The Cloud & The Internet of Things

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Overview

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

- **The report template**

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

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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**

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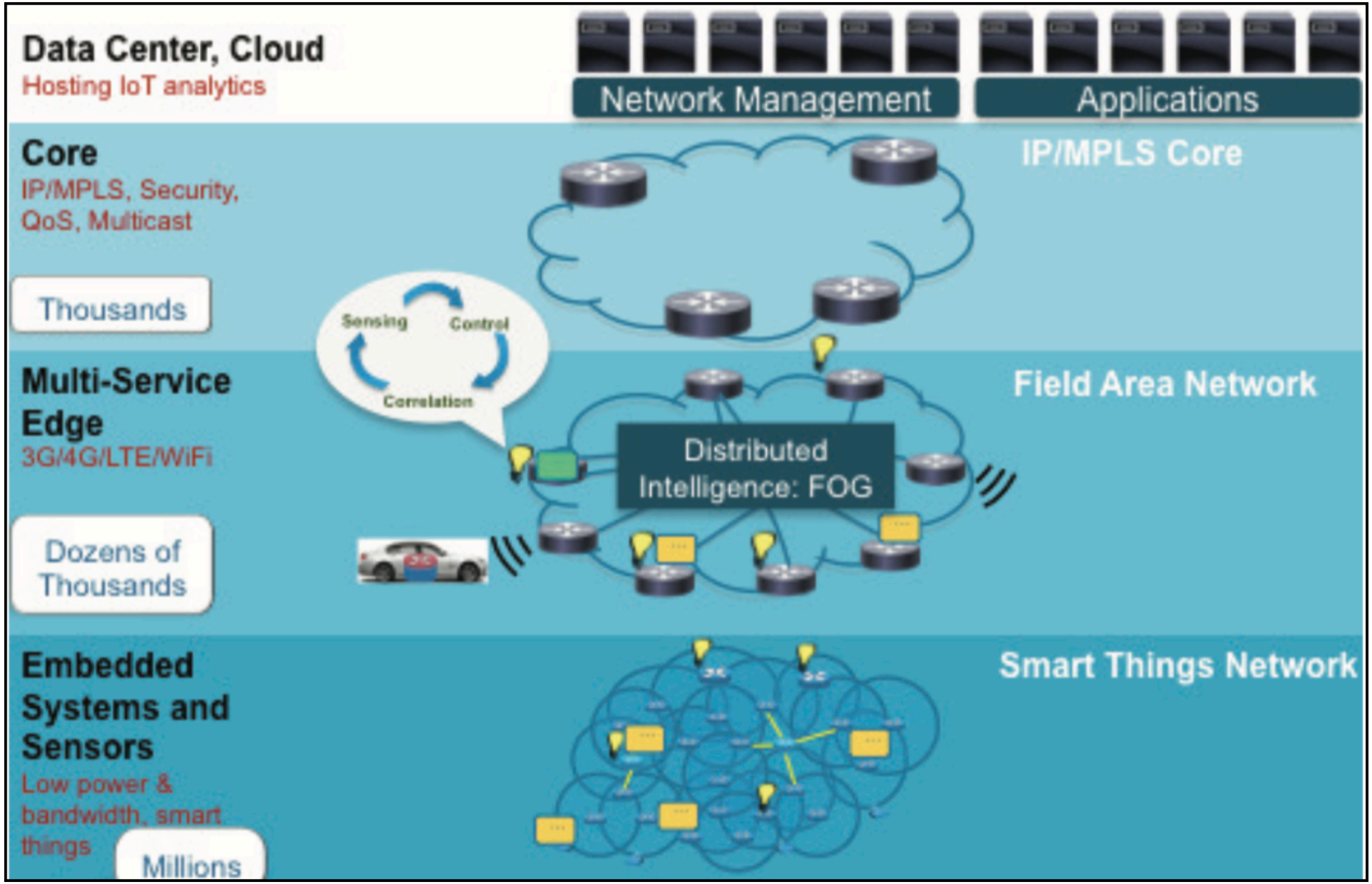
The Cloud descending

