Activity Report 2017

Team MIMOVE

Middleware on the Move

Inria teams are typically groups of researchers working on the definition of a common project, and objectives, with the goal to arrive at the creation of a project-team. Such project-teams may include other partners (universities or research institutions).

RESEARCH CENTER
Paris

THEME
Distributed Systems and middleware

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Team MIMOVE

Creation of the Team: 2014 July 01, updated into Project-Team: 2018 February 01

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1. Personnel

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2. Overall Objectives

2.1. Overall Objectives

This year, Inria Muse team joined MiMove. We provide in Sections 2, 3 and 4 a first overview of our common research vision in the new MiMove team.

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.

Mobile systems with the above specifics further push certain problems related to the Internet and user experience to their extreme: (i) Technology is too complex. Most Internet users are not tech-savvy and hence cannot fix performance problems and anomalous network behavior by themselves. The complexity of most Internet applications makes it hard even for networking experts to fully diagnose and fix problems. Users can't even know whether they are getting the Internet performance that they are paying their providers for. (ii) There is too much content. The proliferation of user-generated content (produced anywhere with mobile devices and immediately published in social media) along with the vast amount of information produced by traditional media (e.g., newspapers, television, radio) poses new challenges in achieving an effective, near real-time information awareness and personalization. For instance, users need novel filtering and recommendation tools for helping them to decide which articles to read or which movie to watch.

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 enable automated diagnosis and optimization of networks and systems in the Internet and IoT environment for improving the QoE of their users?
- How to raise human centric crowd-sensing to a reliable means of sensing world phenomena?
- How to deal with combination, analysis and privacy aspects of Web/social media and IoT crowd-sensing data streams?

3. Research Program

3.1. Introduction

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:

3.2. 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].

3.3. 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.

3.4. 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.

3.5. Active and passive probing methods

We are developing methods that actively introduce probes in the network to discover properties of the connected devices and network segments. We are focusing in particular on methods to discover properties of home networks (connected devices and their types) and to distinguish if performance bottlenecks lie within the home network versus outside. Our goal is to develop adaptative methods that can leverage the collaboration of the set of available devices (including end-user devices and the home router, depending on which devices are running the measurement software).

We are also developing passive methods that simply observe network traffic to infer the performance of networked applications and the location of performance bottlenecks, as well as to extract patterns of web content consumption. We are working on techniques to collect network traffic both at user's end-devices and at home routers. We also have access to network traffic traces collected on a campus network and on a large European broadband access provider.

3.6. Inferring user online experience

We are developing hybrid measurement methods that combine passive network measurement techniques to infer application performance with techniques from HCI to measure user perception. We will later use the resulting datasets to build models of user perception of network performance based only on data that we can obtain automatically from the user device or from user's traffic observed in the network.

3.7. Big data stream mining and processing

The challenge of deriving insights from the Internet of Things (IoT) has been recognized as one of the most exciting and key opportunities for both academia and industry. Advanced analysis of big data streams from sensors embedded in the environment and wearable or mobile user devices is bound to become a key area of

data mining research as the number of applications requiring such processing increases. However, the *high data speed (velocity)* in conjunction with the *low data quality (veracity)* of IoT data streams challenges traditional Machine-Learning (ML) approaches assuming that a good quality training set is available a priori to learn models that may be effectively applied to new data collected under very similar conditions. As previous work has observed, data quality issues are detrimental to data analysis [1]. Good quality training data are typically the result of a thorough *data pre-processing* comprising data aggregation/integration, data cleaning/normalization, data dimensionality reduction, etc. The offline nature of these data engineering tasks represent nowadays one of the biggest technical barriers for supporting a high-value data analytics in real-time for various IoT settings (e.g., residential, industrial, urban, etc.). Furthermore, existing techniques for data quality management are usually agnostic of the analytical process that is to be applied on the data. For this reason, analysts either clean everything, which is impossible for Big Data, or clean random subsets and hope for the best. We are interested in studying the following research questions: (a) what specific characteristics of the data quality (e.g., incomplete, extreme or erroneous values) led to the improvement, or lack thereof, in the performance of a ML algorithm (e.g., regression, classification)? (b) how we can identify influential data that are both unusual in the predictor variables and do not follow the general trend of the data relative to a prediction? (c) to what extend we can automate data pre-processing tasks (in particular cleaning) for specific streaming data analytics scenarios?

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. However, given the importance of conducting empirical studies to assess and nurture our research, we focus on one application area that 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 is 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 intend to focus on, further leveraging our research on emergent mobile distributed systems, large-scale mobile sensing & actuation, and mobile social crowd-sensing.

In a first step, we concentrate on the following specialized applications, which we investigate in close collaboration with other researchers, in particular as part of the dedicated Inria Project Lab *CityLab@Inria*:

[1] US National Research Council. 2013. Frontiers in Massive Data Analysis. The National Academies Press. http://www.nap.edu/openbook.php?record_id=18374

- **Democratization of urban data for healthy cities.** The objective here is to integrate the various urban data sources, especially by way of crowd-Xing, to better understand city nuisances 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).
- **Socially-aware urban mobility.** Mobility within mega-cities is known as one of the major challenges to face urgently due to the fact that today's mobility patterns do not scale and to the negative effect on the environment and health. It is our belief that mobile social and physical sensing may significantly help in promoting the use of public transport, which we have started to investigate through empirical study based on the development and release of dedicated apps.
- **Social applications.** Mobile applications are being considered by sociologists as a major vehicle to actively involve citizens and thereby prompt them to become activists. This is especially studied with the Social Apps Lab at UC Berkeley. Our objective is to study such a vehicle from the ICT perspective and in particular elicit relevant middleware solutions to ease the development and development of such "*civic apps*".

Acknowledging the need for collaborative research in the application domain of smart cities, MiMove is heavily involved and actually leading CityLab@Inria [2]. The Inria Project Lab CityLab is focused on the study of ICT solutions promoting social sustainability in smart cities, and involves the following Inria project-teams in addition to MiMove: CLIME, DICE, FUN, MYRIADS, SMIS, URBANET and WILLOW. CityLab further involves strong collaboration with California universities affiliated with CITRIS (Center for Information Technology Research in the Interest of Society) and especially UC Berkeley, in relation with the *Inria@SiliconValley* program. We note that Valérie Issarny acts as scientific manager of Inria@SiliconValley and is currently visiting scholar at CITRIS at UC Berkeley. In this context, MiMove researchers are working closely with colleagues of UC Berkeley, including researchers from various disciplines interested in smart cities (most notably sociologists).

4.2. Home Network Diagnosis

With the availability of cheap broadband connectivity, Internet access from the home has become a ubiquity. Modern households host a multitude of networked devices, ranging from personal devices such as laptops and smartphones to printers and media centers. These devices connect among themselves and to the Internet via a local-area network —a *home network*– that has become an important part of the "Interne experience". In fact, ample anecdotal evidence suggests that the home network can cause a wide array of connectivity impediments, but their nature, prevalence, and significance remain largely unstudied.

