

The Cloud and The Internet of Things



Niels Olof Bouvin

Overview

- **Cloud computing**
- **The Cloud and the Internet of Things**
- **Fog computing**
- **Putting it all together in the Internet of Things**

- **The report template: Analysis & Design**

The Cloud?

- **Not just marketing-speak for someone else's computer**
 - (though it is that too)

Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources that can be rapidly provisioned and released with minimal management effort or service provider interaction.

[NIST Definition]

On-demand self-service

- The user of the cloud service can add additional resources (computing, storage, network) as they wish, and when they wish directly through an interface
- It might even be possible for the system to add additional resources automatically, depending on the configuration and service plan
 - e.g., add more servers, if there is a spike in traffic

Broad access

- The cloud service is accessible through standard networking protocols

Resource pooling

- The cloud provider can pool their resources, and provide access to their users dynamically
- Access is independent of location of the provided machine
 - though it can be specified, e.g., “give me a server within EU”

Measured service

- The user is billed according to the use of resources
- This can be continually and dynamically monitored by the cloud provider and user

Overview

- Cloud computing
- **The Cloud and the Internet of Things**
- Fog computing
- Putting it all together in the Internet of Things
- The report template: Analysis & Design

The Cloud and the Internet of Things

- A fine match
- The Cloud is highly scalable (for a price...), and the IoT has much need for scalability
 - storage
 - analytics
 - networking
 - access
- Most commercial IoT systems rely on Cloud services for access
 - sometimes that is not a good thing, e.g., if the company shuts down or is hacked

The Cloud for everything?

- **Not necessarily**
 - while the Cloud is great for scalability, it can also become expensive
- **'Edge computing' (also known as P2P) is *free***
- **A combination**
 - Cloud for the backbone, discovery, and the always-on aspects of your system
 - plus elements that people *pay* for
 - P2P for everything else
 - Heavy lifting at the edges, coordination at the center
- **Probably wise, or at least nice, to ensure that your device can function without the Cloud service**

Overview

- Cloud computing
- The Cloud and the Internet of Things
- **Fog computing**
- Putting it all together in the Internet of Things

