Intelligent Home Automation

Combining IoT and Machine Learning

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April 20, 2016

IBM Analytics

PLAN

Introduction

Home Automation versus Intelligent Home

Human Recognition

Learning from the user: IBM Watson

Ideas and prototypes

INTRODUCTION

Introduction

What is IoT?

Successes and failures

Home Automation versus Intelligent Home

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Internet of Things or connected objects?

Internet of Things according to Wikipedia

The Internet of Things (IoT) is the network of physical objects—devices, vehicles, buildings and other items—embedded with electronics, software, sensors, and network connectivity that enables these objects to collect and exchange data. The IoT allows objects to be sensed and controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit;

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To summarize:

1. network, i.e. the usage of OSI model or TCP/IP model.
2. collect data, involving user inputs and sensors.
3. exchange data, involving data analyzis.
4. controlled remotely.
5. direct integration of the digital world into the physical world.

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PROMISES

For many years, we heard about
the IoT and Automation revolution, but...

INTERNET OF THINGS & AUTOMATION

Success in industry for 20 years:

1. Autonomous Pallet Jacks, Forklifts, Stackers,...
2. Autonomous Robotic Handlers, Palletizer,...
3. Autonomous Warehouse, Storeroom,...
4. Smart grid for electric network.

Using laser-guided, sonar, wifi, 3D camera, diverse sensors.

And massive failure outside of the industry... Why?

Some reasons:

1. Mainly useless gadgets.
2. Lack of integration.
3. Involve too much the user.

It generates technology frustration.

I propose the following measure of technological success for general public: **invisibility**.

Obtained by:

1. Not changing (too much) the user behavior.
2. Not involving too much the user.

HOME AUTOMATION VERSUS INTELLIGENT HOME

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The recipe

Some use cases

Feasibility

A word on ethic

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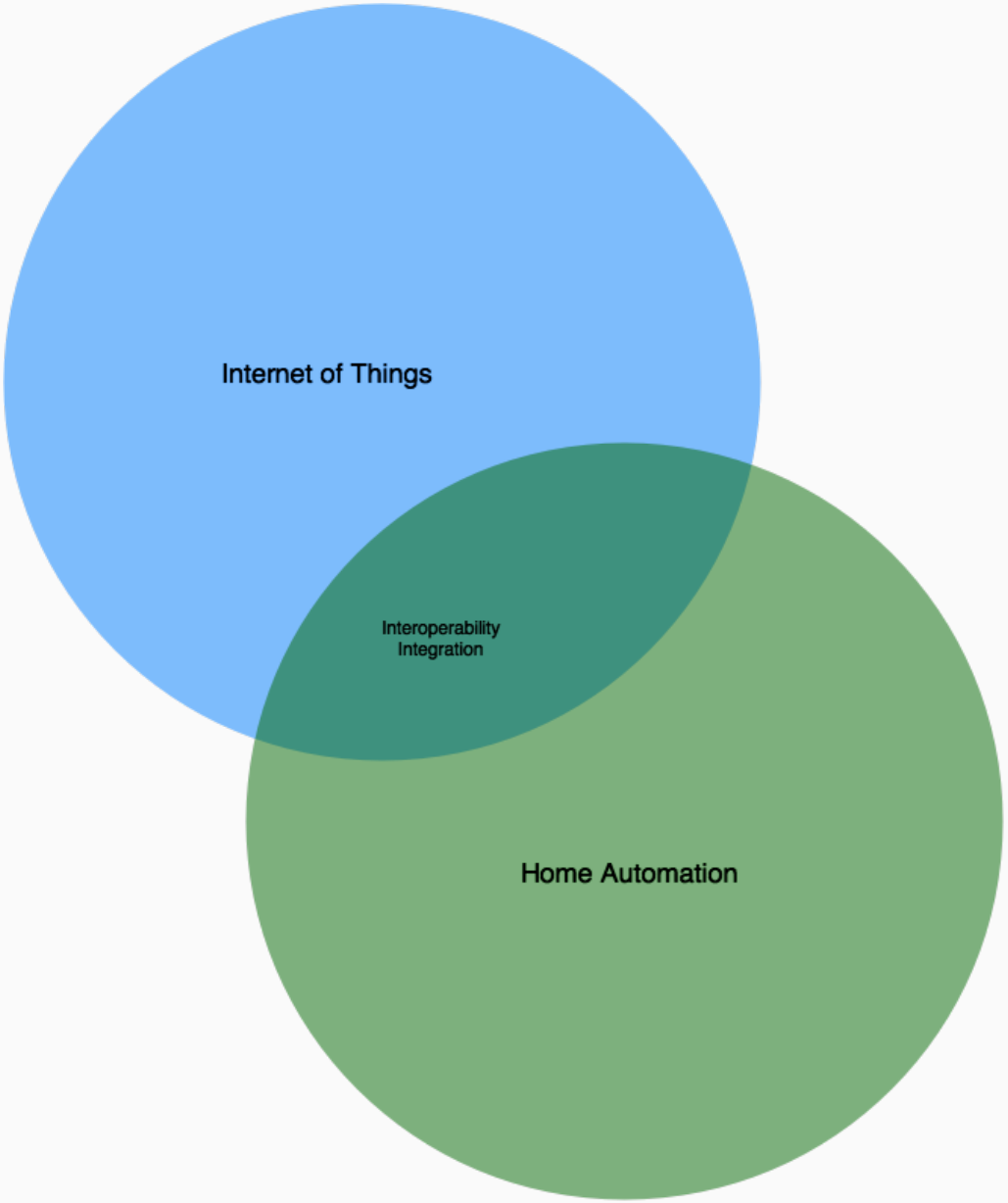
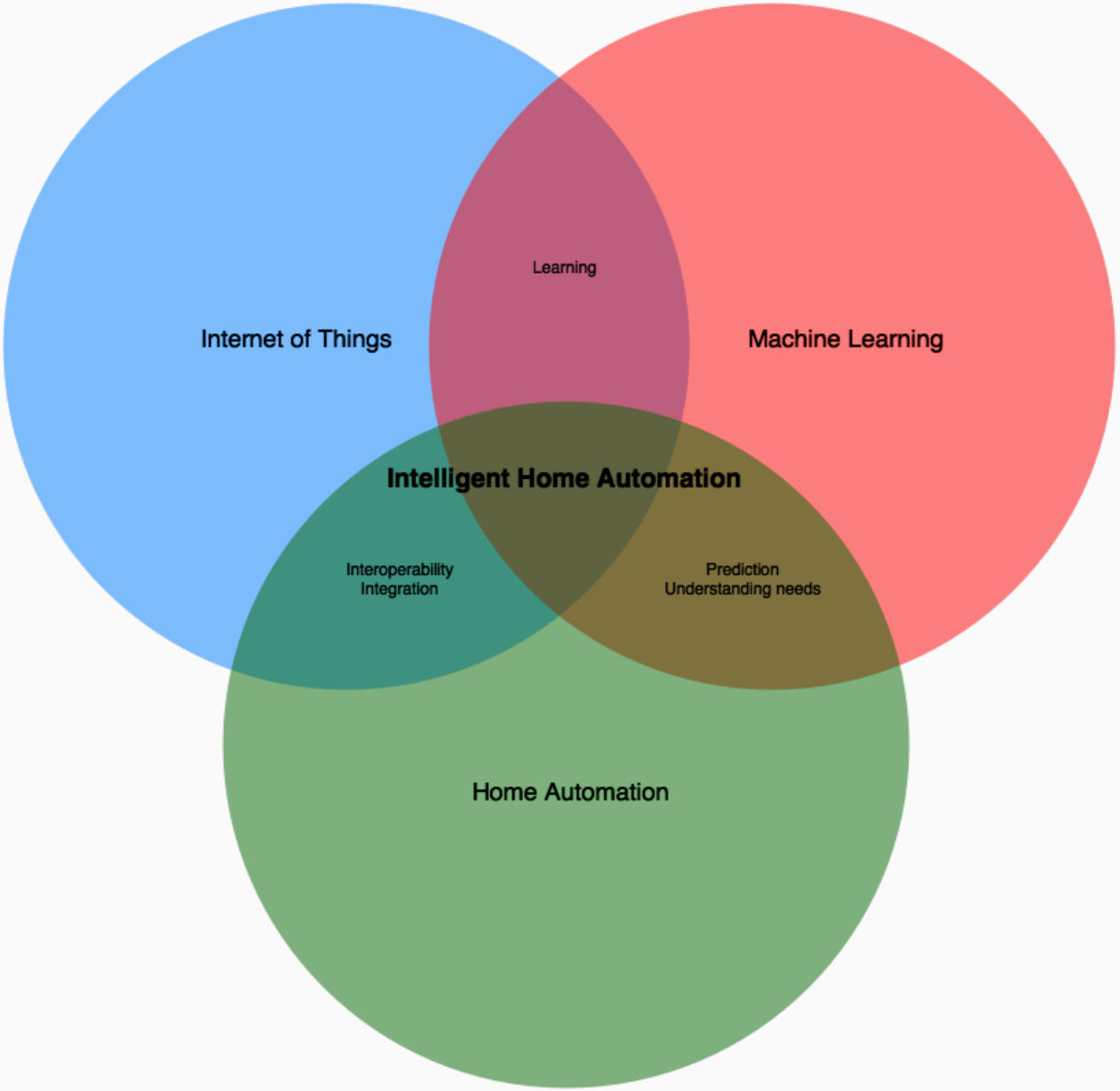