Our long-term goal is to assist users with concrete indicators of the causes of potential problems and—ideally—ways to fix them. We intend to develop a set of easy-to-use home network diagnosis tools that can reliably identify performance and functionality shortcomings rooted in the home. The development of home network diagnosis tools brings a number of challenges. First, home networks are heterogeneous. The set of devices, configurations, and applications in home networks vary significantly from one home to another. We must develop sophisticated techniques that can learn and adapt to any home network as well as to the level of expertise of the user. Second, there are numerous ways in which applications can fail or experience poor performance in home networks. Often there are a number of explanations for a given symptom. We must devise techniques that can identify the most likely cause(s) for a given problem from a set of possible causes. Third, even if we can identify the cause of the problem, we must then be able to identify a solution. It is important that the output of the diagnosis tools we build is "actionable". Users should understand the output and know what to do.

We are conceiving methods for two application scenarios: (i) when the end user in the home deploys our diagnostic tools either on the home gateway (the gateway often combines a DSL/cable modem and an access point; it connects the home network to the ISP) or on devices connected to the home network and (ii) when ISPs collect measurements from homes of subscribers and then correlate these measurements to help identify problems.

[2] http://citylab.inria.fr

Assisting end users. We are developing algorithms to determine whether network performance problems lie inside or outside the home network. Given that the home gateway connects the home with the rest of the Internet, we are designing an algorithm (called *HoA*) that analyzes traffic that traverses the gateway to distinguish access link and home network bottlenecks. A measurement vantage point on the gateway is key for determining if the performance bottleneck lies within the home network or the access ISP, but we also need to deploy diagnosis tools in end-devices. First, some users may not want (or not know how) to deploy a new home gateway in their homes. Second, some problems will be hard to diagnose with only the vantage point of the gateway (for example, when a device cannot send traffic or when the wireless is poor in certain locations of a home). We can obtain more complete visibility by leveraging *multiple* measurement nodes around the home, potentially including the home gateway, all participating jointly in the measurement task. We have an ongoing project to realize a home network analyzer as a web-based measurement application built on top of our team's recently developed browser-based measurement platform, *Fathom*. To integrate the home gateway in the analyzer, we plan to engage the BISmark Project. BISmark already provides a web server as well as extensive configurability, allowing us to experiment freely with both passive as well as active measurements. We must develop a home network analyzer that can first discover the set of devices connected to the home network that can collaborate on the diagnosis task. We will then develop tomography algorithms to infer where performance problems lie given measurements taken from the set of available vantage points.

Assisting Internet Service Providers (ISPs). Our discussions with several large access ISPs reveal that service calls are costly, ranging from $9–25 per call, and as many as 75% of service calls from customers are usually caused by problems that have nothing to do with the ISP. Therefore, ISPs are eager to deploy techniques to assist in home network diagnosis. In many countries ISPs control the home gateway and set-top-boxes in the home. We plan to develop more efficient mechanisms for home users to report trouble to their home ISP and consequently reduce the cost of service calls. This project is in collaboration with Technicolor and Portugal Telecom. Technicolor is a large manufacturer of home gateways and set-top-boxes. Portugal Telecom is the largest broadband access provider in Portugal. Technicolor already collects data from 200 homes in Portugal. We are working with the data collected in this deployment together with controlled experiments to develop methods to diagnose problems in the home wireless.

4.3. Quality of Experience

An increasing number of residential users consume online services (e.g., VoD, Web browsing, or Skype) in their everyday activities (e.g., for education or entertainment purposes), using a variety of devices (e.g., tablets, smartphones, laptops). A high Quality of Service (QoS) is essential for sustaining the revenue of service providers, carriers, and device manufactures. Yet, the perceived Quality of Experience (QoE) of users is far from perfect e.g., videos that get stalled or that take a long time to load. Dissatisfied users may change Internet Service Providers (ISPs) or the online services. Hence, the incentives for measuring and improving QoE in home networks are high while mapping network and application QoS to QoE is a challenging problem. In this work we have focused in measuring several network Quality-of-Service (QoS) metrics, such as latency and bandwidth, both in residential Wi-Fi as well as broadband networks, homes are using for connecting to the Internet.

The WiFi Context. Residential Wi-Fi performance, however, is highly variable. Competing Wi-Fi networks can cause contention and interference while poor channel conditions between the station and the access point (AP) can cause frame losses and low bandwidth. In some cases, the home Wi-Fi network can bottleneck Internet access. While problems in the Wi-Fi network may affect several network QoS metrics, users will typically only notice a problem when poor Wi-Fi affects the QoE of Internet applications. For example, a Wi-Fi network with low bandwidth may go unnoticed unless the time to load Web pages increases significantly. A user observing degraded QoE due to Wi-Fi problems may mistakenly assume there is a problem with the Internet Service Provider (ISP) network. Our discussions with residential ISPs confirm that often customers call to complain about problems in the home Wi-Fi and not the ISP network.

Prior work has focused on QoS metrics for some applications (e.g., on-line video, Web browsing, or Skype) with no attempt to identify when Wi-Fi quality affects QoE. We are particularly interested in assisting ISPs to predict when home Wi-Fi quality degrades QoE. ISPs can use this system to detect customers experiencing poor QoE to proactively trigger Wi-Fi troubleshooting. ISPs often control the home AP, so we leverage Wi-Fi metrics that are available on commercial APs. Detecting when Wi-Fi quality degrades QoE using these metrics is challenging. First, we have no information about the applications customers are running at any given time. ISPs avoid capturing per-packet traffic traces from customers, because of privacy considerations and the overload of per-packet capture. Thus, we must estimate the effect of Wi-Fi quality on QoE of popular applications, which most customers are likely to run. In this context, we study Web as a proof of concept, as a large fraction of home traffic corresponds to Web. Second, application QoE may be degraded by factors other than the Wi-Fi quality (e.g., poor Internet performance or an overloaded server). Although a general system to explain any QoE degradation would be extremely helpful, our monitoring at the AP prevents us from having the end-to-end view necessary for such general task. Instead, we focus on identifying when Wi-Fi quality degrades QoE. Finally, Wi-Fi metrics available in APs are coarse aggregates such as the average PHY rate or the fraction of busy times. It is open how to effectively map these coarse metrics into QoE.

Predicting QoE. Clearly, different actors in the online service chain (e.g., video streaming services, ISPs) have different incentives and means to measure and affect the user QoE. Uncovering statistically equivalent subsets of QoS metrics across and within levels provides actionable knowledge for building QoE predictors. To achieve this goal, we leverage recent advances on feature selection algorithms to exploit available experimental evidence of the joint probability distributions of QoE/QoS metrics. This type of statistical reasoning will enable us to determine local causal relationships between a target QoE variable, seen as effect, and multiple QoS metrics across or within levels, seen as causes. Such data-driven analysis is justified by the multiplicity of dependencies that exist between network or application QoS metrics as different adaptation mechanisms (e.g., TCP congestion avoidance, HTTP bitrate adaptation) are activated at each level in real life. Building optimal predictors based on (eventually several) probabilistically minimal subsets of features opens the way for a principled comparison of the predictors.

