Team SemLIS

Semantics, Logics, Information Systems for Data-User Interaction

Rennes

Activity Report

2017

Abstract. The main objective of the SemLIS team is **to bring back to users the power on their data**. It aims at facilitating data-user interaction by making users more autonomous and agile, by providing flexibility and expressivity, and yet control and confidence in the information system. It should support users in the semantic representation of heterogeneous data, and in the collaborative acquisition of domain knowledge. Its scientific foundations are logics and formal languages for knowledge representation and reasoning, the Semantic Web, information systems, natural language processing, symbolic data mining, and user-data interaction. A key idea is to reconcile the power of formal languages and the usability of natural language and interaction. On the application side, the focus will be put on social sciences and on business intelligence.

Keywords: information systems, knowledge representation, logics, formal languages, natural language processing, data mining, user-data interaction, business intelligence, group decision and negotiation.

1 Team Members

Head of the team

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- Aurélie Patier

Université Rennes 1 staff

- Olivier Ridoux, Professor
- Sébastien Ferré, Associate Professor, HDR
- Annie Foret, Associate Professor, HDR

INSA Rennes staff

- Mireille Ducassé, Professor
- Peggy Cellier, Associate Professor (part time: 80%)

Postdocs

- Pierre Maillot, ANR IDFRAud project
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PhD students

- Clément Gautrais, supervised by Peggy Cellier (25%), Thomas Guyet (25%), René Quiniou (25%), Alexandre Termier (25%)[1]
- Aurélien Lamercerie, supervised by Annie Foret and Benoît Caillaud[2]

Master students

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Licence students

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[1] Team Lacodam - IRISA
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2 Scientific and Historical Context

The SemLIS team is a follow-up of the LIS team. LIS stands for *Logical Information Systems* [22], and the first team was created in 2007. Its main purpose was to combine logics and user navigation to break some limitations of existing systems to retrieve and update information (e.g., hierarchies vs Boolean search). The topic had emerged around 2000 with the PhD thesis of S. Ferré [24], supervised by O. Ridoux. Despite the diversity of our works since then, there is a common pattern: *the design and application of formal languages and formal methods to data and knowledge with a user-centered approach.*

Formal Concept Analysis (FCA) is a central community for the team, and we have had a strong implication in it as authors, committee members, and program chairs. FCA provided the rationale for deriving the navigation structure from data, and for driving the user-system dialogue. Our first contribution was to generalize FCA to the use of logics for representing knowledge [19]. After 2000, a number of new LIS members and PhD students contributed to widen the theoretical and application scopes. The PhD of Yoann Padioleau led to applications to file systems [33]. The PhD of Peggy Cellier led to the domain of data mining applied to software engineering [12]. The PhD of Olivier Bedel led to applications for geographical information systems [5], and a collaboration with geographers. The arrival of Annie Foret led to applications to linguistic resources, and to the domain of logics for the analysis of natural languages [30]. The PhD of Pierre Allard led to the domain of business intelligence (à la OLAP) for richer visualizations [1]. The PhD of Alice Hermann led to the community of the Semantic Web [17, 32], which now plays a central role. LIS results and prototypes have been extended from FCA to the richer knowledge representations of the Semantic Web. In 2008, Mireille Ducassé switched from software engineering applications to the use of *logical information systems* as a support system for group decision and negotiation [15, 13]. Finally, the PhD of Mouhamadou Ba led to the application domain of bioinformatic workflows [3]. In the meantime, connections were made with the community of Faceted Search, and this led to a collaborative book [34], and participation to a COST action.

The development and experimentation of softwares has played a central role in the scientific development of the LIS team (e.g., CAMELIS, LISFS, GEOLIS, SEWELIS[3]). They have been built at different system levels (file system, desktop, Web application), and applied to various domains (personal data, software engineering, geographical data, linguistic resources, etc.). SEWELIS is the most recent and advanced implementation of *logical information systems*. It is a generic tool for editing, querying, and exploring a Semantic Web dataset. Its users are guided in all tasks, and are never exposed directly to the formal languages used by the system for reasoning on knowledge. SEWELIS is the current version under development, and will be the basis for a number of future works.

3 Scientific Foundations and Former Results

A distinctive aspect of our team is the application of formal methods coming from software engineering and theoretical computer science (formal languages and grammars, logics, type

[3] `http://www.irisa.fr/LIS/softwares/`

theory, declarative programming languages, theorem proving) to artificial intelligence tasks (knowledge representation and reasoning, data mining, user-data interaction). This is explained by the combination of a theoretical background shared by permanent members and a real interest for data and their users. Some members, Olivier Ridoux and Mireille Ducassé, have had a long research experience in software engineering in general, and in logic programming in particular. Annie Foret studies different variants of substructural logics for the analysis of natural languages. Peggy Cellier did her PhD thesis on the application of data mining to the localization of faults in programs. Sébastien Ferré relies on formal languages to formalize user-data interaction models, and to prove usability properties such as the safeness and completeness of user guidance.

We briefly describe the scientific foundations of the team, organized by high-level research topics, along with references to a few former contributions in each topic.

Knowledge Representation and Querying. The team uses symbolic approaches, and in particular the Semantic Web technologies [AvH04,HKR09]. Indeed, those are an active research domain, and provide W3C standards for concepts introduced by widely recognized formalisms for knowledge representation: e.g., Datalog [CGT89], description logics [BCM+03], or conceptual graphs [CM08]. The Semantic Web defines languages for the representation of facts and rules (RDF, RDFS, OWL, SWRL), and for their querying (SPARQL). Moreover, the Semantic Web has an active community, both in academy and in industry. That research domain solicits competencies in formal languages (syntax and semantics), in logics, and in automated reasoning. In those topics, we have for instance contributed to the modular composition of logics [20], and to the representation of complex expressions in RDF [28].

Natural Language Processing. Here again, the team uses symbolic approaches. One task is to extract structured and semantic information from texts. The employed techniques are: a) categorial grammars [MR12] associating syntactic/semantic types to words, b) Montague grammars [DWP81] associating grammars, lambda calcul, and logic, and c) sequential patterns [AS95].

[AvH04] G. Antoniou, F. van Harmelen, *A Semantic Web Primer*, MIT Press, 2004.

[HKR09] P. Hitzler, M. Krötzsch, S. Rudolph, *Foundations of Semantic Web Technologies*, Chapman & Hall/CRC, 2009.

[CGT89] S. Ceri, G. Gottlob, L. Tanca, "What you Always Wanted to Know About Datalog (And Never Dared to Ask)", *IEEE Trans. Knowl. Data Eng. 1*, 1, 1989, p. 146–166.

[BCM+03] F. Baader, D. Calvanese, D. L. McGuinness, D. Nardi, P. F. Patel-Schneider (editors), *The Description Logic Handbook: Theory, Implementation, and Applications*, Cambridge University Press, 2003.

[CM08] M. Chein, M.-L. Mugnier, *Graph-based knowledge representation: computational foundations of conceptual graphs*, *Advanced Information and Knowledge Processing*, Springer, 2008.

[MR12] R. Moot, C. Retoré, *The Logic of Categorial Grammars: A Deductive Account of Natural Language Syntax and Semantics*, *FoLLI-LNCS*, Springer, 2012, `https://hal.archives-ouvertes.fr/hal-00829051`.

[DWP81] D. R. Dowty, R. E. Wall, S. Peters, *Introduction to Montague Semantics*, D. Reidel Publishing Company, 1981.

[AS95] R. Agrawal, R. Srikant, "Mining Sequential Patterns", *in: Proceedings of the Eleventh International Conference on Data Engineering*, *ICDE '95*, IEEE Computer Society, p. 3–14,

Those techniques can be used for syntactic/semantic analysis of sentences, for Information Extraction (IE), and for defining Controlled Natural Languages (CNL) [Kuh13]. In those topics, we have for instance contributed to the learnability of pregroup grammars [7], and their extension with option and iteration [6], to a CNL (SQUALL) for querying and updating RDF graphs [27], and to the discovery of linguistic patterns from texts [9].

Symbolic Data Mining. The team has competencies in the conception and application of symbolic data mining algorithms, in particular for sequential patterns, and their application to texts [9]. It also has competencies in learning the grammar of natural languages from a structured corpus [7]. Moreover, the LIS team was scientifically founded on Formal Concept Analysis (FCA) [GW99]. It produced FCA-based contributions for data mining [11] and machine learning [21], as well as for data exploration [25].