Internet of Things
Interoperability
Integration
Home Automation


Internet of Things
Machine Learning
Home Automation
Learning
Intelligent Home Automation
Interoperability
Integration
Prediction
Understanding needs

Intelligent home automation: the recipe

- A lot of sensors, connected.
- Human Recognition.
- Learning habits.
- Natural Language Processing.
- Imagination :)

Intelligent home automation: the recipe

- A lot of sensors, connected.
- Human Recognition. **Requires Machine Learning**
- Learning habits. **Requires Machine Learning**
- Natural Language Processing. **Requires Machine Learning**
- Imagination :)

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HOME AUTOMATION VERSUS INTELLIGENT HOME

Some examples among thousands:

- Coffee: programmed at 6am vs at wakeup.

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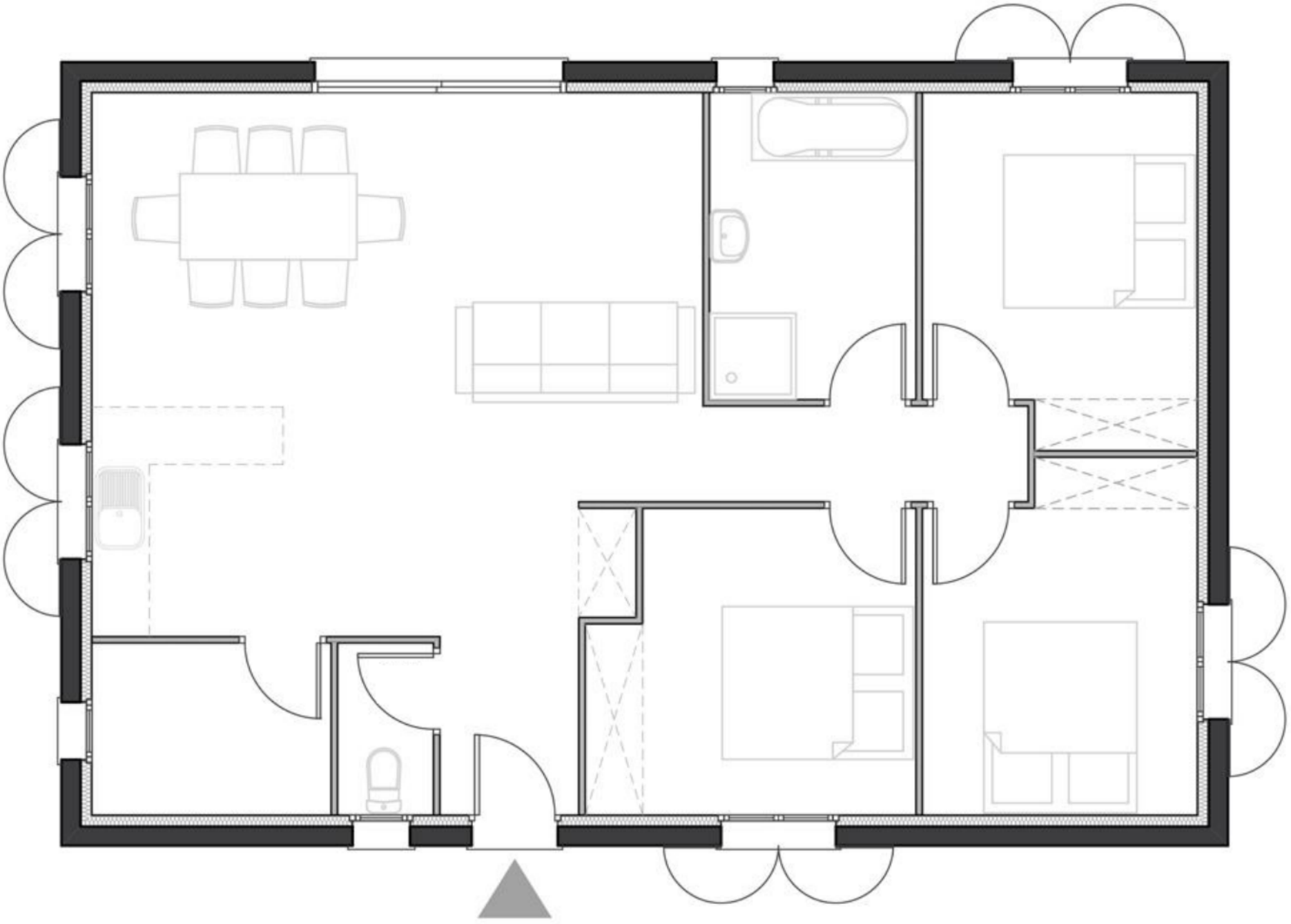
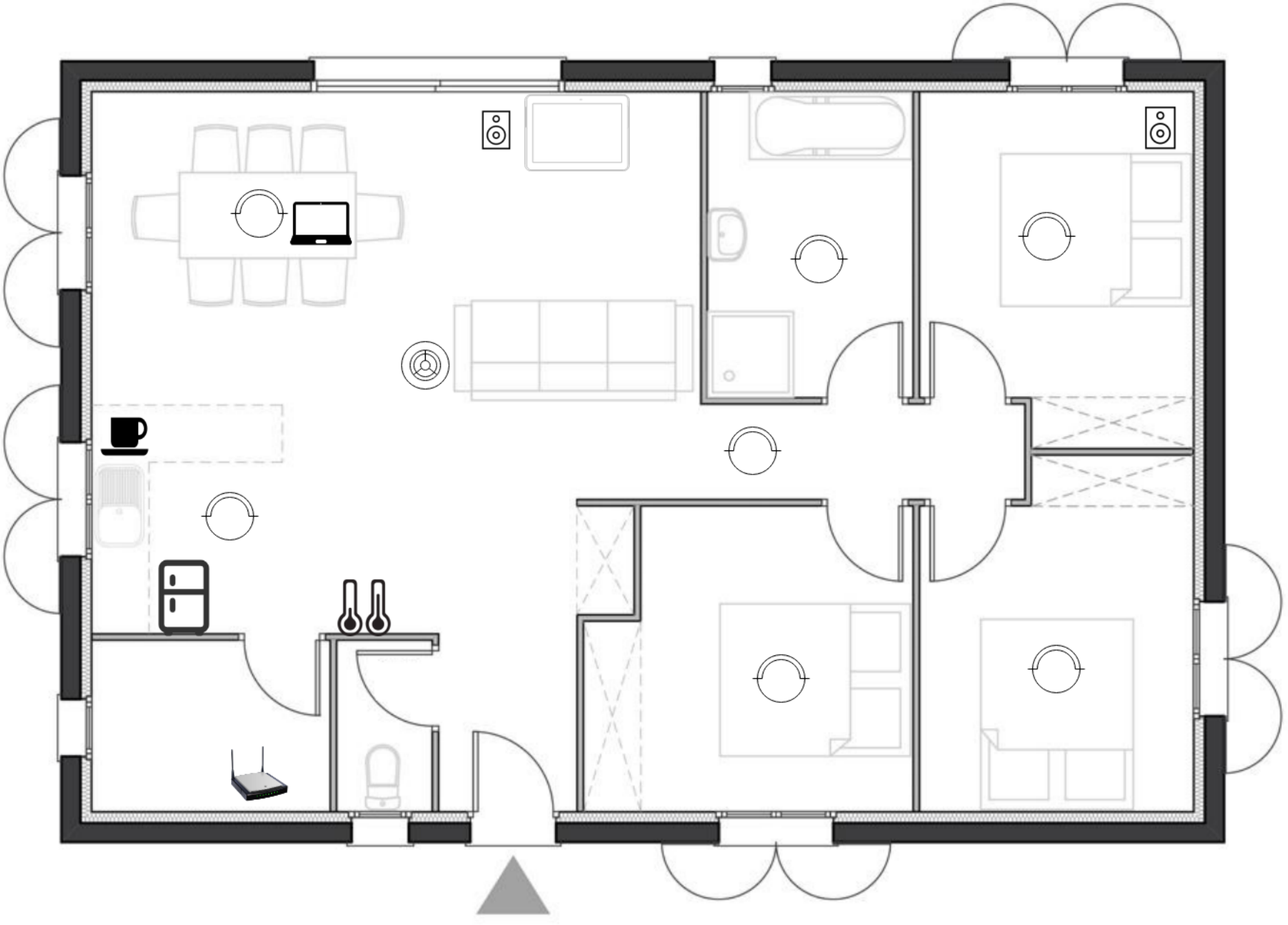
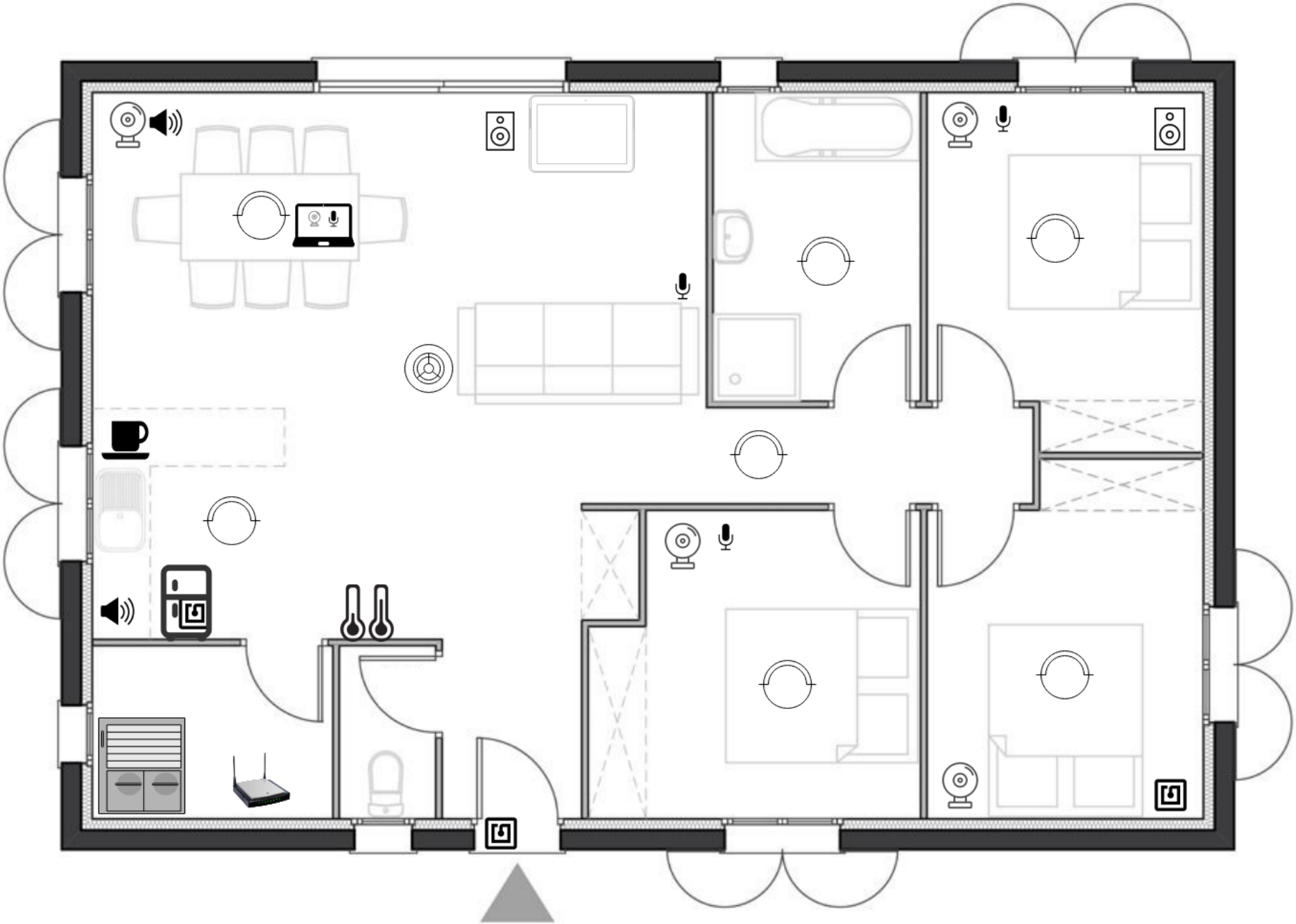
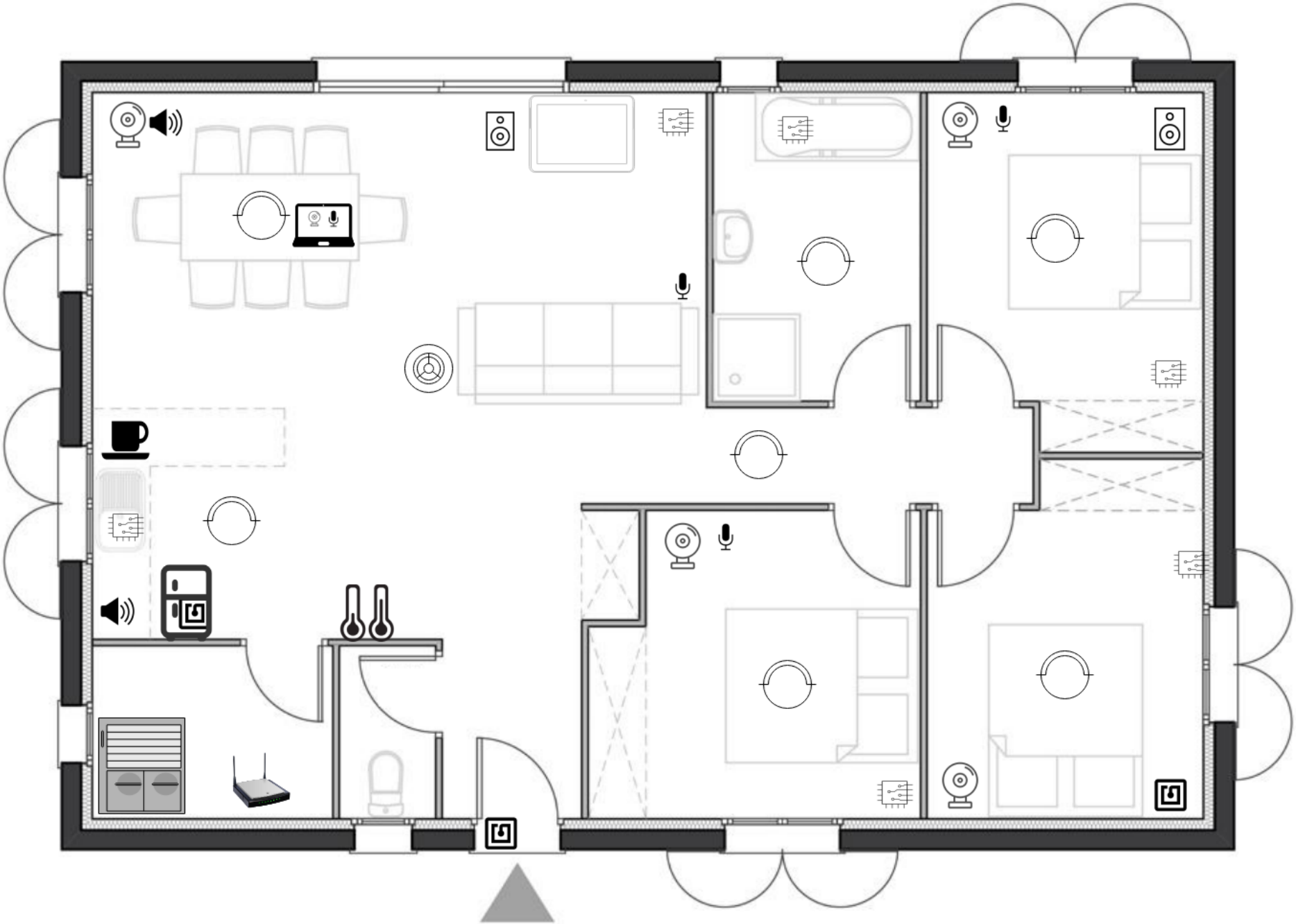
- Cost optimization: No one in the house? Shutdown any device that requires electricty?