4.4. Crowd-sourced Information Filtering and Summarization

With the explosion of the People-centric Web, there is a proliferation of crowd-sourced content either under the form of qualitative reviews (mainly textual) and quantitative ratings (as 5 star ratings) regarding diverse products or services or under the form of various "real-time" feedback events (e.g., re-tweets, replies, likes, clicks, etc.) on published web content (ranging from traditional news, TV series, and movies to specialized blogs and posts shared over social networks). Such content captures the wisdom of the crowd and is valuable information source for building collaborative filtering systems and text summarization tools coping with information overload. For example, they can assist users to pick the most interesting web pages (e.g. Delicious) or to choose which movie to watch next (e.g. Netflix).

Implicit Feedback in Communities of a Place. We are initially interested in addressing one of the main limitation of collaborative filtering systems namely, the strong user engagement required to provide the necessary input (e.g., regarding their friends, tags or sites of preference) which is usual platform specific (i.e., for a particular social network, tagging, or bookmark system). The lack of user engagement translates into cold start and data sparsity. To cope with this limitation, we are developing a system called WeBrowse that passively observes network traffic to extract user clicks (i.e., the URLs users visit) for group of people who live, study, or work in the same place. Examples of such communities of a place are: (i) the students of a campus, (ii) the people living in a neighbourhood or (iii) researchers working in the same site. WeBrowse then promotes the hottest and most popular content to the community members sharing common interests.

Personalized Review Summarization. Finally, we are interested in helping people to take informed decisions regarding their shopping or entertainment activities. The automated summarization of a review corpus (for example, movie reviews from Rotten Tomatoes or IMDB; or restaurant reviews from Yelp) aims to assist people to form an opinion regarding a product/service of interest, by producing a coherent summary that is helpful and can be easily assimilated by humans. We are working on review summarisation methods that

combine both objective (i.e., related to the review corpus) and subjective (i.e., related to the end-user interests) interestingness criteria of the produced reviews. In this respect we are exploiting domain models (e.g., Oscar's merit categories for movies) to elicit user preferences and mine the aspects of products/services actually commented in the textual sentences of reviews. For example, different summaries should be produced when a user is more interested in the actors' performance rather than the movie story. We are particularly interested in extracting automatically the signatures of aspects (based on a set of seed terms) and rank review sentences on their importance and relevance w.r.t. the aspects they comment. Last but not least we are optimizing the automatically constructed summary w.r.t. to a number of criteria such as the number of the length of included sentences from the original reviews, the polarity of sentiments in the described aspects, etc.

5. Highlights of the Year

5.1. Highlights of the Year

5.1.1. Awards

- R. Teixeira was selected to appear in the 2017 list of "N2Women: Stars in Computer Networking and Communications".
- The AppCivist project, which is a joint initiative between the Social Apps Lab at UC Berkeley and the MiMove team at Inria, won the 2016-17 Chancellor's Award for Public Service in the category of Campus-Community Partnership in collaboration with the City of Vallejo [20].

BEST PAPER AWARD:

[19]
R. ANGARITA, N. GEORGANTAS, V. ISSARNY. *USNB: Enabling Universal Online Social Interactions*, in "IEEE International Conference on Collaboration and Internet Computing", San Jose, United States, October 2017, https://hal.inria.fr/hal-01591757

6. New Software and Platforms

6.1. SoundCity - Ambiciti

KEYWORDS: Crowd-sensing - Mobile application
FUNCTIONAL DESCRIPTION: Is your exposure to noise too high on certain days? How is air pollution in your street? Will air quality improve in the next hours? Do you want to measure the noise pollution on the way between your home and your office? What pollution levels are considered harmful for your health? Ambiciti (previously SoundCity) provides answers to these questions and many others.

Noise pollution. Ambiciti (previously called SoundCity) measures the actual noise levels to which you are exposed. Ambiciti can monitor noise levels throughout the day and inform you about your instantaneous, hourly and daily exposures. If you want to contribute to the improvement of the noise map in your city, you can anonymously send your measurements.

Air pollution. Ambiciti computes the air quality index in your region or at the exact location where you stand. You can also access to forecasts and find information about the main pollutants. Depending on your location, you may have access to hourly air quality maps, at street resolution, in real time and for the next two days. Currently, only Paris (France) enjoys such fine maps, but other cities are on the way to be included.

Since 2017, the software is exclusively licensed to the Ambiciti start-up company.

- Authors: Fadwa Rebhi, Pierre-Guillaume Raverdy, Cong Kinh Nguyen, Rajiv Bhatia, Valérie Issarny and Vivien Mallet
- Partners: Ambientic - The Civic Engine
- Contact: Valérie Issarny

6.2. SocialBus

Universal Social Network Bus
KEYWORDS: Middleware - Interoperability - Social networks - Software Oriented Service (SOA)
FUNCTIONAL DESCRIPTION: Online social network services (OSNSs) have become an integral part of our daily lives. At the same time, the aggressive market competition has led to the emergence of multiple competing siloed OSNSs that cannot interoperate. As a consequence, people face the burden of creating and managing multiple OSNS accounts and learning how to use them, to stay connected. The goal of the Universal Social Network Bus (USNB) is to relieve users from such a burden, letting them use their favorite applications to communicate.

Social Entities. Social entities can be humans or systems. They can create a profile in the USNB and link it with their OSNSs identities. Social entities can also choose the OSNS identity they want to use when contacted through the USNB or specify one or more OSNS identities for message reception concerning specific events or senders.

Personae. Personae are USNB entities interacting with users within concrete OSNSs or systems, achieving interoperability between heterogeneous OSNSs. New personae can be developed, registered in the USNB, discovered and used to include additional OSNSs.

Privacy & Security. The USNB is designed to be as less intrusive as possible. It does not ask users their credentials nor any kind of authorization concerning their OSNS accounts.

- Authors: Rafael Angarita Arocha, Nikolaos Georgantas and Valérie Issarny
- Contact: Valérie Issarny
- URL: https://gitlab.inria.fr/usnb/universal-social-network-bus

6.3. WeBrowse

KEYWORDS: Web Usage Mining - Content analysis - Recommendation systems
FUNCTIONAL DESCRIPTION: The amount of information available on the web today, and the fast rate with which new information appears, overwhelm most users. The goal of our research is to assist Web users in discovering content. One of the most powerful means today to help people discover new web content is sharing between members of online communities. In the case of communities of a place (e.g., people who live, study, or work together) people share common interests, but often fail to actively share content. To address this problem, we have developed WeBrowse, a passive crowdsourced content discovery system for communities of a place.

