DIONASYS project overview
year 3

chist-era meeting
April 2018
Paris
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

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
  - ... 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
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
Emergent overlays

Dense zone

Sparse and highly-mobile zone

Dense zone

Use of flooding in dense region 😕 Collisions & Contentions 😕

Flooding remains best for mobile and sparse networks

Autonomous emergent overlays in self-determined dense regions 😊
Results

Node mobility, two zones: one dense/static, one sparse/dynamic

Energy consumption

Dissemination of single message

Less collisions means better coverage (less retries)

Energy consumption reduced by using overlay only where necessary
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
Detection based on aggregation and comparison of system signatures over time
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
Pleiades framework [DSN 2018]

Emerging shapes

Self-repair after network partition
Overlay adaptation for geo-replicated storage

- 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
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

![Graph showing latency over time for WRITEs and READs](image-url)
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
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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