Lately, the team has also focused on exploiting frequent itemset extraction techniques to analyze the structural similarity of graphs [13], and to provide tools to evaluate the evolution of RDF graphs.

User-Data Interaction. Because of the importance that we give to user-data interaction, the team invested into techniques that enable to structure and reason on those interactions. We can refer, in particular, to faceted search [ST09] (often used in e-commerce platforms), On-Line Analytical Processing (OLAP, often used in business intelligence) [CCS93], and Geographical Information Systems (GIS) [LT92]. In those topics, we have for instance contributed to the exploration of geographical data [5], to the discovery of functional dependencies and association rules with OLAP cubes [1], and to the extension of faceted search to RDF graphs [17].

Although the above four topics correspond to traditionally distinct research domains and communities, they are often found in combinations in today's research challenges and conferences. Many of our contributions actually lie at the crossing of several topics: e.g., the application of symbolic data mining to linguistic data such as texts [9], the interactive exploration and filtering of data mining results [10], the representation and querying of natural language resources such as lexicalized grammars [30], or the combination of a query language, natural language generation, and user-data interaction to help users explore the Semantic Web [4]. We believe that all those topics are essential, and need to be combined, in order to achieve our objectives.

1995.

[Kuh13] T. Kuhn, "A Survey and Classification of Controlled Natural Languages", *Computational Linguistics*, 2013.

[GW99] B. Ganter, R. Wille, *Formal Concept Analysis — Mathematical Foundations*, Springer, 1999.

[ST09] G. M. Sacco, Y. Tzitzikas (editors), *Dynamic taxonomies and faceted search, The information retrieval series*, Springer, 2009.

[CCS93] E. Codd, S. Codd, C. Salley, *Providing OLAP (On-line Analytical Processing) to User-Analysts: An IT Mandate*, Codd & Date, Inc, San Jose, 1993.

[LT92] R. Laurini, D. Thompson, *Fundamentals of Spatial Information Systems*, Elsevier, Academic Press Limited, 1992.

4 Objectives and Scientific Challenges

We first state the high-level objectives of the team proposal, before illustrating them on a concrete scenario. We then list a number of specific goals at different time ranges (short/mid/long term).

4.1 High-Level Objectives

In a context of ever-increasing volumes of data and knowledge, both in quantity and in diversity (Big Data), **the main objective of SemLIS is to bring back to users the power on their data**. By users we mean any individual or group who has a strong interest over some data, and the need to exploit them in order to derive new knowledge and to take decisions. That includes tasks such as search, authoring, data mining, and business intelligence. Those data can range from the personal data of an individual to the information systems of large companies, through project management inside a team. We take a subjective view on "Big Data" where the complexity does not lie in efficiently performing a given task on a large volume of data (e.g., query evaluation), but in enabling users to perform tasks that could not be anticipated (e.g, query formulation). In that subjective view, "Big" only means an amount of data that is too large or too complex for users to grasp and analyze by hand or by simple needs (e.g., spreadsheets).

Our objectives fit in the scope of axis 26 (human-machine collaboration) of challenge 7 (society of information and communication) of the national strategy for research[4]. We particularly agree with the notion of man-machine collaboration, where the machine is not supposed, in our view, to *replace* humans by full automation, but rather to *support* them in information-intensive tasks. In this view, both the human and the machine should learn one from the other.

> *One will review the human-computer interaction in the light of natural human behavior and progress in the decisional and operational autonomy of machines. To develop a real collaboration between man and machine, research on self-learning process between man and machine must be amplified. The machine should adapt to unpredictable aspects of user behavior, and develop a greater wealth of interactions for "intelligent" automation.*

That main objective of **bringing back to users the power on their data** can be decomposed into five high-level objectives:

AUTO (O1): to make users **autonomous and agile** in the process of exploiting data and knowledge by avoiding intermediates (e.g., database administrators);

SEM (O2): to facilitate the **semantic** representation and alignment of heterogeneous and multi-source data;

[4] `http://www.enseignementsup-recherche.gouv.fr/cid86746/strategie-nationale-de-recherche-rapport-de-proposit`
`html`

FLEX (O3): to provide **flexibility** by enabling out-of-schema data acquisition, and continuous evolution of the data schema;

CON (O4): to provide **control and confidence** in the information system by promoting transparency and predictability of system actions;

COLL (O5): to support the **collaborative** acquisition and verification of data and knowledge.

Those objectives are the different facets of a same approach that targets user guidance as a trade-off between full automation (aka. artificial intelligence) and no automation (aka. programming). We are conscious that this set of objectives is ambitious but we think we can address them because we do not target the hard problems of full automation, and because we now have an effective design pattern, ACN (Abstract Conceptual Navigation) [26], to encapsulate an expressive formal language into data-user interaction and natural language.

4.2 Illustration Scenario

> *To illustrate our objectives, we imagine a scenario in the near future where a* Logical Information System (LIS) *enriched by solutions to the above objectives O1-O5 is put to use. This scenario aims at giving a more concrete shape to our objectives, and pushing the limits of imagination of the reader (as well as the author!). As a disclaimer, it certainly shares motivations with other teams, and there would be many relevant work to cite, but we refrain to do so here for the sake of narration and conciseness (citations are given in Section 4.3 along with more detailed objectives).*

Let us consider a group of people whose mission is to improve collaboration between different services of a company. Each member of the group comes from a different service, and has therefore a different point of view and knowledge on the company. Of course, each service has already an information system but each information system has its own schemas, and APIs. The first task is therefore to merge them. The group creates a new *LIS* – this is as easy as creating a new document on a collaborative platform – and selects the right wrapper for each data source in order to project them all in a same representation format (based on Semantic Web technologies) [FLEX]. The *LIS* makes it possible for all members to explore the different data sources, and to acquire some knowledge about the other services [AUTO]. Because the data sources have evolved independently, they probably use different *ontologies* – or no ontology at all! – and are therefore largely disconnected and incomparable. The members collaborate through the *LIS* to *align* the different ontologies so that the different data sources share a same vocabulary, and become tightly interlinked [SEM]. The tedious process of alignment can be done incrementally, on the need, and the *LIS* assists the process through examples and transformations rather than through formal specifications [CON].

At that point, the group can perform deep analytics of the joint activities of the different services [AUTO]. Dynamic views, dashboards, and feeds can be defined, and can be broadcasted to a large audience or sent to particular individuals according to their information needs. Those definitions are internally expressed in expressive formal languages (queries, visualizations, scripts, etc.), and yet, all interactions and specifications go through point-and-click

interfaces and natural language [AUTO]. Moreover, everything is expressed concretely in terms of the actual data, and feedback about user actions are given at all time [CON].

The analytics have revealed to the group missing information, and inadequate modelling in the ontologies. The members collaborate under system guidance to incrementally improve the ontology, and to fill in the gaps [FLEX,COLL]. The *LIS* assists them in applying data transformations that preserve the consistency of the whole [CON]. When new information are input, machine learning techniques are used to *align* them on existing information [SEM]. In this way, it is easier to preserve the data invariants, even when they are implicit. When the new information are massive or unknown to the group members, rows of questions can be generated and sent to people in the company according to their profile [COLL]. When a person receives such a question, the *LIS* assists him/her like above to build an answer [AUTO]. The answers are automatically integrated by the *LIS*, and the group can analyze them globally to check and correct them [COLL]. In more complex situations, the group can set up a workflow that makes people and machines work together: the machines run automatic processes, possibly acting on the external world, and people do any task that cannot or should not be automated, like taking decisions. Workflows can themselves be defined by users, relying on the same guidance as for analytics, with suggestions derived from previous user actions [AUTO]. Again, no formal language is exposed, and users retain full control of what the *LIS* can do.

The *LIS* co-evolves with its users, without any separation in time between design and production [FLEX]. It can start simple, and then grow in complexity. It is not intelligent in itself, but it builds on the intelligence of its users, and magnifies it at the collective level [COLL]. It gains knowledge from its users, and offers them powerful information access, assistance, and automation.