WeBrowse leverages the passive observation of web-clicks (i.e., the URLs users intentionally visit) as an indication of users' interest in a piece of content. Intuitively, the more users click on a URL, the higher the interest in the content on the corresponding page. Our approach is then to leverage the collective clicks in a community to automatically discover relevant content to promote to users of the community.

To implement passive crowdsourcing, one must be in a position to observe the aggregated web-clicks of the community. Luckily, in many communities of a place, users will connect to the Internet from the same network, such as, e.g., the campus/enterprise network or the network of a residential Internet Service Provider (ISP) in a neighborhood. WeBrowse (i) observes web packets flowing through a network link, (ii) passively extracts HTTP logs (i.e., streams recording the headers of HTTP requests), and (iii) detects and decides on-the-fly the set of URLs to show to users.

- Contact: Renata Cruz Teixeira
- URL: https://team.inria.fr/muse/webrowse-info-page/

6.4. TA

TA - Traffic Analysis
KEYWORDS: Quality of Experience - Network monitoring - Video analysis

FUNCTIONAL DESCRIPTION: System running at the home getaway that analyzes traffic generated by DASH on-demand and live video streams. The system tracks traffic patterns to infer key video QoE metrics such as average bitrate and re-buffering events. Moreover, the system exploits novel algorithms that use probing techniques, i.e. lightweight pings and traceroutes, to detect possible congestion location.

- Participants: Francesco Bronzino and Renata Cruz Teixeira
- Contact: Francesco Bronzino

6.5. HostView

KEYWORDS: Quality of Experience - Network monitoring
FUNCTIONAL DESCRIPTION: End-host performance monitoring and user feedback reporting.

- Participants: Anna-Kaisa Pietilainen, Francesco Bronzino, George Rosca and Renata Cruz Teixeira
- Contact: Renata Cruz Teixeira
- URL: https://github.com/inria-muse/hostview-win

6.6. VSB

eVolution Service Bus
KEYWORDS: Service and Thing choreographies - Middleware protocol interoperability - Enterprise service bus
FUNCTIONAL DESCRIPTION: VSB is a development and runtime environment dedicated to complex distributed applications of the Future Internet. Such applications are open, dynamic choreographies of extremely heterogeneous services and Things, including lightweight embedded systems (e.g., sensors, actuators and networks of them), mobile systems (e.g., smartphone applications), and resource-rich IT systems (e.g., systems hosted on enterprise servers and Cloud infrastructures). VSB's objective is to seamlessly interconnect, inside choreographies, services and Things that employ heterogeneous interaction protocols at the middleware level, e.g., SOAP Web services, REST Web services, Things using CoAP. This is based on runtime conversions between such protocols, with respect to their primitives and data type systems, while properly mapping between their semantics. This also includes mapping between the public interfaces of services/Things, regarding their operations and data, from the viewpoint of the middleware: the latter means that operations and data are converted based on their middleware-level semantics, while their business semantics remains transparent to the conversion. VSB follows the well-known Enterprise Service Bus (ESB) paradigm. We propose a generic interface description, which we call GIDL, for application components that employ VSB. Based on GIDL, we enable automated synthesis of binding components for connecting heterogeneous services and Things onto VSB.

- Participants: Georgios Bouloukakis, Nikolaos Georgantas and Patient Ntumba
- Contact: Nikolaos Georgantas
- URL: https://github.com/sidutta/vsb

7. New Results

7.1. Living with Interpersonal Data: Observability and Accountability in the Age of Pervasive ICT

Participants: Murray Goulden (University of Nottingham), Peter Tolmie (University of Nottingham), Richard Mortier (University of Cambridge), Tom Lodge (University of Nottingham), Anna-Kaisa Pietilainen (Google), Renata Teixeira

The Internet of Things, alongside existing mobile digital technologies, herald a world in which pervasive sensing constantly captures data about us. Simultaneous with this technology programme are moves by policymakers to shore up the digital economy, through the legislating of new models of data management. These moves seek to give individuals control and oversight of their personal data. Within shared settings the consequences of these changes are the large-scale generation of interpersonal data, generated by and acting on the group rather than individual. We consider how such systems create new forms of observability and hence accountability amongst members of the home, and draw on the work of Simmel (1906) and Goffman (1971) to explore how these demands are managed. Such management mitigates the more extreme possibilities for domestic monitoring posited by these systems, yet without careful design there remains a considerable danger of unanticipated negative consequences.

7.2. Predicting the effect of home Wi-Fi quality on QoE

Participants: Diego da Hora (Telecom Paris Tech), Karel van Doorselaer (Technicolor), Koen van Oost (Technicolor), Renata Teixeira

Poor Wi-Fi quality can disrupt home users' internet experience, or the Quality of Experience (QoE). Detecting when Wi-Fi degrades QoE is extremely valuable for residential Internet Service Providers (ISPs) as home users often hold the ISP responsible whenever QoE degrades. Yet, ISPs have little visibility within the home to assist users. Our goal is to develop a system that runs on commodity access points (APs) to assist ISPs in detecting when Wi-Fi degrades QoE. Our first contribution is to develop a method to detect instances of poor QoE based on the passive observation of Wi-Fi quality metrics available in commodity APs (e.g., PHY rate). We use support vector regression to build predictors of QoE given Wi-Fi quality for popular internet applications. We then use K-means clustering to combine per-application predictors to identify regions of Wi-Fi quality where QoE is poor across applications. We call samples in these regions as poor QoE samples. Our second contribution is to apply our predictors to Wi-Fi metrics collected over one month from 3,479 APs of customers of a large residential ISP. Our results show that QoE is good on the vast majority of samples of the deployment, still we find 11.6% of poor QoE samples. Worse, approximately 21% of stations have more than 25% poor QoE samples. In some cases, we estimate that Wi-Fi quality causes poor QoE for many hours, though in most cases poor QoE events are short.

7.3. Narrowing the gap between QoS metrics and Web QoE using Above-the-fold metrics

Participants: Diego da Hora (Telecom Paris Tech), Alemnew Sheferaw Asrese (Aalto University), Vassilis Christophides, Renata Teixeira, Dario Rossi (Telecom Paris Tech)

Page load time (PLT) is still the most common application Quality of Service (QoS) metric to estimate the Quality of Experience (QoE) of Web users. Yet, recent literature abounds with proposals for alternative metrics (e.g., Above The Fold, SpeedIndex and variants) that aim at better estimating user QoE. The main purpose of this work is thus to thoroughly investigate a mapping between established and recently proposed objective metrics and user QoE. We obtain ground truth QoE via user experiments where we collect QoS metrics over 3,000 Web accesses annotated with explicit user ratings in a scale of 1 to 5, which we make available to the community. In particular, we contrast domain expert models (such as ITU-T and IQX) fed with a single QoS metric, to models trained using our ground-truth dataset over multiple QoS metrics as features. Results of our experiments show that, albeit very simple, ex- pert models have a comparable accuracy to machine learning approaches. Furthermore, the model accuracy improves considerably when building per-page QoE models, which may raise scalability concerns as we discuss.

