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Open Source Frameworks for Integrating the Internet of Things

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Key Takeaways

IoT integration...

- is part of a hybrid integration architecture

- includes process engines, data ingestion and streaming analytics

- at the edge is getting more and more important

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Agenda

1) IoT Trends and Challenges

2) Hybrid Integration Architecture

3) IoT Integration

   o Dataflow Pipeline

   o Stream Processing

   o Process Engine

4) Open Source IoT Process Engines

   o Eclipse Kura (+ Apache Camel)

   o Node-RED

   o Flogo

5) Cloud IoT Platforms

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1) **IoT Trends and Challenges**

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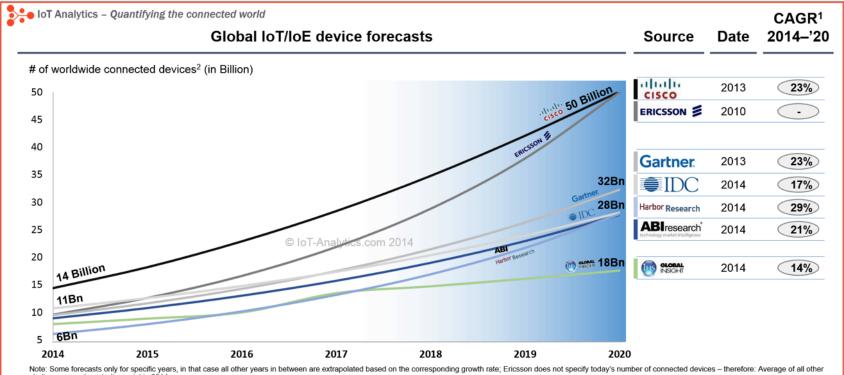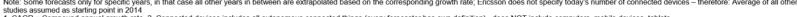5) Cloud IoT Platforms

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Internet of Things (IoT)

… refers to the ever-growing network of physical objects that feature an IP address for internet connectivity, and the communication that occurs between these objects and other Internet-enabled devices and systems.

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Forecast for Year 2020 → 20+ Billion Devices

IoT Analytics – *Quantifying the connected world*

Global IoT/IoE device forecasts

# of worldwide connected devices[2] (in Billion)

	Source	Date	CAGR[1] 2014–'20
CISCO	2013	23%
ERICSSON	2010	-
Gartner	2013	23%
IDC	2014	17%
Harbor Research	2014	29%
ABI research technology market intelligence	2014	21%
IHS GLOBAL INSIGHT	2014	14%

Chart data labels: 50, 45, 40, 35, 30, 25, 20, 15, 10, 5 (y-axis); 2014, 2015, 2016, 2017, 2018, 2019, 2020 (x-axis)

CISCO 50 Billion, ERICSSON, 14 Billion, 11Bn, 6Bn, Gartner 32Bn, IDC 28Bn, ABI, Harbor Research, GLOBAL INSIGHT 18Bn

© IoT-Analytics.com 2014

Note: Some forecasts only for specific years, in that case all other years in between are extrapolated based on the corresponding growth rate; Ericsson does not specify today's number of connected devices – therefore: Average of all other studies assumed as starting point in 2014
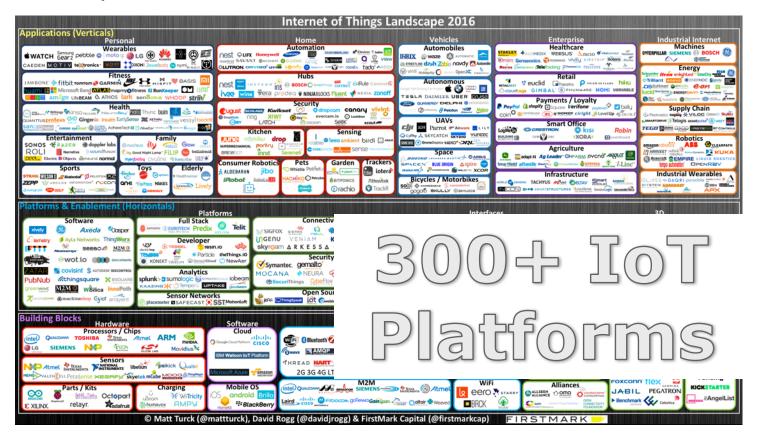1. CAGR = Compound annual growth rate 2. Connected devices includes all autonomous connected things (every forecaster has own definition) - does NOT include computers, mobile devices, tablets
Sources: Cisco, Ericsson, ABI Research, Gartner, IHS, IDC, Harbor Research, IoT-Analytics.com

IoT Landscape 2016

The IoT Landscape 2016 Edition - Matt Turck & David Rogg, First Mark Capital

Challenges

Great IoT standards available

- MQTT, CoaP, OPC UA, many more
- Different abstraction levels
- Not the one single standard

IoT raises several other new challenges

- Devices are not connected to the cloud
- Devices have low bandwidth to connect
- Latency of connectivity is significant
- Connectivity is not reliable
- Connectivity is not cost-effective

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Integration is Key for Success of IoT Projects

Gartner

Market Guide for IoT Integration

"Through 2018, half the cost of implementing IoT solutions will be spent on integration."

Strategic Planning Assumption,
Benoit J. Lheureux, Massimo Pezzini, Alfonso Velosa

!

