CLOUD PLATFORMS FOR THE INTERNET OF THINGS: HOW DO THEY STACK UP?

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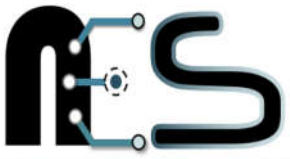

NETWORKED EMBEDDED SOFTWARE LAB

About Me!

- Masters Student at Politecnico di Milano (PoliMi), Italy
- Networked Embedded Software Lab, PoliMi
- Internet of Things Enthusiast
- First timer at an Open Source event

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Goals for this talk

- Why do we need Cloud Platforms for Internet of Things?
- What are some of the cloud platforms out there?
- What are the parameters we use to analyze these platforms?
- How do we choose a platform in a use-case scenario?
- Do open source platforms really stand out?

Outline:

INTRODUCTION TO IOT AND CLOUD PLATFORMS

MOTIVATION FOR THE TALK

ARCHITECTURAL DESIGN CHOICES

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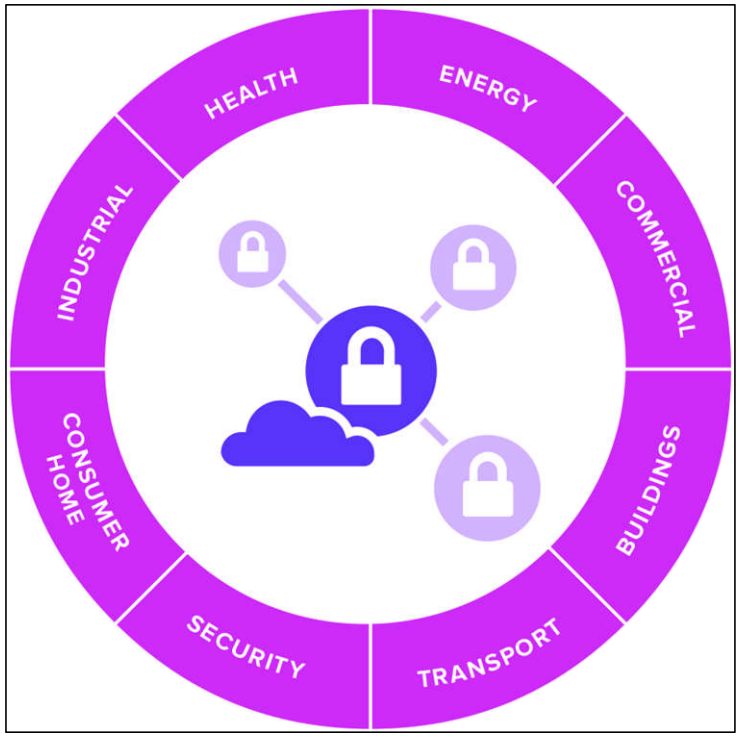
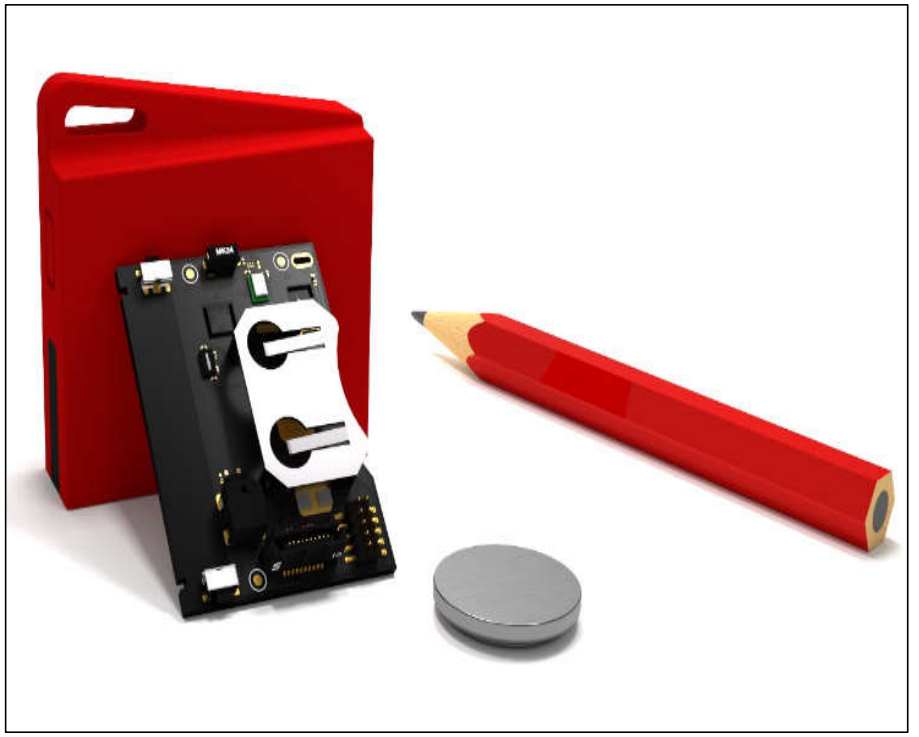
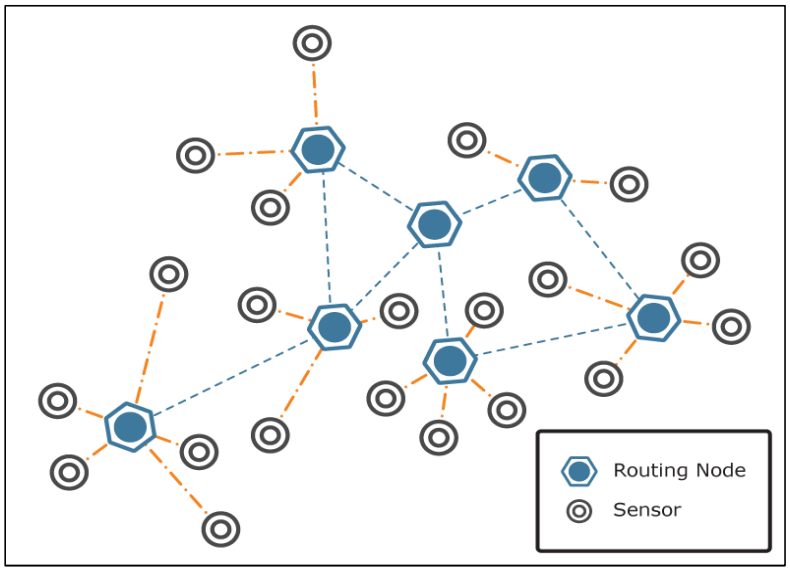
IoT: Growing Bigger, Getting Smaller