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WHY IT IS FEASIBLE?

Very cheap sensors to prototype:

- Temperature 0.50€
- Humidity 5.22€
- Obstacle 5.75€
- Accelerometer 10€
- Reflectance 1€80
- Light sensor 2€20
- Tilt (piezzo) 0.60€
- Button 1.50€
- Touch button 4€68
- Movement detector 7€08
- Alcool detection (!) 6€60
- Angle detection 3.48
- Camera HD 35€
- Force sensor 8€40
- Water detection 3.48
- Color detection RGB 9€54
- Magnetometer 11.94
- UV sensor 11.94€
- Vibration 7€08
- Microphone 5€95
- GSR sensor 11€88

WHY IT IS FEASIBLE?

Fancy sensors:

- Muscle sensors
- Fingerprint
- Pulse sensor
- Heart rate
- Dust sensor
- Flex sensor
- Liquid flow meter
- Electronic valves
- Circular Soft Potentiometer (Ribbon Sensor)
- NFC Door Locks

WHY IT IS FEASIBLE?

Very mature and easy to use technologies:

- Websocket, Bluetooth, Wifi, etc.
- Natural Language Processing.
- Computer Vision.

REST API for almost everything:

- Entertainment: Youtube, Spotify, Netflix, etc.
- Basic data: time, weather, pollution, traffic.
- Shopping: Local grocery, drive markets, etc.

https://programmableweb.com/apis/directory (+14k APIs !)

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A WORD ON ETHIC

Never under-estimate ethic!

Data governance:

One standard to rule them all: ISO/IEC 38500

- Standard on data and meta-data profile.
- Standard on data and meta-data granularity.
- Standard on data security and confidentiality.

HUMAN RECOGNITION

TRACKING OR NOT TRACKING

Why tracking the user?

It is not enough knowing an appliance has been use:

- Depending on the user, the usage of a same device can be different.
- We want to learn about a user, not about an accomodation.

And the objects?

Tracking the movable connected objects is also important.

Let’s review some methods to track the user.

HUMAN RECOGNITION

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Home Automation versus Intelligent Home

Human Recognition

- Indoor geolocalization
- Speaker recognition
- Webcam Tracking

Learning from the user: IBM Watson

Ideas and prototypes

WIFI POSITIONING SYSTEM

Pro

- Really easy to setup.
- Geolocalization.