Without Integration there is <u>no</u> Internet of Things!
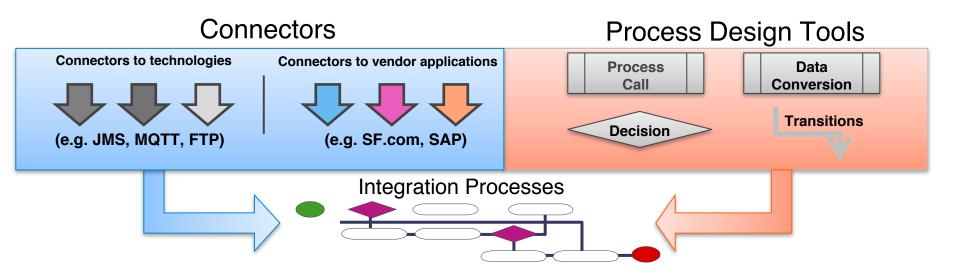
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Integration Frameworks

Connectors

Connectors to technologies

(e.g. JMS, MQTT, FTP)

Connectors to vendor applications

(e.g. SF.com, SAP)

Process Design Tools

| Process Call | Data Conversion |

Decision

Transitions

Integration Processes

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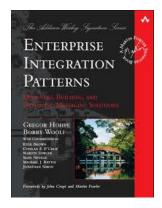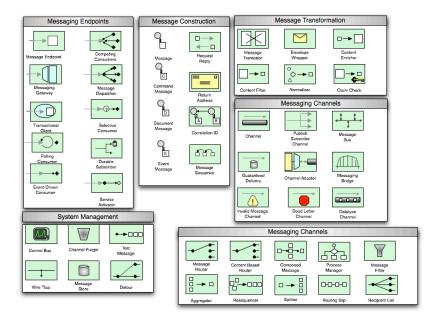
Enterprise Integration Patterns

"The goal of EIPs is to document technology-independent design guidance that helps developers and architects describe and develop robust integration solutions."
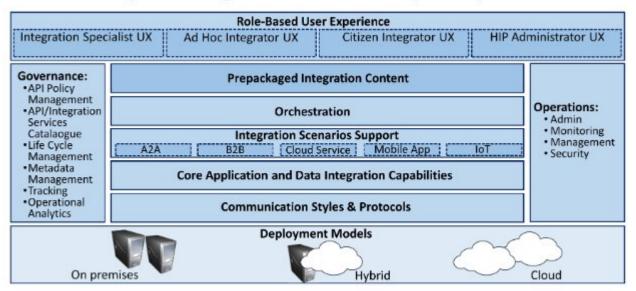
http://www.eaipatterns.com

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Pervasive Integration with different Technologies _and_ User Roles

Gartner Hybrid Integration Platform Capability Framework

There is _no_ "one-size-fits-all" IoT integration!

Hybrid Integration Platform (HIP)

Process Integration

Business Process Management Platform

Streaming Analytics

API Management

Application Integration

Application Integration (on a PaaS)

iPaaS

Integration Platform as a Service

iSaaS

Integration Software as a Service

Edge Integration

Cloud-Ready

Cloud-Native

On Premise Public Cloud

On Premise Public Cloud

Public Cloud

Public Cloud

Fog Computing Edge Devices

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Hybrid Integration Platform (HIP)

Process Integration
Business Process Management Platform

Streaming Analytics

Application Integration

IoT

API Management

Application Integration (on a PaaS)

iPaaS
Integration Platform as a Service

iSaaS
Integration Software as a Service

Edge Integration

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On Premise Public Cloud

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Dataflow Pipeline – Extract, Transform, Load

Dataflow Pipeline - Characteristics

- Flow-based Programming
- Ingest data from various sources
- Extract (E) – Transform (T) – Load (L)
- Transform / Filter / Route / Aggregate / Enrich …
- High-throughput straight-through data flows
- Data lineage
- Synchronous and asynchronous communication
- Batch or stream processing
- Visual coding with flow editor
- <u>Not</u> to be mixed-up with stream processing for event correlation

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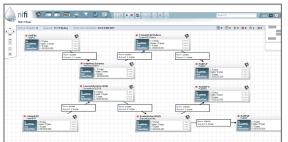
Dataflow Pipeline – Examples
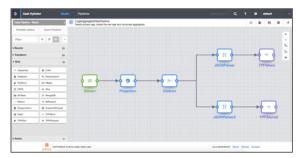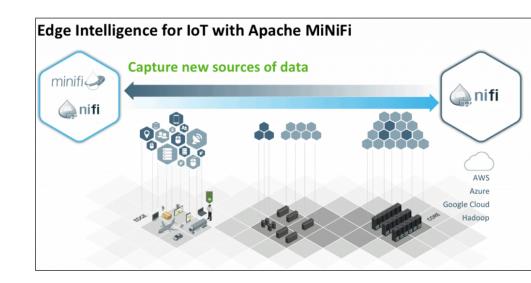
Apache MiNiFi: Data Ingestion at the Edge

