Master-Praktikum: IoT

(IN2106, IN4224)

IoT Core Team

Final Presentation
30.07.2018

Topic

Presenting the design and capabilities of the reinvented IoT platform

Presenters

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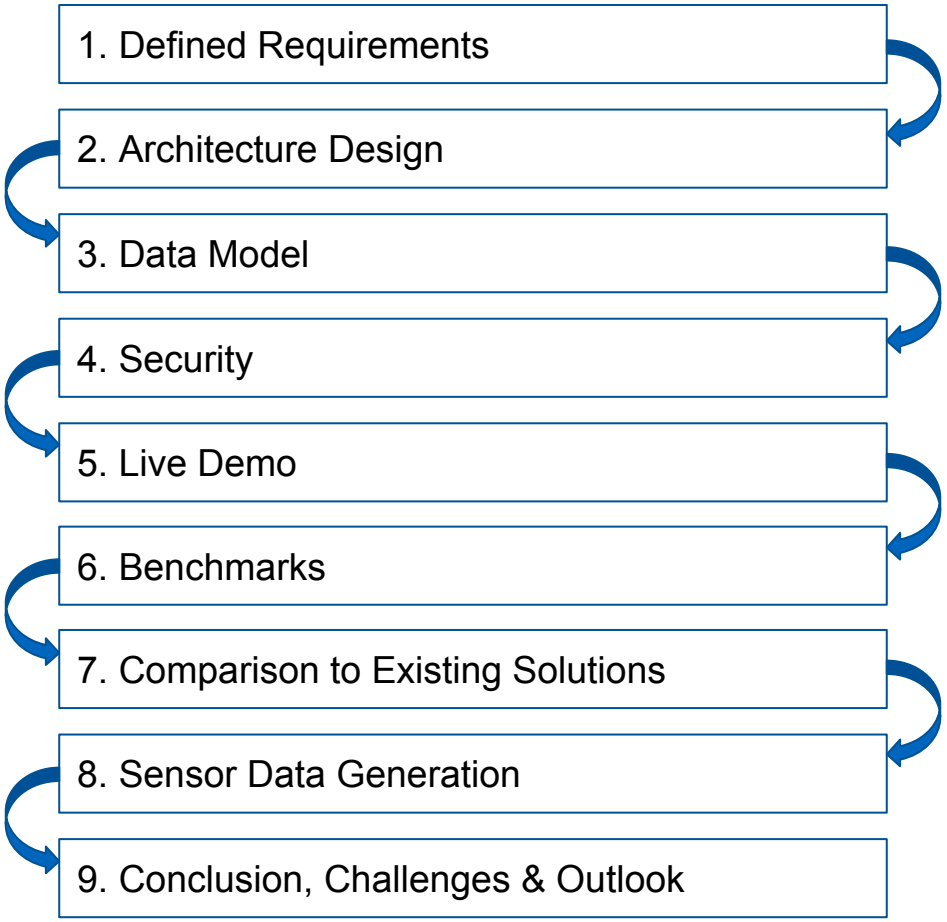
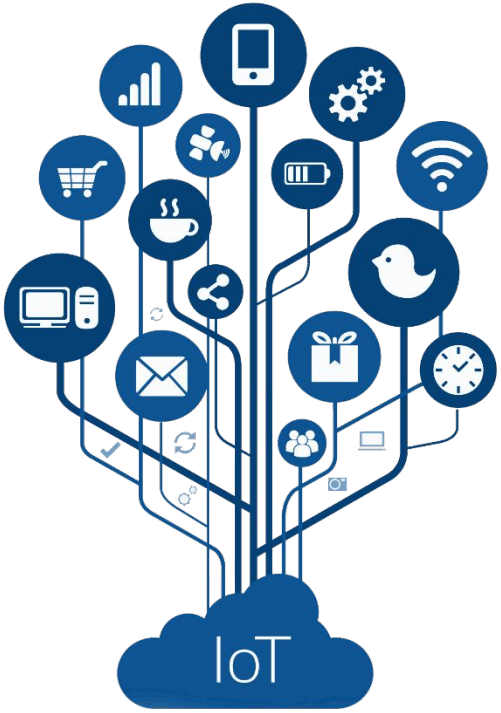
Hans Kirchner

