DIONASYS

Declarative and Interoperable Overlay Networks,
Applications to Systems of Systems

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DIONASYS project overview phase 1

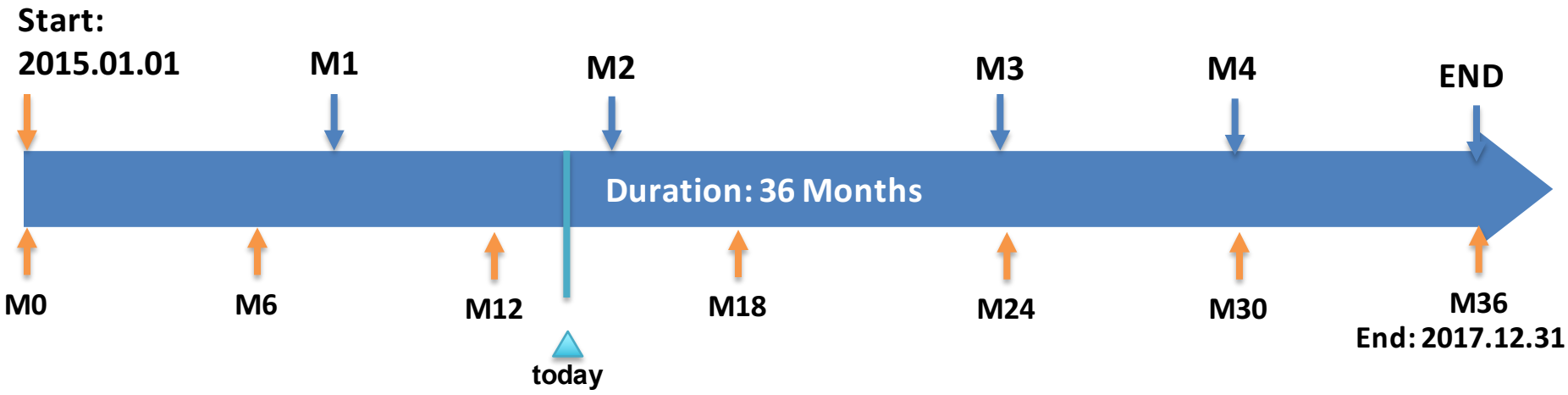
chist-era meeting

April 27th 2016

Bern

Introduction

- Declarative and Interoperable Overlay Networks, and Applications to Systems of Systems
- Call 2013 – topic Heterogeneous Distributed Computing
- 3 years: January 2015 – December 2017



Context

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- Proliferation of heterogeneous and isolated systems
  - Cloud systems
  - Wireless and sensor networks
  - Smart environments
- Composition in systems-of-systems leads to advanced services
  - Multi-cloud
  - Cloud-assisted IoT, e.g. environmental surveillance
  - Edge and fog computing

Motivation

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- Programming complex, heterogeneous large-scale systems
  - Requires thinking "global"
    - What are the services, the guarantees, the structure
  - But to act "local"
    - Implementing complex interactions at the level of individual nodes
- Problems
  - ☹ Maintainability over time
  - ☹ Adaptation and evolution of functionalities
  - ☹ Interoperability among systems
  - ☹ Composition of existing and future systems
  - ➢ Abstraction mismatch