Evolution of the Internet of Things

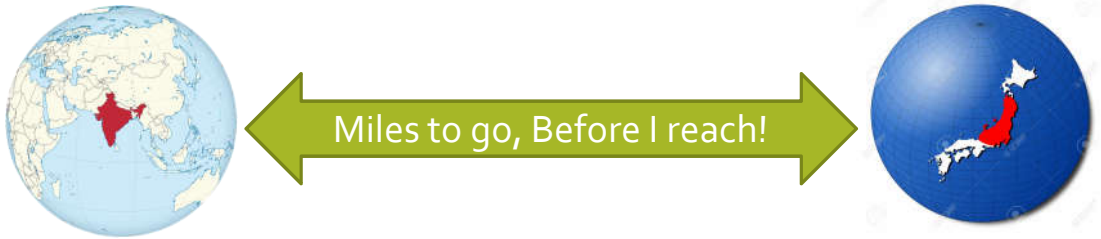


Motivation for Cloud Platforms in IoT

- Large number of connected devices, how to store the data?
- Difficulty to process large sets of data locally
- Base Station storage and processing limited
- Lack of remote access to the data
- Need for Cloud Platforms to address these issues

The Downside?

- Storing and extracting data from the cloud incurs delay
- Data Center might be geographically remote
- Delay can be quite significant for sensing-actuation applications



Sensor Network

Data Center Location

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The IoT Architecture

Sensors and Actuators

Gateway

Cloud Platforms

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Where do I come in?

- Circo Massimo requires regular maintenance and monitoring
- Archaeologists from Univ. of Trieste are monitoring the site
- They wanted to improve their monitoring with the ‘Internet of Things’

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What did they need?

- Data from the sensors deployed on site
- Being able to visualize the data for a given period
- To be able to show the data to others
- Get statistical measures on the data on given periods

What does a Cloud Platform for IoT offer?

