RESEARCH CENTRE

Inria Paris Centre

2024 ACTIVITY REPORT

Project-Team MIMOVE

Middleware on the Move

DOMAIN

Networks, Systems and Services, Distributed Computing

THEME

Distributed Systems and middleware

Inria

Contents

Project-Team MIMOVE

Creation of the Project-Team: 2018 February 01

Keywords

Computer sciences and digital sciences

A1.2.1. – Dynamic reconfiguration
A1.2.3. – Routing
A1.2.4. – QoS, performance evaluation
A1.2.5. – Internet of things
A1.2.6. – Sensor networks
A1.2.7. – Cyber-physical systems
A1.3. – Distributed Systems
A1.4. – Ubiquitous Systems
A1.5. – Complex systems
A1.5.1. – Systems of systems
A1.5.2. – Communicating systems
A2.5. – Software engineering
A2.6.2. – Middleware
A3.1.7. – Open data
A3.1.8. – Big data (production, storage, transfer)
A3.3. – Data and knowledge analysis
A3.5. – Social networks

Other research topics and application domains

B6.3. – Network functions
B6.4. – Internet of things
B6.5. – Information systems
B8.2. – Connected city
B8.5.1. – Participative democracy

1 Team members, visitors, external collaborators

Research Scientists

- Nikolaos Georgantas [Team leader, INRIA, Researcher, HDR]
- Maroua Bahri [INRIA, Starting Research Position, until Aug 2024]

PhD Students

- Shahin Abdoul Soukour [INRIA, until Sep 2024]
- Emile Royer [INRIA, from Nov 2024]
- Haidong Zhao [INRIA]

Technical Staff

- Shahin Abdoul Soukour [INRIA, Engineer, from Oct 2024]
- William Aboucaya [INRIA, Engineer, until Sep 2024]
- Zakaria Benomar [INRIA, Engineer, until Jun 2024]

Interns and Apprentices

- Emile Royer [INRIA, Intern, from Mar 2024 until Aug 2024]

Administrative Assistants

- Meriem Guemair [INRIA]
- Diana Marino Duarte [INRIA]
- Eugenie-Marie Montagne [INRIA, from Mar 2024]

External Collaborators

- William Aboucaya [Université Paris Dauphine - PSL, from Sep 2024]
- Rachit Agarwal [IIT Kanpur]
- Rafael Angarita Arocha [Université Paris Nanterre, Associate Professor]
- Maroua Bahri [Sorbonne Université, from Sep 2024, Associate Professor]
- Zakaria Benomar [Thales, from Jun 2024]
- Georgios Bouloukakis [Télécom SudParis, Associate Professor]
- Vassilis Christophides [ENSEA, Professor]
- Patient Ntumba Wa Ntumba [Cnam]
- Françoise Sailhan [IMT-Atlantique, Professor, HDR]

2 Overall objectives

Given the prevalence of global networking and computing infrastructures (such as the Internet and the Cloud), mobile networking environments, powerful hand-held user devices, and physical-world sensing and actuation devices, the possibilities of new mobile distributed systems have reached unprecedented levels. Such systems are dynamically composed of networked resources in the environment, which may span from the immediate neighborhood of the users – as advocated by pervasive computing – up to the entire globe – as envisioned by the Future Internet and one of its major constituents, the Internet of Things. Hence, we can now talk about truly ubiquitous computing.

The resulting ubiquitous systems have a number of unique – individually or in their combination – features, such as dynamicity due to volatile resources and user mobility, heterogeneity due to constituent resources developed and run independently, and context-dependence due to the highly changing characteristics of the execution environment, whether technical, physical or social. The latter two aspects are particularly manifested through the physical but also social sensing and actuation capabilities of mobile devices and their users. More specifically, leveraging the massive adoption of smart phones and other user-controlled mobile devices, besides physical sensing – where a device's sensor passively reports the sensed phenomena – *social sensing/ crowd sensing* comes into play, where the user is aware of and indeed aids in the sensing of the environment.

This challenging context raises key research questions:

- How to deal with heterogeneity and dynamicity, which create runtime uncertainty, when developing and running mobile systems in the open and constantly evolving Internet and IoT environment?
- How to raise human centric crowd-sensing to a reliable means of sensing world phenomena?