Agenda



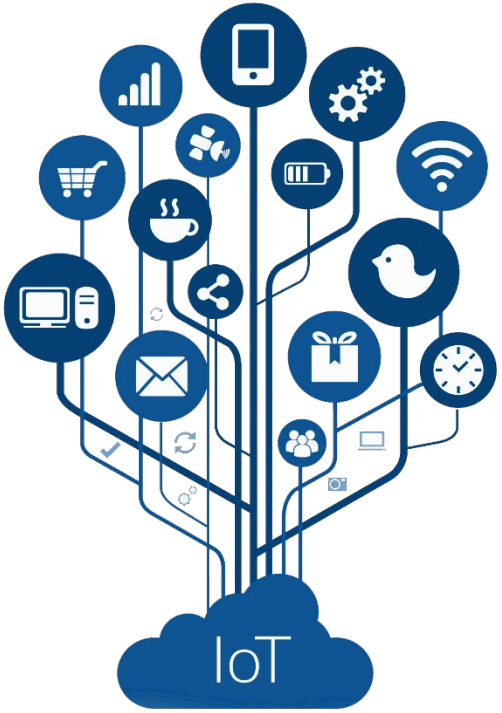
Defined Requirements



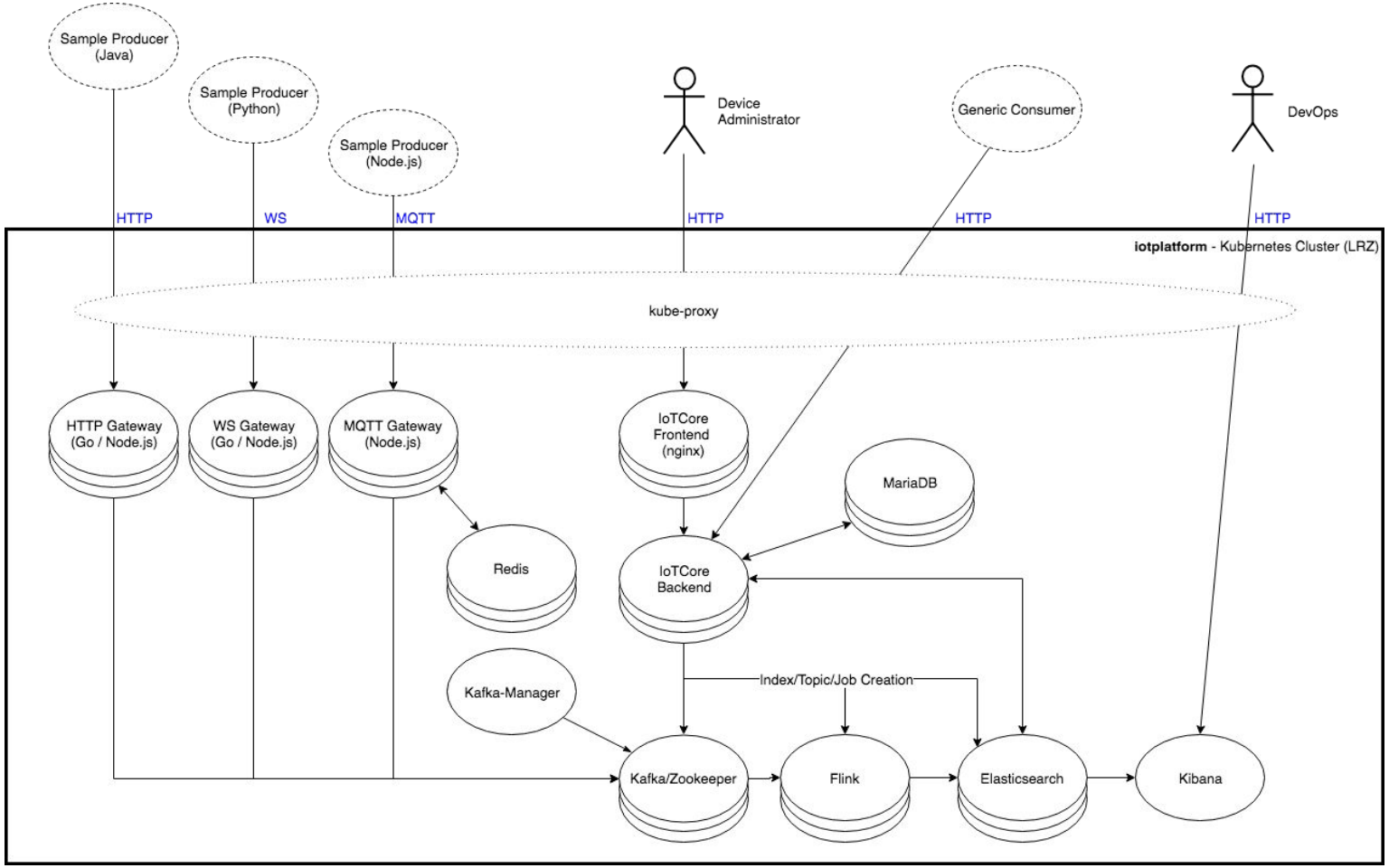
Defined Requirements

	Requirement	Previous Status
R1	Secure communication & transmission of data	✘ n.a.
R2	Storage	✔ Persisted inside VM
R3	Data Provisioning to Consumers	✔ REST-API
R4	Processing large amounts of data (>100k msg/sec) backed by scalability and load balancing on all tiers - ingestion to extraction	✘ n.a.
R5	Load throughput testing	✘ n.a.
R6	Ensure platform-independence, platform should be deployable on commonly used OS	✘ n.a.
R7	Ensure that platform can be deployed with beginner knowledge	~ long, detailed guide available
R8	Guide for Deployment & Usage	~ long, detailed guide available
R9	Multitenancy	✘ n.a.
R10	Support Ingestion via MQTT	✘ n.a.

Architecture Design

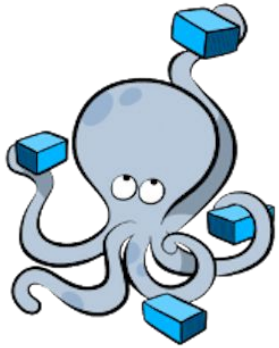


Architecture Design - Pipeline



Architecture Design - Deployment

Development Env (Local)



docker-compose

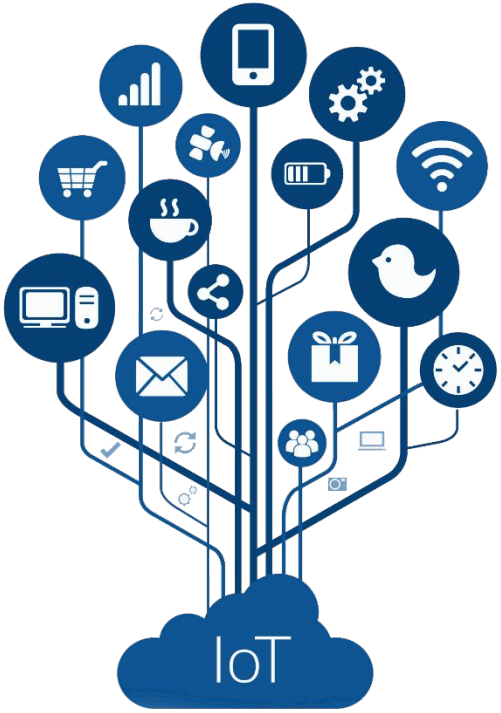
Travis CI

- Install Helm & K8s
- Load Cluster Config
- Docker Login
- Attempt to Rebuild from Previous Version
- Push to Container Registry
- Install new Deployment from Helm Chart

Production Env (LRZ)