"designed to solve the difficulties of managing and transmitting data feeds to and from the source of origin, often the first/last mile of digital signal."
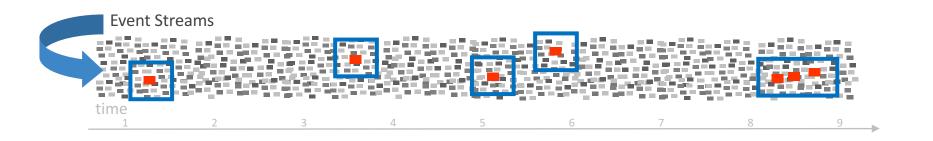

https://nifi.apache.org/minifi/

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Stream Processing

Event Streams

time
1 2 3 4 5 6 7 8 9
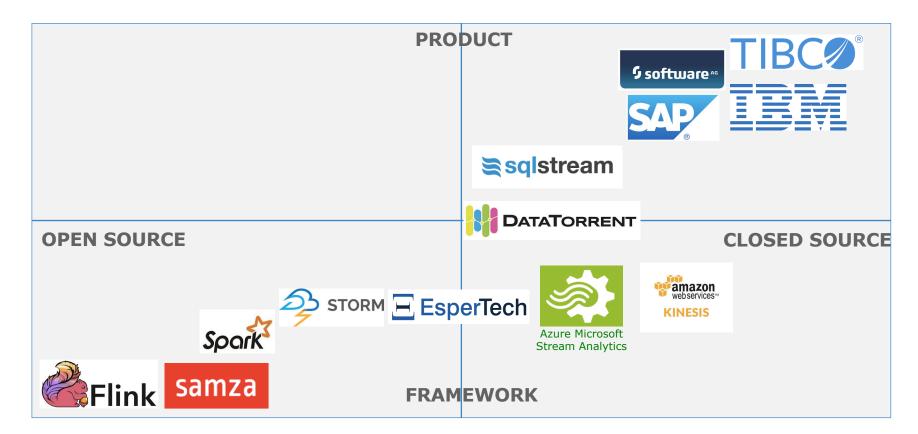
- Continuous Queries
- Sliding Windows
- Filter
- Aggregation
- Correlation
- …

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Stream Processing
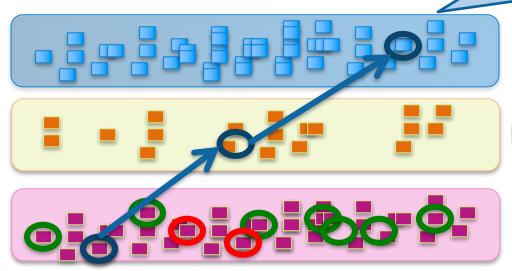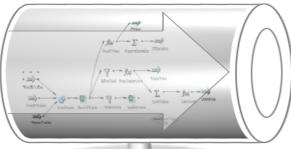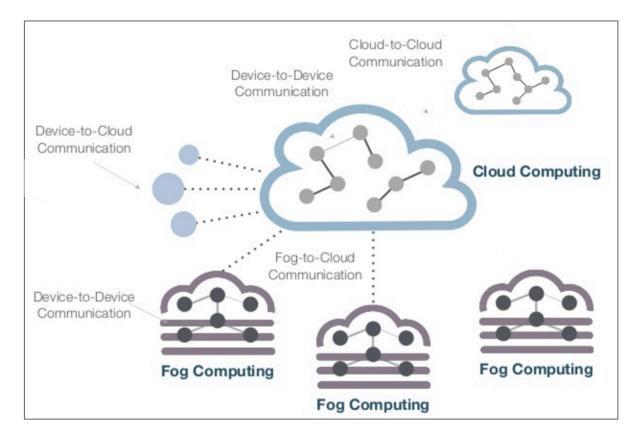
Streaming Analytics → Predictive Maintenance

Temporal analytic: "If **vibration spike** is followed by **temp spike** then **voltage spike** [within 4 hours] then flag **high severity alert**."

Voltage

Temperature

Vibration

Device history

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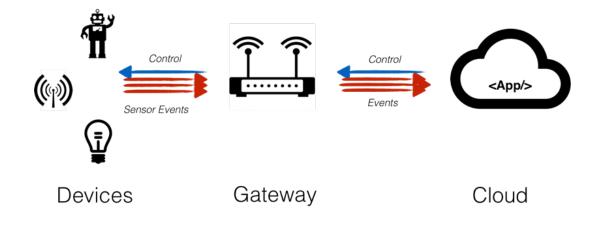# Fog Computing (sometimes also called Edge Computing)

!

… keep data closer 'to the edge'

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Typical IoT Integration Scenario

Devices   Gateway   Cloud
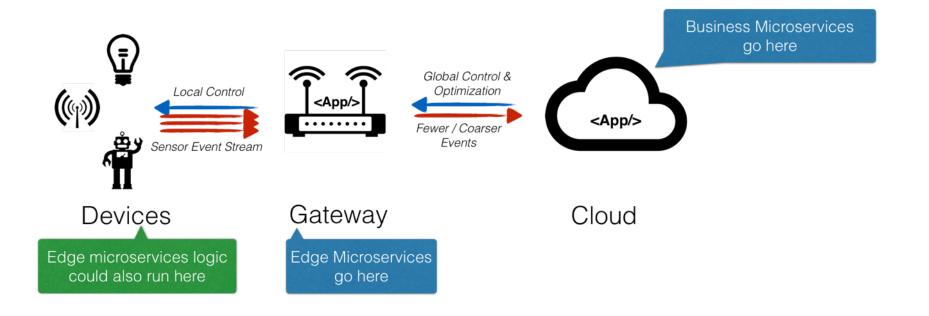
What's wrong with
Cloud-only IoT Integration?