3 Research program

The research questions identified above call for radically new ways in conceiving, developing and running mobile distributed systems. In response to this challenge, MiMove's research aims at enabling next-generation mobile distributed systems that are the focus of the following research topics.

3.1 Emergent mobile distributed systems

Uncertainty in the execution environment calls for designing mobile distributed systems that are able to run in a beforehand unknown, ever-changing context. Nevertheless, the complexity of such change cannot be tackled at system design-time. Emergent mobile distributed systems are systems which, due to their automated, dynamic, environment-dependent composition and execution, *emerge* in a possibly non-anticipated way and manifest *emergent properties*, i.e., both systems and their properties take their complete form only at runtime and may evolve afterwards. This contrasts with the typical software engineering process, where a system is finalized during its design phase. MiMove's research focuses on enabling the emergence of mobile distributed systems while assuring that their required properties are met. This objective builds upon pioneering research effort in the area of *emergent middleware* initiated by members of the team and collaborators [2, 4].

3.2 Large-scale mobile sensing and actuation

The extremely large scale and dynamicity expected in future mobile sensing and actuation systems lead to the clear need for algorithms and protocols for addressing the resulting challenges. More specifically, since connected devices will have the capability to sense physical phenomena, perform computations to arrive at decisions based on the sensed data, and drive actuation to change the environment, enabling proper coordination among them will be key to unlocking their true potential. Although similar challenges have been addressed in the domain of networked sensing, including by members of the team [8], the specific challenges arising from the *extremely large scale* of mobile devices – a great number of which will be attached to people, with uncontrolled mobility behavior – are expected to require a significant rethink in this domain. MiMove's research investigates techniques for efficient coordination of future mobile sensing and actuation systems with a special focus on their dependability.

3.3 Mobile social crowd-sensing

While mobile social sensing opens up the ability of sensing phenomena that may be costly or impossible to sense using embedded sensors (e.g., subjective crowdedness causing discomfort or joyfulness, as in a bus or in a concert) and leading to a feeling of being more socially involved for the citizens, there are unique consequent challenges. Specifically, MiMove's research focuses on the problems involved in the combination of the physically sensed data, which are quantitative and objective, with the mostly qualitative and subjective data arising from social sensing. Enabling the latter calls for introducing mechanisms for incentivising user participation and ensuring the privacy of user data, as well as running empirical studies for understanding the complex social behaviors involved. These objectives build upon previous research work by members of the team on mobile social ecosystems and privacy, as well as a number of efforts and collaborations in the domain of smart cities and transport that have resulted in novel mobile applications enabling empirical studies of social sensing systems.

4 Application domains

4.1 Mobile urban systems for smarter cities

With the massive scale adoption of mobile devices and further expected significant growth in relation with the Internet of Things, mobile computing is impacting most – if not all – the ICT application domains. One such domain is the one of "*smart cities*". The smart city vision anticipates that the whole urban space, including buildings, power lines, gas lines, roadways, transport networks, and cell phones, can all be wired together and monitored. Detailed information about the functioning of the city then becomes available to both city dwellers and businesses, thus enabling better understanding and consequently management of the city's infrastructure and resources. This raises the prospect that cities will become more sustainable environments, ultimately enhancing the citizens' well being. There is the further promise of enabling radically new ways of living in, regulating, operating and managing cities, through the increasing active involvement of citizens by ways of crowd-sourcing/sensing and social networking.

Still, the vision of what smart cities should be about has been and keeps evolving at a fast pace in close concert with the latest technology trends. It is notably worth highlighting how mobile and social network use has reignited citizen engagement, thereby opening new perspectives for smart cities beyond data analytics that have been initially one of the core foci for smart cities technologies. Similarly, open data programs foster the engagement of citizens in the city operation and overall contribute to make our cities more sustainable. The unprecedented democratization of urban data fueled by open data channels, social networks and crowd sourcing enables not only the monitoring of the activities of the city but also the assessment of their nuisances based on their impact on the citizens, thereby prompting social and political actions. However, the comprehensive integration of urban data sources for the sake of sustainability remains largely unexplored. This is an application domain that we focus on, further leveraging our research on emergent mobile distributed systems, large-scale mobile sensing & actuation, and mobile social crowd-sensing.

