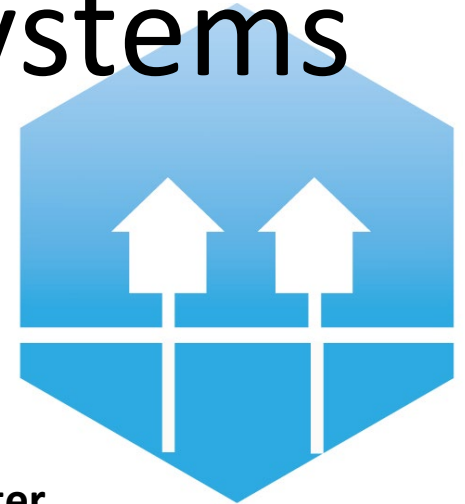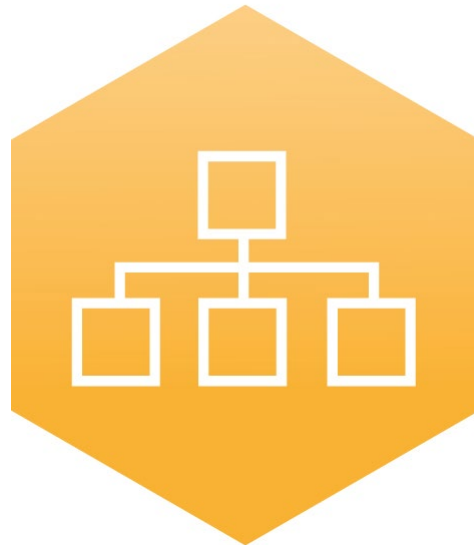# Interoperability of Smart Energy Systems