- Connectivity is unreliable
- Non-trivial latency in hops
- Networks costs add up quickly

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A better IoT Integration Blueprint

Process Engine
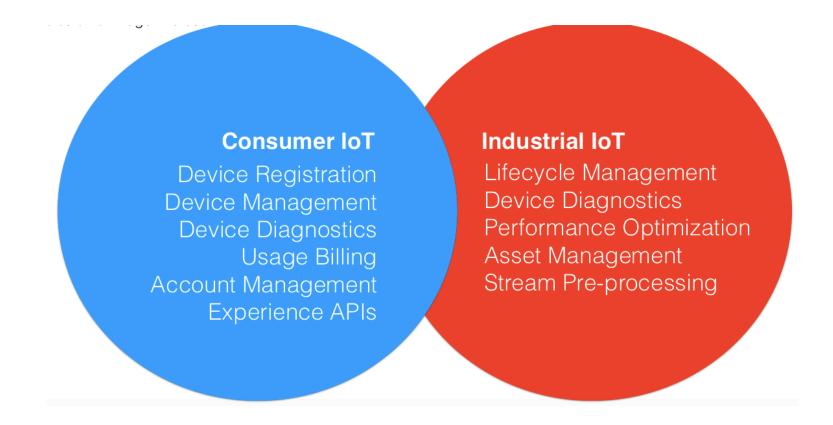
- Integrate and orchestrate various data sources
- Wire together hardware devices, APIs and online services
- Transform / Filter / Route / Aggregate / Enrich …
- Error handling, Re-Try, Re-Routing, Wait, Resume, …
- Not just Extract-Transform-Load
- Synchronous and asynchronous communication
- Typically real time processing
- Visual coding with flow editor
- Deployed at the edge

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Real World IoT Use Cases for a Process Engine

Consumer IoT
Device Registration
Device Management
Device Diagnostics
Usage Billing
Account Management
Experience APIs

Industrial IoT
Lifecycle Management
Device Diagnostics
Performance Optimization
Asset Management
Stream Pre-processing

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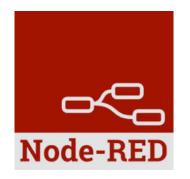   o Node-RED

   o Flogo

5) Cloud IoT Platforms

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Open Source IoT Process Engines

Commonalities:

- Open source frameworks
- Connectivity to IoT technologies (MQTT, CoaP, REST, …)
- Web UI for visual coding, testing, debugging
- Deployable "at the edge"
- For developers / integration specialists / citizen integrators
- Extendable SDKs / APIs
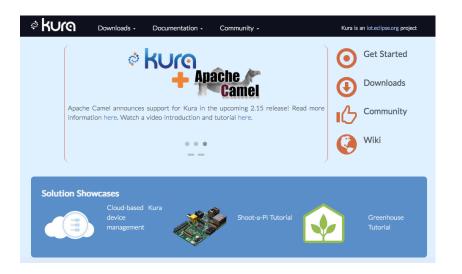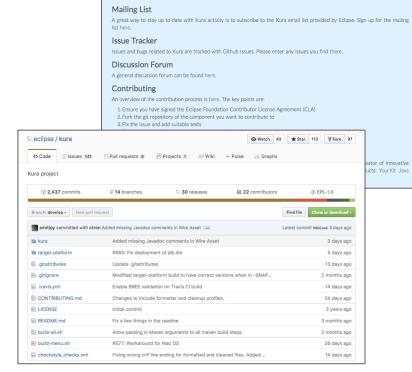
A lot in common
but
different focus!

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   o **Eclipse Kura (+ Apache Camel)**

   o Node-RED

   o Flogo

5) Cloud IoT Platforms

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Eclipse Kura

http://www.eclipse.org/kura

Eclipse Kura (+ Apache Camel) → Facts

- Focus on IoT Gateway
- Set of Java and OSGi services
  - including I/O services, Data Services, Cloud Services, Networking, etc.
  - Web UI for Configuration (Devices, Network, Protocols, etc.)
- Eclipse Public License 1.0
- Mature framework (~3 years old, code based committed in December 2013)
- Best of breed with focus on coding instead of a visual designer
  - Eclipse IoT Projects
    - IoT Gateway --> Eclipse Kura
    - Services like Eclipse SmartHome
    - Standard implementations like Mosquitto (MQTT Server)
    - Connectivity via Eclipse Paho (MQTT Client)
  - Apache Camel Connector
    - Integration Framework (connectivity, enterprise integration patterns)
    - Visual coding via JBoss or Talend (both available as open source edition)
- For Developers / Integration Specialists only
  - More complex to install and build a first IoT integration flow
  - Write source code
- Can be run on a variety of platforms (on premise, cloud, edge devices, container)
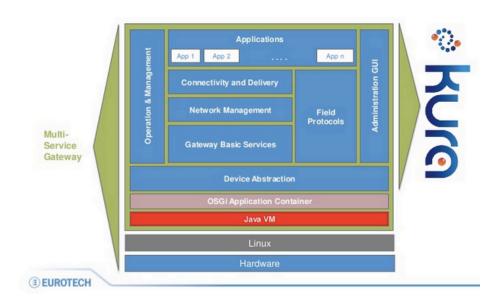
Eclipse Kura – Functionality Overview and Architecture