In particular, we concentrate on the following specialized applications:

- **Democratization of urban data for healthy cities.** We integrate the various urban data sources, especially by way of crowd-Xing, to better understand city nuisances. This goes from raw pollution sensing (e.g., sensing noise) to the sensing of its impact on citizens (e.g., how people react to urban noise and how this affects their health).
- **Social applications.** Mobile applications are being considered by sociologists as a major vehicle to actively involve citizens and thereby prompt them to become activists. We study such a vehicle from the ICT perspective and in particular elicit relevant middleware solutions to ease the development of such "*civic apps*".

5 New software, platforms, open data

5.1 New software

5.1.1 DeXMS-Sec

Name: Data eXchange Mediator Synthesizer - Secure

Keywords: Internet of things, Middleware protocol interoperability, Edge Computing

Functional Description: To deal with the high technology diversity of the IoT solutions landscape, we have introduced a systematic solution to the IoT interoperability problem at the middleware layer. We identify common interaction abstractions across the multitude of existing heterogeneous IoT protocols and model them into the DeX (Data eXchange) API & connector model. We further elicit the DeXIDL (Interface Description) language to describe the application interfaces of Things in a common abstract way. Based on DeX and DeXIDL, we introduce an architecture for mediators that can bridge heterogeneous Things and their protocols. The outcome of our overall effort is the DeXMS (Mediator Synthesizer) development & runtime framework, which supports the automated synthesis, deployment and execution of mediators at the edge. DeXMS-Sec is the latest version of DeXMS. This framework is built on top of the DeXMS project and adds support of TLS / DTLS-secured protocols.

URL: https://gitlab.inria.fr/waboucay/dexms-sec

Contact: Nikolaos Georgantas

Participants: Zakaria Benomar, William Aboucaya, Nikolaos Georgantas, Georgios Bouloukakis, Patient Ntumba Wa Ntumba, Pierre Guillaume Raverdy

6 New results

6.1 The Future of e-Democracy: Analyzing and Optimizing Citizen Participation Platforms

Participants: William Aboucaya, Rafael Angarita, Valérie Issarny.

As e-democracy evolves, online participatory platforms are revolutionizing citizen engagement in public decision making, enabling unprecedented scale and geographic reach. This study delves into the diverse landscape of these platforms, uncovering their unique objectives and challenges through semi-structured interviews with platform administrators. Our analysis reveals critical areas for improvement, particularly in managing large-scale participation and fostering collaborative citizen contributions. We propose innovative solutions, including leveraging machine learning for efficient processing of voluminous inputs and implementing collaborative editing tools to enhance collective decision-making. These advancements promise to transform e-democracy, making it more inclusive, efficient, and impactful. Our findings offer valuable guidance for platform administrators and designers, paving the way for the next generation of digital civic engagement tools.

6.2 Finding Conflicts of Opinion in Citizen Participation Platforms

Participants: William Aboucaya, Oana Balalau, Rafael Angarita, Valérie Issarny.

Online citizen participation platforms are powerful democratic tools that allow large numbers of contributors to be involved in public decision-making. However, for large groups of contributors to collaborate,

we need to provide tools for users and decision makers to navigate and understand high volumes of content. Towards this goal, we introduce an approach based on natural language processing to detect pairs of contradictory and equivalent proposals in online citizen participation contexts. We apply this approach on two major national citizen consultations: the République Numérique and Revenu Universel d'Activité consultations. We highlight the potential of our method in two use cases. First, our method is a high-quality tool for finding idea communities in online content. Second, we demonstrate that the method improves on the state-of-the-art for finding relevant complementary content for a user, by identifying new relevant views for 76 % of the proposals tested.

6.3 Leveraging Knowledge Graphs for Goal Model Generation

Participants: Shahin Abdoul Soukour, William Aboucaya, Nikolaos Georgantas.

KAOS is one of the most widely used Goal-Oriented Requirements Engineering (GORE) methods. The goal model is the central element of KAOS, employed to represent the goals of a system in the form of a hierarchy, where higher-level goals are refined into lower-level ones. The process of constructing a KAOS goal model for a new application can present challenges, requiring significant time and effort. Existing approaches have tried to partially automate the construction of goal models, however, this largely remains a complex, manual task. In this paper, we propose leveraging domain knowledge in the form of a Knowledge Graph (KG), which can assist the application designer in creating goals that are inspired from this knowledge. To accomplish this, we leverage semantic similarity measurement and Natural Language Inference (NLI) to effectively extract triples from the KG that are relevant to a high-level goal formulated by the designer. The extracted triples are further processed through sentiment analysis and graph-to-text generation, before presented to the designer. Via step-by-step interaction with our solution, the designer can gradually refine their initial goals into a goal hierarchy. We demonstrate our approach by applying it to the design of a flood management system, based on a handcrafted domain KG.