- The report template: Analysis & Design

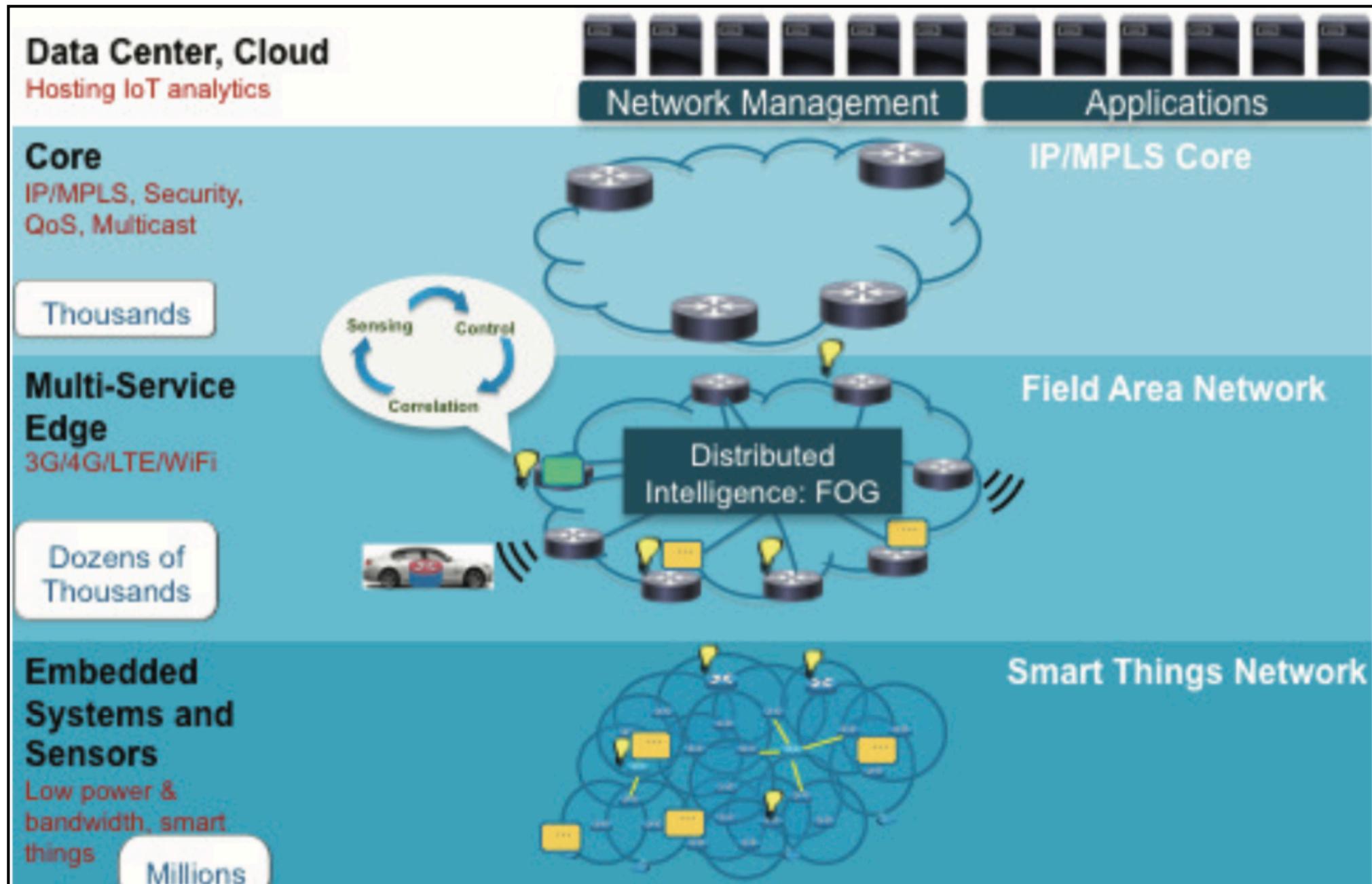
The Cloud descending

- **Fog computing**
 - originally pioneered by Cisco, a *very* large networking company
- **Like the Cloud, but closer to the user:**

Fog Computing is a highly virtualized platform that provides compute, storage, and networking services between end devices and traditional Cloud Computing Data Centers, typically, but not exclusively located at the edge of network