7.4. Performance Modeling of the Middleware Overlay Infrastructure of Mobile Things

Participants: Georgios Bouloukakis, Nikolaos Georgantas, Valérie Issarny.

Internet of Things (IoT) applications consist of diverse Things (sensors and devices) in terms of hardware resources. Furthermore, such applications are characterized by the Things' mobility and multiple interaction types, such as synchronous, asynchronous, and streaming. Middleware IoT protocols consider the above limitations and support the development of effective applications by providing several Quality of Service features. These features aim to enable application developers to tune an application by switching different levels of response times and delivery success rates. However, the profusion of the developed IoT protocols and the intermittent connectivity of mobile Things, result to a non-trivial application tuning. In this work, we model the performance of the middleware overlay infrastructure using Queueing Network Models. To represent the mobile Thing's connections/disconnections, we model and solve analytically an ON/OFF queueing center. We apply our approach to streaming interactions with mobile peers. Finally, we validate our model using simulations. The deviations between the performance results foreseen by the analytical model and the ones provided by the simulator are shown to be less than 5%.

7.5. USNB: Enabling Universal Online Social Interactions

Participants: Rafael Angarita, Nikolaos Georgantas, Valérie Issarny.

Online social network services (OSNSs) have become an integral part of our daily lives. At the same time, the aggressive market competition has led to the emergence of multiple competing siloed OSNSs that cannot interoperate. As a consequence, people face the burden of creating and managing multiple OSNS accounts and learning how to use them to stay connected. This work is concerned with relieving users from such a burden by enabling universal online social interactions. The contributions of this work span: (1) a model of the universal social network bus (USNB) for OSNS interoperability; (2) a prototype for universal online social interactions that builds upon the proposed model; and (3) a preliminary experimental evaluation involving 50 participants. Results show that people are positive about the solution as they are able to reach out a larger community of users independently of the OSNSs they use.

7.6. Opportunistic Multiparty Calibration for Robust Participatory Sensing

Participants: Françoise Sailhan, Valérie Issarny, Otto Tavares Nascimento.

While bringing massive-scale sensing at low cost, mobile participatory sensing is challenged by the low accuracy of the sensors embedded in and/or connected to the smartphones. The mobile measurements that are collected need to be corrected so as to accurately match the phenomena being observed. This paper addresses this challenge by introducing a multi-hop, multiparty calibration method that operates in the background in an automated way. Using our method, sensors that are within a relevant sensing (and communication) range coordinate so that the observations of the participating (previously) calibrated sensors serve calibrating the other participants. As a result, our method is particularly well suited for participatory sensing within crowd meetings, as as for instance within public spaces. Our solution leverages multivariate linear regression, together with robust regression so as to discard the measurements that are of too low quality for being meaningful. To the best of our knowledge, we are the first to introduce a multiparty calibration algorithm, while previous work in the area focused on pairwise calibration. This work further introduces a supporting prototype implemented over Android, and related experiment in the context of noise sensing. We show that the proposed multiparty calibration system enhances the accuracy of the mobile noise sensing application.

7.7. Extracting usage patterns of home IoT devices

Participants: Vassilis Christophides, Gevorg Poghosyan (Insight Centre for Data Analytics), Ioannis Pefkianakis (Hewlett Packard Labs), Pascal Le Guyadec (Technicolor)

We have initially investigated how data analytics for Machine-to-Machine (M2M) data (connectivity, performance, usage) produced by connected devices in residential Intranet of Things, could support novel *home automation services* that enrich the living experience in smart homes. We have investigated new data mining techniques that go beyond binary association rule mining for traditional market basket analysis, considered by previous works. We design a multidimensional pattern mining framework, which collects raw data from operational home gateways, it discretizes and annotates the raw data, it produces traffic usage logs which are fed in a multidimensional association rule miner, and finally it extracts home residents' habits. Using our analysis engine, we extract complex device co-usage patterns of 201 residential broadband users of an ISP, subscribed to a n-play service. Such fine-grained device usage patterns provide valuable insights for emerging use cases, such as adaptive usage of home devices (aka horizontal integration of things). Such use cases fall within the wider area of human-cognizant Machine-to-Machine communication aiming to predict user needs and complete tasks without users initiating the action or interfering with the service. While this is not a new concept, according to Gartner cognizant computing is a natural evolution of a world driven not by devices but collections of applications and services that span across multiple devices, in which human intervention becomes as little as possible, by analyzing past human habits. To realize this vision, we are interested in co-usage patterns featuring spatio-temporal information regarding the context under which devices have been actually used in homes. For example, a network extender which is currently turned off, could be turned on at a certain day period (e.g., evening) when it has been observed to be highly used along with other devices (e.g., a laptop or a tablet). Alternatively, the identification of frequent co-usage of particular devices at a home (say iPhone with media player), could be used by a things' recommender to advertise the same set of devices at another home (say another iPhone user could be interested in a media player).

8. Bilateral Contracts and Grants with Industry

8.1. Bilateral Grants with Industry

"Monitoring and diagnosis of Internet QoE", Google Faculty Award to R. Teixeira (Inria) and D. Choffnes (Northeastern University), 2017.

9. Partnerships and Cooperations

9.1. National Initiatives

"BottleNet: Understanding and Diagnosing End-to-end Communication Bottlenecks of the Internet", project funded by the French research agency (ANR), from Feb 2016 to Sep 2020.

9.1.1. Inria Support

9.1.1.1. Inria IPL CityLab@Inria

Participants: Valérie Issarny [correspondent], Fadwa Rebhi.

- **Name:** CityLab@Inria – *Overcoming the Smart City Challenge – Toward Environmental and Social Sustainability*
- **Period:** [January 2014 – November 2018]
- **Inria teams:** CLIME/ANGE, DICE, FUN, MIMOVE, MYRIADS, SMIS, URBANET, WILLOW
- **URL:** http://citylab.inria.fr

The Inria Project Lab (IPL) CityLab@Inria studies ICT solutions toward smart cities that promote both social and environmental sustainability. A strong emphasis of the Lab is on the undertaking of a multi-disciplinary research program through the integration of relevant scientific and technology studies, from sensing up to analytics and advanced applications, so as to actually enact the foreseen smart city Systems of Systems. Obviously, running experiments is a central concern of the Lab, so that we are able to confront proposed approaches to actual settings.

9.1.1.2. Inria IPL BetterNet

Participants: Renata Teixeira, Vassilis Christophides, Francesco Bronzino.

- **Name:** BetterNet – *An observatory to measure and improve Internet service access from user experience*
- **Period:** [2016 – 2019]
- **Inria teams:** Diana, Dionysos, Inria Chile, Madynes, MiMove, Spirals
- **URL:** https://project.inria.fr/betternet/

BetterNet aims at building and delivering a scientific and technical collaborative observatory to measure and improve the Internet service access as perceived by users. In this Inria Project Lab, we will propose new original user-centered measurement methods, which will associate social sciences to better understand Internet usage and the quality of services and networks. Our observatory can be defined as a vantage point, where:

1. tools, models and algorithms/heuristics will be provided to collect data,
2. acquired data will be analyzed, and shared appropriately with scientists, stakeholders and civil society,
3. and new value-added services will be proposed to end-users.