6.4 An Interactive Tool for Goal Model Construction using a Knowledge Graph

Participants: Shahin Abdoul Soukour, William Aboucaya, Nikolaos Georgantas.

The goal model is an essential model in Goal-Oriented Requirements Engineering. It is used to describe the system's goals using a hierarchical structure in which high-level goals are refined into more specific ones. Constructing a goal model for a new application can present challenges, demanding considerable time and effort. Although there have been attempts to automate or semi-automate the construction of goal models, these tasks remain complex and manual. This paper presents an interactive graphical tool that leverages a domain Knowledge Graph (KG) to assist the application designer in creating goals derived from this knowledge, thereby facilitating the creation of goal models. We use semantic similarity measurement and Natural Language Inference (NLI) to effectively extract and align triples from the KG with the high-level initial goals formulated by the application designer. The extracted triples undergo sentiment analysis and Graph-to-Text (G2T) generation to build meaningful subgoals. Nevertheless, processing KGs with Natural Language Processing (NLP) techniques can be a lengthy process. We introduce a restriction based approach to bound the exploration of the KG to the most promising nodes. By tuning KG exploration bounds while using our tool in a case study, we analyze the trade-off between the quality of the resulting goal model and time performance, which is a key factor for an interactive approach. Our paper highlights the relevance of our restriction based approach to information retrieval in KGs to facilitate goal model generation.

6.5 ASML: A Scalable and Efficient AutoML Solution for Data Streams

Participants: Nilesh Verma, Albert Bifet, Bernhard Pfahringer, Maroua Bahri.

Online learning poses a significant challenge to AutoML, as the best model and configuration may change depending on the data distribution. To address this challenge, we propose Automated Streaming Machine Learning (ASML), an online learning framework that automatically finds the best machine learning models and their configurations for changing data streams. It adapts to the online learning scenario by continuously exploring a large and diverse pipeline configuration space. It uses an adaptive optimisation technique that utilizes the current best design, adaptive random directed nearby search, and an ensemble of best performing pipelines. We experimented with real and synthetic drifting data streams and showed that ASML can build accurate and adaptive pipelines by constantly exploring and responding to changes. In several datasets, it outperforms existing online AutoML and state-of-the-art online learning algorithms.

6.6 Adaptive Scheduling of Continuous Operators for IoT Edge analytics

Participants: Patient Ntumba, Nikolaos Georgantas, Vassilis Christophides.

In this paper, we address the problem of adaptive scheduling of data stream processing and analytics (DSPA) applications in a shared edge fog cloud (EFC) continuum with response time constraints. The focus is on handling the dynamic workload of DSPA applications caused by the variability of their input data stream rates generated by mobile IoT devices, and the dynamically available resource capacity in the EFC continuum. To address these challenges, we characterise the different types of resources in the EFC continuum, as well as the operators that make up a DSPA application. Based on this characterisation, we propose models to evaluate the response time and the cost of using the resources in the always dynamic EFC continuum. We then formulate the problem of adaptive scheduling of a DSPA application in the EFC continuum with the objective of minimising the cost of using the shared resources subject to the constraints of the response time and the available capacity of the EFC resources. We propose a heuristic algorithm that dynamically computes a new scheduling of the DSPA application, taking into account its current deployment state and the current state of the shared resources in the EFC continuum. Experimental results, using simulation, show the effectiveness of our proposed algorithm against algorithms of related work.

6.7 Automating the evaluation of interoperability effectiveness in heterogeneous IoT systems

Participants: Georgios Bouloukakis, Nikolaos Georgantas, Ajay Kattepur, Houssam Hajj Hassan, Valérie Issarny.

