**DOSSIER DE CANDIDATURE –Packages**

## Appel à projets Packages -2013-2014 – DOSSIER A REMPLIR PAR LE CANDIDAT

**Nom du candidat :** Hassan Aït-Kaci

**Intitulé du projet :**

*LivEMUSIC*—*Liv*ing-*E*nvironment *M*onitoring *U*se *S*cenarios with *I*ntelligent *C*ontrol

**Etablissement porteur de la candidature :** Université Claude Bernard Lyon 1

**Laboratoire d'Accueil :** Laboratoire d'InfoRmatique en Image et Systèmes d'information (LIRIS)

***Les engagements du candidat***

- *Reporting*
- *Obligation de communication*
- *Valorisation des travaux de recherche assurée par le service valorisation de l'Université de Lyon*

## 1)-CV du candidat

*(CV restreint de 3 pages avec les quatre publications les plus significatives sur les six dernières années et les dix publications les plus significatives de la carrière)*

Hassan Aït-Kaci holds a PhD in Computer Science from the University of Pennsylvania (1984), and a Research Director Habilitation from University of Paris 7 (1990). He is holding an ANR Chair of Excellence in Intelligent Systems at the Université Claude Bernard Lyon 1 on "Constraint Event-Driven Automated Reasoning" (the CEDAR Project). Dr. Aït-Kaci's research contribution has been in automated reasoning, knowledge representation, declarative programming, and language processing. In these areas, he has been a fervent advocate of ***constraint-based computing*** as the versatile key to essential locks that all these subjects have in common, and that we are facing in the pursuit of making the Semantic Web an intelligent reality.

### EXPERIENCE

Since January 2013, Hassan Aït-Kaci occupies an ANR Chair of Excellence in Intelligent Systems at the Université Claude Bernard Lyon 1. Until December 2012, he was a Senior Member of Technical Staff at IBM Canada Ltd. since IBM's acquisition of ILOG, the French INRIA spin-off that made its business success and fame in the technology of constraint-processing and Business Rules (BR). He had joined ILOG in 2000, as a Distinguished Scientist, originally on leave from Simon Fraser University (SFU), where he was senior NSERC[1] Research Chair in Intelligent Systems, a tenured full professor in the SFU School of Computing Science since 1994. Before that, he was Project Leader at Digital Equipment's Paris Research Lab, where he led the Paradise project developing the OSF-constraint programming language LIFE.[2] Before joining Digital in 1989, he was a member of technical staff at the Microelectronics and Computer technology Corporation (MCC), in Austin, TX (USA), in Bob Boyer's Intelligent Architecture group, part

[1] Natural Sciences and Engineering Research Council of Canada.

[2] LIFE stands for "Logic, Inheritance, Functions, Equations," the essential paradigms underlying its design and implementation.

of MCC's AI Program headed by the late Woody Bledsoe. There, he headed a research team that designed and prototyped the original version of LIFE.

For the past three decades, Hassan has pioneered the use of Order-Sorted Featured (OSF) constraints in KR, field traditionally using logical or graphical formalisms. His motivation is that most, if not all, KR formalisms developed in AI have been variations on labeled-graph notations taking meaning in some logic interpretation. However, with the advent of the Semantic Web, there has been a growing tension between proposed standard formal notations describing knowledge, on one hand, and the proof theory for these notations on the other hand. While formal notation to express knowledge has been striving for simplicity, this is usually offset by the algorithmic complexity and implementation of reasoning using this notation (syntax-directed semantics). Even when this tension is somehow resolved through clever techniques, these do not scale up to very large KBs. Indeed, the main challenge faced by any KR system today, whatever its formal basis may be, is managing effective reasoning over KBs of enormous size distributed over all sorts of networks and repositories. While classical DB technology has been useful for many parts, there are important differences between the essential natures of the two worlds (data *vs.* knowledge) to warrant a new approach tailored to the idiosyncrasies of Knowledge Base management. This is essentially what Hassan's research has contributed to: reconciling the most intuitive and popular representations of knowledge (*i.e.* , labeled graphs) with formal semantics including efficient and scalable proof methods based on graph-constraint normalization. This proposal's essential objective is to put this claim to the test.

## NOTABLE RECENT LECTURES

- "Is It Possible to Make the Semantic Web a Reality?" Invited keynote speaker, *3rd International Workshop on Web Services and Formal Methods (INTIS 2013)*, November 29–30, 2013, Tangier, Morocco.
- "Reasoning and the Semantic Web" Invited panel member in the Ontolog Forum's panel on Ontology, Rules, and Logic Programming for Reasoning and Applications *(RulesReasoningLP) mini-series of virtual panel sessions - Nov. 21, 2013*).
- "Rule-based Computing in Industry—Concepts, Issues, and Perspectives" Invited keynote speaker, *8th International Workshop on Web Services and Formal Methods (WS-FM'11)*, September 1–2, 2011, Clermont-Ferrand, France.
- "A Sorted-Graph Unification Approach to the SemanticWeb" Invited keynote speaker, *IEEE/WIC/ACM International Conferences on Web Intelligence and Intelligent Agent Technology, Web Intelligence (WI-IAT 2011)*, 22–27 August 2011, Lyon, France

## NOTABLE RECENT COMPLETED PROJECT DELIVERABLES

- "*Complexity and Optimization of Combinations of Rules and Ontologies*" M24 Deliverable D3.3, (coordinated by Cristina Feier, with contributions from Hassan Aït-Kaci, Jürgen Angele, Jos de Bruijn, Hugues Citeau, Thomas Eiter, Adil El Ghali, Volha Kerhet, Eva Kiss, Roman Korf, Thomas Krekeler, Thomas Krennwallner, Stijn Heymans, Alessandro Mosca, Martín Rezk, Guohui Xiao), ONTORULE Project Technical Report, 2010.
- "*Initial Combinations of Rules and Ontologies*" M12 Deliverable D3.2, (coordinated by Stijn Heymans with contributions from Jos de Bruijn, Martín Rezk, Hassan Aït-Kaci, Hugues Citeau, Roman Korf, Jörg Pührer, Cristina Feier, and Thomas Eiter) , ONTORULE Project Technical Report, 2009.
- "*Processing of initial combinations of rules and ontologies*" M12 Deliverable D3.5, ONTORULE Project Technical Report IST-2009-231875, (author/coordinator Hassan Aït-Kaci, with contributions from Hugues Citeau and Roman Korf), 2009.