Con

- Precision.
- Requires Internet Connection + Wifi receiver.
- Works better with many Access Points.
- No microlocalization.

Technical implementation

WLAN Indoor Positionning Algorithm Based On Sub-Regions Information Gain Theory (2013)

- RSS (Received signal strength indication) to create a fingerprint.
- Refinement using K-means clustering + KNN.

Radio frequency identification and NFC

Pro

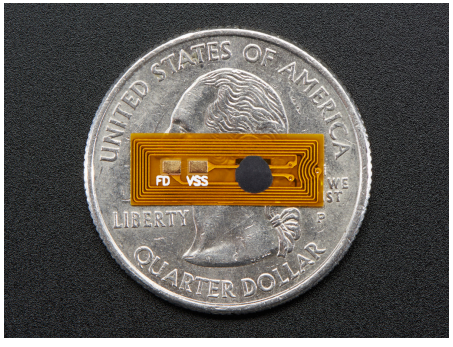
- Microlocalization.
- e-textile and wearable tags.
- Data transfert (+ secure)

Con

- No geolocalization.

Characteristics

- Uses radio frequencies.
- Active: embedded source of energy $\Longrightarrow$ limited lifelength.
- Passive: almost unlimited lifelength but requires energy from a reader.



BEACON

Pro

- Low energy consumption (Bluetooth Low Energy).

Con

- No microlocalization.
- Not OSI, not TCP/IP $\Longrightarrow$ requires a gateway.
- Need a lot of beacons for geolocalization.

GEOMAGNETIC FIELD LOCATION

Pro

- Best precision (0.1 meter).
- Every modern mobile is capable of reading magnetic fields.

Con

- Require to acquire a fingerprint first.
- No microlocalization.

Simultaneous localization and mapping (SLAM)

(HMM) : $P(s_t, x_t | o_{1;t})$

$$P(s_t | x_t, o_{1;t}) = \sum_{x_t, s_t} P(s_t | x_t, s_{t-1}, o_t) P(s_{t-1}, x_t | o_{1;t-1}, s_{t-1})$$

Solved by Expectation-Maximisation algorithm (e.g. Baum–Welch).

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The purposes of speaker recognition

- Using a particular user profile.
- Security.

SPEAR: A Speaker Recognition Toolkit based on Bob

http://pythonhosted.org/bob.bio.base/

The rocket-science

Cepstrum transformation on the signal f:

$$Cf(t) = \mathcal{F}^{-1}(\log \mathcal{F}(f(t))$$

Then typical pattern problem:

- Hiden Markov Model
- Gaussian Mixture Model
- Neural Networks
- Decision Tree

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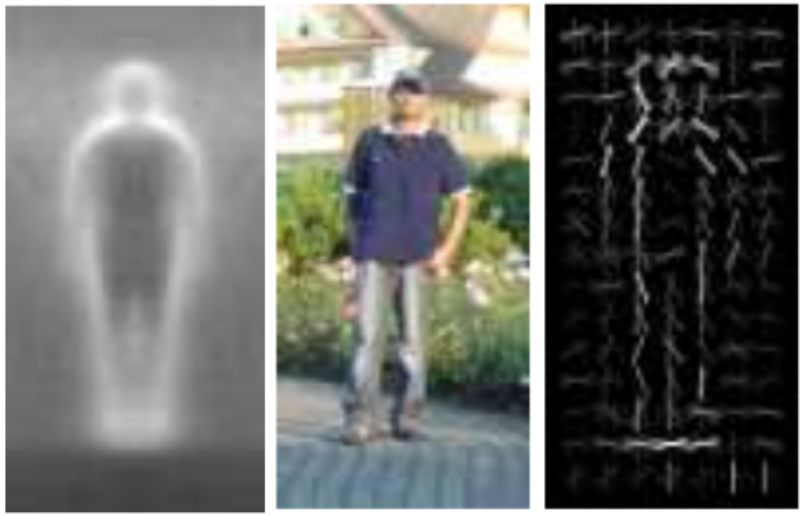
HUMAN DETECTION

Very rich litterature:

- An improved adaptive background mixture model for real-time tracking with shadow detection.
- Improved adaptive Gaussian mixture model for background subtraction.
- Visual Tracking of Human Visitors under Variable-Lighting Conditions for a Responsive Audio Art Installation.
- Real-Time Pedestrian Detection With Deep Network Cascades.
- Histogram of Oriented Gradients descriptor for object recognition.

My choice

- Histogram of oriented gradients (http://lear.inrialpes.fr/data)
- Linear Support Vector Machine (Vapnik-Chervonenkis theory)



Then, add facial recognition.

EYE-TRACKING - VIEW ESTIMATION

The purpose of eye-tracking

- Displaying info on the device the user looks at.
- Long distance movement recognition.

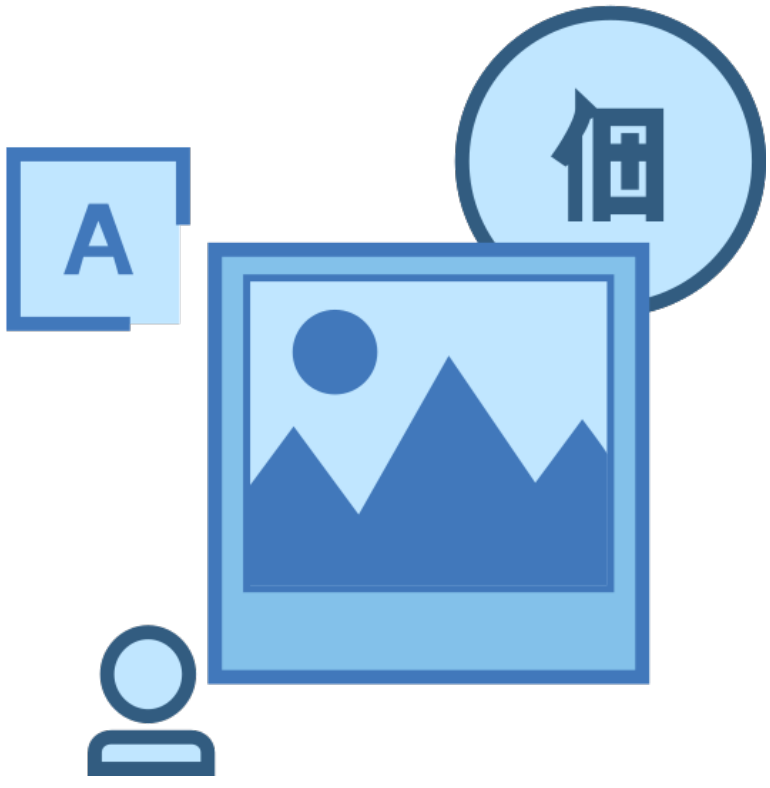
Still not very reliable but nice experimentations using PyGaze.

WIDE-ANGLE LENSES
OMAX

LEARNING FROM THE USER: IBM WATSON

ALCHEMYLANGUAGE

ALCHEMY LANGUAGE?



