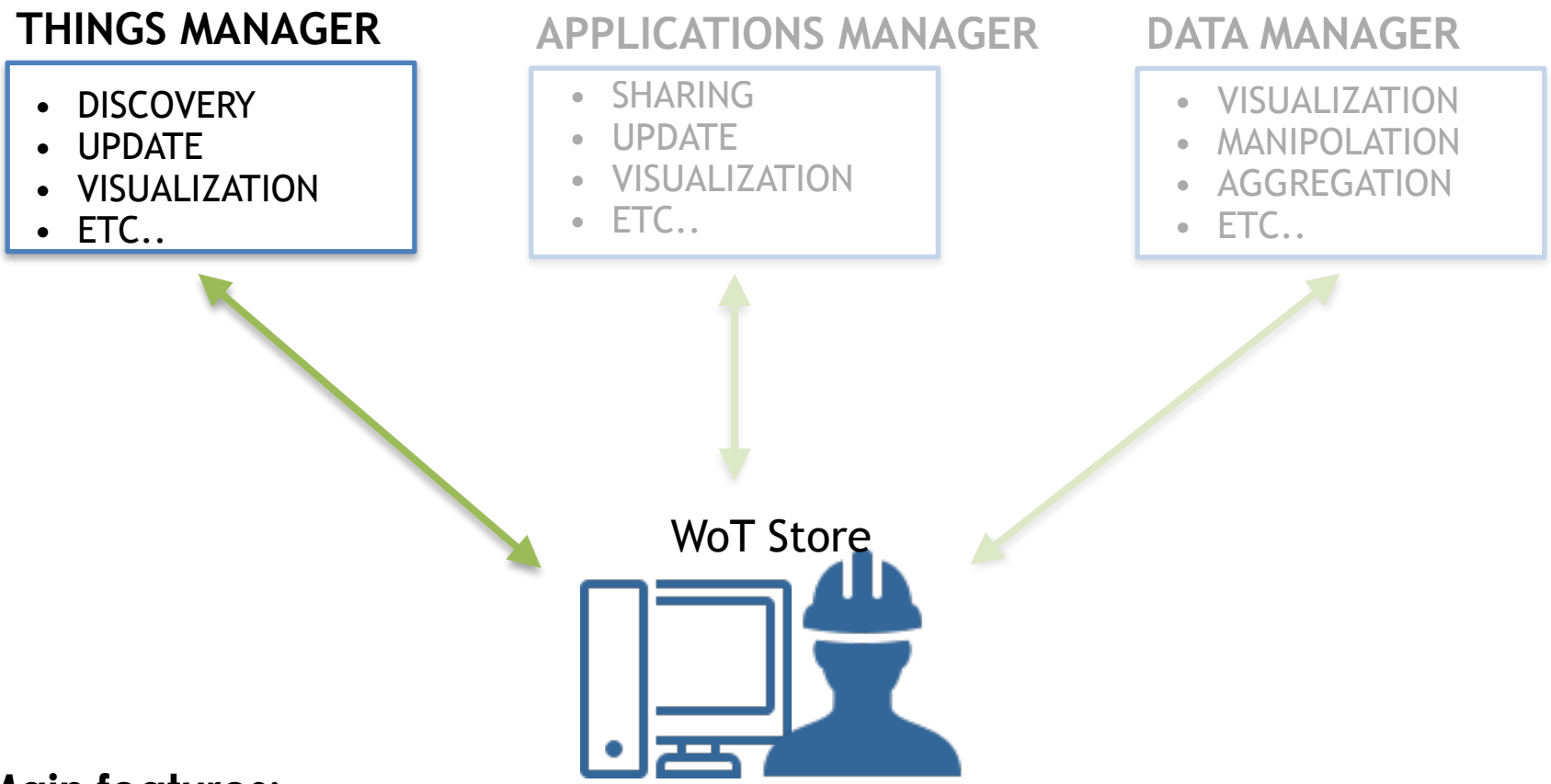
WoT Store: generic software platform for the management of W3C-compliant Things and applications of the WoT SECO.

L. Sciullo, C. Aguzzi , M. Di Felice, T. Salmon Cinotti,
"WoT Store: EnablingThings and Applications Discovery for the W3C Web of Things",
on Proceedings of IEEE CCNC 2019, Las Vegas, NV, January 11-14, 2019

WoT Store


THINGS MANAGER
DISCOVERY
UPDATE
VISUALIZATION
ETC..
APPLICATIONS MANAGER
SHARING
UPDATE
VISUALIZATION
ETC..
DATA MANAGER
VISUALIZATION
MANIPOLATION
AGGREGATION
ETC..
WoT Store