## NOTABLE PUBLICATIONS

- "An Abstract, Reusable, and Extensible Programming Language Design Architecture" in: *Essays dedicated to Peter Buneman—In Search of Elegance in the Theory and Practice of Computation (Edinburgh,UK)*, Val Tannen, Limsoon Wong, Leonid Libkin, Wenfei Fan, Wang-Chiew Tan, and Michael Fourman (Eds.), Lecture Notes in Computer Science Volume 8000, pp. 112–166. October 27–28, 2013.
- "Proceedings of the RuleML2012@ECAI Challenge" *6th International Symposiumon Rules (Montpellier, France)*, co-edited by Hassan Aït-Kaci, Yuh-Jong Hu, Grzegorz J. Nalepa, Monica Palmirani, and Dumitru Roman, August 27–29, 2012.
- "Life Su Doku" in *Proceedings of the 2nd Tunisia–Japan Workshop on Symbolic Computation in Software Science (SCSS 2009)*,12 Gammarth, Tunisia, September 2009.
- "Children's Magic Won't Deliver the SemanticWeb" *Communications of the ACM*, Vol. 52, no. 3, pp. 8–9, March 2009.

- "Data models as constraint systems: A key to the semantic web" *Constraint Programming Letters*, vol. 1, pp. 33–88, November 2007.
- "Description Logic vs. Order-Sorted Feature Logic" *Proceedings of the 20th Workshop on Description Logics (Brixen-Bressanone, Italy)*, June 2007.
- "SatisfiabilityModulo Structures as Constraint Satisfaction: an Introduction" (with Bruno Berstel, Ulrich Junker, Michel Leconte, and Andreas Podelski), *Actes des Journées Francophones sur les Langages Applicatifs (Aix-les-Bains, France)*, January 2007, pp. 2–8.
- "An Axiomatic Approach to Feature Term Generalization" (with Yutaka Sasaki), Proceedings of the European Conference on Machine Learning, Freiburg, Germany, September 2001.
- "Order-Sorted Feature Theory Unification" (with Andreas Podelski and Seth Copen Goldstein) Journal of Logic Programming, 30(2), pp. 99–124, February 1997.
- "A Graphical Toolkit in LIFE" (with Bruno Dumant) *Proceeding of the Euro-GraphicsWorkshop on Programming Paradigms in Graphics (Maastricht, The Netherlands)*, pp. 161–173,March 1995.
- "Label-Selective λ-Calculus—Syntax and Confluence" (with JacquesGarrigue) *Theoretical Computer Science* 151, pp. 353–383, 1995.
- "Functions as Passive Constraints in LIFE" (with Andreas Podelski) *ACM Transactions on Programming Languages and Systems*, 16(4), pp. 1279–1318, July 1994.
- "A Database Interface for Complex Objects" (with Marcel Holsheimer and Rolf de By) *Proceedings of the 11th International Conference on Logic Programming, (Genoa, Italy)*, June 13–17, 1994.
- "The Typed Polymorphic Label-Selective λ-Calculus" (with Jacques Garrigue) *Proceedings of the 21st Annual ACM Symposium on Principles of Programming Languages (Portland, Oregon)*, pp. 35–47. January, 1994.
- "An Introduction to LIFE—Programming with Logic, Inheritance, Functions, and Equations" *Proceedings of the 10th International Logic Programming Symposium (Vancouver, BC, Canada)*, October 1993, pp. 1–17.
- "A Feature Constraint System for Logic Programming with Entailment" (with Andreas Podelski and Gert Smolka) *Theoretical Computer Science*, 122, pp. 263–283. 1994.
- "Entailment and Disentailment of Order-Sorted Feature Constraints" (with Andreas Podelski) *Proceedings of the 4th International Conference on Logic Programming and Automated Reasoning (Saint Petersburg, Russia)*, Andrei Voronkov, editor, Lecture Notes in A.I. 698, Springer-Verlag, pp. 1–18. 1993.
- "Towards a Meaning of LIFE" (with Andreas Podelski) *Journal of Logic Programming*, 16(3-4), pp. 195–234. 1993.
- "Logic Programming with Functions over Order-Sorted Feature Terms" (with Andreas Podelski) *Proceedings of the 3rd International Workshop on Extensions of Logic Programming (Bologna, Italy)*, E. Lamma and P. Mello, editors. Springer-Verlag, LNAI 660, pp. 100–119. 1992.
- "*Warren's Abstract Machine: A Tutorial Reconstruction*" MIT Press, Series in Logic Programming, 1991.
- "An Overview of LIFE" *Next Generation Information System Technology: Proceedings of the 1st International East/West Data Base Workshop (Kiev, USSR)*, October, 1990, J.W. Schmidt and A.A. Stogny, editors. Springer-Verlag, LNCS 504, pp. 42–58. 1991.
- "A Glimpse of Paradise" *Next Generation Information System Technology: Proceedings of the 1st International East/West Data Base Workshop (Kiev, USSR)*, October, 1990, J.W. Schmidt and A.A. Stogny, editors. Springer-Verlag, LNCS 504, pp. 17–25. 1991.
- "LIFE—a Natural Language for Natural Language" (with Patrick Lincoln) *T.A. Informations*, 30(1-2), Association pour le Traitement Automatique des Langues, Paris, France, pp. 37–67. 1989.
- "Implementing a Knowledge-Based Library Information System with Typed Horn Logic" (with Roger Nasr and Jungyun Seo) *Information Processing & Management* 26(2), pp. 249–268. 1990.
- *Resolution of Equations in Algebraic Structures* , Vols. I and II, (co-editor with Maurice Nivat), Academic Press, Boston, 1989.
- "Inheritance Hierarchies: Semantics and Unification" (with Gert Smolka) *Journal of Symbolic Computation* 7, pp. 343–370. 1989.
- "Efficient Implementation of Lattice Operations" (with Robert Boyer, Patrick Lincoln and Roger Nasr) *ACM Transactions on Programming Languages and Systems*, 11(1), pp. 115–146. January 1989.
- "Integrating Logic and Functional Programming" (with Roger Nasr) *Journal of Lisp and Symbolic Computation* 2, pp. 51–89. 1989.
- "BABEL: A Base for an Experimental Library" (with Roger Nasr and Jungyun Seo) *Proceedings of the ACM SIGIR International Conference on Information Retrieval (Grenoble, France)*, June 1988.
- "Integrating Data Type Inheritance into Logic Programming" (with Roger Nasr) Data Types and Persistence, M. Atkinson, P. Buneman, and R. Morrison, editors, Springer-Verlag, pp. 121–136. 1988.
- "Le Fun: Logic, equations, and Functions" (with Patrick Lincoln and Roger Nasr) *Proceedings of the Symposium on Logic Programming (San Francisco, CA, USA)*, pp. 17–23. September 1987.