Jan van Deventer
Luleå University of Technology
jan.van.deventer@ltu.se

4DH
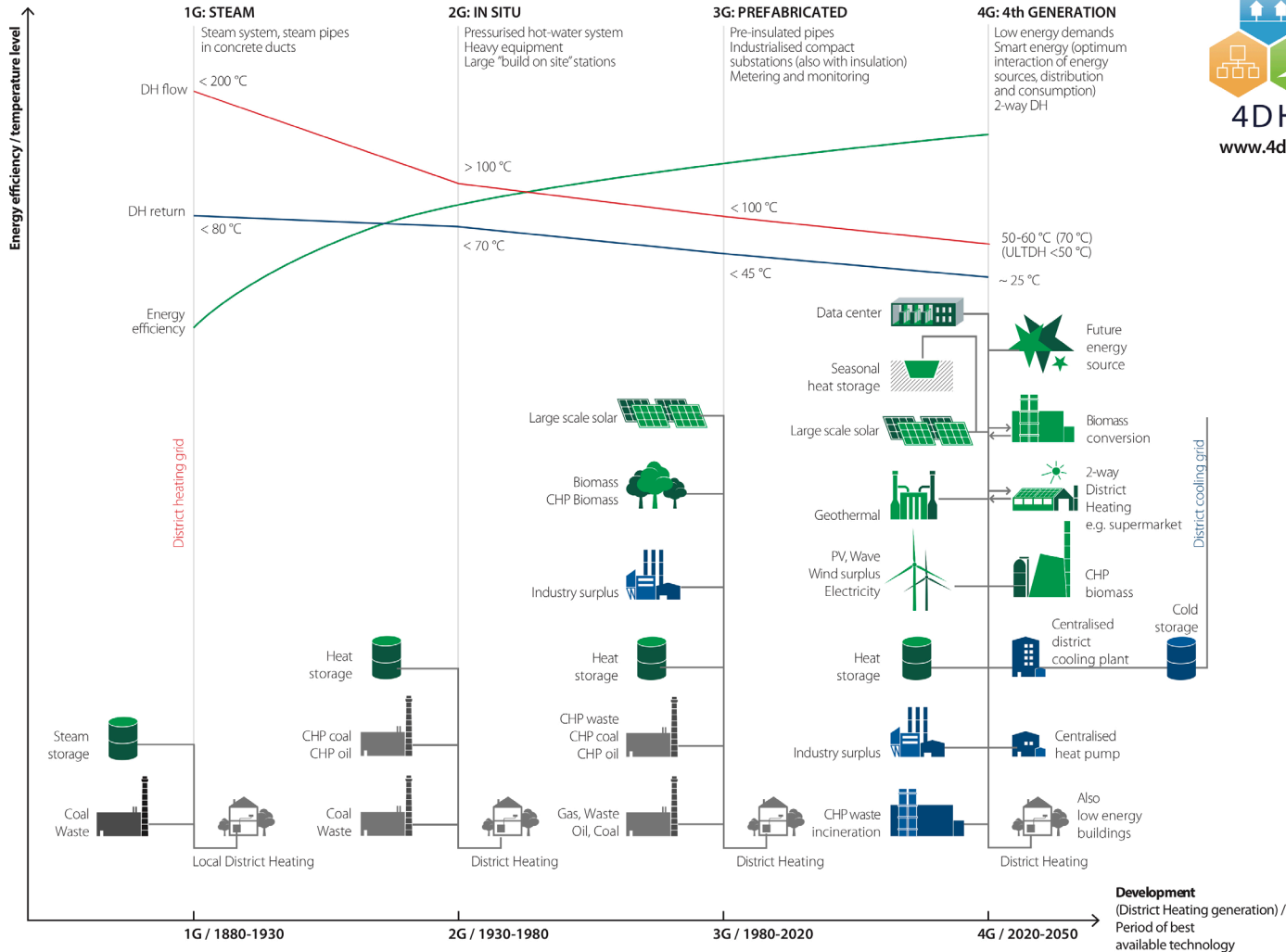**4th Generation District Heating**