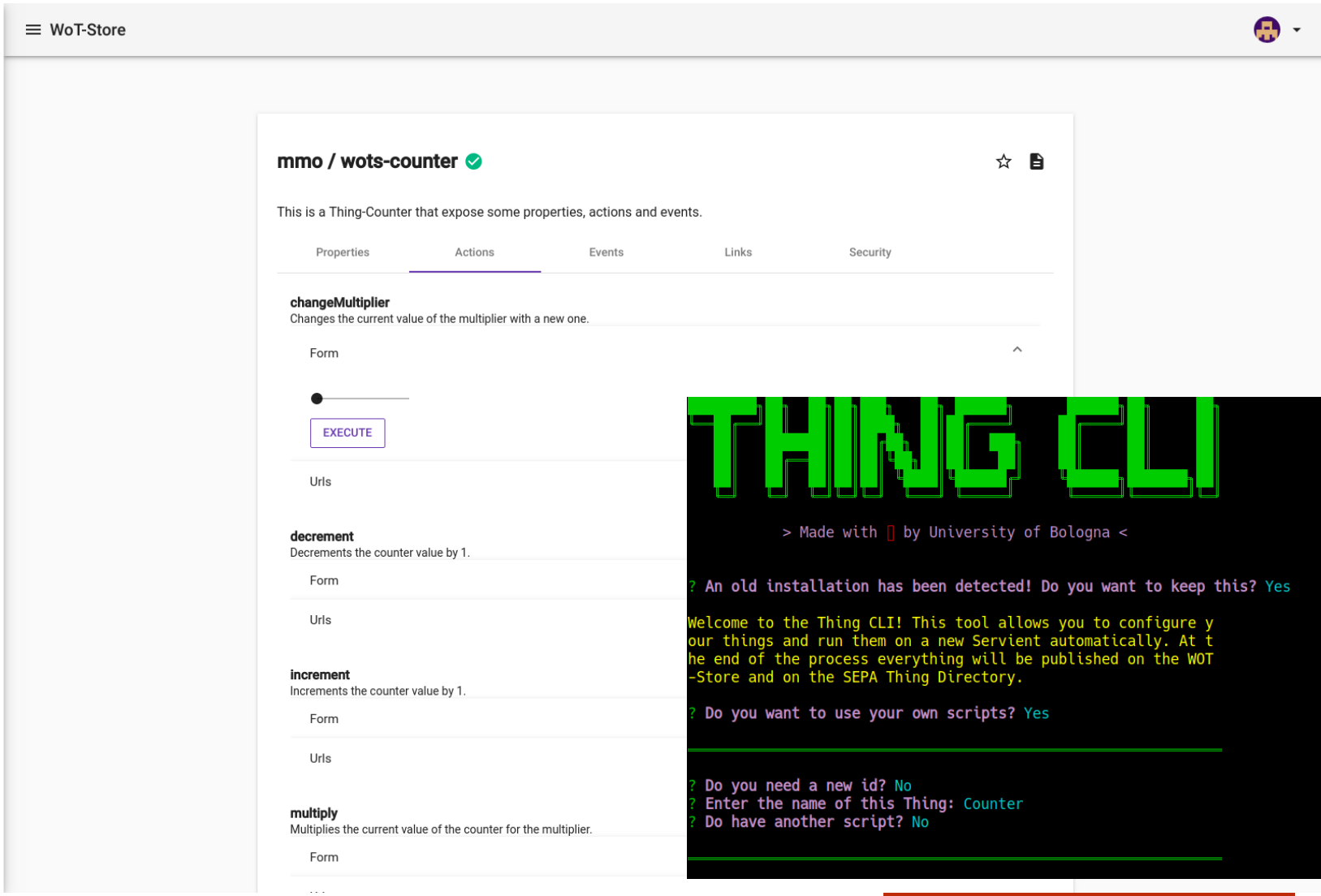
WoT Store: Things Manager



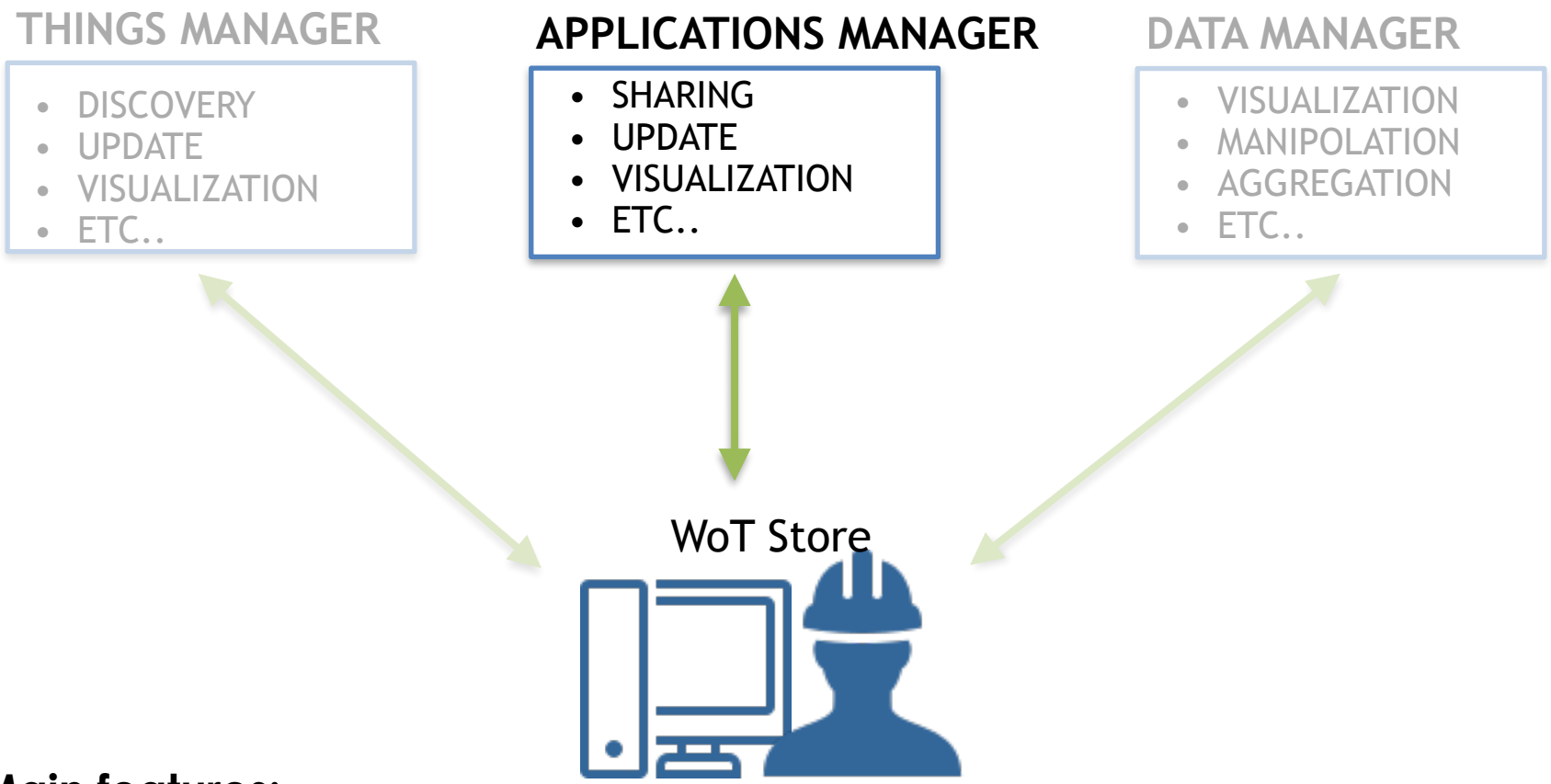
Main features:

- Things discovery
- Manage/Update Thing description
- List of active/not active Things
- Watch events and issue actions of Things

Web & Command line Interface



WoT Store: Applications Manager



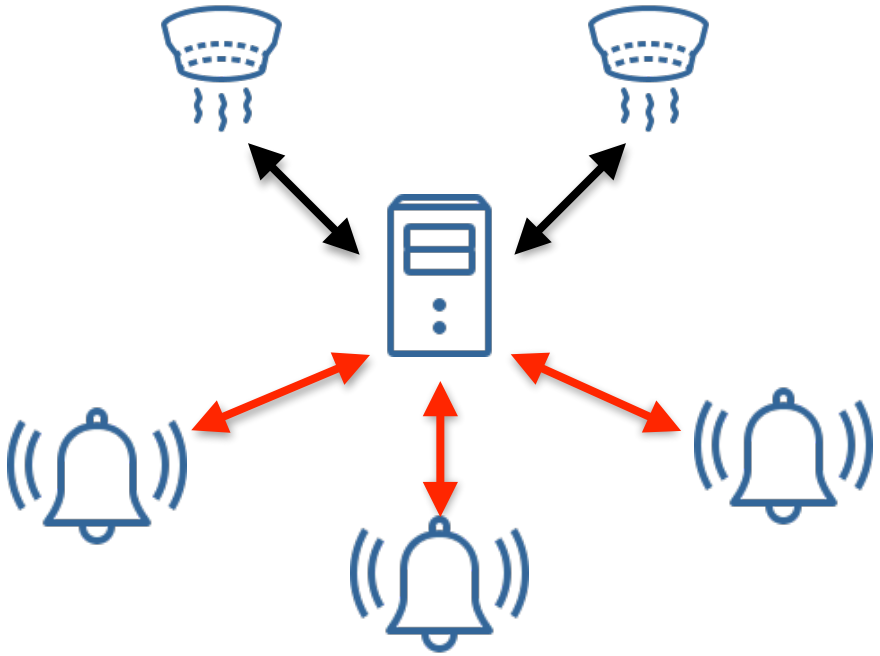
Main features:

- Online Thing Application UPDATE-ALL
- Semantic discovery of Applications (Thing and Mashup ones)
- Cloud Mashup Application

Thing Application (TD) and Mashup Application (MA)

Thing Application

Thing Behaviour Source code:
Properties, *Actions*, *Events*

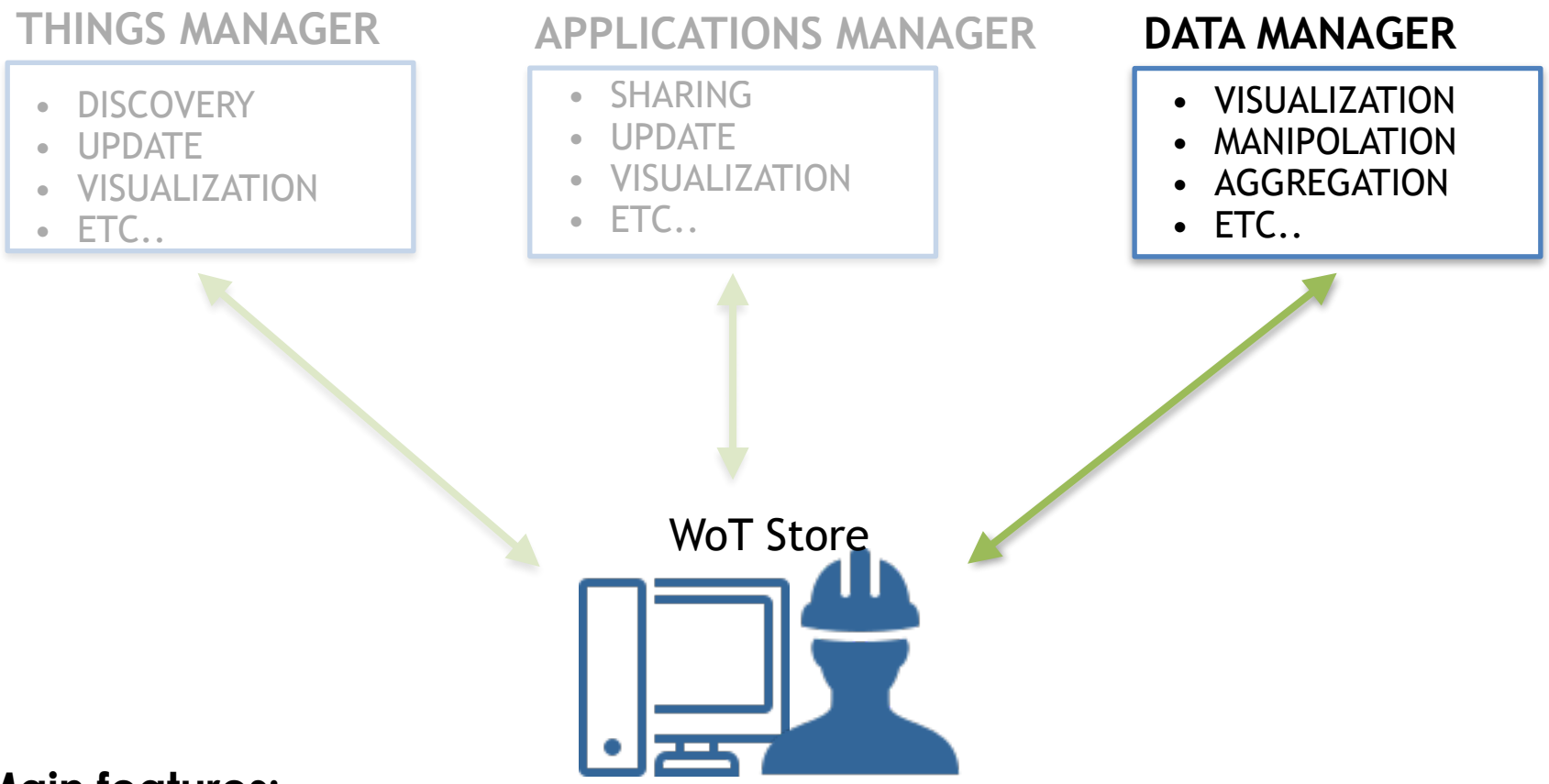


Mashup Application

Application producing new outputs or providing new services from a set of existing Things