- "An Algebraic-Semantics Approach to the Effective Resolution of Type Equations" *Theoretical Computer Science* 45, pp. 293–351. 1986.
- "LogIn: A Logic-Programming Language with Built-In Inheritance" (with Roger Nasr) *Journal of Logic Programming* 3, pp. 185–215. 1986.
- "Logic and Inheritance" (with Roger Nasr) *Proceedings of the 13th ACM Symposium on Principles of Programming Language ( Saint-Petersburg, FL, USA)*, pp. 219–228. January 1986.
- "Type Subsumption as a Model of Computation" *Expert Database Systems* L. Kerschberg, editor. Benjamin Cummings Publishing Co., pp. 115–139. 1986.

## 2)-Projet Scientifique

**Abstract** This document is a research proposal in response to the "*appel d'offre*" emitted by the "Programme Avenir Lyon Saint-Étienne" (PALSE) in September 2013.[1] Its objective is to develop a convincing use case in intelligent living-environment monitoring. The technology to be demonstrated in this use case derives from the author's lifelong contribution in terms of knowledge representation and automated reasoning as means to enable "smart" monitoring of living environments, focusing on urban and social milieux. This project is to act as a transition from the author's on-going work done as part of a Chair of Excellence from the "*Agence Nationale de la Recherche*" toward a more ambitious project to be soon proposed to the European Research Council's Advanced Grants program.[2] In this regard, the present proposal abides by the essential preconized motivation explicated in the PALSE call for proposals.

### 1. Motivation

All aspects of life are being overseen, monitored, and controlled through hybrid Perception/Analysis/Control (PAC) networks. Software-enabled technology prevails as the ubiquitous glue bringing all aspects of such monitoring to bear on its inner workings. However, human actors bring most, if not all, of the intelligence of such software. With the increased networking of all aspects of society, software intelligence has made great strides in showing a capacity for increased autonomy in the distributed monitoring of PAC networks—the most critical part being the "A" (Analysis). This project lies precisely in this line of technologies that attempt to meet the needs for the development of an intelligent monitoring framework that can provide policy makers and analysts with high added value information. The project seeks to combine specific, more semantic-based, techniques for distributed knowledge and information handling developed in areas such as knowledge representation and reasoning and query processing. The projects research objectives address several critical domains where unified access to distributed information for distributed monitoring is of central importance, such as: (1) enrich the semantics of extracted information from sources with formal models of information quality; (2) enrich the semantics of extracted information to enable conflict resolution and easy integration; (3) make use of ontologies to support semantic mapping across various domains (*e.g.*, health, transportation, education).

In a concomitant ERC Advanced Grants proposal,[3] we are offering to develop an effective technology for Practical and Efficient Reasoning for Scalable Ontological Networking (PERSON) [2]. This technology is to provide the formal knowledge representation and automated reasoning enabling the "smart" analysis of collected data organized into ontologies. Such a PERSON, using relevant ontological knowledge aware of a global context, would make monitoring of living environments more intelligent. By this, we mean that our PERSON using this knowledge would render smoother control possible, since such intelligent monitoring may be made to anticipate notable situations by inferred interpretation of perceived measurements. As a result, with the right knowledge and deductive capabilities, this PERSON would, for example, eliminate abrupt, or uselessly thrashing, ex-post facto control adjustments caused by raw data readings. We will use ontologies as a means to selecting and integrating of distributed information pieces.

Anticipating the needs of a living population in its environment in order to satisfy them in a timely and efficient manner is what intelligent monitoring vies to achieve.

[1] http://www.biosyl.org/jobs/appel-a-projets-packages-2013-2014

[2, 3] http://erc.europa.eu/advanced-grants

## 1.1 CONTEXT

Living environments, at all scales (global, national, regional, urban, domestic) are connected. The need for intelligent monitoring has become a priority. Monitoring can provide essential information to regulators, legislators, industry, decision makers and the public about the conditions of the ecosystems that human life depends upon. Ecological monitoring usually requires measurements over a large temporal and geographic scale. As new technologies allow us to collect massive sets of data across broad geographical areas, a critical challenge lies with how we will manage and exploit such large data sets. The objective is to allow users to access these data in real time, to analyze them quickly. Many questions related to the complexities of our environment lie at interfaces:[4] the interface of atmosphere with soil systems, soil with freshwater aquatic systems, and freshwater with marine ecosystems. Understanding these interactions requires real-time linkages between data streams from sensor operating in different contexts.

In fact, major industrial players have now acknowledged the need for orienting our technology to meet such challenges. IBM's "Smarter Planet" initiative, to cite one, is a typical orientation setup for bringing intelligence into living-environment monitoring.[5] To paraphrase them, the challenge is to move from passive observation leading to reactive control, to proactive anticipation monitoring. Such could be intuitively illustrated by, say, replacing a thermal control system abruptly adjusting the ambient temperature to a higher temperature as the weather chills, to one that does so gradually and preventively by understanding the trend of weather from local data such as temperature, pressure, and precipitations, as well as global networked weather measurements and reports. This is in essence the motivation for the Research for IT Driven Energy Efficiency RIDER project,[6] a major collaborative effort involving IBM France and the CNRS at the *Laboratoire d'Informatique, de Robotique et de Microélectronique de Montpellier* (LIRMM).[7] As illustrated in Fig. 1 borrowed from the project's overview,[8] they have for objective the complete automation of urban living environments from sensors to control via ontological reasoning.

More and more, when dealing with living-environment monitoring, one can come across terms such as "Intelligent Cities"[9] and "Knowledge Ecosystems."[10] The university of Lyon has already acknowledged the challenge and has invested sizable efforts with its "Intelligence des Mondes Urbains."[11]

At the European level as well, a substantial effort towards "ontologizing" urban life has been undertaken [12]. Specifically, Action C21 of the "European Cooperation in Science and Technology" (COST)[12] program has been preoccupied with achieving a knowledge representation of urban living environments [13]. COST is also active in several other domains relevant to intelligent environment management (*viz.*, Earth System Science and Environmental Management,[13] Transport and Urban Development,[14] Forests, their Products and Services,[15] *etc*, ...).

## 1.2 RELEVANCE AND STRATEGIC NATURE OF THE PROJECT

In what follows, we will sometimes use the term "smart cities" to refer to a living-environment monitoring context.