Internet of Things (IoT) applications consist of diverse resource-constrained/rich devices with a considerable portion being mobile. Such devices demand lightweight, loosely coupled interactions in terms of time, space, and synchronization. IoT protocols at the middleware layer support several interaction types (e.g., asynchronous messaging, streaming, etc.) ensuring successful interactions between devices that use the same protocol. Additionally, they introduce different Quality of Service (QoS) delivery modes for data exchange with respect to available device and network resources. On the other hand, interconnecting heterogeneous IoT devices requires mapping both their functional and QoS properties. This calls for advanced interoperability solutions integrated with QoS modeling and analysis techniques. This paper introduces an automated synthesis of QoS-aware mediating artifacts. Such mediators enable the interconnection between IoT devices employing heterogeneous middleware protocols. Additionally, representative QoS models are synthesized. Leveraging these models, system designers can evaluate

the effectiveness of the interconnection in terms of end-to-end QoS. We evaluate the usefulness of our approach through experimentation with a case study employing heterogeneous middleware protocols. In particular, we statistically analyze through simulations the effect of varying system parameters on the end-to-end QoS.

6.8 Bridging IoT Protocols with the Web of Things: A Path to Enhanced Interoperability

Participants: Zakaria Benomar, Marco Garofalo, Nikolaos Georgantas, Francesco Longo, Giovanni Merlino, Antonio Puliafito.

Nowadays, the Internet of Things (IoT) is reshaping numerous application domains. Amidst the different communication protocols currently available (MQTT, CoAP, AMQP, DPWS, etc.) and the abundance of management platforms, the IoT domain has stumbled into vertical silos of proprietary systems hindering interoperability. Within this intricate and fragmented ecosystem, the need for an intelligent and scalable architecture promoting interoperability becomes imperative to maximize the potential of IoT. This paper introduces a system designed to enhance the convergence of IoT protocols (e.g., MQTT, CoAP, AMQP, etc.) with the Web of Things (WoT) paradigm. Our proposed gateway-based solution integrates two systems: Stack4Things (S4T) and Data eXchange Mediator Synthesizer (DeXMS). The role of the latter is to adapt, at the gateway level, the IoT protocols and expose the resources/functionalities of the IoT devices as RESTful APIs using HTTP. Meanwhile, the former (i.e., S4T), leveraging its Dynamic DNS system, ensures that these RESTful resources (exposed at the gateway) are accessible over the Web using publicly routable Uniform Resource Locators (URLs) even when the gateway is deployed behind networking middleboxes (e.g., NATs and firewalls).

6.9 FaaS for IoT: Evolving Serverless towards Deviceless in I/O clouds

Participants: Giovanni Merlino, Giuseppe Tricomi, Luca D'Agati, Zakaria Benomar, Francesco Longo, Antonio Puliafito.

The burgeoning paradigms of Fog and Edge computing propose delegating Cloud-related tasks to the network's periphery, thus placing computational resources closer to data producers. This shift promises to boost the performance of IoT-based services, providing swift response times while conserving bandwidth. Despite their potential, the current Edge/Fog computing platforms must provide the required flexibility for dynamic service orchestration within a data-oriented context. Addressing this gap, the Function-as-a-Service (FaaS) model emerges as an exceptional strategy for Edge/Fog deployments. Its ability to manage an ever-expanding ecosystem of devices with remarkable flexibility and efficiency holds considerable promise. This paper articulates a novel approach to enhancing the adaptability of IoT Edge/Fog deployments. We propose an innovative extension to OpenStack, an open-source Cloud management system, which pushes its functionality towards the network Edge. Our approach empowers OpenStack to facilitate FaaS services within a distributed IoT infrastructure, thus infusing unprecedented adaptability and efficiency into the Edge/Fog computing paradigms.

7 Partnerships and cooperations

7.1 European initiatives

7.1.1 Horizon Europe

SEDIMARK

Participants: Maroua Bahri, Shahin Abdoul Soukour, Nikolaos Georgantas.