https://icons8.com

WoT Store: Applications Manager

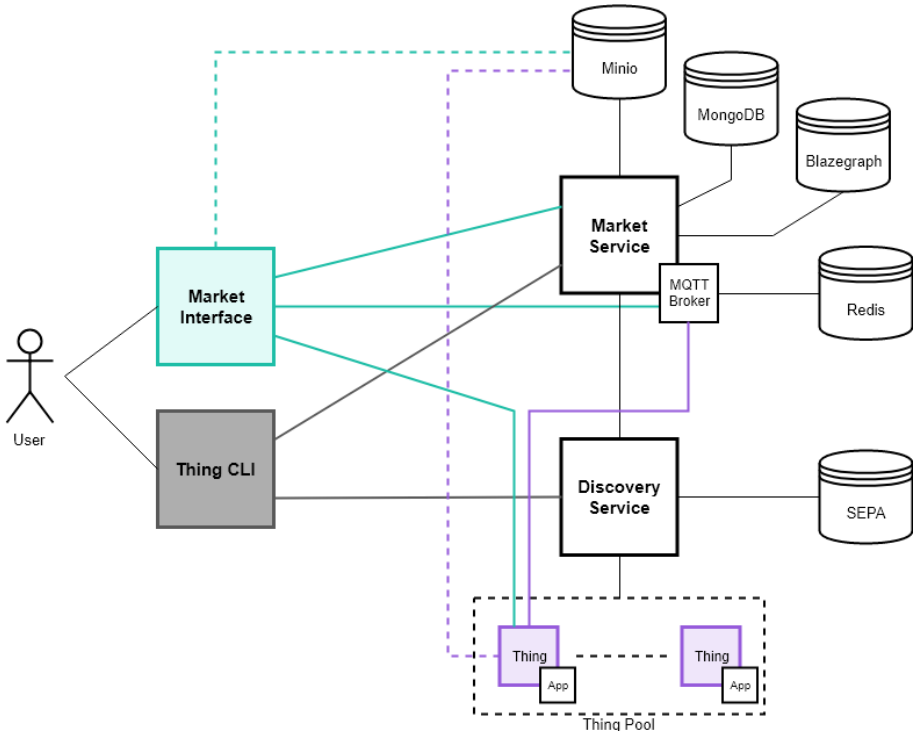


Main features:

- Data Filtering
- Data flows aggregation
- Data plotting

WoT Store: Architecture

- **Market Interface (MI):** web application offering the main features of WoT Store
- **Thing CLI:** command line tool that helps the configuration and then the online publication of a Thing



- **Market Service (MS):** REST API enabling the interaction with the main system resources
- **Discovery Service**: semantic discovery of Things and monitoring of Things updates

WoT Store implementation: technologies

LoopBack.io
Node.js API Framework

MINIO

redis

eclipse/thingweb.node-wot

mongoDB®

WoT Store use cases

Main use cases

Industry 4.0

- Update-all
- MA deployment
- Data analysis

Home automation

- New Thing integration
- User Interface
- Mashup Application

Smart Agriculture

- Update-all
- MA deployment
- Data analysis

MAC4PRO

SWAMP
SMART WATER MANAGEMENT PLATFORM

Conclusions and future works

WoT Store is a novel and effective platform for the management of
W3C-compliant Things and Applications

Future works include, among others:

- Data analytics features, based on machine learning and data mining techniques
- Control access mechanism in order to manage all the access requests made by and toward each Things directly from the WoT Store
- Digital twin representation

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Thank you for the attention!

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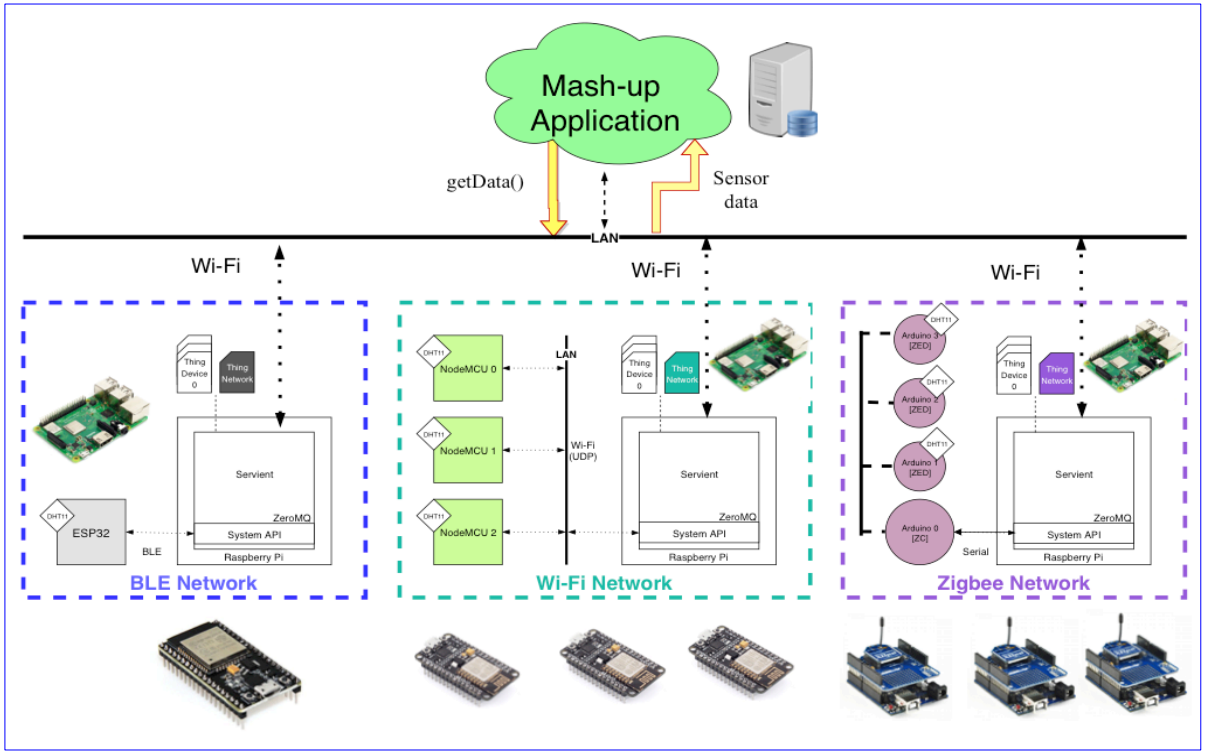
WoT Store Testbed