Regarding its functions as well as its purposes, a smart city can perhaps be defined as a city that "*strategically utilizes many smart factors such as Information and Communication Technology to increase the city's sustainable growth and strengthen city functions, while guaranteeing citizens' happiness and wellness.*" ([9], Clause 49)

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4 http://www.environment.ucla.edu/reportcard/article.asp?parentid=1506
5 http://www.ibm.com/smarterplanet/us/en/overview/ideas/
6 http://www.rider-project.com/
7 http://www.lirmm.fr/
8 http://energie.cnrs.fr/2011/RIDER.pdf
9 http://en.wikipedia.org/wiki/Intelligent_cities
10 http://en.wikipedia.org/wiki/Knowledge_ecosystem
11 http://imu.universite-lyon.fr/
12 http://www.cost.eu/
13 http://www.cost.eu/domains_actions/essem
14 http://www.cost.eu/domains_actions/tud
15 http://www.cost.eu/domains_actions/fps

Many cities over the world have embarked on smart-city projects. Examples, among others, are Seoul,[16] Barcelona,[17] New York,[18] Tokyo,[19] Shanghai,[20] Singapore,[21] Amsterdam,[22] and Lyon.[23]

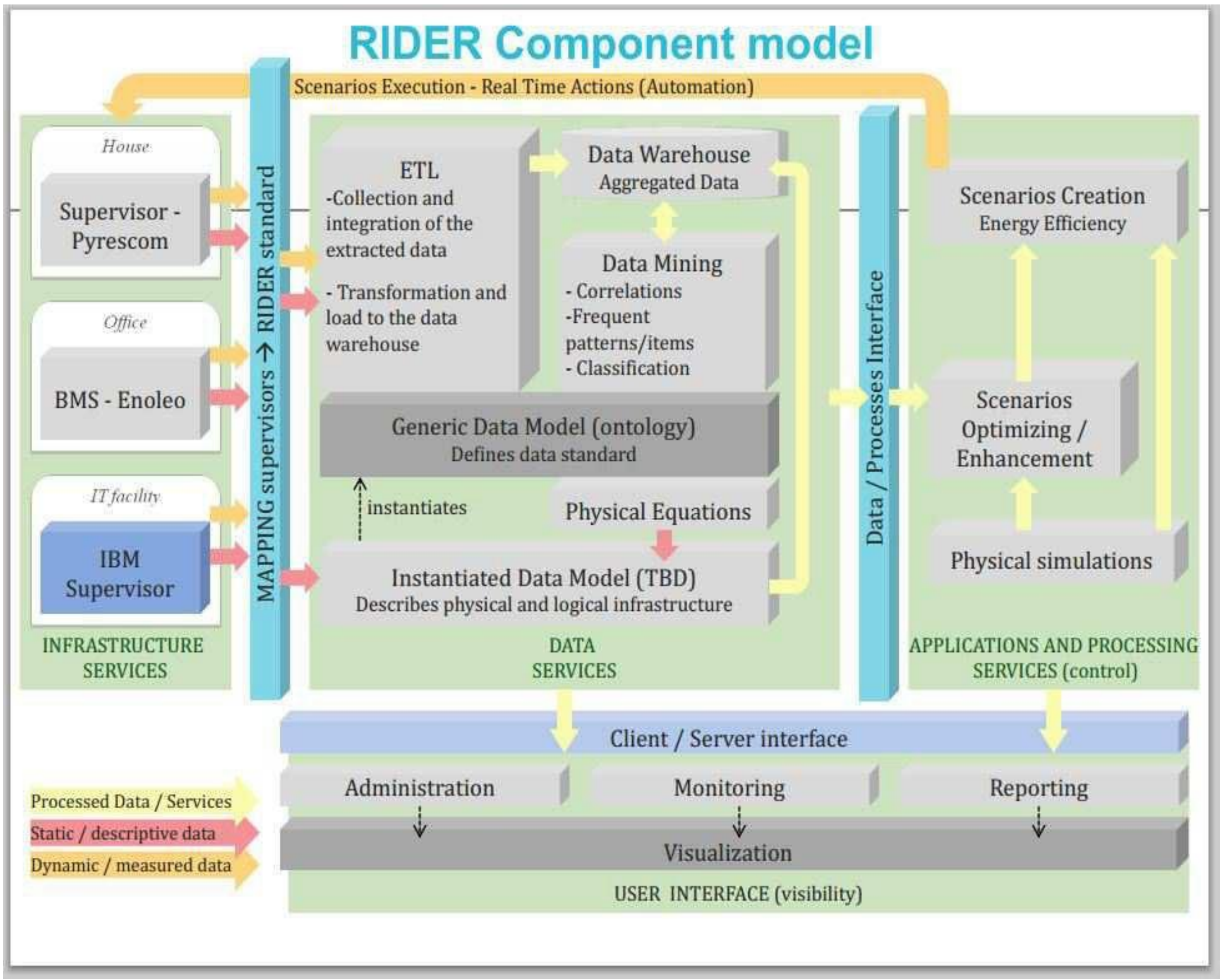


Figure 1: The RIDER Project's Component Model

Some of the outcomes of the activities that characterize smart cities are best described in the following quotes.

- "*A city well performing in a forward-looking way [in economy, people, governance, mobility, environment, and living] built on the 'smart' combination of endowments and activities of self-decisive, independent and aware citizens*." ([6], Page 11)
- "*A city that monitors and integrates conditions of all of its critical infrastructures including roads, bridges, tunnels, rails, subways, airports, sea-ports, communications, water, power, even major buildings, can better optimize its resources, plan its preventive maintenance activities, and monitor security aspects while maximizing services to its citizens*." ([8], Page 1)

[16] http://www.scribd.com/doc/129744991/Smart-Cities-Seoul-A-Case-Study
[17] http://www.majorcities.eu/workshops/2012-helsinki/helsinki2012_barcelona.pdf
[18] http://www.usa.siemens.com/sustainable-cities/pdf/smarter-neighborhoods-smarter-city.pdf
[19] http://www.metro.tokyo.jp/ENGLISH/PROFILE/policy02.htm
[20] http://www.shanghai.gov.cn/shanghai/node27118/node27973/u22ai70898.html
[21] http://www.ida.gov.sg/Infocomm-Landscape/Infrastructure/Smart-City-Programme-Office
[22] http://amsterdamsmartcity.com/
[23] http://www.aimsun.com/wp/?p=5117

Hence, this project fits into the context of the societal challenges reported by many research agencies[24, 25] and organizations.[26,27] We are particularly interested in addressing the challenge of deploying a value chain of data from end to end that involves the collection and integration of multi-source data. The objective is to design, implement and validate tools for the collection of relevant data to produce value-added information for decision-making purposes in the context of smart monitoring of urban environments. Our concerns in this project are also reflected in the call for proposals regarding future investments launched by the government, application areas: tourism, city and transportation are part of the recommendations made by Allistene and competitiveness clusters of the National Strategy for Research Science and Technology Digital.[28] Smart cities are identified as a target research and innovation area in Horizon 2020 as part of "societal challenges."[29]

### 1.3 Related Projects

Several initiatives have emerged in Europe,[30] the USA,[31,32] and Japan[33] to develop technologies for smart cities. In this section, we list a few notable projects dealing with data management for monitoring in the context of smart cities.[34]

- **URB-Grade**:[35] This project aims to develop a decision support platform that will enable authorities in charge of the management of a city to elaborate effective action to provide changes while guaranteeing an energetic comfort in neighborhoods. The platform displays three (3) features: (a) collecting data from distributed sensors, from open data sources, and from available reports; (b) data processing by relying to Complex Event Processing (CEP) technology; and, (c) using of this information to help policy makers with recommendations.