kubernetes

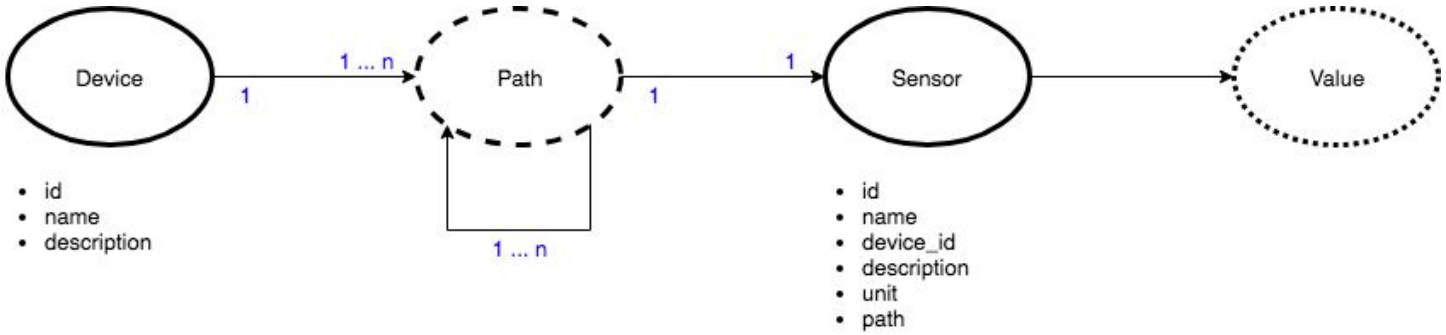
Data Model



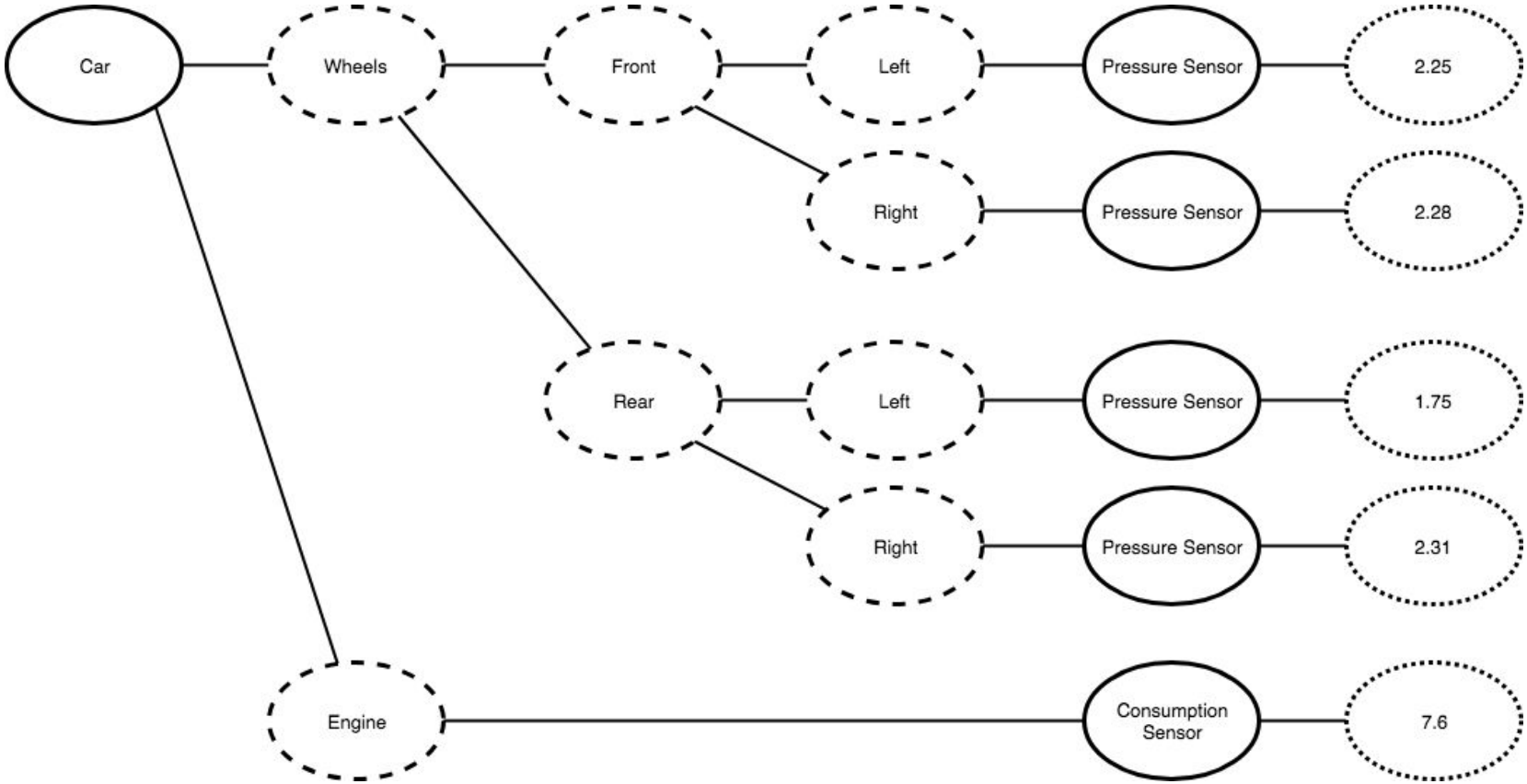
Data Model - Device-/Sensor Model

- Our Intent
  - Support of generic devices
  - Enable (optional) multi level nesting of sensors

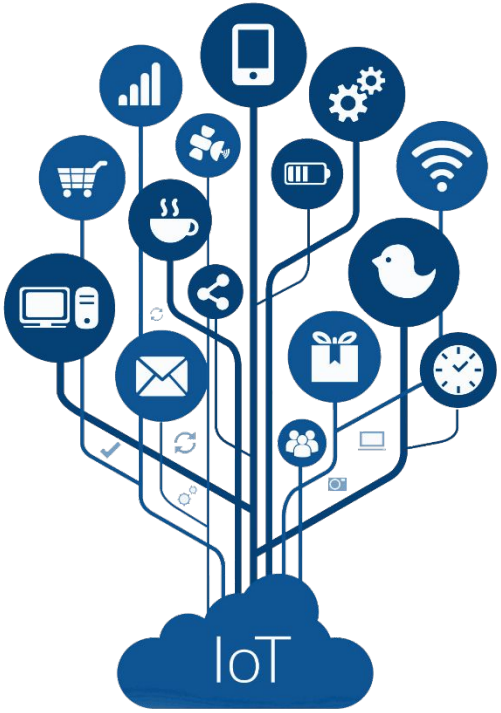
- Device
  - Entity that may contain one or many sensors
  - Represents a single physical logical unit
- Sensor
  - Entity that belongs to a device
  - Represents a single physical measuring point, producing a time series of data



Data Model - Example



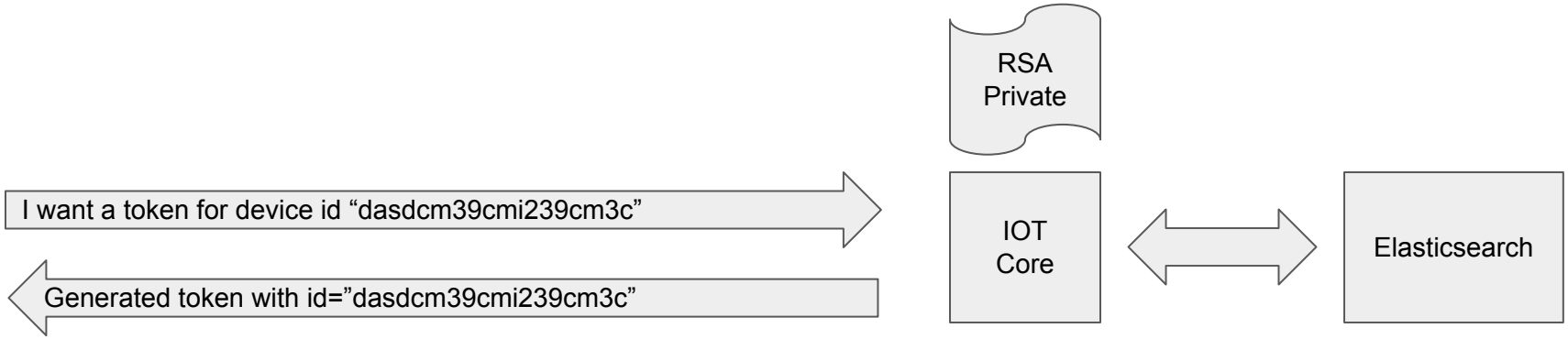
Security



Security

Security via JWT (JSON Web Token, IETF RFC7519 standard) [https://tools.ietf.org/html/rfc7519]

Retrieving JWT Tokens:



eyJhbGciOiJIUzI1NiIsInR5cCI6Ikp
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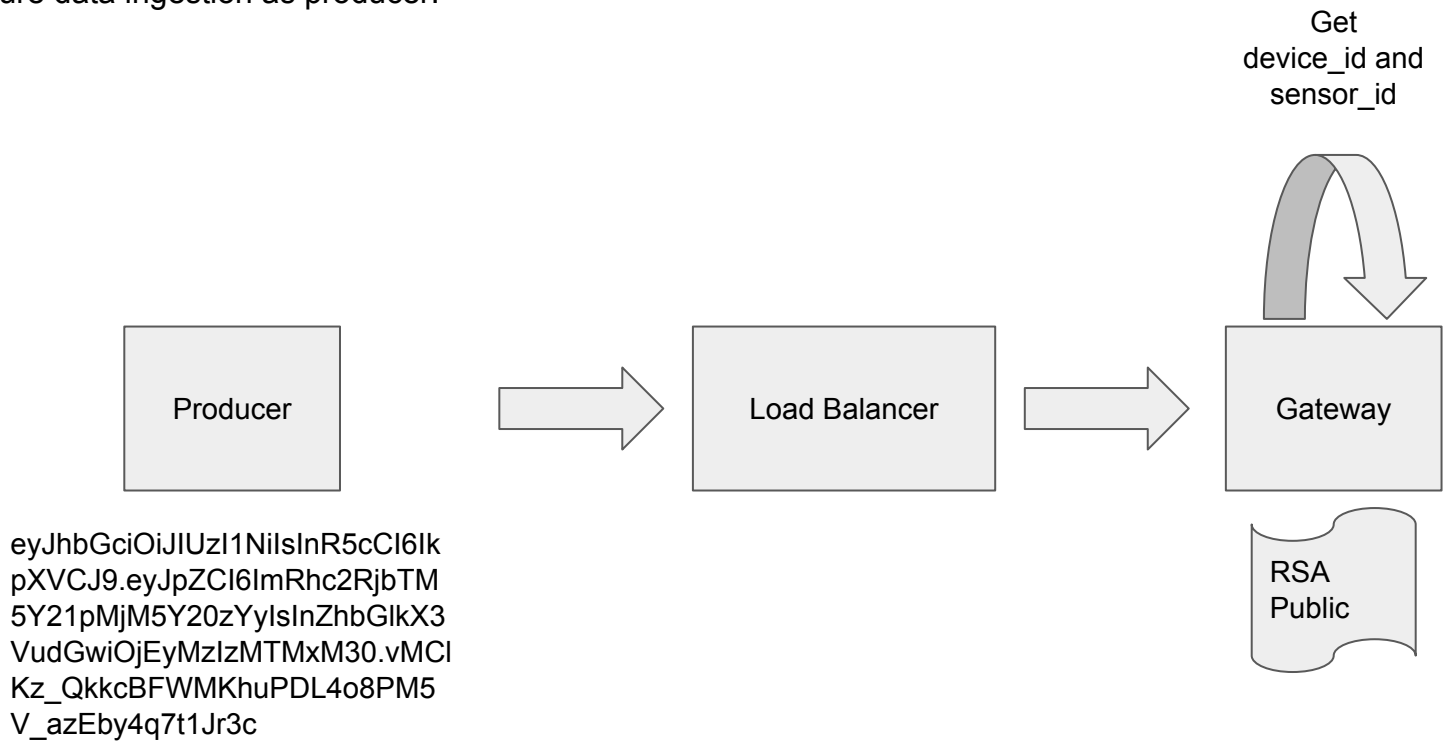
GwiOjEyMzIzMTMxM30.vMClKz_
QkkcBFWMKhuPDL4o8PM5V_az
Eby4q7t1Jr3c

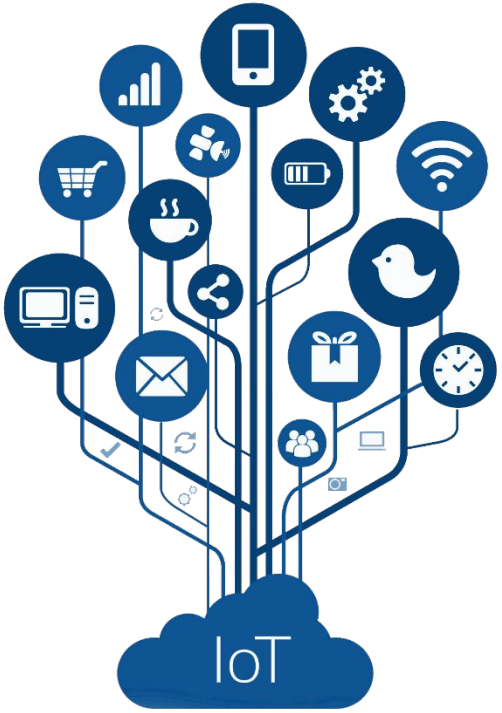
Security

Security via JWT (JSON Web Token, IETF RFC7519 standard) [https://tools.ietf.org/html/rfc7519]

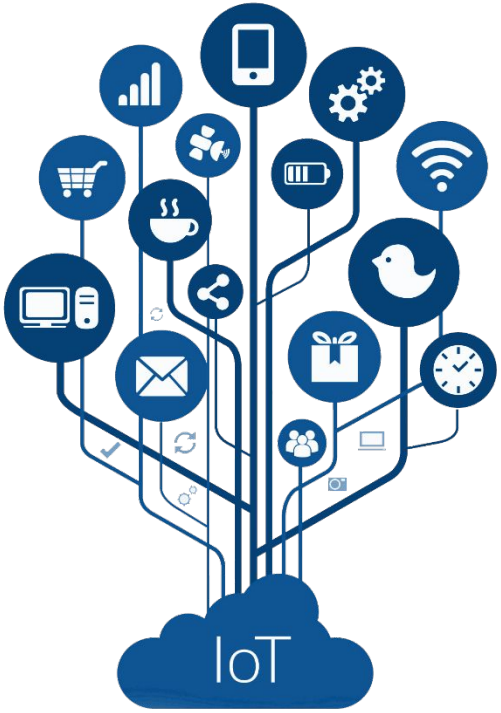
Secure data ingestion as producer:



Live Demo



Benchmarks



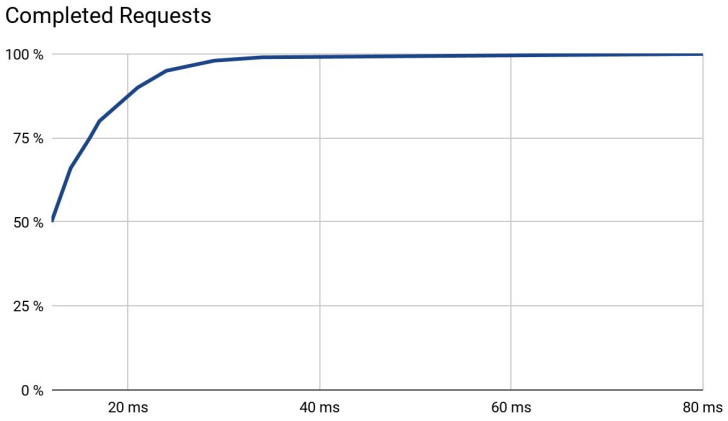
Benchmarks - HTTP - w/ Auth

Performance on Hetzner, cx41: 4 vCPUs, 16Gb of RAM

Testcase:
- 100 devices
- 200,000 msg
- Max-Throughput

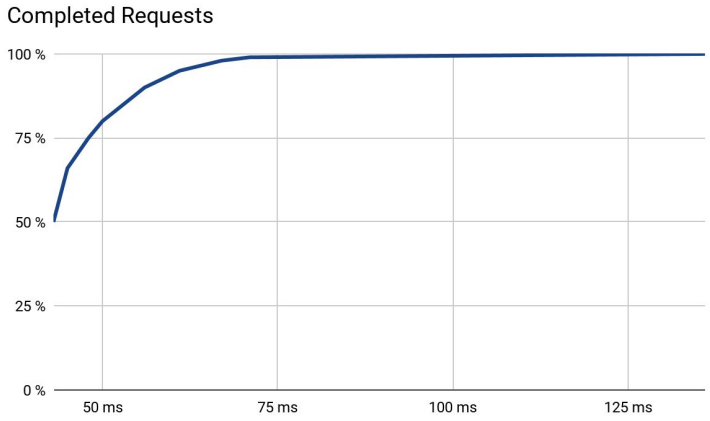
Go

Statistics:
- Mean: 13.236 ms
- Max: 80 ms
- Req/s: 7,554.87



Testcase:
- 100 devices
- 200,000 msg
- Max-Throughput

Statistics:
- Mean: 44.942 ms
- Max: 136 ms
- Req/s: 2,205.08



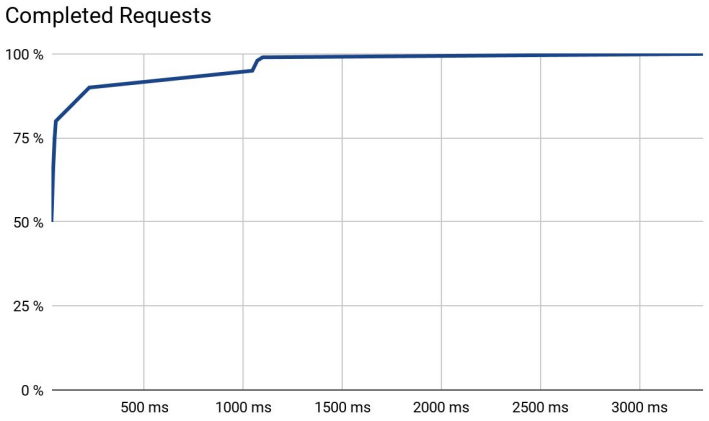
Benchmarks - HTTP - w/ Auth

Performance on Hetzner, cx41: 4 vCPUs, 16Gb of RAM

Testcase:
- 1,000 devices
- 100,000 msg
- Max-Throughput

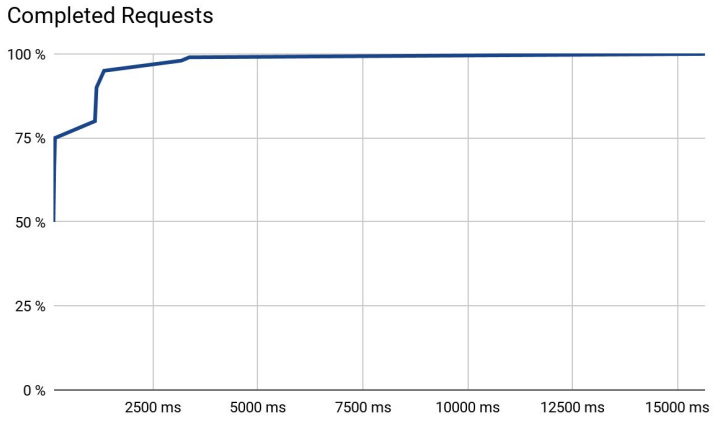
Go

Statistics:
- Mean: 131.057 ms
- Max: 3,321 ms
- Req/s: 7,630.28



Testcase:
- 1,000 devices
- 100,000 msg
- Max-Throughput

Statistics:
- Mean: 452.459 ms
- Max: 15,662 ms
- Req/s: 2,210.14



Benchmarks - WebSockets - w/ Auth

Performance on Hetzner, cx41: 4 vCPUs, 16Gb of RAM

Go

Testcase:

- 1,000 devices
- 1,000 msg/device
- Connections pre-established

Statistics:

- Mean: 0.542 ms
- Max: 923 ms
- Req/s: 800,319.53

Testcase:

- 1,000 devices
- 1,000 msg/device
- Connections pre-established

Statistics:

- Mean: 0.549 ms
- Max: 726 ms
- Req/s: 783,266.05

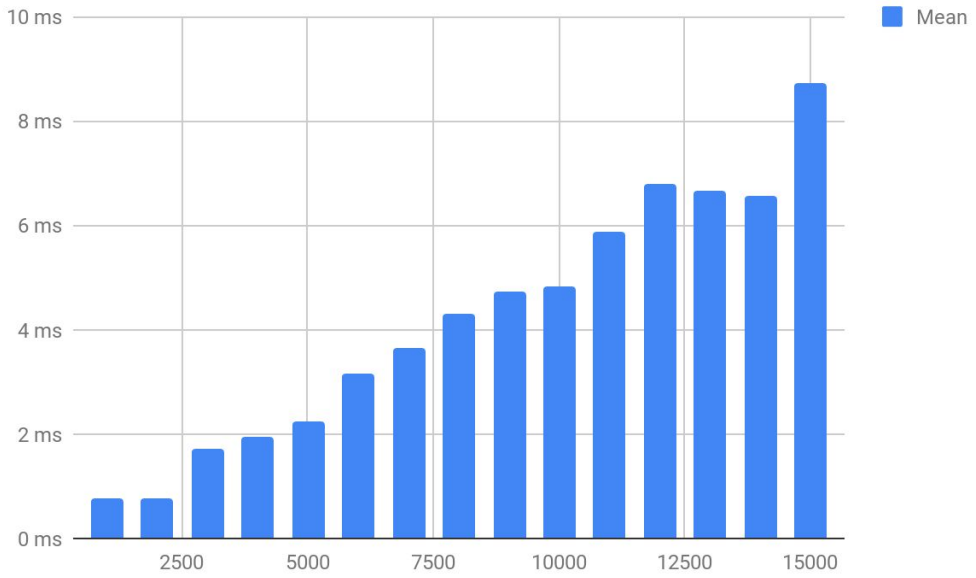
Benchmarks - WebSockets - Golang, w/ Auth

Performance on Hetzner, cx41: 4 vCPUs, 16Gb of RAM

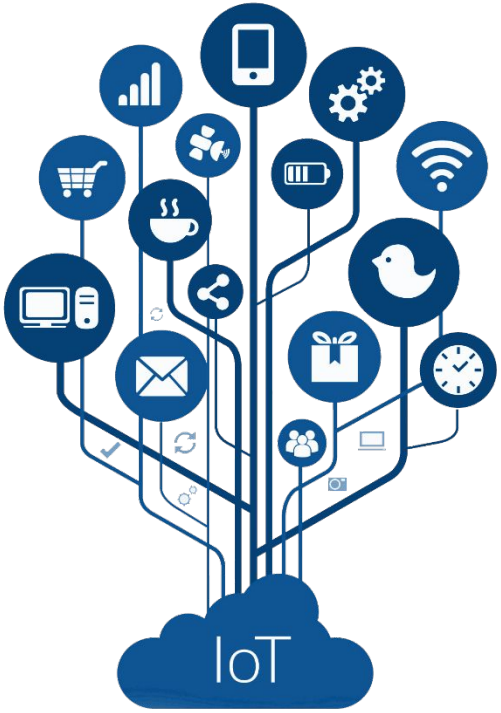
Go

Testcase:

- n devices
- 1,000 msg/device
- Connections pre-established



Comparison to Existing Solutions



Comparison to Existing Solutions - 

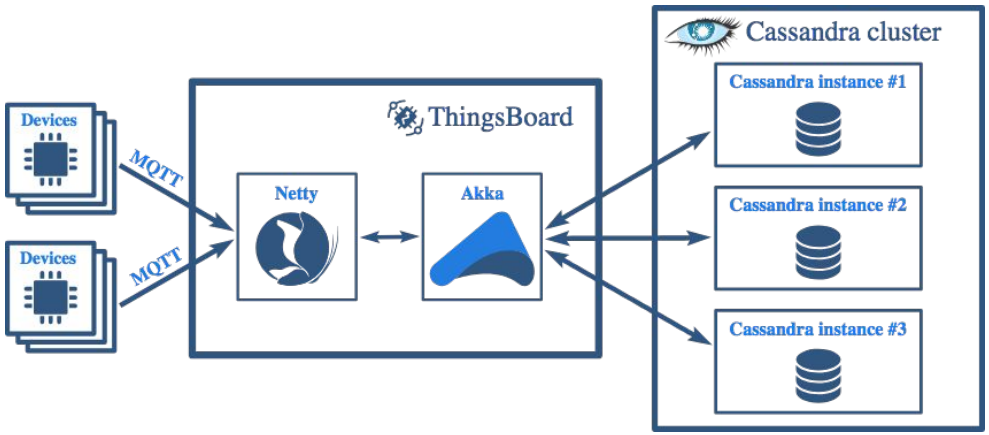
FEATURE	AVOCADO ARCHIPELAGO	BANANA BEACH (Early Access Only)
Architecture	Monolithic	Microservices
Connectivity protocol	Proprietary	Open, standards-based
Gateway connectivity model	One connection per device	Single, multiplexed connection
Communication security	RSA+AES	(D)TLS
Device credential management	No	Yes
Device metadata	Structured	Structured or unstructured
Data collection	Single data type, structured only	Unlimited types, isolated flows, structured or unstructured
Configuration management	Structured only	Structured or unstructured
Data processing and analytics	3-rd party integrations	Built-in or 3-rd party integrations
Data visualization	3-rd party integrations	Built-in customizable dashboards or 3-rd party integrations
Device notifications	Yes	No, superseded by commands
Command execution	No	Yes
Over-the-air updates	No	Yes
Technology stack	Mainly Java	Polylingual
Scalability, elasticity, self-healing	Manual	Automated container orchestration
Server configuration	Non-portable, stored in DB	Portable declarative blueprint

[https://www.kaaproject.org/whats-new/]

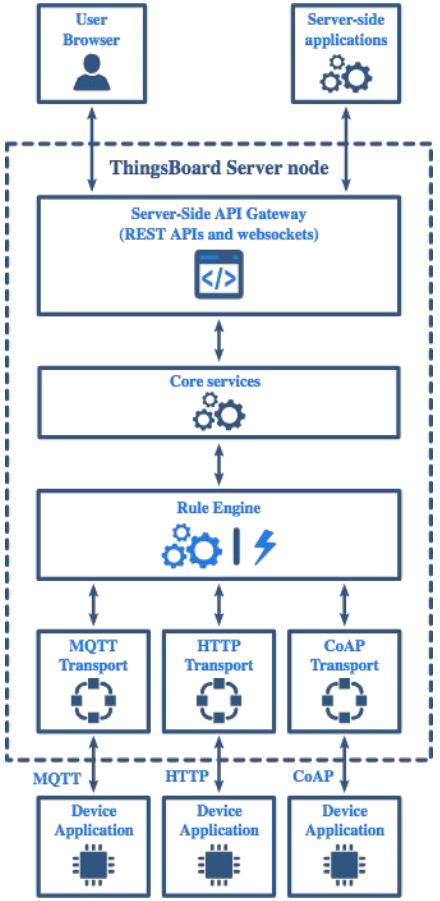
Comparison to Existing Solutions - ThingsBoard

Core Services:

- Device and credentials
- Rule chains and rule nodes
- Tenants and customers
- Widgets and dashboards
- Alarms and events



[https://thingsboard.io/docs/reference/performance/]

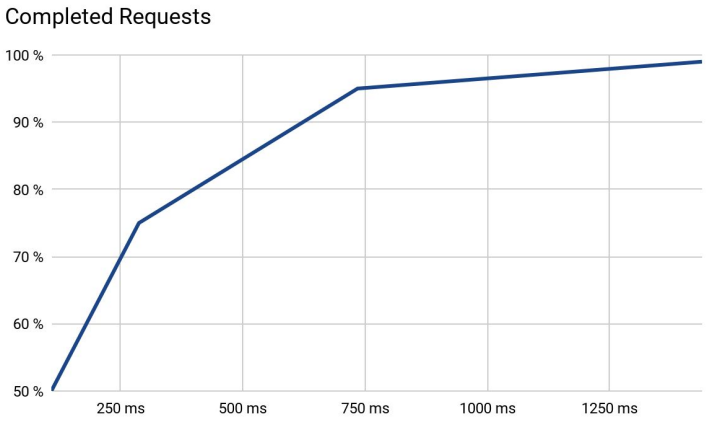


[https://thingsboard.io/docs/reference/architecture/]

Comparison to Existing Solutions - ThingsBoard

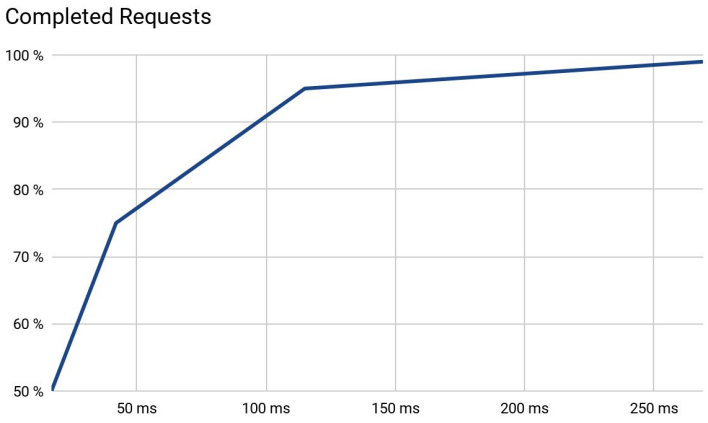
AWS, c4.2xlarge: 4 vCPUs, 7.5Gb of RAM
- MQTT
- 10000 devices
- 1 msg/sec/device
- total load: 10000 msg/sec

Statistics:
- Mean: 217 ms
- Max: 10887 ms
- Req/s: 6818.182



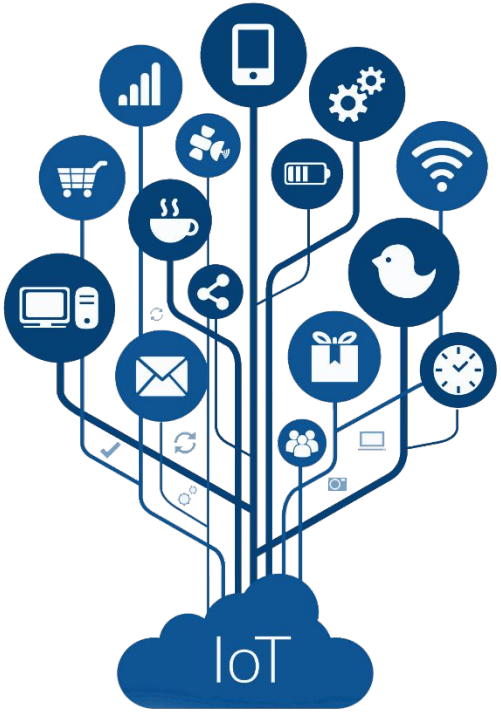
AWS, c4.2xlarge: 8 vCPUs, 15Gb of RAM
- MQTT
- 10000 devices
- 1 msg/sec/device
- total load: 10000 msg/sec

Statistics:
- Mean: 38 ms
- Max: 3270 ms
- Req/s: 8823.529



[https://thingsboard.io/docs/reference/performance/]