- **It complements, rather than replaces, the Cloud**

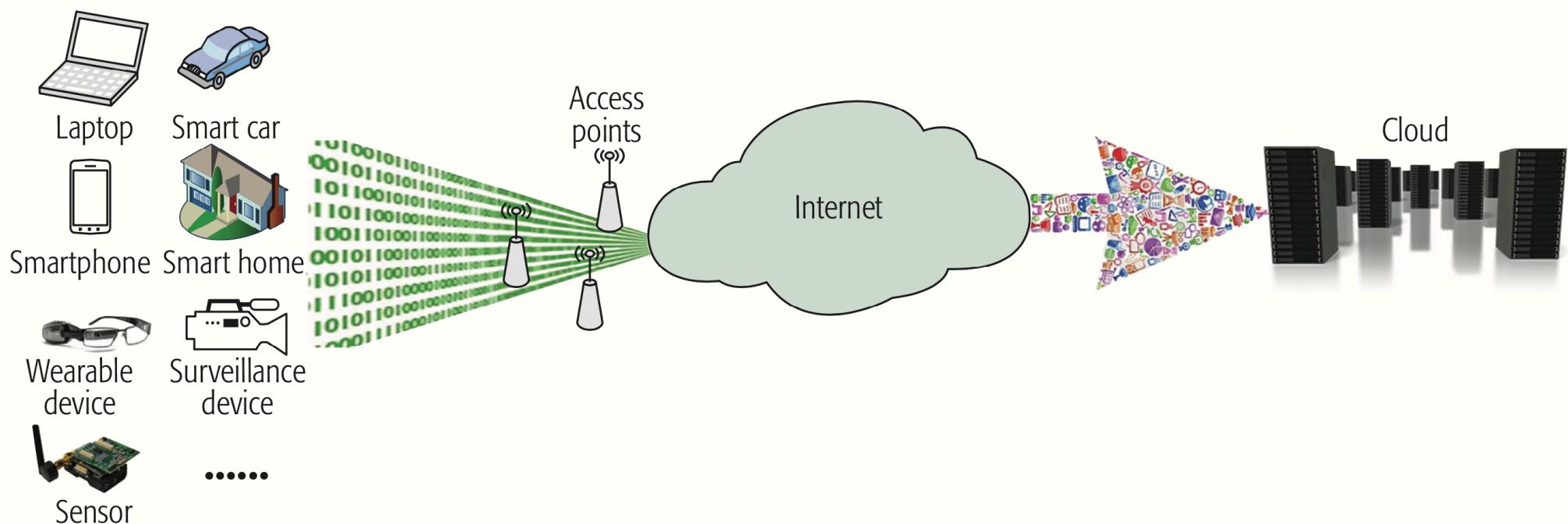
The Fog Computing architecture



edgeloT

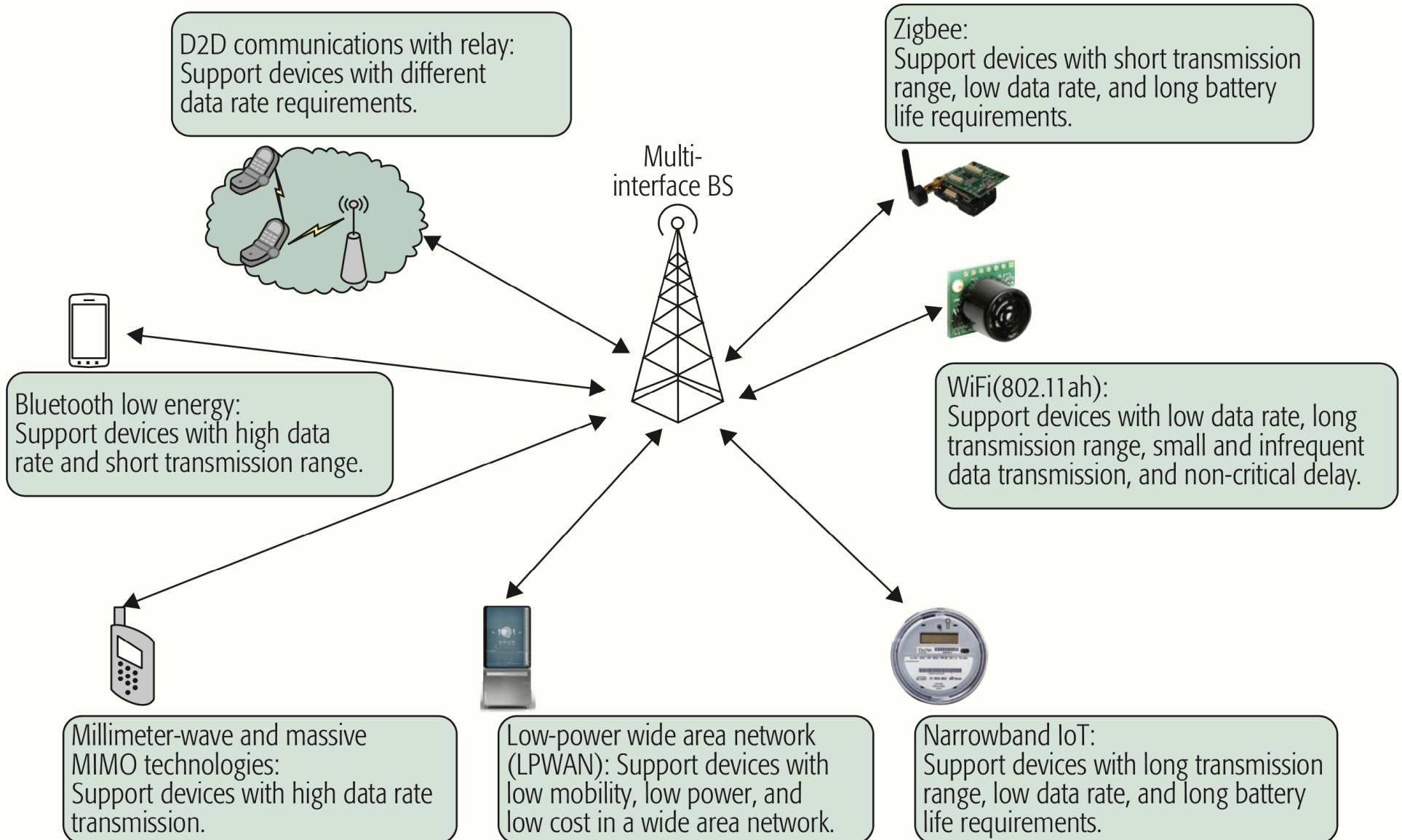
- **One suggested architecture for a Fog/Edge computing based Internet of Things**
 - one of the claims is reducing the overall backbone network traffic
- **Users' apps and activities have associated virtual machines (VMs) that reside on fog nodes**
 - these VMs move, split up, and consolidate, as the user moves about
- **Processing of sensitive data takes place on the users' VMs, and aggregates may be compiled by more central services**
 - one example being a terrorist detection application (!)