4.3 Scientific Challenges and Goals

The realization of the high-level objectives O1-O5 requires solutions to a number of scientific challenges. In the following, we shortly define four major scientific challenges, and list for each of them a number of more concrete goals at different time scales: short term, mid term, long term. We do not provide a systematic correspondance between objectives and scientific challenges because a challenge often involves several objectives, and the concrete goals provide a progression in the realisation of the objectives. For each goal, we give the initials of the main participants.

4.3.1 Information Extraction

This challenge is on acquiring structured and semantic data (typically RDF), by extraction from raw data (e.g., texts, GPS tracks). It mostly concerns objective SEM. There will be a progress from relatively structured data such as GPS tracks or tables to less and less structured data. The least structured data come from texts and images, and we may rely on existing techniques (such as developed by team LinkMedia at IRISA) as a first analysis step.

RDF representation of temporal and spatial data (short term) [OR,SF]. Temporal representations are not only about dates and times but also about periods, durations, repeated

events, and also relative expressions (e.g., yesterday, last Christmas). Spatial representations include geo-positions, geometries, shapes, directions, or topological relationships (e.g., "next to", "in"). A challenge is to combine expressivity (e.g., geometries like points, lines, polygons), conciseness of representations, and tractability of computations (e.g., computing durations or distances). There exists some work (e.g, Strabon [KKK12]) that can be integrated into SEWELIS, and improved further.

Sequence discretization and segmentation (mid term) [PC,OR]. Sequences are a common form of data, and are typically generated automatically by sensors, as system logs, or as user histories. In order to apply symbolic approaches, and to make sense of sequential data, an important task is their discretization and segmentation. A tool like SAX [SK08] can be used to discretize numeric sequences, and pattern mining algorithms can be used to segment sequences according to repeated patterns [AS95].

RDFization of semi-structured Open Data (mid term) [MD,SF]. Open Data often comes in the form of semi-structured data: e.g., spreadsheets, CSV files [HFP+06], lists. It is also often noisy and inconsistent in its terminology and notations. A fully automatic RDFization seems illusory, and the challenge is to support the user as much as possible in the RDFization process. The tool OpenRefine[5] is a good starting point in this goal. A possible approach would be a naive RDFization followed by the application of successive RDF transformations, which would be guided by the system but under control of the user.

Information extraction from texts (long term) [AF,PC]. There exist mature solutions for named entity recognition, and for analyzing texts at the word level. However, making full use of syntax and pragmatics to generate a rich semantic representation of the content of a text remains an ambitious challenge. We would first focus on the extraction of relationships between entities in order to produce RDF graphs from texts.

4.3.2 Expressivity

This challenge is on reconciling the expressive power of formal languages (e.g., SQL) and the ease-of-use of graphical interfaces and navigation (e.g., Excel). It mostly impacts objectives AUTO (autonomy), and FLEX (flexibility). Our approach to this challenge is based on the

[5] `https://github.com/OpenRefine`

[KKK12] K. Kyzirakos, M. Karpathiotakis, M. Koubarakis, "Strabon: A Semantic Geospatial DBMS", *in: Int. Semantic Web Conf.*, Springer, 2012, p. 295–311.

[SK08] J. Shieh, E. Keogh, "i SAX: indexing and mining terabyte sized time series", *in: ACM SIGKDD int. conf. Knowledge discovery and data mining*, ACM, p. 623–631, 2008.

[AS95] R. Agrawal, R. Srikant, "Mining Sequential Patterns", *in: Proceedings of the Eleventh International Conference on Data Engineering, ICDE '95*, IEEE Computer Society, p. 3–14, 1995.

[HFP+06] L. Han, T. Finin, C. Parr, J. Sachs, A. Joshi, "RDF123: a mechanism to transform spreadsheets to RDF", *in: Nat. Conf. Artificial Intelligence (AAAI)*, AAAI Press, 2006.

ACN framework, Abstract Conceptual Navigation [26]. In ACN, navigation places are concepts, which are characterized by formal expressions, and navigation links are transformations of those expressions. Guidance in the navigation space should be designed to be safe (no dead-ends) and complete w.r.t. the formal language. Formal expressions and transformations can be hidden behind more natural presentations (e.g., natural language, graphics) because all user input goes through the selection of suggested transformations.

Analytical queries (short term) [SF,OR]. Analytical queries are typically offered by OLAP or spreadsheets and used in Business Intelligence (BI). SEWELIS does not yet support such queries, despite the fact that they can be expressed in SPARQL 1.1 thanks to multi-dimensional queries, computations, and aggregations. Therefore, extending SEWELIS to analytical queries can be done by increasing SEWELIS' expressivity and guidance to cover those SPARQL features. An objective is to perform analytical queries directly against RDF graphs, while existing approaches in the Semantic Web generally propose to first extract tabular views over RDF graphs, and then apply classical approaches to those [KH11,CGMR14]. The problem with the latter approach is that domain experts rely on SW experts for the extraction of views, and that it is difficult to anticipate all useful data views. Indeed, because of their relational nature, RDF graphs can be the source of many different views on data. In our approach, the additional SPARQL features would translate to increased expressivity and navigability.

Automation (mid term) [SF,MD]. Automation comes under different forms in information systems: inference rules based on logic, business rules triggered by some conditions and performing actions, workflows to coordinate people actions and automatic processes. In each case, a formal language has to be chosen or designed, and the challenge is to extend guidance to cover them in a safe, complete, and usable way. A key to usability, and a difficulty, is to support the definition of rules as general as possible, while giving suggestions and feedback as close to concrete examples as possible. The standard SBVR (Semantics of Business Vocabulary and Business Rules[6]) proposed by the OMG may help solving this problem and could be a good source of inspiration.

Exploring the immaterial (long term) [PC,SF,AF]. ACN applications have so far been "material" in that concept extensions are made of concrete objects (e.g., query results). Immaterial ACN applications are where formal expressions have no concrete instance or an intractable number of instances. Two interesting examples are constraint solving problems and programming. In the case of constraints, a formal expression would be a set of user-defined constraints, and its instances would be all possible solutions. In the case of programming, a formal expression would be a program, and its instances would be all possible execution traces.

[6] `http://www.omg.org/spec/SBVR/1.3/PDF/`

[KH11] B. Kämpgen, A. Harth, "Transforming statistical linked data for use in OLAP systems", *in: Int. Conf. Semantic systems*, ACM, p. 33–40, 2011.

[CGMR14] D. Colazzo, F. Goasdoué, I. Manolescu, A. Roatiş, "RDF analytics: lenses over semantic graphs", *in: Int. Conf. World Wide Web*, ACM, p. 467–478, 2014.

The challenge is to provide guidance that is based on possible instances, without having to compute explicitly those instances, like we do in SEWELIS with query results. The choice of the formal language is also a key issue for usability given the high expressivity of constraint and programming languages. A nice starting point for interactive programming user interfaces is Scratch from MIT [RMMH+09]. In the continuation of the Web of data (aka. the Semantic Web), one could also imagine a *Web of programs*, with ideas from Unison[7].

4.3.3 Intelligent Assistance

This challenge is on defining an intelligent assistance based on data mining, which should be as complete as possible while avoiding to overload users with information. Such an assistance can be applied to information retrieval, knowledge discovery, knowledge authoring, and decision making. This challenge mostly concerns objectives CON (confidence and control), and AUTO (autonomy).

Graph pattern mining (short term) [PC,SF]. Graph patterns are already used in SEWELIS queries, but are built step-by-step by users. The goal is here to mine interesting (e.g., frequent) graph patterns in RDF graphs to support more intelligent assistance. Unlike existing graph mining approaches, the objective would be to compute graph patterns lazily, and to avoid showing them to users. For example, SEWELIS uses tree patterns to find objects that are similar to a new object, and uses similar objects to suggest additional descriptors for the new object. Extending tree patterns to graph patterns would enable a more accurate notion of similarity. On user's request, graph patterns could be shown to users as an explanation for suggestions, and could also be used to generate inference or business rules (see 'Automation' in previous section).

Planning-based guidance (mid term) [MD,SF]. In instances of our ACN framework where a navigation goal can be specified, guidance safeness may not be decidable at the level of navigation steps but only at the level of navigation paths. An example is the construction of a workflow where input and output types are specified. The insertion of a service may be valid while not making any progress from inputs to outputs. In such cases, planning techniques could be used to check, for each possible step, the existence of navigation paths leading to the navigation goal.