9.1.1.3. Inria ADT MOSQUITO

Participants: Renata Teixeira, Francesco Bronzino, Romain Rouvoy.

- **Name:** MOSQUITO – *A mobile platform to measure the quality of Internet connectivity*
- **Period:** [November 2016 – October 2018]
- **Partners:** Inria MiMove, Inria SPIRALS.

The ADT MOSQUITO is part of the Inria Project Lab (IPL) initiative BetterNet. This ADT project focuses on the design and the development of a measurement platform for the quality of mobile Internet access by federating the existing mobile platforms identified in the BetterNet IPL. Beyond the priceless value of such a measurement platform for the research community, this ADT also aims to publish live reports on the quality of mobile Internet access through the BetterNet initiative.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

9.2.1.1. H2020 ICT CHOReVOLUTION

Participants: Nikolaos Georgantas [correspondent], Valérie Issarny [correspondent].

Name: CHOReVOLUTION – *Automated Synthesis of Dynamic and Secured Choreographies for the Future Internet*

URL: http://www.chorevolution.eu

Type: Research & Innovation Action (ICT)

Topic: Tools and Methods for Software Development

Period: [January 2015 - December 2017]

Partners: CEFRIEL (Italy), Inria MiMove, OW2 Consortium (France), Thales Communications S.A. (France) [**coordinator**], Università degli Studi dell'Aquila (Italy) [**scientific leader**], Softeco Sismat SrL (Italy), Tirasa (Italy), Viktoria Swedish ICT (Sweden).

The Future Internet (FI) represents an age of unprecedented opportunities for social, economic, and business growth thanks to the global scale connectivity of the virtual as well as of the physical world. This indeed opens up a wealth of innovative and revolutionary real-life scenarios, as for instance illustrated by the smarter cities perspectives where envisioned scenarios significantly ease daily human activities and give support for the growth of new markets and employment opportunities. However, leveraging the FI for the development of innovative software applications remain a challenging task even though major enablers are readily available by ways of service-oriented and cloud computing. It is in particular our vision that enabling the choreography of FI services shall play a significant role in the provisioning of innovative applications. However, existing choreography-based service composition approaches are rather static and are poorly suited to the need of the FI that is a highly dynamic networking environment, further bringing together highly heterogeneous services ranging from Thing- to Business-based services that span different security domains. As a result, the technology is not mature enough for market take-up. CHOReVOLUTION elevates the Readiness Level of existing choreography technologies in order to drop the dynamism and cross-organization security barriers via the automated synthesis of dynamic and secured choreographies in the FI. To meet its objectives, CHOReVOLUTION undertakes both research and innovation tasks. The former concentrates on choreography modelling, synthesis, adaptation, service bus, security, and cloud; the latter focus on industrial validation, development support and integration platform, and the establishment of a CHOReVOLUTION community and market take- up. Last but not least CHOReVOLUTION outcomes are assessed by experimenting with new applications in the field of Intelligent Transportation Systems.

9.2.1.2. H2020 ICT FIESTA-IoT

Participants: Valérie Issarny [correspondent], Nikolaos Georgantas [correspondent].

Name: FIESTA-IoT – *Federated Interoperable Semantic IoT/cloud Testbeds and Applications*

URL: http://fiesta-iot.eu

Type: Research & Innovation Action (ICT)

Topic: FIRE+ (Future Internet Research & Experimentation)

Period: [February 2015 - January 2018]

Partners: Fraunhofer FOKUS (Germany) [**coordinator**], INSIGHT @ National University of Galway (Ireland) [**co-coordinator**], University of Southampton IT Innovation Centre (UK), Inria MiMove, University of Surrey (UK), Unparallel Innovation Lda (Portugal), Easy Global Market (France), NEC Europe Ltd (UK), University of Cantabria (Spain), Com4innov (France), Athens Information Technology (Greece), SOCIEDAD PARA EL DESARROLLO REGIONAL DE CANTABRIA (Spain), Ayuntamiento de Santander (Spain), Korea Electronics Technology Institute (Korea).

Despite the proliferation of IoT and smart cities testbeds, there is still no easy way to conduct large scale experiments that leverage data and resources from multiple geographically and administratively distributed IoT platforms. Recent advances in IoT semantic interoperability provide a sound basis for implementing novel cloud-based infrastructures that could allow testbed-agnostic access to IoT data and resources. FIESTA will open new horizons in IoT experimentation at a global scale, based on the interconnection and interoperability of diverse IoT testbeds. FIESTA will produce a first-of-a-kind blueprint experimental infrastructure (tools, techniques and best practices) enabling testbed operators to interconnect their facilities in an interoperable way, while at the same time facilitating researchers in deploying integrated experiments, which seamlessly transcend the boundaries of multiple IoT platforms. FIESTA will be validated and evaluated based on the interconnection of four testbeds (in Spain, UK, France and Korea), as well as based on the execution of novel experiments in the areas of mobile crowd-sensing, IoT applications portability, and dynamic intelligent discovery of IoT resources. In order to achieve global outreach and maximum impact, FIESTA will integrate an additional testbed and experiments from Korea, while it will also collaborate with IoT experts from USA. The participation of a Korean partner (based its own funding) will maximize FIESTA's value for EC money. Moreover, the project will take advantage of open calls processes towards attracting third-parties that will engage in the integration of their platforms within FIESTA or in the conduction of added-value experiments.

As part of its sustainability strategy, FIESTA will establish a global market confidence programme for IoT interoperability, which will enable innovative platform providers and solution integrators to ensure/certify the openness and interoperability of their developments.

9.2.2. Collaborations in European Programs, Except FP7 & H2020

9.2.2.1. EIT Digital Env&You

Participant: Valérie Issarny [correspondent].

> **Name:** Env&You – *Personalizing environmental science for your home, your neighborhood and your life*
>
> **URL:** http://ambiciti.io
>
> **Period:** [January 2017 - December 2017]
>
> **Partners:** Ambiciti (F), Forum Virium Helsinki (FI), Inria CLIME/ANGE, Inria MIMOVE [**coordinator**], NumTech (F), TheCivicEngine (USA).

There is a clear, and probably increasing, desire from the citizens to better know their individual exposure to pollution. Partial solutions exist to the exposure data problem but each focuses on one or another domain of information – crowdsourcing exposure, translating government open data to usable consumer information, harnessing social media information, harnessing biometrics – what is unique about Env&You is that we assimilate a multi-dimensional picture of exposure and provide the integrated information to citizen, government, and business use (spanning: B2G, B2B and B2C business cases).

9.2.2.2. EIT Digital CivicBudget

Participants: Valérie Issarny [correspondent], Nikolaos Georgantas [correspondent].