AlchemyLanguage

Collection of API for Natural Language Processing:

- Entity Extraction
- Sentiment Analysis
- Keyword Extraction
- Concept Tagging
- Relation Extraction
- Taxonomy Classification
- Author Extraction
- Language Detection
- Text Extraction
- ...

CONCEPT INSIGHTS

CONCEPT INSIGHTS

Concept Insights

- Analyze a text input to extract concepts and propose related content from different sources.
- Generate concept graphes or used default one (Wikipedia).

Usage example

Automatically provide further readings for articles, targeted advertisement, automatic content tagging.

DIALOG

I'm Watson! I can help you order a pizza. What size?
Great! Can I get a medium?
Perfect. What toppings are you in the mood for today?

DIALOG

Dialog

- Creation of natural language dialogues.
- Include profile tracking for learning.

Usage example

Ordering online, first line online support, intelligent home automation.

NATURAL LANGUAGE CLASSIFIER

NATURAL LANGUAGE CLASSIFIER

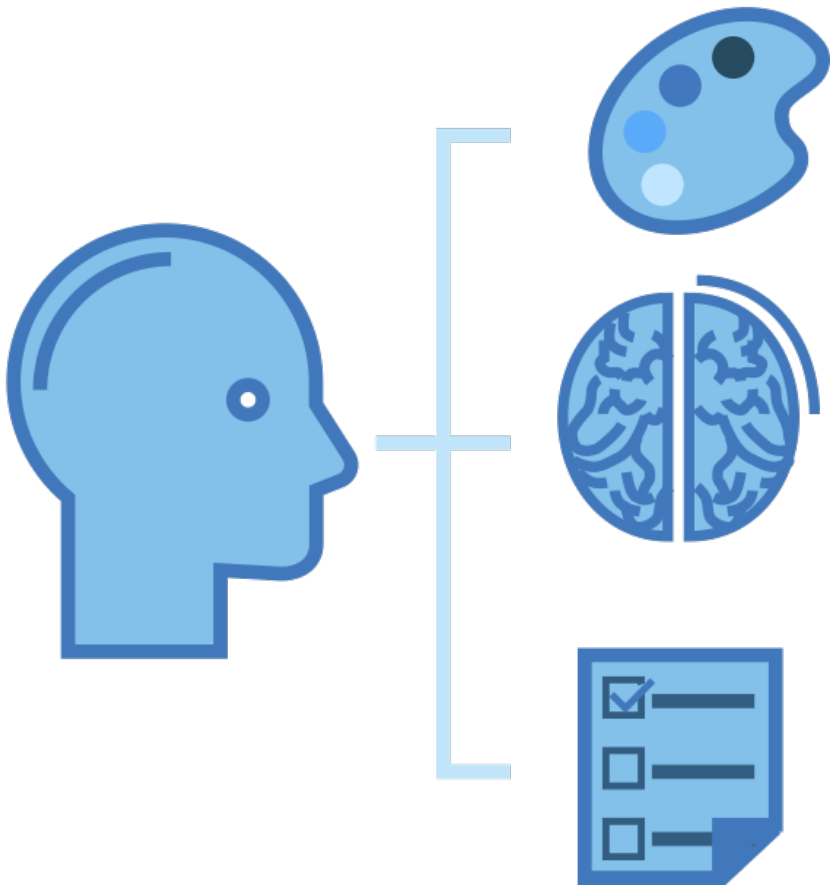
Natural Language Classifier

- Deep learning classification for Natural Language queries.
- Provide classification with confidence interval.

Usage example

Automatic tagging of content, classification of emails, intelligent dialogues.

PERSONALITY INSIGHTS



PERSONALITY INSIGHTS

Personality Insights

- Personality (Five Factors Model), needs and values extraction.
- Needs at least 3.5k words.
- Any source: twitter, book,...

Usage example

Individual customer service or marketing, job applicant analysis, market analysis.

TONE ANALYZER

TONE ANALYZER

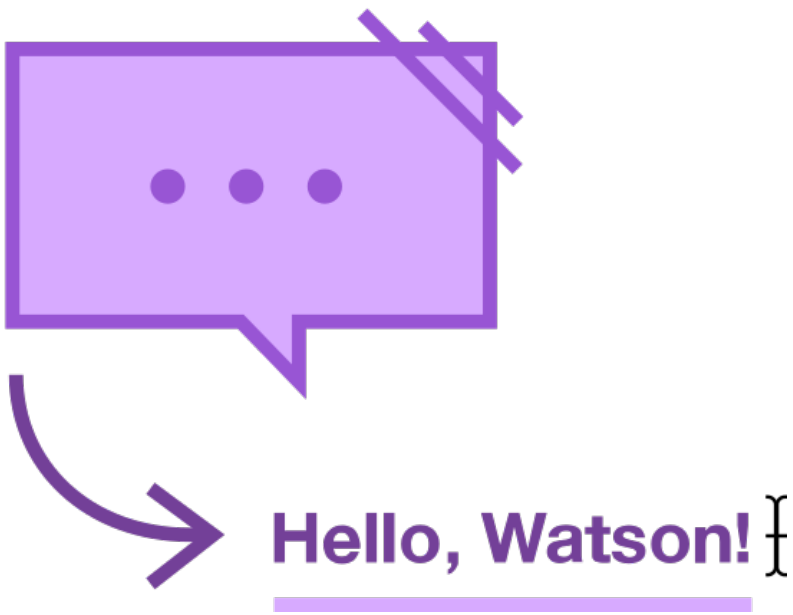
Tone Analyzer

- Analyze emotion and language tones in text.
- Provide Emotion, Language and Social analysis.

Usage example

Study on the impact of your anouncements.

SPEECH TO TEXT



SPEECH TO TEXT

Speech to Text

- IBM speech recognition to text output.
- Stream or recorded input.
- Several languages supported.
- Keyword extraction.

Usage example

Accessibility, transcription of conferences or meetings.

TEXT TO SPEECH

What can I do for you today

TEXT TO SPEECH

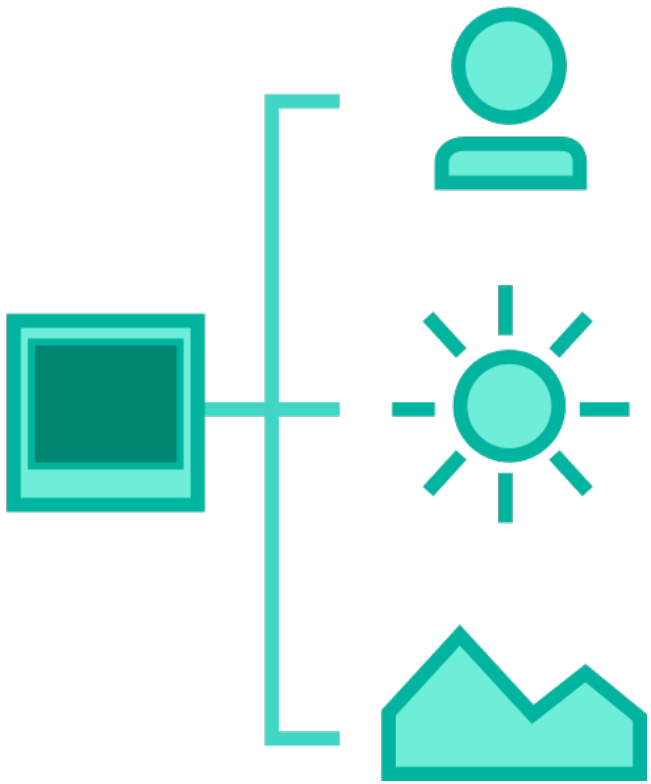
Text to Speech

- Low latency audio synthesis.
- Several languages supported.
- Specific words pronunciation tuning through the REST API.