The "Imitation Game" (long term) [SF,PC]. The game here is not for the system to fool the users, but to strive to anticipate user actions in order to progressively automate them. Its task is to learn from user actions and interactions, to predict the next user actions and to suggest them to users. It is analogous to predictive text input but generalized to any action and interaction with the information system. A possible approach is to apply graph pattern

[7] `https://pchiusano.github.io/2014-09-14/unison.html`

[RMMH+09] M. Resnick, J. Maloney, A. Monroy-Hernández, N. Rusk, E. Eastmond, K. Brennan, A. Millner, E. Rosenbaum, J. Silver, B. Silverman *et al.*, "Scratch: programming for all", *Communications of the ACM 52*, 11, 2009, p. 60–67.

mining on the structured RDF representation of user actions and interactions. In our view, the system only make suggestions, and the user retains full control and decision. Automation comes either by user commitment to suggested rules, or by explicit delegation of decision, inside a fixed perimeter, based on trust. In this way, the information system is more an extension of users' intelligence than a replacement.

4.3.4 Practicality

Necessary conditions for the practicality of information systems in real situations include scalability, usability, and collaboration. The three are related to amount: amount of data that can be handled (scalability), amount of people that can use it (usability), and amount of people that can use it together (collaboration). In our case, scalability is more concerned with achieving low complexity for algorithms (ideally, linear) than with managing huge volumes of data (a billion RDF triples is already quite big). This challenge is on finding approaches and algorithms that are compatible with both large amounts of data and large amounts of people. The usability challenge mostly impacts objective AUTO (autonomy), and COLL (collaboration).

Visualization of query results (short term) [OR,SF,MD]. The goal is to go beyond textual and tabular results with graphical visualizations such as charts, maps, timelines, etc. Like for expressing queries, our objective is to combine flexibility, usability, and intelligent assistance. It should not be possible to generate visualizations that are ill-typed or look ugly because of inadequate data distribution. A declarative and compositional visualization language would make it possible to combine the different kinds of visulizations in a safe and flexible way, rather than in pre-defined idiomatic ways. Also, the visualizations would dynamically adjust through navigational steps that change the query, and hence the visualized data, like in Allard's thesis [2].

Interaction in natural language (mid term) [AF,SF]. While step-by-step navigation is safe and supportive for users, especially when they have not a precise knowledge of the system capabilities, it is less efficient than dialogue in written or spoken natural language (NL). The goal would be to add such a dialogue layer on top of the navigation layer. Standard NLP tools would be used to analyze user utterances, and the navigation layer would be used to interpret them in the specific context of the information system. In case an utterance would not be fully understood by the system, users could resort to navigation to fill in the gaps.

5 Application Domains

The application field of SemLIS is widely open as it covers the field of the Semantic Web. According to a study done in September 2011, the Semantic Web that is available as Linked Open Data (LOD) counts 30 billions triples covering many domains: e.g., life sciences, media, governmental organizations, publications, geography. In addition to those public data, we can count the numerous internal data of companies and other organizations, as well as personal data. Social networks and wikis are yet another source of semantic data: e.g., photo annotations, relationships between people, restaurant ratings.

The approach to applications of the team is to first design generic information systems, then to evaluate the generic design on different use cases or domains, and finally to specialize and adapt it to a particular application if need be. This follows software engineering of reusability and orthogonality.

Our past and current experiences and collaborations have led us to target in priority the large domains below. In particular, we target users in the middle of the spectrum going from pure IT people to the general public, i.e., individuals and groups who are experts in a domain that implies data and knowledge management. Our objective is to enable those users to perform tasks that normally require IT technical competencies.

Social Sciences [AF,OR,MD]. Here, users are often other researchers in domains that have been strongly impacted by the increasing availability of digital data: e.g., geography, linguistics, law, group decision and negotiation. Our objective is not to solve their own scientific problems, but to make those users more autonomous and more efficient in the management and exploration of their data, and to guide them in the knowledge extraction process.

Business Intelligence [SF,MD,PC]. Here, users are groups of various sizes (e.g., teams, committees, companies, organizations) collaborating around one or several projects (e.g., strategic orientation, recruitment process). Our priority will go to small- to medium-sized groups because our emphasis is on expressivity rather than scalability. The objective is to enable a group to capitalize facts and knowledge continuously, to analyze data for self-evaluation or diagnostic, and help in decision making. To be effective, those functions should be coupled with information systems and private social networks.

We detail below a few application domains for which we have already done concrete work and contributions, and for which we have a long-lasting interest.

5.1 Group Decision and Negotiation

Participants: Mireille Ducassé, Peggy Cellier.

Group decision and negotiation focuses on complex and self-organizing processes that constitute multiparticipant, multicriteria, ill-structured, dynamic, and often evolutionary problems. Group decision and negotiation refers to the whole process or flow of activities relevant to reaching a group decision, and not merely to the final choice - aspects of the process in group decision and negotiation include scanning, communication and information sharing, problem definition (representation) and evolution, alternative generation, and social-emotional interaction. Group decision support systems (GDSS) and negotiation support systems (GDNSS) are amongst the major approaches to address the problems.

In the current thread of research, we are showing that Logical Information Systems provide an innovative technological support for most of the above mentioned aspects of GDSS. In particular, the navigation and filtering capabilities of LIS help detect inconsistencies and missing knowledge during meetings. The updating capabilities of LIS enable participants to add objects, features and links between them on the fly. As a result the group has a more

complete and relevant set of information. Furthermore, the compact views provided by LIS help participants embrace the whole required knowledge. The group can therefore build a shared understanding of the relevant information previously distributed amongst the participants. Lastly, the navigation and filtering capabilities of LIS are relevant to quickly converge on a reduced number of targets. A future trend of research will be to investigate how LIS can also support negotiation.

5.2 Geographical Information Systems

Participants: Olivier Ridoux, Peggy Cellier, Sébastien Ferré.

Geographical Information Systems (GIS) is an important, fast developing domain of Information technology, and it is almost absent from INRIA projects. It is especially important for local communities (e.g. region and city councils).

Geographical information systems [LT92] handle information that are localized in space (*geolocalized*). GIS form an area which incorporates various technologies such as web, databases, or imaging. One characteristic of GIS is their organization as *layers*. This is inherited from the plastic sheets that where used until recently for drawing maps. A layer represents the road system, another the fluvial system, another the relief, etc. This is another instance of the tyranny of the dominant decomposition, and is not satisfactory: to which layer belong bridges, into which layer can we represent a multimodal network? Moreover, mining GIS is known to be difficult for the same reason; the layer structure makes inter layer relationships difficult to discover.

The first advantage of applying LIS to GIS is to allow cross-layer navigation. Another advantage is to permit a logical handling of scales. In current GIS systems, scales are treated as different layers, and it is difficult to keep the consistency between all layers that describe the same object. Another advantage that we have observed in a preliminary work is that LIS helps cleaning a data-base. This was not expected, and opens an interesting research area. Another characteristic of GIS is an intensive usage of topological relations (touches, overlaps, etc) and geographical relations (North, upstream, etc). Logic offers a rich language for expressing these relations and combining them.

5.3 Software Engineering

Participants: Olivier Ridoux, Annie Foret.

This application domain can be seen as a particular case of the "social sciences" domain where the object of study is not a living organism or a territory but a software, and where the domain experts are developers. That domain plays an important role in the history of the team. The formal nature of computer programs (syntactic structure, type systems, versioning) lends itself to a structured and semantic representation. However, software also contains elements in natural language (e.g., comments, commit messages). Possible applications are the retrieval of software components and their composition, or the analysis of code or program traces.

[LT92] R. Laurini, D. Thompson, *Fundamentals of Spatial Information Systems*, Elsevier, Academic Press Limited, 1992.

6 Software

6.1 Camelis, Sewelis, and Sparklis

Participants: Sébastien Ferré.

Camelis is a stand-alone application that allows to store, retrieve and update objects through a graphical interface. Its main purpose is to experiment with the LIS paradigm. In particular, it has been very useful for refining the query-answer principle in special circumstances (e.g. when there are many answers, or when there are few answers). It is currently used as a personal storage device for handling photos, music, bibliographical references, etc, up to tens of thousands of objects. It implements as closely as possible the LIS paradigm. It is generic w.r.t. logics, and is compatible with our library of logic functors, LogFun. It is available on Linux and Windows, and comes with a user manual.