The DIONASYS objectives

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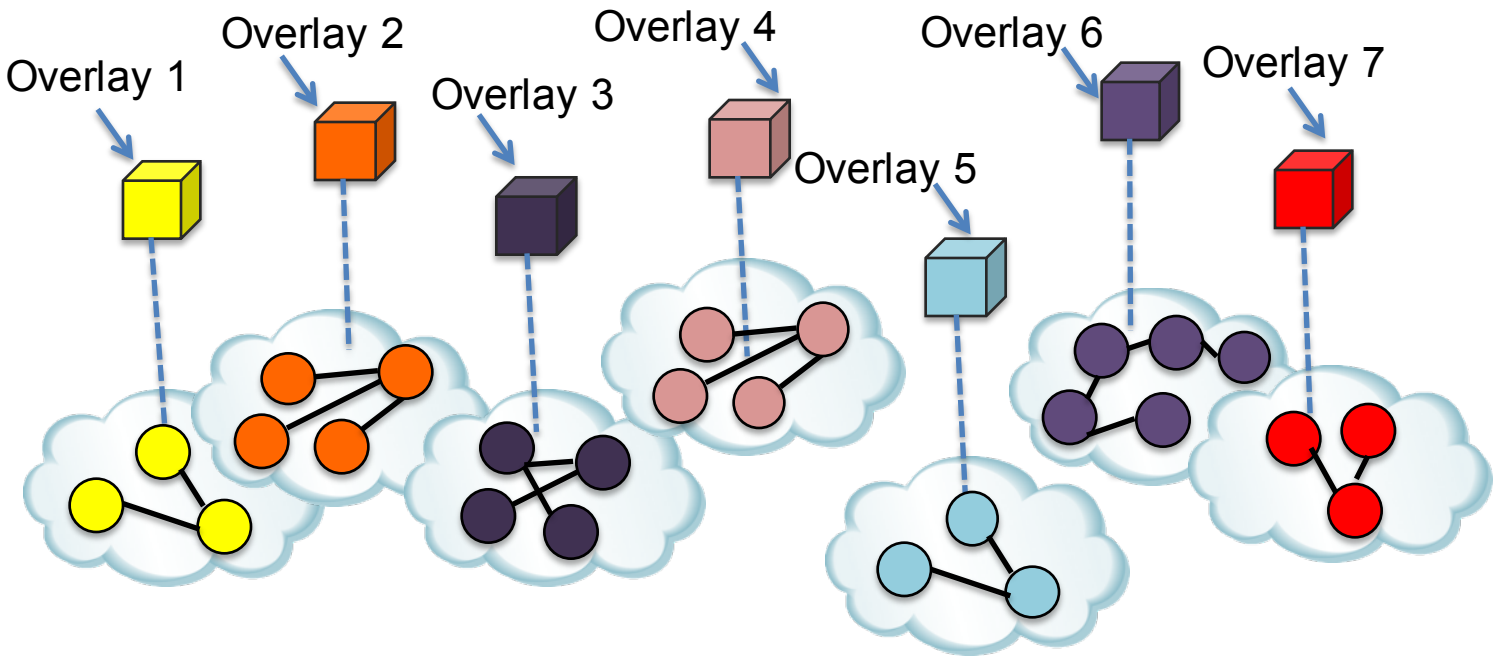
- Raise the level of abstraction for specifying and operating complex systems and system of systems

- Think global, *act* global
  - Declare the function and structure of the system ...