Storage

Processing

Remote Access

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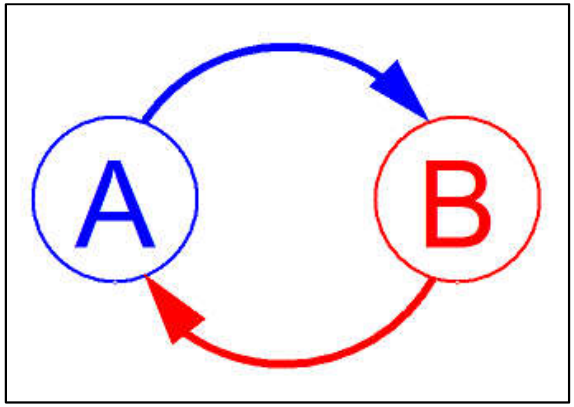
Optionally!

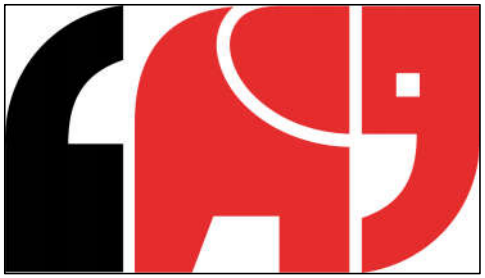
Visualization

#include

Libraries for IoT devices



Triggers



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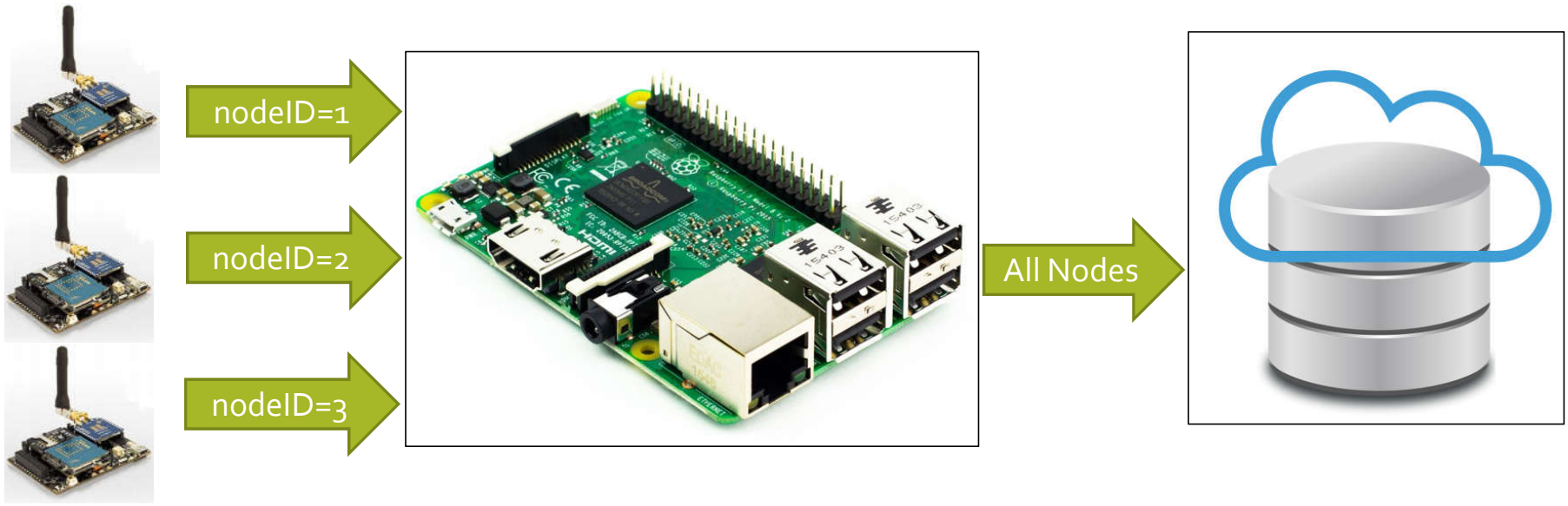
Architecture: Gateway Based



'Things'