Three different wireless sensor networks deployed: Wi-Fi, BLE e Zigbee

The Mashup application is in charge to choose from which sensors it has to collect data, basing on user defined policies, like for instance:

- latency-driven
- reliability-driven
- energy-driven



Semantic discovery of Thing Applications (TAs)

Users can query the store catalogue and download applications compatible with their Things.

Search criteria can include: user-defined parameters, like the **semantic type of the Thing**, **the permissions required by the application** (root, GPIO access, etc..), **the platform involved** (Arduino, Raspberry Pi, etc..), etc..

subject	predicate	object
<WoTStore://raspberryLedApplication>	schema:downloadUrl	coap://wotstore.cs.unibo.it:8081/market/actions/getThingApplication?application=raspberryLedApplication
<WoTStore://raspberryLedApplication>	schema:downloadUrl	http://wotstore.cs.unibo.it:8080/market/actions/getThingApplication?application=raspberryLedApplication
<WoTStore://raspberryLedApplication>	wotstore:involve	sosa:Actuator
<WoTStore://raspberryLedApplication>	rdf:type	wotstore:ThingApplication
<WoTStore://raspberryLedApplication>	rdfs:label	raspberryLedApplication
<WoTStore://raspberryLedApplication>	schema:availableOnDevice	Raspberry Pi

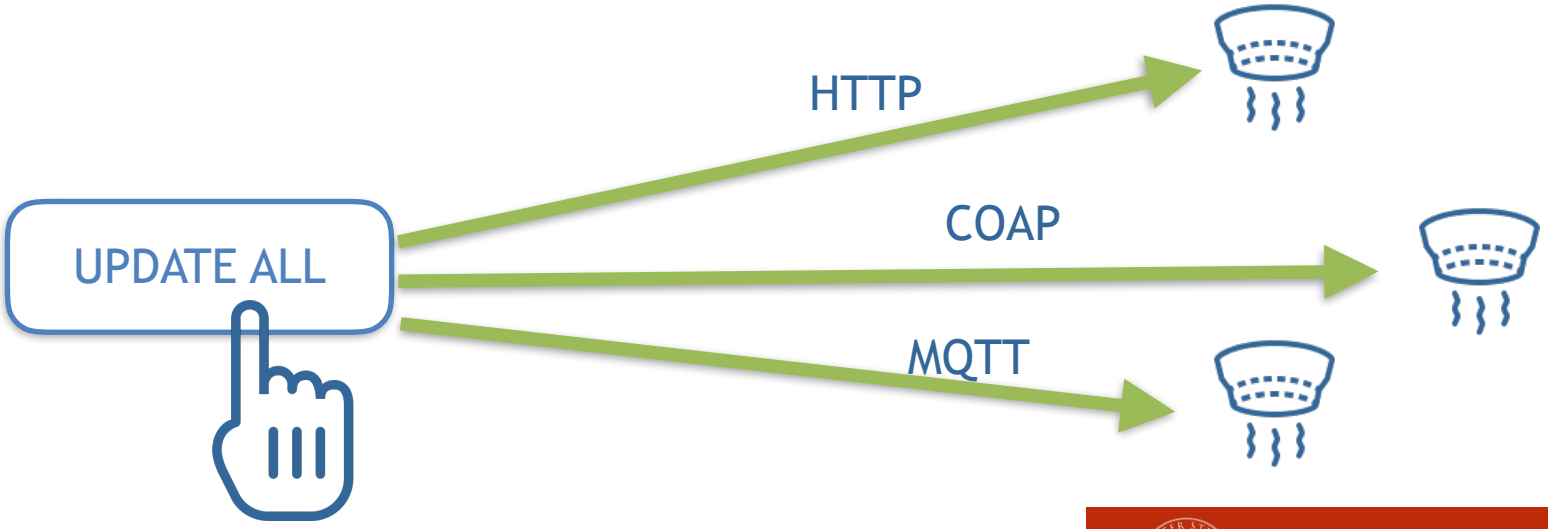
Semantic discovery of Mashup Applications (MAs)

Users can query the store catalogue and download mashup applications compatible with their needs. User can issue semantic queries for the application, specifying for instance **the desired temperature format** (e.g. Celsius), **the database type** (e.g. NoSQL), or t**he aggregation interval** (e.g. every minute).

subject	predicate	object
<WoTStore://temperatureMonitor>	schema:applicationCategory	Domotics
<WoTStore://temperatureMonitor>	schema:downloadUrl	coap://wotstore.cs.unibo.it:8081/market/actions/getApplication?application=temperatureMonitor
<WoTStore://temperatureMonitor>	schema:downloadUrl	http://wotstore.cs.unibo.it:8080/market/actions/getApplication?application=temperatureMonitor
<WoTStore://temperatureMonitor>	wotstore:involve	sosa:Sensor
<WoTStore://temperatureMonitor>	rdf:type	schema:SoftwareApplication
<WoTStore://temperatureMonitor>	rdfs:label	temperatureMonitor