IoT Gateway Duties

- **Hardware and Field Abstraction**
  - Sensor Connectivity
  - I/O Access
- **Manage Network and Connectivity**
  - Wireless Modems, Firewall, Wi-Fi Hotspot, VPN
  - Online / Offline mode
- **Manage Applications**
  - Remote Start/Stop, Install/Uninstall of applications
  - Remote Configuration Management and Snapshots
- **Manage IoT Connectivity**
  - MQTT / CoAP Connections
  - Data Buffering and Retries
  - Provisioning, Credentials and Certificates
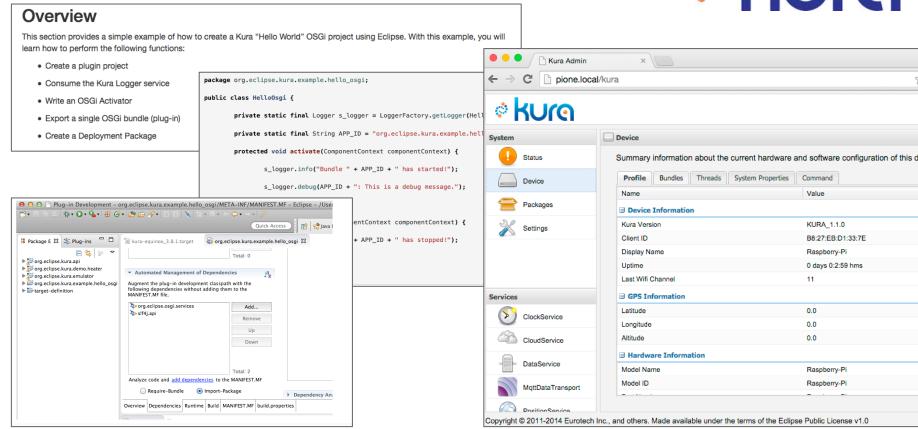
https://www.youtube.com/watch?v=ia8cLnR1uFI

http://www.slideshare.net/Eurotechchannel/kuram2miotgateway
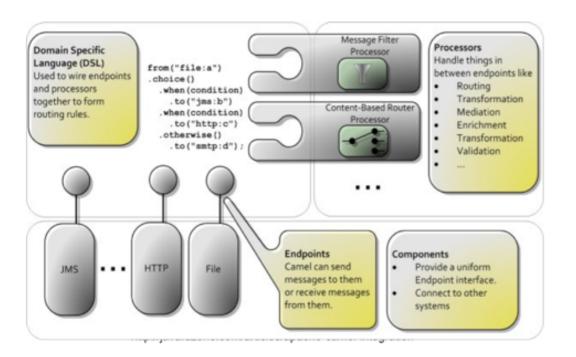
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Eclipse Kura – Hello World

https://eclipse.github.io/kura/doc/hello-example.html

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Apache Camel

```java
public class IntegrationRoute extends RouteBuilder {

@Override

public void configure() throws Exception {

from("file:target/orders")

    .unmarshal().csv()

    .split(body().tokenize(","))

    .choice()

        .when(body().contains("DVD"))

                .to("file:target/outbox/dvd")

        .when(body().contains("CD"))

                .to("jms:CD_Orders")

        .otherwise()

                .to("mock:others");

    }

}
```

Apache Camel (in conjunction with Eclipse Kura)

Eclipse Kura component

ⓘ Kura component is available starting from Camel **2.15**.

This documentation page covers the integration options of Camel with the Eclipse Kura M2M gateway. The common reason to deploy Camel routes into the Eclipse Kura is to provide enterprise integration patterns and Camel components to the messaging M2M gateway. For example you might want to install Kura on Raspberry PI, then read temperature from the sensor attached to that Raspberry PI using Kura services and finally forward the current temperature value to your data center service using Camel EIP and components.

Creating Camel routes for Eclipse Kura

```java
1 public class GatewayRouter extends KuraRouter {
2
3    @Override
4    public void configure() throws Exception {
5      from("timer://heartbeat").
6        to("log:heartbeat");
7    }
8
9    ...
10
11 }
```

https://dzone.com/articles/creating-camel-routes-for-eclipse-kura

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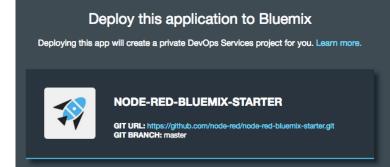
   o   **Node-RED**

   o   Flogo

5) Cloud IoT Platforms

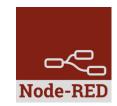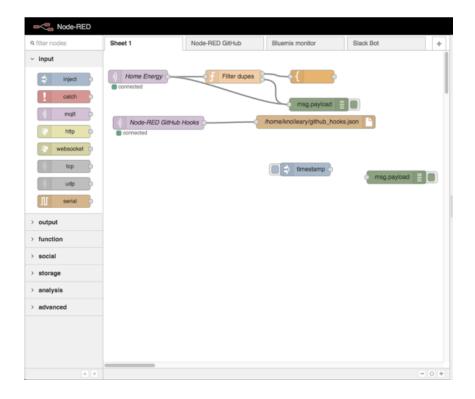TIBCO®
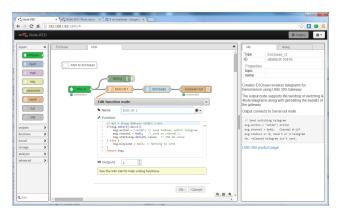
Node-RED

https://nodered.org/

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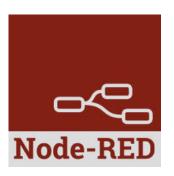# Node-RED