Gateway

Cloud Platform

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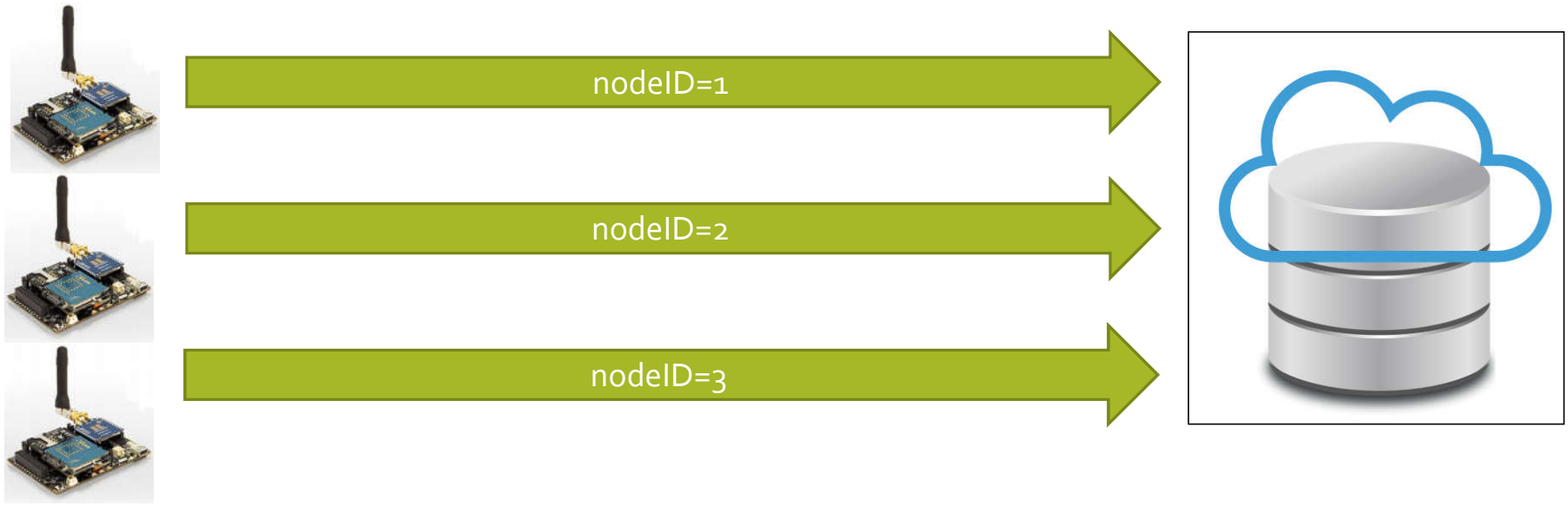
Architecture: Bypassing the Gateway



'Things'

Cloud Platform

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Architecture:

Gateway-based

- ✓ Energy efficient for the devices
- ✓ Cloud platform agnostic to device-gateway communications
- ✓ Cloud platform sees fewer devices
- ✗ Granularity compromised
- ✗ Gateway single point of failure

Bypassing the Gateway

- ✓ Granularity of data sustained
- ✓ Easier management of the network from the cloud
- ✗ Higher energy consumption for devices
- ✗ Variable latency for devices

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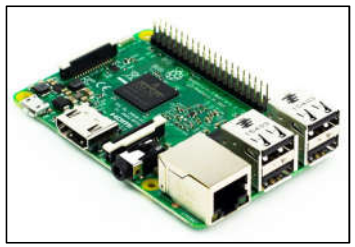
How to judge the Cloud Platforms?

- Protocol used
- Type of service (X-aaS)
- Openness of the platform
- Libraries for platforms
- Cost
- Authorization Policies
- Privacy of data

Protocols Used

- Request Response Model
  - Constrained Application Protocol (CoAP)
  - Hyper Text Transfer Protocol (HTTP)
  - Example: Xively, SenseIoT, Thingspeak, IBM IoT, Amazon AWS IoT



Gateway

Hey, its -11°C, I'm freezing

Cool, got that!

Cloud Endpoint
'storedata.here.com'

How is Pi doing?

Freezing!

User/Application

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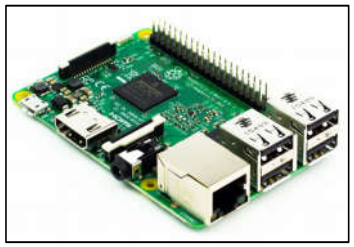
Protocols Used

- Message Passing Model
  - Advanced Message Queuing Protocol (AMQP)
  - Message Queuing Telemetry Transport (MQTT)
  - Example: Amazon AWS, Microsoft Azure IoT, IBM IoT, SicsthSense



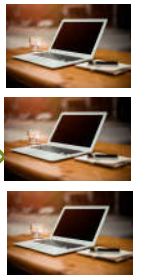
Message Publisher

Lets talk about the weather in Berlin, its pleasant!