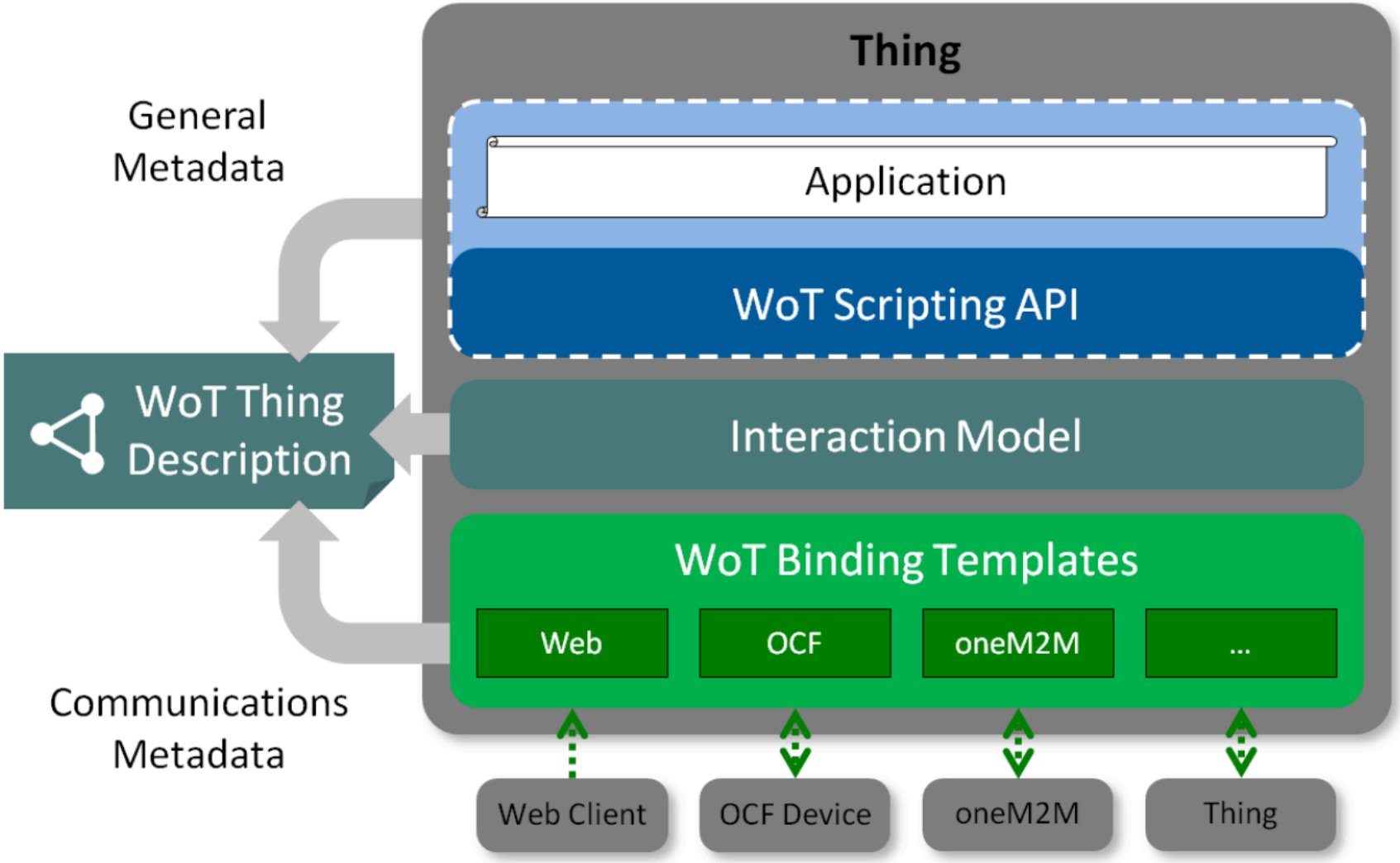
Automatic deploy of TA software on Things

WoT STORE enables the automatic installation and execution of the application code on target Thing(s). This is implemented through an additional Thing search engine, which allows users to issue semantic queries (e.g. indicating the Thing type and capabilities)