An important extension, Sewelis, has been developped to browse RDF(S) graphs, a Semantic Web standard. It uses a query language whose expressivity is similar to SPARQL, the reference query language of the Semantic Web. The LIS navigation has been proved safe (i.e., does not lead to dead-ends), and complete (i.e., can reach all conjunctive queries), so that users can perform complex searches easily and safely [17]. Sewelis also supports the guided creation and update of objects, according to the UTILIS approach [32]. In 2015, some code of Portalis (see 2014 report) was integrated to Sewelis to make it a multi-user Web application. A beta version is available online.

Sparklis is a re-implementation of the querying capabilities of Sewelis as a Web application on top of SPARQL endpoints. Its main advantages compared to Sewelis are: (1) no setup, just load a page in a browser, (2) direct exploration of remote SPARQL endpoints, (3) scaling up to large triple stores that contain up to billions triples, like DBpedia, and (4) verbalization of queries in natural language for better readability.

In 2017, a major result is the official adoption of Sparklis at Persée, a bibliographic portal for Humanities and social sciences whose users are researchers in those domains. Our collaboration with Persée has already led to a number of improvements of Sparklis in terms of features and usability. Funding was also obtained from Ouest Valorisation for pre-industrial development around Sparklis (project SEMELEV), with the final objective of creating a startup for the development and commercialisation of services and products based on Sparklis. SEMELEV funds two things. First, Pierre Maillot was hired in December on a 18-months contract as a research engineer. Second, a marketing study was initiated by Ouest Valorisation, and conducted by In Extenso. As in previous years, a number of demos were given, in particular at the SEMANTiCS conference in Amsterdam (11-13 September) [15], and to companies such as Dassaults Systems, and Mediadone.

6.2 Typed grammars

Participants: Annie Foret [contact point], Denis Béchet [LINA-Nantes].

A Pregroup ToolBox is under development on the gforge Inria as a collaborative work with LINA. It includes a generic pregroup parser (LINA) and grammar lexicon definitions

and manipulation tools based on XML. An interface with Camelis has been developped (from Camelis to the Pregroup XML format, and the other way round). It has been used to define and experiment grammar prototypes for different natural languages.

6.3 Terminology

Participants: Annie Foret.

TermLis (2015-) is a logical information context for terminological resources as an application of the Logical Information System approach to this field. The current version is to be used with Camelis. It is available at http://www.irisa.fr/LIS/softwares/TermLis/.

The tool has several variants (FranceTerme, EuroVoc [16], Breton data).

6.4 Legal documents

Participants: Annie Foret [contact point], Alex Chauvet [Bordeaux].

The tool (2017-), presented in [6], is a logical information context for browsing legal documents as an application of the Logical Information System approach to this field. The current version concerns the "conseil constitutionnel" decisions and is to be used with Camelis.

6.5 SDMC: Sequential Data Mining under Constraints

Participants: Pierre Holat [LIPN], Nicolas Béchet [IRISA/Vannes], Peggy Cellier, Thierry Charnois [LIPN], Bruno Crémilleux [GREYC].

SDMC is a tool to extract sequential patterns [4][8]. It is specially adapted for text mining, allowing part-of-speech extraction and linguistic constraints like gap and membership. Already used by other institutions, the tool can be useful for many text mining tasks like clustering or named entity recognition.

SDMC is available as a Web application: `http://tal.lipn.univ-paris13.fr/sdmc/`.

6.6 SQUALL: a Semantic Query and Update High-Level Language

Participants: Sébastien Ferré.

SQUALL (Semantic Query and Update High-Level Language) is a controlled natural language (CNL) for querying and updating RDF graphs [27]. The main advantage of CNLs is to reconcile the high-level and natural syntax of natural languages, and the precision and lack of ambiguity of formal languages. SQUALL has a strong adequacy with RDF, and covers all constructs of SPARQL, and most constructs of SPARQL 1.1. Its syntax completely abstracts from low-level notions such as bindings and relational algebra. It features disjunction, negation, quantifiers, built-in predicates, aggregations with grouping, and n-ary relations through reification.

[8] N. Béchet, P. Cellier, T. Charnois, B. Crémilleux, "SDMC : un outil en ligne d'extraction de motifs séquentiels pour la fouille de textes", in: Extraction et gestion des connaissances (EGC'2013 - Session démo), A. F. Gelbukh (editor), 2013.

SQUALL is available as a Web application at under two forms: one that translates SQUALL sentences to SPARQL, and another one that directly return query answers from a SPARQL endpoint.

6.7 PEW: Possible World Explorer

Participants: Sébastien Ferré, Sebastian Rudolph.

The Possible World Explorer (PEW) targets ontology designers, and aims to help them correct and complete their ontologies. It reuses the query-based faceted search principles of Sewelis for exploring the "possible worlds" (i.e., models) of an OWL ontology. Users are guided in the incremental construction of class expressions, such that only satisfiable classes are reachable. All classes made of qualified existential restrictions, nominals, intersections, unions, and atomic negations are reachable.

PEW not only supports the exploration of an ontology's possible worlds, but also supports its completion by the addition of axioms [23]. When a class is found satisfiable, and this contradicts domain knowledge (e.g., a man that is not a person), the undesirable possible worlds can be excluded ("pew pew!") by asserting an axiom saying that this class is unsatisfiable (e.g., every man is a person). This could be made a game, where the player would strive to exclude as many undesirable worlds as possible. The benefits are to complete the ontology with more knowledge, and therefore to improve its deduction power.

In addition to completing existing ontologies, PEW also allows the edition of ontologies *de novo* [29]. It allows for the extension of the signature by creating new classes, properties, and individuals; and it covers a wide range of OWL axioms.

7 Contracts and Collaborations

7.1 IDFRAud: An Operational Automatic Framework for Identity Document Fraud Detection and Profiling (ANR)

Participants: Sébastien Ferré, Peggy Cellier, Pierre Maillot.

The ANR IDFRAud aims at allowing the automated recognition of ID documents, and the detection of false documents, by applying techniques for document analysis, classification, and knowledge management. The leader is Montaser Awal (replacing Abdullah Almaksour in 2016) from the AriadNEXT innovating company, and other partners are the IRISA laboratory, IRCGN ("Institut de Recherche Criminelle de la Gendarmerie Nationale"), and ENSP (National School of Police). Sébastien Ferré is the scientific head for the IRISA partner. The project started in February 2015. For the SemLIS team, the project funds 2 postdoc years and research costs (e.g., missions, machines).

This year, a consortium meeting was held on June 1st, as well as a number of working meetings with AriadNEXT on various topics (knowledge base, knowledge acquisition, document analysis workflow inference, data mining of false documents, ...). We delivered FORMULIS, an intelligent form-based user interface for the guided acquisition of RDF metadata. We also delivered a prototype about the clustering of false documents according to their description, as

entered in FORMULIS. This prototype combines two approaches: Formal Concept Analysis and MDL-based data mining (KRIMP [VVLS11]). A short paper was presented at the 28th International Conference on Database and Expert Systems Applications DEXA 2017 [14]. A joint paper with AriadNEXT was presented at the Industry Track of ISWC'17 [7] about their adoption of the Semantic Web technologies, and the benefits it brought them.

7.2 PEGASE: Improved pharmacovigilance and signal detection with groupings

Participants: Sébastien Ferré, Carlos Bobed-Lisbona, Annie Foret, Peggy Cellier, Mireille Ducassé.

The SemLIS team was invited to join the PEGASE project for its Sparklis software, as a way to reconcile the formal aspect of Semantic Web languages, and the need for usability for the end-users, here pharmacovigilance experts.

The mission of those experts is to collect, annotate, store, analyze, and prevent the undesirable effects of drugs. They rely on the MedDRA terminology (Medical Dictionary for Regulatory Activities) to annotate new cases, and to retrieve former cases. An important issue is the large size of MedDRA (about 20,000 terms), and the fact that several terms must generally be used to retrieve all relevant cases from the base. A Semantic Web version of that terminology, the OntoADR ontology, already exists. It allows the precise querying of MedDRA with formal languages like SPARQL. The objective of the project is to develop and compare several user interfaces enabling pharmacovigilance experts to navigate and query the terminology in order to identify the relevant terms.