Really? That's nice

Message Broker
Temperature/Berlin

You wanted to know about Berlin? Its pleasant



Message Subscriber

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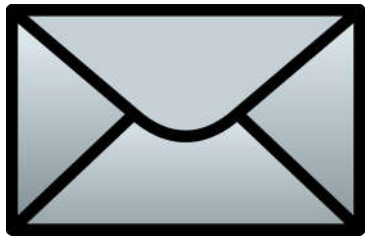
Openness of Platforms

- Closed Platforms:
  - Most commercial platforms are closed
  - The platforms are hosted by the company themselves
  - Services are paid and limited by the prices for the services
    - Example: Amazon AWS, Azure IoT, IBM IoT
- Open Source Platforms:
  - The platforms are available for contribution from the community
  - Can be locally hosted on own hardware
    - Example: Sparkfun, SicsthSense, Parse

Type of Service Offered (X-aaS)

- Platform as a Service (PaaS)
  - Service offers a platform that can be used for development
  - Parse, Xively, Phant, Amazon AWS, Azure IoT, IBM IoT, Sparkfun, Ubidots
- Software as a Service (SaaS)
  - Service offers a software which is being hosted remotely
  - Element Blue, Devicify
- Infrastructure as a Service (IaaS)
  - The service offers storage, hardware, server, as well as software
  - IoTSens, offering IaaS for smart cities

Cost



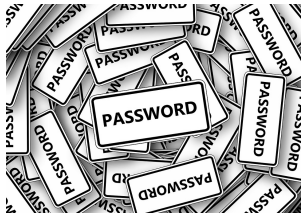
N° of messages (AWS IoT, SenseIoT)

N° of devices (IBM Watson IoT)

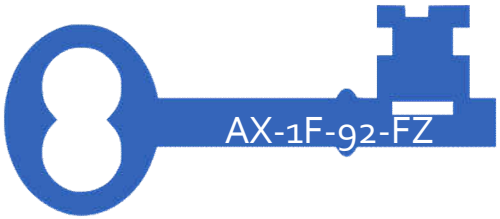
Storage (Azure)

Visualization (Ubidots)

Authorization



User name and Password (SenseIoT)



API Keys (Xively)

```
-----BEGIN CERTIFICATE-----
MIIDXTCCAkWgAwIBAgIJAJC1HiIAZAiIMA0GCSqGSIb3Df
BAYTAkFVMRMwEQYDVQQIDApTb21lLVN0YXRlMSEwHwYDVx
aWRnaXRzIFB0eSBMdGQwHhcNMTExMjMxMDg1OTQ0WhcNMT
A .... MANY LINES LIKE THAT ....
JjyzfN746vaInA1KxYEeI1Rx5KXY8zIdj6a7hhphpj2E04
C3Fayua4DRHyZOLmlvQ6tIChY0ClXXuefbmVSDeUHwc8Yu
B7xxt8BVc69rLeHV15A0qyx77CLSj3tCx2IUXVqRs5mlSb
vA==
-----END CERTIFICATE-----
```

Authorization Certificates (AWS IoT)

ACL	Device 1	Device 2
Resource 1	✓	✓
Resource 2	✗	✓

Access Control List (Parse)

Libraries

- Makes cloud platforms easier to use
- Offers various utilities and methods to access the cloud platform
- Offered in various languages and device platforms

Client Devices

Server Applications

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Amazon: AWS IoT

- Platform hosted by Amazon, offers subscription to services
- Multiple protocol options offered: MQTT, HTTP, Web Sockets
- Offers data aggregation from the devices
- For processing and storing data, additional modules are required
- Data reception can be used as a trigger to these modules

Amazon: AWS IoT

- Additional Modules:
  - AWS Lambda: Adding cloud code to triggers
  - DynamoDB: NoSQL database for storage
  - CloudWatch: For monitoring the services
  - S3: Storing the data in files
- Modules entail additional costs based on usage