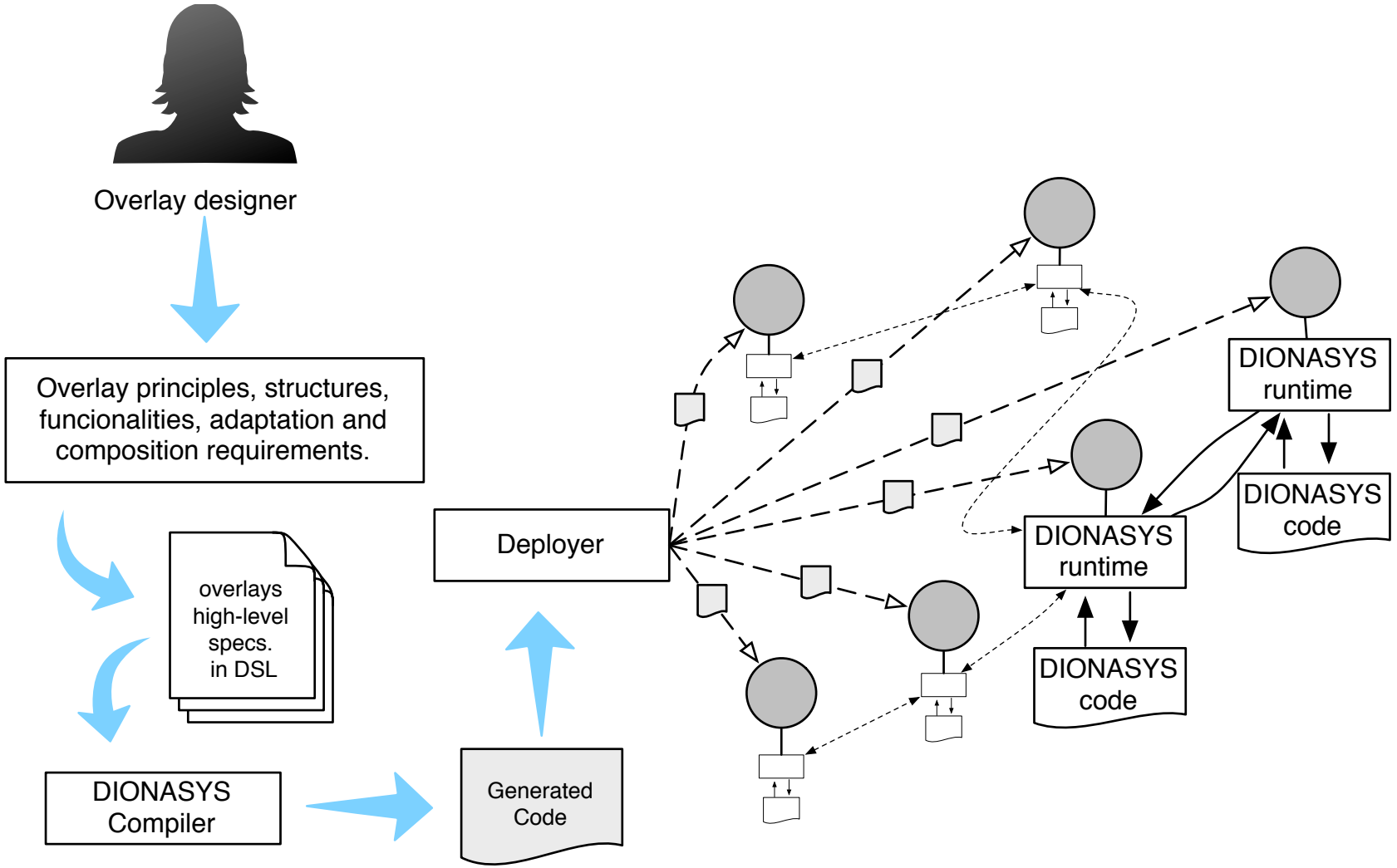
- Leverage generative programming for overlay networks with gossip-based self-organization and software-defined networks
  - … and let DIONASYS generate, augment, evolve, and bridge the corresponding implementation