SEDIMARK project on cordis.europa.eu

Title: SEcure Decentralised Intelligent Data MARKetplace

Duration: From October 1, 2022 to September 30, 2025

Partners:

- INSTITUT NATIONAL DE RECHERCHE EN INFORMATIQUE ET AUTOMATIQUE (INRIA), France
- WINGS ICT SOLUTIONS TECHNOLOGIES PLIROFORIKIS KAI EPIKOINONION ANONYMI ETAIREIA (WINGS ICT SOLUTIONS AE), Greece
- UNIVERSITY COLLEGE DUBLIN, NATIONAL UNIVERSITY OF IRELAND, DUBLIN (NUID UCD), Ireland
- FORUM VIRIUM HELSINKI OY (RADIO- JATELEVISIOTEKNIIKAN TUTKIMUS RTT), Finland
- SIEMENS SRL, Romania
- ATOS SPAIN SA, Spain
- AYUNTAMIENTO DE SANTANDER, Spain
- METLEN ENERGY & METALS AE (METLEN), Greece
- UNIVERSIDAD DE CANTABRIA (UC), Spain
- FONDAZIONE LINKS - LEADING INNOVATION & KNOWLEDGE FOR SOCIETY (FONDAZIONE LINKS), Italy
- ATOS IT SOLUTIONS AND SERVICES IBERIA SL (ATOS IT), Spain
- UNIVERSITY OF SURREY (SURREY), United Kingdom
- EGM (EGM SAS), France

Inria contact: Nikolaos Georgantas

Coordinator: ATOS SPAIN SA, Spain

Summary: The EU data economy has grown tremendously, with forecasts predicting to reach 800 Billion Euros in 2025. Data are becoming the new currency, being exchanged as products or services in marketplaces. Data markets are predicted to reach a size of 100 Billion Euros in 2025. Existing data marketplaces are centralised, store the data on the cloud, provide limited to no guarantees about data quality and they are governed by single entities that make the rules. SEDIMARK merges the expertise of a large team of experts to build a secure, trusted and intelligent decentralised data and services marketplace, based on Distributed Ledger Technology and Artificial Intelligence. SEDIMARK enables distributed heterogeneous data within the EU to be easily and seamlessly linked, shared and exploited for diverse business and research scenarios. SEDIMARK builds upon the concept of FAIR data, ensuring that data are of the highest quality, unbiased, enriched and annotated, so that they can be discovered, accessed, and easily reused. SEDIMARK includes a distributed registry of resources (data/services) stored on edge systems, close to where they are generated and where the data are cleaned, labelled, validated and anonymised. Security is applied with strong access control, privacy techniques for data minimisation and purpose limitation, exploiting blockchain for enforcing trust, decentralised identities, and data verification. Energy efficient AI techniques will be used for automated data quality management, labelling and classification of data as well as for providing (distributed) analytics and advanced services on top of the data. Semantic interoperability based on common ontologies and data models will allow the easy and efficient discovery, sharing and federation of heterogeneous data from multiple sources. The system is built on top of existing platforms of the consortium, starting from TRL5 and will be tested and demonstrated in four real world scenarios, reaching TRL-8.

7.2 National initiatives

BPI – France Relance – 5G Events Labs

Participants: Nikolaos Georgantas, Zakaria Benomar, William Aboucaya, Shahin Abdoul Soukour.

Partner Institutions:

- Orange
- Ericsson
- INRIA
- CEA - Centre de Saclay

Duration: 2021 - 2024

Additional info: The 5G Events Labs project aims to boost the economic activity of the events, culture and sports sectors, around ten major sites in France where Orange and its partners will offer 5G coverage, technological platforms and adapted support enabling companies to leverage these technologies and incubate innovations in the areas of services for attendees and organizers. MIMOVE brings expertise in middleware solutions for the IoT that support intelligent spaces and applications across the mobile-edge-cloud continuum.

BPI – France Relance – Cloud Platform For Smart City (CP4SC)

Participants: Nikolaos Georgantas, Zakaria Benomar, William Aboucaya.

Partner Institutions:

- ATOS
- Ericsson
- INRIA
- INRAE
- IFPEN
- Oslandia
- Vertical M2M

Duration: 2023 - 2025

Additional info: The objective of the CP4SC platform is to help governments implement ambitious policies towards carbon neutrality by ingesting data from different verticals such as mobility, energy management and earth and environmental observation. MIMOVE brings expertise in middleware solutions for the IoT that support communication protocol and application data exchange interoperability.

8 Dissemination

8.1 Promoting scientific activities

8.1.1 Scientific events: selection

Member of the conference program committees

- Nikolaos Georgantas, member of the TPC of the following international conferences: ACM SAC'24, IEEE SOSE'24, IEEE SMARTCOMP'24, IEEE MetaCom'24, IEEE WETICE'24, CoopIS'24, MODELSWARD'25.
- Maroua Bahri, member of the TPC of the following international conference: ACM SAC'24.