edgelot



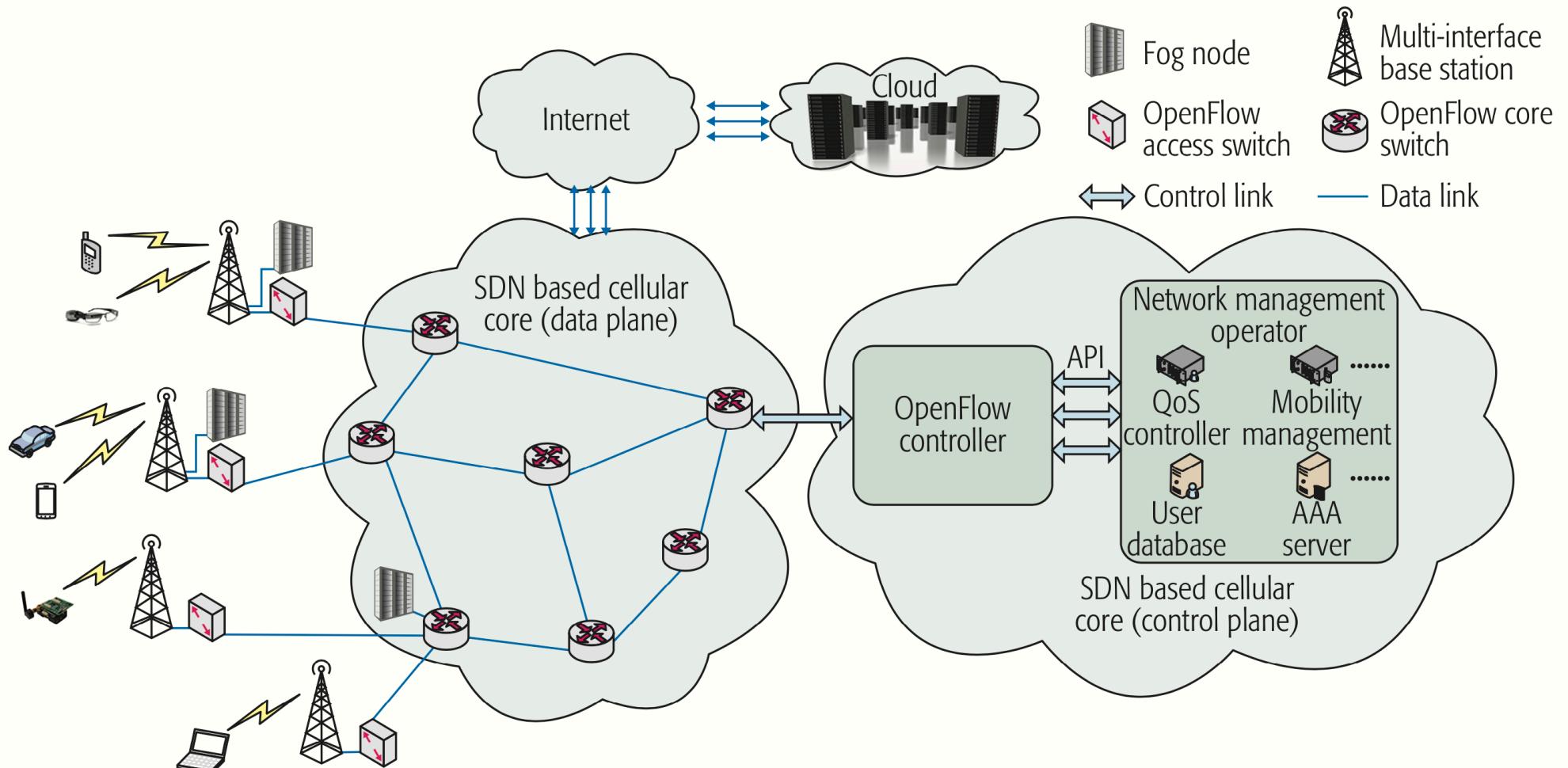
- **The traditional IoT Cloud architecture**
 - all data goes through the network to the Cloud servers