Node-RED → Facts

- Focus on Integration on an IoT Gateway

- Built on Node.js and Javascript

- Very easy to install and build a first IoT integration flow

- For developers / integration specialists and ciziten integrators

- Visual coding via web designer

- Apache 2.0 License

- Mature framework (~3 years old) with many examples and docs

- Native integration into IBM Bluemix cloud platform
  - Leverage other Bluemix services

- Can be run on a variety of platforms (on premise, cloud, edge devices, container)
  - Flows can be shared as JSON strings / files
  - Always needed to run the full node.js engine to execute a flow

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Node-RED in Action

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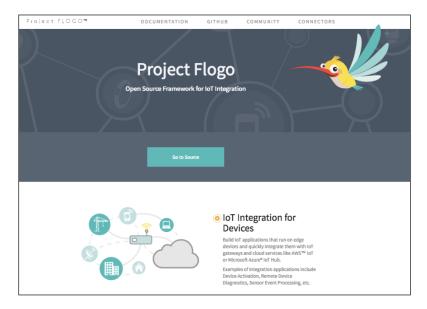# Agenda

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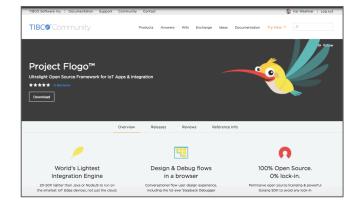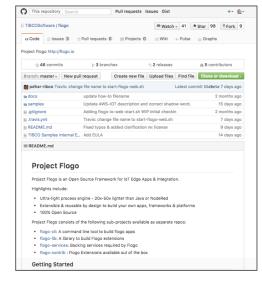5) Cloud IoT Platforms

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Flogo

http://www.flogo.io

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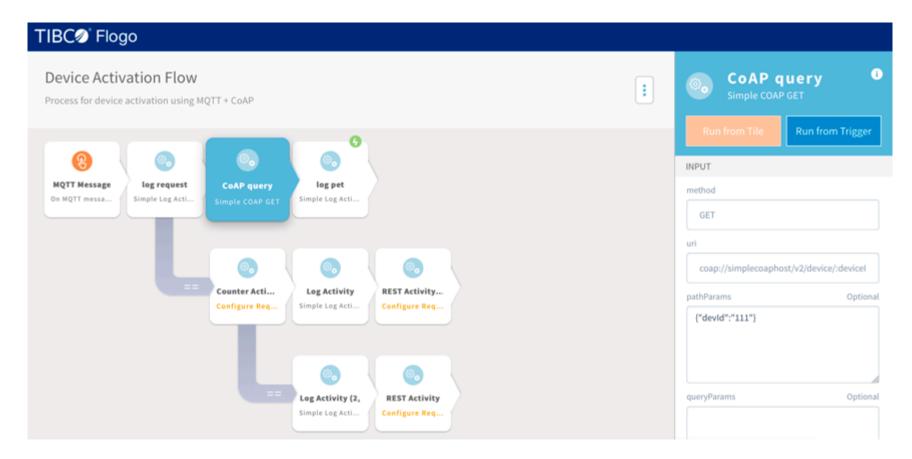
Project Flogo IoT Example

Flogo → Facts
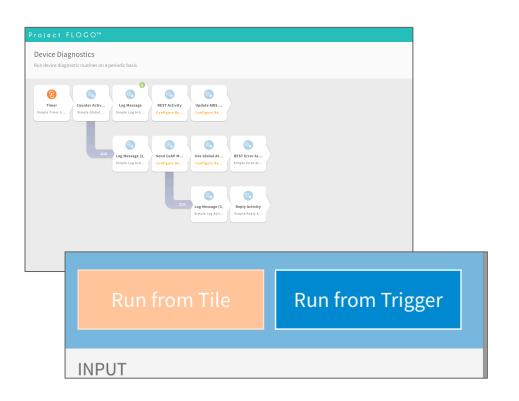
- Focus on Integration on IoT Devices / Gateways and very lightweight edge applications

- Powered by Golang

- Very easy to install and build a first IoT integration flow

- Ultra-lightweight footprint with zero dependency model

- For developers / integration specialists and citizen integrators

- Visual coding via web designer

- BSD-style License

- Developer Preview (released in October 2016)

- Can be run on a variety of platforms (on premise, cloud, edge devices, container)
  - Flows can be shared as JSON strings / files
  - Lightweight binaries with zero dependencies can be shared and deployed on devices

Web-Native Step-Back Debugger

- Step back in a flow
- Interactively design/debug your process
- Simulate sensor events
- Change data or configuration and run from Trigger or any Activity
- Underlying technology could be used to support remote ops debugging of failed flows

Flogo in Action

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What technology to build edge apps?