The leader of the project is Cédric Bousquet from SSPIM ("Service de santé publique et de l'information médicale") and CHU St Etienne. The project gathers computer scientists from LIMICS (INSERM U1142) and IRISA, pharmacovigilance experts from 4 regional centers (Besançon, Lille, Paris HEGP, Toulouse), and ergonoms of the medical domain from CIC-IT Evalab.

This year, a consortium meeting was held on June 20th. Actual work started when Carlos Bobed-Lisbona was hired as a postdoc on the project. We managed to collect the relevant data (MedDRA terminology, OntoADR mapping from MedDRA to SNOMED CT, and patient data from FAERS), and to model and convert it in RDF. Sparklis was extended to handle hierarchies and multiple selections, both of which had been identified as important for PEGASE by the ergonomists at CIC-IT. A first meeting with CIC-IT took place on December 7th in order to prepare usability studies to be conducted by them in 2018.

7.3 LangNum-br-fr : a DGLF-LF "Langue et numérique" project

This project (leaded by Annie Foret) is funded by the "Delegation générale à la langue française et aux langues de france" (DGLF-LF, French culture minister) in the theme "languages and digital" and concerns the French-Breton language pair. The general approach of the scientific

[VVLS11] J. Vreeken, M. Van Leeuwen, A. Siebes, "Krimp: mining itemsets that compress", *Data Mining and Knowledge Discovery 23*, 1, 2011, p. 169–214.

project is multidisciplinary, involving computer scientists specialized in natural language processing [Partner A: IRISA and Rennes 1 University, Partner B: LIG Grenoble, Partner C: IT Laboratory in Tours), linguists specialized in Celtic languages [Partner D: CRBC and Rennes2] and specialists in ICT usage [Partner E: Loustic Laboratory]. This work includes technical design work (partners A, B, C in TAL), linguistic work (CRBC) and work on usages (Loustic).

The current challenge is to improve and develop resources and tools for Breton, in coordination between different disciplines, and with a pedagogical concern. A state of the art on tools and resources, and new proposals can be found in our previous contributions. Before defining a software development (a processing chain), an analysis of usages and needs is undertaken with support from a specific Loustic project involving one month engineer.

7.4 Other Collaborations

- Since the end of 2016, Peggy Cellier is involved in the FUI project REUs (started at the end of 2016) in collaboration with the GREYC (Caen) about information extraction from meeting reports. For this collaboration she works with Bruno Crémilleux (Professor at Unviserity of Caen), Thierry Charnois (Professor at LIPN), Albrecht Zimmerman (Associate professor at University of Caen) and Pegah Alizadeh (Post-doc on the project) about extrating information from meeting transcripts.

  Since the end of 2016, she also collaborates with Esther Galbrun (Researcher at INRIA Nancy) and other members of the industrial project ITRAMI (started in 2015) led by Alexandre Termier about the analysis of traces.

- Mireille Ducassé collaborates with Ivane Javakhishvili Tbilisi State University, in Georgia (Caucasus). A proposal has been made to the Georgian National Science Foundation regarding "A Georgian Language Based Semantic Search “Engine” Algorithm Development" by Manana Khachidze and Magda Tsintsadze with a contribution of SemLIS. Results are pending. Mireille Ducassé also collaborates with the B. K. Birla Institute of Engineering & Technology, in India. A short paper about Compact Visualization of Database Tables has been published at a local conference [8].

- Sébastien Ferré collaborates with Persée, a research unit in the domain of humanities and social sciences, on the use of Sparklis (see 6.1).

- Annie Foret collaborates with LINA (research lab. Nantes), TALN team (Natural Language Processing), she is a member of “Agence Universitaire de la Francophonie” (AUF), LTT network on “Lexicologie, terminologie et traduction”. Annie Foret is member of ATALA (Association pour le Traitement automatique des Langues), and of SIF (Société Informatique de France).

8 New Results

8.1 Sparklis: An Expressive Query Builder for SPARQL Endpoints with Guidance in Natural Language

Participants: Sébastien Ferré.

Linked data is increasingly available through SPARQL endpoints, but exploration and question answering by regular Web users largely remain an open challenge. Users have to choose between the expressivity of formal languages such as SPARQL, and the usability of tools based on navigation and visualization. In a previous work, we have proposed Query-based Faceted Search (QFS) as a way to reconcile the expressivity of formal languages and the usability of faceted search. In this work [4, 15], we further reconciled QFS with scalability and portability by building QFS over SPARQL endpoints. We also improved expressivity and readability. Many SPARQL features are now covered: multidimensional queries, union, negation, optional, filters, aggregations, ordering. Queries are now verbalized in English (and French), so that no knowledge of SPARQL is ever necessary.

All of this is implemented in a portable Web application, Sparklis, and has been evaluated on many endpoints and questions. No endpoint-specific configuration is necessary as the data schema is discovered on the fly by the tool. Online since April 2014, thousands of queries have been formed by hundreds of users over more than a hundred endpoints. We have analysed in detail usage logs, which show that a number of users have applied Sparklis to their own data, in particular in bioinformatics, and managed to build complex questions in order to satisfy their information needs.

8.2 Nested Forms with Dynamic Suggestions for Quality RDF Authoring

Participants: Pierre Maillot, Sébastien Ferré, Peggy Cellier, Mireille Ducassé.

Abstract Knowledge acquisition is a central issue of the Semantic Web. Knowledge cannot always be automatically extracted from existing data, thus domain experts are required to manually produce it. On the one hand, learning formal languages such as RDF represents an important obstacle to non-IT experts. On the other hand, well-known data input interfaces do not address well the relational nature and flexibility of RDF. Furthermore, it is difficult to maintain data quality through time, and across contributors. We propose FORMULIS, a form-based interface for guided RDF authoring. It hides RDF notations, addresses the relational aspects with nested forms, and guides users by computing intelligent filling suggestions. Two user experiments show that FORMULIS helps users maintain good data quality, and can be used by users without Semantic Web knowledge [14].

8.3 Concepts of Nearest Neighbours in Knowledge Graphs

Participants: Sébastien Ferré.

We have introduced the notion of *concept of neighbours* as an alternative to the notion of numerical distance with the objective to identify the most similar objects to a query object, like

in the nearest neighbours approach. Each concept of neighbours is composed of an intention that describes in a symbolic way what two objects have in common, and of an extension that covers all objects that are in between the two objects. We have defined those concepts of neighbours for complex data, knowledge graphs, where nodes play the role of objects. We have described an *anytime* algorithm that tackles the high computing complexity of the task, and we reported first experiments on RDF graphs having more than 120,000 triples [9].

8.4 Using Bids, Arguments and Preferences in Sensitive Multi-unit Assignments: A p-Equitable Process

Participants: Mireille Ducassé, Peggy Cellier.

Bonus distribution in enterprises or course allocation at universities are examples of sensitive multi-unit assignment problems, where a set of resources is to be allocated among a set of agents having multi-unit demands. Automatic processes exist, based on quantitative information, for example bids or preference ranking, or even on lotteries. In sensitive cases, however, decisions are taken by persons also using qualitative information. At present, no multi-unit assignment system supports both quantitative and qualitative information. In this paper, we propose an interactive process for multi-assignment problems where, in addition to bids and preferences, agents can give arguments to motivate their choices. Bids are used to automatically make pre-assignments, qualitative arguments and preferences help decision makers break ties in a founded way. A group decision support system, based on Logical Information Systems, allows decision makers to handle bids, arguments and preferences in a unified interface. We say that a process is *p-equitable* for a property p if all agents satisfying p are treated equally. We formally demonstrate that the proposed process is p-equitable for a number of properties on bids, arguments and preferences. It is also Pareto-efficient and Gale-Shapley-stable with respect to bids. It has been tested on a course allocation case study that spans over two university years. The decision makers were confident about the process and the resulting assignment. Furthermore, the students, even the ones who did not get all their wishes, found the process to be equitable [14]. In 2017, the team supervised two interns who produced a preliminary prototype to handle the process in a more user-friendly way than the generic interface of Sewelis.

8.5 Topic Signatures in Political Campaign Speeches

Participants: Clément Gautrais, Peggy Cellier, René Quiniou, Alexandre Termier.