edgelot



- **Base Stations able to handle all kinds of networking**

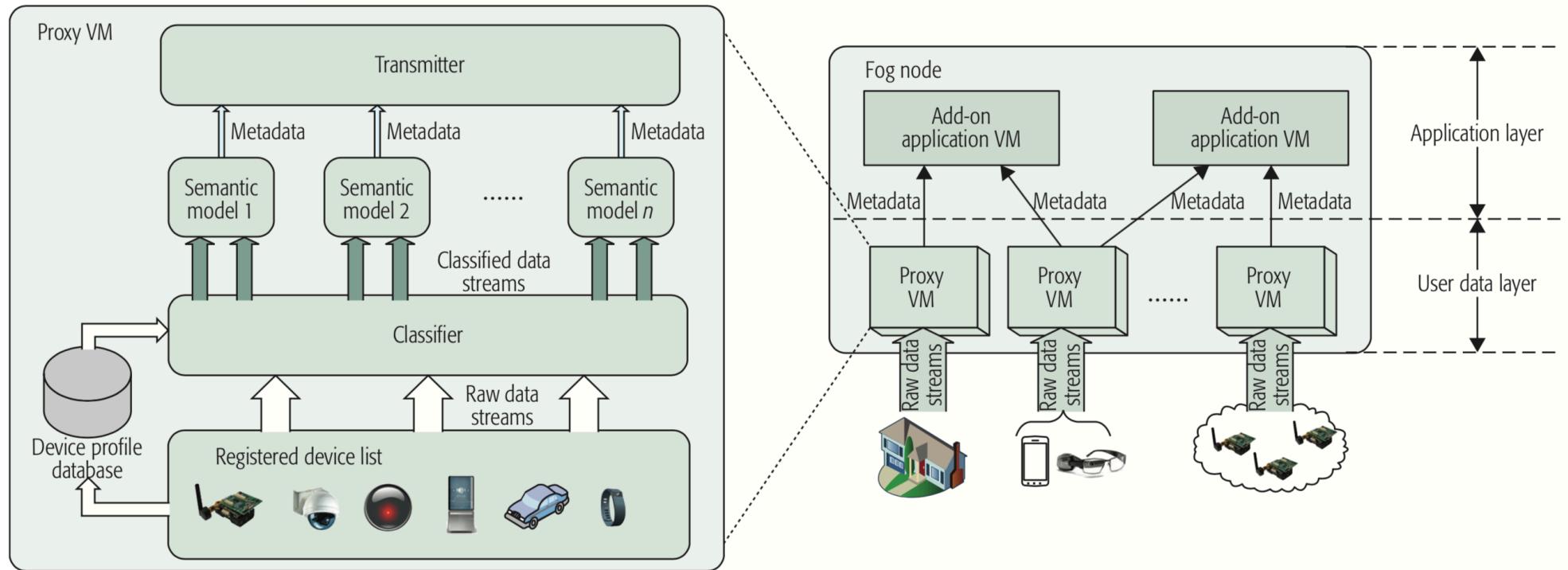
edgeloT



- **The proposed edgeloT architecture**

- the data flow from the IoT devices are dynamically rerouted across a (more local) fog computing fabric with a Software Defined Networking infrastructure

edgelot



- **The Proxy VMs handle and process the generated data**
 - the data is aggregated into metadata that may be used by more centralised components

Characteristics of Fog computing

- **All communication is wireless**
 - through WiFi, mobile data, etc
- **Lower latency**
 - the devices are much closer to the user
- **Geographically dispersed**
 - aimed at, e.g., video streaming in cars, or collecting wireless sensor network data
- **What can be processed locally, stays there**
 - this might protect privacy, or could optimise communication to the central cloud
 - (Cisco gets to sell a lot of equipment)