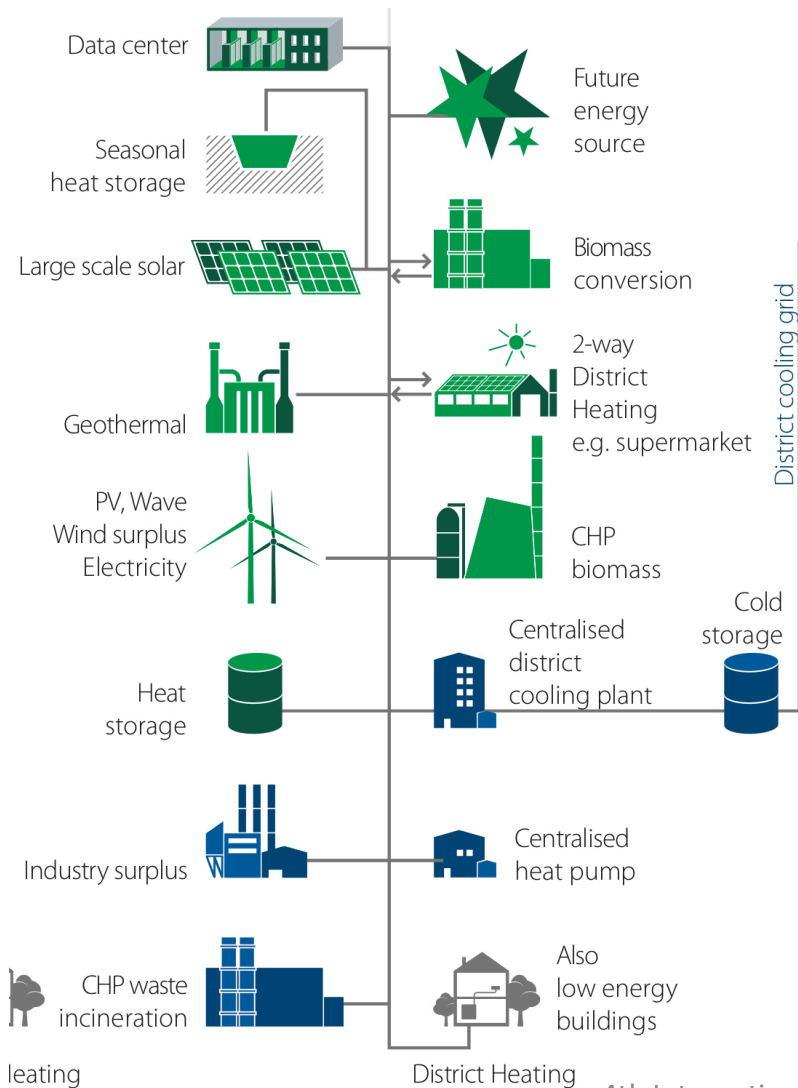**Technologies and Systems**
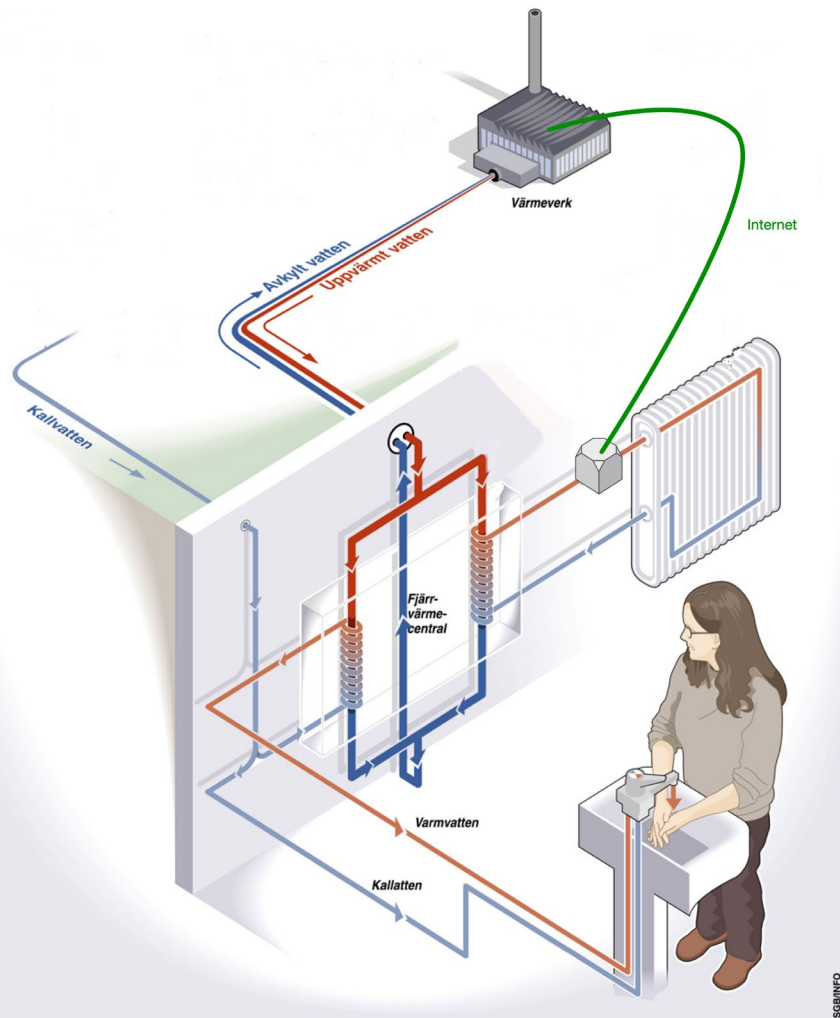
Towards a Sustainable Future