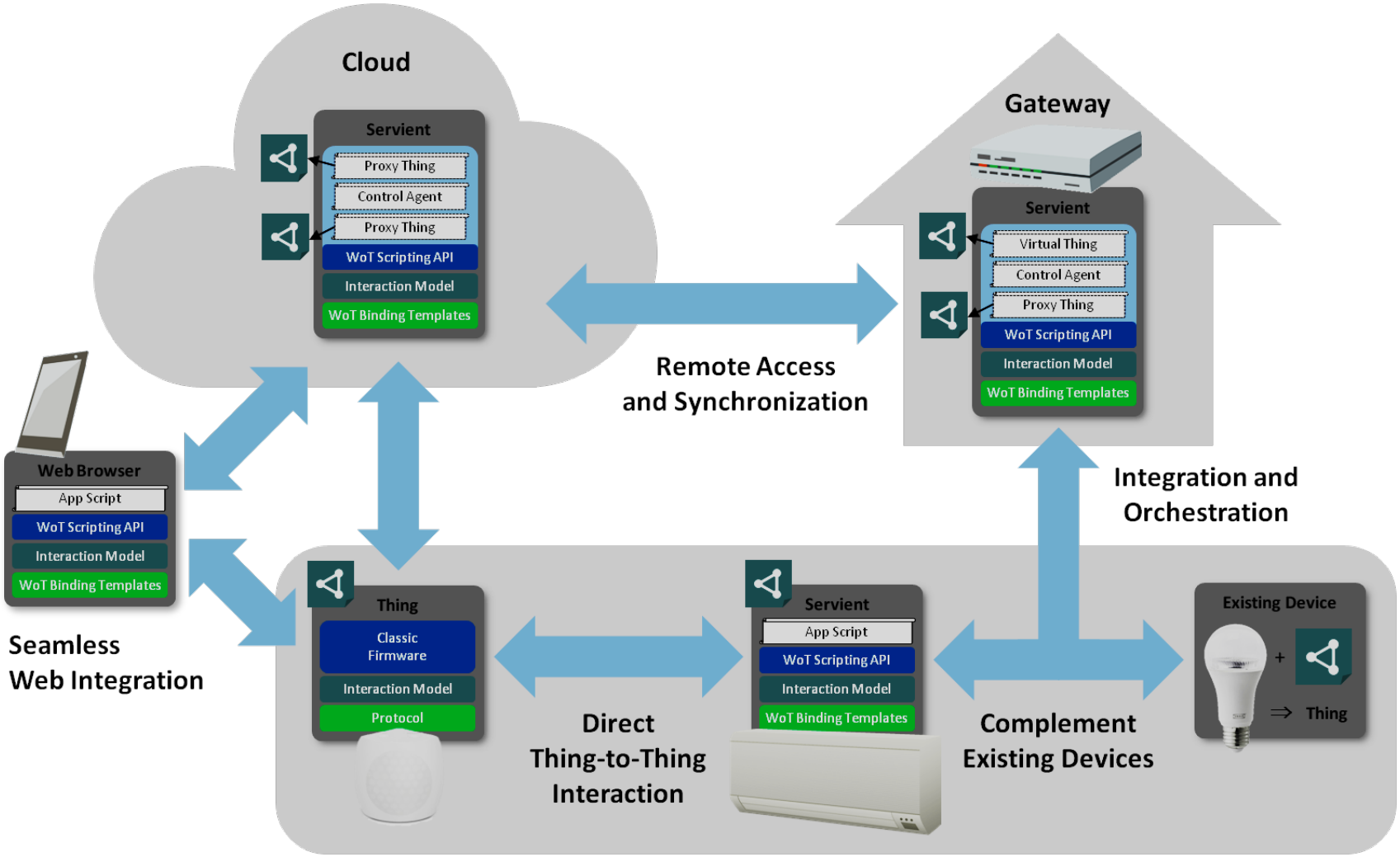


https://icons8.com

Conceptional Architecture of a W3C Thing



W3C WoT Architecture



Semantic description of a TA: example

subject	predicate	object
<WoTStore://raspberryLedApplication>	schema:applicationCategory	Making
<WoTStore://raspberryLedApplication>	schema:downloadUrl	*coap://wotstore.cs.unibo.it:8081/market/actions/getThingApplication?application=raspberryLedApplication*
<WoTStore://raspberryLedApplication>	schema:downloadUrl	*http://wotstore.cs.unibo.it:8080/market/actions/getThingApplication?application=raspberryLedApplication*
<WoTStore://raspberryLedApplication>	wotstore:involve	sosa:Actuator
<WoTStore://raspberryLedApplication>	rdf:type	wotstore:ThingApplication
<WoTStore://raspberryLedApplication>	rdfs:label	raspberryLedApplication
<WoTStore://raspberryLedApplication>	schema:availableOnDevice	Raspberry Pi
<WoTStore://raspberryLedApplication>	dcterm:description	RaspberryLedApplication is a simple application for controlling a led on the GPIO of a Raspberry Pi with the JohnnyFive framework. It provides the turnOn, turnOff and Blink actions.
<WoTStore://raspberryLedApplication>	schema:permissions	GPIO

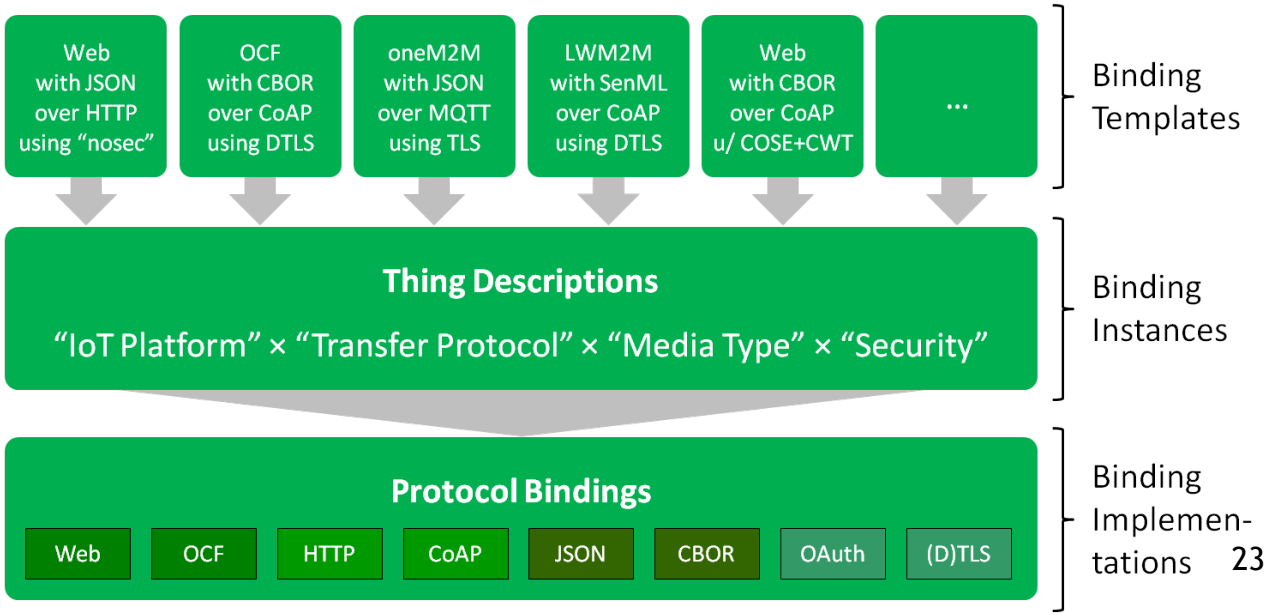
Semantic description of a MA: example

subject	predicate	object
<WoTStore://temperatureMonitor>	schema:applicationCategory	Domotics
<WoTStore://temperatureMonitor>	schema:downloadUrl	coap://wotstore.cs.unibo.it:8081/market/actions/getApplication?application=temperatureMonitor
<WoTStore://temperatureMonitor>	schema:downloadUrl	http://wotstore.cs.unibo.it:8080/market/actions/getApplication?application=temperatureMonitor
<WoTStore://temperatureMonitor>	wotstore:involve	sosa:Sensor
<WoTStore://temperatureMonitor>	rdf:type	schema:SoftwareApplication
<WoTStore://temperatureMonitor>	dcterm:description	temperatureMonitor is an application that takes the temperature from several sensors and returns the average
<WoTStore://temperatureMonitor>	rdfs:label	temperatureMonitor