Overview

- Cloud computing
- The Cloud and the Internet of Things
- Fog computing
- **Putting it all together in the Internet of Things**

- **The report template: Analysis & Design**

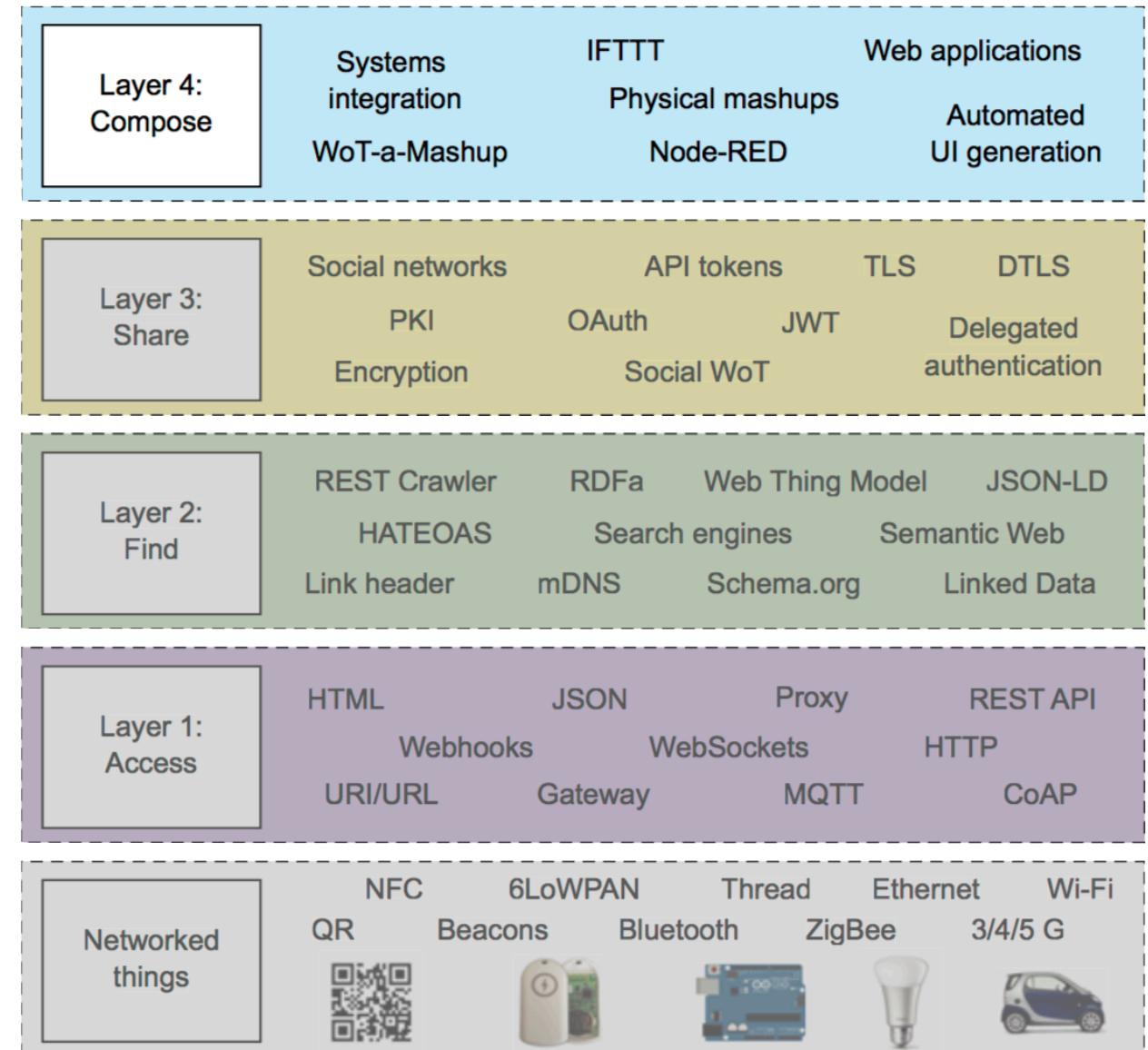
The Compose layer: mash-ups

- **Combining services to form new ones**

- e.g., combining a temperature sensor with a tweeting service

- **Requirements**

- standard interfaces
- network accessible
- (so well suited for Cloud computing as well as a Web based architecture)