Overlays as first class entities

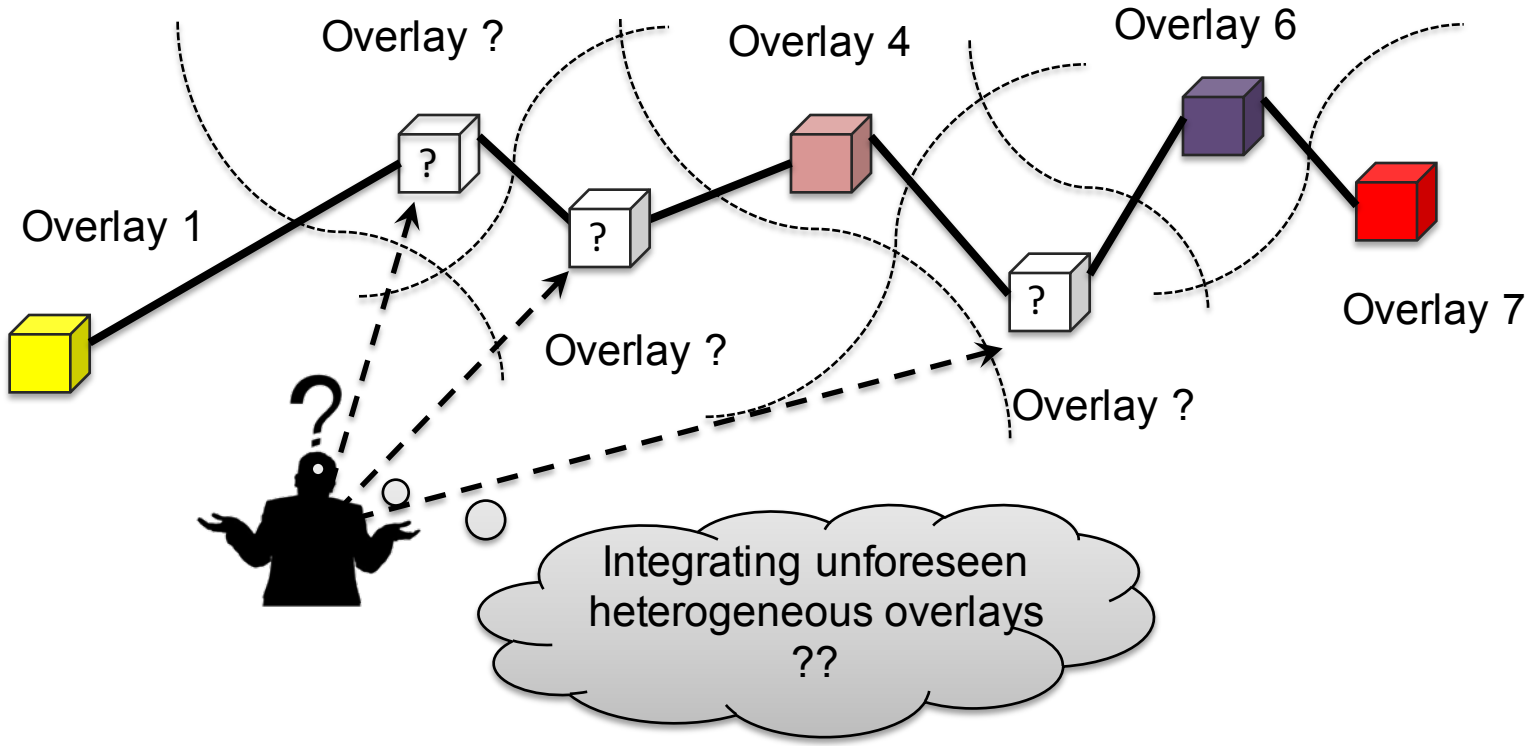


- Virtual graph connecting system nodes, implementing services
- Well-principled guarantees, structures, APIs
- System of systems through overlay composition

Generative programming approach



Runtime opportunistic composition



- Integrate new systems, bridge with already existing ones
- Automate reasoning on overlays structures and functionalities

Target contributions

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- Conceptual framework
  - Principled systems composition
- Declarative approaches for overlay structures and composition
  - Domain-Specific Languages and compilers
- Self-organization using gossip-based overlay construction
- Adaptation and interoperability
  - Formalization and runtime support
- Integration of advanced networking support

Potential impact

- Principled techniques for systems-of-systems programming
  - Potential for use in IoT and IoT-Cloud environments
- Better understanding of inter-overlay adaptation and interoperation
  - Including functional and non-functional aspects
- Open the way for the composition and interoperation of future and already deployed systems