- **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



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)

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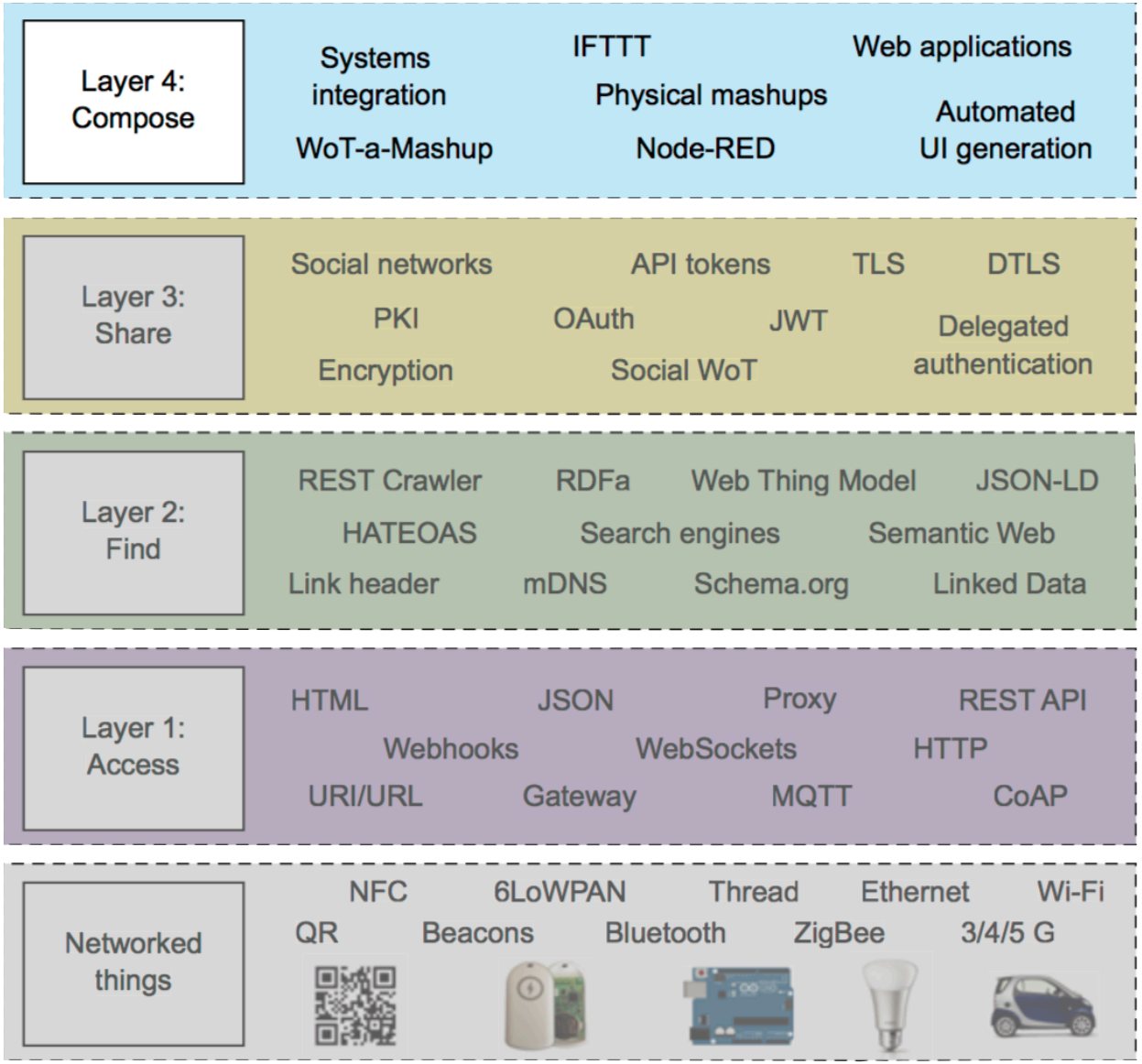
The Compose layer: mash-ups