8.1.2 Journal

Reviewer - reviewing activities

- Nikolaos Georgantas, reviewer for IEEE Transactions on Network and Service Management.

8.1.3 Invited talks

- Maroua Bahri, "AutoML for Data stream", LIP6, Sorbonne Université, May 2024.
- Maroua Bahri, "Efficient Data stream mining", Laboratoire DAVID, UVSQ, March 2024.

8.1.4 Scientific expertise

- Nikolaos Georgantas, member of the recruitment committee for a post of Associate Professor at the Computer Science Department of Télécom SudParis, Institut Polytechnique de Paris.
- Nikolaos Georgantas, member of the PhD monitoring committee of Himadri Chhaya-Shailesh (Sorbonne Université), Victorien Romain (Cnam), Victor Laforet (Sorbonne Université).

8.2 Teaching - Supervision - Juries

- Maroua Bahri, "Navigating Complex Machine Learning Challenges in Streaming Data - A Hands-On", tutorial at ECML-PKDD 2024.

8.2.1 Supervision

- Engineering school degree thesis defense: Emile Royer, "Optimisation automatique de l'apprentissage en ligne", EPF, Oct 2024, Maroua Bahri, Nikolaos Georgantas.
- PhDs in progress:
  - Shahin Abdoul Soukour (from October 2020): "Leveraging domain knowledge in requirements engineering for IoT applications", Sorbonne University, Nikolaos Georgantas.
  - Haidong Zhao (from March 2023): "Edge Inference Serving System for Industrial Monitoring", Sorbonne Université, Nikolaos Georgantas.
  - Emile Royer (from November 2024): "Distributed automated machine learning with application on IoT data", Sorbonne Université, Maroua Bahri, Nikolaos Georgantas.

9 Scientific production

9.1 Major publications

[1] R. Angarita, B. Lefèvre, S. Ahvar, E. Ahvar, N. Georgantas and V. Issarny. 'Universal Social Network Bus: Towards the Federation of Heterogeneous Online Social Network Services'. In: *ACM Transactions on Internet Technology* (2019). DOI: 10.1145/3323333. URL: https://hal.inria.fr/hal-02072544.

[2] A. Bennaceur and V. Issarny. 'Automated Synthesis of Mediators to Support Component Interoperability'. In: *IEEE Transactions on Software Engineering* (2015), p. 22. URL: https://hal.inria.fr/hal-01076176 (cit. on p. 3).

[3] B. Billet and V. Issarny. 'Spinel: An Opportunistic Proxy for Connecting Sensors to the Internet of Things'. In: *ACM Transactions on Internet Technology* 17.2 (Mar. 2017), pp. 1–21. DOI: 10.1145/3041025. URL: https://hal.inria.fr/hal-01505879.

[4] G. Blair, A. Bennaceur, N. Georgantas, P. Grace, V. Issarny, V. Nundloll and M. Paolucci. 'The Role of Ontologies in Emergent Middleware: Supporting Interoperability in Complex Distributed Systems'. In: *Big Ideas track of ACM/IFIP/USENIX 12th International Middleware Conference*. Lisbon, Portugal, 2011. URL: http://hal.inria.fr/inria-00629059/en (cit. on p. 3).

[5] G. Bouloukakis, N. Georgantas, P. Ntumba and V. Issarny. 'Automated synthesis of mediators for middleware-layer protocol interoperability in the IoT'. In: *Future Generation Computer Systems* 101 (Dec. 2019), pp. 1271–1294. DOI: 10.1016/j.future.2019.05.064. URL: https://hal.inria.fr/hal-02304074.

[6] M. Caporuscio, P.-G. Raverdy and V. Issarny. 'ubiSOAP: A Service Oriented Middleware for Ubiquitous Networking'. In: *IEEE Transactions on Services Computing* 99 (2012). DOI: \url{http://doi.ieeecomputersociety.org/10.1109/TSC.2010.60}. URL: http://hal.inria.fr/inria-00519577.

[7] Y. Du, F. Sailhan and V. Issarny. 'Let Opportunistic Crowdsensors Work Together for Resource-efficient, Quality-aware Observations'. In: *PerCom 2020: IEEE International Conference on Pervasive Computing and Communications*. Austin / Virtual, United States, Mar. 2020. DOI: 10.1109/PerCom45495.2020.9127391. URL: https://hal.archives-ouvertes.fr/hal-02463610.