Cooperating Smart Systems?

Interoperability

- **Between Smart Energy Systems?**
- **With Existing Systems?**
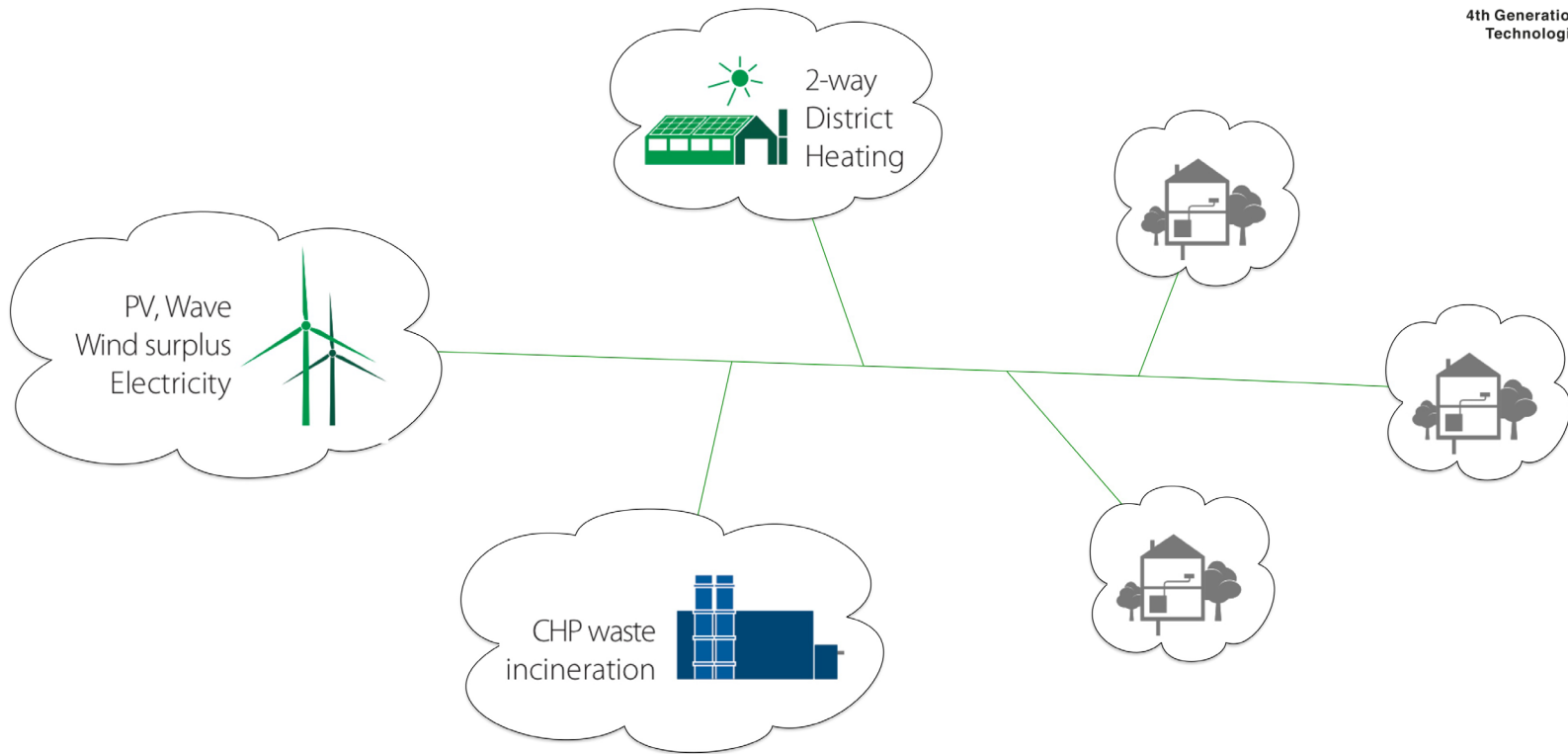 - Integration and Maintenance
- **With Future Systems?**

(Industrial) IoT

With IoT, a heat plant can control a radiator valve at the end customer (not that is desired, but possible) to balance production and demand.

Through the Internet, Smart Energy Systems can offer and ask for services from each other (e.g., Power As A Service).

# System of Systems with Local Clouds

Flat hierarchy promoting systems integration and manageability to address energy production variations and peak loads.