Highlighting the recurrence of topics usage in candidates speeches is a key feature to identify the main ideas of each candidate during a political campaign. We propose a method combining standard topic modeling with signature mining for analyzing topic recurrence in speeches of Clinton and Trump during the 2016 American presidential campaign [11]. The results show that the method extracts automatically the main ideas of each candidate and, in addition, provides information about the evolution of these topics during the campaign.

8.6 Purchase Signatures of Retail Customers

Participants: Clément Gautrais, René Quiniou, Peggy Cellier, Thomas Guyet, Alexandre Termier.

In the retail context, there is an increasing need for understanding individual customer behavior in order to personalize marketing actions. We propose the novel concept of customer signature, that identifies a set of important products that the customer refills regularly [12]. Both the set of products and the refilling time periods give new insights on the customer behavior. Our approach is inspired by methods from the domain of sequence segmentation, thus benefiting from efficient exact and approximate algorithms. Experiments on a real massive retail dataset show the interest of the signatures for understanding individual customers.

8.7 Exploration of Textual Sequential Patterns

Participants: Hedi-Théo Sahraoui, Pierre Holat, Peggy Cellier, Thierry Charnois, Sébastien Ferré.

The extraction of regularities in texts is important for several natural language processing tasks. For instance, in information extraction, the regularities can allow to discover linguistic patterns or to study the stylistics of authors. When looking for those regularities, some specificities of textual data have to be taken into account: the sequentiality of the data (i.e., the order between words), the different levels of abstractions (i.e., words, lemma, Part-Of-Speech (POS) tags) and specific constraints (e.g., "the regularities have to contain a verb"). SDMC (Sequential Data Mining under Constraints)[9] is a sequential pattern mining tool that deals with all those requirements. From a text, the tool extracts regularities called *sequential patterns*, i.e sequences of words, lemmas, and POS tags that frequently appear together in the text. In order to extract such patterns mixing different levels of abstraction, each word in the text is represented by itself but also by its lemma and its POS tags. In addition, SDMC allows to apply constraints to filter the extracted patterns: widespread constraints in data mining like minimum frequency (support) but also text-specific constraints like *"contains a verb"*.

A well-known drawback of pattern mining is the huge number of patterns that can be extracted. Even if SDMC manages the computation issue through constraints, the set of extracted patterns can be very large and hard to assess for users. In a previous work, we have used the Logical Information Systems (LIS) paradigm to explore a set of patterns. The main advantage of this approach is that users can benefit from their background knowledge to navigate through the patterns.

In this work [17] we show how we have instantiated the LIS paradigm into SDMC to help users deal with their patterns and their texts. Indeed, we propose to explore the sequential patterns that appear in a text with a visualization of the sentences where those patterns occur. That exploration functionality is available online in the "Concordancier" menu as "Navigation dans les motifs".

[9] `http://tal.lipn.univ-paris13.fr/sdmc/`

8.8 Legal domain

Participants: Guillaume Aucher, Annie Foret, Olivier Ridoux.

In [5] we describe the theoretical principles that underlie the design of a software tool which could be used by judges for writing judgements and for making decisions about litigations. The tool is based on Binary Decision Diagrams (BDD), which are graphical representations of truthvalued functions associated to propositional formulas. Given a specific litigation, the tool asks questions to the judge; each question is represented by a propositional atom. Their answers, true or false, allow to evaluate the truth value of the formula which encodes the overall recommendation of the software about the litigation. Our approach combines some sort of 'theoretical' or 'legal' reasoning dealing with the core of the litigation itself together with some sort of 'procedural' reasoning dealing with the protocol that has to be followed by the judge during the trial: some questions or group of questions must necessarily be examined and sometimes in a specific order. That is why we consider extensions of BDDs called Multi-BDDs. They are BDDs with multiple entries corresponding to the different specific issues that must necessarily be addressed by the judge during the trial. We illustrate our ideas on a case study dealing with French union trade elections, an example that has been used throughout a project with the French Cour de cassation. We end the article by sketching the architecture of a prototype software that has been developed during this project.,

In [10, 6] we contributed to two related events on "convergences du droit et du numérique", where we consider information systems in the domain of law and possible applications of the LIS approach in this field. This study in [6] concerns information systems in law and proposes a new prototype. We discuss the information systems currently used by legal researchers, including their limitations. We present the principles of a new prototype for a better system. This work is accompanied by a first concrete realization, a system with semantic facets, result of our processing chain on a set of decisions of the Constitutional Council.

8.9 Linguistic Data and Logical Information Systems

Participants: Annie Foret.

We have recently undertaken the Logical Concept Analysis (LCA) that extends the Formal Concept Analysis (FCA) for terminology, a workflow has been developed to go from XML data to a logical information context. Through experiments on specific resources, facet designs have been tuned to facilitate the search and control on the data. With this prototype, we consider several usages of such contexts and illustrate benefits of the approach. This was done initially using the FranceTerme resource, containing terms of different scientific and technical fields; we have carried on this development, [16] considering the EuroVoc resource, a Multilingual Thesaurus of the European Union. In these data, each concept is related to a domain, with an attempt to avoid ambiguities.

8.10 Measuring Structural Similarity Between RDF Graphs

Participants: Pierre Maillot, Carlos Bobed.

In the latest years, there has been a huge effort to deploy large amounts of data, making it available in the form of RDF data thanks, among others, to the Linked Data initiative. In this context, using shared ontologies has been crucial to gain interoperability, and to be able to integrate and exploit third party datasets. However, using the same ontology does not suffice to successfully query or integrate external data within your own dataset: the actual usage of the vocabulary (e.g., which concepts have instances, which properties are actually populated and how, etc.) is crucial for these tasks. Being able to compare different RDF graphs at the actual usage level would indeed help in such situations. Unfortunately, the complexity of graph comparison is an obstacle to the scalability of many approaches.

In [13], we present our *structural similarity measure*, designed to compare structural similarity of low-level data between two different RDF graphs according to the patterns they share. To obtain such patterns, we leverage a data mining method (KRIMP) which allows to extract the most descriptive patterns appearing in a transactional database. We adapt this method to the particularities of RDF data, proposing two different conversions for an RDF graph. Once we have the descriptive patterns, we evaluate how much two graphs can compress each other to give a numerical measure depending on the common data structures they share. We have carried out several experiments to show its ability to capture the structural differences of actual vocabulary usage.

9 Dissemination

9.1 Invited Talks and Visits

- Carlos Bobed, a postdoc from University of Zaragoza, Spain, was visiting the SemLIS team since November 2016. He has worked on the Semantic Web, question answering, and mobile applications. He is working with Sébastien Ferré on making Sparklis more linguistic-aware. His visit lasted until June, and continued on a postdoc position related to the PEGASE project since September.

- Mireille Ducassé visited Ivane Javakhishvili Tbilisi State University, Georgia, in April and November 2017 within the framework of an Erasmus+ International Credit Mobility project. She gave courses (see Teaching Section), recruted students for future incoming mobility and had preliminary reserach discussions about Georgian verb conjugation. She also visited the Akaki Tsereteli Kutaisi State University, and the Tbilissi Free University, Georgia, in November, in order to set up new partnerships.

- Annie Foret visited ILCC (the Institute for Language, Cognition and Computation), Edinburgh University in february 2017, within the collaboration project "From Texts to Logical representations" supported by University of Rennes1.

- Peggy Cellier visited and received the visit of Pegah Alizadeh in December 2017 in the context of the FUI project REUs. She also participated to the mini-Symposium organized by MASTODON project DECADE (découverte et exploitation des connaissances pour l'aide à la décision en chimie thérapeutique) in November in Lyon.

9.2 Young Researchers

- Pierre Maillot is member of the team as postdoc since December 2015 as part of the ANR IDfraud in a two years position. He has defended his thesis in November 2015 on new methods for distributed queries and data quality maintenance in the Semantic Web. During his stay, he has developed FORMULIS, a system for intelligent guided RDF data creation based on SEWELIS. FORMULIS was presented this year as a short paper at DEXA'17 [14]. As part of the IDFraud project, he has also participated to technology transfer with the AriadNext company by presenting them Semantic Web technologies.

- Aurélien Lamercerie is a new PhD student since novembre 2017. The PHD is entitled "From texts carrying deontic modalities to their formal representations, in interaction with the user." It involves two IRISA teams, with a co-supervision by Annie Foret (SemLIS) and Benoît Caillaud (Hycomes). The challenge is to link natural language sentences to formal representations, with a particular focus on deontic modalities (texts that contain expressions of obligations, optionality, interdictions).