[8] S. Hachem, A. Pathak and V. Issarny. 'Service-Oriented Middleware for Large-Scale Mobile Participatory Sensing'. In: *Pervasive and Mobile Computing* (2014). URL: http://hal.inria.fr/hal-00872407 (cit. on p. 3).

9.2 Publications of the year

International journals

[9] G. Merlino, G. Tricomi, L. D'Agati, Z. Benomar, F. Longo and A. Puliafito. 'FaaS for IoT: Evolving Serverless towards Deviceless in I/Oclouds'. In: *Future Generation Computer Systems* (2nd Jan. 2024). DOI: 10.1016/j.future.2023.12.029. URL: https://hal.science/hal-04405277.

[10] P. Ntumba, N. Georgantas and V. Christophides. 'Adaptive Scheduling of Continuous Operators for IoT Edge analytics'. In: *Future Generation Computer Systems* (15th Apr. 2024). DOI: 10.1016/j.future.2024.04.029. URL: https://hal.science/hal-04558794.

International peer-reviewed conferences

[11] S. Abdoul Soukour, W. Aboucaya and N. Georgantas. 'An Interactive Tool for Goal Model Construction using a Knowledge Graph'. In: REFSQ 2025 - 31st International Working Conference on Requirement Engineering: Foundation for Software Quality. Barcelona, Spain, 7th Apr. 2025, p. 15. URL: https://inria.hal.science/hal-04907365.

[12] S. Abdoul Soukour, W. Aboucaya and N. Georgantas. 'Leveraging Knowledge Graphs for Goal Model Generation'. In: 7th Workshop on Natural Language Processing for Requirements Engineering (NLP4RE) in conjuction with the 30th International Woking Conference on Requirements Engineering: Foundation for Software Quality (REFSQ 2024). Winterthur, Switzerland, 8th Apr. 2024, p. 11. URL: https://inria.hal.science/hal-04486653.

[13] W. Aboucaya, R. Angarita and V. Issarny. 'The Future of e-Democracy: Analyzing and Optimizing Citizen Participation Platforms'. In: UV2024: IEEE 7th International Conference on Universal Village. Boston, MA, United States, 19th Oct. 2024, p. 8. URL: https://inria.hal.science/hal-04871287.

[14] W. Aboucaya, O. Balalau, R. Angarita and V. Issarny. 'Finding Conflicts of Opinion in Citizen Participation Platforms'. In: 2024 IEEE International Conference on Web Intelligence and Intelligent Agent Technology (WI-IAT). Bangkok, Thailand, 9th Dec. 2024, p. 8. URL: https://inria.hal.science/hal-04870985.

[15] Z. Benomar, M. Garofalo, N. Georgantas, F. Longo, G. Merlino and A. Puliafito. 'Bridging IoT Protocols with the Web of Things: A Path to Enhanced Interoperability'. In: 17th IEEE International Conference on Internet of Things (iThings 2024). Copenhagen, Denmark, 19th Aug. 2024. URL: https://inria.hal.science/hal-04708266.

[16] G. Bouloukakis, N. Georgantas, A. Kattepur, H. Hajj Hassan and V. Issarny. 'Automating the evaluation of interoperability effectiveness in heterogeneous IoT systems'. In: *ICSA 2024 : 21st IEEE International Conference on Software Architecture*. 21st IEEE International Conference on Software Architecture (ICSA 2024). Charminar, Hyderabad, India: IEEE, 24th July 2024. DOI: 10.1109/ICSA59870.2024.00014. URL: https://inria.hal.science/hal-04482364.

[17] N. Verma, A. Bifet, B. Pfahringer and M. Bahri. 'ASML: A Scalable and Efficient AutoML Solution for Data Streams'. In: AutoML 2024 - International Conference on Automated Machine Learning. Paris, France, 9th Sept. 2024. URL: https://inria.hal.science/hal-04581479.

Other scientific publications

[18] É. Royer. 'Optimisation automatique de l'apprentissage en ligne'. Cachan: EPF, 18th Oct. 2024, p. 29. URL: https://inria.hal.science/hal-04921796.