# DIONASYS

Declarative and Interoperable Overlay Networks, Applications to Systems of Systems



### DIONASYS project overview year 3

chist-era meeting

April 2018

Paris

### Introduction



- Declarative and Interoperable Overlay Networks, and Applications to Systems of Systems
- Call 2013 topic Heterogeneous Distributed Computing
- January 2015 December 2018
  - Initially until December 2017
  - But extended for one year (until December 2018)

#### Changes in consortium

- Replacement of Université de Neuchâtel (CH) by UCLouvain (BE)
  - Coordinator changed institution
- Split of LaBRI tasks between LaBRI and University of Rennes
  - Co-PI changed institution



### Context chist-era Proliferation of heterogeneous and isolated systems Many forms of Cloud systems deployment Wireless and sensor networks Internet of Things Complex networks Composition in systems-of-systems leading to advanced services

- Geo-distributed Cloud systems
- IoT-Cloud and smart environments
- Edge and fog computing

### Motivation



- 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 and performance
- Interoperability among systems
- Composition of existing and future systems
- Abstraction mismatch



### **DIONASYS** objectives



- Raise the level of abstraction for specifying and operating complex systems and system of systems, based on overlays
  - Think global, act global
    - Declare the function and structure of the system ...
    - Including functional and non-functional properties
  - Leverage generative programming for overlay networks with gossip-based self-organization and software-defined networks
    - In and let DIONASYS generate, augment, evolve, and bridge the corresponding implementation



### Target and previous contributions

- Conceptual framework
  - Principled systems of systems composition
  - Holons framework [2014]
  - Declarative approaches for overlay structures and composition
- Self-organization using gossip-based overlay construction
  Libdio library of self-organizing structures [2015]
- Adaptation and interoperability
- Integration of programmable networking support and overlay management
  - Multi-site testbed based on open-stack + OpenFlow

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### **Contributions in year 3**



#### Overlay adaptation for wireless systems and adhoc networks

- Emergent overlays Collaboration UCL/UniNE, LaBRI, & Lancaster
- Partition detection and routing adaptation Collaboration UCL/UniNE, U. Rennes

#### Overlay composition

Declarative systems-of-systems construction Collaboration LaBRI, U. Rennes

#### Network adaptation

Adaptive routing for multi-site edge clouds Collaboration UCL/UniNE, TUCN

Intent-driven routing Lancaster

### Adaptive overlays for MANET broadcast

#### Broadcast in mobile ad-hoc networks

- Collisions, energy constraints, heterogeneity
- Reactive vs. multiple variants of overlay-based approaches
- Not one size fits all
  - Depending primarily on density and mobility [ICDCS 17]

#### **Emergent overlays**

- Observation of deployment conditions
- Autonomous shift between protocols
- Safety guarantees for dissemination

#### Under submission





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### Partition detection and repair



- Application of principle of opportunistic composition
  - Holons [ARM 2016], previous contribution of project
  - Dynamic bridging of heterogeneous systems
- Example scenario: MANET deployed in adverse environments
  - Emergency teams on disaster area
  - Remote environments with no connectivity
  - Favor end-to-end routing using ad-hoc routing (cheap in energy)
  - Switch to external infrastructure under partitions (costly)
    - Example: deployment of a FANET (Flying Adhoc Network swarm of drones)
  - Autonomous overlay adaptation

#### Under review

#### Partition detection and repair chist-era Detection based on aggregation and comparison of system signatures over time System S Start of Epoch e Start of Epoch e+1 5 partition 2 gossip qossip exchanges exchanges Initial initial A's filter A's filter = A's signature = A's signature multiple 3 multiple gossiping gossiping rounds rounds End of Epoch e+1 <sup>6</sup>C's converged End of Epoch e C) filter Je+1 В A's converged partition detected filter Slide 13 **DIONASYS chist-era workshop, April 2018, Paris**

### **Declarative overlay composition**

#### Pleiades framework [DSN 2018]

- Complex overlay system defined as composition of elementary shapes
- Declaration of structural invariants
- Autonomous construction and repair
- Combination of self-stabilizing protocols
- Domain-specific language for composition specification



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## Overlay adaptation for geo-replicated storage (c)

Multi-site cloud testbed with NFV support



Geo-replicated ZooKeeper: disaster tolerance and local *reads* 

Impact of WAN link due to strong consistency for writes



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### Overlay adaptation for geo-replicated storage



- Edge control of network traffic and application of indirect routing
  - Open vSwitch at the 4 sites, SDN controller
  - Traffic and QoS monitoring to detect Triangle Inequality Violation (TIV)
  - Indirect routing mitigates performance impact on coherence protocol
  - Dynamic changes in overlay layout without application reconfiguration
- Published [LANMAN 2017], current work:
  - Automatic adaptation using SDN controller
  - Adaptation for microservice-based applications deployed in edge clouds



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### Intent-driven networking



- Problem: network layer only sees use of overlay links without indication of non-functional properties
  - QoS, priorities, expected flow lifetimes, ...
- Intent-driven networking: hints from app. layer to optimize networking
  - Application-driven overlay adaptation at the network level
  - Incrementally-deployable design
  - Published [CNSM 2017] and ongoing developments



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### Outputs



20 scientific publications (journals and conferences)

- Distributed systems
- Networking
- Software engineering
- Dependability
- 20 scientific publications (journals and conferences)
  - + 2 under review
  - 5 in collaboration between institutions
  - 7 in collaboration with external institutions
  - 7 single-partner publications
- Organization of two workshops (cross-cloud & ARM) together with major systems conferences (ACM Middleware & EuroSys)



### THANK YOU!

http://www.dionasys.eu



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