- **3e-Houses**:[36] This project aims to integrate the most sophisticated information technology to develop services for achieving energy efficiency in social housing. The resulting system should allow the monitoring of energy consumption in real time, the integration of renewable energy, as well as make recommendations to reduce energy consumption.

- **SMARTKYE**:[37] This project aims to develop a collaborative platform (Integrated Management System) for sharing information on energy consumption. The characteristics of the platform reside in its ability to process information in real time to extract useful analysis to an effective monitoring and the development of strategies to control the energy consumption level at the level of a neighborhood.

- **NRG4CAST**:[38] This project aims at developing a system for the management, analysis and prediction in real time of the consumption and distribution of energy in urban and rural networks. This project is based on the analysis of the typology of the distribution network and related components, the demand and consumption, and the environmental data. The outcome will be a software tool for prediction and which will be integrated into a system of network monitoring; into an anomaly detection system. . . The ensuing services will exploit advanced knowledge technologies such as learning, data mining, knowledge representation, and reasoning.

- **KNOHOLEM**:[39] This project focuses on the development of an energy management solution that is able to reduce energy consumption in buildings. The expected system will rest on an optimization approach based on knowledge representation technologies such as ontologies and knowledge management.

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[24] http://ec.europa.eu/eip/smartcities/files/sipfinalen.pdf
[25] http://www.agence-nationale-recherche.fr/fileadmin/aap/2014/pa-anr-2014-aap-generique.pdf
[26] http://www.urenio.org/wp-content/uploads/2012/04/2012-FIREBALL-White-Paper-Final.pdf
[27] http://www.tmcnet.com/tmc/whitepapers/documents/whitepapers/2013/6764-getting-smart-smart-cities-market-analysis.pdf
[28] https://www.allistene.fr/
[29] http://www.balcon-project.eu/uploads/files/EU_documents/BALCON_ICT_in_HORIZON2020_Aug2013.pdf
[30] http://cordis.europa.eu/fp7/ict/fire/connected-smart-cities/csc_en.html
[31] http://www.nsf.gov/awardsearch/showAward?AWD_ID=1239021
[32] http://www.bu.edu/ece/2012/09/28/smart-city-research/
[33] http://jscp.nepc.or.jp/en/
[34] For additional projects, see http://urb-grade.eu/related-projects/.
[35] http://urb-grade.eu/
[36] http://www.3ehouses.eu/
[37] http://smartkye.eu/
[38] http://www.fir.rwth-aachen.de/en/research/research-projects/nrg4cast-600074
[39] http://www.knoholem.eu/page.jsp?id=2

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- **SCRIBE**:[40] This project investigates a way to build modular ontologies with facilities to compose them in order to maintain and monitor information flows between discrete agencies, applications, citizens and business in cities that chose to exchange information and collaborate in order to reduce the costs of maintaining a good quality of life in cities. This research relates to knowledge engineering as well as to model-driven development.

- **SOFIA**:[41] This project aimed to make information in the physical world available for smart services. The proposed architecture makes it possible to mash-up and integrate information between all applications and domains—from embedded domains to the Web. The functional architecture uses a semantic broker together with Common ontology models as information interoperability enabler. It is an Event Driven Architecture[42] that allows the management and cooperation of heterogeneous sensors for monitoring public spaces. The main components of the architecture are implemented in a testbed on a subway scenario with the objective to demonstrate that the proposed solution can enhance the detection of anomalous events and simplify both the operators tasks and the communications to passengers in case of emergency.

- **OPTICITIES**:[43] This project deals with approaches to optimize urban mobility by mainly considering the user needs, urban mobility public policy, and business models of service providers. It investigates a collaborative approach between public and private stakeholders. In this vision European cities consolidate all mobility data available at local level and provide it to service operators through a standardized gateway. The key assets of this approach are: (1) a geographical and modal urban mobility data completeness thus reinforcing services quality, (2) deploying truly multimodal services, supporting the diversity of services offer, sustaining high value services, and (3) ensuring coherency between user-oriented services and urban mobility public policies.

## 2. PROPOSAL

### 2.1 OBJECTIVES

To cope with the social, economic, environmental and territorial perspectives of urban development,[44] and its multiple and dynamic interlinking, policy-makers need an appropriate information base and management tools for it.[45] Nowadays, there are many sources of rich and massive data. For example, the availability of sensors in all aspects of real life has made it possible to collect many types of data in huge quantities. Users or groups of users are also producing large amounts of what is called user generated content. Examples of such data include: weather data, traffic records (accident records, traffic jam data), car location (from the GPS navigation system), social networking data such as location tagged photos of short texts, and many others. The number of data sources and their size make difficult the task of the expert regarding the extraction of useful information from the data. Combining different data sources can give insights not available using only one source, and different data sources can cover for each other when data becomes unavailable from one source.

Using ontologies to extract precise information, we are interested in is one way to use these rich data sources. Indeed, querying data sources in presence of ontologies has several interests and leads to significantly improved operating environments of information systems. In most cases, new information systems should support very large, distributed and heterogeneous data sets. They implement complex processes to handle these data sets: data transformation, data correlation and data analysis. For example querying data sources in the presence of ontologies can improve responses to queries by taking into account domain knowledge. This approach has several potential applications: health data management systems, risk management systems, enterprise, and Web data integration and exchange. The adoption of this approach requires effective solutions to several challenges: (1) scalability of query evaluation algorithms in presence of several ontologies, (2) handling incomplete information and data inconsistencies, and (3) support of data streams.