Promoting Scalability and Manageability

- **Introduction with the need for Smart Energy Systems Interoperability towards integration**

- **Within the Local Cloud**

  - **Demonstrators and Documentation**

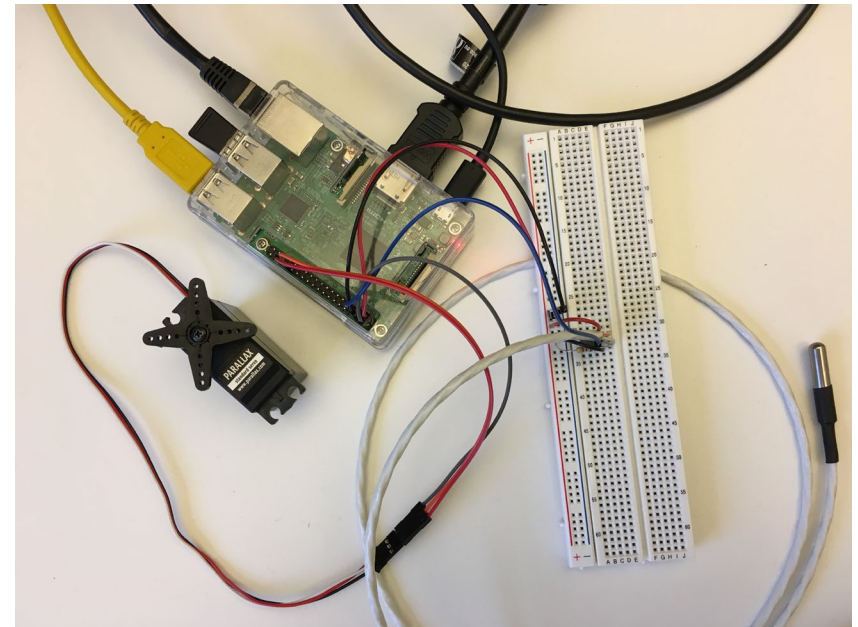- **Inter-Cloud Use Case**

The Arrowhead Framework as a solution
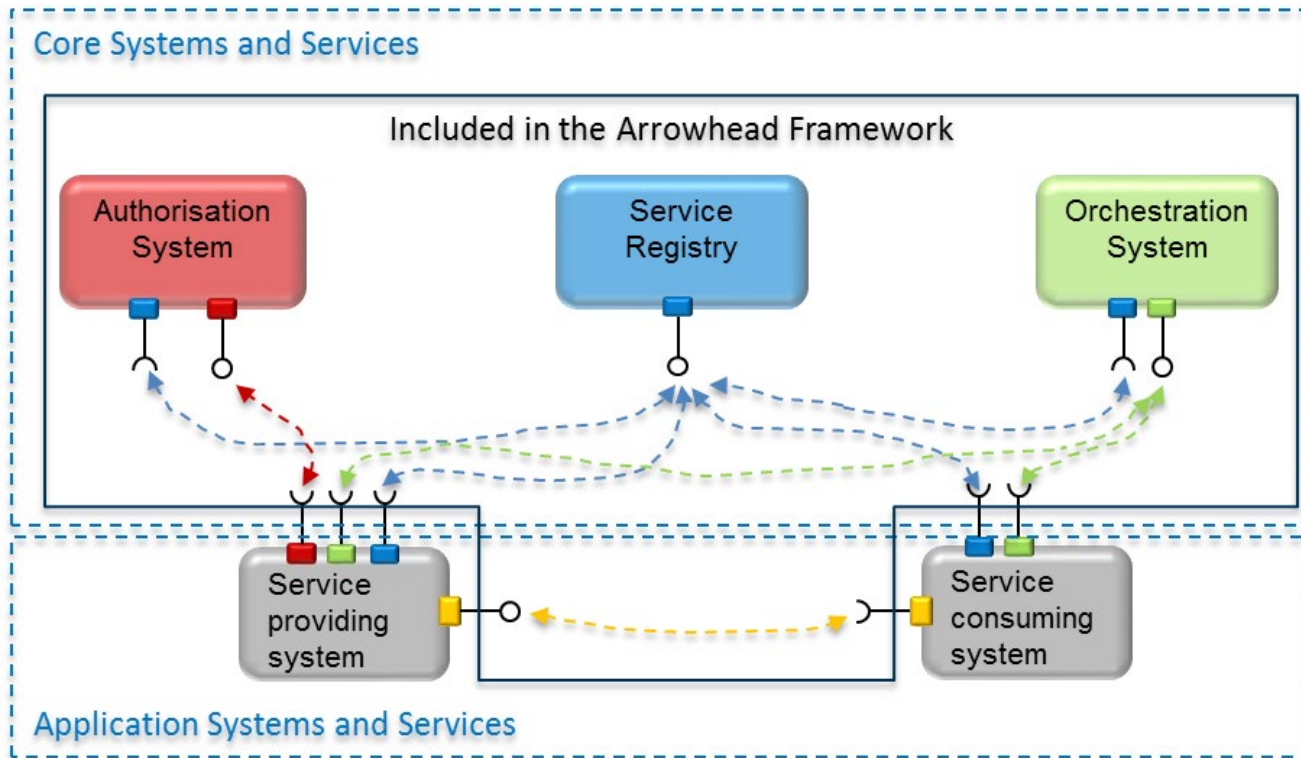
The open source Arrowhead Framework answers at continuously at run time the question: *"What are the currently available services that fit my needs and which I am authorized to use?"*