Usage example

Accessibility.

A_CHEMY VISION



AlchemyVision

- Face, words, persons detection.
- Age estimation, tagging and classification.
- Similar content suggestions.

Usage example

Targeted add, help for criminal recognition, image search engine.

IDEAS AND PROTOTYPES

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Ideas and prototypes

- Gesture Control
- Watson Home Assistant

GESTURE CONTROL

```
1  gest.options.subscribeWithCallback(function(gesture) {
2    var message = '';
3    if (gesture.direction) {
4      message = gesture.direction;
5      if(message == 'Right') {
6        document.getElementsByClassName("next-playlist-
             list-item")[0].click();
7      } else if(message == 'Left') {
8        document.getElementsByClassName("prev-playlist-
             list-item")[0].click();
9      }
10   } else {
11     message = gesture.error.message;
12   }
13 });
14 gest.start();
```

IDEAS AND PROTOTYPES

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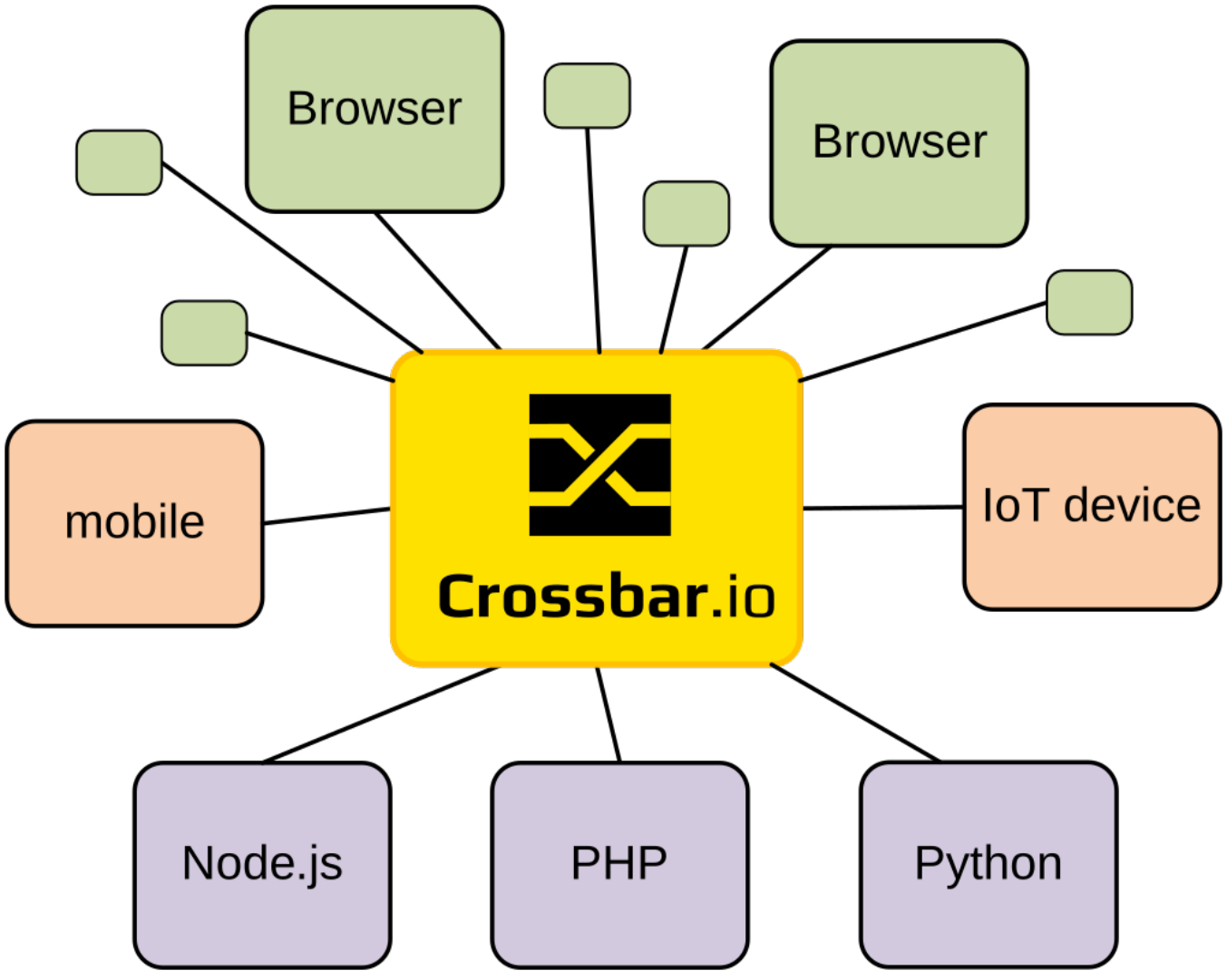
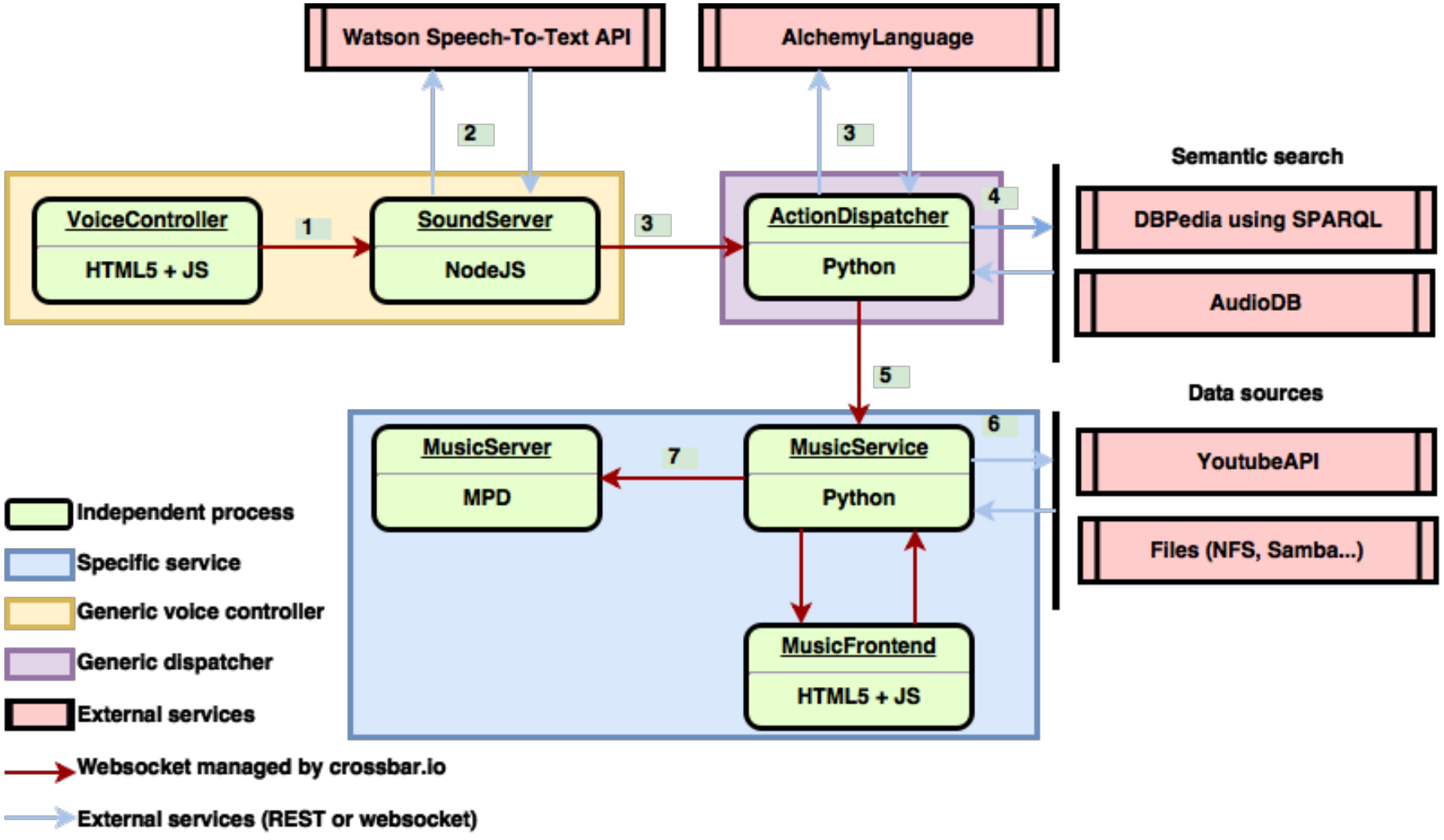
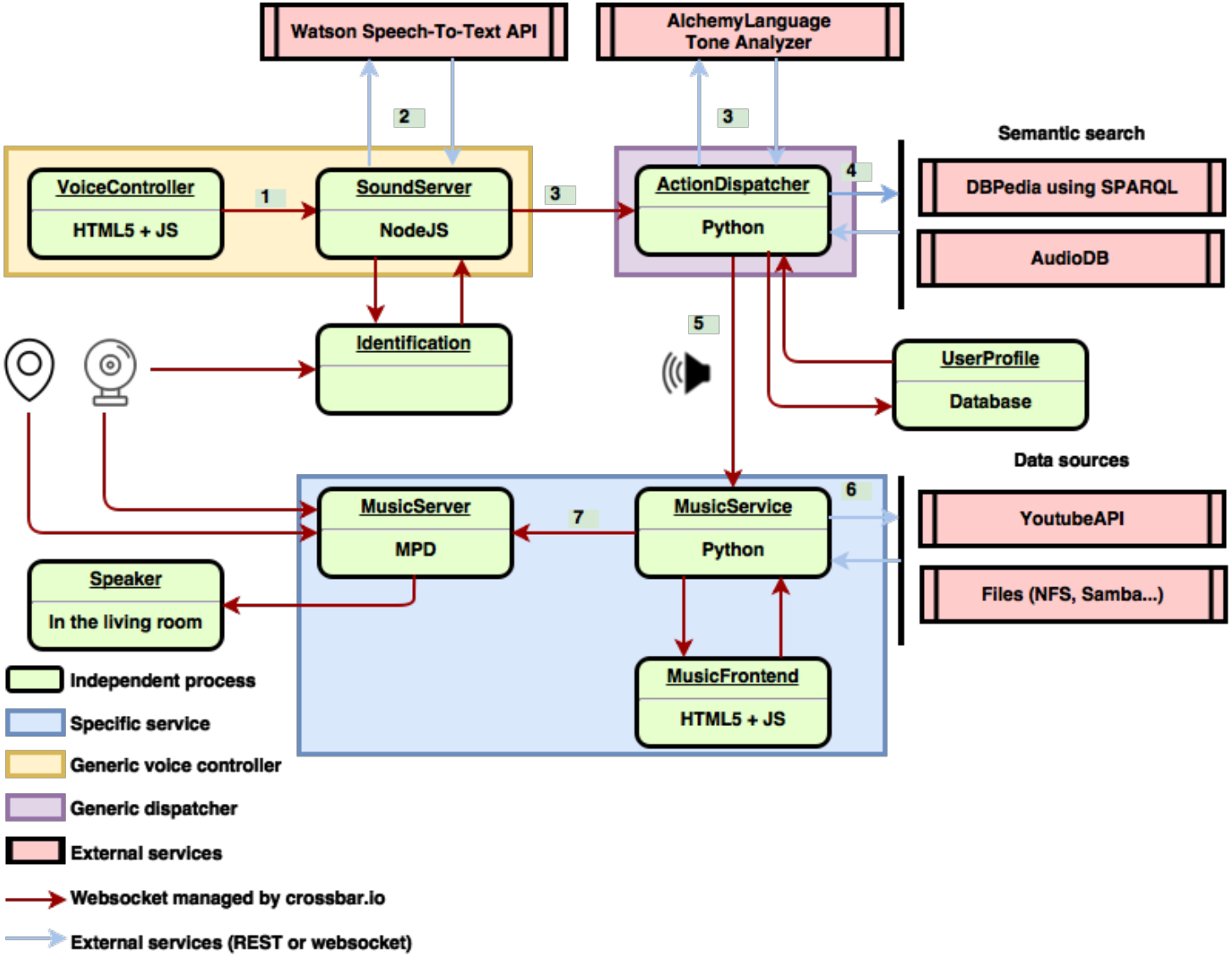
A PROTOTYPE


Browser
Browser
mobile
Crossbar.io
IoT device
Node.js
PHP
Python

A PROTOTYPE


Watson Speech-To-Text API
AlchemyLanguage
2
3
Semantic search
VoiceController
HTML5 + JS
1
SoundServer
NodeJS
3
ActionDispatcher
Python
4
DBPedia using SPARQL
AudioDB
5
Data sources
MusicServer
MPD
7
MusicService
Python
6
YoutubeAPI
Files (NFS, Samba...)
MusicFrontend
HTML5 + JS
Independent process
Specific service
Generic voice controller
Generic dispatcher
External services
Websocket managed by crossbar.io
External services (REST or websocket)

A PROTOTYPE (IF I WAS NOT LAZY)



A PROTOTYPE

https://github.com/aquemy/watson-homeautomation

THE END

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Thank you for your attention!
Questions?