The main objective of this project is to address these major challenges in the context of urban monitoring. We will build

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[40] http://researcher.watson.ibm.com/researcher/view_project.php?id=2505

[41] http://www.indracompany.com/en/sostenibilidad-e-innovacion/proyectos-innovacion/sofia-smart-objects-for-intelligent-applications-8

[42] http://www.sofia-community.org/files/SOFIA_D3-56-FinalPrototype.pdf

[43] http://www.opticities.com/

[44] http://ec.europa.eu/regional_policy/archive/consultation/terco/pdf/lookingglass.pdf

[45] http://iume.ew.eea.europa.eu/about-1

on our expertise in the design of hybrid and constraint-logic languages such as *LIFE* [1] adapted to RDF-based linked data and other formats such as Common Logic,[46] and our current work on integration of knowledge representation and database technologies in the framework of the *CEDAR* project.[47]

The work we plan to conduct fits perfectly with the objectives of LabEx IMU,[48] Theme 5 (Environment, Nature, Environmental Technologies). Expected results can also be integrated into the overall objectives of OPTICITIES project's Objective 2 (A contractual framework on data access and exchange policy allowing enlarged access to high quality data), and Objective 3 (European interoperability of urban mobility data and mobility solutions).[49]

## 2.2 Approach

From an IT perspective, the main requirements of a monitoring system are: [7]

- **Data Collection**: The size of the deployment of sensors depends on the required spatial granularity and the available resources.
- **Data Delivery**: The data collected from the locations are expected to be delivered to users with a latency in the order of hours to days. The major engineering challenge lies in the fact that these quality guarantees need to be met in the presence of hard power constraints and limitations of connectivity.
- **Data Management**: The collected data should be easily accessible to scientists at various levels of detail with low latency. Another major challenge is provenance. A number of transformation steps are necessary to convert raw data into usable data. In many situations, intermediate results need to be stored allowing the origins of every piece of data to be traced. This motivates the need for a unified system that manages the data gathered by sensors and also stores various intermediate results.
- **Data Integrity**: It is important to assess the quality of the data gathered, by sensors before presenting them to the uers.

Our proposed work will consist in:

- **characterizing** the specific issues proper to ecological monitoring and how this field differs from or resembles other contexts;
- **evaluating** the state of the art in intelligent monitoring in general, and specifically applied to applications to living environment;
- **providing** a synthesis of the state of the art and propose a model that is adequate for the specifics of ecological monitoring;
- **developing** a proof-of-concept ontological reasoning system capable of analyzing collected ecological data and provide sensible monitoring actions and reports.

The functional architecture of the framework that we propose to design is shown in Figure 2. A set of data sources are continuously harvested to extract relevant information. The extracted data are then stored in RDF-triple stores. Domain ontologies (*e.g.*, transportation, roads) to structure the concepts and constraints inherent in each field, specify events and define links and/or dependencies between data will serve as an entry point into the system. Applications (*e.g.*, information retrieval, monitoring, analysis) can then be developed on top of the ontologies. A query is initially enriched by semantic information stemming from relevant ontologies and then subjected to evaluation by a distributed management system (here we will use the MapReduce paradigm and we will build on Hadoop).[50]

## 2.2 Use Cases

Due to the novel and rapidly evolving nature of the application domain, the issue of intelligent living-system monitoring has to conjugate several advanced technologies, the core of which consisting of putting to use an efficient formalism that lends itself to being:

- **sufficiently expressive** to represent the specific kind of knowledge proper to inference tasks required for the job;

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[46] http://www.iso.org/iso/iso catalogue/catalogue t/catalogue detail.htm?csnumber=39175
[47] http://cedar.liris.cnrs.fr
[48] http://imu.universite-lyon.fr/presentation/le-labex-imu-170917.kjsp
[49] http://www.opticities.com/project/objectives/
[50] https://hadoop.apache.org/docs/r1.2.1/mapred_tutorial.html

- **effective, efficient, and scalable** in "real-life" conditions over a network of sensors, data analyzers, ontological inference engines, and control feedbacks;
- **as simple as possible** to build and maintain and adapt to changing contexts and conditions.

It is therefore critical to define a **clear** **use case** specifying in detail the *what*, *why*, and *how* of:

- **what** is to be measured, analyzed, and understood, in living environments;
- **why** these factors can influence monitoring; and,
- **how** to structure a knowledge base of ontologies abstracting from raw data to enable intelligent control guided by inferential processing of the measured factors.