Realizations

Conceptual contributions

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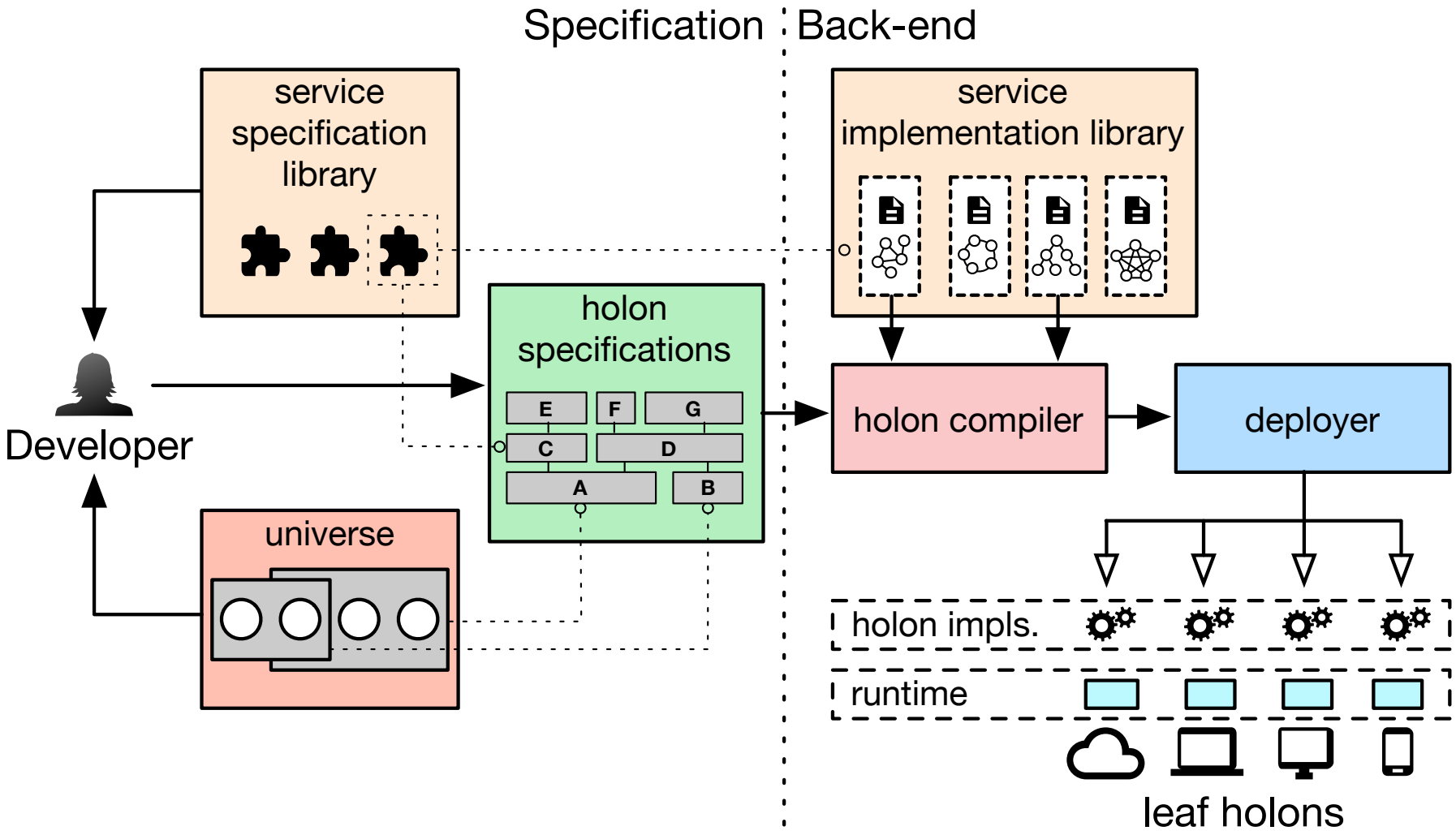
- Tectons: principled opportunistic composition [AOC 2015]
- First version of the holon framework [ARM 2015]
  - Framework for principled systems composition
  - Discussion of challenges and definition of use cases
  - Roadmap for project objectives
- Intent-driven networking [Arxiv, under submission]
  - Framework for applications to declare *intent* on use of network
  - Optimization and adaptation framework