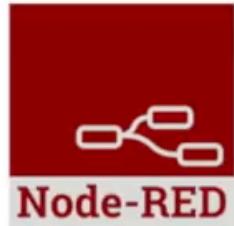


Standard interfaces

- **If services or devices are to talk together, they must use a shared standard for communication**
 - one example could be the Web Thing Model described by Guinard & Trifa
- **This enables, e.g., automatic generation of UI**

Node-RED

IBM Emerging Technology



Nick O'Leary : @knolleary

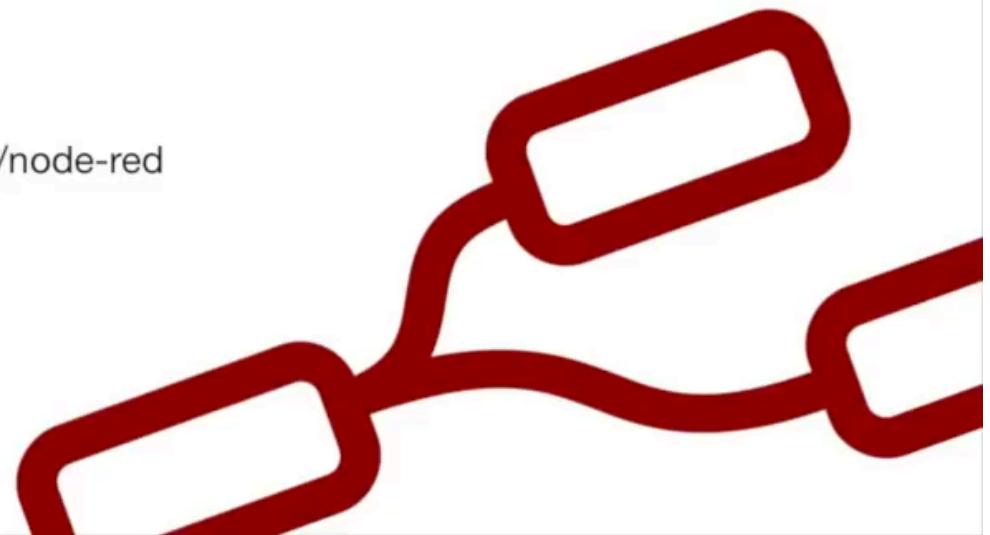
Dave Conway-Jones : @ceejay

nodered.org @NodeRED

Mailing List <https://groups.google.com/forum/#!forum/node-red>

Slack <http://nodered.org/slack/>

IBM



- A Node.js based tool for flow programming on the Web

Node-RED flows and nodes

- Node-RED is open source, and there are many, many more flows and components than this
- Runs on everything from RPi to various Cloud services
- Can talk to Arduino



Summary

- The Cloud offers a rich set of not only technologies, but also services that can be combined with Things to provide a richer and more seamless experience
- The more standardised the interfaces between the components are, the easier and stronger the interaction can be
- With the right kind of interfaces, building a mash-up can be (nearly) as easy as drawing lines between blocks

Overview

- Cloud computing
- The Cloud and the Internet of Things
- Fog computing
- Putting it all together in the Internet of Things
- **The report template: Analysis & Design**

Analysis

- **Turning *Related Work* into *Relevant Work***
 - how can you use the Related Work in the context of your project?
 - remind the reader of your hypotheses and use those to analyse and select what is *relevant* from the related work
 - which aspects are desirable, and which challenges are yet to be met?
 - what is it *you* wish to do better or differently?
- **If you need to make small experiments to decide between design alternatives, this is the place for it**
 - not to be confused with the experiments in the Evaluation chapter

Design

- **The crystallisation of the analysis**
 - based on your analysis, the design should be obvious to the reader
- **The abstract design of your system**
 - an UML or sequence diagram can be very helpful to communicate your design decisions
- **Can involve more than what you will end up building**
 - the implementation should only concern itself with what is needed to investigate your hypotheses