Java
- Heavy (>200MB)
- Not agile
- Robust
- Licensing risk

Node.js
- Lighter (~70MB)
- Agile
- Not IoT robust
- Clear licensing

C/C++
- Lightest
- Not Agile
- Robust
- Clear licensing

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Why Go?

Modern programming language
Getting a lot of traction due to usage in frameworks like Docker or Kubernetes

Concurrency
Built into the language (Goroutines, channels, no explicit thread programming)

Memory management
Modern Garbage collector

Statically typed
Type-safe development with no "surprises" during runtime

"Partly" object-oriented
Simple and flexible type system, composition instead of inheritance

Zero-dependency programming model
All-included binary file, no dependent "external" libraries
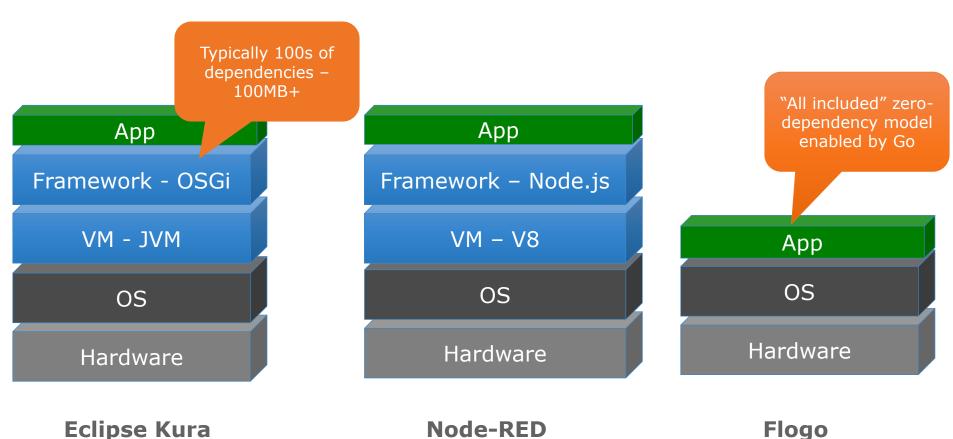
Speed
Ultra fast compilation and startup time, very lightweight footprint
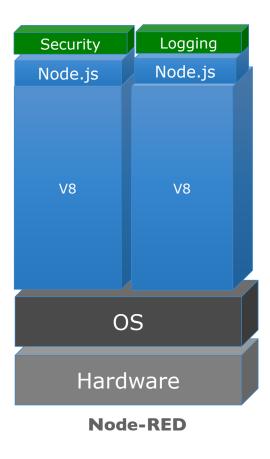
Infrastructure Layers

Eclipse Kura

Typically 100s of dependencies – 100MB+

| App |
| Framework - OSGi |
| VM - JVM |
| OS |
| Hardware |

Node-RED

| App |
| Framework – Node.js |
| VM – V8 |
| OS |
| Hardware |

Flogo

"All included" zero-dependency model enabled by Go

| App |
| OS |
| Hardware |
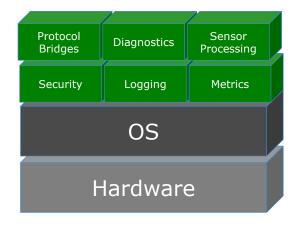
Resource Requirements

	Eclipse Kura	Node-RED	Flogo
VM	JVM	V8	Golang
Base Disk Space	59 MB	56 MB	~ 0 MB
Base Runtime Memory	~ 170 MB (with Open JDK) ~ 20 MB (with Oracle Embedded Java)	> 50 MB	~ 5 MB
Startup time	Slow (~8 sec)	Slow (~5 sec)	Fast (~1 sec)
Application Build	Slow	Not Applicable	Fast (~2 secs)

Outlook: Flogo Nanoservices on Microcontrollers

Freescale KL03 microcontroller

ARM® Cortex®-M0+ processor

48 MHz
32 KB Flash, 8KB boot ROM, 2 KB RAM
35uA/MHz low-power active mode
1 uA sleep mode

2mm x 1.6mm

FLOGO™

Flogo nanoservices that target microcontrollers like ARM M0

Offload I/O centric compute farther off to the edge.