Holon framework



Overlay based systems

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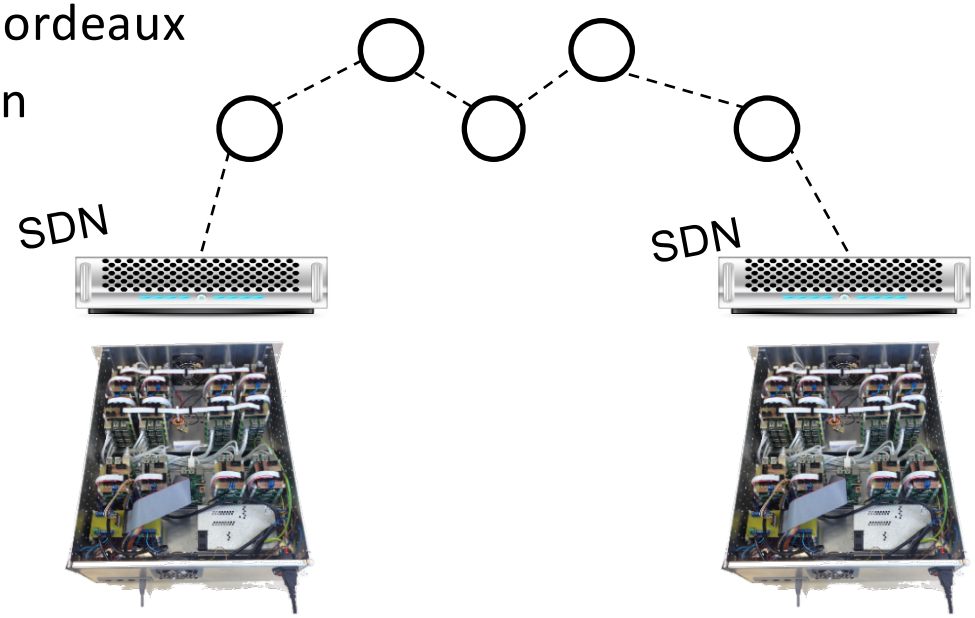
- Declarative programming support for self-organizing overlays
  - Under submission and reviewed for open source release
  - Systematic classification of overlay structures and self-organizing construction complexity (ongoing)
  - Application: study of self-organizing DHT robustness under churn [DAIS16]
- Adaptation of overlays in heterogeneous contexts
  - Application to WSN overlay-based broadcast
  - Use of formalized representation based on timed automata
  - Principles and techniques for automatic and safe protocol switch
  - Work in progress, open sourced

Testbed infrastructure

- Integration of a multi-site testbed based on OpenStack and SDN [ATN 2016]
  - Nodes in Cluj, Neuchâtel and Bordeaux
  - Allows inter-overlay SDN-driven interoperation
  - Control using Splay [COMM 2016]



- *grape* cluster
  - Custom design 4U rack
  - 48 RaspberryPI (~200 cores)
  - Includes networking, power management, optimized power supply