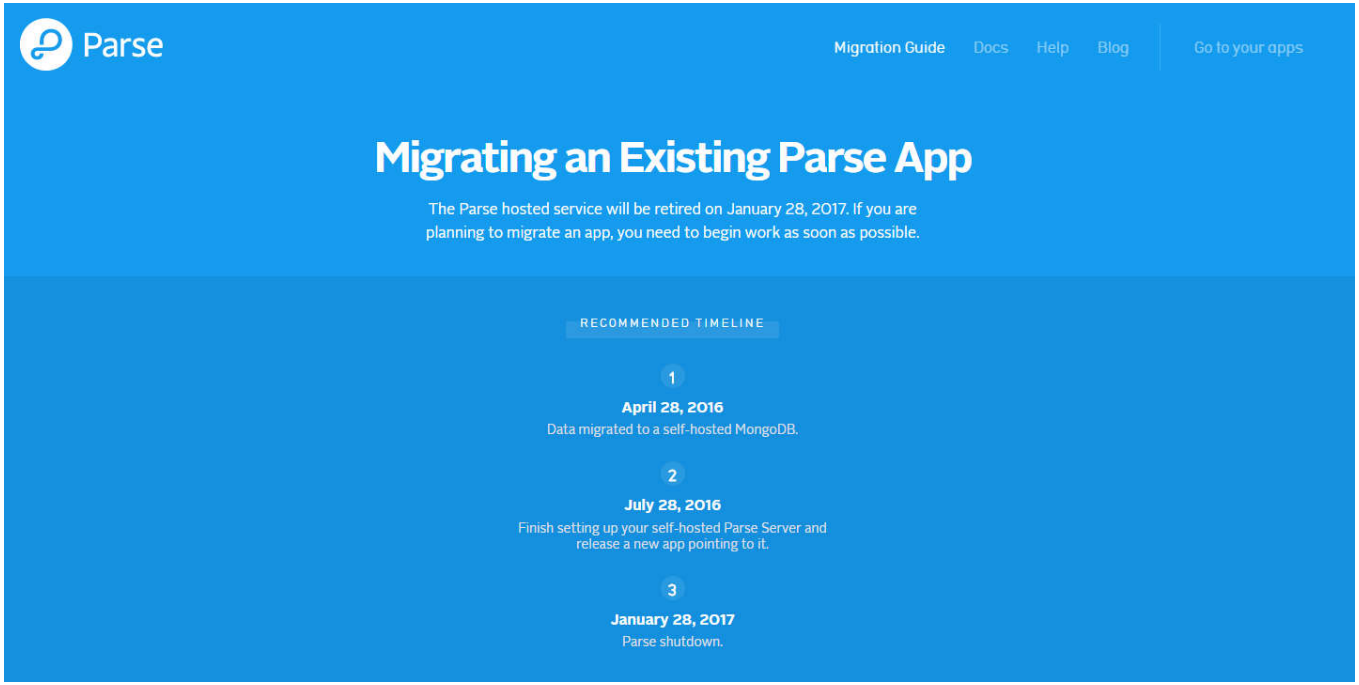
Sparkfun (Phant)

- Open Source Data logging platform for IoT
- Source code available for hosting
- Also hosted on data.sparkfun.com, free to use
- REST API based interaction model
- Data published to data-streams accessible by API

Sparkfun: Where does it differ?

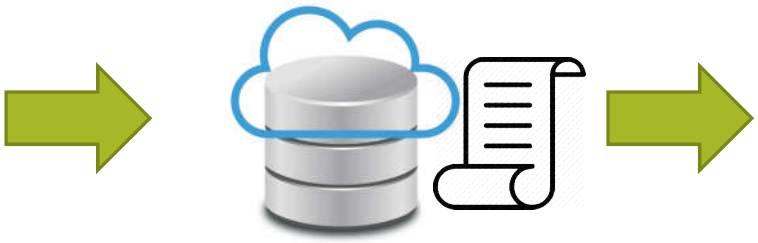
- In development stages
  - Data published to data.sparkfun.com is open
  - Can be accessed by anyone with the URL
  - Tradeoff: Does it matter for your specific application?
- Limits on number of requests
  - 100 log requests for 15 minutes
  - Not limited by costs, but a parametric limit set by the platform

Parse: Open to the World



What does Parse offer?

- Open source server is offered for cloning and hosting
- Based on REST API, communication based on objects
- Open source libraries for embedded devices and other data sources
- Libraries offered in C, Python, JavaScript, Java, .NET



```
{"Timestamp": 1463648886,
"ID":13,
"HU":40.41}
```

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Parse: How does it stand out?

- Cloud Code
  - Functions on Parse Cloud, can be invoked remotely
  - Can be leveraged to create WebHooks and Triggers
- Live Query
  - Subscription based model for getting updates on objects
  - Flexibility to set cache and websocket timeouts
- Offers the option to send push notifications to clients