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1) IoT Trends and Challenges
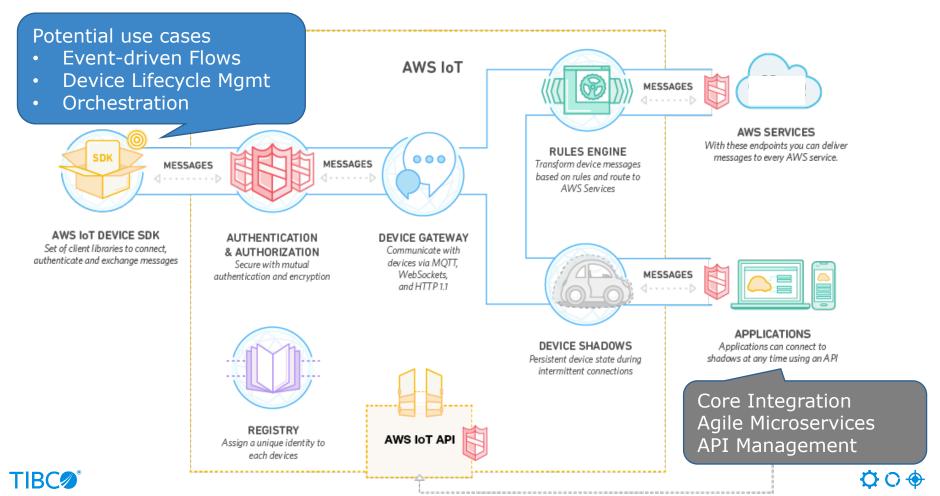
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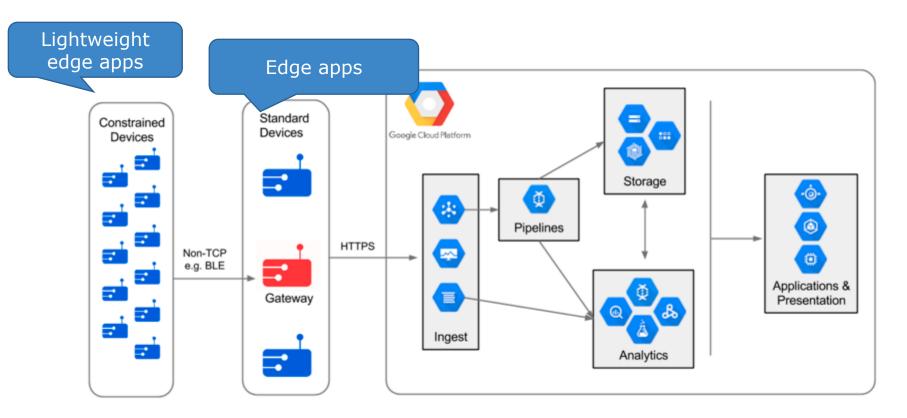
   o Node-RED

   o Flogo

5) **Cloud IoT Platforms**

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Amazon IoT Reference Architecture

Potential use cases
- Event-driven Flows
- Device Lifecycle Mgmt
- Orchestration

AWS IoT

MESSAGES

AWS SERVICES
With these endpoints you can deliver messages to every AWS service.

RULES ENGINE
Transform device messages based on rules and route to AWS Services

MESSAGES

AWS IoT DEVICE SDK
Set of client libraries to connect, authenticate and exchange messages

MESSAGES

AUTHENTICATION & AUTHORIZATION
Secure with mutual authentication and encryption

DEVICE GATEWAY
Communicate with devices via MQTT, WebSockets, and HTTP 1.1

MESSAGES

DEVICE SHADOWS
Persistent device state during intermittent connections

APPLICATIONS
Applications can connect to shadows at any time using an API

REGISTRY
Assign a unique identity to each devices

AWS IoT API

Core Integration
Agile Microservices
API Management

TIBC

Google IoT Reference Architecture

Intel IoT Reference Architecture

Potential use cases
- Event-driven flows & rules
- Device Lifecycle Mgmt
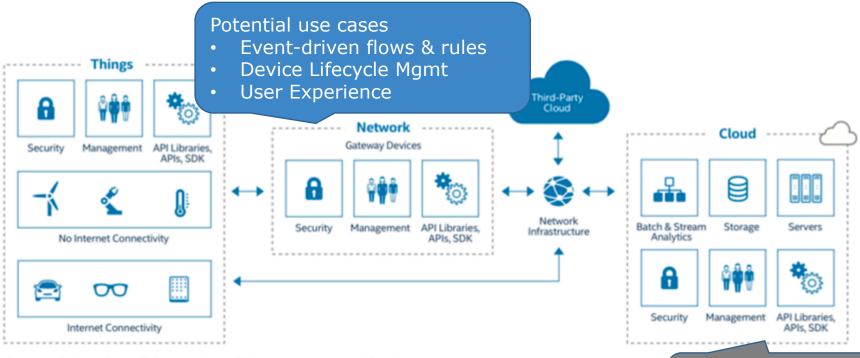- User Experience

Figure 1. End-to-End IoT Solution from Things to Network to Cloud
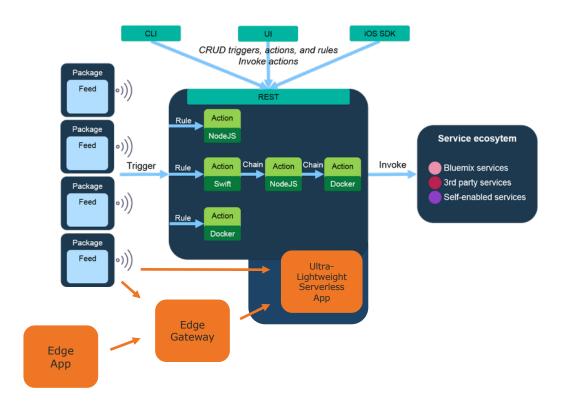Source: *The Intel® IoT Platform Architecture Specification White Paper Internet of Things (IoT)*

Core Integration
Agile Microservices
API Management

TIBC✷®

Serverless Architecture with IBM's OpenWhisk (Open Source)

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Hybrid Integration Architecture is the New Default

Key Takeaways

IoT integration...

- is part of a hybrid integration architecture

- includes process engines, data ingestion and streaming analytics

- at the edge is getting more and more important

TIBCO®

Questions? Please contact me!

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