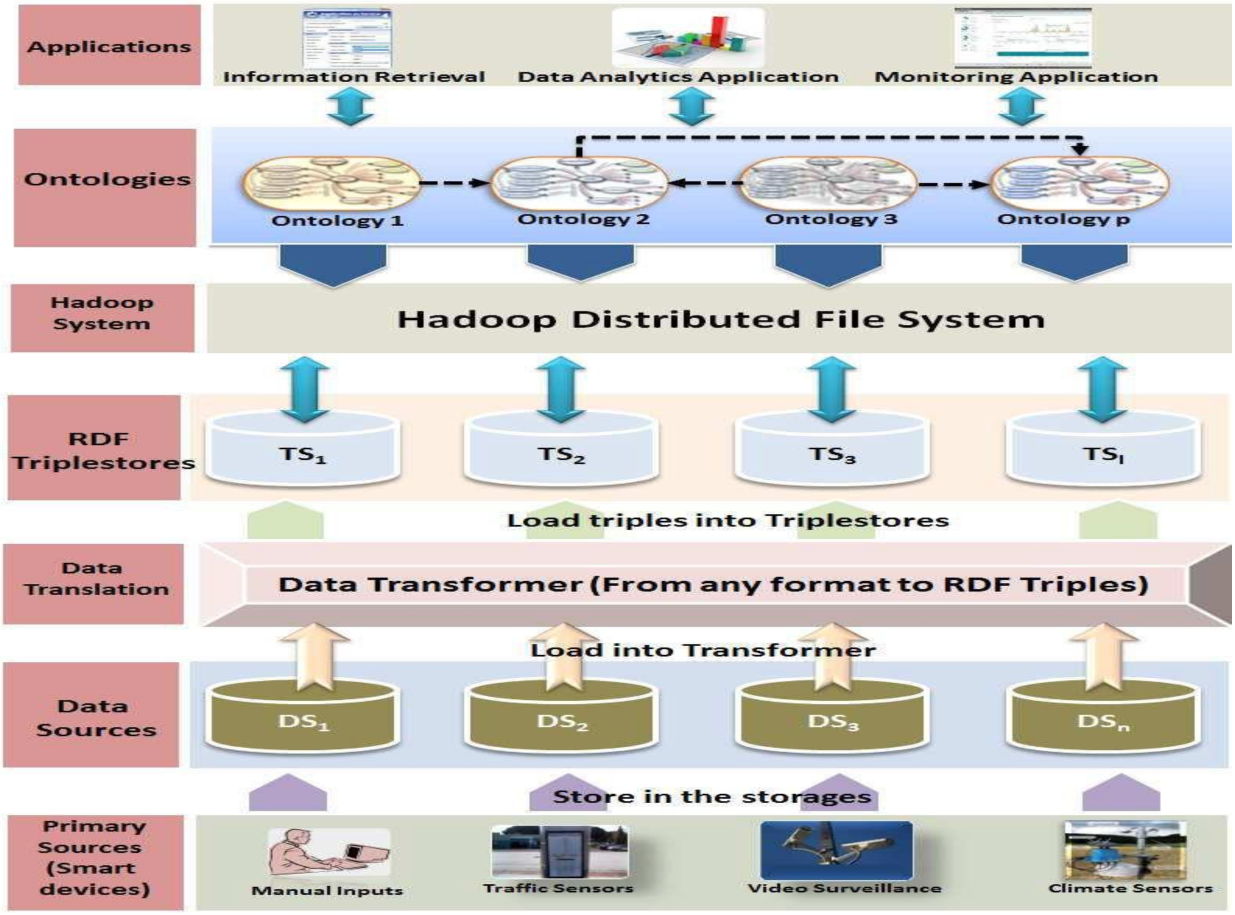



**Figure 2: The *LivEMUSIC* System Architecture**

This is essentially what this proposal's purports to achieve: **the study and development of a detailed use case and afferent technical aspects for intelligent living-environment monitoring**. Care must be taken to delineate a non-elementary realistic context of use. The point is to enable a convincing specification and experimental proof-of-concept with purpose to demonstrate both the viability and scalability of the technology that a full *PERSON* (such as [2]) should provide for intelligent living-environment monitoring. Such a *PERSON*, the result of a major software design and implementation project's effort, is the objective of a concomitant ERC Advanced Grants proposal to be submitted by the author to be hosted by the LIRIS. [51]

As for experimental framework, we will exploit public data provided by the Grand Lyon through its platform SmartData.[52] We can thus have 378 datasets at our disposal. This data, mostly open data, are varied: the number of kilometers of sidewalks, directory of ponds and wetlands, cycling stations (*vélo'v*),[53] *etc.*, . . . Our objective is to facilitate the development and use of ontological knowledge about the nature et properties of this data.

[51] http://cedar.liris.cnrs.fr/papers/cedar.pdf
[52] http://smartdata.grandlyon.com/
[53] http://www.velov.grandlyon.com/

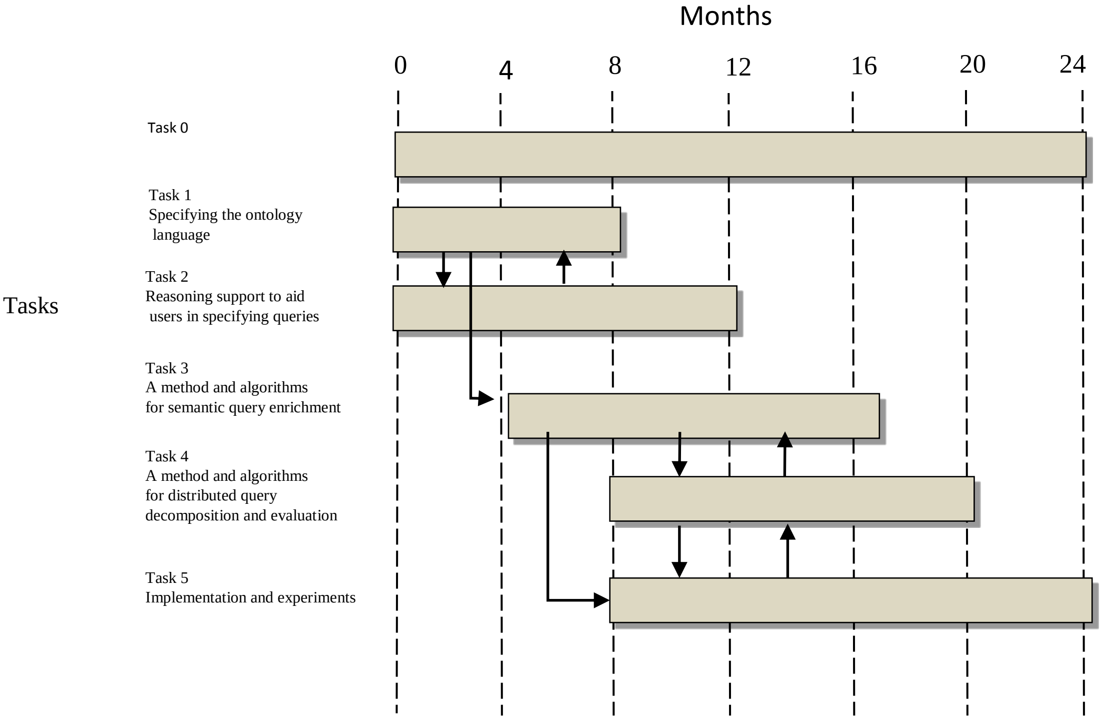
# 3 PROJECT ORGANIZATION

- **Task 0: Project management**—As this is a short-term project with results to show, coordination is essential to its success. Weekly project meetings (each lasting 2-3 hours) will ensure regular interaction among project participants. These meetings will serve to review progress, discuss obstacles that may arise, and to decide upon modifications to the project organization, if necessary. They will also allow participants to present their results, to conduct brainstorming on next steps, and to discuss recent advances in smart monitoring of relevance to our project. The other activities in Task 0 include:
  - Creation and maintenance of a project website, to disseminate the results of the project and enhance its visibility.
  - Organization of an open seminar towards the mid of the project.
  - Organization of a workshop towards the end of the project.
  - Preparation for project review(s) and the final project report.
- **Task 1: Specification of the ontology language**—The aim of this task is to develop a core ontology language for specifying domain ontologies that are relevant for living-environment monitoring by accommodating constraints and data dependencies. The proposal of this language will result from detailed analysis and identification of gaps in existing languages (*e.g.*, [4, 5, 14]).
- **Task 2: Reasoning support to aid users in specifying queries**—The objective of this task is to develop an approach for aiding users in specifying queries. Depending of the application, the general approach idea would be to present the user with domain ontologies, let her/him select the target entities, dependencies, constraints and events and then check the resulting query for consistency.
- **Task 3: A method and algorithms for semantic query enrichment**—A query can be enriched by various semantic knowledge conveyed by the ontologies and possibly elicited by an interaction with the user. The semantic enrichment targets the relevance of the result and also the optimization of query evaluation. First, we will identify best practices search refinement and enrichment methods (*e.g.*, [10, 3]) then we will explore how semantic refinement and enrichment may be carried out in the context of multiple ontologies.
- **Task 4: A method and algorithms for distributed query decomposition and evaluation**—In the application context we are interested in (see Figure 2), the query evaluation process requires the identification of sources that can provide parts of the answer. The information sources that need to be searched are known only through indexes built from the content of the ontologies and the data repositories (triple stores in our case). Here, a query evaluation and optimization process should consider two issues: (1) determine an optimal access plan to data sources to retrieve fragments candidates for the composition; and, (2) determine an optimal strategy for composing returned fragments. In this task, we will propose a general framework for distributed query answering which captures existing algorithms as special cases. This general framework will allow us to study how different alternative query answering approaches may be fruitfully combined.
- **Task 5: Implementation and Experiments**—This task handles the implementation of the framework proposed in the other parts of the project. The result will be a prototype used to validate models and algorithms. In order to reduce risks of failure, each part will be implemented as an independent module, before integrating all the proposals:
  - implementing a parser for translating bases expressed in sources formats into triples;
  - implementing a reasoner for linking ontologies by discovering dependencies;
  - implementing an algorithm for semantic query enrichment;
  - implementing an algorithm for query decomposition and optimization.