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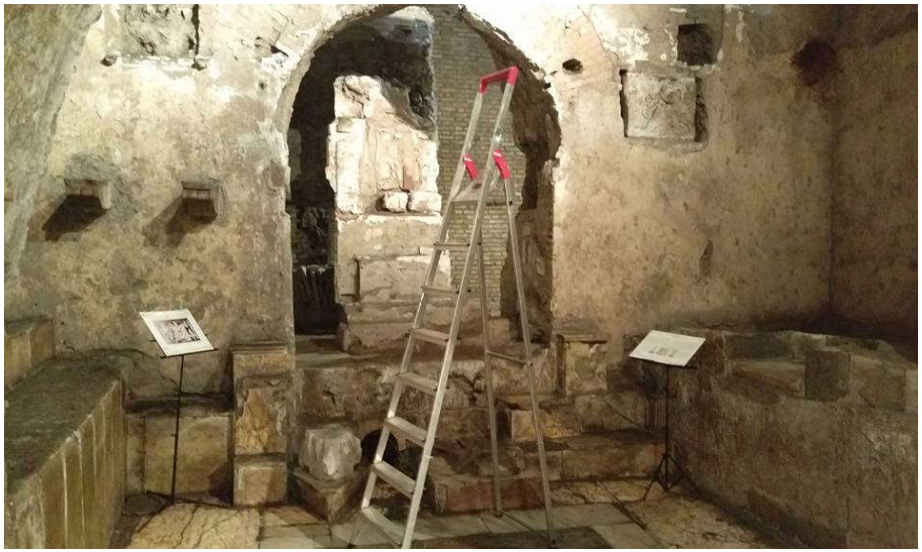
Use Case: Circo Massimo



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The Deployment:

LDR Sensor

Temperature Sensor

CO_2 Sensor

Libelium Mote

Humidity Sensor

Soil Temperature Sensor

802.15.4

Libelium Gateway

Serial

Raspberry Pi

WiFi

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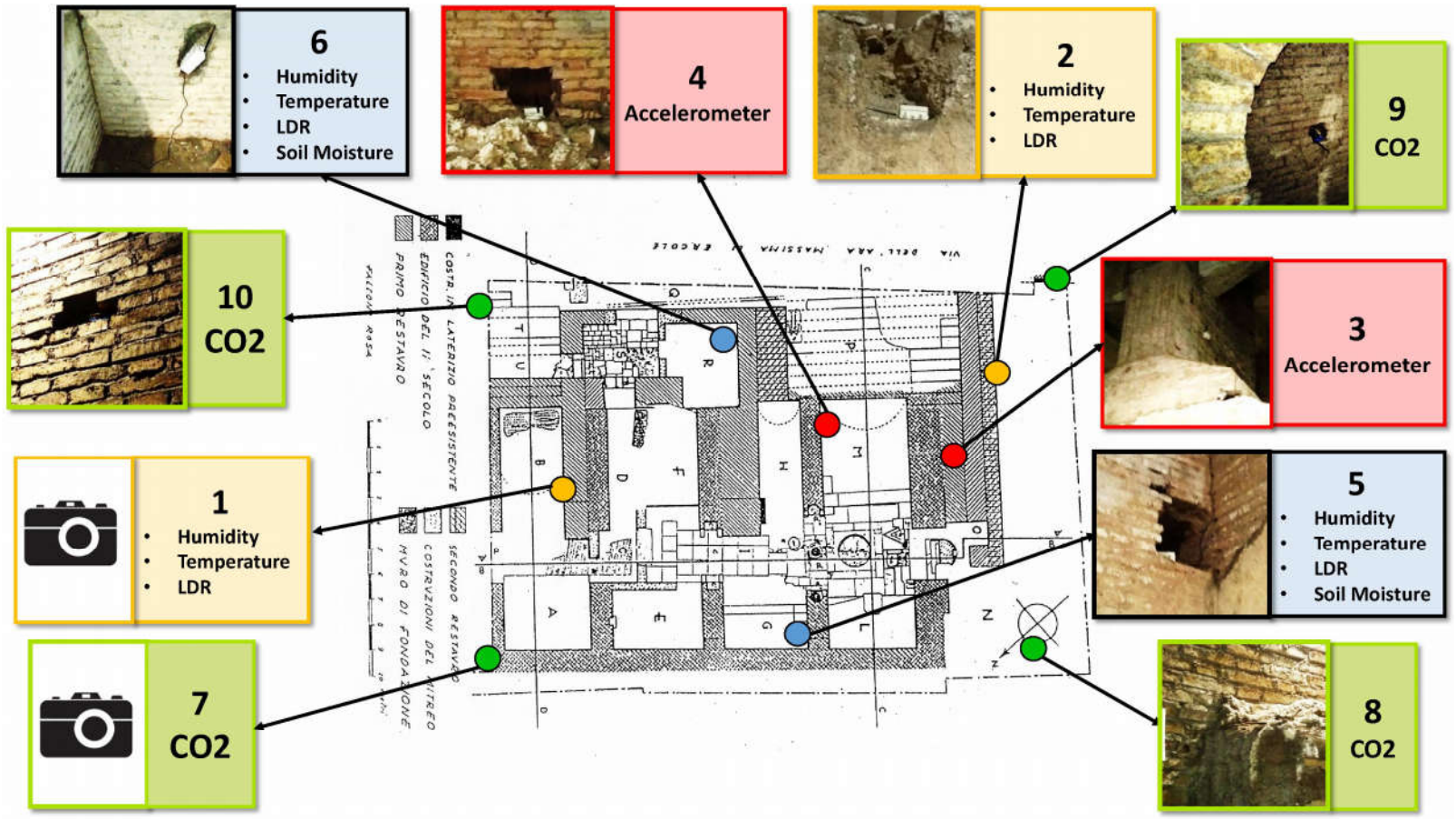