- Hedi-Théo Sahraoui (M1 MIAGE at University of Rennes 1) and Melaine Boué (L3 MIAGE at University of Rennes 1) did their internship in the team supervised by Peggy Cellier, Mireille Ducassé and Sébastien Ferré. Their project were part of the "Group Decision and Negotiation" work in the team. Hedi-Théo Sahraoui worked on an assignment tool, whereas Melaine Boué worked on an electronic wallet for choice bidding.

9.3 Involvement in Scientific Communities

- Peggy Cellier and Sébastien Ferré were the Conference Chairs of the 14th International Conference on Formal Concept Analysis (ICFCA) [1], which took place at IRISA, Rennes on 13-16 June. ICFCA 2017 was a real success with a total of 85 participants coming from 13 countries on 3 continents. The program included:

  - 4 keynote talks by Laurent Miclet, Alexandra Poulovassilis, Jilles Vreeken, and Marie-Christine Rousset;
  - 3 tutorials;
  - 18 talks of accepted papers;
  - 12 posters and demos.

- Sébastien Ferré is a member of the Editorial Board of the International Conference on Formal Concept Analysis (ICFCA). He was also in 2017 a member of the program committee of several conferences (ISWC, ESWC, ISMIS, FQAS), and several workshops (GKR@IJCAI). Finally, he served as an external reviewer for journals: Discrete Applied Mathematics, and Fundamenta Informaticae. He produced 16 reviews in total.

  Sébastien served as a referee in the PhD committees of:

  - January 12th: Julie Sauvage-Vincent (Université de Bretagne Occidentale) on "Un langage contrôlé pour les Instructions nautiques du Service Hydrographique

et Océanographique de la Marine", supervised by Yannis Haralambous and John Puentes;

– October 13th: Cristina Nica (Université de Strasbourg) on "Exploring Sequential Data with Relational Concept Analysis", supervised by Florence Le Ber and Agnès Braud.

He is also a member of thesis supervision committee of Lucas Bourneuf, supervised by Jacques Nicolas in the DYLISS team at IRISA, and whose subject is "Justifiable graph decomposition to assist biological network understanding".

- Peggy Cellier is a member of the Editorial Board of the International Conference on Formal Concept Analysis (ICFCA). She served as Senior PC for the french conference EGC (Extraction et Gestion de la connaissance). She was also in 2017 a member of the program committee of ECMLPKDD (European Conference on Machine Learning and Data Mining) and a workshop: DEMO at EGC. Finally, she served as an external reviewer for MOTAIST (numéro spécial "Modèles, traitements et analyses dédiés aux informations spatiales et temporelles" de la revue internationale de géomatique).

  Peggy co-organized with Thierry Charnois, Andreas Hotho, Stan Matwin, Marie-Francine Moens and Yannick Toussaint, the workshop "DMNLP" [2] at ECMLPKDD (Skopje, Macedonia) in Septembre 2017 (`https://dmnlp.irisa.fr`).

  She served as an examiner in the PhD defense committee (University of Rennes 1, July 18th) of Mohsen Sayed on "Knowledge Discovery Considering Domain Litterature and Ontologies: Application to rare diseases".

  Peggy is a supervisor of the PhD of Clément Gautrais with Thomas Guyet, René Quiniou and Alexandre Termier. She co-supervised the internships of: Hedi-Théo Sahraoui ; and Melaine Boué with Mireille Ducassé and Sébastien Ferré on "An assignment tool" and "A tool to manage electronic student purse".

  She was also member of the thesis supervision committee of Alban Siffer (University of Rennes 1) and of Clément Dalloux (University of Rennes 1).

- Annie Foret is a member of the Editorial Board of the "Formal Grammar" International Conference (FG), affiliated with ESSLLI, see [3]. In 2017, she was chair of the 22nd Formal Grammar conference, and member of its program committee. In 2017, she has been a reviewer for the following journal : Knowledge and Information Systems (KAIS international journal).

  Annie Foret is a member of the thesis-committee of Juliette Talibart at IRISA on "Learning Grammars on Proteins with Direct Coupling Analysis".

  Annie Foret is co-supervising the PHD thesis of Aurélien Lamercerie.

- Pierre Maillot served as an external reviewer for the french-speaking conference Extraction et Gestion de Connaissance (EGC 2017).

9.4 Academic Responsabilities

- Olivier Ridoux is the head of the DKM department since October 2014, and member of IRISA "Conseil de laboratoire" (laboratory board). Olivier Ridoux is a member of the EcoInfo CNRS service group on sustainable development and information technology (`http://ecoinfo.cnrs.fr`).

- Mireille Ducassé has been awarded the rank of "Chevalier dans l'ordre des palmes académiques" - Promotion of the 14 July 2017. She is the director of international relations of the INSA of Rennes since december 2010. As such, she is a member of the direction of the INSA Rennes. Since March 2014 she is also the coordinator of the international relations of Groupe INSA. In particular, she is responsible for exchange programs involving around 400 student mobilities and 30 staff mobilities per year. She set up a number of dual degrees programs over the past years. She set up an Erasmus+ consortium for Groupe INSA and International programs with Tbilisi State University in Georgia, UEMF, Morrocco and ITC in Cambodgia. She is responsible of a BRAFITEC agreement for Groupe INSA with Universidade Federal da Paraiba (UFPB) and Universidade Federal de Campina Grande (UFCG), Brazil.

- Sébastien Ferré is vice-director of the MIAGE at ISTIC, and was in charge of Master 1 internships (80 students) until August.

- Olivier Ridoux and Sébastien Ferré are members of the committee of the DKM scientific department (Data and Knowledge Management) at IRISA.

- Annie Foret is an elected member of the scientic committee of ISTIC/Rennes 1. She is a member of the IRISA local committee on sustainable development. She is responsible of the internships of computer science students (Master 1 IL and SSR)

- Peggy Cellier is an elected member of the "Conseil de Composante IRISA/INSA" at INSA. She is also an elected member of the "Conseil de laboratoire" at IRISA.

  She organized the bibliographic and internship defense for the Research in Computer Science (MRI) specialism. Since September, 2013 she is responsible of the internships of computer science students (Licence 3 - 75 students, Master 1 - 65 students, and Master 2 - 65 students). She has also been involved in the IDPE (Ingénieur diplômé par l'état) diploma. She participated to the recruitement committes of 1st year students (interviews of candidates).

9.5 Teaching

- At INSA, Peggy Cellier is responsible of two courses: *Databases and web development* (Licence 3) and *Data-Based Knowledge Acquisition: Symbolic Methods* (Licence 3). She also teaches some other courses: *Database* (Licence 2), *Use and functionalities of an operating system* (Licence 3). She also gave a 10 hours course on data mining at master level in ENSSAT (Lannion). She participated to the PPI (Projet Professionel Individualisé) interviews.

- Mireille Ducassé, at INSA, is responsible of three courses, taught in English: *Formal Methods for Software Engineering* (with the "B formal method") and *Constraint Programming* at Master 1 level, as well as *Participatory Design* at Master 2 level. She gave two 10 hours Prolog courses at Ivane Javakhishvili Tbilisi State University to prepare future incoming students, in April and November.

- Sébastien Ferré teaches symbolic data mining, Semantic Web, and compiler techniques at the master level. He also teaches functional programming at license level. This year, he gave a 24h course on the Semantic Web at master level at Polytech Nantes.

- Annie Foret teaches university courses including formal logic and formal methods for computer scientists, xml technology and related notions (Rennes 1 second-fifth year, fourth year and industry specific sessions) and databases (Rennes 1 and e-miage).

- Olivier Ridoux teaches data-bases, algorithmics, the theory of formal languages and compilation in the engineering school ESIR. He is also in charge of the innovation training in the school, in which he also teaches sustainable development w.r.t. IT, and disruptive innovation (à la Clayton Christensen) w.r.t. scientific revolution (à la Thomas Kuhn). He also teaches logic and constraint programming at the Master level, and an introduction to the principles of IT systems at the Bachelor level. He is also in charge of the institutional communication of ESIR.

- Pierre Maillot supervised practicals of knowledge acquisition in third year and of constraint programming in fourth year at INSA Rennes.

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