Experiments will be performed on one or two applications that will be decided jointly with IMU and Greater Lyon.

# 4 TASK SCHEDULES AND DELIVERABLES

The following diagram summarizes the project's tasks, the interaction between tasks, and the expected start and end date for each task.




## Project deliverables

Task 0: Final project report at T0+24
Task 1: Progress reports at T0 + 4 and T0 + 8
Task 2: Progress reports at T0+4, T0+8 and T0+12
Task 3: Progress report at T0+8, T0+12 and T0+16
Task 4: Progress reports at T0+12, T0+16, T0+20
Task 5:

- Progress reports at T0+12, T0+16, T0+20 and T0+24
- Demos at T0 + 22
- Online demos (with facilities, *e.g.*, web services) at T0 + 24

## Project milestones

- Specification of the ontology language for *Living-Environment Monitoring*, developed in Task 1, required in Tasks 2 and 3 (first version due T0 + 6, it will be refined when available).
- Algorithms for *semantic query enrichment*, elaborated in Task 3, to be used in Task 4 (first version due T0+12, it will be refined when available).
- Elaboration of the *scenarios together with their ontologies and their data sets* (as part of Task 5) to be used for experiments (due T0+16).
- A *prototype implementation of the whole process* in Task 5 (due T0+20)
- A *demo on the basis of the built scenarios* in Task 5 (due T0+22)

## Dissemination

The methods of dissemination will take the form of publications and demos in major international (specialized) conferences and journals. When appropriate, we may also publish our work in related fields, like database, data integration, decision support in order to communicate our results to a larger scientific public.

To ensure the visibility of the project, and the dissemination of its results, a project website will be maintained and it will contain online demos/videos[*]. The project's visibility will be further reinforced by the organization of an open seminar (towards the mid of the project) and a workshop (towards the end of the project) devoted to smart cities and intelligent monitoring. The workshop will involve both French and international researchers. The improved version of the *LiveMUSIC* software developed in Task 5 will be made available for download on the project's web site for non-commercial use.

[*] As done, *e.g*, in the USA (`http://worldmap.harvard.edu/tweetmap/`) and in Japan (`http://jscp.nepc.or.jp/en/`)

# 5 CONCLUSION

We have reviewed the state of the art in "smart-city" research and experimentation around the world and proposed the LivEMUSIC project whose objective is the systematic development of tools and algorithms facilitating the management of realistic use case scenarios for the intelligent monitoring of live data. Among the few existing projects at the forefront is the Rhônes-Alpes region—*viz.*, OPTICITIES [54] where one of the pilot cities is the Grand Lyon—*i.e.*, the source of our "smart data,"[55] along with the IMU.[56] A major element of the technology required for such an ambitious project as OPTICITIES is the intelligent processing of sensor information (knowledge representation, automated reasoning and learning). Proposing the LivEMUSIC project is all the more pertinent in that the CEDAR project is currently being hosted at the *Université Claude Bernard Lyon 1*.[57] The CEDAR Project is led by this proposal's author and soon-to-be candidate for an ERC Advanced Grant that will develop a practical intelligent platform [2]. Indeed, the LivEMUSIC project is a natural hinge for transferring the technology experimented in the CEDAR project and to be consolidated in the PERSON project. Such technology, working concomitantly with intelligent environment monitoring through sensors deployed as federated "smart objects" [11] could thus be tested on realistic use case scenarios elaborated and validated thanks to the LivEMUSIC project's proposed tools.

# APPENDIX

## A. HOST INSTITUTION

The project is to be hosted by the LIRIS, at the Université Claude Bernard Lyon 1. Some members of the LIRIS and Prof. Aït-Kaci have been collaborating on the CEDAR project.

## B. HUMAN RESOURCES

### B.1. PRINCIPAL INVESTIGATOR

The Principal Investigator for the proposed work is Hassan Aït-Kaci.[58] He is currently holding an ANR Chair of Excellence on Constraint and Event Driven Automated Reasoning (CEDAR)[59] hosted by the LIRIS, at the University Claude Bernard Lyon 1, from January 2013 until January 2015.[60] He is concomitantly in the process of preparing a proposal for an ERC Advanced Grant [2].[61]

### B.2. TECHNICAL ASSISTANCE

- one researcher, post-doctoral level, to be recruited, with a strong background in knowledge processing technology, networking, and data analysis, and with an active interest in living-environment monitoring;
- two master-level interns, to be recruited, with strong technical skills in programming and networking, and with an interest in ontological processing.

### B.3. COMPUTINGENVIRONMENT

We already set up required software and hardware facilities. This project will take benefit from such an environment made of a platform[62] which consists in a cluster that can reach 100 virtual machines with a total storage capacity of 52 TB. This platform will be used in the context of this project to provide the contributors with simulation-based data sets and tools.

[54] http://www.opticities.com/
[55] http://smartdata.grandlyon.com/
[56] http://imu.universite-lyon.fr/presentation/le-labex-imu-170917.kjsp
[57] http://cedar.liris.cnrs.fr
[58] http://www.hassan-ait-kaci.net/
[59] http://cedar.liris.cnrs.fr/
[60] http://cedar.liris.cnrs.fr/papers/cedar.pdf
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[69] http://www.osti.gov/scitech/servlets/purl/773961

[70] http://www.un-documents.net/ocf-01.htm

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[72] http://doi.acm.org/10.1145/1456223.1456225

[73] http://link.springer.com/book/10.1007/978-3-540-71976-2/page/1

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