> **Name:** CivicBudget – *Software platform supporting Internet-based participatory budgeting campaigns*
>
> **Period:** [January 2017 - December 2017]
>
> **Partners:** CITRIS@UCB (USA), Inria MIMOVE, MissionsPubliques (F) [**coordinator**], Nexus (DE), and TU Berlin (DE).

Many cities in Europe and the U.S.A, and around the world, commit a percentage of their annual budget (often 5%) to implement citizen-proposed projects through a process called Participatory Budgeting (PB). However, supporting urban-scale participatory budgeting campaigns is greatly challenged as it still principally relies on physical meetings. CivicBudget addresses this challenge by leveraging latest ICT so as to promote urban-scale inclusion. CivicBudget fosters a new and inclusive urban public sphere of citizenship. It is especially designed for community groups and activists who want to participate in the PB process. City governments will also be able to promote its use. CivicBudget will facilitate the mobilization of residents both to promote their proposals and to monitor their progress through the PB process to implementation.

9.3. International Initiatives

9.3.1. Inria International Labs

Valérie Issarny acts as scientific manager of the Inria@Silicon Valley program (https://project.inria.fr/inria-siliconvalley/) since summer 2013; she is visiting scholar at the EECS Department of University of California, Berkeley, and hosted by CITRIS.

9.3.2. Inria Associate Teams Not Involved in an Inria International Lab

9.3.2.1. HOMENET

Title: *Home network diagnosis and security*

International Partner: Princeton (United States) - Nick Feamster

Start year: 2017

Website: https://team.inria.fr/homenet/

Modern households connect a multitude of networked devices (ranging from laptops and smartphones to a number of Internet of Things devices) via a home network. Most home networks, however, do not have a technically skilled network administrator for managing the network, for example to identify faulty equipment or take steps to secure end hosts such as applying security patches. Home networks represent a particularly challenging environment due to the diversity of devices, applications, and services users may connect. The goal of HOMENET is to assist users in diagnosing and securing their home networks. Our approach is based on developing new algorithms and mechanisms that will run on the home router (or in-collaboration with the router). The router connects the home network to the rest of the Internet; it is hence the ideal place to secure home devices and to distinguish problems that happen in the home from those happening elsewhere. We will address a number of research challenges for example in device discovery and fingerprinting, anomaly detection in the Internet of Things, home network diagnosis (including wireless diagnosis). HOMENET will bring together two leading research teams in the network measurement arena with successful prior collaboration. Moreover, Princeton brings an existing home router platform and expertise in security, wireless, and software-defined networks; and MiMove brings an existing Web-based measurement platform, and expertise in traffic-based profiling and anomaly detection.

9.3.2.2. ACHOR

Participant: Nikolaos Georgantas [correspondent].

Title: *Adaptive enactment of service choreographies*

International Partner: Universidade Federal de Goiás (UFG), Brazil - Fabio Costa

Start year: 2016

Website: http://www.inf.ufg.br/projects/achor

Service choreographies are distributed compositions of services (e.g., Web services) that coordinate their execution and interactions without centralized control. Due to this decentralized coordination and the ability to compose third-party services, choreographies have shown great potential as an approach to automate the construction of large-scale, on-demand, distributed applications. Technologies to enable this approach are reaching maturity level, such as modeling languages for choreography specification and engines that operate the deployment of services and enactment of choreographies at Future Internet scales. Nevertheless, a number of problems remain open on the way to fully realize the approach, among them: (i) Deployment of multiple choreographies on top of a collection of shared services (considering service sharing as an effective way to increase the utilization of resources); (ii) Dynamic adaptation of functional and non-functional properties due to runtime changes in the environment and user requirements (adapting the set of services and/or the resources used to run the services in order to add/remove/change functions and maintain QoS properties, respectively); and (iii) Seamless and dynamic integration of mobile services (e.g., smartphone apps, sensors and actuators on handhelds and wearables) and cloud- based services (including the need to consider: mobility of both devices and services, resource constraints of mobile devices, temporary disconnection, interoperability between different interaction paradigms (message-passing, event-based, data-sharing) at the middleware layer, and effect of these paradigms on end-to-end QoS). The overall goal of the project is to design an architecture for adaptive middleware to support service choreographies in large-scale scenarios that involve dynamicity and diversity in terms of application requirements, service interaction protocols, and the use of shared local, mobile and cloud resources.

9.3.3. Inria International Partners

9.3.3.1. Informal International Partners

Northeastern University (Prof. David Choffnes and his student Arash Molavi): we are working on monitoring and diagnosing Internet QoE.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

9.4.1.1. Internships

Kushagra Singh (from Jun 2017 until Jul 2017)

Internship funded by H2020 CHOReVOLUTION project.

Subject: *Towards correction of outliers in spatial dataset*

Institution: Indraprastha Institute of Information Technology (IIIT) Delhi (India)

9.4.2. Visits to International Teams

9.4.2.1. Research Stays Abroad

- Valérie Issarny is visiting scholar at the EECS Department at UC Berkeley; she is hosted by CITRIS in the context of which she carries out collaborative research in the area of smart cities and acts as scientific coordinator of the Inria@SiliconValley program.
- Rachit Agarwal was visiting professor at Fundacao Getulio Vargas (FGV), Rio De Janerio, Brazil (from Jun 2017 until Aug 2017). He was hosted at EMAp (Escola de Matematica Aplicada) department within FGV. He taught a Network Science course to Master's students.

10. Dissemination

10.1. Promoting Scientific Activities

10.1.1. Scientific Events Organisation

10.1.1.1. General Chair, Scientific Chair

Valérie Issarny is co-chair of the BIS'17 workshop, which is the yearly workshop organized by Inria@SiliconValley to present the state of scientific collaborations and to work on proposals for future ambitious joint projects.

10.1.2. Scientific Events Selection

10.1.2.1. Chair of Conference Program Committees

- Valérie Issarny is PC co-chair of ICSE-SEIS'2018 - The Software Engineering in Society Track of the ICSE'18 conference.
- R. Teixeira, Co-chair of the program committee of ACM IMC 2017.
- R. Teixeira, Co-chair of the program committee of ACM/ISOC ANRW 2017.

10.1.2.2. Member of the Conference Program Committees

- R. Teixeira, PC member of 2017 ACM SIGCOMM conference.
- Vassilis Christophides, PC member of 34th IEEE International Conference on Data Engineering.
- Vassilis Christophides, PC member of 2nd IFIP/IEEE International Workshop on Analytics for Network and Service Management (AnNet 2017)
- Nikolaos Georgantas is PC member of the following international conferences: FiCloud'17, ICSE'17 Poster Track, SAC'17 &'18, WETICE'17, AmI'17, SOSE'17&'18

- Nikolaos Georgantas is PC member of the following international workshops: CASA'17, MRT'17, SERENE'17, IoT-ASAP'17.
- Valérie Issarny is PC member of the following International Conferences: AIMS'17 & 18, EUROSYS'17, FASE'17 & 18, ICDCS'18, ICSE-SEIS'17, ICSE'18, ISEC'17, SEAMS'17.
- Valérie Issarny is PC member of the following international workshops: AMS'18, InterIoT'17.
- R. Agarwal, PC member of 10th International Conference of Contemporary Computing.