Sensor Data Generation



Sensor Data Generation

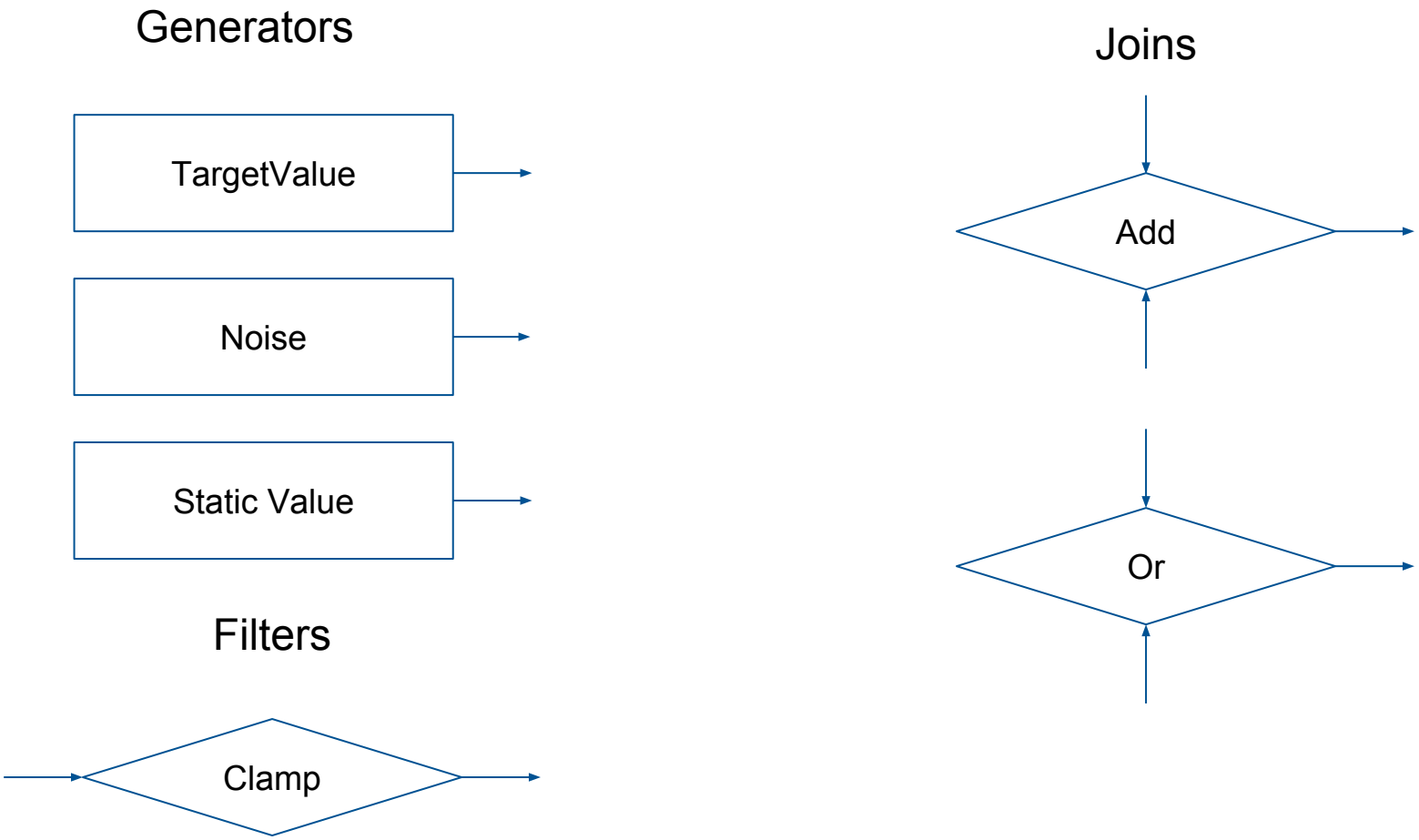
Goals:

- Generate sensor data that ‘looks real’
  - Different types of sensors (moving physical object, temperature, switch, ...)
  - Noise
  - Outliers
- Never save sensor for later replay but use a seed for the PRNG
- (Possibly) endless stream of data

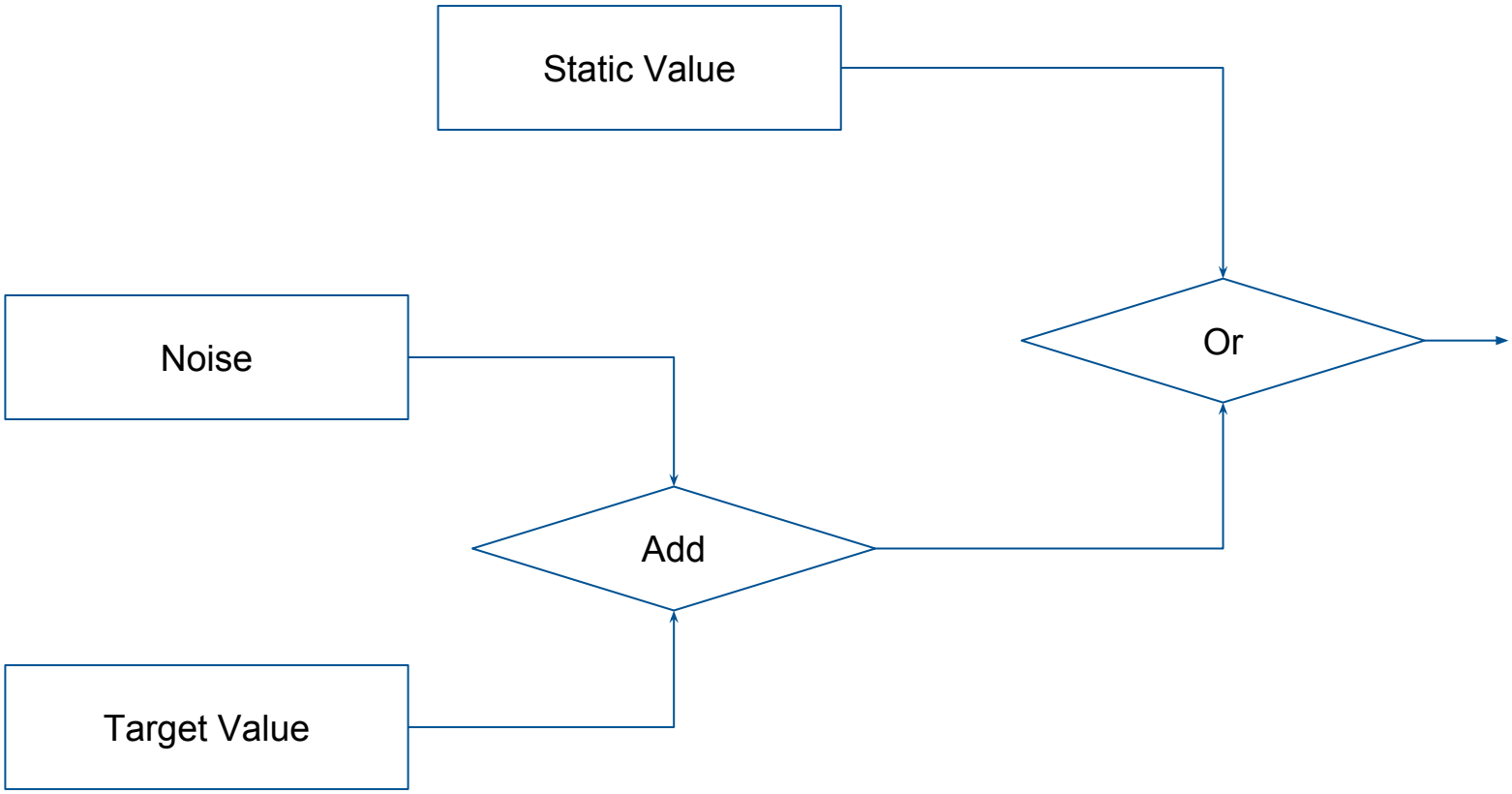
Implementation:

- Pluggable components
  - Generators output an endless stream of sensor values
  - Filters take a sensor value and modify it
  - Joins take several sensor values and combine them

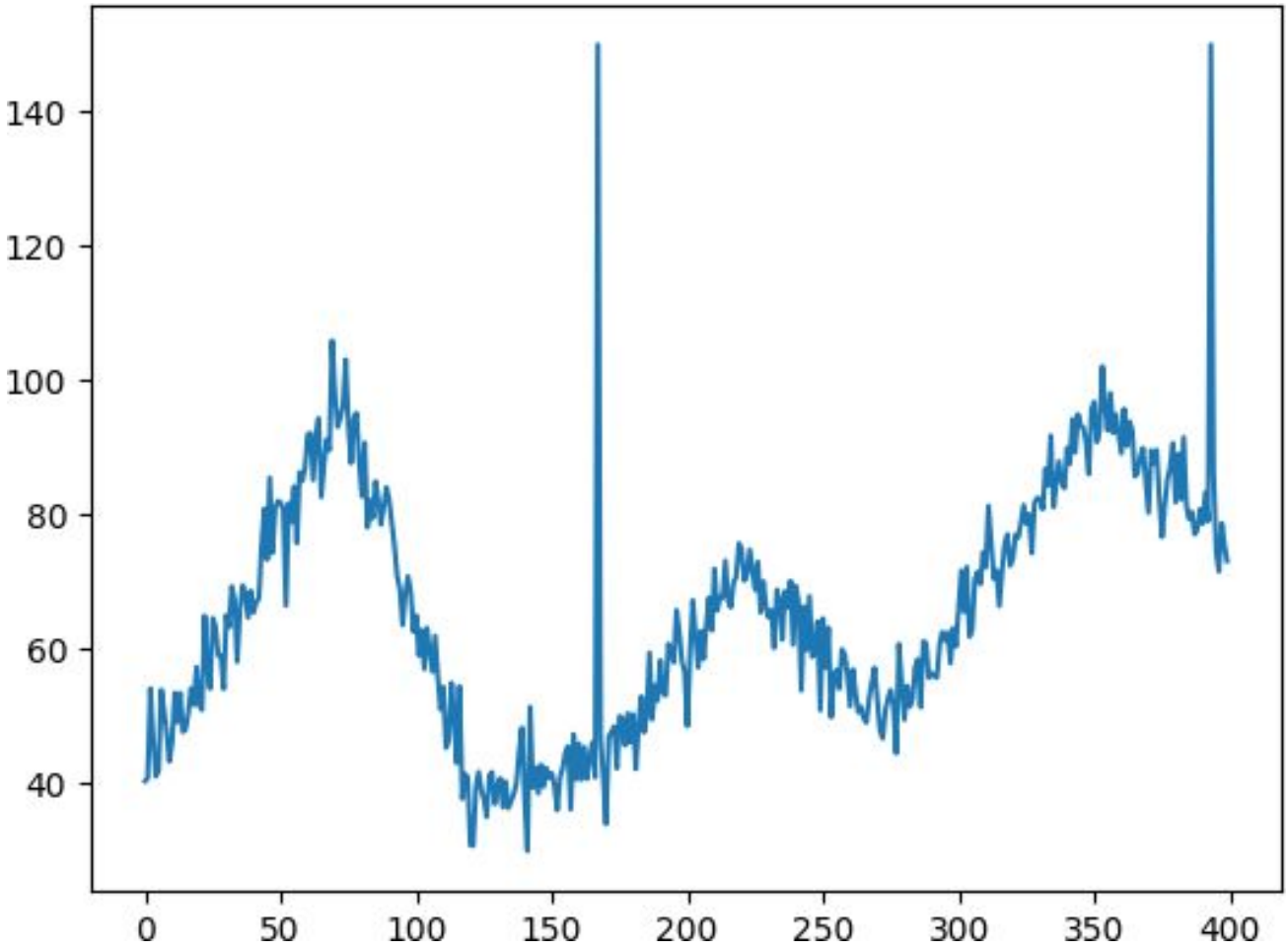
Sensor Data Generation



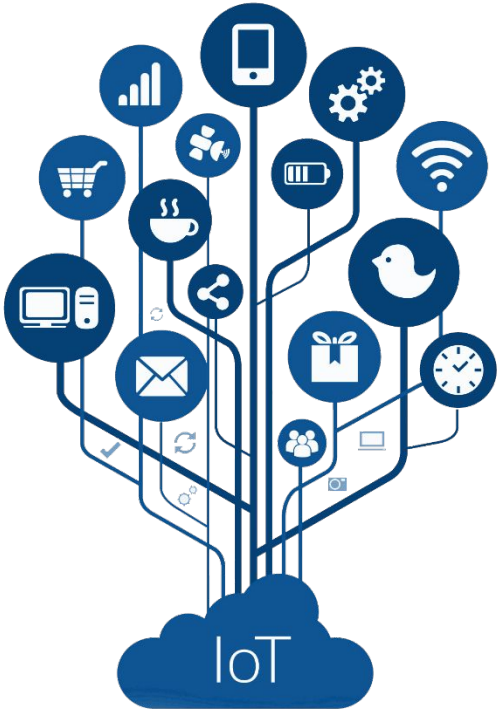
Sensor Data Generation



Sensor Data Generation



Conclusion, Challenges & Outlook

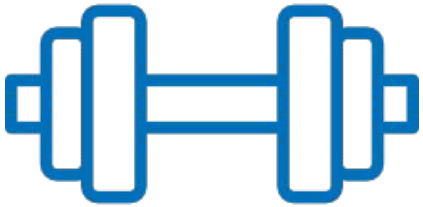


Conclusion

	Requirement	Current Status
R1	Secure communication & transmission of data	✔ Messaging & device administration secured via JWT
R2	Storage	✔ Persisted in ES container within cluster
R3	Data provisioning to consumers	✔ Secure REST-API to ES
R4	Processing large amounts of data, scalability in all tiers - ingestion to extraction	✔ Large amounts of data ~ Autoscaling capabilities via K8s
R5	Load throughput testing	✔ Gateway capabilities tested + language comparisons
R6	Ensure platform-independence	✔ Guaranteed thanks to dockerized application design
R7	Ensure accessibility with beginner knowledge	✔ As easy as “docker-compose up”
R8	Guide for deployment & usage	✔ Detailed Github Readme + docs
R9	Multitenancy	✔ Private tokens for devices
R10	Support ingestion via MQTT	✔ MQTT, HTTP & WS gateways available

Challenges

- Team members had to evolve an understanding of the considerable technology stack
- Ambitious scope
- Opinion: previous architecture design not suited for the requirements given to us
  - Almost inevitable to redesign and reimplement, adding considerable workload
- Cooperation with HAL team
  - Difficult since they have to rely on running architecture, which is hard if it is being reworked
  - Integration now possible
- JWT Authorization - Node.js library converts HTTP headers to lower case
  - Either: loop over raw headers (sacking performance), change header (abusing the standard)



Outlook

- Activate true persistence, surviving rolling deployments (only Flink missing)
- Finish up on autoscaling
- Improve frontend UX
- Security testing
- Actuator expansion (e.g. connected to Flink)
- Provide more default Flink jobs for analytics
- MQTT performance testing
- Set up alternative to Node.js MQTT gateway (e.g. Emitter.io)
- Enable document/object ingestion in Flink/ES (e.g. gyro sensor data)