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Deployment:

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Connecting to the Cloud: Parse

- Locally hosted on a server
- Data gathered over REST API and JavaScript SDK
- Visualization: Use Cloud Code to send data to Freeboard
- Visualization of data in the form of widgets
- Basic statistical operations: Implemented on Cloud Code
- Sharing the data: Share the dashboard for particular sensor

Connecting to the Cloud: Sparkfun

- Data sent from the gateway to the datastreams over HTTP
- Data stored in the form of JSON Objects
- Statistical Operations: Can be done by querying the stream
- Data Visualization using Google Charts Library
- Sharing the Data: Can be achieved by using PUBLIC_KEY
- Only Read access on datastreams using PUBLIC_KEY

Connecting to the Cloud: Amazon

- Connect to Amazon's endpoint for IoT devices
- Data gathered over MQTT and Python
- Action based on message received:
  - Insert to Database (DynamoDB) using AWS Lambda
  - Visualize data using AWS Cloud Watch
- Basic statistical operations: Scripts on AWS Lambda
- Visualization with Amazon QuickSight (in future!)
- Cost becomes a major factor: Pay per usage

Comparing these platforms:

	Amazon (AWS IoT)	Parse Platform	Sparkfun (Phant)
Hosted by organization?	YES	NO	YES
Can be locally hosted?	NO	YES	YES
Protocol Used	MQTT	HTTP (REST)	HTTP (REST)
Installation Cost (Hosting)	NO	YES	YES
Usage Cost	As Per Use	NO	NO
Authorization	Certificate, Access Policy	Access Control List, Keys	API Keys
Libraries	CLOSED	OPEN-SOURCE	OPEN-SOURCE
Modify Platform	NO	YES	YES
Cloud Code	YES	YES	NO

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Why go for Open Source?

- Cost
  - Only pay for hosting the server
  - Estimation of total cost easier
  - No price driven limits for number of messages/devices
- More control
  - Fine tune platform parameters according to requirements
- Flexibility
  - Want to change something you don’t like?
  - Contribute and improve the platform
- Simplicity: Connect the modules and voila!

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Closed platforms: When to use?

- Tradeoff between operational and setup cost
- In certain cases, setup cost>operational cost
  - Sparse data generation, handled in free tier
- Complex operations on data, requires complex modules
- Stringent data privacy and authorization measures
- Lack of expertise to setup an open source platform

Conclusion:

- Choosing a platform is not an easy task, there are many available
- Narrow down requirements, ask the right questions!
  - What kind of protocol suits my use case?
  - How frequently do I need to send messages to the platform?
  - How much storage do I need?
- Open source platforms offer flexibility and simplicity
  - Catch: I have to host it myself!
- Is it worth paying for a commercial/closed platform for my requirements?
- There is no single answer to these questions, there are always tradeoffs!

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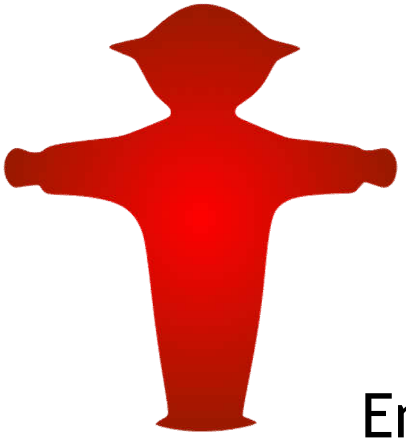
SUGGESTIONS AND QUESTIONS!



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