DH Desktop Demonstrator (single cloud)

We consider here the primary circuit valve control of a district heating system whose position is a function of secondary space heating temperature.

In its simplest implementation, it has 6 systems that interact with each other on 1 device (Raspberry Pi).
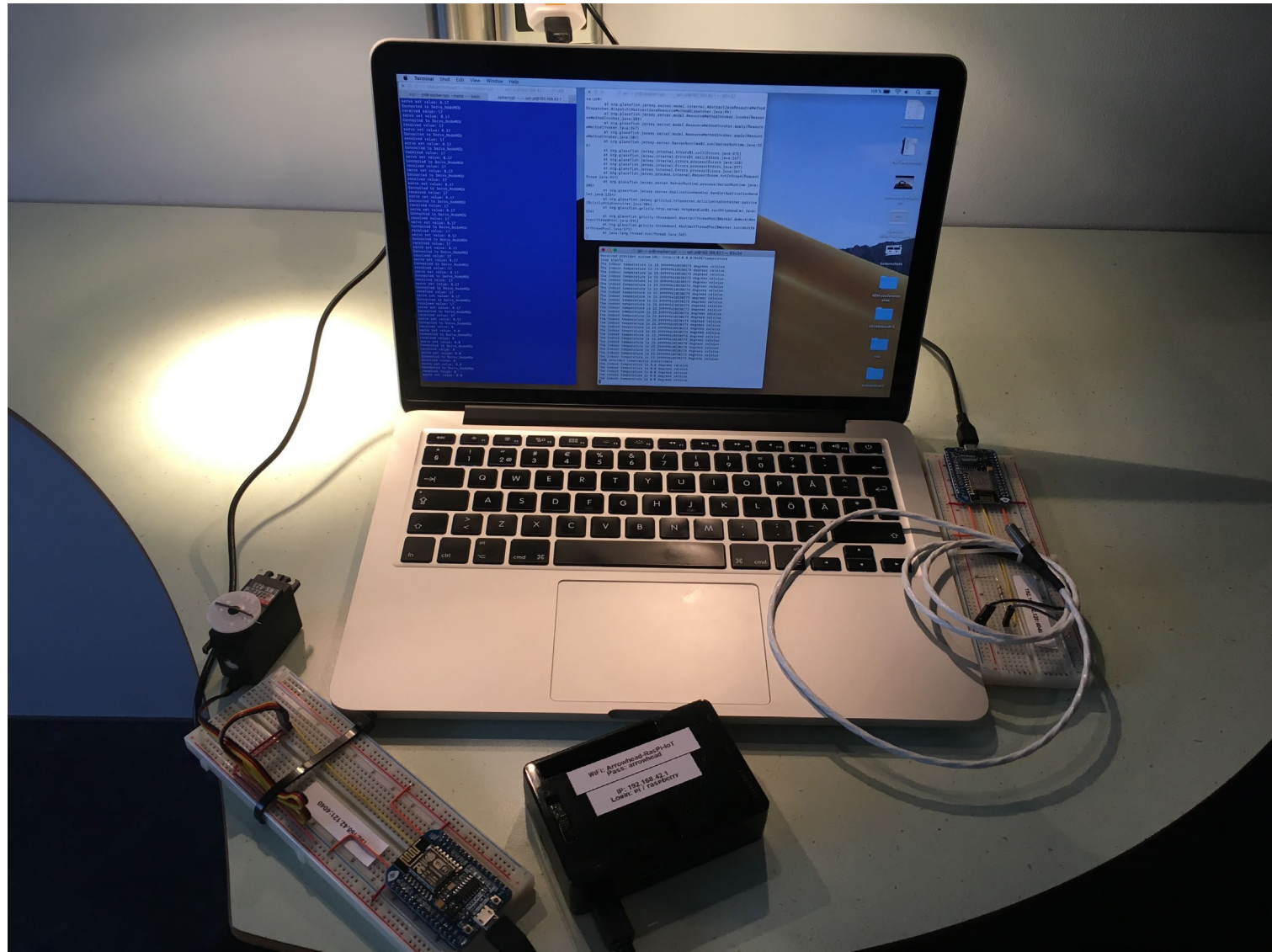
- **Three Mandatory Core Systems** (Service Registry, Orchestrator, Authorization System)
- **Two service providers** (Temperature sensor and Valve)
- **One service consumer** (Control algorithm)