Consortium

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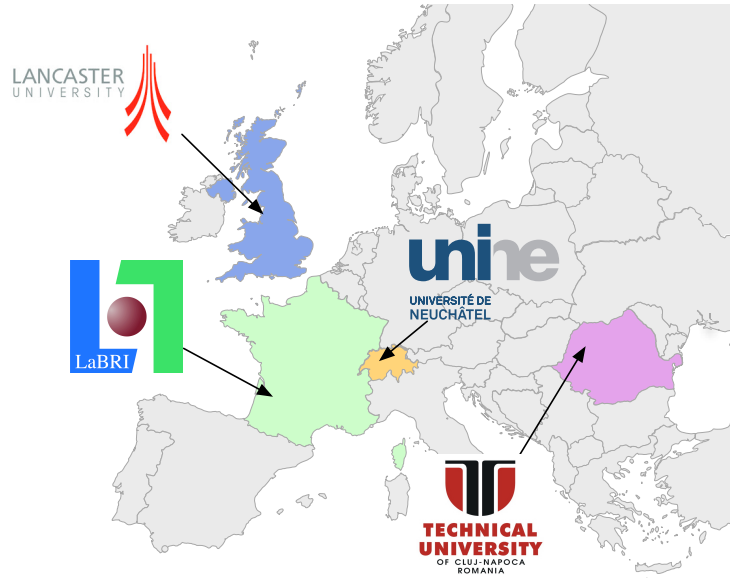
Consortium

- 4 partners
  - Université de Neuchâtel (CH) – coordinator
  - LaBRI, Bordeaux (FR)
  - Lancaster University (UK)
  - Technical university of Cluj-Napoca (RO)
- ~1 M Euros funding from chist-era



Expertise domain / Partner	1. UniNE	2. LaBRI	3. Lancaster	4. TUCN
(domain-specific) Languages and compilation	+	+ + +	+ +	+
Large-scale networked systems	+ + +	+ +	+ +	+++
Wireless networked systems, sensor networks	+ +	+	+ + +	++
Gossip-based and self-organizing systems	+ + +	+	+	++
Middleware adaptation	+	+ + +	+ + +	+
Interoperability, complex systems composition	+	+ +	+ + +	++
QoS-oriented routing and composition	+	++	+	+++
Distributed execution frameworks	+ + +	+	+ +	+
Distributed systems evaluation	+ + +	+ +	+ +	+

University of Neuchâtel, Switzerland

- Key personnel: *Etienne Rivière (coordinator)*
- Computer Science dept. @ UniNE

- Key competencies
  - Large-Scale Distributed Systems
  - Experimental support for Dist. Systems
  - Overlay networks and Gossip-based protocols

UNIVERSITÉ DE NEUCHÂTEL

LaBRI - Bordeaux

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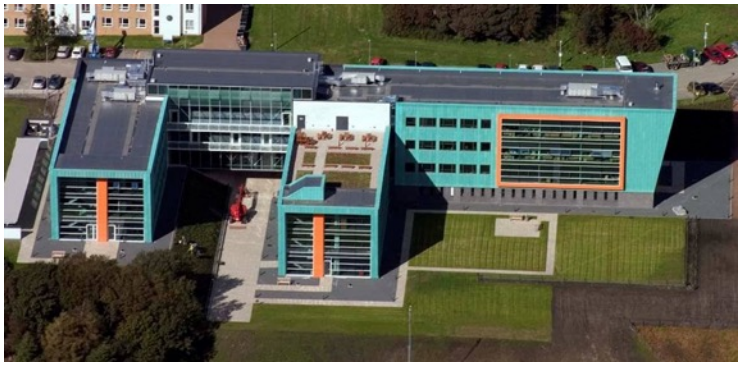
- Key personnel: *Floréal Morandat, Laurent Réveillère*
- Associate member: *David Bromberg* (U. Rennes 1)
- Competences
  - Languages and compilation
  - Middleware adaptation
  - Large-scale distributed systems

LaBRI

Lancaster University, UK

- Key personnel: *Gordon Blair, Geoff Coulson, Yehia El Khatib*
- Competencies:
  - adaptive and reflective middleware,
  - component-based systems,
  - cloud computing,
  - network programming

Lancaster University



Technical University of Cluj-Napoca, Romania

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- Key personnel: *Virgil Dobrota*

- Competencies
  - SDN (Software Defined Networking), OpenFlow
  - Cross-Layer QoS
  - Active/passive measurements in Internet
  - Networking

THANK YOU!

http://www.dionasys.eu

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