Building Blocks: Binding Templates

Problem: enable interactions with a myriad of different IoT Platforms

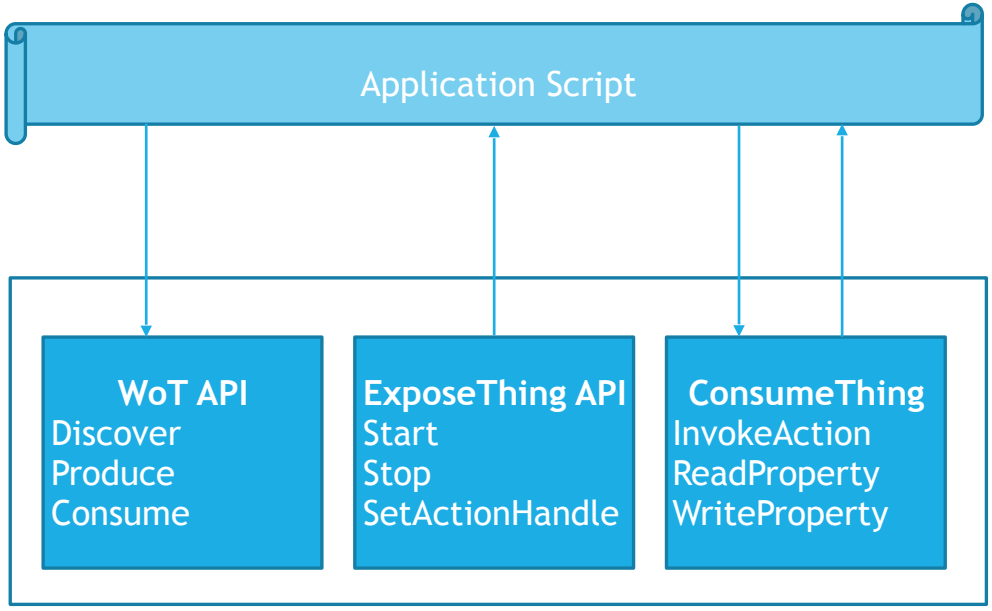
Solution: define multiple vocabularies (**Binding Template**) to describe communication between Things and provide **extension points** in the Thing Descriptor.



Building Blocks: Scripting API

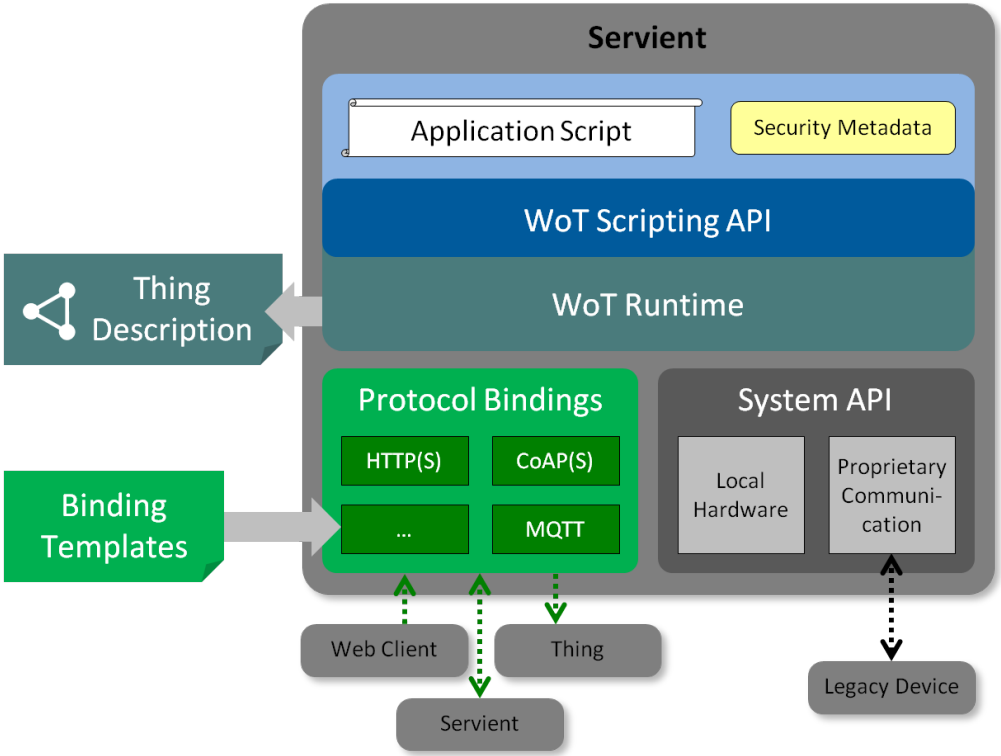
The WoT Scripting API is the runtime system for IoT applications.

- It improves **productivity**
- It reduces the **integration** costs
- It enables **portability** for application modules



Servient

- **Application**: Thing business logic; implement or using a script or in the firmware
- **WoT Scripting API**: contract between applications and the runtime system (Optional Component)
- **WoT Runtime**: contains Thing and interaction model abstractions. (Optional Component)
- **Protocol Bindings**: implementations of Binding templates, the actual network interface between things
- **System API**: things can access local hardware or system services. (out of scope of WoT standardization)



Minimal Servient