10.1.3. Journal

10.1.3.1. Member of the Editorial Boards

- Nikolaos Georgantas is associate editor of the International Journal of Ambient Computing and Intelligence (IJACI);
- Valérie Issarny is associate editor of the IEEE transactions on Software Engineering.
- Valérie Issarny is associate editor of the IEEE Transactions on Services Computing.
- Valérie Issarny is associate editor of the Springer JISA Journal of Internet Services and Applications.

10.1.4. Invited Talks

- R. Teixeira, invited talk at Politecnico di Torino, "Home network QoE diagnosis", October 2017.
- R. Teixeira, jounées scientifiques Inria, "Home network QoE diagnosis", June 2017.
- R. Teixeira, LINCS workshop, "WeBrowse: a passive crowdsourced content discovery platform for communities of a place", June 2017.
- R. Teixeira, keynote speaker at the Simpósio Brasileiro de Redes de Computadores (Brazilian networking conference), "Home network QoE diagnosis", May 2017.
- R. Teixeira, tutorial at the Simpósio Brasileiro de Redes de Computadores (Brazilian networking conference), "Internet Measurements: Bandwidth", May 2017.
- R. Teixeira, tutorial at the Simpósio Brasileiro de Redes de Computadores (Brazilian networking conference), "Internet Traffic Measurements", May 2017.
- R. Agarwal: "Extracting mobility information from CDRs and using it towards achieving enhanced dissemination in wireless networks", EMAp FGV seminar, 3 August 2017, Rio De Janerio, Brazil.
- Vassilis Christophides, "Web-scale Blocking, Iterative and Progressive Entity Resolution", with K. Stefanidis, V. Efthymiou ICDE 2017.
- Vassilis Christophides, "Web-scale Entity Resolution", Invited lecture at the 3rd EGC Winter School (Ecole EGC), 23 & 24 January 2017, Grenoble, France.
- Nikolaos Georgantas, "Enabling emergent mobile systems in the IoT: Functional and QoS interoperability aspects at the middleware layer", Invited keynote talk at MSPN'17 (International Conference on Mobile, Secure and Programmable Networking), June 2017.

10.1.5. Leadership within the Scientific Community

- V. Issarny, Council member, ACM Europe (since July 2017).
- R. Teixeira, Vice-chair of ACM SIGCOMM (July 2013 – June 2017).
- R. Teixeira, Chair of the ACM SIGCOMM Industrial Liaison Board (October 2013 – June 2017).
- V. Christophides, Member of the EDBT Association (since 2014).

10.1.6. Scientific Expertise

- R. Teixeira, Reviewer of H2020 projects: CogNet, SUPERFLUIDITY, MONROE, MAMI.
- R. Teixeira, Technical advisory board of the project "Mapping of Broadband Services in Europe".
- Valérie Issarny is elected member of the *Commission d'Evaluation Inria*.
- Valérie Issarny is member of the Inria DR2 (Research Director position) selection committee.

10.1.7. Research Administration

- Valérie Issarny is scientific coordinator of Inria@Silicon Valley and CityLab@Inria;
- Nikolaos Georgantas is member of the PhD monitoring committee at Inria Paris.

10.2. Teaching - Supervision - Juries

10.2.1. Teaching

Master : R. Teixeira, "Methodology for research in networking", 10h eqTD, M2, UPMC, France

Master : R. Teixeira, "Network Metrology", 22h CM, M2, UPMC, France

Master: Rachit Agarwal, "Network Science", semester course at Fundacao Getulio Vargas (FGV), Rio De Janerio, Brazil

Master: Rachit Agarwal, "Urban data democratization and its application to access urban concepts" as part of "Gestion de données ambiantes et internet des objets", 9 hours eqTD, Niveau M2, UVSQ, France

E-learning

Valérie Issarny, MOOC *Villes intelligentes : défis technologiques et sociétaux* , 5 weeks, 4,085 registered students in the session of March 2017.

E-learning

Mooc : R. Teixeira, "Internet Measurements: a Hands-on Introduction", 5 weeks in FUN platform, 1,204 registered students.

10.2.2. Supervision

PhD : Diego da Hora, "Predicting Home Wi-Fi QoE from Passive Measurements on Commodity Access Points", UPMC, 27/04/2017, R. Teixeira and K. van Doorselaer.

PhD: Georgios Bouloukakis, "Enabling Emergent Mobile Systems in the IoT: from Middleware-layer Communication Interoperability to Associated QoS Analysis", UPMC, 01/08/2017, Nikolaos Georgantas and Valérie Issarny.

PhD: Amel Belaggoun, "Adaptabilité et reconfiguration des systèmes temps-réel embarquées", UPMC, 10/10/2017, Valérie Issarny and Ansgar Radermacher (CEA-LISE).

PhD: Vassilis Efthimiou, "Entity resolution in the Web of Data", University of Crete, 27/09/2017, V. Christophides.

PhD in progress: F. Dilmi, "End-to-end monitoring and diagnosis of video Quality of Experience", October 2017, R. Teixeira.

PhD in progress: S. Wassermann, "Passive analysis and opitimization of Internet Quality of Experience", October 2017, R. Teixeira.

PhD in progress: S. El Aouad, "Building a personalized summary from movie reviews", May 2013, V. Christophides, R. Teixeira, P. Perez.

PhD in progress : Radha Pallavali, "Dynamic adaptation of middleware-layer protocols for emergent mobile systems", UPMC, November 2016, Nikolaos Georgantas and Valérie Issarny.

PhD in progress: Yifan Du, "In-network collaborative crowd-Xing", UPMC, October 2017, Valérie Issarny and Françoise Sailhan.

10.2.3. Juries

Nikolaos Georgantas was examiner for the PhD thesis of Adrien Carteron, *Une approche événementielle pour le développement de services multi-métiers dédiés à l'assistance domiciliaire*, defended in December 2017, Université de Bordeaux, France, advised by Charles Consel and Nic Volanschi.

Valerie Issarny was examiner for the HDR of Sonia Ben Mokhtar, *Contributions To Building Reliable Distributed Systems*, defended in December 2017, INSA Lyon, France.

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[3] B. BILLET, V. ISSARNY. *Spinel: An Opportunistic Proxy for Connecting Sensors to the Internet of Things*, in "ACM Transactions on Internet Technology", March 2017, vol. 17, n° 2, pp. 1 - 21 [*DOI :* 10.1145/3041025], https://hal.inria.fr/hal-01505879

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[12] D. DA HORA. *Predicting Home Wi-Fi QoE from Passive Measurements on Commodity Access Points*, Université Paris 6 (UPMC), April 2017, https://hal.inria.fr/tel-01670997

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[19] *Best Paper*
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