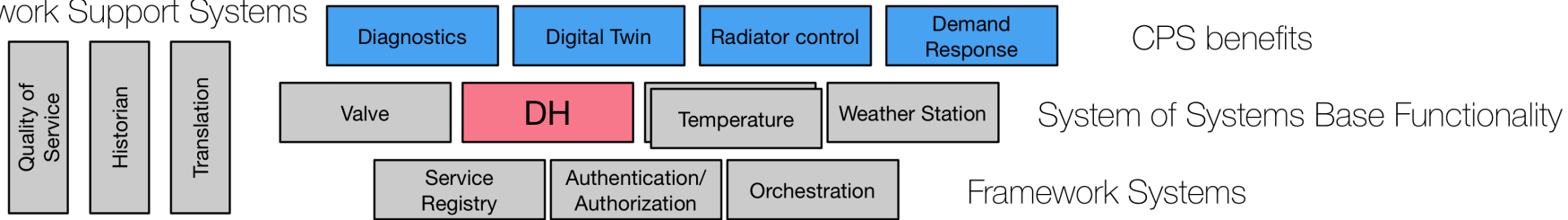# The 2€ Wireless Extension to the DH Desktop Demonstrator

The Benefits

Framework Support Systems

| Quality of Service | Historian | Translation |

| Diagnostics | Digital Twin | Radiator control | Demand Response | CPS benefits
| Valve | DH | Temperature | Weather Station | System of Systems Base Functionality
| Service Registry | Authentication/ Authorization | Orchestration | Framework Systems

Migrating to an IoT solution is a paradigm shift but with the right framework it is a small step.

Maintaining and expanding the System of Systems is relatively easy.

Documentation and code

The Arrowhead Framework is documented:

- **IoT Automation: Arrowhead Framework book**

- **Online Wiki**

Its code is available on Github with examples
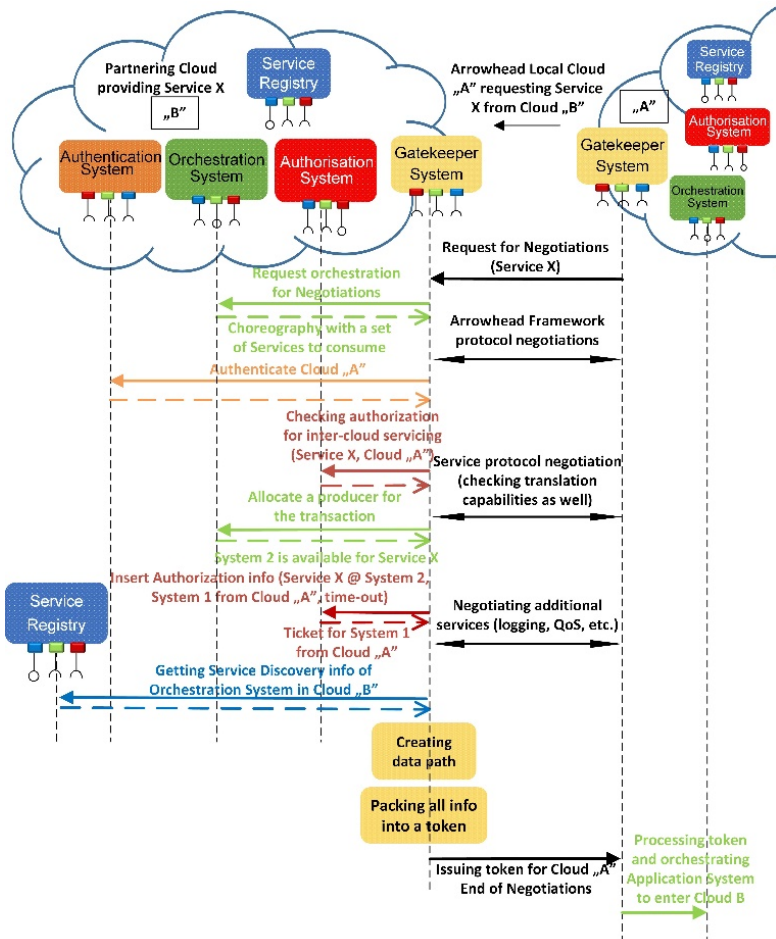
https://github.com/arrowhead-f

    (with example of "*Energy forecast SoS Overview*" from Distributed, Embedded and Intelligent Systems, Department of Computer Science, *Aalborg University*)
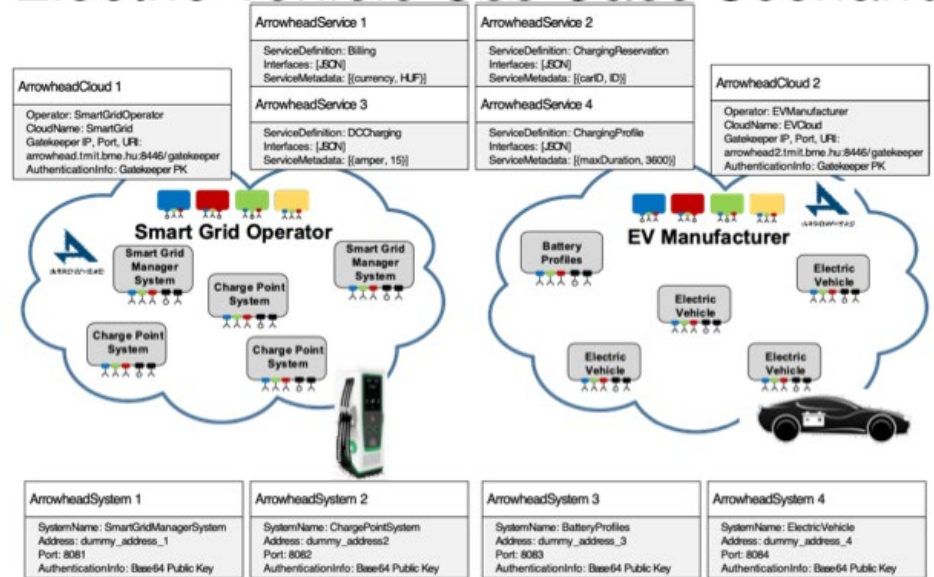
Multi-Cloud Interactions with the Gate Keeper System

Jan van Deventer
Luleå University of Technology
jan.van.deventer@ltu.se

Questions ???

Acknowledgement: the research is funded by the Productive 4.0 project.