- **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**
  - one example could be the Web Thing Model described by Guinard & Trifa
- **This enables, e.g., automatic generation of UI**

Node-RED

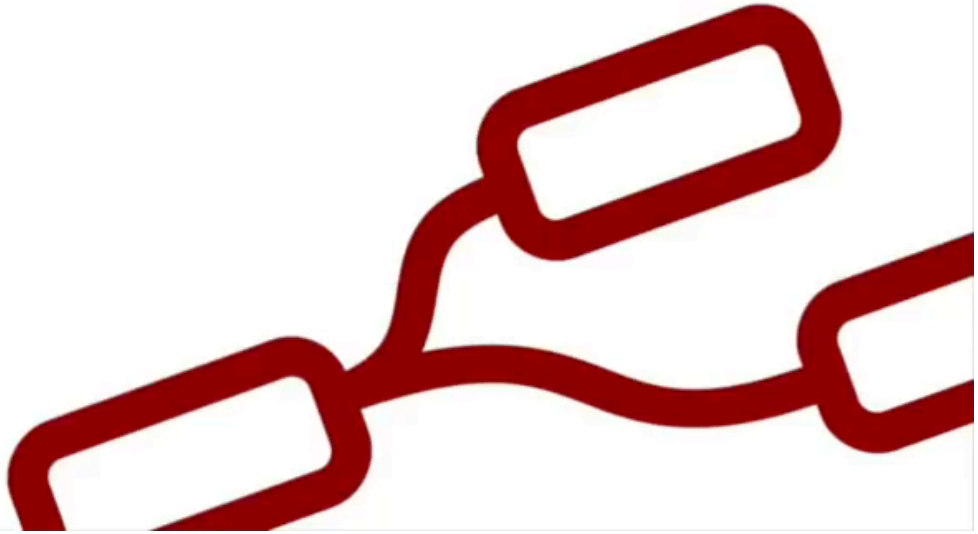
IBM Emerging Technology

Node-RED

A visual tool for wiring the Internet of Things

Nick O'Leary
Dave Conway-Jones

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

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The report template

- It's *my* job to read your reports, so I get to decide how they are structured and what they look like
- A LaTeX template based on the work by André Miede, who in turn was inspired by the excellent *"The Elements of Typographic Style"* by Robert Bringhurst
- I have used it for a couple of years with my master thesis students, but it works just as well for reports

Getting the template

```
git clone https://users-cs.au.dk/bouvin/git/thesis.git
```

- As well as a link to a PDF and zip-file on the frontpage
- Link to ShareLaTeX version forthcoming today or tomorrow, baring surprises

The overall structure

- **Part I**
  - the proper structure of a thesis (written by yours truly)
- **Part II & Part III**
  - formatting instructions and suggestions (by André Miede)

The proper structure of a report

- Introduction
- Related work
- Analysis
- Design
- Implementation
- Evaluation
- Conclusion

Introduction

- What is it? Why is it interesting?
- What is the use case for it?
- What are the central questions/hypotheses about it?
- How can those questions be tested?

Related work

- Scientific and technical works that are *relevant* and *contribute* to the analysis of the problem domain
- Identify central aspects in the literature
- Use those aspects to systematise your write-up of each article or system
- Discuss *only* the work of others—your own work comes later!

Analysis

- How can you use the Related Work in the context of your project?
- Which aspects are desirable, and which challenges are yet to be met?
- What is it you wish to do better or differently?

Design

- The crystallisation of the analysis
- The abstract design of your system
- Can involve more than what you will end up building

Implementation

- **The parts of the design necessary to answer the questions in the introduction implemented**
- **The purpose of your implementation is *strictly* to evaluate your hypotheses**
  - no more, no less

Evaluation

- Testing your implementation to investigate your questions or hypotheses
- Make your experiments as clear and focused as possible
- Compare expectations and results, and discuss

Conclusion

- Wrapping up your work
- Ideally, you should be able to read the introduction and the conclusion, and make sense of what you have done
- Revisit the questions and hypotheses from the introduction? Have they been answered adequately?
- What are still open questions?
- What are the consequences of your results?